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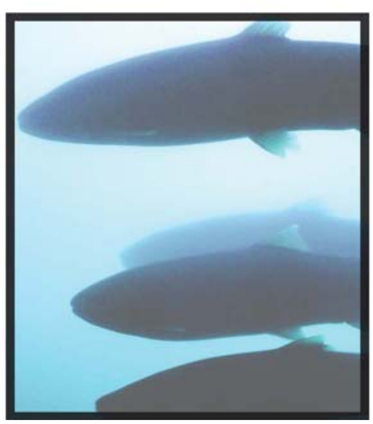
Annual Review

Nov 29 – Dec 2, 2010
Portland, Oregon








Anadromous Fish Evaluation Program

Annual Review 2010

November 29 - December 2, 2010

Prepared by the
U.S. Army Corps of Engineers
Portland District

Sponsored by

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AGENDA

Presentations are 20 minutes long unless otherwise noted.

MONDAY – November 29, 2010			
1200	Opening Remarks	Brad Eppard	CENWP
1205	Key Note Speaker	David Ponganis	CENWD
Adult Salmon Studies			
1215	*Moderator – Sean Tackley*		*CENWP*
1220	Evaluation of Adult Spring-Summer Chinook Salmon Passage at Lower Columbia River Dams, 2010	Chris Caudill	UI
1240	Using In-stream PIT-tag Technology to Estimate System-wide Straying	Matthew Nesbit	NOAA
1300	Hydroacoustic Evaluation of Overwintering Summer Steelhead Fallback and Kelt Passage at The Dalles Dam, 2009-2010	Fenton Khan	PNNL
1320	Monitoring the Use of the Mainstem Columbia River by Bull Trout from the Walla Walla Basin	Don Anglin	USFWS
1340	Development of a Conceptual Chum Salmon Emergence Model for Ives Island	David Geist	PNNL
1400	*Break*		
Transportation Studies			
1420	*Moderator – Dean Holecek*		*CENWW*
1425	Survival of Yearling Chinook salmon during barge transport	Michael Hughes	PNNL
1445	Snake River Transport Studies , 2010	Douglas M. Marsh	NOAA
1505	Using Scales From Returning Snake River Fall Chinook Salmon to Better Understand Their Early Life History	Douglas M. Marsh	NOAA
1525	Juvenile Salmon Marine Survival Related to Ocean Entry Time	Robert Emmett	NOAA
1545	Ocean Condition & Salmon Survival: Post-release Performance of Natural and Hatchery Subyearling Fall Chinook Salmon in the Snake and Clearwater Rivers	William Connor	USFWS
1605	Willamette Valley Project BiOp Program Overview	David Griffith	CENWP
1625	Fish-and-Water Management Tools (FWMT) Project Contributions to Stock Rebuilding of Okanagan Sockeye Salmon (2004-2010)	Kim Hyatt	BC Fisheries
1645	*End of Monday Session*		

TUESDAY – November 30, 2010			
Juvenile Salmon Passage Studies			
0900	*Moderator – Brad Eppard*		*CENWP*
0905	PIT Tag Reach Survival Estimates 2010	Bill Muir	NOAA
0925	Survival of Acoustic and PIT-tagged Yearling Chinook Salmon in the Snake and Columbia Rivers	Rich Brown	PNNL
0945	Optimal Suturing Technique and Number of Sutures for Surgical Implantation of Acoustic Transmitters in Juvenile Salmonids	Rich Brown	PNNL
1005	Performance Assessment of Suture Number in Juvenile Chinook Salmon Implanted with Acoustic Transmitters: the Influence of Simulated Turbine Passage	Alison Colotelo	PNNL
1025	How Flow and Project Operations Affect Survival of Fish Passing McNary Dam: A multi-year analysis of survival data collected at McNary Dam, 2004-2009	Noah Adams	USGS
1045	How Fish Pass McNary Dam: A multi-year synthesis and analysis of passage and behavior data collected at McNary Dam, 2006-2009	Noah Adams	USGS
1105	*Break*		
1125	Evaluation of Juvenile Salmonid Gatewell Egress Using Updated Orifice Lighting Treatments at McNary Dam	Gordon A. Axel	NOAA
1145	Evaluation of Juvenile Salmonid Condition (Descaling) Under Different Turbine Operating Conditions at McNary Dam, 2010	Jesse J. Lamb	NOAA
1205	*Lunch*		
1305	Estimate of Direct Effects of Passage Through John Day Dam Spillbay 20 with a Modified Flow Deflector	Joanne Fulmer	Normandeau
1325	Sensor Fish Characterization of Fish Passage Conditions thru John Day Dam Spillbay 20 with a Modified Flow Deflector	Joanne Duncan	PNNL
1345	Lower Columbia River Survival Study, 2010: An Introduction	Brad Eppard	NWP
1405	Lower Columbia River Survival Study, 2010: Methods	James Hughes	PNNL
1425	Lower Columbia River Survival Study, 2010: Fish Condition Assessment	Christa Woodley	PNNL
1445	Lower Columbia River Survival Study, 2010: Passage Behavior and Survival at John Day Dam	Mark Weiland	PNNL
1505	*Break*		

TUESDAY – November 30, 2010 (continued)			
1525	Lower Columbia River Survival Study, 2010: BiOp Compliance Monitoring at The Dalles Dam	John Skalski	PNNL
1545	Lower Columbia River Survival Study, 2010: Passage Behavior and Survival at Bonneville Dam	Gene Ploskey	PNNL
1605	A study of Salmonid Survival and Behavior through the Columbia River Estuary using Acoustic Tags: Fixed Arrays	Geoff McMichael	PNNL
1625	Sampling to Detect Juvenile PIT-Tagged Salmonids with a Surface Pair-Trawl in the Columbia River Estuary, 2010	Robert J. Magie	NOAA
1645	Using Program ROSTER to Assess the Effect of Bypass Passage on Adult Returns	Rebecca Buchanan	UW
1705	*End of Tuesday Session*		

WEDNESDAY – December 1, 2010			
Estuary Studies			
0900	*Moderator – Cindy Studebaker*		*CENWP*
0905	Contribution of Tidal Fluvial Habitats in the Columbia River Estuary to the Recovery of Diverse Salmon ESUs	Dan Bottom	NOAA
0925	Migratory Pathways and Survival of Juvenile Salmonids in the Lower Columbia River Estuary, 2010	Ryan Harnish	PNNL
0945	Use of Acoustic Mobile Tracking to Evaluate Timing, Behavior, and Fate of Juvenile Salmonid Migrants Through the Lower Columbia River and Estuary, 2010	Lynn McComas	NOAA
1005	Initial Results from the 2010 COAST (formerly POST) Study: Downstream and Early Marine Survival and Movements of Yearling Chinook Salmon	David Welch	Kintama
1025	Post Construction Assessment of Fishes, Habitats and Tide Gates in Sloughs on the Mainland	Jeffrey Johnson	USFW
1045	*Break*		
1105	Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary	Heida Diefenderfer	PNNL
1125	Evaluating Cumulative Ecosystem Response to Habitat Restoration Projects in the Lower Columbia River and Estuary	Ronald M. Thom	PNNL
1145	Juvenile Salmon Ecology and Restoration of Tidal Freshwater Habitats	Nichole Sather	PNNL
1205	*Lunch*		

WEDNESDAY – December 1, 2010 (continued)			
Turbine Survival Program			
1305	*Moderator – Robert Johnson*		*CENWW*
1310	Mortal Injury of Juvenile Chinook Salmon during Hydroturbine Passage: Implications for hydroturbine operation and design	Andrew Gingerich	PNNL
1330	Maximum Acclimation Depth of Juvenile Chinook Salmon: Implications for survival during hydroturbine passage	Brett Pflugrath	PNNL
1350	Bias in Juvenile Salmon Survival Estimates through Hydroturbines Due to Transmitter Presence: Implications for hydroturbine operations and management	Richard S. Brown	PNNL
1410	Historical Trends in Survival of Juvenile Salmon Passing through Turbines at McNary and John Day Dams	John W. Beeman	USGS
Predation Studies			
1430	*Moderator – Chris Pinney*		*CENWW*
1435	Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace, 2008-2010	Robert Stansell	CENWP-Bonn
1455	Avian Predation in the Columbia River Estuary and Monitoring Implementation of the Caspian Tern Management Plan	Dan Roby	Oregon State University
1515	Avian Predation at John Day and The Dalles Dams,2010: Estimated Fish Consumption using Direct Observation with Diet Analysis	Nathan Zorich	CENWP-Bonn
1535	Avian Predation on the Columbia Plateau: Impacts on smolts from the Upper Columbia and Snake rivers	Allen Evans	Real Time Research, Inc
1555	Electronic Recovery of Passive Integrated Transponder (PIT) Tags on Avian Breeding Colonies in the Columbia River Basin, 2010	Scott Sebring	NOAA
1615	*End of Wednesday Session*		

THURSDAY – December 2, 2010			
Lamprey Studies			
0900	*Moderator – Sean Tackley*		*CENWP*
0905	Estimating Upstream Passage Metrics and Performance in Pacific Lamprey: Overview and patterns from the Columbia River hydrosystem	Chris Caudill	University of Idaho
0925	Adult Lamprey Passage Success and Behavior in the Lower Columbia River, 2010	Matt Keefer	University of Idaho
0945	Improving Adult Pacific Lamprey Passage at Bonneville Dam	Mary Moser	NOAA
1005	Fishway Use and Passage Success of Adult Pacific Lamprey at Bonneville Dam including the Modified Cascades Island Entrance, 2010	Chris Caudill	University of Idaho
1025	Video Monitoring of Adult Pacific Lamprey in the John Day Dam Fishway	Chris Peery	FWS - Idaho
1045	*Break*		
1105	Evaluation of Adult Pacific Lamprey Behavior in Columbia River Reservoirs using the Juvenile Salmon Acoustic Telemetry (JSAT) System, 2010	Chris Caudill	University of Idaho
1125	Evaluation of Adult Pacific Lamprey Passage and Behavior at McNary Dam, 2010 and Multi-year Summary of Passage Metrics	Charles Boggs	University of Idaho
1145	Video Monitoring of Adult Fish Ladder Modifications to Improve Pacific Lamprey Passage at the McNary Dam Oregon Shore Fishway, 2010	Kai Eder	UC Davis
1205	Development of Standard Protocols for PIT Tagging Juvenile Lampreys	Matthew G. Mesa	USGS
1225	Developing Active Telemetry Tagging Methods for Juvenile Lampreys	Chris Peery	FWS - Idaho
1245	Passive Sampling Approach to Determine Juvenile Lamprey Presence/Absence in Deep Water	Evan Arntzen	PNNL
1305	Closing Remarks	Brad Eppard	CENWP

MONDAY – November 29, 2010			
Adult Salmon Studies			
1220	Evaluation of Adult Spring-Summer Chinook Salmon Passage at Lower Columbia River Dams, 2010	Chris Caudill	UI
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1300	Hydroacoustic Evaluation of Overwintering Summer Steelhead Fallback and Kelt Passage at The Dalles Dam, 2009-2010	Fenton Khan	PNNL
1320	Monitoring the Use of the Mainstem Columbia River by Bull Trout from the Walla Walla Basin	Don Anglin	USFWS
1340	Development of a Conceptual Chum Salmon Emergence Model for Ives Island	David Geist	PNNL

Evaluation of Adult Spring–Summer Chinook Salmon Passage at Lower Columbia River Dams, 2010

Christopher Caudill[1*], Michael Jepson[1], Tami Clabough[1], Matthew Keefer[1], and Brian Burke[2]

Abstract

Background and Methods

Modifications to fishways and other structures at dams potentially affect fish behavior and passage. In 2010, we collected and radio-tagged 598 adult spring–summer Chinook salmon at Bonneville Dam to evaluate their behavior at the modified Cascades Island fishway entrance at Bonneville Dam, the spillwall and north fishway entrance at The Dalles Dam, and near the modified north count window at John Day Dam.

Results

<u>Bonneville Dam Cascades Island Fishway Modifications</u>

In 2010, we conducted a second year of radiotelemetry studies to evaluate if modifications made at the Cascades Island (CI) fishway to facilitate adult Pacific lamprey passage adversely affected adult salmon passage. Results from 2009 indicated some behavioral differences near the CI fishway opening relative to pre-modification years but the 2010 results were less conclusive. Specifically, in 2009 a relatively low percentage of spring Chinook salmon that approached the CI fishway subsequently entered and those that did enter took a relatively longer time to do so. In contrast, the 2010 entrance efficiency estimate in 2010 was 0.90, at the high end of the range (range = 0.56-0.98) observed in pre-modification years. The median CI approach-entrance time in 2010 was 42 minutes, also within the range of median times from pre-modification years (range = 2-46 min). For summer Chinook salmon, the CI entrance efficiency estimate was 0.70 in 2009 and 0.71 in 2010, the two lowest efficiencies of the five study years but similar to 2004. Median CI approach-entrance times for summer Chinook salmon in 2010 was < 1 minute, compared to 6-12 minutes in pre-modification years. Overall, any adverse effects associated with the modifications appeared to be reduced in 2010 compared to 2009.

<u>The Dalles Dam Spillwall</u>

The construction of a ~145 meter spillwall at The Dalles Dam was completed in April 2010 and was designed to improve the survival of spillway-passed juvenile salmonids by directing them toward deeper water with fewer predators. We evaluated how the new spillwall, spill volume, and a spill pattern directing most water though the northern-most spillbays may have affected behaviors and passage times of radio-tagged adult spring–summer Chinook salmon in 2010. Tagged salmon had little apparent difficulty locating and using the north fishway at low (0-50 kcfs) and medium (>50-100 kcfs) spill volumes. At high spill volumes (>100-150 kcfs), tagged salmon were significantly less likely to use the north fishway and entrance efficiency decreased to 67% (from 95% at both low and medium spill volumes). The new spillwall and the spill pattern used in 2010 did not appear to impede the ability of tagged salmon to seek and find alternate passage routes when spill volumes were high or when approaches at the north fishway did not result in a fishway entry. Dam passage times for radio-tagged Chinook salmon in 2010 were the fastest among all comparison

years (median = 12.1 h, n = 285). Detailed evaluation of the relationships between individual passage behaviors and environmental conditions are ongoing.

John Day Dam North Counting Window Modifications

The counting window at the John Day Dam north fishway underwent extensive structural modifications in spring 2010 intended to improve passage conditions at that location. Radio-tagged Chinook salmon consistently used less time (monthly medians) to pass the counting window in 2010 compared to results in 1998, the lone comparison year. Results suggest the 2010 modifications had little or no adverse effect on adult salmon passage.

[1]Idaho Cooperative Fish and Wildlife Research Unit
[2]NOAA, Northwest Fisheries Science Center

Using In-stream PIT-tag Technology to Estimate System-wide Straying

Matthew Nesbit, Jesse Lamb, Nathan Dumdei, Eric Hockersmith and Sandra Downing

Abstract

In order to determine the effectiveness of using instream PIT-tag technology for estimating systemwide straying, a prototype PIT-tag system was installed near McDonald Ferry on the John Day River in September 2007. This site is in the lower reach of the river (near RM 20) and below all major spawning locations. The detection system consists of six antennas installed as two arrays in the thalweg portion of the river to monitor where most of the salmonids would migrate. By installing two antenna arrays, researchers can infer travel direction and the overall tag-detection efficiency of the PIT-tag system is increased.

Since 27 September 2007, the detection system has operated continuously to monitor migrating PIT-tagged adult salmonids. Through October 2010, ~1,100 PIT-tagged adult fish have been detected by the system. The majority of the fish detected (~85%) have been adult steelhead. The observed migration distribution for steelhead is protracted over the summer, fall and winter months. The spring Chinook salmon migration distribution is acute, primarily during the spring months.

Of the 1,100 adult salmonids detected since 2007, 250 are considered strays because they were tagged as juveniles outside of the John Day River basin; the majority were steelhead. This summer and fall (04 July through 21 October 2010), 78 adult steelhead have been detected; of which, 15 are considered strays. More than one-third (n=6) were transported as juveniles from Lower Granite Dam.

The 6 transported steelhead from Lower Granite Dam were all detected at Bonneville Dam between 12 July and 5 September. During this time period, 936 adult steelhead with the same history (i.e., transported as juveniles from Lower Granite Dam) were also detected at Bonneville Dam. This would suggest a straying rate of about 0.5% so far for this group of transported steelhead from the Snake River entering the John Day basin.

Starting in September 2008, we began evaluating the detection efficiency of the PIT-tag system using double tagged adult steelhead. The steelhead were tagged with both PIT and radio tags. Four radiotelemetry arrays (two below and two above the PIT-tag antennas) were used to monitor the movement of the double tagged fish. The goal was to double tag 100 steelhead caught by hook and line and monitor their movement and passage over the PIT-tag antennas. We have met that goal and will present all data to date.

From October 2008 through October 2010, we have collected genetic samples from 170 steelhead and double tagged 116. We will present results from all double-tagged fish over the life of the study; this will be preliminary data as some of the fish tagged this fall will continue to move through the spring. So far this fall, we have observed ~35% of our double tagged fish moving up the John Day River with the radiotelemetry equipment and the PIT-tag system has detected 100% of these fish.

Hydroacoustic Evaluation of Overwintering Summer Steelhead Fallback and Kelt Passage at The Dalles Dam, 2009–2010

Fenton Khan, G.E. Johnson, and M.A. Weiland

Abstract

This abstract presents the results of an evaluation of overwintering summer steelhead (Oncorhynchus mykiss) fallback and early out-migrating steelhead kelts downstream passage at The Dalles Dam (TDA) sluiceway and turbines during fall/winter 2009 through early spring 2010. The study was conducted by the Pacific Northwest National Laboratory for the U.S. Army Corps of Engineers, Portland District. The goal of this study was to characterize adult steelhead spatial and temporal distributions and passage rates at the sluiceway and turbines for fisheries managers and engineers to use in decision-making relative to sluiceway operations.

The study period was from November 1, 2009 to April 10, 2010 (161 days total). The objectives were to 1) estimate the number and distribution of overwintering summer steelhead fallbacks and kelt-sized acoustic targets passing into the sluiceway and turbines at TDA between November 1 and December 15, 2009 and March 1 and April 10, 2010, and 2) estimate the numbers and distribution of adult steelhead and kelt-sized targets passing into turbine units between December 16, 2009 and February 28, 2010. This study was conducted with four operating sluice entrances (1-2, 1-3, 18-1, 18-2) and all operating turbine units. We obtained fish passage data using fixed-location hydroacoustics.

For the fall/winter turbine and sluiceway period, steelhead fallback occurred throughout the study period. We estimated a total of 879 ± 165 (95% CI) steelhead targets passed through the turbine intakes and operating sluice entrances during this period. Ninety two percent of these fish passed through the sluiceway. Run timing peaked in early December, but fish continued to pass the dam until December 15. Horizontal distribution data indicated that Sluice 1 is the preferred route for these fish during fallback through the dam. Diel distribution was variable with no apparent distinct patterns.

