U.S. DEPARTMENT OF ENERGY

PNNL-18561

Prepared for the Bonneville Power Administration, Division of Fish and Wildlife,
under a Government Order with the U.S. Department of Energy
Contract DE-AC05-76RL01830

Temperature and Water Depth Monitoring Within Chum Salmon Spawning Habitat Below Bonneville Dam

Annual Report – October 2007–September 2008

EV Arntzen

July 2009

Pacific Northwest NATIONAL LABORATORY

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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

The overall goal of the project described in this report is to provide a sound scientific basis for operation of the Federal Columbia River Power System (FCRPS) in ways that will effectively protect and enhance chum salmon populations— a species listed in March 1999 as threatened under the *Endangered Species Act of 1973* (ESA). The study objective during fiscal year 2008 was to provide real-time data on Ives Island area water temperature and water surface elevations from the onset of chum salmon spawning through the end of chum salmon emergence. Sampling locations included areas where riverbed temperatures were elevated, potentially influencing alevin development and emergence timing. In these locations, hydrosystem operation caused large, frequent changes in river discharge that affected salmon habitat by dewatering redds and altering egg pocket temperatures. The 2008 objective was accomplished using temperature and water-level sensors deployed inside piezometers. Sensors were integrated with a radio telemetry system such that real-time data could be downloaded remotely and posted hourly on the Internet.

During our overall monitoring period (October 2007 through June 2008), mean temperature in chum spawning areas was nearly 2°C warmer within the riverbed than in the overlying river. During chum salmon spawning (mid-November 2007 through December2007), mean riverbed temperature in the Ives Island area was 14.5°C, more than 5°C higher than in the river, where mean temperature was 9.4°C. During the incubation period (January 2008 through mid-May 2008), riverbed temperature was approximately 3°C greater than in the overlying river (10.5°C and 7.2°C, respectively). Chum salmon preferentially select spawning locations where riverbed temperatures are elevated; consequently the incubation time of alevin is shortened before they emerge in the spring.

Acknowledgments

Nathan Phillips and Chris Anderson, Pacific Northwest National Laboratory (PNNL), assisted with field work. Gregg Gustafsen and Sean Venable, Instrumentation Northwest (Kirkland, Washington) helped maintain the real-time data collection system. Andrea Currie, PNNL, provided editorial assistance. Pacific Northwest National Laboratory is operated by Battelle for the U.S. Department of Energy under Contract DE-AC05-76RL01830.

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1.0 Introduction

Although historically abundant, Columbia River run sizes of chum salmon (*Oncorhynchus keta*) had decreased dramatically by the 1950s as a result of habitat degradation, water diversion, overharvest, and artificial propagation (National Marine Fisheries Service 1998). Populations spawning downstream from Bonneville Dam are currently listed as threatened under the *Endangered Species Act of 1973* (U.S. Fish and Wildlife Service 1999). Spawning surveys conducted at Ives Island since 1998 indicated that chum salmon spawn in spatially distinct clusters (U.S. Fish and Wildlife Service and Oregon Department of Fish and Wildlife, unpublished data). During 1999, fisheries researchers from the Pacific Northwest National Laboratory (PNNL) identified areas in which relatively warm subsurface water upwelled through chum salmon spawning gravels in the Ives Island spawning complex (Geist et al. 2002). Since 1999, PNNL has monitored river and bed temperatures in the Ives Island channel to assist with emergence timing predictions for chum salmon and to assess the impacts of hydrosystem operation on groundwater–surface water interaction within chum salmon spawning locations (Geist et al. 2008). PNNL also monitored water surface elevations within these areas to assist with redd dewatering estimates. During FY 2008, the objective of the project was to provide real-time data on Ives Island area water temperature and water surface elevations from the onset of chum salmon spawning through the end of chum salmon emergence. The data collected by PNNL are provided to the Fish Passage Center and used by state and federal agencies to estimate emergence timing and redd dewatering.

This report summarizes the methods used and temperature and water surface elevation data obtained by PNNL during the 2007–2008 study year. A digital appendix containing all temperature and water surface elevation data collected is included.

2.0 Study Site

Data were collected from spawning areas adjacent to the Pierce National Wildlife Refuge in the north Ives Island channel (rkm 230; Figure 1). The location coordinates of all sensors used to collect data presented in this chapter are included in Appendix A.

3.0 Methods

We used three monitoring locations in the Ives Island area, all within chum salmon spawning areas (Figure 2). At locations T1LB, T2LB, and T2MC, we continued to maintain the real-time temperature and water level data collection system installed during 2003 (Arntzen et al. 2006, 2007, 2008). The real-time data collection system employed pressure and temperature sensors (Model PT2X, Instrumentation Northwest, Inc., Kirkland, Washington) at paired locations within the river and riverbed. Hourly data were collected at each location from October 1, 2007, through September 30, 2008. PT2X sensors record temperature with a resolution of 0.1°C; water level is recorded with an accuracy of ±0.6 cm.

