

Anadromous Fish Evaluation Program Annual Review 2008

December 8 - 11, 2008

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U.S. Army Corps of Engineers
Portland District

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Northwestern Division – Portland District
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AGENDA



AGENDA

Schedule Subject to Change Without Notice

Presentations are 20 minutes long unless otherwise noted

MONDAY December 8, 2008		
Opening Comments	Mike Langeslay, USACE	
1:05-1:20	Opening Remarks	
Willamette Studies		
Moderator	David Griffith	
1:20-1:40	Willamette Valley Project BiOp Program Overview	David Griffith
1:40-2:00	An Assessment of Energetic Condition for Two Populations of Adult Summer Chinook Salmon in the Willamette Valley of Central Oregon	Ryan Mann, Greg Taylor & Chris Caudill
2:00-2:20	Analysis of genetic variation in upper Willamette bull trout populations	USFWS-Patrick Dehaan
2:20-2:35	Break	
Lamprey		
2:35-2:55	Adult lamprey passage success and behavior at Lower Columbia River dams 2008	Matt Keefer
2:55-3:15	Evaluation of adult lamprey use of the Lamprey Passage Structures (LPS) at Bonneville Dam, 2008	Mary Moser
3:15-3:35	Developing a separator for juvenile lamprey	Mary Moser
3:35-3:55	Relationship between energetic status and migratory behavior and success in pacific lamprey: preliminary results	Ben Ho
3:55-4:15	Effects Of Water Velocity On Fishway Entrance Success By Pacific Lamprey and Fishway Use Summaries At Bonneville Dam, 2008	Eric Johnson
4:15-4:35	Evaluation of adult Pacific lamprey passage success at McNary and Ice Harbor dams	Chuck Boggs
4:35-4:55	Use of night video to quantify adult lamprey passage at Bonneville and The Dalles dams 2007 and preliminary 2008 results	Tami Clabough
TUESDAY December 9, 2008		
Adult Studies/Bull Trout		
Moderators	David Clugston and Fred Higgenbotham	
7:55-8:00	Intro to Little Goose Adult passage	Fred Higginbotham

8:00-8:20	Adult salmon and steelhead passage at Little Goose Dam in relation to spill operations, 2008	Michael Jepson
8:20-8:40	Adult salmon and steelhead passage at Lower Granite Dam with modified transition pool and in relation to ladder temperature--comparison to passage at Little Goose Dam and prior years	Tami Clabough
8:40-9:00	Investigation of adult salmon and steelhead straying in the lower Columbia River	Sandy Downing
9:00-9:20	Evaluation of steelhead kelt passage through the Bonneville Dam Second Powerhouse Corner Collector Prior to the Juvenile Migration Season, 2007 - 2008	Mark Weiland
9:20-9:40	Use of In-stream PIT Arrays to Monitor Movement of Bull Trout between the Walla Walla and Columbia Rivers - 2008	Darren Gallion
9:40-10:00	Evaluate Bull Trout Migration Between the Tucannon River and the Mainstem Snake river Using Streamwidth Passive Integrated Transponder Tag Interrogation Systems	Carrie Bretz
10:00-10:10	Break	
Columbia River Estuary		
Moderator	Blaine Ebberts	
10:10-10:30	Evaluation of the relationship among the time of ocean entry, physical and biological characteristics of the estuary and plume environment, and adult return rates	Robert Emmett
10:30-10:50	System wide analysis of JSATs acoustic telemetry data from 2006 data	Geoff McMichael
10:50-11:10	A Study to Estimate Salmonid Survival Through the Columbia River Estuary Using Acoustic Tags, Mobile Tracking Efforts	Lynn McComas
11:10-11:30	Evaluating Cumulative Ecosystem Responses to Restoration Projects in the Columbia River Estuary	Heida Diefenderfer
11:30-11:50	Salmon Life Histories, Habitat, and Food Webs in the Columbia River Estuary; an Overview of Research Results 2002-2007	Dan Bottom
11:50-12:10	Pre and Post monitoring at two Ecosystem Restoration Sites, Julia Butler Hansen National Wildlife Refuge, 2005-2008	Jeff Johnson
12:10-1:00	Lunch	
Salmonid Predation Studies		
Moderator	Scott Dunmire	
1:00-1:20	Aviation Predation in the Columbia River Estuary: Monitoring Management of Caspian Terns and Evaluating Impacts of	Dan Roby

	Double-Crested Cormorants	
1:20-1:40	Avian Predation on the Mid-Columbia River: Colony Sizes for Caspian Terns, Double-Crested Cormorants, and Other Piscivorous Waterbirds Nesting on the Columbia Plateau	Dan Roby
1:40-2:00	Detection of Passive Integrated Transponder (PIT) Tags on Breeding Colonies of Avian Piscivores in the Columbia River Basin, 2008	Scott Sebring
2:00-2:20	Steelhead Vulnerability to Avian Predators in the Snake and Columbia Rivers	Allen Evans
2:20-2:40	Evaluation of Sea Lion Predation in the Bonneville Dam Tailrace	Sean Tackley
Transportation and Delayed Mortality Studies		
Moderator	Derek Fryer	
2:40-3:00	Alternative Barging Strategies to Improve Survival of Transported Juvenile Salmonids	Bill Muir
3:00-3:20	Review of Potential Effects of Alternative Barging Strategies on Predation of In-river Salmonids in the Lower Columbia River	Bruce Watson
3:20-3:40	Break	
3:40-4:00	Transmission of the pathogen <i>Renibacterium salmoninarum</i> under different laboratory-controlled barging conditions	Joseph Dietrich
4:00-4:20	Influence of migration history and Columbia River estuary conditions on differential delayed mortality of Snake River hatchery Spring/Summer Chinook salmon	Kai Eder
4:20-4:40	Survival Estimate of Run-of-River Transported Yearling Chinook Salmon Originating From Snake River Basin in the Lower Columbia River and Estuary With Emphasis On Increasing Understanding of Causes of Differential Delayed Mortality	Frank Loge
WEDNESDAY December 10, 2008		
Transportation and Delayed Mortality Studies (Continued)		
Moderators	Derek Fryer	
8:00-8:20	Sampling PIT-tagged Juvenile Salmonids Migrating in the Columbia River Estuary	Dick Ledgerwood
8:20-8:40	A study to compare SARs of in-river migrating versus	Doug Marsh

	transported Snake River yearling anadromous salmonids	
8:40-9:00	McNary Transportation Studies	Doug Marsh
9:00-9:20	Post Release Performance of Natural and Surrogate Fall Chinook from the Clearwater and Snake River Basins	Billy Conner
9:20-9:40	A Study to Understand the Early Life History of Snake River Fall Chinook Salmon, 2007	Doug Marsh
Juvenile Passage Studies		
Moderators	Portland and Walla Walla Corps Biologists	
9:40-10:00	Estimation of Juvenile Passage and Survival over a Newly Constructed Wanapum Dam Fish Bypass.	Curt Dotson
10:00-10:05	Lower Monumental passage and survival	Robert Johnson
10:05-10:25	RSW Post Construction evaluation of Passage and Survival for Radio-Tagged Yearling Chinook Salmon and Juvenile Steelhead at Lower Monumental, 2008	Eric Hockersmith
10:25-10:40	Break	
10:40-11:00	RSW Post Construction evaluation of Passage and Survival for Radio-Tagged Subyearling Chinook Salmon at Lower Monumental, 2008	Randy Absolon
11:00-11:20	Direct Injury Survival of Juvenile Chinook Salmon Passing Through the Removable Spillway Weir (RSW) at Lower Monumental Dam, 2008	Paul Heisey
11:20-11:40	Head Injury Biomarker Expression and Sensor fish evaluation through the RSW at Lower Monumental Dam.	Ann Miracle
11:40-12:00	Passage Behavior and Survival for Yearling Chinook Salmon, Steelhead, and Fall Chinook Passing Ice Harbor Dam during Two Spill Treatments, 2008	Gordon Axel
12:00-1:00	Lunch	
1:00-1:05	McNary passage and survival	Ann Setter
1:05-1:25	Passage, survival, and approach patterns of juvenile salmonids at McNary Dam	Noah Adams
1:25-1:45	The John Day Configuration Study	Robert Wertheimer
1:45-2:05	Acoustic Telemetry Study to Evaluate Juvenile Fish-Passage Efficiency and Survival Associated with Surface-Spill Treatments at John Day Dam in 2008	Mark Weiland
2:05-2:25	Tailrace Egress and Hydraulic Conditions During Tests of a Top Spillway Weir (TSW) at John Day Dam, 2008	Theresa L Liedtke

2:25-2:45	Acoustic Telemetry Study of Juvenile Salmonid Dam and Spillway Survival at Bonneville Dam in 2008	Gene Ploskey
2:45-3:05	Acoustic Telemetry Evaluation Of A Behavioral Guidance Structure At Bonneville Dam Second Powerhouse	Derrek Faber
3:05-3:20	Break	
3:20-3:40	Total Dissolved Gas Effects on Incubating Chum Salmon Below Bonneville Dam	Evan Arntzen
3:40-4:00	Post-Passage Condition And Gatewell Retention Time Of Subyearling And Yearling Chinook Salmon Guided From Modified Bonneville Dam Second Powerhouse Turbine Intakes	Lyle Gilbreath
THURSDAY December 10, 2008		
Juvenile Passage Studies (Continued)		
Moderators	Portland and Walla Walla Corps Biologists	
9:00-9:20	Differential post-hydrosystem mortality of transported and in-river passing spring Chinook from the Snake River	James Anderson
9:20-9:40	Determine Mechanisms of Latent Mortality	Jennifer Tran
9:40-10:00	Flow Velocity Enhancement System - Preliminary Results From Field Test to Guide Smolts	Dr. Charles Coutant
10:00-10:20	Reach survival estimates, 2008	Bill Muir
10:20-10:40	The 2008 POST Study: Technical Performance and Biological Results for Snake & Yakima R Chinook	David Welch
10:40-11:00	Break	
11:00-11:20	Tag effects and state of the science for acoustic telemetry	Brad Eppard
11:20-11:40	Comparative survival and behavior of spring Chinook salmon implanted with either PIT tags or acoustic transmitters in the Snake and Columbia Rivers	Dr. Richard Brown, PNNL
11:40-12:00	Comparative Performance of Acoustic-Tagged and PIT-tagged Juvenile Salmonids: 2008 Yearling and Subyearling Chinook Laboratory Studies	Dr. Michelle Rub, NMFS
12:00-12:20	Smolt Responses to Hydrodynamic Conditions in Forebay Flow Nets of Surface Flow Outlets	Gary E. Johnson
Turbine Survival Program		
12:20-12:40	Pressure Investigations To Support Biological Index Testing	Tom Carlson
Closing Remarks	Mike Langslay	

Revised Agenda

MONDAY December 8, 2008		
12:00-1:00	Open registration	
1:00	Welcome	Mike Langeslay, CENWP
1:05	Intro Address	LTC Jose Aguilar, Deputy Commander CENWP
Willamette Studies (Moderator: David Griffith)		
1:20	Willamette Valley Project BiOp Program Overview	David Griffith
1:40	Condition and Prespawning Mortality of Spring Chinook Salmon in Two Populations, 2008	Ryan Mann, Greg Taylor & Chris Caudill
2:00	Analysis of Genetic Variation in Upper Willamette Bull Trout Populations	Patrick Dehaan
2:20	Break	
Lamprey (Moderator: David Clugston)		
2:35	Adult Lamprey Passage Success and Behavior at Lower Columbia River Dams, 2008	Matt Keefer
2:55	Evaluation of Adult Lamprey Use of the Lamprey Passage Structures (LPS) at Bonneville Dam, 2008	Mary Moser
3:15	Developing a Juvenile Lamprey Separator	Mary Moser
3:35	Lamprey Energetic Condition and Migration Behavior: Preliminary Results	Eric Johnson
4:15	Evaluation of Adult Pacific Lamprey Passage Success at McNary and Ice Harbor Dams, 2008	Chuck Boggs
4:35	Use of Night Video to Quantify Adult Lamprey Passage at Bonneville and The Dalles Dams 2007 and Preliminary 2008 Results	Chris Caudill

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Adult Studies/Bull Trout (Moderators: David Clugston & Fred Higgenbotham)

7:55	Intro to Little Goose Adult Passage	Fred Higgenbotham
8:00	Adult Salmon and Steelhead Passage at Little Goose Dam in Relation to Spill Operations, 2008	Chris Caudill
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9:00	Evaluation of steelhead kelt passage through the B2 corner collector prior to the juvenile migration season	Mark Weiland
9:20	PIT Monitoring for Bull Trout passage from the Walla Walla River	Darren Galion
9:40	Evaluate Bull Trout Migration Between the Tucannon River and the Mainstem Snake river Using Streamwidth Passive Integrated Transponder Tag Interrogation Systems	Carrie Bretz
10:00	Break	

Columbia River Estuary (Moderator: Blaine Ebberts)

10:10	Biological characteristics of the estuary and plume environment, and adult return rates	Robert Emmett
10:30	A Study to Estimate Salmonid Survival Through the Columbia River Estuary Using Acoustic Tags, 2008	Geoff McMichael
10:50	A Study to Estimate Salmonid Survival Through the Columbia River Estuary Using Acoustic Tags, Mobile Tracking Efforts	Lynn McComas
11:10	Evaluating Cumulative Ecosystem Responses to Restoration Projects in the Columbia River Estuary	Heida Diefenderfer
11:30	Salmon Life Histories, Habitat, and Food Webs in the Columbia River Estuary; an Overview of Research Results 2002-2007	Dan Bottom
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12:10 –	Lunch	

Salmonid Predation Studies (Moderator: Scott Dunmire)

1:00	Avian Predation in the Columbia River Estuary: Monitoring Management of Caspian Terns and Evaluating Impacts of Double-crested Cormorants	Dan Roby
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Tuesday December 9, 2008 (Cont.)

Salmonid Predation Studies (Moderator: Scott Dunmire)

1:20	<u>Avian Predation on the Mid-Columbia River: Colony Sizes and Trends for Caspian Terns, Double-Crested Cormorants, and other Piscivorous Waterbirds nesting on the Columbia Plateau</u>	Dan Roby
1:40	<u>Electronic Recovery of PIT tags from Piscivorous Bird Colonies in the Columbia River Basin</u>	Scott Sebring
2:00	<u>Steelhead Vulnerability to Avian Predators in the Snake and Columbia Rivers</u>	Allen Evans
2:20	<u>Evaluation Of Sea Lion Predation in The Bonneville Dam Tailrace</u>	Sean Tackley
Transportation and Delayed Mortality Studies (Moderator: Derek Fryer)		
2:40	<u>Alternative Barging Strategies to Improve Survival of Transported Juvenile Salmonids</u>	Bill Muir
3:00	<u>Review of Potential Effects of Alternative Barging Strategies on Predation of In-river Salmonids in the Lower Columbia River</u>	Bruce Watson
3:20	Break	
3:40	<u>Transmission of the pathogen Renibacterium salmoninarum under different laboratory-controlled barging conditions</u>	Joseph Dietrich
4:00	Influence of migration history and Columbia River estuary conditions on differential delayed mortality of Snake River hatchery Spring/Summer Chinook salmon	Kai Eder
4:20	Estimate the effects of in-river and transportation migration strategies on the differential delayed mortality of yearling Chinook salmon in the Snake and Columbia Rivers and Estuary with a Juvenile Salmon Acoustic Telemetry System (JSATS)	Frank Loge

WEDNESDAY December 10, 2008**Transportation and Delayed Mortality Studies (Continued)**

8:00	Sampling PIT-tagged Juvenile Salmonids Migrating in the Columbia River Estuary	Dick Ledgerwood
8:20	Snake River Transportation Studies	Doug Marsh
8:40	Columbia River Transportation Studies	Doug Marsh
9:00	Post Release Performance of Natural and Surrogate Fall Chinook from the Clearwater and Snake River Basins	Billy Conner
9:20	Fall Chinook Scale Analysis of Returning Adults	Doug Marsh
Juvenile Studies (Moderators: Various)		
9:30	Program overview	
9:40	Estimation of Juvenile Passage and Survival Over a Newly Constructed Wanapum Dam Fish Bypass	Curt Dotson
10:00	Lower Monumental passage and survival	Robert Johnson
10:05	RSW Post Construction evaluation of Passage and Survival for Radio-Tagged Yearling Chinook Salmon and Juvenile Steelhead at Lower Monumental, 2008	Eric Hockersmith
10:25	Break	
10:40	RSW Post Construction evaluation of Passage and Survival for Radio-Tagged Subyearling Chinook Salmon at Lower Monumental, 2008	Randy Absolon
11:00	Estimation of Direct Injury rates and survival through the Lower Monumental Removable Spillway Weir	Paul Heisey
11:20	Head Injury Biomarker Expression and Sensor fish evaluation through the RSW at Lower Monumental Dam.	Ann Miracle
11:40	Passage Behavior and Survival for Radio-Tagged Yearling Chinook Salmon, Juvenile Steelhead, and Subyearling Chinook salmon at Ice Harbor Dam, 2008	Gordon Axel
12:00	Lunch	

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1:00	McNary passage and survival	Ann Setter
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3:20	Effects Of Total Dissolved Gas On Chum Fry	Evan Artzen
3:40	Post-Passage Condition And Gatewell Retention Time Of Subyearling And Yearling Chinook Salmon Guided From Modified Bonneville Dam Second Powerhouse Turbine Intakes	Lyle Gilbreath

THURSDAY December 11, 2008**Juvenile Passage Studies (Continued)**

9:00	Differential post-hydrosystem mortality of transported and in-river passing spring Chinook from the Snake River	James Anderson
9:20	Determine Mechanisms of Latent Mortality	Jennifer Tran
9:40	Flow Velocity Enhancement System - Preliminary Results From Field Test to Guide Smolts	Charles Coutant
10:00	PIT-tag reach survival estimates	Bill Muir
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11:00	Tag effects and state of the science for acoustic telemetry	Brad Eppard
11:20	Comparative Performance of Acoustic-Tagged and PIT-tagged Juvenile Salmonids: 2008 Yearling Chinook Field Study	Richard Brown
11:40	Comparative Performance of Acoustic-Tagged and PIT-tagged Juvenile Salmonids: 2008 Yearling and Subyearling Chinook Laboratory Studies	Michelle Rub
12:00	Smolt Responses to Hydrodynamic Conditions in Forebay Flow Nets of Surface Flow Outlets	Gary E. Johnson
Turbine Survival Program		
12:20	Pressure Investigations To Support Biological Index Testing	Tom Carlson
Closing Remarks	Mike Langeslay, CENWP	

WILLAMETTE STUDIES



WILLAMETTE VALLEY PROJECT BiOp PROGRAM OVERVIEW

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ABSTRACT

The United States Army Corps of Engineers constructed 13 dams in the Willamette Valley from 1941 until 1969. Collectively these, as well as five fish hatcheries, and 42 miles of revetments, are managed by the Corps as the Willamette Valley Project (WVP). The principal congressionally authorized purposes of the WVP are; flood damage reduction, navigation, hydropower generation, recreation, fish and wildlife, water quality, and for water supply for municipal, industrial, and irrigation.

Due to the many anthropogenic impacts associated with the settlement and development of the Willamette Valley, including the effects of the WVP, many native fish species have been in decline. The United States Fish and Wildlife Service (USFWS) listed Oregon Chub (*Oregonichthys crameri*) as endangered in 1993, and Columbia River bull trout (*Salvelinus confluentus*) as threatened in 1998. Upper Willamette River (UWR) spring Chinook (*Oncorhynchus tshawytscha*) and UWR winter steelhead (*Oncorhynchus mykiss*) were both listed by the National Marine Fisheries Service (NMFS) as threatened in 1999.