For the winter turbine only period, adult steelhead passage occurred between mid January and February. We estimated a total of 62 ± 40 (95% CI) adult steelhead targets passed through the turbine intakes during this period. Horizontal distribution data indicated turbine unit 18 passed the majority of fish. Fish passage occurred during morning periods only.

For the early spring turbine and sluiceway period, overwintering summer steelhead and early out-migrating kelt downstream passage occurred throughout the study period. A total of 1,985 ± 234 (95% CI) kelt-size targets were estimated to have passed through the turbine intakes and operating sluices. Ninety-nine percent of these fish passed through the sluiceway. Run timing peaked in late March and again in early April. Horizontal distribution indicated that Sluice 1 is the preferred route for these adult salmonids. No clear pattern was seen for diel distribution of overwintering steelhead and early out-migrating kelt passage.

The results of this study strongly suggest that operating the TDA sluiceway for steelhead passage (fallbacks and kelts) during the late fall, winter, and early spring months will provide an optimal, non-turbine route for these fishes to pass the dam.

Monitoring the Use of the Mainstem Columbia River by Bull Trout from the Walla Walla Basin

Don Anglin

Abstract

Little is known about use of the Columbia River by bull trout Salvelinus confluentus from the Walla Walla Basin. Mainstem Snake and Columbia River dams have the potential to impact both the connectivity between bull trout Core Areas (metapopulations), and the connectivity within migratory corridors. The need for research and monitoring of bull trout use of the Columbia and Snake rivers is identified in the U.S. Fish and Wildlife Service Biological Opinion. From April 2005 through December 2009, use of the Columbia River by Walla Walla Basin bull trout was investigated by operating a Passive Integrated Transponder (PIT) detection array at Oasis Road Bridge (ORB) near the mouth of the Walla Walla River to determine bull trout abundance and describe the migration timing between the Walla Walla and Columbia rivers. A quantitative estimate of the number of migratory Walla Walla Basin bull trout that moved into the Columbia River over the duration of this study was developed by utilizing empirical data consisting of monthly array detections in combination with physical detection efficiencies and annual estimates of the proportion of the population that was tagged based on hook and line sampling. Migration timing periodicity was described by examining detections at the ORB detection array, observations from a screw trap operated near the mouth of the Walla Walla River, and detections at mainstem dams. We estimate a total of 192 bull trout emigrated from the Walla Walla Basin to the Columbia River from November 2007 through December 2009. Over the duration of the study, only one bull trout was detected returning to the Walla Walla River from the Columbia River. The timing of migratory bull trout emigration from the Walla Walla River to the Columbia River varied from year to year, but overall, occurred from October through May, peaking between November and February. Variation in streamflow patterns across migration seasons appears to influence emigration timing to a greater extent than changing water temperatures. Four Walla Walla Basin bull trout were detected at mainstem Columbia River dams over the duration of this study. Detections in the juvenile bypass systems at John Day and McNary dams indicated two of these bull trout were moving downstream. Detections in the adult fish ladders at McNary and Priest Rapids dams indicated two of these bull trout were moving upstream. Walla Walla Basin connectivity with the mainstem Columbia River, and connectivity within the Columbia River migratory corridor is required to maintain genetic diversity of the Core Area metapopulations in the Columbia River Distinct Population Segment, and for re-colonization of areas where local populations have been extirpated by natural stochastic events or impacts from human-related activities. The goal of the current research that began in 2010 is to determine migration patterns, spatial and temporal distribution, habitat use, and passage behavior of Walla Walla Basin migratory bull trout in the FCRPS reservoirs and around mainstem Columbia River FCRPS hydropower projects using acoustic telemetry.

Development of a Conceptual Chum Salmon Emergence Model for Ives Island

Christopher Murray, David Geist, Evan Arntzen, Yi-Ju Bott, and Marc Nabelek

Abstract

The objective of this project is to develop a conceptual model that can be used to predict the timing of chum salmon emergence in the Ives Island area. The model uses bed and river temperatures to predict the cumulative percent distribution of chum salmon emergence by date during the incubation period, and then continually updates these predictions during the incubation season as temperature data are collected. The model was developed using real-time hourly temperature data from 3 locations in the Ives Island spawning area that were instrumented with paired hyporheic and river sensors beginning in 2003. These data were supplemented by additional temperature data collected in the Ives Island area during 2006-2007, including 5 additional paired hyporheic and river sensors and 32 hyporheic sensors that measured temperature at approximately 15 cm below the bed surface. Using these data, we calculated accumulated thermal units (ATUs) for each location; we assumed emergence occurred at 932 ATUs based on the time to 50% emergence in previous laboratory studies. We found that mixing various proportions of hyporheic and river temperature data from the real time sensors could be used to reproduce the number of days to emergence for the full range of sensor locations in 2006-2007. The number of days to emergence that were mapped in the Ives Island area were spatially coherent, with much shorter time to emergence in the western part of the channel relative to more easterly parts of the channel. These results are similar to earlier studies that showed that bed temperatures in the Ives Island area tend to be spatially continuous and mappable. An estimate of emergence dates for future years will be determined by interpolating the days to emergence for each redd location from the map of 2006-2007 redds and temperatures. The map will be used to identify the mixture of hyporheic and river temperature data from the real time system that would provide the closest match for the estimated days to emergence for each redd location. The identified mixture would then be used to update the emergence estimates for each redd during the incubation season as new hyporheic and river temperature data become available from the real time system. This method assumes that the spatial distribution of areas with warm and cool hyporheic temperatures near Ives Island tends to be relatively constant, as suggested by the results of earlier mapping studies. A case study is being prepared using redd location data from 2009-2010 to illustrate use of the conceptual model.

MONDAY – November 29, 2010			
Transportation Studies			
1425	Survival of Yearling Chinook salmon during barge transport	Michael Hughes	PNNL
1445	Snake River Transport Studies , 2010	Douglas M. Marsh	NOAA
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Survival of Yearling Chinook Salmon During Barge Transport

Geoffrey McMichael[1], Katherine Deters[1], Kenneth Ham[1], John Skalski[2], Michael Hughes[1], Jina Kim[1], Ryan Harnish[1]

Abstract

Transportation of salmonid smolts has been a major strategy to mitigate the effects of the Columbia and Snake River dams on salmonid migration. To better understand the effects of transportation on juvenile salmonids, we estimated the mortality of yearling Chinook salmon within the barge during transport from Lower Granite Dam to the release site downstream of Bonneville Dam near Skamania, Washington (rkm 222 to 227). The study consisted of three release groups of acoustic-tagged fish placed into individual barges over six separate days (April 29, and May 1, 4, 7, 10, 13). One group (RB) consisted of tagged fish placed into a barge hold with the general population of fish to be transported from Lower Granite Dam. In order to determine mortality in the barge, two additional groups of acoustic-tagged fish–one group consisting of fish known to be alive (RA) and a second consisting of fish known to be dead (RD)–were maintained in net pens within the barge during transport and released into the general barge population prior to smolt evacuation below Bonneville Dam. Detection arrays located downstream of the barge release area at rkm 153 and rkm 113 were used to determine the relative recovery rates of tagged smolts from the three release groups in order to estimate within-barge mortality. The use of RD allowed greater precision in the estimation of barge mortality by confirming that detections of dead RB fish at downstream arrays had not occurred. The ratio of RB to RA survival to a downstream detection array corresponds to the within-barge survival of RB fish. The median travel time for fish to migrate to rkm 153 after release was 1.45 days for RB and 1.42 days for RA. An estimated 96.6% and 99.1% of RB and RA, respectively, survived to rkm 153. The estimated within-barge survival for RB fish (based on detections at rkm 153) was 97.5%. The median travel time for fish to migrate from the release location to rkm 113 was 2.02 days for RB and 2.01 days for RA. An estimated 95.3% and 98.6% of RB and RA, respectively, survived to rkm 113 (higher detection probability at this array, i.e. more accurate survival estimates) and the estimated within-barge survival for RB fish was 96.6%. Additionally, multiple downstream detection arrays were used to test whether alive fish from RB and RA had similar downstream survivals. Probability of surviving from rkm 153 to rkm 113 was lower for RB (0.95 [SE =0.008]) compared to RA (0.99 [0.005]) which could indicate that the barge survival estimates are underestimated (i.e., minimum survival estimates). Survival from release to the mouth rkm 8.3 of the estuary was similar for both groups.

[1]Pacific Northwest National Laboratory
[2] University of Washington, Columbia Basin Research

Snake River Transport Studies, 2010

Douglas M. Marsh, Darren A. Ogden, and William D. Muir

Abstract

In 2010, we continued several research studies to determine the potential of transport to increase adult returns of anadromous salmonids. We PIT tagged wild yearling spring/summer Chinook salmon and steelhead smolts at Lower Granite Dam (LWG) and also detected returning adult Chinook salmon and steelhead PIT-tagged as smolts in 2005-2009.

Seasonal effects study

From 2007 releases, we detected a total of 108 wild LWG transported adults (smolt-to-adult return rate (SAR) of 0.90%), 40 wild adults that were not detected as juveniles, and 46 wild adults that were returned to the river at one or more collector dam (we are still estimating the number of juveniles in these last two groups). Prior to 1 May 2007, we made only one transport release per week, which resulted in the loss of fine scale analysis of temporal patterns during this time of year. Based on the weekly data points prior to 1 May and the daily patterns after, it appears an increase in transport SARs occurred during the third week of April.

In 2007, our study design for steelhead was the same as detailed above for wild yearling Chinook salmon. We detected a total of 249 wild LWG transported adults (SAR of 2.64%), 24 wild not detected adults, and 15 wild adults that were returned to the river at one or more collector dam (we are still estimating the number of juveniles in these last two groups). As mentioned above, we only had one data point per week prior to 1 May. Transport SARs during that time were low (0.5-2.0%). The first week of May, transport SARs were over 3.0%, peaked on 14 May, and remained above 2.0% until the first week of June.

Snake River fall Chinook salmon transport study

Adult fall Chinook salmon returns from the 2005 cooperative (NOAA and USFWS-DWOR) transport study are complete. For the first time, we pre-designated which fish would be bypassed if collected and which fish would be transported if collected. It was also the first year we released fish in the Clearwater River. Overall SARs were 0.10% and 0.12% for the bypass and transport groups, respectively, yielding a T/B of 1.18 (95% CI 0.88, 1.58). For Snake River releases, the T/B was 0.67 (95% CI 0.41, 1.09), and for Clearwater River releases, the T/B was 1.63 (95% CI 1.12, 2.36).

Alternate barge release site study

This study compares the SARs of fish released at night on an outgoing tide from river kilometer (rkm) 10 (below Astoria, Oregon) (AS) to the SARs of fish released at the current Skamania release site (SK) below Bonneville Dam (rkm 245). Results from the 2007 study year showed that neither Chinook (AS/SK = 0.94; 95% CI 0.72, 1.23) nor steelhead (AS/SK = 0.88; 95% CI 0.77, 1.00) showed a benefit from release at Astoria. Results for the 2008 study year and for the entire three year study will be final in 2011.

Using Scales from Returning Snake River Fall Chinook Salmon to Better Understand Their Early Life History

Douglas M. Marsh[1], William P. Connor[2], and William D. Muir[1]

Abstract

From 1998 through 2004, the U. S. Fish and Wildlife Service used the adult trap and separation-by-code system at Lower Granite Dam (LGR) to collect scales from returning fall Chinook salmon adults that had been PIT tagged as part of their research efforts. Their goals included determining whether the adults had entered the ocean as subyearlings or yearlings. They then coupled this information with juvenile PIT tag detection histories to look for patterns. In 2005, NOAA Fisheries joined with the USFWS effort, adding all transport study fall Chinook to the pool of targeted adults. From each scale sample, Washington Department of Fish and Wildlife's (WDFW) staff assigned age at ocean entry (subyearling or yearling), which we then compared to that adult's juvenile PIT-tag detection history.

A total of 1,712 scale samples were taken from PIT-tagged adults and jacks at LGR between 1998 and 2008, with most (1,435) being collected in 2007 and 2008. WDFW staff were able to assign age at ocean entry to 1,543 of these. Of the remaining 169, age at ocean entry could not be assigned for 157 and, at the time this abstract was written, 12 were known to have been misread. Of the 1,543 scale samples assigned an age at ocean entry, 1,015 were determined to have entered the ocean as subyearlings and 528 entered the ocean as yearlings. All juvenile detection history categories had at least one yearling ocean entrant. The percentage of returning adults that showed a yearling age at ocean entry ranged from 3.9% and 6.5% for fish transported or last detected during the summer of the year they were released, respectively, to 100% for fish last detected after transport ended in late fall and before it began again in early spring of the following year. As expected, all returning fish that could be assigned an age at ocean entry and were last detected as juveniles in the spring following the year they were released had yearling ocean entry scale patterns.

We will show how age at ocean entry varied by juvenile PIT tag detection history and rearing strategy, and how age at ocean affected adult age class distribution, sex ratio, and size.

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[2]US Fish and Wildlife Service

Juvenile Salmon Marine Survival Related to Ocean Entry Time

Robert L. Emmett

Abstract

Columbia River juvenile salmon marine survival is related to timing of ocean entry and associated with fluctuating physical and biological characteristics of the estuary and nearshore ocean plume environment. Smolt-to-adult return rates (SARs) for various spring Chinook salmon CWT and PIT-tagged releases in the lower Columbia River are being tracked. While we are still working on data analysis, preliminary results indicate that 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 strongly influence SARs and influenced by time of ocean entry. The last three years bottom mounted acoustic profilers have been used to identify daily fluctuations is forage fish and zooplankton abundance off the Columbia River. Preliminary analysis indicates that the movement of forage fish to the mouth of the Columbia River happens suddenly and is strongly controlled by ocean conditions. The arrival and movements of forage fishes probably has a large influence on marine predation rates. While ocean conditions is 2008 and 2009 were relatively good for salmon marine survival, 2010 appears to have been a very poor survival year.

Ocean Condition & Salmon Survival: Post-release Performance of Natural and Hatchery Subyearling Fall Chinook Salmon in the Snake and Clearwater Rivers

William P. Connor

Abstract

In 2009, we continued a multi-year study to compare smolt-to-adult return rate (SAR) ratios between two groups of Snake River Basin PIT-tagged fall Chinook salmon 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 PIT tagged them. Because we could not collect sufficient numbers of natural fish to conduct a study that would provide precise comparisons of SAR ratios, we supplemented the treatment groups with PIT-tagged Lyons Ferry Hatchery subyearlings raised under a surrogate rearing strategy and released them into the Snake and Clearwater rivers. 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 2009 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 2009 as part of research on dam passage experiences (i.e., transported from a dam, dam passage via bypass, dam passage via turbine intakes or spillways). Culturing production subyearlings involves accelerating growth at Lyons Ferry, Nez Perce Tribal, Umatilla, and Oxbow hatcheries, sometimes followed by a few weeks of acclimation at sites along the Snake and Clearwater rivers before release from May to June. The objective of this presentation is to compare the postrelease performance of 2009 releases of natural subyearlings to the postrelease performance of 2009 releases of surrogate and production subyearlings. The attributes of postrelease performance include: detection timing, detection during implementation of summer spill, travel time, migrant size, and the joint probability of migration and survival. This comparison provides the fisheries community with the empirical information needed to evaluate the efficacy of the surrogate release strategy and interpret patterns in future SARs from PIT-tagged surrogate and production subyearlings with different passage experiences. Based on the results of both objectives combined, we conclude that (1) juvenile life history varies markedly between the natural and production populations and (2) postrelease performance was much more similar between natural and surrogate subyearlings than between natural and production subyearlings. 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.

Fish and Water Management Tools (FWMT) Project Contributions to Stock Rebuilding of Okanagan Sockeye Salmon (2004-2010)

Dr. Kim Hyatt

Abstract

Record breaking returns of sockeye salmon in 2010 marked the culmination of a remarkable turnaround for populations of this species in the Columbia River Basin. The sockeye salmon aggregate in the Columbia is composed of just three populations of this species originating from Redfish Lake in Idaho, Wenatchee Lake in Washington State and Osoyoos Lake in British Columbia. Although all three of these populations have exhibited recent-year increases in returns relative to their multi-decadal averages, Okanagan sockeye salmon have accounted for more than 75% of the aggregate return since the year 2000 and accounted for no less than 295,000 of the roughly 386,000 sockeye adults that passed Bonneville Dam in the summer and fall of 2010. Media and management agencies have engaged in a wide range of speculation about the causes for the resurgence of these sockeye populations. Here we review the recent history of stock management and restoration efforts focused on Okanagan sockeye in both the U.S. and Canada to identify the factors associated with its spectacular increase in total production. Our results indicate that a combination of intentional management actions and fortuitous events have enabled Okanagan sockeye salmon to rebound to levels at or above their historic maximum. The actions and events involved include: (1) rejection of historic escapement objectives that capped total production far below the carrying capacity of freshwater spawning and rearing environments, (2) development and operational deployment of the FWMT decision support system to facilitate "fish friendly" water storage and release decisions where the latter have greatly reduced density-independent losses of sockeye eggs and fry to flood-and-scour or drought-and-desiccation events, (3) FWMT enabled identification and mitigation of rearing habitat reductions for juvenile sockeye due to oxygen-temperature "squeeze" conditions in Osoyoos Lake, (4) supplemental production from recent year introductions of hatchery-origin sockeye fry into Skaha Lake and (5) improvements in juvenile fish-passage in the Columbia River combined with a coincidental return to survival-favourable conditions for southern sockeye stocks in coastal marine waters. Taken together, our results serve as encouraging evidence of the potential resilience of wild salmon populations and the great strides that are possible when agencies, industry and resource users on both sides of the Canada-U.S. border set aside their differences to work towards a common objective such as salmon restoration.