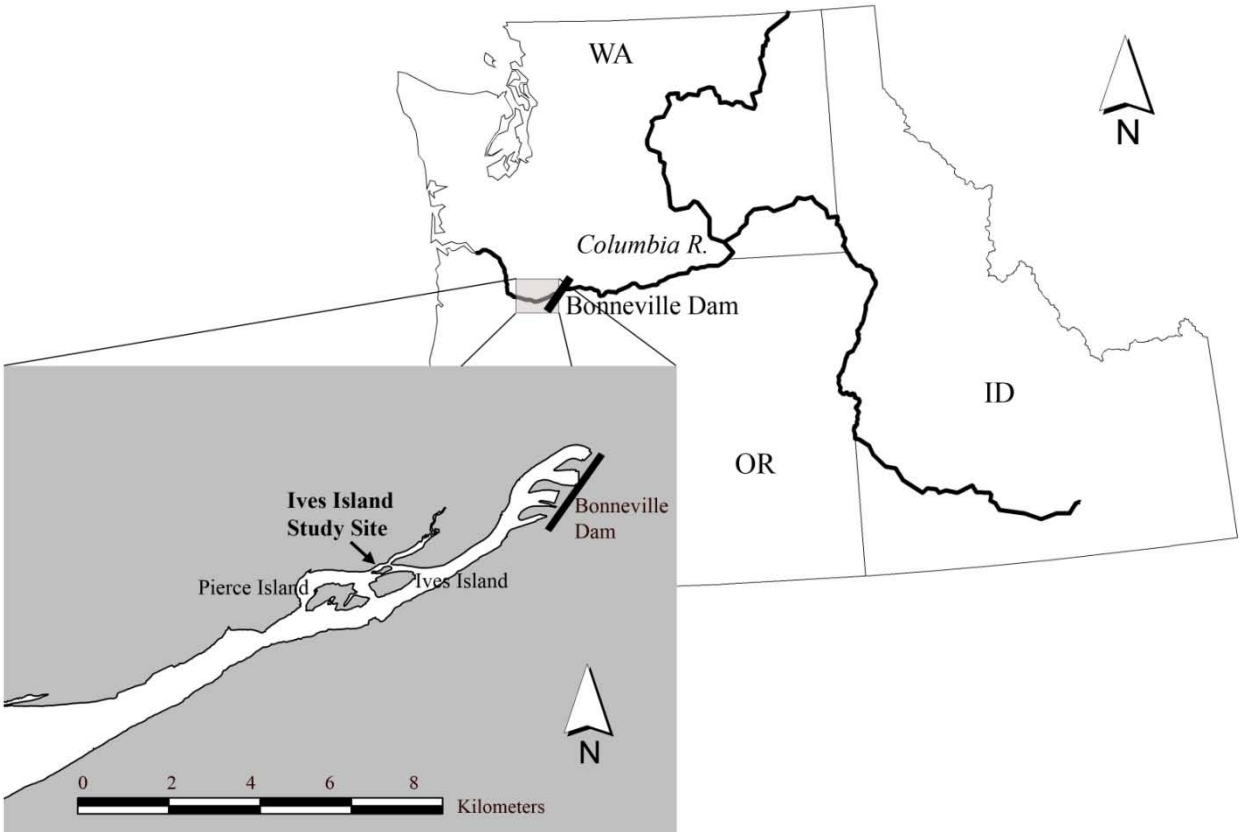

Figure 1. Location of Ives Island study site downstream from Bonneville Dam on the north side of the Columbia River, Washington

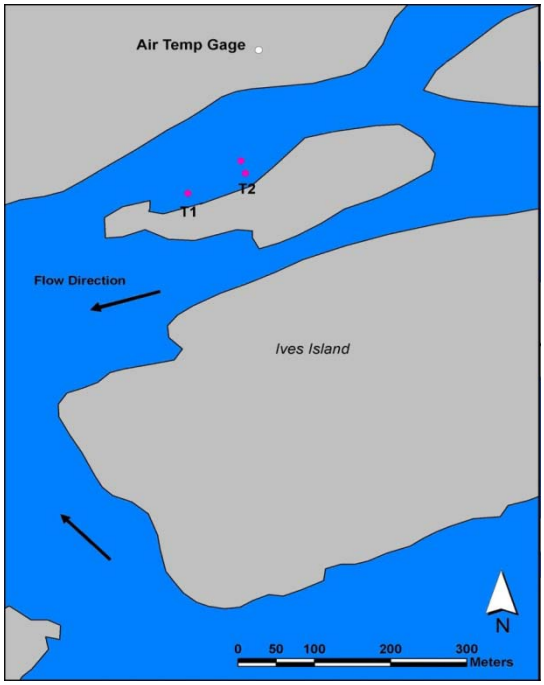

Figure 2. Piezometer locations (red circles) within Ives Island chum salmon spawning areas