After the listing of these species ESA section 7 consultations between the action agencies (USACE, BPA, USBR) and the consulting agencies (USFWS, NMFS) began the spring of 2000. This culminated in the July 11th 2008, release of the Biological Opinions (BiOp) for the Willamette Valley Project by USFWS and NMFS. The term of the BiOps is through the year 2023 and it identifies a suite of activities are required by the Action Agencies to insure that ESA-listed fish species persist with operation and maintenance of the WVP. These efforts include improvements to; dam operations, habitat, fish passage, hatchery facilities and operations, downstream water quality, and flow management. The Action Agencies will implement a comprehensive Research, Monitoring, and Evaluation program to identify and compare operational and structural modification to meet the goals of the biological opinions that will also constitute a major effort.

The WVP implementation poses many difficult challenges not seen the Columbia or Snake Rivers, these will require innovative approaches to RM&E, fish passage, and operations. Attempts to solve the fish passage issues associated with high head dams have been made in the past with limited success.

AN ASSESSMENT OF ENERGETIC CONDITION FOR TWO POPULATIONS OF ADULT SUMMER CHINOOK SALMON IN THE WILLAMETTE VALLEY OF CENTRAL OREGON

Ryan Mann¹, Greg A. Taylor², Christopher A. Peery^{1a}, and Christopher C. Caudill^{1*}

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ABSTRACT

In recent years, a high proportion (80-90%) of adult Chinook salmon transported above dams in some Willamette River tributaries have died prior to spawning. In 2008, we surveyed the energetic status of two populations of summer Chinook salmon in the Willamette River Valley of Central Oregon to assess whether initial energetic status is associated with prespawn mortality.

Between May 15th and July 14th, 2008 a total of 399 fish were sampled between two sites in the area, including 195 fish at Fall Creek Dam and 204 fish collected at the Dexter Dam Trap on the Middle Fork of the Willamette River. Salmon sampled at the Dexter Dam Trap were used for hatchery broodstock. Spawning success could not be assessed for this group. Fish collected, assessed for energetic condition, and PIT tagged at Fall Creek Dam were transported above the dam and allowed to spawn naturally. A total of 32 PIT tagged salmon were recovered from spawning ground surveys on Fall Creek, representing a recapture rate of 16.41%. Only three (9.4%) of the recovered fish were determined to be pre-spawn mortalities, and there was no clear relationship between these mortalities and initial energetic state. Notably, temperatures in the stream were uncharacteristically low and flow rates were high in 2008, which may provide an explanation for the good survival rates observed this year.

This result and other observations suggest prespawn mortality results from an interaction of environmental factors (particularly temperature) and energetic status. Multi-year sampling of adult energetic status and other metrics of condition will 1) provide insights to the factors causing prespawn mortality; 2) determine how the mean condition of fish varies from year to year in response to other environmental factors such as ocean conditions; and 3) will assist in the development of effective management strategies that minimize prespawn mortality in spawning tributaries.

ANALYSIS OF GENETIC VARIATION IN UPPER WILLAMETTE RIVER BULL TROUT POPULATIONS

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ABSTRACT

Bull trout (*Salvelinus confluentus*) are currently listed as a threatened species by the U.S. Fish and Wildlife Service. The long term persistence of many bull trout populations is dependent on the availability of suitable habitat and connectivity among local populations. Within the upper Willamette River bull trout habitat has been extensively fragmented due to the construction of impassible dams and other barriers to migration (e.g. culverts). Presently four populations of bull trout persist at low numbers in the upper Willamette River. In order to supplement population declines, fry have been transferred among populations within the basin and naturally produced fry have been taken to a fish hatchery for rearing before being released back into the upper Willamette. To date it is unclear what effect these management actions have had on long term population persistence and levels of genetic variation within the basin. In this project we will use genetic markers to determine how genetic variation is partitioned within the Willamette River system and to determine the effects that past management practices have had on levels of genetic variation. Our project has four main objectives: 1) To determine the levels of genetic variation within and among bull trout populations in the upper Willamette system 2) To determine the genetic risks and benefits associated with transporting individuals among populations 3) To determine which populations within the upper Willamette system are the most appropriate source populations for translocations of individuals and 4) To determine if the levels of genetic variation in the individuals reared in a fish hatchery are characteristic of individuals in the wild source population. This information will be critical for guiding bull trout conservation and management activities in the upper Willamette River system. Genetic information from this project will form the basis of a genetic management plan for bull trout in the upper Willamette River.

LAMPREY STUDIES



ADULT LAMPREY PASSAGE SUCCESS AND BEHAVIOR IN THE LOWER COLUMBIA RIVER, 2008

Matthew Keefer^{1*}, Charles Boggs¹, Eric Johnson¹, Christopher A. Peery^{1a}, Christopher C. Caudill¹, and Mary Moser²

¹Idaho Cooperative Fish and Wildlife Research Unit, U.S. Geological Survey & Department of Fish and Wildlife Resources
University of Idaho, Moscow, ID, 83844-1141

²Northwest Fisheries Science Center
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Seattle, WA, 98112

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ABSTRACT

Monitoring Pacific lamprey (*Lampetra tridentata*) migration behaviors in the Columbia River basin is difficult given their cryptic and photo-negative behaviors and size-related tagging limitations. In 2008, we tagged adult lamprey with half-duplex passive integrated transponder (HD-PIT) tags and/or radio tags and monitored their passage at Bonneville, The Dalles, John Day, McNary, Ice Harbor, and Priest Rapids dams. Our primary objectives for this summary were to estimate lamprey escapement past the monitored sites and to calculate lamprey passage times over a variety of reaches. A secondary objective was to evaluate detection efficiencies for both HD-PIT and radiotelemetry antennas using double-tagged fish.

In total, we radio-tagged 298, HD-PIT tagged 610, and double-tagged 298 lampreys. Lampreys with radio transmitters were significantly larger than those with only HD-PIT tags. Escapement estimates from release below Bonneville Dam to top-of-ladder antennas were 22% for fish with radio tags only, 52% for HD-PIT tagged fish, and 28% for double-tagged fish. Escapement estimates past McNary Dam were 5% for HD-PIT only fish and < 2% for radio- and double-tagged fish. Reach escapement estimates were consistently higher for fish with HD-PIT tags only, both past multiple dams and through dam-to-dam reaches. This result could not be explained by differences in detection efficiency. As in previous years, large lampreys were significantly more likely than small lampreys to pass through most of the monitored reaches. Higher escapement estimates by HD-PIT tagged fish, compared to radio- and double tagged fish, suggest radio-tags negatively affected performance. In general, detection efficiencies were lower for HD-PIT antenna sites than for telemetry antennas. This was expected given the much greater detection range for active radio tags versus passive HD-PIT tags. The HD-PIT and telemetry results provide complimentary data, and the combination provides both fine-scale and system-wide migration information.

Lamprey migration times were highly variable, but tended to be slow at dams (especially Bonneville Dam) and relatively rapid through reservoirs. As examples, median passage times ranged from 5.5–7.6 days from release to past Bonneville Dam, from 16.7–21.4 days from release to past John Day Dam, and from 3.8–5.8 d in the Bonneville-The Dalles and The Dalles-John Day reaches (each included one dam and one reservoir). Lampreys migrated more rapidly as water temperatures increased and river discharge decreased.

EVALUATION OF ADULT LAMPREY USE OF LAMPREY PASSAGE STRUCTURES AT BONNEVILLE DAM

Mary Moser*

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2725 Montlake Blvd. East, Seattle, WA 98112, mary.moser@noaa.gov

Howard Pennington and Anthony Battista
Pacific States Marine Fisheries Commission

ABSTRACT

At Bonneville Dam, lamprey passage structures (LPSs) provide adult Pacific lamprey (*Lampetra tridentata*) with a passage route from the auxiliary water supply channels (AWSs) to the powerhouse forebays. In 2008, the LPS at the Bradford Island AWS passed 6,441 fish, a higher percentage of the Bradford Island count than in any other year of its operation (2004-08). Passage success for lamprey detected entering this structure was 100% and the median time to pass through the structure was 0.8 h. At the Washington-shore AWS LPS, 1,985 lamprey were counted as they exited the AWS LPS in the period from 19 May to 28 October. A lower percentage of lamprey used this structure and passage efficiency was also apparently less than at the Bradford Island LPS. Of the 609 lamprey that we tagged with a half-duplex passive integrated transponder (PIT) and released below Bonneville Dam, 55 were detected in the Bradford Island AWS LPS (9%) and 16 in the Washington-shore LPS (3%). These data suggest that together the AWS LPSs contribute significantly to overall passage of adult lamprey at Bonneville Dam.

Poor passage at Bonneville Dam fishway entrances has also been the focus of recent mitigation efforts for adult Pacific lamprey. In 2008, the Washington-shore fishway entrance collector captured 490 lamprey and 16 of these had a PIT tag (3%). Both the efficiency and collection rate for this structure were higher than in any other year of operation (2005-08). Preparations are underway to install a similar LPS collection system at the Cascades Island fishway entrance next year. In 2008, a significant number of PIT-tagged lamprey (9%) was detected as they entered the flow control region of this fishway. These data indicate that large numbers of lamprey use this fishway and that providing aids to passage immediately inside this fishway entrance may afford passage to a greater number of fish.

DEVELOPING A SEPARATOR FOR JUVENILE LAMPREY

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ABSTRACT

Juvenile Pacific lamprey are often inadvertently collected at juvenile bypass facilities designed to divert juvenile salmonids away from turbine intakes. We set out to develop a device that would allow separation of juvenile lamprey from salmonids in the bypass raceways at McNary Dam. Our experiments examined behavior of both lamprey larvae (ammocoetes) and recently metamorphosed juveniles (macrophthalmia). Experiments with macrophthalmia were conducted in a flume supplied with ambient Columbia River water at the McNary Juvenile Bypass Facility. For each 1 h experiment, five replicates using 10 lamprey each were done with two different screen materials: 6.5 mm square stainless steel woven mesh and stainless steel plate with staggered 6 × 25-mm oval perforations. For each material, we tested the screen in horizontal, angled (9°), and vertical orientations. We found that the macrophthalmia moved most readily through materials oriented vertically (both the mesh and the plate) and were reluctant to move through an angled or horizontal separator. We conducted longer (24 h) experiments using both macrophthalmia and ammocoetes to determine whether fish would volitionally move either vertically, or horizontally through a variety of materials (6.5 mm – 12 mm openings). The results of this work confirmed that macrophthalmia were resistant to moving downward, while ammocoetes readily moved in a downward direction. Both groups moved horizontally through all materials. Based on these findings, we designed, built and installed a lamprey-friendly raceway screen at the McNary Juvenile Bypass holding raceways. The new screen was oriented vertically and made from 6.5 mm square stainless steel woven mesh. Preliminary sampling of raceways with and without the lamprey-friendly screen indicated that fewer juvenile lamprey were retained or impinged by the lamprey-friendly material.

RELATIONSHIP BETWEEN ENERGETIC STATUS AND MIGRATORY BEHAVIOR AND SUCCESS IN PACIFIC LAMPREY: PRELIMINARY RESULTS

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ABSTRACT

Little is known about the migratory ecology of Pacific Lamprey, *Lampetra tridentata*. Notably, lamprey have a high lipid content compared to bony fishes and are thought to be more flexible in their migration behavior than anadromous salmonids. The objectives of this study were to determine whether lipid content of lampreys can be non-invasively determined with a Distell Fatmeter, determine the associations between lipid content and other fish traits, and to examine the relationship between initial lipid content as a measure of energetic status and lamprey migratory behavior and success.

In 2008, tissue from 20 lamprey were sampled for proximate biochemical analysis to determine the ability of Fatmeter to successfully estimate tissue lipid content. The Fatmeter estimates were significantly associated with tissue lipid level, though the strength of this relationship was not as strong as previously observed for adult salmon. Using a Distell fat meter, a estimate of tissue lipid content was obtained during tagging for radio tagged fish at Bonneville Dam in 2007 and 2008 and HD PIT-tagged lampreys in 2008.

Preliminary study results will include comparison of the mean and variability in lipid content in the sample population, associations of lipid content with length, girth, mass and condition factor, seasonal pattern of lipid content during the run season, and an examination of the relationships between initial lipid content and migration behaviors including migration success to lower Columbia River dams and total migration distance. Increased knowledge of initial condition and migratory behavior may facilitate development of appropriate management and restoration plans for Pacific Lamprey in the Columbia River Basin.

EFFECTS OF WATER VELOCITY ON FISHWAY ENTRANCE SUCCESS BY PACIFIC LAMPREY AND FISHWAY USE SUMMARIES AT BONNEVILLE DAM, 2008

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ABSTRACT

Adult Pacific lamprey *Lampetra tridentata* encounter various obstacles to upstream migration at Columbia and Snake River hydropower dams. Previous radiotelemetry studies indicate that lamprey have particular difficulty entering fishway entrances, passing through transition areas, passing count windows, and negotiating serpentine weir sections of the fish ladders. The primary objectives of the 2008 radiotelemetry study were to 1) evaluate lamprey passage efficiencies, passage times, fishway entrance use patterns, and fallback; 2) evaluate the effects of placing PH2 fish units on standby at night to clean trash racks; and 3) to experimentally evaluate the response of lamprey to proposed modifications at the Cascade Island fishway entrance. Pending modifications include redesigning the entrance, adding artificial rock structures to the bottom of the fishway to create velocity refuges for lamprey passage during high flows, and building a lamprey passage structure (LPS). Tests were conducted in an experimental flume at Bonneville Dam to evaluate passage times and behavior of lamprey under high flow conditions with and without velocity refuges. Additional tests were also performed to determine if lamprey using these refuges could be directed to a LPS.

Of the 596 lamprey radio-tagged and released, 431 (72%) had approached the dam at the time of this writing, 309 (52%) had entered, 142 (24%) had passed the dam. Seventy-six percent of all known approaches occurred at PH2 (52% did so at one of the north openings) followed by PH1 (14%) and the spillway (10%). As in previous years, overall entrance efficiencies were lower at PH2 (23% at PH2 south and 6% at PH2 north) compared to PH1 (25%) and the spillway (32%). Median passage times were 1.5 d to approach dam from tailrace (2.6 d in 2007), 1.4 h to enter dam after first detection outside face of dam (0.9 h in 2007) and 1.9 d to pass dam after entering (1.2 d in 2007). Lamprey fallback percentages were 19%. Telemetry results indicate that there was a negative affect of placing PH2 fish units on standby at night (resulting in zero head differential at fishway entrances). A total of 10 approaches (< 1% of total at PH2) were made with the fish units on standby resulting in 2 entrances.

Based on our comparison of passage efficiencies and times between treatments, the benefits of closely spaced artificial velocity refuges were unfavorable at the highest flows (24" head and > 11 ft-s⁻¹) and insignificant at intermediate flows (18" head and < 10.1 ft-s⁻¹). When velocity refuges were present, passage times (from release to passage through the submerged orifice)

were significantly longer. Conversion rates through the flume during the high velocity treatments decreased from 60-90% success without rock refuges to < 20% with refuges. In contrast, Daigle et al. (2005) using a using similar prototype rock structures observed passage efficiencies greater than 90% for seven of eight treatment groups with and without velocity refuges at head differentials ranging from 11-16” and water velocities < 8.8 ft·s⁻¹, as would occur within fishways. They found that velocity refuges at those velocities significantly decreased the passage time through the submerged orifice as well as through the fishway. The two trials (n = 20) that we ran with 18” head and water velocities between 9.7-10.1 ft·s⁻¹ resulted in similar passage efficiencies (90%). However, the presence of refuges did not significantly improve passage efficiencies or passage times. Statistically, there was not a significant difference in the side of flume selected by lamprey, relative to rock placement.

Our results, including visual observations of fish behavior during trials, indicate that velocity refuges can aid lamprey passage but that the optimal spacing, placement, and dimensions of refuge substrate varies with velocity. At intermediate velocities (4 to 8 ft·s⁻¹), as exist at submerged orifice in fishways, the pattern as tested was effective. At higher velocities (>10 ft·s⁻¹), as occur at fishway entrances, turbulent flow made it difficult for lamprey to maneuver between closed-spaced refuges, especially just downstream from the entrance. We recommend scaling up the size and spacing of refuges for structures to be tested at Cascades Island entrance in 2009.

EVALUATION OF ADULT PACIFIC LAMPREY PASSAGE AND BEHAVIOR AT McNARY AND ICE HARBOR DAMS

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ABSTRACT

Due to precipitous declines in numbers of returning fish, dam passage and escapement of adult Pacific lamprey (*Lampetra tridentata*) in the Columbia River basin has received increasing concern from fisheries managers. Between July and September of 2008 we trapped a total of 34 adult lamprey from the Oregon shore fishway of McNary Dam and tagged them with both a 2.2 gram radio-transmitters (RT) and 23 mm half-duplex (HD) PIT tags. The relatively low number of tagged adults resulted from low overall run size returning to McNary Dam compared to recent study years. All study animals were released approximately 1.5 km downstream of the dam and their subsequent behavior and passage at McNary and upstream dams were monitored using telemetry receivers and half-duplex reader/antenna systems located within the fishways of McNary, Ice Harbor and Priest Rapids dams.

Of the 34 tagged lamprey released downstream of McNary Dam, 25 (74%) were detected re-approaching the dam and 19 (56%) were detected in fishways by one or both monitoring systems. Of those 19 lamprey detected within fishways, 15 (79%) were known to have passed the dam (44% of all tagged fish). In 2007, the rate of re-approach was 23% and the rate of fishway entrance was 21%, with 12 of 13 fish that entered eventually passing the dam (20% of all tagged fish).

Passage times for lamprey at McNary Dam varied widely among fish. Median time from release to first dam approach was 1.6 d (N=25, range 0.6-13.6 d), from first approach to fishway entrance was 0.01 d (N= 18, range 0.002-10.1 d) and from fishway entrance to fishway exit was 0.6 d (N=14, range 0.17-7.0 d). In 2007, these values were 7.6 d (N=14, range 0.7-42.5 d), 0.001 d (N= 10, range 0.001-4.9 d) and 2.8 d (N=7, range 0.2-8.2 d), respectively.

Of the 15 lamprey known to pass McNary Dam, eight have been detected at upriver sites. Five lamprey were detected at Priest Rapids Dam and four were detected at Ice Harbor Dam with one fish detected at both projects. All five lamprey detected at Priest Rapids were detected on fishway exit antennas as were two of the four lamprey detected at Ice Harbor. Performance of lamprey in 2009 was likely aided by mild river conditions this summer.

USE OF NIGHT VIDEO TO QUANTIFY ADULT LAMPREY PASSAGE AT BONNEVILLE AND THE DALLES DAMS, 2007 AND PRELIMINARY 2008 RESULTS

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ABSTRACT

In order to estimate total daily passage of Pacific lamprey (*Lampetra tridentata*) in the lower Columbia River, we used video cameras to record the nighttime (2100-0500 h) movements of lamprey at the count windows of Bonneville and The Dalles Dams. Lamprey movements were recorded from mid-May through early September 2007 during approximately 100 nights (8 h per night) at all count windows. The equipment at the Bonneville Dam Washington shore window experienced a high outage rate (54 nights). Lamprey movements were also recorded in 2008 from the end of May until the end of September at Bonneville and The Dalles dams (~132 nights).