TUESDAY – November 30, 2010			
Juvenile Salmon Passage Studies			
0905	PIT Tag Reach Survival Estimates 2010	Bill Muir	NOAA
0925	Survival of Acoustic and PIT-tagged Yearling Chinook Salmon in the Snake and Columbia Rivers	Rich Brown	PNNL
0945	Optimal Suturing Technique and Number of Sutures for Surgical Implantation of Acoustic Transmitters in Juvenile Salmonids	Rich Brown	PNNL
1005	Performance Assessment of Suture Number in Juvenile Chinook Salmon Implanted with Acoustic Transmitters: the Influence of Simulated Turbine Passage	Alison Colotelo	PNNL
1025	How Flow and Project Operations Affect Survival of Fish Passing McNary Dam: A multi-year analysis of survival data collected at McNary Dam, 2004-2009	Noah Adams	USGS
1045	How Fish Pass McNary Dam: A multi-year synthesis and analysis of passage and behavior data collected at McNary Dam, 2006-2009	Noah Adams	USGS
1125	Evaluation of Juvenile Salmonid Gatewell Egress Using Updated Orifice Lighting Treatments at McNary Dam	Gordon A. Axel	NOAA
1145	Evaluation of Juvenile Salmonid Condition (Descaling) Under Different Turbine Operating Conditions at McNary Dam, 2010	Jesse J. Lamb	NOAA
1305	Estimate of Direct Effects of Passage Through John Day Dam Spillbay 20 with a Modified Flow Deflector	Joanne Fulmer	Normandeau
1325	Sensor Fish Characterization of Fish Passage Conditions thru John Day Dam Spillbay 20 with a Modified Flow Deflector	Joanne Duncan	PNNL
1345	Lower Columbia River Survival Study, 2010: An Introduction	Brad Eppard	NWP
1405	Lower Columbia River Survival Study, 2010: Methods	James Hughes	PNNL
1425	Lower Columbia River Survival Study, 2010: Fish Condition Assessment	Christa Woodley	PNNL
1445	Lower Columbia River Survival Study, 2010: Passage Behavior and Survival at John Day Dam	Mark Weiland	PNNL
1525	Lower Columbia River Survival Study, 2010: BiOp Compliance Monitoring at The Dalles Dam	John Skalski	PNNL
1545	Lower Columbia River Survival Study, 2010: Passage Behavior and Survival at Bonneville Dam	Gene Ploskey	PNNL
1605	A study of Salmonid Survival and Behavior through the Columbia River Estuary using Acoustic Tags: Fixed Arrays	Geoff McMichael	PNNL
1625	Sampling to Detect Juvenile PIT-Tagged Salmonids with a Surface Pair-Trawl in the Columbia River Estuary, 2010	Robert J. Magie	NOAA
1645	Using Program ROSTER to Assess the Effect of Bypass Passage on Adult Returns	Rebecca Buchanan	UW

PIT Tag Reach Survival Estimates, 2010

William D. Muir, James R. Faulkner, Douglas M. Marsh, Steven G. Smith, and John G. Williams

Abstract

Background
NOAA Fisheries began conducting PIT tag reach survival studies in the Snake and Columbia Rivers in 1993 to provide managers the information needed to assess structural and operational improvements made within the hydropower system to decrease travel time and increase juvenile survival.

Methods
Seven of the eight mainstem dams that Snake River stocks pass during their downstream migration have PIT tag detection systems within their juvenile fish bypass systems. Additionally, in the Lower Columbia River, NOAA Fisheries operates a 2-boat trawl with a PIT-tag detector in the cod end. Using the detection history of each individually tagged migrant (detected and not detected at each dam) and detections from the trawl, we use Cormack-Jolly-Seber methods to estimate survival of PIT-tagged juveniles through individual reaches (one reservoir and dam combination) and combined reaches.

Results/Management Action
During the 2010 spring migration, flow and spill levels were relatively low, but spill level as a percentage of flow was high. Survival through individual reaches averaged 93.2% for yearling Chinook salmon and 95.1% for steelhead. Survival through the entire 750 km hydropower system (Snake River trap to Bonneville Dam tailrace) was 54.8% for yearling Chinook salmon 61.7% for steelhead, the second highest yet measured for steelhead since our study began.

High spill rates coupled with surface passage structures at all 4 Snake River dams in 2010, and a delayed start to transportation resulted in a greater number of non PIT-tagged smolts in the Snake River than in earlier years. As a result, fewer PIT-tagged steelhead were likely eaten near the confluence of the Snake and Columbia Rivers by piscivorous birds, resulting in increased estimated survival through the Snake River. Further, the high spill rates and surface passage structures resulted in rapid migration for smolts despite the low flow conditions.

Survival of Acoustic and PIT-tagged Yearling Chinook Salmon in the Snake and Columbia Rivers

Rich Brown

Abstract

Studies examining survival of juvenile salmon as they emigrate to the ocean provide important information regarding the management of regulated river systems. These studies are used to modify the structural make-up of hydroelectric dams and modify their operations. Acoustic telemetry is currently the tool of choice for evaluating passage behavior and survival for juvenile salmonids in the Columbia Basin. This methodology requires surgical implantation of transmitters into the intra-peritoneal cavity of study animals. Therefore, it is important to determine how the surgical tagging process and the presence of a transmitter affects survival so any biases can be anticipated, accounted for, or eliminated. Field research was conducted from 2006-2008 on yearling and subyearling Chinook salmon to determine if the survival and behavior of PIT tagged Chinook salmon differed from individuals implanted with both an acoustic transmitter and a PIT tag. While differences in survival and behavior were present in some locations, it was not known how the size of fish or tag burden influenced survival. Therefore, this research utilized all three years of data to examine the effects of fish size and tag type (i.e., PIT tag only versus PIT and acoustic transmitter) on the survival of yearling and subyearling Chinook salmon from release at Lower Granite Dam to multiple locations within the Snake and Columbia rivers.

Optimal Suturing Technique and Number of Sutures for Surgical Implantation of Acoustic Transmitters in Juvenile Salmonids

Rich Brown

Abstract

The size reduction of acoustic transmitters has led to a reduction in the length of incision needed to implant a transmitter. Smaller suture knot profiles and fewer sutures may be adequate for closing an incision used to surgically implant an acoustic micro-transmitter. As a result, faster surgery times and reduced tissue trauma could lead to increased survival and decreased infection for implanted fish. The objective of this study was to assess the effects of five suturing techniques (various suture numbers, suture patterns, and knot types) on mortality, tag and suture retention, incision openness, ulceration, and redness in juvenile Chinook salmon implanted with micro-acoustic transmitters. Suturing was performed by three surgeons and study fish were held at two water temperatures (12°C and 17°C). Mortality was low and tag retention was high for all treatments on all examination days (7, 14, 21, 28 days post-surgery). Since there was surgeon variation in suture retention among the treatments, further analyses only included the one surgeon who received feedback training in all suturing techniques. Incision openness and tissue redness did not differ among the treatments. The only difference observed among treatments was in tissue ulceration. Incisions closed with a horizontal mattress pattern had more ulceration than other treatments among fish held for 28 d at 17°C. Results from this study suggest that one simple interrupted 1x1x1x1 suture is adequate for closing incisions on fish under most circumstances. However, the authors do not advise a single suture closure for fish likely to experience rapid decompression (similar to turbine passage) due to the likelihood of viscera expulsion. In dynamic environments, two simple interrupted 1x1x1x1 sutures should provide adequate incision closure.

Performance Assessment of Suture Number in Juvenile Chinook Salmon Implanted with Acoustic Transmitters: the Influence of Simulated Turbine Passage

Alison Colotelo

Abstract

Size reductions of acoustic transmitters implanted in migrating juvenile salmonids have resulted in the use of a shorter incision—one that may warrant only one suture for closure. The effects of turbine passage on migrating juvenile salmonids with single-suture incision closure have not been evaluated. It is not known if a single suture will sufficiently close the incision when fish are decompressed and outward pressure is placed on the surgical site. The objectives of this study were to evaluate five response variables in juvenile Chinook salmon subjected to simulated turbine passage. Fish were implanted with an acoustic transmitter (0.43 g in air) and a passive integrated transponder tag (0.10 g in air); incisions (6 mm) were closed with either one or two sutures. Following exposure, no transmitters were expelled. In addition, suture and incision tearing and mortal injury did not differ between treatment and control fish. Viscera expulsion was higher in treatment (12%) than control (1%) fish. The higher incidence of viscera expulsion through single-suture incisions warrants concern. Consequently, the authors do not recommend using one suture to close 6-mm incisions associated with acoustic transmitter implantation when juvenile salmonids may be exposed to turbine passage.

How Flow and Project Operations Affect Survival of Fish Passing McNary Dam: A multi-year analysis of survival data collected at McNary Dam, 2004-2009

Noah S. Adams, Christopher E. Walker, and Russell W. Perry

Abstract

From 2004-2009, the U.S. Geological Survey conducted radio and acoustic telemetry studies at McNary Dam. We analyzed this data with the goal of determining the major drivers of survival of fish using available passage routes.

For yearling Chinook salmon, 9,696 fish were detected passing McNary Dam. Of those, 1,321 went through turbine routes, 2,932 passed through the juvenile bypass system, and 5,443 passed the dam through the spillway. We detected 6,073 steelhead passing McNary Dam, and of those 375 fish went through turbines, 1,384 passed through the juvenile bypass system, and 4,314 passed the dam through the spillway. For subyearling Chinook salmon, 8,717 were detected passing the dam. Of those, 2,024 passed through turbines, 1,833 went through the juvenile bypass system, and 4,860 fish passed through the spillway. From 2004-2009 there were several thousand fish released in the tailrace of McNary Dam to serve as control fish, which were also included in our analysis.

To examine how environmental variables and dam operations influence survival of juvenile salmonids passing through McNary Dam, we incorporated individual covariates into Cormack-Jolly-Seber release-recapture models. Environmental variables such as discharge, percent spill, photoperiod, fish weight, and water temperature were included in analyses.

For subyearling Chinook salmon, water temperature was an important variable explaining variation in survival passing through all routes, but especially for fish passing through the juvenile bypass system and turbines. Survival predicted by water temperature ranged from 0.486 at the highest temperature to 0.899 at the lowest temperature for fish passing through turbines. Survival predicted by water temperature ranged from 0.548 at the highest temperature to 0.972 at the lowest temperature for fish passing through the juvenile bypass system. Survival estimates predicted by water temperature for fish that passed the dam through the spillway or that were released in the tailrace ranged from about 0.75 to 0.98. River discharge was also an important variable describing variation of survival and was positively related to survival for fish passing through the spillway. The interaction of discharge and percent spill influenced survival through turbines. Survival through the juvenile bypass system was best explained solely by tailrace water temperature. Since subyearling Chinook salmon are known to residualize in some reaches of the Federal Columbia River Power System, we caution that our analysis quantifies the influence of environmental variables on the joint probability of both surviving and migrating through the study area. The relationship between environmental variables and survival of yearling Chinook salmon and steelhead will also be discussed, as well as a thorough examination of the major factors influencing which passage route fish travel through.

How Fish Pass McNary Dam: A multi-year synthesis and analysis of passage and behavior data collected at McNary Dam, 2006-2009

Noah S. Adams

Abstract

Between 2006 and 2009, the U.S. Geological Survey conducted acoustic telemetry studies at McNary Dam to obtain approach, passage, and survival information about yearling and subyearling Chinook salmon and juvenile steelhead released 18 km upstream from the dam. We also collected fish passage and behavior data from acoustic-tagged fish released at dams in the Mid-Columbia River by Grant County and Chelan County public utility districts. During this time the Temporary Spillway Weirs (TSWs) were installed (2007) and evaluated. Conducting studies over multiple years allowed us to examine TSW performance in various locations and during different operating conditions and river flows. Although the annual studies have provided valuable information, studies conducted in any given year must deal with the environmental conditions that nature delivers, which often leads to a narrow range of study conditions. Multi-year analyses are better suited to developing quantitative relationships than annual studies.

In 2010 we summarized results from 2006 through 2009 into a concise document to ensure that passage and survival metrics were consistently calculated and presented for all years and readily available for future reference to make management decisions at McNary Dam. One of the challenges we faced was to develop a way to summarize the behavior data from 11,012 yearling Chinook salmon, 6,055 steelhead, and 11,837 subyearling Chinook salmon. To accomplish this we explored both qualitative and quantitative tools. We applied a stochastic process (Markov chain) as a way to quantify fish behavior data and examine how environmental factors and dam operations influenced fish behavior. In this analysis, a probability matrix is used to describe the factors that have the largest influence on fish behavior at McNary Dam. Qualitatively, we used visualization software (EonFusion) as a way to summarize and present the results of the quantitative analysis. This software was also used to query and visualize fish behavior data within and across all four years of study. We will present highlights from our synthesis and analysis of the multi-year passage and behavior data collected at McNary Dam.

Evaluation of Juvenile Salmonid Gatewell Egress Using Updated Orifice Lighting Treatments at McNary Dam, 2010

Gordon A. Axel, Jesse J. Lamb, Benjamin P. Sandford, and Nathan D. Dumdei

Abstract

Artificial lighting in gatewell orifices is currently being utilized, in varying applications and intensities, at all Columbia and Snake River United States Army Corps of Engineers (USACE) projects. While previous studies have shown a variable response to light for each salmonid species, the literature suggests that improvements can be made with respect to orifice passage efficiency (OPE) if light intensity, wavelength, or directionality can be optimized in order to allow juvenile salmonids to find the orifice more readily. Pacific Northwest National Laboratory (PNNL) personnel developed and fabricated a light ring that fit around the outer circumference of the existing 12" orifice in gatewell 6B (south orifice) at McNary Dam. NOAA Fisheries Pasco staff collaborated with the design and fabrication a track system to lower, retrieve, and position the light ring.

We evaluated three treatments to determine if there was a difference in gatewell egress associated with each: 50 lux, 300 lux, and light off. The light ring utilized for this study directed the majority of the light inward with a glow projected outward into the gatewell. Prior to fish releases, a light meter was used to measure the output of the light ring in order to set the output to the desired treatment. As turbidity increased, the amount of output required to meet each treatment varied slightly as we observed low turbidity for most of the study period, especially during the spring. PIT-tagged groups of fish were released via hose behind the trash rack for entrainment into the gatewell of turbine unit 6B. Tagged fish were allowed to move out of the gatewell, volitionally passing through the orifice during each prescribed treatment, and into the orifice trap where two in-line PIT detectors recorded subsequent PIT-tag detection. We released fish for one light treatment per day, during both the morning and evening, and monitored detections for each group over a 12-hour period. For each fish group released, we estimated mean passage time from release until first detection in the orifice trap. Estimates were made by modeling passage distributions using time-to-event methods. The models included three factors [Week (1-6), Diel (Day/Night) and Treatment (300L, 50L, and Off)] and three covariates (Fish fork length, Turbidity, and Unit Flow). An information-theoretic method, Akaike Information Criterion (AIC), was used to determine which set of factors and covariates were best supported by the data. Prediction of 50% passage was estimated for each cohort from the model-averaged individual estimates, and averages calculated for factor interactions supported by the data.

The presence of light at the orifice influenced juvenile salmonid gatewell egress for yearling and subyearling Chinook salmon, sockeye salmon, and juvenile steelhead. Sample sizes for coho salmon were insufficient for analysis. While there was not a large difference between the lighted treatments, there was a significant reduction in gatewell egress when compared to the light off treatment. Diel results revealed a significant reduction in passage delay during the night and during periods of higher turbidity during the last week of May and the first couple of weeks of June.

Evaluation of Juvenile Salmonid Condition (Descaling) Under Different Turbine Operating Conditions at McNary Dam, 2010

Gordon A. Axel, Michael H. Gessel, Eric E. Hockersmith, Benjamin P. Sandford, and Jesse J. Lamb*

Abstract

The objective of this study was to test for significant differences in descaling rates of steelhead, yearling and subyearling Chinook salmon, coho salmon and sockeye salmon exposed to extended length bar screens (ESBS) and gatewells between two turbine operations. The two turbine operations tested were the Best Operating Point (BOP; 13,300-15,000 cfs) versus the upper end of the 1% operating limit (1%; 11,600-12,400 cfs). Descaling rates tend to be influenced by temporal-related factors such as stock differences, smoltification levels, debris load, and previous migration history; as well as factors such as turbine unit, turbine operation, and experimental handling. In order to compare descaling rates between operational treatments, we measured descaling simultaneously in two turbine unit intake slots (4A and 5A) with one unit operated at the BOP and the other at the upper end of the 1% operating limit. To account for a possible "unit effect", we switched treatments between units every other night. Therefore, each two-day two-unit "block" resulted in a paired test of descaling rates between BOP and 1%.

The analysis utilized logistic regression to model descaling through time because there was an interaction between unit, operational treatment, and time. Factors included in the model were unit operational treatment (BOP or 1%) date, and head differential. We also included two-way interactions between these four variables. We used quasi-likelihood Akaike Information Criterion (QAIC) to compare the models. For each model in the "candidate set", this approach estimated QAIC as twice the log-likelihood from the logistic regression adjusted for sample size, number of model parameters, and estimated binomial over-dispersion. The models were ranked by QAIC and compared using the difference from the model with minimum QAIC. We then model-averaged the models differing by less than 2.0 from the best model by constructing a weighted average across predicted values where the weights were the respective Akaike weights. The candidate set of models ranged from the largest with both factors, both covariates, and all two-way interactions, to the smallest with just the Unit factor. Since Unit was essentially a nuisance factor in this analysis, we included it in all models. From the model-averaged results, we constructed plots of the estimated descaling rates through time for Unit 4A and Unit 5A each operating at BOP and 1%. Empirical values were compared with calculated model-averaged estimated descaling rates. Results from empirical and model-averaged data determined a 2.0 % higher descaling rate for yearling Chinook salmon and 3.8% higher descaling rate for subyearling Chinook salmon that entered the gatewell under the BOP treatment. Descaling rates for sockeye salmon were similar under the BOP and 1% operational treatments. Sample sizes of steelhead and coho salmon were insufficient for analysis.

Estimates of Direct Effects of Passage through John Day Dam Spillway 20 with an Extended Flow Deflector on Juvenile Chinook Salmon

Joanne L. Fulmer

Abstract

Background
The primary objective of this investigation was to evaluate the performance of Spillbay 20 equipped with a 50 ft radius extended (50 ft) flow deflector with respect to passage survival and condition of chinook salmon smolts at two (2.4 and 4.0 kcfs) spill volumes. The statistical criterion of the study was to release a sufficient number of fish to (1) detect a difference of ≥ 5%, 95% of the time between treatments (spill volume of 2.4 and 4.0 kcfs) (2) obtain a precision (ε) on survival and injury estimates within ± 2.5%, 95% of the time.

Methods
A total of 602 treatment fish (300 at 2.4 kcfs, 302 at 4.0 kcfs) were released using the HI-Z tag recapture technique. The total length for the treatment fish ranged from 119 to 164 mm with an average length of 135 mm. No control fish were released. Fish were released so their projected path was 4 ft above Spillbay 20 crest.

Results
The recapture rate (physical retrieval of alive and dead fish) ranged from 97.6 to 97.0% for 2.4 and 4.0 kcfs, respectively. Average retrieval times at 2.4 and 4.0 kcfs were 13.8 min and 11.4 min. The 48 h survival estimates were 99.3% at 2.4 kcfs, and 98.3% at 4.0 kcfs. Precision (ε) on survival estimates for the 2.4 and 4.0 kcfs was within ± 2.5%, 95% of the time and met the prespecified criterion. Difference between the two survival estimates was not significant ($P > 0.05$). The number of fish (16, 5.5%) with passage related visible injuries was identical at the two discharge flows. The respective malady-free (free of visible injuries, scale loss > 20% per side, and loss of equilibrium) estimates were 94.5% and 93.9% for the 2.4 and 4.0 kcfs. The desired precision on the malady-free estimates was achieved and the estimates were not significantly different.

Passage through Spillbay 20 appears to be relatively benign. However, the survival and malady-free rates were slightly lower than those reported for Spillbay 17 (survival 100%, malady-free 96.7%) with a conventional flow deflector and spill volume of 6.2 kcfs. The differences could be due to higher spill volume (6.2 kcfs at Spillbay 17). Hydraulic data recorded on concurrently released Sensor Fish for both studies (Spillbay 17 and 20) indicated that hydraulic conditions were better at the flow deflector interception area for Spillbay 20, with the larger turning radius (50 ft Spillbay 20 versus 15 ft Spillbay 17). The small tainter gate opening for the present study (1.2 and 2.0 ft for 2.4 and 4.0 kcfs spill) did force the fish to be close (within 2 ft) to the spillbay concrete surface and thus increase the chances of physical contact. Also, 20% of the sensor fish collided with the gate at the 1.2 ft opening.