4.0 Results and Discussion

Location coordinates and sensor depths below the riverbed are included for each location where data for temperature or water surface elevation were collected (Appendix A). Temperature data availability is summarized in Appendix B. All temperature data collected from October 2007 through September 2008 are presented in Appendix C. During 2007 through 2008, riverbed and river water temperatures were provided to the Fish Passage Center to assist federal and state agencies in estimating chum and fall Chinook salmon emergence timing and to help determine periods during which redds were dewatered in the Ives Island area. For this reason, our results (including statistical results) focused on time periods that were representative of chum salmon spawning (mid-November 2007 through December 2007) and incubation (January 2008 through mid-May 2008).

In general, temperature patterns observed from October 2007 through June 2008 were similar to those observed during previous years, in that riverbed temperatures were much warmer than the overlying river (Arntzen et al. 2006, 2007, 2008; Geist et al. 2008). Despite substantial variation between monitoring locations, at each location, mean riverbed temperature was at least 2°C warmer than the river temperatures. The mean composite temperature for all chum salmon sampling locations was 11.8°C in the riverbed compared to 9.4°C in the river. Mean (SD) bed temperatures were 11.01°C (1.6°C) at T1LB, 12.2°C (2.8°C) at T2LB, and 12.1°C (2.4°C) at T2MC (Figures 3 through 5). Mean (SD) river temperatures were 8.6°C (3.5°C) at T1LB, 9.5°C (3.4°C) at T2LB, and 10.1°C (2.7°C) at T2MC (Figures 3 through 5).

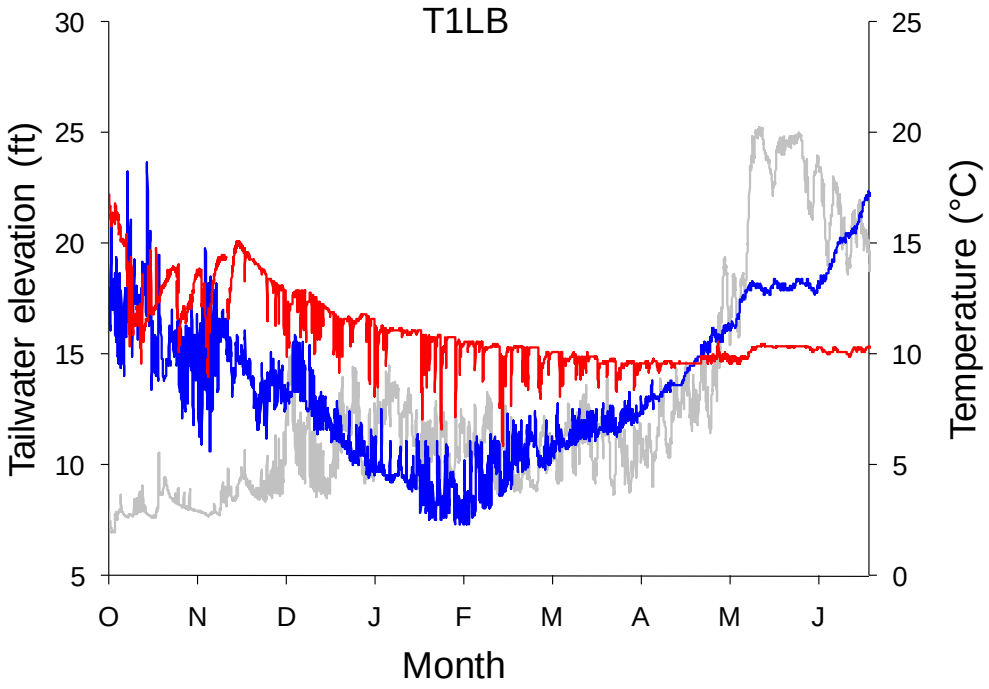

Figure 3. Time series plot of riverbed (red line) and river (blue line) temperature at the T1LB Ives Island chum salmon spawning location during October 2007 through June 2008. The grey line is water surface elevation (recorded at T2MC).