Lamprey numbers have been declining in recent years; the lamprey day count in 2007 at Bonneville Dam was a third of the seven year average (2006-2006) and half of the seven year average at The Dalles Dam. We estimated lamprey escapement at the two dams by summing the day count, the night video count, and the LPS (Lamprey Passage Structure –Bonneville Dam) count. The nighttime net lamprey count (unadjusted for outages) at the Bradford Island fish ladder was 18,352, the day count was 8,430, and the LPS count was 6,817 for a total escapement estimate of 33,599. The Washington Shore fish ladder nighttime video count estimate was -439 (based on the available 56% of data), the day count was 9,931, and the LPS count was 2,013 for a total escapement of 11,505. A net nighttime count of 4,145 lampreys (North=3,137; East =1,010) was estimated for the study period at The Dalles Dam. The day count total at The Dalles Dam was 5,791 (North=3,246; East=2,545) for a total escapement estimate of 9,938.

Nighttime video lamprey behavior indicated upstream lamprey passage events at night accounted for 68% of the total passage events at Bradford Island, 50% at Washington Shore at Bonneville Dam, and 85% at the North ladder and 71% at the East ladder at The Dalles Dam. The proportion of lamprey passage events at night varied by hour with lower percentages of passage in the early evening (2100-2200 h) and in the early morning (0400-0500 h).

Several technical improvements were made for collection of the 2008 video. Of the 2008 nighttime video that has been reviewed, the trends between day and night and among ladders are similar to those found in 2007. Future analyses will determine the accuracy of the day counts as an index of total passage and estimated total escapement based on day, night and LPS counts.

ADULT STUDIES/ BULL TROUT



ADULT CHINOOK SALMON PASSAGE AT LITTLE GOOSE DAM IN RELATION TO SPILL OPERATIONS, 2008

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ABSTRACT

The behaviors and upstream passage times of adult, radio-tagged spring–summer Chinook salmon were evaluated in response to three spillway discharge patterns at Little Goose Dam during 2008. Two of the spill treatments (i.e., Bulk and Alternate) were variations of patterns thought to be produced by a proposed spillway weir. The third treatment (Uniform) was characterized by spilling similar volumes of water through most spillbays.

A total of 360 spring–summer Chinook salmon were radio-tagged and released at Ice Harbor Dam from 15 April through 11 August 2008. Mean daily river discharge at Little Goose Dam ranged from 28.4 to 188.5 kcfs (mean = 79.6 kcfs) from 15 April through 30 August 2008. The target spill volume during the study was 30% of river discharge. Treatment assignments were based on the spill pattern applied when tagged salmon were first recorded in the tailrace of Little Goose Dam.

Among the 360 spring–summer Chinook salmon outfitted with transmitters at Ice Harbor Dam, 290 (81%) were recorded at Little Goose Dam. Of the 290 tagged salmon recorded at the Little Goose Dam, 282 (97%) were recorded passing the dam. Radio-tagged Chinook salmon assigned to the Bulk treatment had the highest (slowest) median time from first tailrace record to first fishway approach (1.6 h, n = 99) and the lowest percentage of first fishway approaches resulting in a fishway entry (22%, n = 106). The highest percentage of first fishway approaches resulting in a fishway entry was for tagged salmon assigned to the Uniform treatment (36%, n = 93), followed by the Alternate treatment (24%, n = 90).

Tagged salmon assigned to the Bulk treatment had the highest median time from first tailrace record to first fishway entry (11.9 h, n = 98), followed by those assigned to the Alternate treatment (7.3 h, n = 81), and the Uniform treatment (5.5 h, n = 83). Of the tagged salmon that entered a fishway, 29% made a fishway exit to the tailrace. Median times from first fishway entry to last record at the ladder top were similar among treatments (range = 2.9 - 3.4 h)

The highest median time from first tailrace record to last record at the ladder top was for tagged salmon assigned to the Bulk treatment (22.2 h, n = 96), followed by those assigned to the Alternate treatment (15.2 h, n = 79), and the Uniform treatment (11.5 h, n = 83). Based on these preliminary analyses, the Uniform treatment appeared to provide the tailrace conditions resulting in the most rapid passage for adult Chinook salmon among all spill patterns applied at Little Goose Dam over the range of river flows encountered during 2008. We are planning additional future evaluations of the relationship between passage times, spill treatment, river discharge, and powerhouse operations.

ADULT SALMON AND STEELHEAD PASSAGE AT LOWER GRANITE DAM WITH A MODIFIED TRANSITION POOL AND IN RELATION TO LADDER TEMPERATURE

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ABSTRACT

Previous passage studies of salmonids at Lower Granite Dam indicated slowed passage at the transition between the tailrace and ladder (the transition pool). In 2001 and 2002, we conducted an experiment to determine if a prototype weir modification improved adult salmon and steelhead passage times through the transition pool. Treatment conditions increased head (1ft) difference at the two downstream weirs, thereby creating faster water velocities. Passage time through the transition pool was significantly lower in spring-summer Chinook salmon during treatment periods, and this effect resulted primarily from a two-fold increase in the proportion of salmon passing through the transition pool on the first attempt during treatment conditions. These results were used to develop new design criteria and modifications of the Lower Granite Dam fishway.

In 2006, the junction pool walls in the fish ladder were narrowed (from 38 ft to 20 ft) and new weir crest panels were added onto the bottom eleven weirs to provide improved head differentials and increased flows through the submerged orifices. In 2008, we measured water elevations in the fish ladder to calculate head differentials and estimate submerged orifice velocities. Target head differentials of 0.25 ft (velocity 4 ft/s) were met during tailwater elevations of 632-634 feet.

In 2006 and 2008, we monitored passage times and behavior of radio-tagged adult Chinook salmon and steelhead in the modified transition pool. Spring-summer Chinook salmon transition pool passage times in 2006 were significantly lower compared to those in 2003 and 2004 (unmodified years). Transition pool passages times in 2008 were also lower than 2003 and 2004, however, these differences were not statistically significant. A higher percentage of fish passed straight through the transition pool in 2006 and 2008 compared to 2003 and 2004. We also tested to see if there was a significant difference between the passage time of fish at Little Goose and Lower Granite dam each year to ask whether relatively “fast” fish at Little Goose Dam were also fast at Lower Granite Dam before and after the modification. The median difference in transition pool passage times between the two dams in 2006 were significantly lower than in 2003, and 2004 and 2008 passage times were significantly lower than in 2003.

In 2008, we also monitored water temperatures in the fish ladder at Lower Granite Dam to examine whether high temperature differences were associated with longer passage times. Eight temperature loggers were distributed from the bottom to the top of the fish ladder and recorded hourly temperatures. Preliminary analyses suggest that water temperatures during 2008 were cool compared to previous years and ladder temperature differences were modest. Future analyses will examine the relationship between ladder temperatures and passage behavior.

INVESTIGATION OF ADULT SALMON AND STEELHEAD STRAYING IN THE LOWER COLUMBIA RIVER

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ABSTRACT

A prototype PIT-tag system was installed near McDonald Ferry on the John Day River in September 2007. This site is located in the lower reach of the river (around RM 20) and is below all of the major spawning creeks. The detection system consists of six antennas installed as two arrays into the thalweg portion of the river to monitor the section of the river where most of the salmonids will be migrating. By installing two antenna arrays, researchers can infer travel direction and increase the overall tag-detection efficiency of the PIT-tag system.

Since 27 September 2007, the detection system has been operating continuously to monitor migrating PIT-tagged adult salmonids. Through 24 November 2008, we had detected 217 PIT-tagged adult salmonids and around 40 juveniles. Of the adults, ~85% have been steelhead. From the monitoring, we have already learned that steelhead appear to be actively migrating over longer periods of time and at different times than had previously been thought while the native Spring Chinook migration pattern has followed the expected springtime-only migration pattern. We will continue to monitor the river in 2009 and 2010 to see if this year's patterns are unique or reflect the normal migration patterns for this river. We have already detected almost twice as many tagged steelhead this fall as during last fall (2007).

Of the 186 steelhead detected, 69 have been straying fish of known non-John Day River origin. Most (55) of the straying steelhead have been fish transported from Lower Granite Dam. These were detected at Bonneville Dam between July 2007 and October 2008 when ~3,300 other fish with similar transported history were also detected. This would suggest an overall straying rate of around 2%; however, certain release locations within this larger group yielded higher rates.

We know what tagged fish the system detects, but we do not know what it does not detect. Therefore, during the fall of 2008, we started the evaluation to determine the detection efficiency of the multiple antenna-array design using double-tagged test fish. The goal was to double tag ~100 steelhead that would be collected by angling the fish in the John Day River below the antennas. In September, NOAA Fisheries set up four radiotelemetry antenna arrays with two below and two above the PIT-tag antennas to monitor the double-tagged fish. Originally, our permits were for tagging only hatchery steelhead. Since we have only caught and tagged 5 hatchery fish in 8 weeks while we have caught 55 wild fish, we are modifying our permits to sample some wild fish. The native run is strong this year. During the talk, we will present the latest results on how well the PIT-tag system has detected the double-tagged steelhead.

EVALUATION OF STEELHEAD KELT PASSAGE THROUGH THE BONNEVILLE DAM SECOND POWERHOUSE CORNER COLLECTOR PRIOR TO THE JUVENILE MIGRATION SEASON, 2007-2008

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ABSTRACT

Surface flow outlets, which readily pass juvenile salmonid migrants, may also be an effective non-turbine passage route for steelhead kelt (*Oncorhynchus mykiss*) moving downstream in early spring before the main juvenile emigration season. At the Bonneville Dam Second Powerhouse, a surface flow outlet, called the corner collector (B2CC), has been routinely operated to pass juvenile salmonids since 2004. To evaluate the potential use of the B2CC by steelhead kelt, we performed a fixed-location hydroacoustic study during March 2 to April 10, 2007 and during March 13 to April 15, 2008. The study objectives were to estimate, for each year separately, the total number of kelt-sized fish (mean target strength > -36 dB || 1 μ Pa at 1 m) passing into the B2CC, run timing, diel distribution, and vertical distribution. Six side-looking split-beam transducers were arrayed vertically and deployed from a barge anchored to the dam to the south of the of the B2CC entrance. The transducers were aimed across and slightly downstream of the region immediately upstream of the weir to sample steelhead kelt passage into the B2CC.

Estimates of steelhead kelt passage were 172 and 223 fish during the 2007 and 2008 sampling periods, or 4 and 7 fish per sample day, respectively. Run timing on a daily basis was sporadic, with daily passage ranging from 0 to 18 fish per day in 2007 and 0 to 31 fish per day in 2008. Fish were observed passing the dam from the beginning of the sampling periods in early March through the end of sampling in mid-April. Passage peaks occurred on April 8, 2007 and April 5, 2008. Diel distributions were variable with no distinct patterns apparent either year. The hours with highest passage were 1100-1200 h during 2007 and 1800-1900 h during 2008. The 2007 vertical distribution of fish was somewhat skewed toward the surface with the highest passage proportion (0.29) in the surface bin (2-5 ft) and the lowest (0.09) in the deepest bin (20-25 ft) out of five depth bins analyzed. During 2008, the passage proportion in the 10-15-ft depth bin was highest (0.43), whereas the shallowest depth bin (3-5 ft) had the lowest passage proportion (0.14) out of the four depth bins analyzed. During the same period in 2007 and 2008 16 and 5 adult steelhead, respectively, passed through the B2 Juvenile Bypass System (JBS) while 4 and 17, respectively, were PIT detected at the B2CC. In conclusion, the B2CC has been known to effectively pass smolt with a very rate of high survival. This study provides evidence that the B2CC can also be an effective route for passing steelhead kelt and should be much safer than turbine passage.

USE OF IN-STREAM PIT ARRAYS TO MONITOR MOVEMENT OF BULL TROUT
BETWEEN THE WALLA WALLA AND COLUMBIA RIVERS – 2008

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ABSTRACT

Bull Trout were listed under the Endangered Species Act in June 1998. A key to recovery of bull trout populations in the Walla Walla Basin is the maintenance of the migratory life history form. Improving connectivity between populations of Columbia River bull trout is a necessary action identified in the FWS Biological Opinion and should help protect against local extinction events.

Our goal for this project is to determine the number of PIT tagged bull trout moving between the Columbia and the Walla Walla Rivers and the timing of their movements. During November 1 2007 to October 31 2008, 234 migratory bull trout were tagged in the lower Walla Walla Basin. In addition, 1,272 migratory and resident bull trout were tagged in the upper Walla Walla basin.

A full stream width pass through PIT array has been in operation since 2005 near the mouth of the Walla Walla River at Oasis Road Bridge (ORB) to monitor movements of PIT tagged bull trout between the Walla Walla and Columbia rivers. During November 1 2007 to October 31 2008, 6 bull trout, 892 Chinook salmon, and 1,747 steelhead were detected at the ORB PIT array. Detections suggest the six bull trout were emigrating from the basin during November 2007 through January 2008. Detections were associated with cooler water temperatures and higher flow. None of the bull trout leaving the Walla Walla Basin have been detected returning to the basin.

We were unable to test the efficiency of the array in detecting bull trout outfitted with 23 mm PIT tags. Using steelhead smolts as a surrogate for bull trout and two different methods of estimating detection efficiency, we estimated it ranged from 42.4 to 43.5% during April through May, 2008.

EVALUATE BULL TROUT MIGRATION BETWEEN THE TUCANNON RIVER AND THE MAINSTEM SNAKE RIVER USING STREAMWIDTH PASSIVE INTEGRATED TRANSPONDER TAG INTERROGATION SYSTEMS

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ABSTRACT

Data on the migration timing and distribution of PIT-tagged bull trout (*Salvelinus confluentus*) was collected by streamwidth PIT tag interrogation systems installed in the lower reaches of the Tucannon River.

Interrogation data collected between October, 2005 and October, 2007, documented the use of the mainstem Snake River by bull trout originating from the Tucannon River. During this period, 31 unique bull trout interrogations were recorded at the PIT tag array. One bull trout made repeated, consecutive year migrations in 2006, 2007 and 2008.

Between October, 2007 and October, 2008, five bull trout were interrogated at the PIT tag array and two additional bull trout were tracked downstream of the PIT tag arrays using radio telemetry. Of the 5 bull trout that were interrogated at the PIT tag arrays, 3 returned to the Tucannon River during the spawning migration in 2008; 1 did not return to the Tucannon River in 2008; and 1 outmigrated in late October, 2008.

Bull trout were detected in October through December and March through May, periods that coincide with immigration into the mainstem Snake River and the spawning migration into the Tucannon River.

No bull trout originating from the Tucannon River have been observed using the fishways of lower Snake River dams.

COLUMBIA RIVER ESTUARY



**EVALUATION OF THE RELATIONSHIP AMONG TIME OF OCEAN ENTRY,
PHYSICAL AND BIOLOGICAL CHARACTERISTICS OF THE ESTUARY AND PLUME
ENVIRONMENT, AND ADULT RETURN RATES**

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ABSTRACT

This study examines the relationship among time of juvenile salmon ocean entry, physical and biological characteristics of the estuary and nearshore ocean plume environment, and smolt-to-adult return rates (SARs) for spring Chinook salmon reared by the Clatsop Economic Development Committee Fisheries Project (CEDC) in the lower Columbia River. From 2002 through 2006, six serial releases of about 25,000 coded-wire-tagged (CWT) smolts were made at 10 day intervals through the migration each year, totaling 726,584 fish over 5 years. Adults were recovered primarily from terminal gill net fisheries in Blind Slough, with returns nearly complete from all years (some 3-ocean adults expected in 2009 from 2006 releases). Returns were highly variable among years, with very few adults returning in some years. Annual oceanographic conditions appear to affect all releases within a year similarly. For example, during bad oceanographic conditions SARs were depressed for all releases. However, within years there still appeared specific periods (releases) when SARs were better than other periods. Preliminary investigations indicate that ocean temperatures, forage fish abundance, and possibly predator abundance may strongly influence SARs in influenced by time of ocean entry.

A STUDY TO ESTIMATE JUVENILE SALMONID SURVIVAL THROUGH THE COLUMBIA RIVER ESTUARY USING ACOUSTIC TAGS, 2008

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ABSTRACT

The study Objectives in 2008 were:

- 1) Estimate yearling and subyearling Chinook salmon survival from Bonneville Dam through the mouth of the Columbia River.
- 2) Quantify and compare latent effects of FCRPS passage history on mortality of emigrant juvenile yearling and subyearling Chinook salmon from Bonneville Dam downstream.
- 3) Monitor and map estuary migration pathway and habitat associations, and relative behaviors.
- 4) Determine the fate of subyearling Chinook salmon that cease their migration in the Columbia River downstream from Bonneville Dam.
- 5) Estimate survival probabilities for yearling and subyearling Chinook salmon within the plume.
- 6) Competitively procure prototypes of “rearing Chinook” acoustic micro-transmitters for function and biocompatibility evaluation.
- 7) Determine the capability and reliability of the JSATS cabled (hard-wired) array.

Progress to date (11/25/2008) relative to the above objectives is summarized below. The results presented should be considered preliminary and subject to change pending further analyses.

Objective 1; analyses are ongoing. Preliminary 2008 survival estimates from Bonneville Dam tailrace to the mouth of the Columbia River were for yearling Chinook salmon averaged 0.785 (range = 0.65 to 0.94) and for subyearling Chinook salmon averaged 0.83 (range = 0.64 to 0.93). The largest loss appeared to occur in the lower 35 km of the river for yearlings and the lower 50 km for subyearling Chinook salmon. The joint probability of migration and survival was much higher later in the season for subyearling Chinook salmon in 2008 than in the previous three years.

Objective 2; analyses are ongoing. Passage route assignments of fish passing JDA and Bonneville Dam from JSATS detections as well as PIT detections in the Juvenile Fish Bypass (JFB) at JDA and BON and Corner Collector at BON will be used to form experimental groups for survival comparisons.

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Objective 3; analyses are ongoing. Migration pathways of 7,926 yearling and 6,751 subyearling Chinook salmon and 2,820 steelhead released for this study and other studies regrouped passing through the Bonneville Dam tailrace or at Rkm 86 (Oak Point) were determined for estuary island side channels and well off the navigation channel into Gray’s Bay in the freshwater tidal portion of the Columbia River Estuary. An average of 8% of the yearling Chinook salmon detected of the yearling Chinook salmon were detected in the estuary islands while 8% were detected in Gray’s Bay. More subyearling Chinook salmon were detected in the islands (13%) and Gray’s Bay (14%). Steelhead were also detected in these non-main-channel migration areas; with 8% detected in the islands and 5 % detected in Gray’s Bay.

Objective 4; this objective will be addressed in the presentation by Lynn McComas on the mobile tracking efforts.

Objective 5; This objective was not funded in 2008, however a separate R&D effort developed and tested a prototype plume and near-ocean receiver that was successfully deployed and tested in 100 m-deep water off the Columbia River Plume.

Objective 6; This objective produced a prototype transmitter weighing 0.30 g in air. This prototype transmitter has been used in preliminary evaluations of bioeffects in a laboratory setting.

Objective 7; this objective will be addressed in the presentation by Lynn McComas on the mobile tracking efforts.

A STUDY TO ESTIMATE SALMONID SURVIVAL THROUGH THE COLUMBIA RIVER ESTUARY USING ACOUSTIC TAGS, MOBILE TRACKING EFFORTS

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ABSTRACT

Deteriorating survival estimates for Chinook salmon migrating through the lower Columbia River have prompted fate determination efforts to reveal specific areas where mortality occurs. To aid in this work, a vessel-mounted tracking unit was used to provide real-time, three-dimensional vectors (range, bearing, and depth) for smolt targets implanted with Juvenile Salmon Acoustic Telemetry System (JSATS) tags. Based on conclusions reached using stationary arrays in 2007, mobile tracking in 2008 was concentrated in the estuary from Tennesillahe (river kilometer, Rkm, 62) through the primary array location at Rkm 8.3.