Sensor Fish Characterization of Fish Passage Conditions through John Day Dam Spillbay 20 with a Modified Flow Deflector

Joanne Duncan

Abstract

Fish passage conditions over a modified deflector in Spillbay 20 at John Day Dam were evaluated by Pacific Northwest National Laboratory using Sensor Fish devices. The objective of the study was to describe and compare passage exposure conditions at a 2.4 kcfs spill discharge at low tailwater levels, and 2.4 and 4.0 kcfs spill discharges at normal tailwater levels, identifying potential regions within the passage route that might cause fish injury or mortality within the routes.

Sensor Fish device releases were interspersed with balloon tagged live fish releases using equivalent methods during the normal tailwater evaluation; low tailwater passage conditions were assessed using Sensor Fish only. Sensor Fish and live fish were deployed at an elevation of 215 ft above mean sea level, determined using a computational fluid dynamics model. Release depth and position were established to introduce the fish and sensors into flow of approximately 5 to 8 fps and were projected to pass 4 ft above the crest of Spillbay 20.

Significant acceleration events (|a|>95g) characterized as collision and/or shear during spillway passage were tabulated. Nearly all Sensor Fish significant events were classified as collisions; the most severe occurred at the gate, on the spillbay chute, or at the deflector transition. Collisions in the gate region were observed only during the 2.4-kcfs discharge, when the tainter gate was open 1.2 ft. One shear event was observed by Sensor Fish during the evaluation, occurring at the deflector transition during passage at the 2.4-kcfs discharge at low tailwater.

The percentage of Sensor Fish experiencing a significant event during passage during normal tailwater levels increased with spill discharge—67% at the 2.4-kcfs discharge and 80% at the 4.0-kcfs discharge; 88% of the Sensor Fish experienced a significant event during the 2.4-kcfs, low-tailwater condition.

The mean acceleration magnitude for significant events observed during normal tailwater conditions at the 2.4-kcfs and 4.0-kcfs discharge averaged 125.9 *g* and 123.3 *g*, respectively, essentially equivalent values. Significant event values averaged 141.8 *g* during the low tailwater condition.

Contrasting passage exposure conditions, the 2.4-kcfs low-tailwater treatment would be most deleterious to fish survival and well-being.

The Lower Columbia River Survival Study: An Introduction

M. Brad Eppard[1], Tom Carlson[2], John R. Skalski[3], Mark Weiland[2], Gene Ploskey[2], Derrek Faber[2], Christa Woodley[2], James Hughes[2], and Gary Johnson[2]

Abstract

The Lower Columbia River Survival Study utilized acoustic-tagged juvenile salmonids to estimate survival in the Columbia River from river km 390 near Arlington, Oregon to river km 113 near Kalama, Washington. Within this 277 km reach, this study provided estimates of dam-passage survival for yearling and subyearling Chinook salmon and juvenile steelhead at John Day, The Dalles, and Bonneville dams. This study was the culmination of multiple years of planning including: development and refinement of the Juvenile Salmon Acoustic Telemetry System; standardization of study methods and metrics; development of the Virtual Paired Release survival model and supporting software and documentation; as well at the development of a study design that incorporates the most recent advancements in knowledge to minimize potential bias in estimating survival with active tag technology.

The primary objective for study at John Day Dam was the evaluation of 30 and 40% spillway flow using passage distribution, efficiency, and timing metrics and survival to compare the two treatments. In addition, this study evaluated the performance of relocated spillway weirs, the modified spillway deflector in Spillbay 20, and the efficacy of the completed tailrace avian wire array. The primary objective at The Dalles Dam was to estimate dam passage survival to assess compliance with the 2008 NOAA Fisheries Biological Opinion Juvenile Dam Passage Performance Standards. This study represented year one of a two year study. The primary objective at Bonneville Dam was to estimate survival across the entire project in spring, and to evaluate two alternative spillway operations during the summer migration of subyearling Chinook salmon. The summer spill treatment test compared a treatment of 85 kcfs daytime spill and 120 kcfs nighttime spill with an alternative treatment of 95 kcfs 24 h spill.

[1] US Army Corps of Engineers, Portland District
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[3] University of Washington, Columbia Basin Research

James Hughes, Gene Ploskey, Mark Weiland, Christa Woodley and Thomas Carlson

Abstract

Juvenile Salmon Acoustic Telemetry System (JSATS) acoustic tags used in the 2010 Columbia River three dam survival study were manufactured by Advanced Telemetry Systems. Each tag averaged 12.02 mm in length, 5.21 mm in width, and 3.72 mm in thickness, and weighed 0.438 g in air. Tags were programmed with a transmission rate of 1 pulse every 3 seconds at a source level of 156 dB. Expected tag life was approximately 23 days, but mean tag life was 33.13 days in spring and 35.54 days in summer. Collection of tagging candidates (yearling Chinook salmon and steelhead in spring, and sub-yearling Chinook salmon in summer) occurred at the John Day Dam smolt monitoring facility during normal facility collection events. Tagging candidates were assessed for condition and acceptable fish were held 18 - 24 hours overnight prior to tagging.

The tagging procedure began with fish being placed in an 18.9-L "knockdown" bucket with an 80 mg/L solution of MS-222 (tricaine methanesulfonate). Once a fish lost equilibrium a PIT and acoustic JSATS tag were assigned and length, weight, and condition comments noted. During the surgical process the fish was placed ventral side up and a gravity-fed anesthesia line supplied a 40 mg/L maintenance solution of MS-222. Using a scalpel a 6-8mm incision was made along the linea alba between the pelvic girdle and pectoral fins and both the PIT and acoustic tags were anteriorly inserted. The incision was closed with a 5-0 monofilament suture. Fish were allowed to recover for 18-24 hrs in an 18.9-L light occlusive bucket before being released.

Fish were released daily from April 28 to June 1, 2010 in spring and June 13 to July 17, 2010 in summer at three release sites. For both spring and summer there were 35 consecutive days of release, alternating daily between day and night. Timing of releases at downstream sites was scheduled to ensure adequate mixing of fish in river reaches common to fish from upstream sites. The number of fish released at each site is listed in Table 1 and time of release is listed in Table 2.

Table 1. Numbers and runs of fish released at three sites in the Lower Columbia River.

	Yearling Chinook	Steelhead	Sub-Yearling
Roosevelt, WA (rkm 390)	2,287	2,288	2,849
The Dalles, OR (rkm 307)	796	799	800
Hood River (rkm 275)	797	798	800
Total	**3,880**	**3,885**	**4,449**

Table 2. Relative release times for series starting during the day and at night.

Release Location	Relative Release Times	
	Daytime Start	Nighttime Start
R_1 (Rkm 390)	Day 1: 0900 h	Day 2: 2000 h
R_2 (Rkm 305)	Day 3: 2000 h	Day 5: 0900 h
R_3 (Rkm 275)	Day 4: 0900 h	Day 5: 2200 h

Lower Columbia River Study: Fish Condition Assessment

Christa M. Woodley[1], Ann L. Miracle[2], Scott M. Carpenter[3], Kasey M. Knox[1], Katie A. Wagner[2], Mark A. Weiland[3], Thomas J. Carlson[1]

Abstract

The goal of this integrated three-dam study is to evaluate the overall performance of structural and operational improvements designed to benefit juvenile salmonids by estimating dam passage survival and associated metrics for yearling and subyearling Chinook salmon and steelhead and to compare these estimates against performance standards for John Day, The Dalles, and Bonneville dams, as stipulated in the 2008 Federal Columbia River Power System Biological Opinion (FCRPS BiOp) and the 2008 Columbia River Fish Accords. As the species move across a heterogeneous environment, both natural and manmade, the question of individual fish condition, loss and gain, movements and behavior are essential to survivorship models. As explained in *Statistical Design for the Lower Columbia River Acoustic-Tag Investigations of Dam Passage Survival and Associated Metrics* by Skalski (2009), there are 10 assumptions, one of which, A1, requires that marked individuals are a representative sample from the population of inference. In the past, this assumption was recognized and addressed during the study by selecting fish that appeared representative of the population by using a set of rejection criteria established by professional opinion. In the past, this assumption (A1) was tested by conducting length: weight frequency analyses of fish selected for tagging whether tagged or not tagged. In the 2010 Lower River Study, we addressed this assumption by assessing both the run-of-the-river and fish selected for tagging, and monitoring surgeon performance and tag effects on temporal and spatial scales.

[1]Marine Biotechnology Group
[2]Biomarkers for Health and Environmental Sustainability
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Lower Columbia River Survival Study, 2010: Passage Behavior and Survival at John Day Dam

Mark Weiland, Gene Ploskey, Daniel Deng, James Hughes, Christa Woodley, and Thomas Carlson

Abstract

Survival was estimated for yearling Chinook salmon and steelhead smolts during spring and subyearling Chinook salmon during summer 2010 at two spill treatment levels, 30% and 40% of total project discharge. The study estimated smolt survival from a virtual release at John Day Dam (JDA) (Rkm 349) based on a single-release-model design and subsequent detections at three survival-detection arrays located at The Dalles Dam (Rkm 309), near Hood River, OR (Rkm 275), and at Bonneville Dam (Rkm 234). We also estimated median forebay residence time, median tailrace egress time, and spill passage efficiency. The Juvenile Salmon Acoustic Telemetry System (JSATS) tag model number ATS-156dB, weighing 0.438 g in air, was used in this investigation. Fish were tagged with JSATS acoustic tags and PIT tags at the JDA Smolt Monitoring Facility (SMF) and were released daily along a line transect across the Columbia River near Roosevelt, WA (rkm 390). Fish detected at the JDA forebay entrance array or the dam face were regrouped to form virtual releases for those locations. A total of 2,287 yearling Chinook salmon, 2,288 steelhead smolts, and 2,849 subyearling Chinook salmon were tagged and released for the investigation. Length of tagged fish comported well with lengths of untagged fish sampled at the JDA SMF. Study results are summarized in table below; subyearling Chinook salmon data will be presented at the AFEP review.

Performance Measures	Yearling Chinook Salmon	Steelhead
Dam-face-passage to TDA Survival	0.947 (SE= 0.008)	0.961 (SE = 0.008)
30% Spill	0.943 (SE = 0.010)	0.943 (SE = 0.010)
40% Spill	0.952 (SE = 0.009)	0.976 (SE = 0.008)
Forebay Entrance array to TDA Survival	0.944 (SE = 0.008)	0.958 (SE = 0.008)
30% Spill	0.937 (SE = 0.010)	0.939 (SE = 0.010)
40% Spill	0.950 (SE = 0.009)	0.975 (SE = 0.009)
100 m Forebay Residence Time (median hours)	0.60 (SE = 0.186)	1.35 (SE = 0.450)
30% Spill	0.81 (SE = 0.263)	1.72 (SE = 0.721)
40% Spill	0.59 (SE = 0.352)	1.35 (SE = 0.607)
Tailrace Egress Time (median hours)	0.61 (SE = 0.350)	0.54 (SE = 0.453)
30% Spill	0.61 (SE = 0.109)	0.54 (SE = 0.360)
40% Spill	0.59 (SE = 0.411)	0.53 (SE = 0.505)
Spill Passage Efficiency[1]	0.897 (SE = 0.011)	0.889 (SE = 0.011)
30% Spill	0.915 (SE = 0.012)	0.879 (SE = 0.014)
40% Spill	0.881 (SE = 0.015)	0.902 (SE = 0.012)

[1] Spill passage efficiency was calculated by dividing the number of fish that passed through the spillway by the number that passed through the entire dam.

Lower Columbia River Survival Study, 2010: Passage Behavior and Survival at The Dalles Dam

John Skalski, Tom Carlson, Gene Ploskey, Fenton Kahn, and Gary Johnson

Abstract

The purpose of this compliance study was to estimate dam passage survival of yearling and subyearling Chinook salmon and steelhead smolts at The Dalles Dam during 2010. Under the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp), dam passage survival should be greater than or equal to 0.96 and estimated with a standard error (SE) less than or equal 0.015. The study also estimated smolt passage survival from the forebay 2 km upstream of the dam to the tailrace 2 km below the dam2, as well as the forebay residence time, tailrace egress time, and spill passage efficiency, as required in the Columbia Basin Fish Accords. A virtual/paired-release design was used to estimate dam passage survival at The Dalles Dam. The approach included releases of acoustic-tagged smolts above John Day Dam that contributed to the formation of a virtual release at the face of The Dalles Dam. A survival estimate from this release was adjusted by a paired release below The Dalles Dam. A total of 3,880 yearling and 4,449 subyearling Chinook salmon and 3,885 steelhead smolts were tagged and released in the investigation. The Juvenile Salmon Acoustic Telemetry System (JSATS) tag model number ATS-156dB, weighing 0.438 g in air, was used in this investigation. The study results are summarized in the following tables. Data for subyearling Chinook salmon will be presented at the AFEP 2010 Annual Meeting.

Table ES.1. Estimates of Dam Passage Survival[3] at The Dalles Dam in 2010

Project	Year	Yearling Chinook Salmon	Steelhead
The Dalles Dam	2010	0.9641 (SE = 0.0096)	0.9534 (SE = 0.0097)

Table ES.2. Fish Accords Performance Measures at The Dalles Dam in 2010

Performance Measures	Yearling Chinook Salmon	Steelhead
Forebay-to-tailrace survival	0.9620 (SE = 0.0097)	0.9526 (SE = 0.0097)
Forebay residence time	0.40 h (SE = 0.014)	1.88 h (SE = 0.253)
Tailrace egress rate	0.84 h (SE = 0.138)	0.97 h (SE = 0.211)
pill passage efficiency[4]	0.8407 (SE = 0.0081)	0.8765 (SE = 0.0073)

[2]The forebay-to-tailrace survival estimate satisfies the "BRZ-to-BRZ" survival estimate called for in the Fish Accords.

[3] Dam passage survival is defined as survival from the upstream face of the dam to a standardized reference point in the tailrace.

[4] By definition in the Fish Accords, SPE includes the spillway and the ice and trash sluiceway at The Dalles Dam. However, the point estimate provided includes only spillway passage, not sluiceway passage because detailed 3-D tracking and route-of-passage assignments other than powerhouse versus spillway have not yet been finalized.

Lower Columbia River Survival Study, 2010: Passage Behavior and Survival at Bonneville Dam

Gene Ploskey*, Derrek Faber, and Thomas Carlson

Abstract

The purpose of this study was to estimate the survival of yearling Chinook salmon and steelhead smolts during spring and of subyearling Chinook salmon during summer 2010 in a portion of the Columbia River that includes Bonneville Dam (BON) and its tailwater. The study estimated smolt survival from a virtual release at BON based on a single-release-model design and subsequent detections at three survival-detection arrays located 81, 121, and 148 km downstream of the dam. There were no reference releases of fish downstream of BON in 2010. We also estimated median forebay residence time, median tailrace egress time, and spill passage efficiency. The Juvenile Salmon Acoustic Telemetry System (JSATS) tag model number ATS-156dB, weighing 0.438 g in air, was used in this investigation. Fish were tagged with JSATS acoustic tags and PIT tags at the John Day Dam (JDA) Smolt Monitoring Facility (SMF) and were released daily along a line transect across the Columbia River near Roosevelt, WA (rkm 390), The Dalles Dam (TDA) tailrace (rkm 307) and near Hood River, OR (rkm 275). Fish detected at the BON forebay entrance array or at the dam face were regrouped to form virtual releases for those locations. A total of 3,880 yearling Chinook salmon, 3,885 steelhead smolts, and 4,449 subyearling Chinook salmon were tagged and released for the investigation. Length of tagged fish comported well with lengths of untagged fish sampled at the JDA SMF. Single release estimates of virtual release survival based on fish from the three release locations did not differ significantly in spring, so fish from all three release sites were used to form virtual releases. In summer, virtual release survival rates were significantly lower for the Roosevelt release than for the TDA tailrace and Hood River releases so we only regrouped fish from the TDA tailrace and Hood River to create virtual releases of subyearlings in summer. Three dimensional tracking of fish to assign routes of passage has not been completed, but eventually will provide route-specific survival estimates as well. There was a spill-treatment test in summer 2010, and dam operators delivered 10 randomly ordered pairs of treatments exactly as prescribed in the study design after flows declined enough to afford them sufficient control. Daily treatments consisted of 24 h of 95,000 cfs spill or 85,000 cfs day and 121,000 cfs night spill. Effects of spill treatments will be evaluated as soon as 3-D tracking and route-of-passage assignments have been made. Performance metrics that could be calculated by the abstract deadline are tabled below:

Performance Measures	Yearling Chinook	Steelhead	Subyearling Chinook
Forebay Entrance array to rkm 153 Survival	0.9631 (SE= 0.0076)	0.9564 (SE= 0.0083)	0.9555 (SE= 0.0053)
Dam-face-passage to rkm 153 Survival	0.9637 (SE= 0.0078)	0.9567 (SE= 0.0082)	0.9576 (SE= 0.0055)
100 m Forebay Residence Time (median hours)	0.17 (SE= 1.080)	1.72 (SE= 0.610)	Not yet available
Tailrace Egress Time (median hours)	0.53 (S = 0.210)	0.47 (SE= 0.526)	Not yet available
Spill Passage Efficiency[5]	0.518 (SE = 0.014)	0.395 (SE = 0.015)	Not yet available

[5] Spill passage efficiency is estimated by the number of fish that passed through the spillway divided by the number that passed through the entire dam.

A Study of Salmonid Survival and Behavior through the Columbia River Estuary Using Acoustic Tags; Fixed Arrays

Geoffrey McMichael[1], Ryan Harnish[1], Kenneth Ham[1], Jina Kim[1], John Skalski[2], Cindy Studebaker[3]

Abstract

To better understand the survival of juvenile salmonid smolts passing through the lower 235 km of the Columbia River and estuary, downstream of the Federal Columbia River Power System (FCRPS), we deployed arrays of Juvenile Salmon Acoustic Telemetry System (JSATS) autonomous receivers to detect JSATS acoustic-tagged fish after they passed Bonneville Dam. Most effort was focused on the lower 50 km of the estuary between Three-tree Point (rkm 50) and the mouth of the river. In addition, a pilot- scale array was deployed in the Columbia River plume. A total of 3,418 Yearling Chinook salmon (CH1), 3,441 steelhead (STH), and 3,505 subyearling Chinook salmon (CH0) were formed into weekly virtual releases of JSATS-tagged fish based on detections at Bonneville Dam (rkm 236). CH1 and STH tended to travel the 235 km between Bonneville Dam and the mouth of the river in 3 to 4 days. CH0 transited the lower 235 km of the river in 3 to 4.25 days, with later groups moving more slowly. Preliminary estimates of CH1 survival in 2010 showed approximately 93% survival from Bonneville Dam to Three-Tree Point at Rkm 50, with sharp declines to the next two arrays at Astoria Bridge (Rkm 22; 86% survival) and East Sand Island (Rkm 8; 80% survival). STH survival to the ocean was again poor in 2010, with a very sharp decline in the final 50 km of the estuary. STH survival from Bonneville Dam to Rkm 50 was 88% and from Bonneville Dam to Rkm 8 was 55%. CH0 survival was relatively high in 2010 but was also lowest in the final 50 km of the river. An estimated 89% survived from Bonneville Dam to Rkm 50 and an estimated 81% survived to Rkm 8. The pilot-scale deployment of 20 autonomous receivers in the Columbia River plume recorded detections of 1,841 JSATS-tagged juvenile salmonids between late April and early August 2010. Most of the CH1 and STH were detected on our 'terminus' line of receivers (15 km off CR mouth). Most of the CH1 and STH that did not pass the terminus array were detected passing the south line prior to mid-May, while that shifted northward during periods between mid-May and mid-June. Most CH0 were detected on the north line, with similar proportions of the remainder being detected on the terminus and south arrays. CH1 and STH had median travel times from rkm 8 to the plume array between 5 and 18 h, with STH moving faster than CH1. CH0 moved more slowly out of the river, with travel times between rkm 8 and the plume array ranging between 0.6 and 2 days. Route assignments and survival estimation of groups of fish with similar passage histories (e.g., passed the lower three dams via surface spill routes) are underway and will be presented at the Annual Review.

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[3]US Army Corps of Engineers, Portland District

Sampling to Detect Juvenile PIT-Tagged Salmonids with a Surface Pair-Trawl in the Columbia River Estuary, 2010

Robert J. Magie[1], Matthew S. Morris[1], Amy L. Cook[1], Richard D. Ledgerwood[2], and Gene M. Matthews[2]

Abstract

In 2010, we sampled in the upper Columbia River estuary (rkm 61 to 83) for migrating juvenile salmonids tagged with passive integrated transponder (PIT) tags. A surface pair trawl was used to guide fish through a specialized underwater PIT-tag antenna. The 6-detection coil 'matrix' antenna system used in 2010 measured 3.0 m tall x 2.6 m wide and weighed about 455 kg in air.

Between March and August, we sampled for 902 h and detected 31,325 PIT-tagged fish. This was the highest annual detection total in the estuary to date. Intermittent sampling began on 23 March, and sample effort gradually increased until 30 April-15 June when 2 daily shifts were used during a period when an estimated 87% of all out-migrating inriver PIT-tagged fish passed through the estuary. Sampling continued with a single daily shift until 4 August, targeting primarily subyearling fall Chinook salmon. In total, we detected 17,161 spring/summer Chinook salmon, 2,859 fall Chinook salmon, 646 coho salmon, 9,323 steelhead, 640 sockeye salmon, 1 cutthroat trout, and 695 tags with unknown release information. During the two-shift sample period, we detected 3.7% of the yearling Chinook salmon and 4.1% of steelhead previously detected at Bonneville Dam which are rough measures of sample efficiency. We also detected similar proportions of fish released from transport barges just downstream from Bonneville Dam.

Data collected with the pair-trawl PIT-tag detection system were used to calculate the reach survival estimates from upstream dams to below Bonneville Dam. The mean estimated survival rates (S.E.) for non-transported yearling Chinook salmon and steelhead from the tailrace of Lower Granite Dam to the tailrace of Bonneville Dam in 2010 were 57% (3.1%) and 61% (2.9%), respectively.

Experimental sampling with a mobile separation by PIT-tag code (MSbyC) vessel fixed to the estuary trawl was conducted intermittently in 2010 to evaluate the prototype system's effectiveness. We diverted to holding 67 PIT-tagged fish. Each PIT-tagged fish was measured for length and condition was evaluated. We periodically sampled fish passing through the trawl to evaluate temporal species composition, size and fish condition, these included: 696 Chinook salmon, 69 coho salmon, 46 steelhead, 177 sockeye salmon, 46 chum salmon, 2 juvenile lamprey, 8 juvenile shad and 8 other species.

[1]NOAA, Pacific States Marine Fisheries Commission
[2] NOAA, Northwest Fisheries Science Center

Using Program ROSTER to Assess the Effect of Bypass Passage on Adult Returns

Rebecca Buchanan[1], John Skalski[1], and Kenneth Ham[2]

Abstract

Eleven years of PIT-tag detection data from hatchery spring and summer Chinook salmon and steelhead from the Snake River were analyzed to assess whether bypassed fish had lower adult return rates than fish that passed dams via the spillway or turbines. For each annual release group from 1996 to 2006, the ROSTER (River-Ocean Survival and Transportation Effects Routine) model was used to predict the number of adults expected to be detected at Lower Granite Dam for each possible pattern of juvenile detections and non-detections at the FCRPS dams, under the assumption that bypassed and non-bypassed fish had common adult return rates. Comparisons between the observed and expected numbers of adult returns was used to determine whether juvenile bypass history was associated with reduced adult return rates.

Both yearling Chinook salmon and steelhead that were never detected as juveniles consistently produced more adults than expected had there been no bypass effects on survival ($P \leq 0.0001$). Yearling Chinook salmon that were bypassed at least once as juveniles produced fewer adults than expected if no bypass effects existed ($P \leq 0.0872$). Steelhead bypassed two or more times also produced fewer adults than expected ($P \leq 0.0004$), while those steelhead bypassed only once showed no reduction in adult return rates ($P=0.5577$). The model-bsaed ROSTER results were supported by a less sensitive model-free analysis.

The PIT-tag analysis found little evidence to suggest that yearling Chinook salmon bypassed at Lower Granite Dam had reduced adult return rates compared with non-bypassed smolts. However, there was evidence that steelhead bypassed at Lower Granite Dam experienced reduced adult return rates. Bypass at Little Goose Dam had a consistent negative effect on adult returns of yearling Chinook salmon, but no obvious effect on steelhead adult returns. Bypass at Lower Monumental Dam was associated with reduced adult return rates for both Chinook salmon and steelhead. Smolts bypassed at McNary Dam tended to return as adults at lower than expected rates, but only if they were also detected at another dam. Bypass at McNary alone did not reduce the number of returning adults observed.

[1]University of Washington, Columbia Basin Research
[2] Pacific Northwest National Laboratories

Wednesday – December 1, 2010			
Estuary Studies			
0905	Contribution of Tidal Fluvial Habitats in the Columbia River Estuary to the Recovery of Diverse Salmon ESUs	Dan Bottom	NOAA
0925	Migratory Pathways and Survival of Juvenile Salmonids in the Lower Columbia River Estuary, 2010	Ryan Harnish	PNNL
0945	Use of Acoustic Mobile Tracking to Evaluate Timing, Behavior, and Fate of Juvenile Salmonid Migrants Through the Lower Columbia River and Estuary, 2010	Lynn McComas	NOAA
1005	Initial Results from the 2010 COAST (formerly POST) Study: Downstream and Early Marine Survival and Movements of Yearling Chinook Salmon	David Welch	Kintama
1025	Post Construction Assessment of Fishes, Habitats and Tide Gates in Sloughs on the Mainland	Jeffrey Johnson	USFW
1105	Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary	Heida Diefenderfer	PNNL
1125	Evaluating Cumulative Ecosystem Response to Habitat Restoration Projects in the Lower Columbia River and Estuary	Ronald M. Thom	PNNL
1145	Juvenile Salmon Ecology and Restoration of Tidal Freshwater Habitats	Nichole Sather	PNNL

Contribution of Tidal Fluvial Habitats in the Columbia River Estuary to the Recovery of Diverse Salmon ESUs

Daniel Bottom, Antonio Baptista, Lance Campbell, Edmundo Casillas, Susan Hinton, Regan McNatt, Curtis Roegner, Charles Simenstad, Lia Stamatiou, David Teel, and Jen Zamon

Abstract

In 2010 we initiated new surveys to determine the Columbia River estuary's contribution to salmon genetic and life history diversity and the implications for habitat restoration. Chinook salmon were sampled in each of three broad habitat types (main stem, backwater, and tributary confluence) in six of eight estuary hydrogeomorphic reaches (C – H) to establish genetic stock-group distributions across the entire tidal-fluvial portion of the estuary. Paired beach and purse seine samples also were collected at Point Adams Beach (reach A) biweekly from 18 March through 28 July to index outmigrant genetic and life history composition; beach seine samples (only) were continued at roughly monthly intervals thereafter. Size distributions in the tidal-fluvial estuary revealed that recently emerged Chinook salmon fry were distributed in most habitats in March and May but by July, few fish <50 mm were present. Whereas subyearlings sampled in March were not hatchery marked, a bimodal size distribution in May coincided with the appearance of large numbers of marked hatchery fish in the 70-80mm size class. Preliminary genetic survey results from March (Reaches C-F) and May (Reaches C-H) show that stock compositions of Chinook salmon juveniles are highly variable spatially and seasonally during juvenile migration. For example, while overall approximately 75% of all samples were estimated to be fall run fish from lower and mid-Columbia River sources, spring Chinook salmon juveniles predominated in some near-shore and off-channel sites during March. Subyearling Willamette River spring run fish comprised a substantial proportion (33%) of samples from Reach F, near the confluence of the Willamette River and were minor contributors in reaches C-E (10%-20%). Spring Chinook salmon subyearlings from the lower Columbia River ESU were more abundant in Reach C (20%) than in reaches D-F (3%-10%). Few fall run fish from the interior Columbia River basin were identified in March and May 2010 sampling in lower reaches, but 53% of the May catches in Reach H were from the Upper Columbia summer/fall stock group. Snake River fall run juveniles were a minor contributor to the Reach H catch in May (7%). These results are consistent with previous findings that interior Columbia River stocks are present later in the summer and are more prevalent above Reach E than at sites closer to the estuary mouth. Our initial results therefore underscore the need for estuary-wide surveys to fully describe the temporal and spatial distributions of salmon from different genetic stock groups.

We developed numerical grids for modeling physical habitat responses to selected management scenarios in the tidal fresh reaches of the estuary. We first created and rough-calibrated a numerical grid from the estuary mouth to Bonneville Dam and Willamette Falls. The grid was then extended to include the continental shelf to account for the influence of shelf winds. We are now refining the river-to-ocean grid with the benefit of high-resolution bathymetry (from LCREP) to provide detailed representation of secondary channels and intertidal flood plain regions. The first project-specific simulation database will be initiated in mid-November. Initial selection and modeling of restoration scenarios will target reach F to complement ongoing estuary classification and habitat assessment activities within this reach.

Migratory Pathways and Survival of Juvenile Salmonids in the Lower Columbia River Estuary, 2010

Ryan Harnish

Abstract

In an effort to better understand juvenile salmonid smolt losses in the lower 50 km of the Columbia River estuary, we examined migration characteristics of acoustic-tagged juvenile salmonids passing through this area during the spring and summer of 2010. We were interested in determining the primary migration pathways used by juvenile salmonids to migrate through the estuary and how use of different pathways influenced survival and travel time. Using data collected from over 70 acoustic telemetry receivers deployed off Three Tree Point (rkm 50), in Clifton Channel (rkm 53), off Harrington Point (rkm 37), in Grays Bay (rkm 34), in Taylor Sands (rkm 29), at the Astoria Bridge (rkm 22), near East Sand Island (rkm 8), and near the mouth of the river (rkm 3), we determined the percentage of yearling (CH1) and subyearling (CH0) Chinook salmon and steelhead (STH) that migrated through various routes from Three Tree Point to the Pacific Ocean. Of the fish detected at rkm 50 (including Clifton Channel), the majority of CH1 (89%), STH (84%), and CH0 (84%) were detected migrating downstream in the main navigation channel. The median travel time of CH1, STH, and CH0 that migrated in the main channel from rkm 50 to rkm 37 was about 5 hours, compared to about 12 hours for fish that migrated through the side channels of Cathlamet Bay. The probability of surviving from rkm 50 to rkm 37 was lower for STH that migrated in the main navigation channel (0.92 [SE=0.01]) compared to those that migrated through the side channels (0.99 [0.04]). However, the opposite was true for CH0; the probability of survival from rkm 50 to rkm 37 was 0.99 (0.01) for fish that migrated in the main channel and 0.95 (0.02) for fish that migrated through the islands. Of the fish detected at rkm 37, the majority of CH1 (90%), STH (85%), and CH0 (90%) were detected in or near the main navigation channel. However, of the fish detected at the Astoria Bridge, the majority of CH1 (68%), STH (50%), and CH0 (82%) were detected in the deep channel along the Washington shoreline, indicating that many fish crossed the shallow tidal flats of Taylor Sands between rkms 37 and 22. The median travel time for fish to migrate from rkm 37 to rkm 22 was about 12 hours for CH1 and CH0 and 10 hours for STH. Fish that migrated through Grays Bay travelled slowest (median = 13-15 hours) and those that migrated in the navigation channel from rkm 37 to rkm 22 travelled fastest (median = 5-10 hours). The probability of survival for CH1 and CH0 migrating from rkm 37 to rkm 22 was relatively high (> 0.95) through all routes, except for those fish that migrated through Grays Bay (CH1 = 0.88 [0.03]; CH0 = 0.85 [0.02]). Median travel times from rkm 22 to East Sand Island were lowest for CH1, STH, and CH0 that migrated from the Astoria Bridge in the Washington channel (2 hours), compared to those that migrated in the navigation channel (3-4 hours). The probability of surviving from rkm 22 to rkm 8 was highest for CH1 that migrated in the Washington channel (0.94 [0.01]) compared to those that migrated in the navigation channel (0.90 [0.02]). Survival of CH0 and STH from rkm 22 to rkm 8 was similar among channels.

Use of Acoustic Mobile Tracking to Evaluate Timing, Behavior, and Fate of Juvenile Salmonid Migrants Through the Lower Columbia River and Estuary, 2010

R. Lynn McComas

Abstract

Declining survival over the course of the yearling and subyearling Chinook salmon outmigration periods has prompted fate determination efforts to define specific areas where mortality occurs the lower Columbia River and estuary. Based on estimates obtained from stationary autonomous Juvenile Salmon Acoustic Telemetry System (JSATS) arrays from 2007 through 2009, the greatest percentage decline was concentrated in the lower estuary from Rice Island (Rkm 35.6) through the primary array location near West Sand Island (Rkm 8.3). In 2010, a vessel-mounted tracking unit providing real-time capability was used to identify mobile and stationary JSATS targets in the lower river and estuary. The goal of this effort was to locate areas of increased mortality as evinced by the presence of stationary targets resting on the substrate.

Four permanent stations were established in the lower estuary to provide a systematic sampling approach. Stations ranged from 2.3 to 7 km (mean = 5.18 km) in length and 216 m to 316 m (mean = 276 m) in width. Each station was sampled a 4 times during the yearling Chinook salmon outmigration period from 5 May through 10 June, and 4 times during the subyearling Chinook salmon outmigration period from 15 June through 29 July. Based on a Figure of Merit definition for the mobile-tracking unit (MT), sampling consisted of navigating the tracking vessel along transects spaced at 63 m intervals to cover each station. Accuracy of the vessel track along each transect was maintained using the chart-plotter track-error function. Reference transmitters were deposited randomly within each area to confirm the ability of the MT unit to detect tags on the substrate through time, and to provide indication of burial or movement rates of stationary transmitters.

A total of 368 JSATS-encoded targets (mobile and stationary) were identified using the MT in the lower river and estuary in 2010. Of these, 292 were from yearling Chinook salmon or steelhead, and76 were from subyearling Chinook salmon. Twelve targets from yearling Chinook salmon or steelhead and 5 targets associated with subyearling Chinook salmon were confirmed stationary in the lower estuary. Of the reference transmitters, none remained acoustically visible for more than 7 d, making quantitative analysis of results questionable.

Initial Results from the 2010 COAST (formerly POST) Study: Downstream and Early Marine Survival and Movements of Yearling Chinook Salmon

David Welch, Erin Rechisky, Aswea Porter, & Melinda Jacobs

Abstract

In 2010 the Coastal Ocean Acoustic Salmon Tracking (COAST) array extended from Lake Bryan (below Lower Granite Dam) to the mouth of the Columbia River, and ~2,300 km northward to SE Alaska. We used the array to estimate in-river and early marine survival of a random mixture of yearling Chinook smolts ≥130 mm FL captured at juvenile fish monitoring facilities at John Day (JDA) and Lower Granite (LGR) dams, and surgically implanted with Vemco V7 transmitters. Smolts tagged at JDA (n=790) were released ~40 km upstream of JDA, and smolts tagged at LGR were either released into the tailrace of LGR (n=380) or transported downstream and released below Bonneville Dam (BON, n=410) to test the validity of the differential delayed mortality hypothesis.

Consistent with previous years, travel time through the lower river and estuary was rapid for all three groups (2010 means =2.8-3.9 days), and travel time from the river mouth to Lippy Point (NW Vancouver Island; 485 km) was approximately one month (2010 means=31-36 days).

Estimated in-river survival of Columbia River smolts from release upstream of JDA to Astoria (near the river mouth; a distance of 365 km) was 66% (SE=2%); early marine survival from Astoria to Willapa Bay (63 km distant) was only 40%; early marine survival (from Astoria to Lippy Point; 548 km) was 10%. Minimum survival (i.e., % of total detected) from above JDA to Lippy Point (912 km total) was 7%.

In-river survival of Snake River smolts released at LGR to below BON (471 km) was 36% (SE=3%); lower river and estuarine survival to Astoria (201 km) was 92%; survival from Astoria to Willapa Bay was 68%, and early marine survival (from Astoria to Lippy Point) was 13%. Post-Bonneville survival to Lippy Point was 12%, and minimum survival of in-river migrating Snake River smolts from LGR to Lippy Point (1220 km total) was 4%.

Lower river and estuarine survival of Snake River transported smolts to Astoria was 74% (SE=3%). Survival from Astoria to Willapa Bay was 58%, and early marine survival from Astoria to Lippy Point was 17%. Minimum survival from release below BON to Lippy Point (750 km total) was 12%.

As preliminary estimates of post-Bonneville survival was 12% for both in-river and transported Snake River yearling Chinook, differential delayed mortality was not evident 750 km and >1 month beyond Bonneville Dam. This estimate is based on a mixture of Snake River smolts tagged at LGR. Post-Bonneville survival to Lippy Point of yearling Chinook released above JDA was 8.5%, therefore survival of a mixture of Upper Columbia & Snake River stocks tagged at JDA was comparable but slightly lower than a mixture of purely Snake River smolts tagged at LGR. Thus delayed mortality due to Snake River dam passage was also not evident. Standard errors on compound survival estimates will be reported at the meeting.