Nearly 300 tracks were recorded for free ranging JSATS-tagged fish in the lower river and estuary. Of these, 253 tracks, varying from several meters to over 5 km in length, were recorded for unique targets. Another 7 targets were identified as stationary on the river bottom, confirmed on successive dates by repeated visits to a given site at least 24 h following initial contact, and by depth sounder readings. Unlike similar data from 2007, these stationary targets were widely distributed on both north and south migration corridors of the estuary. Mobile targets displayed two distinct track types. The more normal behavior, evinced by approximately 99% of tracked individuals, was essentially fixed downstream movement indicative of directed emigration.

During both yearling and subyearling Chinook salmon outmigration periods, a substantial portion of targets were tracked moving through the north channel along the Washington State shoreline from Portuguese Point (Rkm 29.3) to Point Elise Rkm (20.5). Several targets from both groups were also tracked entering Baker Bay between East and West Sand Islands (Rkm 8), particularly during flood tide events.

EVALUATING CUMULATIVE ECOSYSTEM RESPONSE TO RESTORATION
PROJECTS IN THE COLUMBIA RIVER ESTUARY, 2008

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ABSTRACT

The restoration of tidal marshes and swamps, through hydrological reconnection and vegetation reestablishment (including riparian plantings), in the 235-km estuarine portion of the Columbia River is designed to improve juvenile salmonid habitat quality and ecosystem function. Restoration strategies are being implemented by a variety of governmental and non-governmental organizations. This study is establishing a framework by which to evaluate the effectiveness of individual projects as well as methods for assessing estuary-wide cumulative effects of restoration projects. As part of our effort, we released the final protocol manual for monitoring physical and biological metrics in 2008 following extensive field testing and multiagency review since 2004. We intended this manual to standardize data collection critical for analyzing changes following habitat restoration actions in the main stem from Bonneville Dam to the river mouth. The manual contains methods for monitoring fish, vegetation, land elevation, channel morphology, water levels, and landscape features. Our field studies in 2008 evaluated cumulative effects indicators for detecting a signal from restoration actions in the estuarine system focused on 1) fish use of restored sites, as indicated by the stomach contents of juvenile salmon captured onsite; 2) flux of nutrients and chlorophyll between restored sites and the main stem river; and 3) baseline monitoring of vegetation and land elevation prior to tide gate replacements at the Julia Butler Hansen National Wildlife Refuge. We also implemented field studies of three naturally breached sites (accidental dike breaches from the 1960s – 1990s) for the purpose of evaluating long-term restoration trajectories following hydrological reconnection. To evaluate these natural breaches, we used rapid assessment techniques based on the monitoring protocols; analysis of these data together with data from three natural breach sites proposed for 2009 will increase predictive accuracy regarding restoration outcomes in the estuary. Finally, we utilized an existing hydrodynamic model of the Grays River and hydrological data from specific sites to preliminarily evaluate the cumulative effects of various dike-breach scenarios as measured by wetted area and channel edge. Our results to date show that juvenile salmon access and spend time in restored wetlands almost immediately following hydrological reconnection. Further, organic matter, nutrients and prey resources produced in these restored systems appear to be exported to the river, and the model results provide verification of the inundation cycles on the sites and the interconnections among hypothetical restoration sites. Both juvenile salmon use and ecological processes important to the ecosystem can be improved by tidal reconnection of formerly diked tidal wetlands. In 2008, we proposed an adaptive management strategy for adoption in the region that would facilitate the continuing evaluation and improvement of these types of restoration actions in the lower Columbia River and estuary.

SALMON LIFE HISTORIES, HABITAT, AND FOOD WEBS IN THE COLUMBIA RIVER ESTUARY: AN OVERVIEW OF RESEARCH RESULTS, 2002-2007

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ABSTRACT

In 1999 NOAA Fisheries organized a team of researchers to review the status of knowledge about the estuarine ecology of Columbia River salmon and the potential role of the estuary in salmon population decline. The results of this review, summarized in the Salmon at River's End (SARE) report, hypothesized that historic habitat losses had (1) reduced rearing opportunities for salmon; (2) simplified salmon life history diversity; and (3) reduced the contribution of wetland and other macrophytic plants to estuarine food webs, potentially decreasing the estuary's capacity to support juvenile salmon. In 2002 we initiated new studies to investigate salmon distribution and habitat use in the estuary and to evaluate the SARE hypotheses. These studies applied new research tools and methods unavailable during previous estuarine surveys, including a Geographical Information System to map habitat distributions and quantify historic habitat losses; a 3-D physical model to simulate the dynamics of salmon habitat opportunity with changes in river flow and estuarine bathymetry; otolith microchemical techniques and PIT tag studies to quantify estuarine residence times and to classify juvenile salmon life history patterns; stable isotope techniques to track the carbon sources that support contemporary food webs of salmon; and microsatellite DNA markers to estimate the upriver origins of Chinook salmon stocks sampled in the estuary.

Our results confirmed that salmon rearing opportunities in the lower estuary have decreased in the last century and provided new information about the types and distribution of wetland habitat losses. The largest estimated changes have been in scrub/shrub and forested wetland types, which have declined 55 and 58%, respectively. Despite such losses, subyearling Chinook salmon rear extensively in all wetland types—emergent, scrub/shrub, and forested—that we surveyed in the lower 100 km of the estuary. Moreover, individuals throughout the estuary selected disproportionately for food webs linked to wetland plants relative to other available carbon sources. Our findings support the hypothesis that juvenile life histories have become less diverse than those observed during the first Chinook salmon study in the estuary (1913-1916). However, variation was greater and estuarine residence times were longer than other contemporary surveys and tagging studies have suggested. Using stable isotope analyses, we identified 13 different rearing strategies for Chinook salmon based on different combinations of food-web linkages among estuarine-rearing individuals, including freshwater wetland, fluvial, estuarine wetland, and marine food web sources. On average individual salmon interacted with wetland-based food webs for weeks to months. Our genetic results show that all Columbia River ESUs can express estuarine-resident life histories. The estuary's importance as a nursery ground for all stocks implies that restoration actions above Bonneville Dam alone will not be sufficient to meet salmon recovery goals. However, restoration needs throughout the upper estuary (Rkm 100 to

Bonneville Dam), where wetland and floodplain habitat losses are extensive and stock-specific habitat use has not been investigated, remain poorly understood.

PRE AND POST MONITORING AT TWO ECOSYSTEM RESTORATION SITES, JULIA
BUTLER HANSEN NATIONAL WILDLIFE REFUGE, 2005-2008

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ABSTRACT

Restoring tidally influenced wetlands to improve conditions for juvenile anadromous salmonids is an important component of many recovery and management plans and regulatory requirements. Although restoring tidal wetlands and improving fish access to them are major components of recovery strategies for anadromous salmonids, considerable uncertainty exists concerning appropriate restoration actions. Information on specific habitat requirements and restoration needs of juvenile salmonids in these areas is lacking. The U.S Army Corps of Engineers has proposed such restoration actions in Julia Butler Hansen National Wildlife Refuge. As a component of these actions, replacement of traditional top-hinge tide gates with new designed tide gates has been proposed. These new tide gates are designed to provide habitat and fish passage benefits when compared to traditional tide gates. The U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office has begun to monitor biological and physical attributes of treatment and control sloughs to assess the affect of tide-gate replacement. Specific objectives addressed include assessing tide gate function, fish passage opportunity, habitat parameters and fish community composition among treatment and control sloughs. Fundamental differences exist between fish communities and temperature regimes among treatment and control sloughs pre-construction. Though juvenile salmonids will enter sloughs through tide gates, frequency is low when compared to control sloughs. Installation of tide gates designed to allow improved fish passage and improved habitat quality began in summer 2007 and additional replacements will occur in 2009 through 2011. Assessment of these actions will continue.

SALMONID PREDATION STUDIES



AVIAN PREDATION IN THE COLUMBIA RIVER ESTUARY:
MONITORING MANAGEMENT OF CASPIAN TERNS AND
EVALUATING IMPACTS OF DOUBLE-CRESTED CORMORANTS

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ABSTRACT

Implementation of the federal plan “Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary” was initiated in 2008 with construction of two alternative colony sites in interior Oregon: at Crump Lake in Warner Valley and at Fern Ridge Reservoir near Eugene. We deployed Caspian tern social attraction (decoys and sound systems) on these two 1-acre islands and monitored for Caspian tern nesting activity. Caspian terns (*Hydroprogne caspia*) quickly colonized the Crump Lake tern island and about 430 pairs nested there, including 5 terns that had been banded in the Columbia River estuary over 500 km to the northwest. The diet of Crump Lake Caspian terns, based on 2,909 identified bill-load fish, consisted primarily of tui chub (*Gala bicolor*) (59%), introduced bullhead catfish (*Ameiurus* spp.) (23%), and introduced crappie (*Pomoxis* spp.) (16%); however, 5 Warner suckers (*Catostomus warnerensis*) (0.17%), a threatened species, were also identified in the diet. No Caspian terns nested at the Fern Ridge tern island in 2008, but at least 9 different Caspian terns were present on the island late in the nesting season.

In addition to alternative Caspian tern colony sites in interior Oregon, island construction or enhancement is planned for the San Francisco Bay area. We researched the nesting ecology of Caspian tern colonies in the Bay area in preparation for potential colony expansion at Brooks Island in central San Francisco Bay near Richmond. The Brooks Island Caspian tern colony, at about 810 breeding pairs, is the largest in the Bay area, but about 10% of tern diets at this colony consist of juvenile salmonids (*Oncorhynchus* spp.). Consequently, fisheries managers are concerned that relocation of Caspian terns from the Columbia River estuary to Brooks Island might reduce survival of ESA-listed salmonids from the Sacramento River basin. A radio telemetry study of Brooks Island terns, combined with recoveries of smolt coded wire tags from the Brooks Island colony, revealed that nearly all salmonid smolts consumed by Caspian terns from this colony in 2008 were hatchery-reared, non-listed fall-run Chinook (*O. tshawytscha*) that were depredated near net pen release sites in San Pablo Bay.

In 2008, we also continued field studies to assess the impact on survival of juvenile salmonids from Caspian tern predation in the Columbia River estuary. The Caspian tern colony on East Sand Island, the largest of its kind in the world, consisted of about 10,700 breeding pairs in 2008, the highest estimate of colony size since this colony formed in 1999, but not significantly higher

than the estimate in 2007. The proportion of juvenile salmonids in the diet of East Sand Island Caspian terns was 29% in 2008, similar to the proportions in 2006 (31%) and 2007 (30%). Northern anchovy (*Engraulis mordax*) and surfperch (*Embiotocidae*) were the most prevalent non-salmonid prey types in the tern diet. Calculation of juvenile salmonid consumption by East Sand Island Caspian terns in 2008 is still in progress, but is likely similar to 2007, when terns consumed an estimated 5.5 million smolts (95% c.i. = 4.8 – 6.2 million).

East Sand Island is also home to the largest double-crested cormorant (*Phalacrocorax auritus*) colony in western North America. The colony consisted of about 10,950 breeding pairs in 2008, about 20% smaller than 2007 (ca. 13,770 breeding pairs). Despite the sharp and unexpected decline in colony size, nesting success was comparatively high at 2.3 young raised per breeding pair, and an adjacent colony of Brandt's cormorants (*P. penicillatus*) nearly doubled in size to 510 breeding pairs. Juvenile salmonids represented ca. 12% of double-crested cormorant diets in 2008, compared with 9% in 2007. Estimates of total smolt consumption by East Sand Island cormorants in 2008 are pending, but in 2007 East Sand Island cormorants consumed about 9.2 million juvenile salmonids (95% c.i. = 4.4 – 14.1 million), similar to the 2006 estimate (8.9 million). Of the estimated 9.2 million smolts consumed by East Sand Island cormorants in 2007, about 4.8 million were sub-yearling Chinook salmon, 2.7 million were coho salmon (*O. kitsch*), 1.3 million were steelhead (*O. mykiss*), and 1.1 million were yearling Chinook salmon. These species proportions are based on genetic analyses of salmonid tissues recovered from the stomachs of East Sand Island cormorants. During 2006 and 2007, losses of coho, steelhead, and yearling Chinook smolts to cormorant predation in the estuary were considerably higher than average annual losses during 1998-2005. Combined losses of salmonid smolts to double-crested cormorants and Caspian terns in the Columbia River estuary were approximately 14.7 million in 2007, about an order of magnitude greater than losses to avian predators elsewhere in the Columbia Basin.

Analyses of double-crested cormorant genetic structure indicate that the East Sand Island cormorant colony is part of a population that extends along the coast from the Strait of Georgia, BC to Pt. Conception, CA and inland to the Continental Divide. Additional samples collected in 2009 will better clarify the geographic extent of the population. In 2008, satellite tags were deployed on 28 adult double-crested cormorants nesting at East Sand Island in order to track post-breeding movements and identify possible alternative nesting areas. To date, satellite-tagged cormorants have been tracked to roost sites in the greater Puget Sound region (n = 6); the lower Columbia River between Longview, WA and Gresham, OR (n = 5); interior northern California (n = 2); and interior British Columbia along the Fraser River (n = 1). These preliminary results suggest that breeding colonies in NW Washington and SW British Columbia, many of which have declined in the last two decades, have contributed recruits to the East Sand Island cormorant colony. Research on the status of the Pacific Coast population of double-crested cormorants is on-going in preparation for potential cormorant management in the estuary to enhance survival of Columbia Basin salmonids.

AVIAN PREDATION ON THE MID-COLUMBIA RIVER:
COLONY SIZES AND TRENDS FOR CASPIAN TERNS, DOUBLE-CRESTED
CORMORANTS, AND OTHER PISCIVOROUS WATERBIRDS NESTING ON THE
COLUMBIA PLATEAU

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ABSTRACT

Caspian terns (*Hydroprogne caspia*) and double-crested cormorants (*Phalacrocorax auritus*) are responsible for the vast majority of losses of salmonid smolts (*Oncorhynchus* spp.) to avian predators along the mid-Columbia River. There were two breeding colonies of Caspian terns on the mid-Columbia River in 2008: Crescent Island in the McNary pool and Rock Island in the John Day pool. The Crescent Island Caspian tern colony consisted of 388 breeding pairs in 2008, 9% more than in 2007, and still the largest Caspian tern colony on the Columbia Plateau and the 4th largest colony in the Pacific Northwest. Nesting success at the Crescent Island tern colony was only 0.28 young fledged per breeding pair, down about 60% from 2007, and the lowest nesting success recorded for this colony. At Crescent Island, salmonid smolts represented 68% of tern diets in 2008, similar to diet composition during 2000-2007. Based on bioenergetics calculations, Crescent Island Caspian terns consumed about 330,000 juvenile salmonids in 2008 (95% c.i. = 230,000 – 440,000), the lowest annual estimate since 2000. Total annual smolt consumption by this tern colony is inversely related to May-June river flows ($r_2 = 0.43$, $P = 0.05$).

The Rock Island Caspian tern colony consisted of about 100 breeding pairs in 2008, up from about 40 pairs in 2007. The Rock Island tern colony nearly failed in 2008, as only 3 young were fledged. This is the third consecutive that the Rock Island Caspian tern colony has failed or nearly failed. Although no diet data were collected at the Rock Island tern colony, numbers of smolt PIT tags recovered on the colony indicated that salmonids were a significant proportion of the diet.

Three other Caspian tern colonies were monitored on the Columbia Plateau in 2008: about 290 pairs nested on Goose Island in Potholes Reservoir, about 25 pairs nested on Twining Island in Banks Lake, and about 10 pairs nested on Harper Island in Sprague Lake. Diet data for these colonies in 2008 were limited to smolt PIT tag recoveries on Goose and Twining islands, which indicated that at least some terns were foraging on salmonid smolts, particularly steelhead from the mid- and upper Columbia River. Together with the colonies at Crescent Island and Rock Island on the Columbia River, a total of ca. 820 pairs of Caspian terns nested on the Columbia Plateau in 2008, about a 20% decline since 2001. Interestingly, 18 of the 30 banded Caspian

terns that were re-sighted on the new tern island on Crump Lake, Warner Valley, Oregon, were banded at Crescent Island, suggesting that the new island is attracting terns that formerly nested at colonies on the Columbia Plateau over 450 km to the north.

In 2008, the only double-crested cormorant colony on the mid-Columbia River was on Foundation Island in McNary pool, and consisted of > 357 pairs nesting in trees. The largest cormorant colony on the Columbia Plateau, however, was on Potholes Reservoir, where about 1,000 pairs nested in trees at the north end of the reservoir. Sizes of the Foundation Island and North Potholes cormorant colonies have not changed appreciably in the last three years, indicating that the overall cormorant breeding population in the region has been nearly stable in the short term. Based on limited diet data for Foundation Island cormorants in 2008, the proportion of salmonids in the diet was higher than in 2007 and varied widely across the nesting season; in early and mid-May salmonids represented > 50% of the diet, while in June salmonids were nearly absent from the diet. Smolt PIT tag recoveries from 2007 and 2008 suggest that the impact of Foundation Island cormorants on salmonid smolt survival is now comparable to that of Caspian terns nesting at Crescent Island. A new double-crested cormorant colony was discovered on Harper Island in Sprague Lake, where about 35 pairs nested in 2008.

Stomach contents of 38 over-wintering double-crested cormorants collected in 2007 at dams on the lower Snake River indicated that salmonids comprised 11.8% of the diet; only 1 of 4 salmonids found in stomachs was from a listed run of fall Chinook. Surveys in late 2008 indicated that about 375 cormorants over-winter along the lower Snake River, one-third of which are associated with the four lower Snake River dams.

The American white pelican colony on Badger Island in McNary pool is the only known breeding colony for the species in the State of Washington. In 2008, counts of adult pelicans on the island during late incubation averaged 1,350, the highest count so far recorded at this colony; the breeding colony is now likely to consist of > 1,000 nesting pairs. Due to the special conservation status afforded this colony by the State of Washington, island access is restricted and estimates of salmonids consumed by pelicans nesting at this colony are lacking. However, recoveries of smolt PIT tags on-colony after the nesting season indicate that smolt consumption is increasing, but still considerably less than that of the nearby Caspian tern and double-crested cormorant colonies.

Tens of thousands of pairs of California and ring-billed gulls nest on islands on or near the mid-Columbia River. While the gulls at these colonies generally consume few fish and even fewer juvenile salmonids, recent increases in the numbers of smolt PIT tags recovered on the gull colony at Miller Rocks in The Dalles pool have raised new concerns about the impact of gull predation on survival of salmonid smolts in the mid-Columbia River. The increase in consumption of PIT-tagged smolts by Miller Rocks gulls apparently reflects a change in foraging intensity at nearby mainstem dams, rather than an increase in the size of the Miller Rocks gull colony. The magnitude of predation on salmonid smolts by Miller Rocks gulls appears to be unique to this gull colony, which is situated midway between The Dalles and John Day dams.