Post Construction Assessment of Fishes, Habitats and Tide Gates in Sloughs on the Mainland

Jeffrey R. Johnson

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. However, considerable uncertainty exists concerning appropriate restoration activities because the information necessary to determine the effectiveness of specific actions is lacking. The U.S. Fish and Wildlife Service is assessing an aquatic habitat restoration project at Julia Butler Hansen National Wildlife Refuge (JBH) to determine the effectiveness of the restoration and to provide information to managers on the utility of specific actions at future restoration sites. In 2009 and 2010, self-restrained tide gates were installed to replace top-hinge tide gates or were installed at sloughs that were closed at their historical mouth by a levee. These new tide gates are designed to provide habitat and fish passage benefits when compared to traditional tide gates. We collected base-line condition data at treatment and reference sloughs before construction (2007 - 2008) to describe fish passage opportunity, habitat parameters and fish community composition and found fundamental differences in fish communities and temperature regimes. Though juvenile salmonids would enter sloughs through the top-hinge tide gates, frequency was low when compared to control sloughs. One season of post-construction data was collected spring 2010 after three of the five new gates were installed. Two of these gates were installed in sloughs where a levee had previously closed off the historical mouth. Water temperature profiles within these two sloughs approached that of reference sloughs. Numerically, more salmon were captured in treatment sloughs after installation of the new tide gates. Confounding these results, more salmon were also captured in a control slough that continues to be disconnected from its historical mouth.

Evaluation of Life History Diversity, Habitat Connectivity, and Survival Benefits Associated with Habitat Restoration Actions in the Lower Columbia River and Estuary

HL Diefenderfer, GE Johnson, NK Sather, JR Skalski, EM Dawley, AM Colman, KG Ostrand, K Hanson, and D Woodruff

Abstract

During 2010 we continued research on indices for life history diversity, habitat connectivity, and the survival benefits of habitat restoration in the lower river and estuary. We implemented an experimental design incorporating PIT tag antenna arrays to test entrance propensity for juvenile salmon at shallow, off-channel habitats in tidal areas of the lower Columbia River. Three habitat strata in the study area on and near Cottonwood Island are included: main channel, off channel, and wetland channel. Additionally, the design addressed elements of life history diversity (LHD), habitat connectivity, and potential physiological effects of habitat strata. The field study was initiated in April and is expected to be completed in December; thus, experimental results at this time are preliminary. We PIT-tagged 9,000 fall Chinook at Kalama Falls hatchery and additional unmarked fish captured at the screw trap in Kalama River and in beach seines at Cottonwood Island. Water properties and other environmental data were collected in coordination with the Lower Columbia River Estuary Partnership's reference sites and ecosystem monitoring projects. Preliminary analysis of antenna array data in July indicated that < 1% of fish from the hatchery and screw trap releases were detected in the vicinity of Cottonwood Island. Direct releases to the lower Columbia River of tagged unmarked fish captured at the screw trap resulted in a 3.75% detection rate. Detections also included salmonids and northern pike minnow from other sources. Based upon preliminary lab analyses, physiological indicators of fish condition varied among habitats across the sampling period of April through July. We beach seined at Cottonwood Island approximately 1X/month at three main channel, three off-channel, and two wetland channel sites. Beach seine data will be utilized in conjunction with water level data to examine functional habitat connectivity for juvenile salmonids, and in further development of the LHD indices initiated by the project in 2009. While LHD is best described by a combination of species-specific attributes, we have focused our evaluation on metrics that are readily measured by field data collection efforts. Our quantitative evaluation of LHD centers on size of juvenile salmon, migration timing, genetic stock composition, and origin (i.e. marked and unmarked fish). We are evaluating these metrics at multiple scales (e.g., habitat and reach) within the estuary as well as in the context of historical datasets. We are also expanding the habitat connectivity index from the 2009 pilot-scale research to the estuary scale, including passage barrier accounting and the change in potential habitat area following all, site-scale hydrologic reconnection restoration activities for which information is available. Additionally, we have constrained the pilot-scale nearest neighbor distance measurement of habitat connectivity by hydrologic routing and added new restoration sites. We are pilot-testing a third element of the habitat connectivity index with least-cost modeling of connectivity in hydrogeomporphic Reach D, the location of Cottonwood Island.

Evaluating Cumulative Ecosystem Response to Habitat Restoration Projects in the Lower Columbia River and Estuary

Ronald M. Thom[1] and G. Curtis Roegner[2]

Abstract

The goal of the Cumulative Effects Study is to develop a methodology for evaluating the cumulative effects of multiple habitat restoration projects intended to benefit ecosystems supporting juvenile salmonids in the 235-km-long LCRE. Literature review in 2004 revealed no existing methods for such an evaluation and suggested that cumulative effects could be additive or synergistic. From 2005 through 2010, annual field research involved intensive, comparative studies paired by habitat type (tidal swamp versus marsh), trajectory (restoration versus reference site), and restoration action (tide-gate replacement vs. culvert replacement vs. dike breach). During 2010, the specific objectives for the Cumulative Effects Study were as follows:

- Expand and update the meta-analysis of effectiveness monitoring data from habitat restoration projects, including site evaluation cards.
- Perform the initial GIS analysis of Net Ecosystem Improvement from LCRE habitat restoration.
- Apply a levels of evidence approach to assessment of the cumulative effects of ecosystem restoration.
- Develop the applied adaptive management and decision-making for the habitat restoration program in the LCRE.
- Develop the adaptive management infrastructure.

Several manuscripts were part of the objectives for 2010. These included:

- A preliminary assessment of the effects of environmental flows on wetted area estuary-wide.
- Material and nutrient flux from restored wetlands in tidal freshwater of the LCRE, which includes a hydrodynamic modeling of particulate organic matter transport and distribution after a dike breach.
- Forcing factors affecting water surface elevations in the LCRE.
- Ecology of restored wetlands in the LCRE.
- Spatio-temporal patterns of fish usage at the Kandoll restoration site.

When the Cumulative Effects Study concludes in the 2011-2012 project year, we will provide three main deliverables to the USACE: a peer-reviewed, scientific method to evaluate the cumulative effects of multiple habitat restoration projects in the LCRE; an adaptive management framework and specific recommendations for infrastructure to periodically implement a comprehensive LCRE cumulative effects evaluation; and an initial cumulative effects evaluation for the LCRE based on available data and information. Data sources for the cumulative effects evaluation will include

monitoring and GIS analysis performed by state and federal agencies and non-governmental organizations. Conversely, regional entities will be able to use GIS layers developed or improved by the Cumulative Effects Study and the levels-of-evidence approach to synthesize and evaluate their restoration effectiveness monitoring data. In total, these efforts will advance the mission of ecosystem restoration in the LCRE.

[1]Pacific Northwest National Laboratories
[2]NOAA, Northwest Fisheries Science Center

Juvenile Salmon Ecology and Restoration of Tidal Freshwater Habitats

Nichole Sather[1], Gary Johnson[1], David Teel[2], John Skalski[3], Adam Storch[4], Erick VanDyke[4], Christine Mallette[4]

Abstract

Until recently, information pertaining to the ecology of juvenile salmon in tidal freshwater habitats in the Columbia River had been limited. During 2007-2010, we conducted research funded by BPA as part of the Northwest Power and Conservation Council's Fish and Wildlife Program that centered on two fundamental questions: 1) In what types of habitats within the tidal freshwater area of the Columbia River are juvenile salmonids found, when are they present, and under what environmental conditions? 2) What is the ecological contribution of shallow (0–5 m) tidal freshwater habitats to the recovery of ESA-listed salmonids in the Columbia Basin? To characterize fish community and habitat characteristics, the study area includes sites within hydrogeomorphic reaches D and E (Cowlitz to Lewis Rivers) and reach G (vicinity of the Sandy River delta). The 2007-2010 research indicates juvenile salmon are present in a diversity of shallow tidal freshwater habitats throughout the year. However, we have not found fish community structure and salmon density to be associated with a particular habitat type. High variability in biotic and abiotic environmental metrics makes it difficult to reveal statistically significant associations between salmon density and ecosystem structures. Despite the challenges of reducing uncertainties of the ecology of early life stages of salmon in tidal freshwater, our research has provided data concerning the distribution of distinct genetic stocks of juvenile salmon, food habits of Chinook salmon, and residence times of Chinook salmon (>95mm) in shallow water habitats. Our results to date indicate questions centering on juvenile salmon ecology and ecosystem restoration is best informed by data derived from a combination of structural and functional attributes within a variety of habitat types. Research on juvenile salmon ecology and restoration of tidal freshwater habitats will continue in 2011 within the Anadromous Fish Evaluation Program.

[1]Pacific Northwest National Laboratory
[2] NOAA, Northwest Fisheries Science Center
[3]University of Washington, Columbia Basin Research
[4]Oregon Department of Fish and Wildlife

Wednesday – December 1, 2010			
Turbine Survival Program			
1310	Mortal Injury of Juvenile Chinook Salmon during Hydroturbine Passage: Implications for hydroturbine operation and design	Andrew Gingerich	PNNL
1330	Maximum Acclimation Depth of Juvenile Chinook Salmon: Implications for survival during hydroturbine passage	Brett Pflugrath	PNNL
1350	Bias in Juvenile Salmon Survival Estimates through Hydroturbines Due to Transmitter Presence: Implications for hydroturbine operations and management	Richard S. Brown	PNNL
1410	Historical Trends in Survival of Juvenile Salmon Passing through Turbines at McNary and John Day Dams	John W. Beeman	USGS

Mortal injury of juvenile Chinook salmon during hydroturbine passage: Implications for hydroturbine operation and design

Andrew Gingerich

Abstract

Within the Snake and Columbia Rivers, thousands of salmonids pass through hydroelectric dams during annual seaward migration. A proportion of these fish will pass through hydroturbines. A number of misconceptions with this passage exist, including the rate of contact related mortality associated with turbine blades. However, all fish are subjected to varied decompression and may sustain injuries related to barotrauma. We examined this interaction using Chinook salmon (*Oncorhynchus tshawytscha*) in a laboratory setting. Juvenile fish were acclimated to a range of depths and subsequently exposed to simulated turbine passage. These simulations exposed fish to rapid changes in pressure between 6.89 to 413.68 kPa (1 to 60 PSI) using computer controlled hyper/hypobaric chambers. Rates of mortal injury were a function of acclimation depth (pressure equivalent) and exposure pressures. The relationships between barotrauma and pressure exposure can be used to guide turbine operations and turbine design.

Maximum Acclimation Depth of Juvenile Chinook Salmon: implications for survival during hydroturbine passage

Brett Pflugrath

Abstract

This study investigated the maximum depth at which juvenile Chinook salmon, *Oncohynchus tshawytscha,* can attain neutral buoyancy. Three methods were used to obtain swim bladder volumes that were transformed into depth estimations; Gas-puckreflex test (GPT), the increased excess mass test (IEMT), and swim bladder rupture test (SBRT). GPT and SBRT entailed artificially increasing swim bladder volume, inside and outside of the body cavity, through decompression. IEMT forced fish to increase swim bladder volume by increasing the fish's excess mass by externally attaching weights. From these tests, we estimate the maximum acclimation depth for juvenile Chinook salmon is 6.72m (range = 4.57 – 11.55m). These findings have significant implications for survival and behavior of juvenile salmon that pass through large Kaplan turbines typical of those found within the Columbia and Snake River hydropower system.

Bias in juvenile salmon survival estimates through hydroturbines due to transmitter presence: Implications for hydroturbine operations and management

Rich Brown

Abstract

Passage through hydropower turbines exposes fish to rapid decompression and the risk of barotrauma. The lowest pressures experienced can range from near vapor pressure to well above atmospheric pressure. Pressure related mortality and injury to fish depend upon the differential between the pressure (depth) to which fish are acclimated prior to turbine passage and the lowest pressure experienced during passage. In addition, the presence of surgically implanted transmitters may increase the likelihood of injury during turbine passage. Following acclimation, juvenile Chinook salmon surgically implanted with one of several different transmitters in combination with a PIT tag were exposed to simulated turbine pressure time histories using computer controlled hyper / hypobaric chambers. The nadir of the simulated turbine pressure profiles ranged between 1 and 15 PSI absolute. Rates of mortal injury for test fish were a function of the ratio between acclimation pressure and nadir pressure, and the size of the transmitter. Understanding the relationship between barotrauma and the presence of an implanted transmitter is critical when evaluating survival study results of juvenile salmonids passing through hydroelectric dams. Illustrations are provided of how the presence of transmitters can bias (higher mortality with bigger transmitters) survival estimates of fish passing through hydroturbines.

Historical Trends in Survival of Juvenile Salmon Passing through Turbines at McNary and John Day Dams

John Beeman[1], Hal Hansel[1], Russell Perry[1], Eric Hockersmith[2], Ben Sandford[2]

Abstract

Estimating the effects of turbine operating conditions on survival of juvenile salmonids has been difficult, because at most dams in the Federal Columbia River Power System few fish pass turbines relative to the other routes during a single study. We used data from a series of studies of dam passage and survival to determine if dam operating conditions affected survival of juvenile salmonids passing through the turbines. The data were collected from radio- or acoustic-tagged fish used at McNary Dam from 2002–2009 and radio-tagged fish used at John Day Dam from 2002–2003. The studies were not specifically designed to evaluate the effects of turbine operations on fish survival, so most data were collected when turbines were operating within one percent of their peak efficiency, which is currently the standard operating condition (the "1% rule"). We used Cormack-Jolly-Seber models to express turbine passage survival as a function of several biological, environmental, and operational covariates. The covariates included water temperature, photoperiod, tag burden, percent spill, total discharge, turbine unit location, hydraulic head, and turbine unit discharge. Information-theoretic methods were then used to determine which set(s) of covariates were best supported by the data. Few effects of the operational covariates were supported. At McNary Dam quadratic models of head was supported in data from yearling Chinook salmon (*Oncorhynchus tshawytscha)* juvenile steelhead (*O. mykiss*). At John Day Dam a quadratic model of turbine unit discharge was supported in data from subyearling Chinook salmon (*O. tshawytscha*) with an intermediate maximum at about 16 thousand ft^3/s. Negative effects of tag burden were supported for yearling Chinook salmon at both dams, consistent with data from recent laboratory studies, but not for subyearling Chinook salmon or juvenile steelhead. The lack of a supported effect of turbine unit discharge for most groups is inconsistent with the few studies that have examined this directly, but may be related to the range of turbine unit discharge during the studies due to operation within the 1% rule. Analyses of existing data collected at other dams should be examined to determine if these results are consistent throughout the Federal Columbia River Power System.

[1]USGS, Columbia River Research Laboratory
[2]NOAA, Northwest Fisheries Science Center

Wednesday – December 1, 2010			
Predation Studies			
1435	Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace, 2008-2010	Robert Stansell	CENWP-Bonn
1455	Avian Predation in the Columbia River Estuary and Monitoring Implementation of the Caspian Tern Management Plan	Dan Roby	Oregon State University
1515	Avian Predation at John Day and The Dalles Dams,2010: Estimated Fish Consumption using Direct Observation with Diet Analysis	Nathan Zorich	CENWP-Bonn
1535	Avian Predation on the Columbia Plateau: Impacts on smolts from the Upper Columbia and Snake rivers	Allen Evans	Real Time Research, Inc
1555	Electronic Recovery of Passive Integrated Transponder (PIT) Tags on Avian Breeding Colonies in the Columbia River Basin, 2010	Scott Sebring	NOAA

Evaluation of Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace, 2008-2010

Robert J. Stansell[1], Sean C. Tackley[2], Karrie M. Gibbons[1]

Abstract

Background

The USACE conducted surface observations to evaluate the seasonal presence, abundance, and predation activities of pinnipeds, including California sea lions (CSL) Zalophus californianus, Steller's sea lions (SSL)Eumetopias jubatus, and harbor seals Phoca vitulina in the Bonneville Dam tailrace each year since 2002.

Methods

Observers stationed at each of the three major tailrace areas of the dam (Powerhouse 1, Powerhouse 2, and the spillway) recorded pinniped presence, recorded and identified fish catches, and identified individual CSL when possible. Predation estimates were expanded for time not observed. Individual identification was used to generate abundance estimates and to track individual predation and use patterns, both within and among years. Observations generally began in early January and continued through the last week of May.

Results

An estimated 4,466 adult Chinook salmon (Oncorhynchus tshawytscha) and steelhead (O. mykiss) (2.9% of the run) were consumed by pinnipeds in the tailrace of Bonneville Dam during the 2008 1 January to 31 May period. An estimated 4,489 adult salmonids (2.4% of the run) were consumed in 2009, and an estimated 6,081 adult salmonids (2.2% of the run) were consumed in 2010. Pacific lamprey (Lampetra tridentata) comprised 1.4% of the total observed catch from 2008 to 2010, although lamprey catch is probably underestimated. SSL predation on White sturgeon (Acipenser transmontanus), has increased every year since 2006, averaging 2.5% of observed catch before 2008 and 16.0% the last three years. The estimated sturgeon catch increased each year from 315 in 2006 to 1,879 in 2010, so there is growing concern about the potential impacts of SSL on sturgeon at Bonneville Dam. SSL have also increased their consumption of salmonids. They averaged an estimated 19.7 salmonids per year between 2002 and 2007, but averaged an estimated 545.7 salmonids per year between 2008 and 2010.

The number of individual sea lions observed at Bonneville Dam has increased from an average of 83.0 per year between 2002 and 2007 to 123.7 per year for the last three years. This is primarily due to an increase in the presence of SSL (averaging 5.0 per year before 2008 and 46.7 from 2008 to 2010). The number of CSL dropped from 82 in 2008 to 54 in 2009, and rose in 2010 to 89. Overall they averaged 76.2 per year before 2008 and 75.0 the last three years. The highest number of individual pinnipeds observed at the project on any one day increased every year except 2009, with a maximum daily count of 69 in 2010. However, the highest number of CSL seen dropped every year since the peak of 52 in 2007 to 26 the past two years.

The Corps and other federal, state, and tribal agencies implemented a variety of sea lion deterrents at Bonneville Dam from 2008 to 2010. Sea lion exclusion devices (SLEDs) installed at all primary fishway entrances, and floating orifice gate (FOG) barriers continue to be effective in preventing sea lions from entering fishways. Harassment efforts continued each year both from land and boats and continue to show limited local, short term benefits in chasing some sea lions away from fishways and tailrace areas. Acoustic deterrents have shown no impact on the presence of sea lions near the fishway entrances. In 2008, ODFW and WDFW began to capture and permanently remove specific returning CSL at Bonneville Dam. Over the past three years 40 known Bonneville CSL were removed. This is likely the cause of the decline in CSL mean daily presence and maximum numbers seen on any given day, as most of the removed individuals had returned many years and remained at Bonneville Dam for long periods of time.

[1] US Army Corps of Engineers, Portland District, Fisheries Field Unit
[2] US Army Corps of Engineers, Portland District, Environmental Branch

Avian Predation in the Columbia River Estuary and Monitoring Implementation of the Caspian Tern Management Plan

D.D. Roby[1*], K. Collis[2], D.E. Lyons[1], A. Evans[2], Y. Suzuki[1], J.Y. Adkins[1], P.J. Loschl[1], D.S. Battaglia[1], T. Marcella[1], N. Hostetter[2], A. Peck-Richardson[1], A. Patterson[1], B. Cramer[1], S. Collar[1], T. Lawes[1], L. Faulquier[1], L. Bayliss[1], S. Sebring[3], R. Ledgerwood[3], D. Kuligowski[4], K. Courtot[1], & M. Hawbecker[2]

Abstract

We continued field studies in 2010 to (1) assess the impact of avian predation on survival of juvenile salmonids in the Columbia River estuary and (2) monitor the efficacy of on-going Caspian tern management actions designed to reduce their impact on smolt survival in the estuary. The Caspian tern colony on East Sand Island, the largest in the world, consisted of about 8,300 breeding pairs in 2010, a significant decline from 2009 (ca. 9,850 breeding pairs). Caspian tern nesting success at East Sand Island was also very low (< 0.1 young raised per nesting pair), the lowest productivity ever recorded at this colony. The primary factor responsible for the decline in colony size and productivity was apparently the El Nino of 2009-10. The proportion of juvenile salmonids in tern diets during the 2010 nesting season was 33%, similar to recent years.

Caspian tern management actions continued in 2010, with the USACE further reducing the area of suitable tern nesting habitat on East Sand Island to 3.1 acres, 62% of its former area, and building three new islands as alternative tern nesting sites in the Upper Klamath Basin. The drought in the Upper Klamath Basin, however, precluded allocating water to two of the three impoundments where new islands were built. Nevertheless, Caspian terns quickly colonized the new 0.8-acre floating island at Sheepy Lake in Lower Klamath National Wildlife Refuge, where 258 pairs raised 168 young. Nineteen terns that had been banded in the Columbia River estuary were re-sighted at the Sheepy Lake tern island. We continued to monitor four other alternative colony sites constructed by the USACE in interior Oregon in 2008 and 2009. No Caspian terns successfully nested at three of these four islands and the fourth experienced very low nesting success, apparently due to adverse weather conditions and low forage fish availability during the 2010 nesting season.

East Sand Island is also home to the largest known double-crested cormorant colony, consisting of about 12,400 breeding pairs in 2010, only slightly larger than in 2009 (ca. 12,100 breeding pairs). A breeding colony of Brandt's cormorants has formed within the double-crested cormorant colony on East Sand Island, and the numbers of Brandt's cormorants unexpectedly increased to nearly 1,000 breeding pairs in 2010. Juvenile salmonids represented about 17% of the double-crested cormorant diet in 2010, compared to ca. 9% in 2009. Although an estimate of smolt consumption by the double-crested cormorant colony in 2010 is not yet available, estimated consumption is likely to be significantly greater than in 2009, when about 11 million smolts were consumed by cormorants nesting at this colony. As in 2009, cormorant smolt consumption in 2010 is expected to exceed smolt consumption by Caspian terns nesting on East Sand Island in 2010. Fortunately, on-colony smolt PIT tag recoveries indicate that smolt consumption rates by Brandt's cormorants, a marine species, are much less than those of double-crested cormorants. Managers have initiated planning efforts to reduce the size of the East Sand Island double-crested cormorant colony as one

approach to increasing smolt survival in the Columbia River estuary. In future years, we plan to assess potential compensation for reduced Caspian tern predation by monitoring smolt consumption by other avian predators in the estuary, namely double-crested cormorants, Brandt's cormorants, California brown pelicans, various gull species, and the newly-formed colony of American white pelicans on Miller Sands Spit.

[1]USGS, Oregon Cooperative Fish & Wildlife Research Unit
[2]Real Time Research, Inc.
[3]NOAA, Pacific States Marine Fisheries Commission
[4]NOAA, Northwest Fisheries Science Center

Avian Predation at John Day and The Dalles Dams 2010: Estimated fish consumption using direct observation with diet analysis

Nathan A. Zorich, Michael R. Jonas, Patricia L. Madson

Abstract

Background

Avian predators are one highly visible cause of smolt mortality below hydropower dams. If sever enough it may prevent a FCRPS dam from meeting its BiOp required survival goals for ESA listed salmonid passage. In 2010 the Fish Field Unit was tasked with determining the impact of avian predators on fish passing John Day and The Dalles Dams. Our objectives were: 1) Determine species composition and numbers of piscivorous birds; 2) Estimate smolt consumption by gulls; 3) Determine the effectiveness of intense boat hazing and a new synthetic avian line array at John Day Dam.

Methods

To quantify avian consumption observers used binoculars to count gulls (Larus californicus), the rate of attacks (dives), and determine if an attack was successful (fish in bill) during the peak smolt outmigration between 1 April to 30 July. We then estimated salmonid consumption using those variables and diet information from weekly gull stomach collections. Additionally, counts at the projects were collected on a much smaller population of other fish eating birds.

Results

The daily abundance of gulls at John Day ranged from zero on 16 April to a brief high of 118 on 14 June, declining rapidly to tow on 17 June, yielding a seasonal mean of 17. At The Dalles gulls were more numerous. The daily abundance ranged from zero on 12 April to a high of 133 on 19 May, slowly decreasing to four on 27 July, yielding a seasonal mean of 34. The diurnal abundance at both projects showed no real pattern and was likely impacted by successful hazing.

Overall, 349 California Gull (*L. californicus*) stomachs were collected, 194 at John Day Dam and 155 at The Dalles Dam. Gull stomachs from John Day contained 93 salmonids, seven lamprey, three other fish, eight unidentified fish, and insects. We also recovered 14 PIT tags, eight of which were un-readable tags. Gull stomachs from The Dalles contained 72 salmonids, 95 lamprey, and three unidentified fish as well as five readable PIT tags and landfill starches.

At John Day Dam preliminary estimates of smolt consumption, which includes additive and compensatory sources of mortality, were 19,000± 14,000 (95% CI) or between 0.1 and 0.7% of the John Day smolt index during the four month study (ca. 4.5 million smolt). This is a reduction of 61,000 (76%) from 2009 when 80,000 smolt were consumed in only three months. At The Dalles Dam preliminary estimates of smolt consumption, which includes additive and compensatory sources of mortality, were 98,000± 38,000 (95% CI). Since there are no juvenile sampling facilities at The Dalles Dam we did not estimate the percent of the smolt index consumed by gulls.

Avian predation on the Columbia Plateau: Impacts on smolts from the Upper Columbia and Snake rivers

D.D. Roby[1], K. Collis[2], A. Evans[2]*, D.E. Lyons[1], P.J. Loschl[1], N. Hostetter[2], J.Y. Adkins[1], Y. Suzuki[1], B. Cramer[2], T. Marcella[1], J. Tennyson[1], D. Harvey[1], E. Tompkins[1], M. Hawbecker[2], S. Sebring[3], & R. Ledgerwood[3]

Abstract

Caspian terns and double-crested cormorants are the bird species responsible for most losses of salmonid smolts to avian predators on the Columbia Plateau. Management options to reduce the impacts of these two avian predators on smolt survival are currently being considered by resource managers. In 2010, the largest breeding colonies of Caspian terns on the Columbia Plateau were on Crescent Island (Rkm 510 in the McNary Pool) and Goose Island (Potholes Reservoir, WA), where 348 and 358 pairs nested, respectively. Caspian tern nesting success at Crescent Island averaged 0.56 young raised per nesting pair, higher than it has been in recent years, while the Goose Island tern colony experienced almost complete nesting failure in 2010. Three other smaller Caspian tern colonies on the Columbia Plateau also failed or nearly failed to produce any young. In 2010, salmonid smolts represented 71% of tern prey items at the Crescent Island colony and 21% of tern prey items at the Goose Island colony (based on identified bill-loads). The largest colony of double-crested cormorants on the mid-Columbia River was on Foundation Island (Rkm 518 in McNary Pool), where 308 pairs nested in 2010. Sampling during 2005-2010 indicated that ca. 50% (by mass) of the Foundation Island cormorant diet was juvenile salmonids during May (the peak of smolt out-migration), while less than 10% of the diet was salmonids in early April, June, and July. Smolt consumption estimates from tern and cormorant colonies in 2010 are not yet available.

In total, 38,913 PIT tags from 2010 migration year smolts were deposited on avian colonies in the Columbia Plateau. PIT tag recoveries indicated that smolt losses in 2010 were similar for Foundation Island cormorants (8,481 tags) and Crescent Island terns (8,255 tags). Substantial numbers of smolt PIT tags were also detected on the Caspian tern colony on Goose Island in Potholes Reservoir (8,512 tags) and on a mixed California and ring-billed gull colony on Miller Rocks (Rkm 333 in The Dalles Pool; 5,045 tags). Smaller numbers of PIT tags were found on the Crescent Island gull colony (3,985 tags), the Badger Island American white pelican colony (Rkm 511 in McNary Pool; 3,113 tags), and the Blalock Islands Caspian tern colony (Rkm 444 in John Day Pool; 1,099 tags). PIT tags recovered from the Caspian tern colony in Potholes Reservoir were almost exclusively from upper Columbia River salmonid ESUs, while PIT tags recovered on other avian colonies in the Plateau consisted of smolts from the upper Columbia, Snake, and middle Columbia ESUs. Preliminary results indicate that Caspian terns from the Goose Island colony in Potholes Reservoir consumed 10.3% (95% C.I. = 8.9 to 12.1%) of the juvenile steelhead PIT-tagged and released at Rock Island Dam in 2010. Stock-specific predation rates from other avian colonies are not yet available.

Stomach contents from 96 double-crested cormorants collected while over-wintering on the lower Snake River during the winters of 2007-2010 indicated that salmonids comprised roughly 10% of the diet, with the majority of these being ESA-listed Snake River Fall Chinook. Surveys indicated

that less than 400 cormorants over-wintered along the lower Snake River each year, and their distribution varied both spatially and temporally throughout the study period. On average, fewer than 25% of the over-wintering cormorants were observed loafing or foraging at lower Snake River dams.

[1]USGS, Oregon Cooperative Fish & Wildlife Research Unit
[2]Real Time Research, Inc.
[3] NOAA, Pacific States Marine Fisheries Commission

Electronic Recovery of Passive Integrated Transponder (PIT) Tags on Avian Breeding Colonies in the Columbia River Basin, 2010

Scott H. Sebring[1], Michael S. Morrow[1], Richard D. Ledgerwood[2], and Allen Evans[3]

Abstract

During the summer and fall of 2010 biologists with NOAA Fisheries and Pacific States Marine Fisheries Commission collaborated with researchers from Oregon State University and Real Time Research to quantify the effects on PIT-tagged salmonids by colonial waterbirds in the Columbia River basin. Although PIT tag sampling was not completed until November, our initial estimate of total basin-wide PIT tag recoveries from juvenile salmonids migrating during 2010 exceeded 80,000. Approximately 70% of the PIT tags were recovered from avian colonies on East Sand Island in the Columbia River estuary and 20% were recovered on islands in the reservoir formed by McNary Dam. Less than 10% of PIT tag codes were recovered from additional sampling locations in the Columbia River basin (i.e., The Dalles Dam reservoir and John Day Dam reservoir). We measured PIT tag detection efficiency by sowing known numbers of "control" PIT tags in plots at each avian breeding colony. The percentage of control PIT tags recovered following the nesting season ranged from 52-84% and was affected by the substrate type and amount of vegetation present on each breeding colony.

We estimated the number of fish consumed by avian predators that were previously detected at or released from dams located upstream within the same river reach. These reach-specific predation rates are more accurate measures than those using numbers of fish released from initial tagging sites. However, reach-specific predation rates are not adjusted for instream survival. We detected 3% of spring/summer Chinook salmon, 4% of fall Chinook salmon, 6% of coho salmon, and 9.8% of steelhead and on East Sand Island avian colonies that were previously detected at Bonneville Dam. These minimum estimates of predation represent significant sources of mortality within the lower Columbia River and other reaches of the Columbia River basin.

Of particular concern during recent years were the proportions of PIT-tagged subyearling Chinook salmon released downstream of Bonneville Dam and consumed by avian predators, which have exceeded 30% in some years. During 2010 we tagged and released 3,000 subyearling Chinook salmon from four hatcheries downstream of Bonneville Dam: Big Creek Hatchery, Grays River Hatchery, North Toutle Hatchery, and Warrenton Hatchery. Based on preliminary data, we estimate avian predators breeding on East Sand Island will consume at least 20% of these PIT-tagged fish during 2010. This predation rate is consistent with previous years and is among the greatest measured for any salmon ESU in the Columbia River basin.

[1]Pacific States Marine Fisheries Commission
[2]Point Adams Biological Station
[3]Real Time Research, Inc.

Thursday – December 2, 2010			
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Estimating Upstream Passage Metrics and Performance in Pacific Lamprey: Overview and patterns from the Columbia River Hydrosystem

Christopher Caudill[1], Matthew Keefer[1], and Mary Moser[2]

Abstract

Background

Declining counts of adult lamprey in the Columbia and Snake rivers has sparked concern about the influence of dams on migration success, individual reproductive success, population growth rate, and species viability. Telemetry studies on upstream migrating adults to date have revealed that lamprey passage efficiencies at individual dams are low compared to salmonids, have identified problem areas, and have been used to develop and evaluate structural and operational modifications. Currently, there is a need to assess the relative passage success of lampreys across projects in order to prioritize limited conservation funds. A biologically meaningful prioritization requires knowledge of underlying migration behavior and an understanding of how data from differing locations can (and cannot) be compared.

Methods

We will present a broad conceptual context for evaluating upstream migration "success" for Pacific lamprey. We will review the similarity and differences between lamprey and other Columbia Basin anadromous fishes, evaluate the available data relevant to identifying the underlying migration behavior of lamprey (including evidence for homing), summarize available telemetry data at each dam, and identify the strengths and limitations of available datasets.

Results

The primary conclusions are 1) the underlying migration mechanisms in lamprey are unknown, making it difficult to determine whether geographic populations represent biological populations, 2) determining migration success is difficult because the underlying motivation(s) for migration past dams remains unknown, 3) the sample population approaching each dam has differed because of limitations in available sampling methods and passage of larger fish to upstream sites, and 4) telemetry monitoring and tag size have evolved over time. In total these factors render direct comparison of metrics among dams tenuous at best and highlight the need for a greater understanding of underlying biological drivers of adult Pacific lamprey migration behavior. Moreover, the relative contributions of mortality in juvenile vs. ocean vs. adult stages to population growth rates remain unknown, nor is it known whether the Columbia Basin tributary populations represent biological subpopulations or are simply portions of a large, well-mixed regional population. Prioritization in the short term should continue to focus on addressing known passage issues, while we contend that considerable effort should be directed to addressing the above critical uncertainties in an effort to identify cost-effective management strategies.

[1]Idaho Cooperative Fish and Wildlife Research Unit
[2]NOAA, Northwest Fisheries Science Center

Adult Lamprey Passage Success and Behavior in the Lower Columbia River, 2010

Matthew Keefer[1], Charles Boggs[1], Eric Johnson, Christopher Caudill[1], Tami Clabough[1], Ben Ho[1], and Mary Moser[2]

Abstract

Background
Monitoring adult Pacific lamprey (Lampetra tridentata) migration behaviors in the Columbia River basin is an important part of understanding how dams and environmental factors affect lamprey passage success and distribution to spawning areas.

Methods
In 2010, we collected adult lampreys at Bonneville Dam and tagged them with half-duplex passive integrated transponder (HD-PIT) tags and radio transmitters. Fish passage was monitored at Bonneville, The Dalles, John Day, McNary, Ice Harbor, and Priest Rapids dams and in reservoirs and tributaries. Our primary objectives for this summary were to estimate lamprey escapement past the monitored sites, to assess the final known distribution of tagged fish, and to compare 2010 results to those from previous years. The retrospective analysis included lamprey radio-tagged in 1997-2002 and 2007-2009.

Results
The 2010 daytime adult lamprey count at Bonneville Dam (~6,250 fish) was a record low and prompted a series of in-season modifications to study objectives. We tagged 312 adult lampreys with radio and HD-PIT tags. A PIT-tag-only objective was dropped due to small run size. Escapement from release below Bonneville Dam to top-of-ladder antennas was 40% for the double-tagged fish in 2010. This estimate was substantially higher than estimates from directly comparable studies in 2007-2009 (21-31%). Escapement estimates from release past The Dalles Dam (22%) and past John Day Dam (10%) in 2010, were also significantly higher than 2007-2009 results (TD = 5-11%; JD = 2-5%). As in previous years, large lampreys were significantly more likely than small lampreys to pass dams and through lower river study reaches. At this writing, 2010 radiotelemetry data were not yet processed for dams upstream from John Day Dam or for reservoir and tributary sites. Therefore, final lamprey distributions had not been identified.

Preliminary results from the multi-year retrospective analysis indicate that lamprey passage routes at dams are quite sensitive to environmental and operational conditions. In particular, the change in Powerhouse priority at Bonneville Dam from PH1 to PH2 resulted in more lampreys approaching and using fishways at PH2 and the spillway in recent years. Each of these fishways has lower lamprey dam passage efficiency than the PH1 fishway, potentially resulting in lower overall upstream escapement. Standardized passage metrics (i.e., adjusted for lamprey size differences among years) provide some evidence for incrementally improving lamprey performance at Bonneville Dam fishways from 1997-2010.

[1]Idaho Cooperative Fish and Wildlife Research Unit
[2]NOAA, Northwest Fisheries Science Center

Improving Adult Pacific Lamprey Passage at Bonneville Dam

Mary Moser[1], Howard Pennington[2] and Hilary Griffin[2]

Abstract

Lamprey passage structures (LPSs) designed to aid adult Pacific lamprey migration have been installed at auxiliary water supply channels and both inside and outside main fishway entrances at Bonneville Dam. The newest of these was installed inside the Cascades Island fishway entrance in May 2009. This LPS features many of the same design elements tested in previous structures of its kind: an open collector ramp mounted flush with the floor and side of the fishway, closed above-water ramps featuring shallow water depths, and deep rest boxes where lamprey could hold between ramp ascensions. In contrast to earlier versions, lamprey were challenged with steeper ramps, longer continuous ramp lengths, and higher overall elevation gain. To assess lamprey use of this structure, two half-duplex passive integrated transponder (HD-PIT) antennas were seamlessly inserted into the LPS and the structure terminated in a trap where all lamprey could be enumerated prior to release upstream at Stevenson, WA. During the in-water work period in winter of 2010, we also installed two underwater cameras to obtain information regarding lamprey and salmonid behavior in the vicinity of the entrance to this structure. Over 300 fish were double-tagged with radio transmitters and HD-PIT tags and released below Bonneville Dam to assess use of LPSs at Bonneville Dam. In addition, six fish bearing only a PIT and one fish with both a radio and PIT tag were released directly into the Cascades Island LPS to assess their passage rates and efficiency. All six of the fish with only a PIT tag successfully ascended the structure, but the radio-tagged fish did not. A total of 48 lamprey were counted at the Cascades Island LPS terminus, but none of the double-tagged fish were detected in the structure. As in previous years, adult lamprey use of LPSs at the tops of both the Bradford Island (n=1,876) and Washington-shore fishway (n=2,737) indicated that these LPSs continue to provide viable passage routes for adult lamprey.