DETECTION OF PASSIVE INTEGRATED TRANSPONDER (PIT) TAGS ON
BREEDING COLONIES OF AVIAN PISCIVORES IN THE COLUMBIA RIVER BASIN,
2008

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ABSTRACT

Passive integrated transponder (PIT) tag detection efforts for 2008 yielded over 121,000 juvenile salmonid *Oncorhynchus* spp. tags that had not previously been detected on breeding colonies of piscivorous birds in the Columbia River basin. PIT tag recoveries accounted for about 3.7% of all PIT-tagged salmonids released into the Columbia River basin for migration year 2008. The majority of these tags were detected on Caspian tern (*Hydroprogne caspia*) and double-crested cormorant (*Phalacrocorax auritus*) colonies located on East Sand Island in the Columbia River estuary and on Crescent Island near the confluence of the Snake and Columbia Rivers.

On East Sand Island, we detected 11% of the steelhead transported and released downstream from Bonneville Dam and 13% of those detected at Bonneville Dam. Detection percentages on East Sand Island for transported or bypassed Chinook salmon were considerably lower than for steelhead, about 3.5% for each group. We also tagged 3,000 subyearling Chinook salmon at four hatcheries located downstream from Bonneville Dam. These fish were released in May-July, and we detected about 27% of those on East Sand Island.

Consistent with previous years, steelhead continued to be significantly more vulnerable to avian predation than other species in all reaches and for all ESUs except for lower Columbia River subyearling Chinook salmon. Preliminary detection efficiency estimates obtained by scattering control tags pre-, mid-, and post-nesting season on both Crescent Island and East Sand Island tern colonies were consistent with previous years of high detection efficiency with 62% and 92% of the controls tag detected at each location.

STEELHEAD VULNERABILITY TO AVIAN PREDATORS IN THE SNAKE AND COLUMBIA RIVERS

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ABSTRACT

Piscivorous waterbirds nesting along the Columbia River consume millions of juvenile salmonids (*Oncorhynchus* spp.) annually. To estimate predation rates and evaluate the relative impact of various avian colonies, we PIT-tagged, condition-scored, and released steelhead (*O. mykiss*) smolts into the lower Snake ($n = 7,926$ from Lower Monumental Dam) and mid-Columbia ($n = 7,271$ from Rock Island Dam) rivers in 2008. Caspian tern (*Hydroprogne caspia*), double-crested cormorant (*Phalacrocorax auritus*), American white pelican (*Pelecanus erythrorhynchos*), and several gull (*Larus* spp.) colonies were then scanned for PIT tags following the birds' nesting season to evaluate impacts.

Preliminary results indicate that of the PIT-tagged steelhead released into the lower Snake River in 2008, 8.7%, 2.3%, and 22.3% of the available fish (i.e., those surviving to the vicinity of the avian colonies) were estimated to be consumed by colonial waterbirds in McNary pool, John Day/The Dalles pools, and in the Columbia River estuary, respectively. Of the PIT-tagged steelhead released into the mid-Columbia River in 2008, we estimated that 3.5%, 1.9%, and 18.2% were consumed by colonial waterbirds in McNary pool, John Day/The Dalles pools, and in the Columbia River estuary, respectively. A comparison of predation between different avian species indicated that Caspian terns and double-crested cormorants nesting in the estuary consumed the largest proportion of available tagged steelhead smolt, followed by Caspian terns and double-crested cormorants nesting on islands in McNary pool. Predation by Caspian terns nesting at an off-river colony in Potholes Reservoir, WA was also notable, with an estimated predation rate of 7.5% on steelhead smolts released into the mid-Columbia River. Conversely, predation by gulls and American white pelicans was minor (ranging from 0.2% to 2.1%) in comparison to that of terns and cormorants.

Preliminary smolt condition-scoring results demonstrated that smolts exhibiting severe external damage were approximately 1.8 times more likely to be consumed by an avian predator in McNary pool, compared to undamaged smolts. In addition to condition-dependent selection, differences in smolt susceptibility to avian predators based on run-timing, stock, rear-type (hatchery, wild), and fish length were also observed. Finally, a comparison of predation rates between PIT-tagged steelhead smolts and other tagged salmonid species (Chinook, coho, and sockeye smolts) indicates that steelhead are consistently the most vulnerable salmonid to avian predation in the mid-Columbia River.

EVALUATION OF SEA LION PREDATION IN THE BONNEVILLE DAM TAILRACE

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ABSTRACT

Since 2002, we have used surface observations to meet three objectives: (1) estimate the number of adult salmonids (*Oncorhynchus* spp.) and other fish consumed by pinnipeds in the Bonneville Dam tailrace and estimate the proportion of the January-May adult salmonid run impacted; (2) determine the seasonal timing and abundance of pinnipeds at Bonneville Dam, documenting individual California sea lion (*Zalophus californianus*) presence and predation activity when possible; and (3) evaluate the effectiveness of pinniped deterrents used at Bonneville Dam.

In 2008, we observed diurnal pinniped predation on adult salmonids and other fish in the Bonneville Dam tailrace from January 11 to May 31. An estimated 2.9% (4,466) of the January 1 through May 31 Bonneville Dam salmonid run was taken by sea lions at the dam. When adjusted for unidentified catch, the estimate was 3.2% of the run (4,927). Chinook salmon (*O. tshawytscha*) was the most commonly identified prey species, comprising about 93% of observed salmonid catches. Pacific lamprey (*Lampetra tridentata*) comprised only 2.0% (145) of observed catch, the lowest proportion we have recorded in seven years of monitoring. Steller sea lions (*Eumetopias jubatus*) continued to be the dominant white sturgeon (*Acipenser transmontanus*) predator in the area, taking 97.7% of the 606 observed sturgeon catches in 2008.

At least 84 California sea lions, 17 Steller sea lions, and 2 harbor seals (*Phoca vitulina*) were documented during the study period. The highest number of pinnipeds counted on any one day was 63 (April 16) and the longest recorded residence time for an individual California sea lion was 80 days, continuing upward trends in peak abundance and residence time at Bonneville Dam. Steller sea lions were not only more abundant than in previous years, they also did not leave after dam and boat-based hazing efforts began, as they had in 2006 and 2007.

Physical barriers, including sea lion exclusion devices (SLEDs) and floating orifice gate (FOG) barriers, apparently prevented sea lions from entering the fishways, but acoustic deterrents installed near fishway entrances continued to have no visible effect on the sea lions. During daylight hours, dam-based and boat-based crews from partnering agencies used non-lethal pyrotechnics and rubber bullets to haze sea lions in the dam tailrace. Hazing did appear to temporarily alter the behavior of some sea lions, but hazing efforts did not reverse the upward trend in predation estimates.

The Oregon and Washington fish and wildlife departments used four floating sea lion traps to capture, then either mark and release or permanently remove sea lions. Of the 11 California sea lions captured, seven were removed as authorized by NOAA under Section 120 of the Marine Mammal Protection Act, and four were processed (measured, weighed, marked with a 3-digit brand) and released. Four California sea lions and two Steller sea lions died on traps under unknown circumstances on May 4, halting trapping operations for the season.

TRANSPORTATION AND DELAYED MORTALITY STUDIES



ALTERNATIVE BARGING STRATEGIES TO IMPROVE SURVIVAL OF TRANSPORTED JUVENILE SALMONIDS 2008

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ABSTRACT

During spring 2008, we completed the 3rd and final year of a study to test the hypothesis that releasing transported juvenile salmonids in the lower Columbia River estuary would produce higher smolt-to-adult return rates (SARs) than releasing them just below Bonneville Dam. We also determined pathogen loads (*Renibacterium salmoninarum* and *Nucleospora salmonis*) in about 1,800 study fish using non-lethal sampling to evaluate whether pathogens in individual fish affect vulnerability to avian predators as well as SARs.

On six consecutive Sundays, starting in late April 2008, yearling Chinook salmon and steelhead were collected and tagged with PIT tags at the Lower Granite Dam juvenile fish facility. A total of 16,519 hatchery and 3,036 wild yearling Chinook salmon were tagged and released downstream from Astoria at rkm 10, while 23,717 hatchery and 4,520 wild yearling Chinook salmon were tagged and released at Skamania Landing at rkm 225. We also released 25,353 hatchery and 5,686 wild steelhead at rkm 10 and 32,921 hatchery and 7,628 wild steelhead at rkm 225. For non-lethal pathogen testing, gill snip samples were taken at Lower Granite Dam from about 450 fish each of the tagged hatchery and wild Chinook salmon and hatchery and wild steelhead. Gill samples were processed for testing by both nested (non-quantitative) and real-time (quantitative) polymerase chain reaction (PCR) assays.

From 2006 releases, 49 and 124 Chinook salmon (jacks and 2-ocean) have returned to date from Astoria and Skamania Landing releases, respectively for a TA/TS of 0.59, while for steelhead, 445 and 504 fish have returned for a TA/TS of 1.26. From 2007 releases, 20 and 29 Chinook salmon jacks have returned from Astoria and Skamania Landing releases, respectively for a TA/TS of 1.06, while for 1-ocean steelhead, 188 and 305 fish have returned for a TA/TS of 0.85.

REVIEW OF POTENTIAL EFFECTS OF ALTERNATIVE BARGING STRATEGIES ON PREDATION OF IN-RIVER SALMONIDS IN THE LOWER COLUMBIA RIVER

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ABSTRACT

Transporting juvenile fish from Lower Snake River collection points to below Bonneville Dam (BON) is a strategy to move migrating smolts downstream to avoid direct dam and reservoir effects experienced by in-river migrants. The ACOE is evaluating strategies to improve survival of transported fish by extending the release site of transported fish downstream nearer saltwater. The number of transported smolts (Chinook and steelhead) has ranged from 5.0 million to nearly 24 million from 1999 to 2007. Estimates of in-river migrants indicate that transported smolts are more than 50% of the smolt migrants immediately below BON. This percentage declines rapidly downstream as smolts from lower river populations enter the Columbia River.

The purpose of this project is to better understand the predator-prey interactions in the Lower Columbia River specific to the alternate release strategy. While the proposed release strategy could increase overall survival of transported migrants it could also result in greater predation risks to in-river migrants below BON. The analysis will study alternative hypotheses in light of existing predator-prey theory and current knowledge of predator dynamics below BON. The study will provide a better perspective on possible outcomes of the alternate release site and, more importantly, suggest studies to test key hypotheses affecting the outcome.

We present a conceptual model to help us understand possible effects of the alternative release strategy on the survival of in-river migrants (fish originating from upstream and downstream of BON) due to predation effects. This concept will be further developed into a quantitative analysis to predict outcomes for a variety of hypotheses specific to predator-prey interactions.

We identify a variety of hypotheses that would affect the outcome of the transportation strategy on survival of in-river migrants. Our predictions will be very much dependent on how we consider prey preference, predator behavior, and the effect of environmental conditions on predator-prey interactions in the lower river. The purpose of our presentation is to review these hypotheses with the Columbia River scientific community and invite constructive input before developing the analytical model.

TRANSMISSION OF THE PATHOGEN RENIBACTERIUM SALMONINARUM UNDER DIFFERENT LABORATORY-CONTROLLED BARGING CONDITIONS

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ABSTRACT

In this AFEP-funded study, we investigate the likelihood of transmission of infectious disease in the outmigrant juvenile population of yearling Snake River Chinook salmon under controlled laboratory conditions intended to mimic variables that would occur during transportation. In previous AFEP studies, we detected salmonid pathogens by polymerase chain reaction (PCR) in barge hold water at Lower Granite Dam immediately after loading, as well as upon completion of the barge trip at Bonneville Dam. Similarly, we found an increase in the number of fish containing these pathogens after the barge trips relative to fish sampled prior to barging, suggesting pathogen transmission can occur during transport operations. To identify transport conditions that could minimize disease transmission, we evaluated the transmission of *Renibacterium salmoninarum*, the causative agent of Bacterial Kidney Disease (BKD), from infected 'donor' juvenile salmon to 'susceptible' juvenile salmon under three different holding densities (0.05, 0.18, and 0.50 lb/gal) that represented a range of conditions found during the FCRPS transportation season, as well as two different tank exchange rates (2.0 and 5.7 exchanges/hour). The susceptible fish were exposed to the donor fish and the simulated transport conditions for 60 hours in order to mimic the period of raceway collection and holding (24 hours), as well as downriver transport by barge (36 hours). After the 60-hour exposure, the susceptible fish were removed from the donor fish and monitored for 75 days, at which point their kidneys were collected and analyzed by conventional and quantitative PCR for the presence of *R. salmoninarum*. Although the analysis of our final experiment described above is still in progress, our preliminary experiments have demonstrated that one fish infected with *R. salmoninarum* can shed 615 million cells/liter into the surrounding water and pathogens from the infected donors were transmitted to the gills of susceptible fish (>90% detection) following a 60-hour exposure period at an average density of 0.31 lb/gal. The anticipated results of this work will provide USACE and stakeholders with information regarding the influence of basic transport variables on disease transmission and the operating conditions that may reduce the transmission of pathogens.

INFLUENCE OF MIGRATION HISTORY AND COLUMBIA RIVER ESTUARY CONDITIONS ON DIFFERENTIAL DELAYED MORTALITY OF SNAKE RIVER HATCHERY SPRING/SUMMER CHINOOK SALMON

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ABSTRACT

Various methods have been developed to mitigate the effects of the Federal Columbia River Power System (FCRPS) on juvenile salmon migrating to the Pacific Ocean through the Columbia River Basin. Barging fish through the FCRPS is one effort that has been implemented to facilitate juvenile fish outmigration, but former studies have shown that barging juvenile salmon induces stress that may contribute to the incidence of delayed mortality. This study is part of an ongoing effort to determine the extent of delayed mortality in the estuary and to identify the likely factors that contribute to differences in delayed mortality in the estuary of Barged and In-River hatchery-reared Snake River spring/summer Chinook salmon. PIT-tagged Chinook salmon from Rapid River and Clearwater hatcheries were collected from juvenile bypass facilities with separation-by-code (SbyC) systems located at Lower Granite and John Day/Bonneville Dams. Fish collected from the river system were grouped based on their outmigration strategy, with the 'Barged' cohort containing fish that were collected at Lower Granite Dam and transported in barge holds to Bonneville Dam, and the 'In-River' cohort comprised of in-river fish collected at John Day/Bonneville Dams. Both cohorts were trucked to in-situ net-pens located at two estuary sites, Tongue Point and East Sand Island, and held for 28 days to monitor their survival. Cumulative mortality over the 28-day holding period was significantly greater in In-River outmigrants than Barged fish. Furthermore, we observed significantly greater cumulative mortality of fish held at Tongue Point (a freshwater site) in comparison to those at Sand Island (a saline site), independent of their outmigration strategy. Net-pen site-specific differences of cumulative mortality were not seen in control fish (fish raised from eggs at the Hatfield Marine Science Center in Newport OR and deposited into the net pens at each location), supporting the notion that the magnitude of mortality in the estuary is, in large part, dependent upon the duration of time outmigrating fish stay in the estuary prior to ocean entry. We are currently in the process of assessing the pathogen prevalence in Barged and In-River fish, and examining mortalities that occurred during net-pen holding histologically to determine the probable cause of death. Anticipated results of these analyses will be linked to net-pen mortalities to help identify likely factors that contribute to the observed differences in delayed mortality.

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SURVIVAL ESTIMATE OF RUN-OF-RIVER TRANSPORTED YEARLING
CHINOOK SALMON ORIGINATING FROM SNAKE RIVER BASIN IN
THE LOWER COLUMBIA RIVER AND ESTUARY WITH EMPHASIS
ON INCREASING UNDERSTANDING OF CAUSES OF DIFFERENTIAL
DELAYED MORTALITY

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ABSTRACT

In this study, Juvenile Salmon Acoustic Telemetry System (JSATS) acoustic tags and concomitant detection arrays were utilized to estimate differential delayed mortality of transported and in-river yearling Chinook salmon in the lower Columbia River and Estuary (defined as that portion of the river system below Bonneville Dam). In addition, estuary net pens were used to identify potential causes of mortality observed in fish implanted with acoustic tags that migrated through the lower Columbia River and Estuary. In total, 4425 run-of-river yearling Chinook salmon smolts were surgically implanted with acoustic tags. At Lower Granite Dam, 2218 fish were surgically implanted with acoustic tags and transported by barge through the hydropower system. A total of 900 tagged fish were offloaded at Bonneville Dam and deposited into two estuary net pen sites (Sand Island -Rkm 7 and Tongue Point -Rkm 29) and held for 28 days; the remaining 1318 fish were released below Bonneville Dam at the barge release site at Skamania Landing (Rkm 227). Survival estimates of the barged fish released at Skamania were obtained with JSATS detection arrays deployed as part of another ongoing study entitled “A study to estimate juvenile salmonid survival from Bonneville Dam through Columbia River estuary using acoustic tags” (PIs: McComas and McMichael). An additional 1311 run-of-river outmigrant yearling Chinook salmon were surgically implanted with acoustic tags at Lower Granite Dam and released back into the river system. A subgroup of these fish were collected at Bonneville and John Day dams and deposited into net pens at the Sand Island site. Finally, an additional 896 run-of-river outmigrant yearling Chinook salmon were surgically implanted with acoustic tags at Bonneville Dam and transported to the two net pen sites in the estuary for a 28-day holding period. Survival estimates of barged fish were compared to survival estimates of in-river outmigrants to obtain an estimate of differential delayed mortality in the lower river and estuary. Preliminary data suggest that yearling Chinook salmon smolts migrating down the river during middle and late-season (designation based on passage at LGR) had higher survival in the estuary than barged fish released at Skamania Landing. In-river emigrants also appeared to move through the lower Columbia River and Estuary faster than barged fish. Columbia River discharge appeared to be related to migration rates of both barged and in-river groups. Mortality rates at Tongue Point net pens (a freshwater site) were higher in both fish tagged at Bonneville and

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Lower Granite dams than at the Sand Island net pens (a saline site). Assessment of morbidity and mortality in net pen groups will yield possible differences in health of fish with varying transport histories. These health data will be used covariates in statistical models to increase our understanding of possible health-related causes of mortality in barged and in-river fish actively migrating through the lower Columbia River and Estuary.

SNAKE RIVER YEARLING CHINOOK SALMON AND STEELHEAD TRANSPORT STUDIES, 2008

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ABSTRACT

In 2008, we continued research to determine the potential of transportation to increase adult returns of anadromous salmonids. We PIT tagged wild yearling spring/summer Chinook salmon and steelhead smolts at Lower Granite Dam (LWG). At the dam, we also detected returning adult Chinook salmon and steelhead PIT-tagged as smolts in 2005-2007.

From 2005 releases, we detected a total of 28 wild LWG transported adults and 3 adults that were non-detected as juveniles. Because so few non-detected adults returned, we were unable to develop temporal transport-to-non-detected ratios. The temporal pattern for transport SARs was similar to previous years with lower SARs early in the year followed by a drop, then an increase to the highest SARs of the year. The increase occurred during the first week of May.

In 2005, our study design for steelhead was the same as detailed above for wild yearling Chinook salmon. We detected a total of 41 wild LWG transported adults and no wild non-detected adults. Because there were no wild non-detected adult steelhead, we were unable to estimate a transport-to-non-detected ratio. Temporal transport SARs were lower than previous years. Overall, the SARs showed their highest levels in April, and did not hit zero until the end of May.

Adult fall Chinook salmon returns from the 2003 transport study are complete. We detected a total of 15 LWG transported adults (SAR of 0.09) from this study.

MCNARY TRANSPORTATION STUDIES

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ABSTRACT

In 2008, we completed research to evaluate the potential of transportation from McNary Dam to increase adult returns of anadromous salmonids.

During the 2005 study year, collected fish at McNary Dam were separated into transport and full-flume bypass groups on alternating days. The study design was to compare the relative adult returns from these two PIT-tagged groups to adult returns of the PIT-tagged fish passing McNary Dam through spill and turbines. Fish returned to the river after having been routed across the separator were not used in any comparisons.

From our PIT-tagged hatchery steelhead releases, we detected a total of 379 transported adults (SAR of 2.14), 485 full-flume bypassed adults (SAR of 1.98), and 2,888 non-detected adults (SAR of 1.95). These SARs resulted in a transport-to-non-detected ratio of 1.09 (95% CI 0.95, 1.26), a bypassed-to-non-detected ratio of 1.02 (95% CI 0.88, 1.16), and a transport-to-bypass ratio of 1.08 (95% CI 0.83, 1.39).

POST RELEASE PERFORMANCE OF NATURAL AND HATCHERY SUBYEARLING FALL CHINOOK SALMON IN THE SNAKE AND CLEARWATER RIVERS

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ABSTRACT

In 2006, we continued a multi-year study to compare smolt-to-adult return rate (SAR) ratios between two groups of Snake River Basin fall Chinook salmon *Oncorhynchus tshawytscha* that reached the sea through a combination of either (1) transportation and inriver migration or (2) bypass and inriver migration. We captured natural subyearlings rearing along the Snake and Clearwater rivers and implanted them with passive integrated transponder (PIT) tags, but knew in advance that sample sizes of natural fish would not be large enough for precise comparisons of SAR ratios. To increase sample sizes, we also cultured Lyons Ferry Hatchery subyearlings under a surrogate rearing strategy, implanted them with PIT tags, and released them into the Snake and Clearwater rivers to migrate seaward. The surrogate rearing strategy involved slowing growth at Dworshak National Fish Hatchery to match natural subyearlings in size at release as closely as possible, while insuring that all of the surrogate subyearlings were large enough for tagging (i.e., 60-mm fork length). Surrogate subyearlings were released from late May to early July 2006 to coincide with the historical period of peak beach seine catch of natural parr in the Snake and Clearwater rivers. We also PIT tagged a large representative sample of hatchery subyearlings reared under a production rearing strategy and released them into the Snake and Clearwater rivers in 2006 as part of new research on dam passage experiences (i.e., transported from a dam, dam passage via bypass, dam passage via turbine intakes or spillways). The production rearing strategy involved accelerating growth at Lyons Ferry Hatchery, sometimes followed by a few weeks of acclimation at sites along the Snake and Clearwater rivers before release from May to June. Releasing production subyearlings has been suggested as a possible alternative for making inferences on the natural population if surrogate fish were not available. Smolt-to-adult return rates are not reported here, but will be presented in future reports written after workshops and input by federal, state, and tribal researchers. In this report, we compared the postrelease performance of natural subyearlings to the postrelease performance of surrogate and production subyearlings. We made this comparison to help the fisheries community determine which of the two hatchery rearing strategies produced fish that were more similar to natural subyearlings. We compared the following attributes of postrelease performance (1) detection dates at dams, (2) detections during the implementation of summer spill, (3) travel times, (4) migrant sizes, and (5) the joint probability of migration and survival. Overall, we found that postrelease performance was more similar between natural and surrogate subyearlings than between natural and production subyearlings. Further, the similarity between natural and surrogate subyearlings was greater in 2006 than in 2005, partly as the result of changes in incubation and early rearing practices we recommended based on 2005 results.

A STUDY TO UNDERSTAND THE EARLY LIFE HISTORY OF SNAKE RIVER FALL CHINOOK SALMON, 2007

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ABSTRACT

In 2007, NOAA Fisheries and USFWS-DWOR continued a study begun in 2005 to document the downstream passage histories of returning Snake River fall Chinook salmon adults to increase our understanding of their early life history. We analyzed data collected from September to November 2007 on adults (including jacks and mini-jacks) recaptured at Lower Granite Dam that had been PIT-tagged as subyearlings during 2002-2006. From each adult's scale sample, we attempted to determine age at ocean entry (subyearling or yearling), which was then compared to that adult's juvenile PIT-tag detection history.

A total of 635 PIT-tagged adults were recaptured at Lower Granite Dam in 2007 from juveniles that migrated downstream during 2002-2006. Due to the large number of samples taken in 2006 and 2007, and a changeover in staff at the Washington Department of Fish and Wildlife (WDFW) scale lab, only 85 scale samples collected in 2007 had been read at the time this abstract was written. We are currently working with WDFW to prevent this from happening in the future (e.g., pressing the scale ourselves) as the number of scales collected each year continues to increase, with 780 scale samples from adults returning in fall 2008 already collected (through 8 November).

JUVENILE PASSAGE STUDIES



ESTIMATION OF JUVENILE PASSAGE AND SURVIVAL OVER A NEWLY CONSTRUCTED WANAPUM DAM FISH BYPASS DURING 2008

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ABSTRACT

To help the Public Utility District No. 2 of Grant County (Grant PUD) meet its goal of a dam passage survival rate of 95% for juvenile salmonids passing Wanapum Dam, Grant PUD designed and constructed a top-spill fish bypass in the location of a “future turbine unit” of Wanapum Dam. The Wanapum Future Unit Fish Bypass (WFUFB) was designed to pass 20 kcfs as non-turbine fish passage and remove the practice of bottom-tainter gate “fish spill” as a juvenile salmonid downstream passage route.

2008 was the first year of the newly constructed WFUFB. With the use of acoustically tagged steelhead (*Oncorhynchus mykiss*), yearling Chinook (*O. tshawytscha*), and sockeye (*O. nerka*), the fish collection efficiency (FCE) and passage survival rate of the WFUFB could be estimated.

Steelhead used the WFUFB as a passage route passed Wanapum Dam 54% of the time; Sockeye 32% of the time and Chinook 29% of the time. The FCE of the WFUFB for all three species of salmonids tested that were within a 100 ft radial zone from the center of the WFUFB was greater than 95%. As the distance from the WFUFB increased, the FCE decreased. At a distance of 300 ft from the WFUFB, the FCE for steelhead was 81%, yearling Chinook 71% and 68% of the sockeye were collected.

The estimated survival passage rates for the WFUFB consisted of both a paired release for steelhead and a single-point release for Chinook and sockeye. Estimated passage survival rates for the WFUFB ranged from 100% survival rate for steelhead to the mid-90% for sockeye.

RSW POST-CONSTRUCTION EVALUATION OF PASSAGE AND SURVIVAL FOR RADIO-TAGGED YEARLING CHINOOK SALMON AND JUVENILE STEELHEAD AT LOWER MONUMENTAL, 2008

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ABSTRACT

In 2008, NOAA Fisheries evaluated passage behavior and estimated relative survival for radio-tagged river-run yearling Chinook salmon and juvenile steelhead related to operation of a removable spillway weir (RSW) at Lower Monumental Dam on the Snake River. Fish were PIT tagged and surgically implanted with a radio transmitter at Lower Monumental Dam. The treatment groups comprised 1,214 yearling Chinook salmon and 1,208 juvenile steelhead released 5 km below Little Goose Dam. The reference groups comprised 1,001 yearling Chinook salmon and 1,007 juvenile steelhead released into the tailrace of Lower Monumental Dam. Releases occurred during both daytime and nighttime operations for 26 days from 28 April to 23 May. Project operations during the evaluation included spill 24 hours per day. River flow, percent spill, and tailwater elevation during releases averaged 103 kcfs, 33%, and 441 ft msl, respectively.

Yearling Chinook salmon

Median forebay delay was 2.2 hours. The highest percentage of fish (43%) first approached the spillway portion of Lower Monumental Dam near the middle of the dam in the vicinity of the RSW in spillbay 8. Passage distribution was 62, 28, 6, and 4% through the spillway, juvenile bypass system (JBS), turbines, and undetermined routes, respectively. The highest percentage of fish (45%) passed through the RSW in spillbay 8. For fish with a known passage route, fish guidance efficiency (FGE) was 83%, and fish passage efficiency (FPE) was 94%. Median tailrace egress was 7 minutes overall. Spill efficiency was 1.96 to 1 and RSW efficiency was 6.79 to 1.

Relative survival was estimated from detections of treatment and reference groups at a series of downstream telemetry transects between Lower Monumental Dam on the lower Snake River and McNary Dam on the lower Columbia River. Relative dam survival was 0.934 (95% CI, 0.902–0.968). Relative survival for fish passing through the spillway, RSW, and JBS was 0.976 (95% CI, 0.942–1.011), 1.007 (95% CI, 0.974–1.040), and 0.910 (95% CI, 0.830–0.996), respectively.

Juvenile Steelhead

Median forebay delay was 2.2 hours. The highest percentage of fish (48%) first approached the spillway portion of Lower Monumental Dam near the middle of the dam in the vicinity of the RSW in spillbay 8. Passage distribution was 80, 17, 1, and 2% through the spillway, JBS, turbines, and undetermined routes, respectively. The highest percentage of fish (70%) passed through the RSW in spillbay 8. For fish with a known passage route, FGE was 93% and FPE

was 99%. Median tailrace egress was 5 minutes overall. Spill efficiency was 2.50 to 1 and RSW efficiency was 10.31 to 1. Relative dam survival was 0.982 (95% CI, 0.983–1.005). Relative survival for fish passing through the spillway, RSW, and JBS was 1.014 (95% CI, 0.990–1.037), 1.026 (95% CI, 1.004–1.048), and 1.002 (95% CI, 0.901–1.114), respectively.

RSW POST-CONSTRUCTION EVALUATION OF PASSAGE AND SURVIVAL FOR RADIO-TAGGED SUBYEARLING CHINOOK SALMON AT LOWER MONUMENTAL DAM, 2008

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ABSTRACT

In 2008, we evaluated behavior and survival for river-run radio-tagged subyearling Chinook salmon at Lower Monumental Dam from 8 June through 4 July. This included evaluation of the removable spillway weir (RSW) installed prior to the juvenile outmigration. During the study, total river flow averaged 92 kcfs and spill averaged 25 kcfs, which was 28% of total river flow. Discharge through the RSW averaged 6.7 kcfs. Average tailwater elevation was 440 ft msl and water temperature averaged 14.2°C.

We released 2,362 radio-tagged treatment fish 42 km upstream from Lower Monumental Dam and 2,071 radio-tagged control fish into the tailrace of Lower Monumental Dam, with releases made twice per day throughout the study period. Twenty percent of the treatment fish were not detected after release, which was lower than what has been observed in previous years.

Relative spillway passage survival was estimated at 93% and relative dam survival at 89%, both point estimates falling between those observed in 2006 and 2007. Relative concrete survival was 94%, which matched the higher value of the estimates from 2006 and 2007. Relative survival through the RSW was 97%. Spillway passage was estimated at 40%, juvenile bypass passage at 46%, and turbine passage at 13%. This indicates a distinct shift toward the powerhouse over the observed passage routes in 2006 and 2007. Spill efficiency was estimated at 40%, fish guidance efficiency at 78%, and fish passage efficiency at 87%. Median overall forebay residence time was 2.3 h and median tailrace egress time was 8.2 min.

DIRECT INJURY AND SURVIVAL OF JUVENILE CHINOOK SALMON PASSING THROUGH THE REMOVABLE SPILLWAY WEIR (RSW) AT LOWER MONUMENTAL DAM, 2008

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ABSTRACT

Direct passage survival and condition of hatchery HI-Z tagged juvenile (112 mm mean total length) Chinook salmon, *Oncorhynchus tshawytscha*, were assessed at Lower Monumental Dam in March 2008. The primary objective was to determine the condition (survival and injury rates) of fish after passage through Spillbay 8, equipped with a Removable Spillway Weir (RSW), and identify any injury problems associated with RSW passage. The fish were released so their projected path (Computational Fluid Dynamic Analysis) took them 1.5 ft (deep) and 6.5 ft (mid) above the crest of the RSW. A sufficient number of fish were released to detect a 5% difference at $P = 0.05$ in survival and injury estimates between the mid and deep passage locations. The recapture rate (physical retrieval of alive and dead fish) was 95.6% and 97.8% for deep and mid-passed fish. All control fish were recaptured.

Four metrics were utilized to evaluate effects of spillbay passage on fish: (1) direct survival (1 and 48 h), (2) malady-free, (3) conditional probability of fish being malady-free given alive at 48 h, and (4) joint probability of 48 h survival and being malady-free. Maladies included visible injuries, scale loss ($\geq 20\%$ per side), and loss of equilibrium. The use of these metrics was helpful in pointing out fish condition issues associated with deep-released fish and possible mechanisms.

The survival ($P = 0.027$) and malady ($P < 0.01$) estimates for deep-released fish were significantly lower than for mid-released fish. The 48 h survival probabilities were 0.971 (SE = 0.010) and 0.930 (SE = 0.011) for mid and deep-passed fish, respectively. The malady-free probabilities for the mid and deep-passed fish were 0.990 (SE = 0.012) and 0.883 (SE = 0.017), respectively. The conditional probabilities of being malady-free given alive at 48 h were 0.997 (SE = 0.010) for mid passage and 0.905 (SE = 0.016) for deep passage location. The joint probability of 48 h survival and being malady-free estimates were 0.970 (SE = 0.014) and 0.842 (SE = 0.018) for the mid and deep-passed fish.

The entrainment depth also affected injury types and rates. Injury rates were higher (12.8%) for deep-passed fish than for mid-released fish (2.2%). The most prevalent injury was eye damage (hemorrhages, bulged eyes, and/or ruptured pupils) followed by bruises to the head or body. The probable mechanism of injury was primarily shear related.

The higher malady rates for deep-passed fish may be partially due to the steepness of the angle (45°) where fish encounter the flow deflector and/or the transition where the RSW outflow meets the spillbay chute may break up the laminar flow over the RSW enough to cause some of the

deeper passing fish to contact the spillbay chute exposing them to potentially harmful conditions on the chute surface and near the flow deflector. As recorded by Sensor Fish, the number of severe hydraulic events was about three times higher for the deep (1.52 events/release) than for the mid (0.57 events/release) passage routes.

In summary, fish passing near the RSW crest encountered a less benign exit route than those passing higher (within 6.5 ft) in the water column. Further evaluation incorporating vertical fish distribution near the RSW crest may be prudent to estimate the overall impact of this passage route on the fish.

HEAD INJURY BIOMARKER EXPRESSION AND USE OF A SENSOR FISH DEVICE
TO CHARACTERIZE PASSAGE CONDITIONS FOR JUVENILE CHINOOK SALMON
PASSING THROUGH THE REMOVABLE SPILLWAY WEIR AT LOWER
MONUMENTAL DAM, 2008

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ABSTRACT

Fish passage conditions through the newly installed removable spillway weir (RSW) in Spillbay 8 at Lower Monumental Dam were characterized and evaluated by Battelle–Pacific Northwest Division (Battelle) for the U.S. Army Corps of Engineers (USACE) Walla Walla District using Sensor Fish and molecular biomarker assays. The study was performed during March 24–31, 2008, concurrently with HI-Z balloon-tag studies by Normandeau Associates, Inc. Objectives of the Battelle study were to evaluate passage conditions for two injection elevations and the effects of passage on juvenile Chinook salmon wellbeing.

The head injury biomarker assay was used to compare spillway configuration alternatives for passage of migrating juvenile Chinook salmon (*Oncorhynchus tshawytscha*). The expression of α II-spectrin breakdown protein fragments, a diagnostic biomarker used to assess severity of human traumatic brain injury, correlated with observational mortality/malady metrics. Correlation between routinely used fish passage assessment metrics and biomarker assay metrics provided a clear demonstration of the utility of biomarker assays to quantitatively express the difference in safety between fish passage alternatives. Roughly equivalent ability to detect differences between passage route safety for juvenile Chinook required approximately 30 bioassays versus 150 assessments of fish physical injury and mortality.

Sensor Fish that were injected into spill flow at an elevation of 526.5 ft msl (deep-released) were found to have a higher probability of exposure to injurious events (58.7%) than those injected at elevation 531.5 ft msl (mid-released) (42.9%), as well as higher exposure event severity. The most severe events observed using Sensor Fish were collisions on the concrete chute and at the deflector, with deep-released Sensor Fish experiencing the greatest percentage and highest magnitude values for all events. Shear events were only observed at the deflector and in the wake of the deflector for both release elevations, with shear events observed during deep releases having the highest magnitudes. Collisions were most common on the spillway chute, the spillway chute-to-deflector transition, and less frequently on the deflector. Quality of flow was estimated to be better for mid-release than deep release passage routes.

PASSAGE BEHAVIOR AND SURVIVAL FOR YEARLING CHINOOK SALMON,
STEELHEAD, AND FALL CHINOOK PASSING ICE HARBOR DAM DURING TWO
SPILL TREATMENTS, 2008

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ABSTRACT

In 2008, we evaluated behavior, passage distributions, and survival of yearling Chinook salmon, steelhead, and fall Chinook salmon at Ice Harbor Dam on the Snake River to further ascertain effects of the recently installed removable spillway weir (RSW). Fish were collected, PIT tagged, and surgically tagged with a radio transmitter at Lower Monumental Dam. Project operations at Ice Harbor Dam were intended to consist of 2-d random blocks alternating between a reduced spill treatment (~30%) and a BiOp spill utilizing 45 kcfs during the day and gas cap at night. However, 2008, was a high flow year, resulting in involuntary spill levels exceeding prescribed treatment levels. As a result, we did not achieve a reasonable comparison between the two treatments, so results were pooled.

Because of the high flows, the proportion of total river flow through the RSW during spring operations decreased from 11% in 2007 to 7% in 2008, although RSW discharge remained the same during both years at 8 kcfs, due to minimum operating pool level. During the fall Chinook outmigration, the RSW spill proportion dropped from 21% in 2007 to 8% in 2008. As a result, fish passage through the RSW decreased dramatically for yearling Chinook salmon (22%), juvenile steelhead (20%), and fall Chinook (31%), due to more fish being drawn toward the training spill and powerhouse flows.

Survival estimates remained high and relatively consistent with estimates from the previous two years of evaluation for yearling Chinook, steelhead, and fall Chinook.

PASSAGE, SURVIVAL, AND APPROACH PATTERNS OF JUVENILE SALMONIDS
AT MCNARY DAM, 2008

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ABSTRACT

We released 2,373 yearling Chinook salmon, 2,928 subyearling Chinook salmon, and 1,971 juvenile steelhead with surgically implanted tags to conduct a second-year evaluation of fish passage and survival with respect to two Temporary Spillway Weirs (TSW) at McNary Dam. In 2008, the TSWs were inserted in spill bays 19 and 20. We investigated behavior, passage, and survival of acoustic-tagged fish among river reaches, spill treatments, passage locations, and diel periods, and compared these results to a 2007 evaluation.

In 2008, we divided the spring study into an early (before May 17th) and late season based on a distinct increase in total spill and project discharge. The TSWs discharged about 4.8–9.5% of the total discharge. Eighteen percent of yearling Chinook salmon and 41% of juvenile steelhead passed into the TSWs. Passage of fish per unit volume of water was 2.0–2.4:1 for yearling Chinook salmon and 3.9–5.9:1 for juvenile steelhead, whereas conventional spill bays passed 1.0–1.2:1 fish per unit volume of water. TSW passage proportions were reduced during the late spring due to high flows (mean total discharge=375 kcfs), high spill (~50% of total project discharge), and lower allocation of flow through the TSWs (~4.8% of total project discharge).