[1]NOAA, National Fisheries Service Center
[2]NOAA, Pacific States Marine Fisheries Commission

Fishway Use and Passage Success of Adult Pacific Lamprey at Bonneville Dam Including the Modified Cascades Island Entrance, 2010

Christopher Caudill[1*], Eric Johnson[1], Ben Ho[1], Matthew Keefer[1], Tami Clabough[1], and Mary Moser[2]

Abstract

Background

Optimizing fishways to pass multiple species is challenging because life history, swimming ability, and behavior can fundamentally differ among species within native assemblages. In 2010, we calculated adult Pacific lamprey passage metrics as part of a multi-year monitoring effort, evaluated areas where lamprey passage could be improved, and evaluated effects of recent operational and structural modifications on lamprey passage at Bonneville Dam. These included 1) reducing water velocities at the Bonneville Dam Powerhouse 2 (PH2) fishway openings and 2) continued monitoring of a variable-width entrance weir, bottom structures (designed to provide reduced flows for lampreys), and a new Lamprey Passage Structure (LPS) to the Cascades Island (CI) fishway, and 3) examination of fine-scale movements in relation to dam structures and operational data to identify passage bottlenecks.

Methods

We used a combination of radiotelemetry and a half-duplex PIT-tag (HD-PIT) antenna array to evaluate lamprey passage. We double-tagged (n = 312) and HD-PIT tagged (n = 19) and monitored adult lampreys released downstream from Bonneville Dam

Results

We will be presenting results on general dam passage metrics in 2010 compared to prior years including fishway approach and entry sites, fishway entrance and dam passage efficiencies, tailrace and fishway passage times, and identification of problem areas for lamprey passage. We will also present the effects of reduced nighttime fishway velocity at PH2 on lamprey behavior with respect to fishway entrance times and fishway passage metrics in relation to previous years' results. For the Cascades Island evaluation we will present results on Lamprey entrance efficiencies, exit ratios, entrance times (time from first fishway approach to first entrance), and entrance to base-of-ladder times compared to previous years. Evaluation of individual lamprey behaviors and final distributions will be used to identify potential passage obstacles and discuss potential underlying mechanisms.

[1]Idaho Cooperative Fish and Wildlife Research Unit
[2]NOAA, Northwest Fisheries Science Center

Video Monitoring of Adult Pacific lamprey in the John Day Dam Fishway

Christopher Peery[1] and Jeff Fryer[2]

Abstract

The nocturnal nature of adult lamprey while passing mainstem Columbia River dams and their ability to make use of non-standard areas in fishways have challenged our ability to monitor their behavior and passage performance. For example, adult lamprey enter diffuser grating during dewatering, pass Bonneville Dam though the "closed" Cascade Island ladder exit and pass though picket leads used to guide salmon through count window stations. Among other results, the latter allow adult lamprey to pass dams without being counted even when nighttime observations are being made. At John Day Dam, biologist from Confederated Tribes of the Umatilla Reservation have been able to collect adult lamprey using funnel traps placed in the fishway behind the picket leads at the north-shore count window. For this study, we tested the use of underwater cameras connected to digital video recorders to learn more about the number of lamprey that used this route to bypass the count window, and timing that they were used. This year, 2010, was the second year of observations at the John Day Dam north-shore fishway. In 2009, during roughly six weeks of observations, we observed 211 lamprey pass upstream in the area behind picketed leads, during a period when 29 lamprey were counted passing through the count station during daylight hours. Based on our observations, a little more than 35% of lamprey passed upstream during nighttime hours when visual counts were not made at the count station. For 2010, cameras were installed and documented lamprey passage from late June until early October, a period during which more than 1,100 adult lamprey were counted at the John Day north count station. Recorded video are currently being processed. Summaries of 2010 findings will be presented.

[1]US Fish and Wildlife Service
[2]Columbia River Inter-Tribal Fish Commission

Evaluation of adult Pacific lamprey behavior in Columbia River reservoirs using the Juvenile Salmon Acoustic Telemetry (JSATS) system, 2010

Christopher Caudill, George Naughton, Daniel Joosten, Tami Clabough, Eric Johnson, Steven Lee, and Christopher Noyes

Abstract

Background
In previous adult Pacific lamprey studies, most radio- and PIT-tagged fish were last detected in tailraces, in fishways, or at fishway exits. Detection ranges for these technologies have limited monitoring in reservoirs and tributaries, while radio transmitter tag life has made it difficult to monitor final lamprey distribution following overwintering. In response to similar limitations for monitoring juvenile salmonids, the U.S. Army Corps of Engineers has developed a new acoustic telemetry system (Juvenile Salmon Acoustic Telemetry System [JSATS]). In this pilot study, we evaluated the effectiveness of a stationary array of acoustic JSATS receivers and a mobile-tracking device for monitoring the migration of JSATS-tagged adult Pacific lampreys in Bonneville reservoir.

Methods
We tagged 30 adult lampreys with JSAT tags from 20 July through 30 August 2010. All fish were trapped at Bonneville Dam (rkm 235) and released upstream at the Stevenson boat launch (rkm 242.7). We deployed gates of two receivers at three locations in Bonneville reservoir: Stevenson, Wind Mountain (rkm 253), and upstream from the mouth of the Klickitat River (rkm 292). We evaluated the new acoustic mobile-tracking system by range testing and tracking adult lamprey released into Bonneville reservoir. Two test tags were lowered to set depths (2 m from the surface and 2 from the bottom of the reservoir) while the boat simulated a tracking pattern. We also attempted to track JSATS-tagged lamprey by boat from the release site.

Results
All lampreys were recorded by the receiver deployed near the Stevenson boat launch release site, while 8 (27%) fish were recorded by the Oregon-shore receiver opposite the release site. Of the 30 fish released, 17 (57%) and 22 (73%) were recorded by receivers upstream from the Klickitat River near the Washington and Oregon shores, respectively. No fish were recorded by receivers at the Wind Mountain site. Mean travel time from the release site to the receivers near the Klickitat River was 1.8 d (median 0.9 d, range 0.6-11.9 d). Migration rates between the release site and Klickitat River receivers was were approximately 27.0 km/d.

Range testing of the mobile tracking system revealed that detection efficiencies of tags deployed 2 m from the surface and bottom of the reservoir were highest when the boat was less than 60 m from the tags. Detection efficiency decreased substantially at distances greater than 100 m. Evaluation of the mobile tracking system also included tracking two lampreys for approximately 30 minutes each. Although this pilot study was limited in scope, it provides some evidence that JSATs technology may be a viable option for monitoring Pacific lamprey migration in Columbia River reservoirs and other deep-water habitats.

Evaluation of Adult Pacific Lamprey Passage and Behavior at McNary Dam, 2010 and Multi-year Summary of Passage Metrics

Charles Boggs[1], Christopher Caudill[1*], Matthew Keefer[1], and Mary Moser[2]

Abstract

Background
Due to precipitous declines in numbers of interior-basin adult Pacific lamprey (*Lampetra tridentata*) there is a critical need for improved understanding lamprey passage behavior and passage at dams. As part of a multi-year monitoring effort, in 2010 we performed a combined radiotelemetry and half-duplex PIT (HD-PIT) tag study to monitor lamprey behavior in the McNary tailrace and fishways and to estimate escapement past McNary Dam and upriver dams.

Methods
We trapped adult lampreys at McNary Dam in 2010 and tagged them with both a 2.2 g radio transmitter and a 23 mm HD-PIT tag. Behavior and passage were monitored using radiotelemetry receivers and HD-PIT reader/antenna systems inside the fishways at McNary, Ice Priest Rapids, and the four lower Snake River dams. Lamprey performance metrics at McNary Dam, including fishway entrance efficiency and dam passage efficiency, were estimated and compared to results from 2005-2009. We also used the six-year dataset to evaluate environmental, operational, and biological (i.e., lamprey size, migration timing) effects on upstream passage.

Results
Adult lamprey passage at McNary Dam in 2010 was near a record low (daytime count ~ 830) and only 18 fish were collected and radio-tagged using a regionally coordinated handling limit. This was well below the target sample size (n = 100). Passage performance metrics for this small sample were broadly comparable to past years' results. In the multi-year analyses, ~56% of all radio-tagged lampreys returned to McNary Dam after release. About 64% of those that approached a McNary fishway and ~81% that entered a fishway eventually passed the dam. There was evidence for lamprey passage bottlenecks in the south-shore transition pool and both the north fishway and north Powerhouse fishway entrances. The sample will be used in a multi-year test of the effects of reduced entrance velocity on passage behavior.

Across years, larger lampreys were far more likely to return to and pass McNary Dam and to reach upstream dams than were smaller fish. Upstream passage was also significantly timing-dependent, with the probability of passage highest for early migrants and lowest for those collected in late summer and fall. Lamprey count data from John Day and McNary dams and the radiotelemetry results suggest that the proportion of the run that reaches interior basin sites depends on a combination of physiological constraints (e.g., size or energetic effects) and environmental controls (e.g., temperature, discharge, and photoperiod effects). Results have important implications for the interpretation of lamprey performance metrics and for mitigation planning.

[1]Idaho Cooperative Fish and Wildlife Research Unit
[2]NOAA, Northwest Fisheries Science Center

Video Monitoring of Fish Ladder Modifications to Improve Pacific Lamprey Passage at the McNary Dam Oregon Shore Fishway, 2010

Kai Eder[1], Donald Thompson[1], Chuck Boggs[2], Christopher Caudill[2], Danelle Cline[3], and Frank Loge[1]

Abstract

The McNary Dam Oregon shore fish ladder is composed of a series of tilting weirs with orifices located several feet above the fishway floor. While the purpose of these orifices is to permit passage of migrating salmon and steelhead, their elevated location relative to the floor may pose passage problems for lamprey. Prior to the 2010 fish migration season, a total of nine stem walls supporting the tilting weirs were modified by cutting two "lamprey orifices" into each stem wall. These lamprey orifices are flush with the fishway floor, measure 3 inches tall by 18 inches wide, and can be closed by sliding plates. In this study we used underwater infrared cameras and remote video surveillance at three of these modified weirs to assess whether the presence of lamprey orifices impede passage of migrating salmon and steelhead, and to determine behavior of Pacific lamprey as they approach, enter, and pass through these orifices. To facilitate video analysis, an automated event detection and classification system utilized by oceanographic videographers was developed and evaluated for this specific video surveillance application.

Video was both streamed live via the internet and uploaded using a satellite link to a remote location for processing during the entire period of monitoring (April-Sept.). Monitoring at lamprey orifices covered the early and peak portions of the spring, summer, and fall Chinook salmon, and the Sockeye salmon and Steelhead runs. Roughly 1% of the Oregon shore spring and summer Chinook salmon run was seen in the near vicinity of the lamprey orifices; however, neither stock made any passage attempts at these orifices. On average, the time fish spent in view of the camera was less than two seconds. Fall run Chinook salmon were never seen in view of the cameras. For Sockeye salmon, a total of seven fish attempted passage through the lamprey orifices, corresponding to 0.01% of the entire run passing at the Oregon shore fishladder. These interactions typically lasted only several seconds and were characterized by fish nosing into the orifice then turning away. No passage attempts through lamprey orifices were recorded for Steelhead, however, 0.014% of the run at the Oregon shore fishladder were seen in the near vicinity of the orifices.

Lamprey behavior and passage at the orifices was recorded during both day and night. On average, roughly half of the lamprey seen passed successfully through the orifices. Specific behaviors of lamprey at orifices were characterized and quantified. The total number of lamprey observed during video monitoring (260) was considerably higher than the number counted at the fish counting window over the same time period (94), indicating that lamprey routinely pass through the picketed leads and therefore are not counted.

Utilizing an eight-node computer cluster, an automated event detection and classification system (AVEDac) was developed to both mark salient video events and classify objects (salmon and lamprey) according to a neuromorphic selective attention algorithm. Sample video was

successfully processed using AVEDac, and validation and application for routine screening are underway.

[1]University of California Davis, Department of Civil and Environmental Engineering
[2]University of Idaho, Department of Fish and Wildlife Resources
[3]Monterey Bay Aquarium Research Institute

Development of Standard Protocols for PIT Tagging Juvenile Lampreys

Matthew G. Mesa, Elizabeth S. Copeland, and Helena E. Christiansen

Abstract

The ability to mark and tag fish is one of the most important and useful techniques available to fisheries managers and researchers. We previously developed a fast, safe, and effective technique for PIT tagging juvenile (macropthalmia) Pacific lamprey (*Entosphenus tridentata*). Here, we used this technique to test the short-term survival of PIT-tagged juvenile lampreys in freshwater at different temperatures and their long-term survival in seawater. For the freshwater experiment, lampreys were acclimated to 9, 12, 15 or 18°C. From 105-120 lampreys per temperature were PIT-tagged and about an equal number of fish were anesthetized and handled but not tagged (control fish). During the 40 d test, no tags were lost and incisions healed well with few abnormalities. Survival was highest at 9°C (97% for both groups), lowest at 12°C (36% for controls and 28% for tagged fish), and intermediate at 15°C and 18°C (64 and 67% of controls and 79 and 73% of tagged fish survived). The poor survival at 12°C was unexpected since our previous study showed survival of 72-78% at this temperature. At all temperatures, most of the fish that died had an aquatic fungal infection. The initial size of tagged fish that died was significantly smaller than values for fish that survived at all temperatures except 12°C. In general, lampreys 150 mm in length and greater survived well and could be easily tagged, suggesting a size threshold for tagging of near this size until handling procedures are improved. For the seawater experiment, juvenile lampreys were collected at John Day Dam, PIT-tagged or handled only (controls) and held in freshwater for seven days at the dam, and then were transported to our Marrowstone Marine Laboratory and slowly transitioned to seawater. Five tags were shed in the first four days after tagging, but thereafter, no tags were lost. Two fish died during the first week, and no further mortality occurred until day 94 (1 August). Since then, mortality has increased steadily to about 15% and 28% in the two tanks at Marrowstone. This experiment is still ongoing but early results suggest that rearing in seawater reduces fungal infection and improves survival of juvenile lampreys. Results from our freshwater experiment indicate that it would probably be safe to work with young lampreys at 9-10°C but not at temperatures of 19°C or higher. To determine whether it will be safe to work with young lampreys at temperatures in between these extremes, however, will require resolving two issues: (1) the disparate results in our two experiments at 12°C; and (2) the proximate cause of fish mortalities in our study, which we suspect were due to fungal infections. The high incidence of fungal infection in juvenile lampreys held in freshwater may be linked to the stresses of capture and transport, anesthetic solutions, handling and captivity, or some combination thereof. Good long-term survival in seawater suggests that tagging of juvenile lampreys with PIT tags or other tags of similar size is feasible if early fungal infection can be appropriately controlled—and our future work is targeted directly at this issue.

Developing Active Telemetry Tagging Methods for Juvenile Lampreys

Christopher Peery[1] and Frank Loge[2]

Abstract

Relatively little is known of the dynamics of juvenile lamprey (macropthalmia) during their downstream migration to the ocean. Like salmonid smolts, these migrants must pass up to nine dams and reservoirs to transit the hydrosystem. A primary limiting factor for juvenile lamprey research is their small size which inhibits our ability to study their movements using traditional methods such as PIT tags and active telemetry. However, advances in tagging technology provide the potential to develop an active tag that could be used to monitor juvenile lamprey migration performance. For 2010, we continued a study of the biological criteria for an active transmitter that would work with juvenile lamprey migrants. Juvenile lamprey were collected at McNary Dam juvenile bypass system and transported to Dworshak National fish Hatchery for this study.

We used dissections and produced plastic casts of internal body cavity to determine size and shape of spacing available. Dummy transmitters of various sizes and weights were fashioned and surgically inserted to juvenile lamprey migrants. We also tagged some lamprey with PIT tags and sham-tagged lamprey to provide a point of reference. Results from 2009 tests indicated that tag width was the most important dimension influencing lamprey survival and performance. In 2010, we completed additional trials that confirmed that tag width and volume displaced are critical dimensions. We also observed that an oval crossection appeared more conducive than round tags for internal anatomy of a lamprey macropthalmia. For juvenile lamprey that averaged 159 mm length and 5.2 g weight, tags of 15 mm length, 2 to 2.25 mm width and up to 0.35 g appear feasible. However, fish used for tests were larger than for all fish present in the run at large (averaged 140 mm long, 4.4 g).

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A passive sampling approach to determine juvenile lamprey presence/absence in deep water

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Abstract

Pacific lamprey (*Entosphenus tridentatus*) have declined precipitously in abundance over the last few decades. The species is highly valuable both as a cultural resource and ecologically to the food web. In response to the rapid decline of Pacific lamprey throughout the Columbia Basin, hydropower operators are expanding management programs to identify and address project impacts on juvenile Pacific lamprey rearing in the substrate of project reservoirs. The long-term goal of lamprey proponents in the region is to develop a sampling plan in the region's large rivers to better understand where lamprey reside once they leave their natal tributaries. Achievement of this goal will involve sampling juvenile lamprey in deep water habitat. Current methods used to sample juvenile lamprey in deep-water involve either shocking them and using a suction pump to transport them to the surface, or using compressed air to lift them from the riverbed to the surface. While these techniques are effective, they are labor intensive and require handling juveniles which may cause physical damage during the pumping and handling process. The objective of this project is to create a sampling tool that will passively detect juvenile lamprey in deep water (greater than 1m.). This objective will be accomplished using previously developed electroshocking techniques coupled with an optical underwater camera. We will also test detection using relatively new acoustic camera technology. Because the approach is passive (i.e., fish handling at the surface is not necessary), there is a substantial potential for increased sampling volume and an expected reduction to fish injury compared to conventional, non-passive sampling methods.

The system we are developing involves modifying the ABP-2 backpack electrofishing unit for use in deep water in a manner similar to that described by Bergstedt and Genovese (1994). The unit delivers 3 pulses s^{-1} (125 V direct current) at 25% duty cycle, with a 3:1 pulse train (three pulses on, one pulse off) to draw juvenile lamprey from the riverbed. Instead of pumping juvenile lamprey to the surface once they have emerged from the substrate, lamprey presence/absence will be determined using a boat-deployed video system consisting of a high-sensitivity remote camera attached to a weighted platform. Based on previous surveys, the optical video coverage area averages approximately 17 ft^2, depending on water turbidity. Recent advances in acoustic camera technology may allow us to also detect juvenile lamprey using this method. We will test a BlueView sonar (P900-2245) which has a field of view of 45 x 20°, 256 beams with 1 x 20° widths and a range resolution of 1 in. This system may allow the ability to detect juvenile lamprey when turbidity is high and during low ambient light periods when optical video is not effective. Lamprey sampling on the lower Snake River will occur on seven separate sampling events in 2011 that correspond with the migration timing of juvenile Pacific lamprey in the lower Snake River (late March through mid-July). At each location, the sampling sled will be suspended just above the substrate while shocking and filming will occur for approximately 30 s at each sampling point. Lamprey habitat use will be evaluated using total depth, near-bed water velocity, substrate type, and water temperature. Following electrofishing surveys for lamprey, substrate samples will be collected from locations where lamprey are observed to characterize riverbed sediment composition. These data will characterize suitable lamprey habitat for protection or habitat enhancement efforts.

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