The summer study was divided into an early season (before July 4th) without treatment tests and a late season with tests of 40% versus 60% of total discharge spilled. The TSWs discharged about 5.5–9.2% of the total flow and conventional spill bays discharged about 32–52% of the total flow. Overall, the TSWs passed 17% of subyearling Chinook salmon. During the early summer and the 60% spill treatment the spillway passed 56–59% (SE< 2.1) of subyearlings, but during the 40% spill treatment the spillway passed 33% (SE=2.0). Passage of subyearling Chinook salmon per unit volume of water for the TSWs was 2.0–2.3:1 and for conventional spill bays was 1.2:1. Although periods of high flow and spill contributed to lower TSW passage proportions in 2008, evidence also suggested that moving a TSW from its 2007 location may have contributed to lower passage of subyearling Chinook salmon through the structures.

Periods of higher flow and spill during both the spring and summer were associated with higher fish passage through spill and higher survival through the dam. This was most apparent in summer. In early summer and high flows, both treatment and control releases of fish had higher survival through and below the dam ($S_{dam} > 0.94$, $SE < 0.016$) compared to late summer and lower flows ($S_{dam} < 0.90$, $SE < 0.017$). Among the late summer treatment tests, the 60% spill treatment was associated with the higher paired-release survival ($S_{dam} = 0.96$, $SE = 0.024$) compared to the 40% spill treatment ($S_{dam} = 0.93$, $SE = 0.026$). In both the spring and summer, we observed inconsistent differences in survival making it difficult to determine the extent to which TSW design, TSW location, and dam operations are influencing survival.

THE JOHN DAY CONFIGURATION STUDY

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ABSTRACT

John Day Dam (JDA) currently has among the lowest dam passage survival rates for ESA-listed juvenile salmonids among the eight federal Columbia River power system (FCRPS) dams. The targeted goal for fish survival improvements at FCRPS projects is to achieve 96% and 93% survival rates for spring and summer migrants, respectively. The achievement of such survival rates are being attempted under a least cost approach, with the caveat of not negatively affecting other salmonid life histories, other aquatic species, water quality, or recreation activities.

The John Day Configuration and Operation Plan (COP) provide the strategic plan for carrying out fish passage improvements at JDA. Specific COP objectives include: (1) define the baseline condition for fish passage, (2) identify and prioritize fish passage alternatives to be evaluated, (3) develop a decision analysis framework from which alternatives will be evaluated, (4) identify critical information gaps needed to make decisions, and (5) define the schedule and alternative implementation process for reaching targeted survival goals. An overview of physical & numeric modeling techniques used and rationale for FY08 testing - to fill a critical information gap - towards developing alternative(s) to ultimately reach targeted survival rates will be presented at the review. This review will include an overview of both potential Phase I & Phase II alternatives, as outlined in the strategic plan and BiOp. Beyond the strategic plan results from Direct Injury and Survival testing – from released ‘Balloon Tagged’ and ‘Sensor’ Fish – will be also be presented as part of the Configuration Study.

ACOUSTIC TELEMETRY STUDY TO EVALUATE JUVENILE FISH-PASSAGE
EFFICIENCY AND SURVIVAL ASSOCIATED WITH SURFACE-SPILL TREATMENTS
AT JOHN DAY DAM IN 2008

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ABSTRACT

The Juvenile Salmonid Acoustic Telemetry System (JSATS) was used to evaluate effects of adding two top-spill weirs (TSW) in spill bays 15 and 16 and effects of two spill treatments on route-specific fish passage through John Day Dam (JDA). Spring- and summer-run juvenile salmonids tagged with JSATS (0.43 g) and PIT tags were released near Arlington, OR, 41 km upstream of JDA, from May 1 to May 29 in spring and from June 15 through July 13 in summer. A reference group of tagged fish was released 2 km downstream of JDA about 30 hours after each upstream release.

The following results are for subyearling Chinook only. Single-release survival from our release location at Arlington, OR to our forebay array was 0.961 (95% CI 0.953-0.969), and survival from the forebay array to the dam was 0.995 (95% CI 0.993-0.997). Survival estimates were low for both the powerhouse and the spillway. When we separated the spillway into sections we found very low survival south of the two TSW's at spillbays 17-20 (0.686) compared with spillbay survival north of the TSW's (0.961).

Survival was significantly higher at night than during the day for turbine passage fish and fish passing through spill bays 17-20. Higher survival at night than during the day may be due to the high predatory bird population below JDA this year. Most of the birds were congregated between the powerhouse and the spillway. There was a noticeable decline in survival between spillbays 17, 18, and 19, and survival decreased at bays closer to the powerhouse. There were no significant differences between metrics for 30 and 40 percent spill treatments. Likewise, there was no significant difference between dam survival estimates between the two spill conditions, where dam survival was calculated from detection histories of virtual releases of tagging subyearling Chinook salmon into the JDA forebay. Virtual release dam survival was 0.850 (95% CI = 0.826-0.874) under the 30% spill condition and 0.848 (95% CI = 0.823-0.873). It was 0.853 (95% CI = 0.835-0.871) for the entire summer study.

TAILRACE EGRESS AND HYDRAULIC CONDITIONS DURING TESTS OF A TOP SPILLWAY WEIR (TSW) AT JOHN DAY DAM, 2008.

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ABSTRACT

Drift buoys (drogues) were used in the tailrace of John Day Dam to map large-scale hydraulic patterns and assess the effects of a top spillway weir (TSW). Drogues were designed to capture the dominant flow path in the upper water column (down to 2 m). Drogues were equipped with global positioning systems to collect spatial data as they drifted through the tailrace, allowing visualization of drift paths. Two TSW were installed (bays 15 and 16) and two spill conditions were tested. Planned spill levels were 30% spill and 40% spill (24 h spill) in a randomized block design. Drogues were released from the TSW bays, several unmodified spillbays (bays 2, 8, 14 and 17), through the juvenile bypass system (JBS) outfall, and at two turbine units (units 5 and 16). We released 170 drogues from 2 May through 17 July, 2008, coinciding with the migration periods of both yearling and subyearling Chinook salmon. Based on actual spill levels, we divided releases into three periods: early season, mid-season, and late season. Planned spill conditions were met during the early and late seasons (30% and 40% spill), but during the middle season, the maximum spill was only 34%. Generally higher spill resulted in faster egress times. We concluded that spill level had a limited influence because very few statistically significant differences were detected between egress times at different spill levels at a given release site. Egress times from the TSW bays were consistently among the fastest times, regardless of season or spill condition, and were typically 4-5 min. Unit 16 consistently had among the slowest egress times, typically near 20 min. Egress from the JBS was delayed (near 20 min) during 40% spill, but was comparable to other release sites during 30% spill. Drogue drift paths varied with release site and season. The most consistent travel path was for unit 16 which showed strong northward movement prior to any significant downstream movement. This path was consistent across the seasons, regardless of spill level. For other release sites, most travel paths were directly downstream during the early and middle season, with increased variability during the late season when flows were lower. The travel paths for releases at the JBS had a large northerly component during 40% spill in the late season, and drogues released from spillbays 8 and 14 were occasionally delayed in an eddy downstream of the navigation lock, resulting in extended egress times.

ACOUSTIC TELEMETRY STUDY OF JUVENILE SALMONID DAM AND SPILLWAY
SURVIVAL AT BONNEVILLE DAM IN 2008

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ABSTRACT

Survival estimates of fish passing the Bonneville spillway was based on detections of tagged spring- and fall-run juvenile Chinook salmon, *Oncorhynchus tshawytscha*, and spring-run steelhead trout, *Oncorhynchus mykiss*, released for a John Day Dam survival study and of tagged summer-run Chinook salmon smolts released below The Dalles Dam. All fish were surgically implanted with separate Passive Integrated Transponder (PIT) tags and Juvenile Salmonid Acoustic Telemetry System (JSATS) tags weighing 0.433 g in air. NOAA Fisheries tagged and released juvenile Chinook salmon into the Bonneville Second Powerhouse Corner Collector and the Bonneville tailrace. Fish released into the tailrace served as reference releases relative to fish passing the spillway.

Release Location	Spring Chinook		Spring Steelhead		Summer Chinook	
	Live	Dead	Live	Dead	Live	Dead
Arlington, OR	2,448	6	2,448	5	2,483	6
John Day Tailrace	979	14	979	14	982	14
The Dalles Tailrace					2,444	2
BON B2CC	826				1,020	
Bonneville Tailrace	828	48			1,021	51

We mounted 90° x 180° and 180° x 180° hydrophones on piers south of each of 18 spill bays at elevations of 40 ft and 60 ft above mean sea level (MSL). Clocks of computers that controlled sound receiving systems were synchronized to within 150 nanoseconds of each other. Time-differences in arrival of tag signals among hydrophones allowed us to track tagged fish and usually to assign a bay of passage. Fish were classified as passing through end bays (Bays 1-3; 16-18) with deep flow deflectors (7 ft above MSL) or middle bays (Bays 4-15) with shallow flow deflectors (14 ft above MSL) so that we could compare survival.

We deployed and serviced 19 underwater listening devices (autonomous nodes) to provide detections of tagged fish and develop detection histories for survival estimation. These nodes were deployed to cover an entire cross section of the river at three locations: 2 km upstream of Bonneville Dam (Rkm 237), 33 km downstream of the dam (Rkm 202), and 42 km downstream

(Rkm 193). Data from the first two downstream arrays were used as primary and secondary arrays in a survival model, and we used detection data from an Oak Point array at Rkm 86 as a tertiary array for calculating the combined probability of detection and survival. The Oak Point array was deployed and serviced by the Post FCRPS (estuary) survival study.

Estimates of Bonneville Dam survival were made based on downstream detections of virtual releases of fish from the forebay entrance array.

Salmonid	Single Release Survival	95% Confidence Interval (CI)	n	Tailrace Release Survival (SE)	Paired Release Survival	95% Confidence Interval (CI)
Spring Chinook	0.953	0.943-0.963	3,019	0.947 (0.010)	1.010	0.987-1.033
Spring steelhead	0.951	0.941-0.961	3,018			
Summer Chinook	0.949	0.943-0.955	5,110	0.976 (0.017)	0.978	0.961-0.995

One dead tagged Chinook salmon smolt released in the tailrace was detected on the primary array, secondary array and finally on a Kalama array 114 km downstream of Bonneville Dam. There have been two dead fish detections out 159 dead-fish released over three study years, so we assume that the dead-fish detection probability was 0.0126. The paired-release estimate of dam survival for spring Chinook salmon tabled above (1.010) was reduced to 0.976, after we adjusted for the probability of detecting dead fish on downstream survival arrays.

At this time, we have only finalized bay-of-passage assignments for summer-run Chinook salmon. Overall paired release spillway survival was 0.978 (95% CI = 0.960-0.997). Survival of summer-run Chinook salmon smolts passing through end bays [0.984 (95% CI = 0.959-1.008)] was 0.9% higher than that of smolts passing through middle bays [0.975 (95% CI = 0.954-0.996)], but this difference does not appear to be significant based on overlapping 95% confidence intervals. Single release estimates were more precise than paired release estimates but still had overlapping confidence intervals.

Summer Chinook	Single Release Survival	95% Confidence Interval (CI)	n
Spillway	0.949	0.939-0.959	1,921
End Bays	0.954	0.936-0.972	725
Mid Bays	0.946	0.932-0.960	1,196

Tailrace elevations were higher through most of summer 2008 than they were in summer 2007 when we observed significantly higher survival for subyearlings passing end bays with deep flow deflectors than for subyearlings passing middle bays with shallow flow deflectors.

ACOUSTIC TELEMETRY EVALUATION OF A BEHAVIORAL GUIDANCE
STRUCTURE AT
BONNEVILLE DAM SECOND POWERHOUSE

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ABSTRACT

In spring 2008, a 213 m long, 3 m deep Behavioral Guidance Device (BGS) was installed in the immediate forebay of the Washington shore powerhouse at Bonneville Dam (B2) to increase corner collector (B2CC) passage efficiency and survival for juvenile salmon and steelhead. We deployed a cabled Juvenile Salmon Acoustic Telemetry System (JSATS) to evaluate approach distribution to the BGS, passage metrics at B2, and survival of tagged juvenile steelhead, yearling and subyearling Chinook salmon passing B2 routes.

We determined that the 46%, 40% and 71% of the total number of yearling Chinook (YC), subyearling (SYC) Chinook and juvenile steelhead (SH) respectively passed through the B2CC in relation to the total that passed B2. This compares to post-construction evaluations of the B2CC in 2004 and 2005 by USGS where they found B2CC passage efficiency was 33% for YC, 39% for SYC and 70% for SH. Fish passage efficiency (FPE), which is the total number of fish entering the Juvenile Bypass System (JBS) and B2CC divided by total passing B2, was 62% for YC, 57% for SYC and 80% for SH. This compares with the 2005 USGS evaluation of 55% for YC, 55% for SYC, and 83% for SH. The only significant increase between years was for YC passage into the B2CC.

Paired release survival estimates were computed for YC and SYC using virtual releases of fish by route (JBS, B2CC and Turbines) relative to specific releases into the B2CC and tailrace reference releases by NOAA Fisheries. Juvenile steelheads were not released as a part of a control group, therefore only single-release survival estimates were computed for those fish. Also, total dam survival was computed using a triple-release survival model. Single release estimates for total powerhouse survival with ½ 95% CL in parentheses were 0.960 (0.013), 0.959 (0.010), and 0.968 (0.014) for YC, SYC and SH respectively. Similarly, paired release estimates for B2 passage survival were 1.015 (0.026), 0.989 (0.019) for YC and SYC respectively. A triple-release model provided B2 survival estimates 0.95 for YC and 0.99 for SYC.

The BGS guidance efficiency was also evaluated using 1D and 2D fish tracks. This information will be presented in greater detail at the annual review. However, some preliminary trends have emerged. The percent of tagged fish passing through the north gap between the BGS and Washington shoreline varied between spring and summer periods. Fish passing into this gap were less likely to pass into the corner collector. Approximately 7% and 20% of YC and SH migrated through this gap in the springtime, however 51% of the SYC migrated through this gap in summer.. A combination of flow conditions and subyearling behavior are likely the source of this difference. The flow conditions at B2 varied between spring and summer seasons. Turbine 15 was not operational for all of the springtime (yearling Chinook and juvenile steelhead outmigration), but was operational throughout the summer. Turbine 11 was not operational for all of the summer evaluation, but was operating during the spring season. Due to excessive

debris collection, turbine screens at B2 were pulled-out on May 21-23, about 1/3 of the spring evaluation period. Screens were reinstalled in early June, and remained in place for the entire summer evaluation. It is likely that further increases in FGE could be obtained if flow conditions are favorable for continued screen deployment.

In summary, survival at B2 was high for all evaluated species. In addition, the BGS appeared to influence and increase the passage proportion of yearling Chinook salmon at the B2CC, relative to pre-BGS estimates made in 2004 and 2005.

TOTAL DISSOLVED GAS EFFECTS ON INCUBATING CHUM SALMON BELOW BONNEVILLE DAM

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ABSTRACT

To characterize the effects of total dissolved gas (TDG) on incubating fry of chum salmon (*Onchorhynchus keta*) in the lower Columbia River, we collected empirical data on TDG concentrations at Ives Island and Multnomah Falls study sites; performed laboratory toxicity tests on fry at TDG levels ranging up to 130% saturation; and sampled wild chum salmon sac fry from an artificial redd during Bonneville Dam spill operations to determine physiological responses to TDG levels. Depth-compensated total dissolved gas was monitored at the location of our sensors within the hyporheic zone from onset of spill operations through chum salmon emergence. TDG exceeded 103% for approximately 80 hours at Ives Island and zero hours at Multnomah Falls. A risk assessment, conducted by extrapolating monitoring results to surrounding redds in the Ives Island area, suggests that the shallowest redds were exposed to depth-compensated TDG greater than 103% (threshold for potential impacts to sac-fry) for greater than 200 h in 2008 but that 50% of the redds were at an elevation that protected them from TDG for all but 20 h. In the laboratory, TDG ranging up to 120% did not influence direct mortality. Signs of gas bubble trauma including bubbles in the pupil, lateral line, eye, jaw, and operculum began at 121% TDG. The most prevalent symptom was the formation of bubbles in the vitelline membrane, with associated changes in behavior. Mortality began to occur at 124.6%. In the field, wild sac-fry were sampled from egg tubes within an artificial redd during periods when depth-compensated TDG ranged up to 105%-110%. Survival in each egg tube ranged from 0% to 89%. Hemorrhaging fins and eyes were the most common ailment. Other symptoms included small clusters of bubbles in the pupil of the eye, bubbles occluding 5% to 15% of the lateral line, and bubbles in the stomach and hindgut. Fish were generally found with inflated (but not overinflated) swim bladders.

POST-PASSAGE CONDITION AND GATEWELL RETENTION TIME OF SUBYEARLING AND YEARLING CHINOOK SALMON GUIDED FROM MODIFIED BONNEVILLE DAM SECOND POWERHOUSE TURBINE INTAKES

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ABSTRACT

Efforts to improve fish guidance efficiency (FGE) at Bonneville Dam Second Powerhouse have been ongoing since 1983. Between 2001 and spring 2008, all second powerhouse intakes were modified to increase flow into turbine intakes and gatewells, thereby improving FGE. Structural modifications completed during this time included: 1) increasing the length of vertical barrier screens by removing a portion of the concrete beams upon which the screens rest, 2) installation of turning vanes below the STS picking beams, and 3) installation of gap closure devices on the intake ceilings downstream from the top edge of STSs. Prototype modifications were biologically tested in 2001 and 2002. Comparison of FGE between modified and unmodified intakes showed significant FGE increases in modified intakes and fish condition tests showed that mortality and descaling rates were not increased by the modifications.

In 2007, however, peak daily mortalities of 11.7% and 10.1% were observed during March and April passage of tule stock subyearling Chinook salmon released from Spring Creek National Fish Hatchery (NFH). There was no evidence to indicate Second Powerhouse passage facilities were operating out of criteria and no history of disease problems in the 2007 Spring Creek NFH releases. This study was undertaken to determine if passage mortality and adverse fish condition effects are related to turbine operation at higher levels within the 1% peak efficiency range.

At Bonneville Dam Second Powerhouse in 2008, we conducted tests using 32,210 juvenile Chinook salmon obtained from Spring Creek NFH, 1,069 run-of-river (ROR) yearling Chinook salmon, and 2,136 ROR subyearling Chinook salmon. Fish were fin-clipped or PIT-tagged, then released into turbine intakes and gatewells at lower, middle, and upper settings within the 1% peak efficiency range of the turbine units. Test fish were recaptured via 100% sampling (fin-clipped fish) or separation-by-code (PIT-tagged fish) at the juvenile facility.

Release-recapture tests conducted from 4 March to 9 May using subyearling Chinook salmon obtained from Spring Creek NFH consistently showed higher mortality and lower recapture rates as turbine loadings increased within the 1% peak efficiency range. For example, on 4 and 5 March we released fish into the 12A gatewell under three different operational settings. Mortality of fish recaptured averaged 1.6%, 14.3%, and 32.3% for releases at lower, middle, and upper 1% turbine operation, respectively. Recapture rates averaged 98.3% for lower, 94.5% for middle, and 66.6% for upper 1% releases. These and other test results will be discussed during our presentation.

DIFFERENTIAL POST-HYDROSYSTEM MORTALITY OF TRANSPORTED AND IN-RIVER PASSING SPRING CHINOOK FROM THE SNAKE RIVER

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ABSTRACT

Differential post-hydrosystem survival of Snake River spring Chinook from transport and in-river passage routes (D) was evaluated with a multi-linear model that represent the differential effects of passage route, energy density, fish length, and estuary arrival time. Using data provided by W. D. Muir on spring Chinook collected at Lower Granite Dam over the years 1997-2005, the model fit the observed within and across year D for hatchery fish ($r\text{-sqr} = 0.67$). The dominant factor was the difference in cumulative temperature exposure between transport and in-river migrants, which in the model, reflects their differential energy density at estuary arrival. For wild spring Chinook, the differential estuary arrival time was the weakly correlated with D, but no other factor was significant ($r\text{-sqr} = 0.32$).

ESTIMATING SURVIVAL CAPACITY AND DETERMINING MECHANISMS OF LATENT MORTALITY

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ABSTRACT

The main goals of this research study are to estimate survival capacity of transported and in-river yearling Chinook throughout the outmigration season in the Federal Columbia River Power System (FCRPS), determine possible influences on survival capacity and predict T:I ratios. To accomplish these goals, we collected at Bonneville Dam weekly samples of run-of-river yearling Chinook and individuals barged from Lower Granite Dam, and introduced them to challenges of increased water temperature and starvation. They were observed for loss of equilibrium and mortality.

The reciprocal of the average time to mortality ($1/m$), and vitality model parameters were determined, and related to possible factors of survival capacity. Transported vs. in-river migration, degree days, travel time, day of arrival at Bonneville Dam, and cumulative percent spill were tested by linear modeling. The best model determined by AIC was one that predicted $1/m$ from transport vs. in-river migration and degree days, and explained 85.1% of the variation. From the best models of survival capacity measures $1/m$ and vitality r , the ratio of post-Bonneville Dam survival between transported and in-river migrants (D) was determined.

The first year of this current study on yearling Chinook in the FCRPS has already shown promising results for measures of survival capacity based on relatively quick and simple challenge experiments. Futures studies will be briefly discussed.

FLOW VELOCITY ENHANCEMENT SYSTEM – PRELIMINARY RESULTS FROM FIELD TEST TO GUIDE SMOLTS

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ABSTRACT

Juvenile salmon have evolved to follow river currents downstream at time of outmigration. River regulation, however, has created slack-water areas at dams that remove these migratory cues. Also, flows to water diversions misdirect migrants to hazardous areas. It seems logical, therefore, to induce currents to guide juvenile salmonids to aid their migration through low-current zones and guide them to safe migration routes or collection devices. A hydraulic system has been devised that generates water currents with turbulence similar to that in natural streams (Natural Solutions, Helena, MT). Tests in large net pens confirmed that smolts would orient to and follow induced currents. Field experiments in the Cowlitz River, WA, tested the feasibility of deploying the hydraulic system in a remote area and provided fish-guidance information from radio-tagged smolts. Incremental improvements in the hydraulic system and in experimental designs for quantifying fish guidance indicate that the technology has significant promise for managing smolt migrations. This technology, which has been developed largely with private funding, was further tested in 2008 with funding from Bonneville Power Admin. and assistance of Tacoma Power and Light, Washington Dept. of Fish and Wildlife, and the US Geological Survey.

In summer 2008, two-dimensional acoustic telemetry was used to evaluate how juvenile Chinook salmon respond to a flow inducing system in the Cowlitz River. The study was conducted in the mainstem river at the upper end of Riffe Lake between Cowlitz Falls Dam and Taidnapam Park in a location where the flow inducing system has been tested in previous years. The study used juvenile Chinook salmon collected at the Cowlitz Falls Fish Facility. Acoustic telemetry provides a detailed, two-dimensional detection history of each fish that approaches and passes through the flow-inducing system within the detection array. Forty smolts were implanted with acoustic transmitters at the Cowlitz Falls Fish Facility, held for 24 hr and released over time in the tailrace of Cowlitz Falls Dam. Fish were released in groups of 4 per day during a 10-day period in August. The flow-inducing system was operated on a rotating one-day-on, one-day-off schedule to compare natural and guided migration trajectories. An acoustic detection array was positioned by USGS personnel to detect fish approaching the plume from the flow inducer and within the plume. Unusual debris conditions delayed positioning a net trap (as a test of the ability to guide smolts to a collection device) until after the tagged fish had passed through the area. Although results of the automated hydro acoustic detection system are still being analyzed, early indications are that fish were successfully guided by the induced flow field. At least preliminary findings will be included in the presentation.

REACH SURVIVAL ESTIMATES, 2008

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ABSTRACT

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. Using the detection history of each individually tagged migrant (detected and not detected at each dam), we use Cormack-Jolly-Seber methods to estimate survival of PIT-tagged juveniles through individual reaches (one reservoir and dam combination) and combined reaches. During 2008, a high flow and spill year, survival through individual reaches averaged 91% for yearling Chinook salmon and 92% for steelhead. Survival through the entire 750 km hydropower system (Snake River trap to Bonneville Dam tailrace) was 46.1% for yearling Chinook salmon and 47.8% for steelhead. Survival through the final reach, John Day Dam tailrace to Bonneville Dam tailrace, was poor in 2008, particularly for yearling Chinook salmon.

High spill rates coupled with removable spillway weirs at several Snake River dams, and a delayed start to transportation resulted in a greater number of non PIT-tagged smolts in the Snake River in 2007 and 2008. As a result, fewer PIT-tagged steelhead were eaten near the confluence of the Snake and Columbia Rivers by piscivorous birds, resulting in increased estimated survival through the Snake River.

THE 2008 POST STUDY: TECHNICAL PERFORMANCE & BIOLOGICAL RESULTS FOR SNAKE AND YAKIMA R HATCHERY SPRING CHINOOK

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ABSTRACT

Preliminary biological results from Kintama's 2008 POST acoustic tagging study in the Columbia River can be broadly divided into four categories:

- (a) Survival and tag retention of hatchery spring Chinook smolts surgically implanted with dummy acoustic tags (Vemco V7-2L) and held at Snake and Yakima R hatcheries;
- (b) Relative downstream survival of acoustically tagged hatchery smolts with independent survival estimates of PIT-tagged Dworshak hatchery smolts;
- (c) Relative downstream survival of Snake and Yakima R hatchery smolts, to test the delayed mortality hypothesis;
- (d) Relative lower river and coastal ocean survivals for barged and run-of-the-river hatchery smolts, to test the hypothesis that differential delayed mortality is expressed for transported smolts.

(a) Holding experiments: No tag loss or mortality of either PIT or dummy tagged Dworshak spring Chinook smolts was observed to 100 days post-implantation (Smolts were reared and held at Kooskia hatchery for logistical reasons). Zero tag loss occurred for Yakima (Prosser) smolts up to the time when the tag study was inadvertently terminated (38 days post-implantation); at 38 days post-implantation, 89% of Dummy and 96% of PIT tagged fish were still alive. These times correspond to free-ranging Yakima smolts reaching a point on the continental shelf mid-way between Willapa Bay (19 days after release) and northern Vancouver Island (56 d). Thus anticipated direct losses from tagging were either zero (Snake) or minor (Yakima) during the time that free-ranging smolts were studied in 2008 (see below).

(b) PIT vs POST Tag Survivals: Comparison of downstream 2008 survival of acoustically tagged Snake R (Dworshak Hatchery) smolts with independent survival estimates of PIT-tagged Dworshak hatchery smolts is nearly indistinguishable. Fitted curves of survival (S) versus distance (X) travelled are $SPIT=e^{-0.0019X}$, $R^2=0.89$; $SPOST=e^{-0.0021X}$; $R^2=0.93$. These curves are fit to all available data. Importantly, the POST acoustic tagging data shows a generally smooth decline in survival with no sharp changes in survival with distance, even for the ocean. This is the same pattern observed in 2006. (Mortality from Bonneville to Astoria was

negligible, however, in 2008, unlike 2006). Survival for the ocean migration pathway could be followed to NW Vancouver Island, 1,500 km from the release site.

(c) Testing the Delayed Mortality Theory: Historically, Yakima R hatchery spring Chinook have had approximately a 5-fold higher smolt-to-adult return rate when compared with Snake R (Dworshak Hatchery) spring Chinook. This has led to the theory that this is caused by delayed mortality expressed somewhere past Bonneville Dam, but as a result of fish passage through the four Snake River dams. Preliminary estimates of pooled 2008 Snake R spring Chinook survival from release at Kooskia hatchery to Astoria was $29.5 \pm 2.8\%$ (estimate ± 1 SE) while pooled Yakima R spring Chinook survival from release in the lower Yakima River (Chandler Juvenile Monitoring Facility) to Astoria was $46.1 \pm 3.6\%$; significantly higher than Snake R survival if the shorter time and distance to reach Astoria is not taken into account. (Two separate releases of $N=200$ tagged smolts from each stock were pooled in deriving these estimates). However, when survival is plotted against distance traveled, no difference in survival is evident, with both data sets providing nearly identical exponential declines in survival with distance. As Yakima smolts reach a given location sooner than the Snake R smolts because of the longer distance the Snake R smolts must travel, it is important to scale the survival measurements to the POST detection arrays over the time or distance that they are observed. The 2008 study, (as with the 2006 study) is thus inconsistent with the theory that delayed mortality is expressed below Bonneville.

(d) Testing the Differential Mortality Theory: Survival of barged and ROR Snake R smolts from Bonneville dam to Willapa Bay (the first ocean line, sited 40 km north of the Columbia River mouth) is inconsistent with the differential mortality theory, with statistically indistinguishable rates of survival to Willapa Bay ($S_{\text{Barged}}=39 \pm 5.3\%$, $S_{\text{ROR}}=37.9 \pm 6.4\%$). Survival from Bonneville to Lippy Point (NW Vancouver Island) favoured ROR smolts over barged smolts, with 6.5% of barged smolts surviving to reach Lippy Point but 11% (Snake) and 10.7% (Yakima) of ROR smolts surviving to reach the Lippy Point line. (CJS-based estimates of the uncertainty in survival could not be calculated because only one (Snake River ROR) smolt reached the SE Alaska line, 3 months after release).

Our results are inconsistent with the theory that barged smolts suffer differential mortality caused by transportation soon after release (lower river or plume environments), but there is weak evidence for higher survival past Willapa Bay. More generally, our results are consistent with the lower than expected adult return of barged smolts—but probably because daily mortality rates in the ocean are roughly similar to those measured through the hydrosystem. A significant benefit from transportation can only be obtained if smolts moved to the ocean survive better than in the river environment from which they are removed. Our results do not currently support the assumption that survival in the ocean is better than in the hydrosystem for smolts of similar size. This conclusion has important implications for current debates about the importance of improving the speed with which smolts are moved to the ocean by modifications of the hydropower system (for example, increasing flow or drawdown to minimum operating pool). Such actions assume that survival in the ocean is better for smolts of a given size, and thus that actions to move the smolts more rapidly out to sea will provide significant benefit. However, we caution that the number of releases used to date per stock (2) is limited and does not encompass the full range of smolt entry times or sizes, results for wild spring Chinook, or results for other stocks or species.

COMPARATIVE SURVIVAL AND BEHAVIOR OF SPRING CHINOOK SALMON
IMPLANTED WITH EITHER PIT TAGS OR ACOUSTIC TRANSMITTERS IN THE
SNAKE AND COLUMBIA RIVERS

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ABSTRACT

The current model of the Juvenile Salmon Acoustic Telemetry System (JSATS) transmitter is the smallest acoustic transmitter currently available (12.0 x 3.7 x 5.3 mm, and 0.43 g). In 2008, we conducted a field study to determine whether spring Chinook salmon implanted with a JSATS transmitter could provide unbiased estimates of travel time and survival as they migrated seaward through the Columbia River hydropower system. We released 4,140 acoustic-tagged and 48,433 PIT-tagged river-run spring Chinook salmon into the tailrace of Lower Granite Dam in the Snake River. Fork lengths of acoustic-tagged fish ranged from 95-202 mm (mean = 134 mm). Survival and travel times were estimated using PIT and acoustic tag detections of individual fish at multiple detection sites located between Lower Granite Dam and the Columbia River estuary. There was no significant tag effect on survival from release through the Snake River or to McNary Dam in the Columbia River. Survival estimates of PIT-tagged fish to John Day and Bonneville dams in the Columbia River were not reliable, precluding analysis of tag effects on survival to these locations. Travel times were similar between acoustic-tagged and PIT-tagged fish within the Snake River, and to McNary and Bonneville dams. Travel time was slower for acoustic-tagged than PIT-tagged fish to John Day Dam.

COMPARATIVE PERFORMANCE OF ACOUSTIC- AND PIT-TAGGED
JUVENILE SALMONIDS; LABORATORY STUDIES

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ABSTRACT

In 2008, we continued a comprehensive study to compare behavior and survival between juvenile Chinook that were surgically-implanted with acoustic tags and PIT tags (AT fish) and those that were injected with only PIT tags (PIT fish). This study had both inriver (yearling fish) and laboratory components (yearling and subyearling fish). This talk describes the laboratory portion of this work.

In an attempt to obtain more insight into the question of whether tag effects occur over space and time as well as to obtain insight into the potential long term effects of acoustic tagging, a representative portion of each inriver release and treatment group combination were transported to the Juvenile Monitoring Facility at Bonneville Dam for long-term (120 days) holding and observation. In addition, the laboratory setting allowed us to monitor fish for tag loss and to include two control groups that were not part of the field study. The additional groups included fish that were anesthetized and handled in a manner similar to the AT fish, but no surgery was performed (control), and fish that were implanted with PIT tags in a surgical manner (Surgical PIT). A similar laboratory study was conducted using subyearling fall Chinook. In addition to holding laboratory fish to measure survival and tag loss, we obtained kidney samples from each fish to determine the level of *Renibacterium salmoninarum* antigen present at the time of death and collected coded-wire tags to determine hatchery of origin. An ancillary laboratory study was performed on subyearling fish in an attempt to identify potential post-surgical prophylactic treatments that might aid in incision healing. Photographs taken of these fish at 7, 14, 21, and 28 days provided insight into the progression of wound healing in subyearling fish.

For the yearling study fish, overall survival was higher in the laboratory than inriver. At the end of the 120 day holding period, survival was as follows for the yearling fish: PIT 74%, control 70%, AT 69%, and Surgical PIT 65%. PIT tag loss was <0.4% and 0.0%, respectively, for the AT and PIT fish surviving to termination at 120 days. Approximately 8% (n=21) of the yearling Chinook AT fish surviving to 120 days lost or expelled acoustic tags. At the end of the 120-day

holding period, survival was as follows for the subyearling fish: PIT 72%, control 66%, AT 59%, and surgical PIT 61%. No PIT tag loss was observed in either the AT or the PIT fish surviving to termination at 120 days. Approximately 2% (n=5) of the subyearling Chinook AT fish surviving to 120 days lost or expelled acoustic tags. Statistical significance of the group differences will be forthcoming.

SMOLT RESPONSES TO HYDRODYNAMIC CONDITIONS IN FOREBAY FLOW NETS OF SURFACE FLOW OUTLETS, 2007

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ABSTRACT

We integrated data on smolt movements and hydrodynamic conditions at surface flow outlets (SFOs) at McNary and The Dalles dams during 2007 to determine: 1) Which hydraulic variables were most strongly associated with fish behavioral responses? 2) Of these, were there threshold levels that could be used to support SFO design guidelines?

Fish movement data were collected with an acoustic camera (DIDSON). Water velocity and associated hydrodynamic data were obtained from an acoustic Doppler current profiler (ADCP, sampling simultaneously with the DIDSON) and a computational fluid dynamics model (CFD, instituted after the field work). The fundamental biological response variable -- fish swimming effort -- was computed by subtracting the water velocity vector from the observed fish movement vector.

Comparison of the ADCP and CFD results revealed an apparent problem with our application of the ADCP. The instrument was functioning properly, but the assumption that water currents were sufficiently homogenous for a given range in the ADCP beams was not met, producing anomalous water velocity vectors. Therefore, all water-related and fish effort variables were calculated using CFD data. Future studies to collect water velocity simultaneously with fish movements should use a new modified ADCP method that resolves the homogeneity assumption.

The ADCP issue notwithstanding, the 2007 study provided new information having important management implications: 1) Schooling behavior was dynamic and prevalent; the implication is that SFO entrance area must be large enough to accommodate fish schools. 2) Fish behavior was dependent on distance from the SFO entrance; this supports the notion that SFO flow nets need to be expansive enough spatially for smolts to discover despite competing flow fields. 3) Passive fish behavior was observed less than 5% of the time in the SFO flow nets we studied, implying that SFO designs cannot rely only on fish following bulk flow. 4) Active swimming against the flow was the most common behavioral response; thus, SFO performance evaluations should include a metric for fish swimming effort in SFO flow fields. 5) Fish effort variables were correlated with water velocity, acceleration, and strain. The non-linear regressions indicate potential for this approach of merging fish/flow data to lead to SFO design guidelines in the future as the fish/flow dataset is further populated.

In conclusion, analyzing merged fish/flow data from a diversity of sites over multiple years will strengthen the relationships between smolt responses and hydrodynamic conditions such that universal trends may emerge to support bioengineering efforts to improve juvenile salmonid survival rates.

TURBINE SURVIVAL STUDIES



PRESSURE INVESTIGATIONS TO SUPPORT BIOLOGICAL INDEX TESTING

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ABSTRACT

Most Federal Columbia River Power System (FCRPS) hydroturbines, located at mainstem Columbia and Snake River dams are near the end of their design operating lives. Over the next several years, the majority of these turbines will be repaired or replaced. A goal of the Corps' Turbine Survival Program is to develop data that will aid in development of hydroturbine designs and identification of turbine operations that will provide safer passage of juvenile migrants through FCRPS turbines.

During passage through hydroturbines, juvenile salmonids are at risk of injury from collision on structure; strike by turbine runner blades, exposure to shear, and exposure to changes in pressure. The changes in pressure are decompressive in nature and occur as the fish is carried with high velocity flow from the pressure to the suction side of turbine runner blades. This study determined the response of juvenile Chinook salmon to rapid decompression that is typical of that experienced during passage through FCRPS hydroturbines. The report of these findings will be prepared as a design reference for hydroturbine engineers and will be a factor in Corps' biological index testing to optimize hydroturbine operations for safer passage of downstream migrants through the FCRPS.

An initial aspect of the project was test of the assumption that river-run and hatchery juvenile Chinook salmon show the same response to rapid decompression. This assumption was validated and accepted. Following this, a study was designed to systematically evaluate the response of depth acclimated subyearling and yearling sized hatchery Chinook salmon to rapid decompression. The dependent (response) variable for the study was mortal injury (MI), a derived variable based on both fish injury and immediate mortality. The study independent (treatment) variables were acclimation pressure (AP), nadir pressure (NP, the lowest pressure present during turbine passage), total dissolved gas level (TDG), and rate of change in pressure (ROC).

Following acclimation for 16 hours at selected depth equivalent absolute pressure, groups of seven fish, were exposed to simulated turbine passage profiles with selected nadir absolute pressures. Exposed fish were processed to determine the number in each group that suffered mortal injury. The resulting mortal injury data were analyzed to statistically evaluate the response of test fish to treatment factors. Analysis of the acclimation and nadir pressure data resulted in derivation of a metric, the natural logarithm of the ratio of acclimation and nadir pressures (LRP), which permitted a reduction in the dimensionality of the study outcome space. LRP, ROC, and their interaction were found the best describe the probability of mortal injury. TDG was dropped from the model because its contribution was insignificant. The resulting relationships for LRP and mortal injury, holding ROC constant, are sigmoid in form, indicating low risk of mortal injury when the ratio of acclimation and nadir pressures are small then increasing to a probability of mortal injury near 1.0 when the ratio of pressures is large.