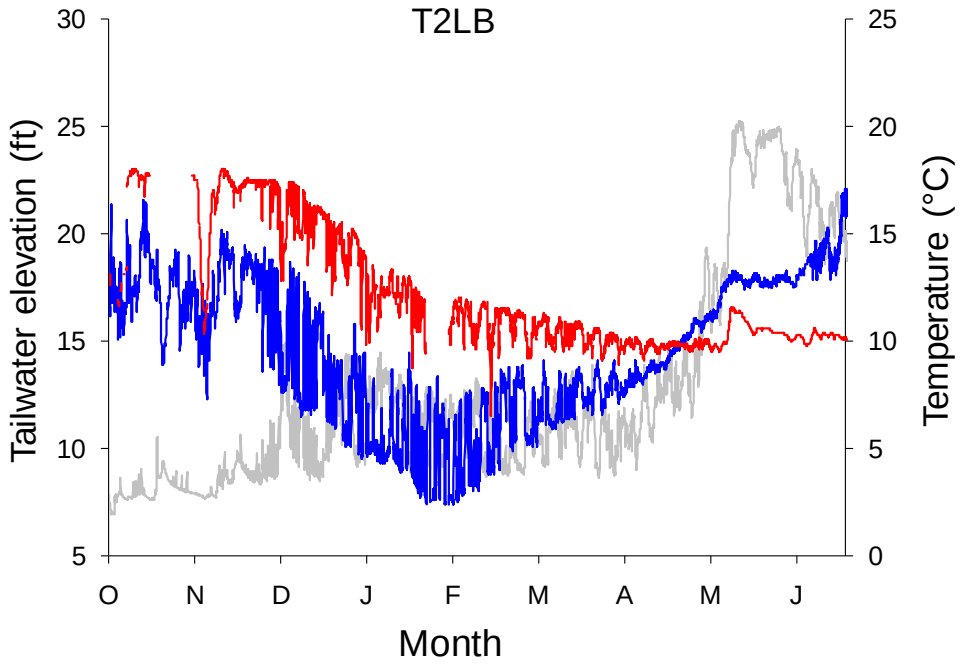

Figure 4. Time series plot of riverbed (red line) and river (blue line) temperature at the T2LB Ives Island chum salmon spawning location during October 2007 through June 2008. The grey line is water surface elevation (recorded at T2MC).

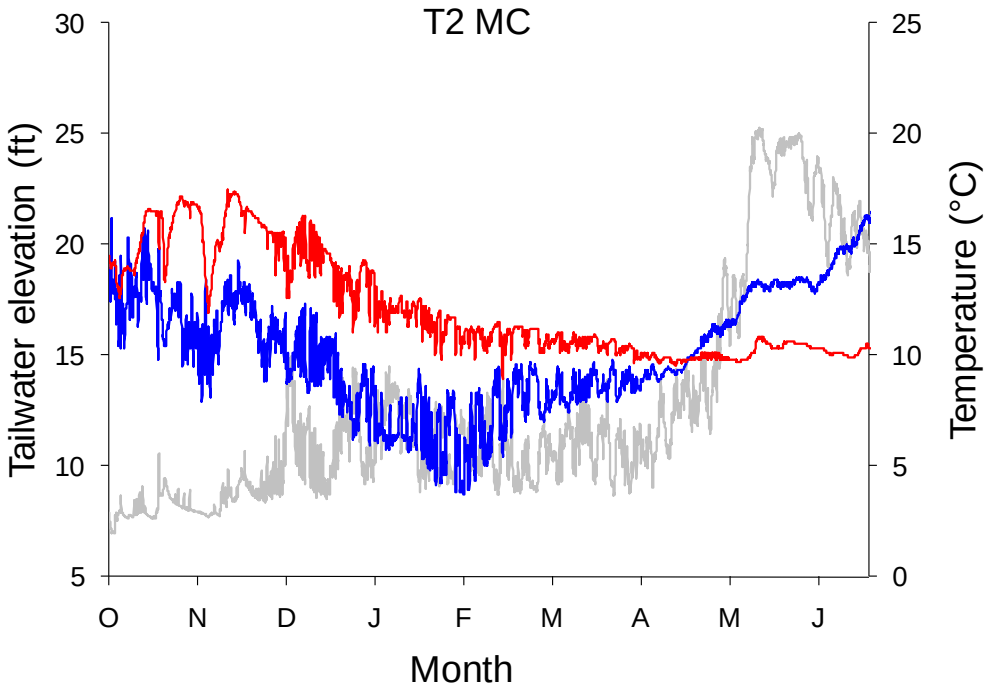

Figure 5. Time series plot of riverbed (red line) and river (blue line) temperature at the T2MC Ives Island chum salmon spawning location during October 2007 through June 2008. The grey line is water surface elevation (recorded at T2MC).

The temperature difference between the riverbed and the overlying river was greater during chum salmon spawning (November 15 through December 31, 2007) than during chum salmon incubation (January 1through May 15, 2008). During chum salmon spawning, composite mean temperature was14.5°C in the riverbed and 9.4°C in the river. The difference between mean riverbed temperature and river temperature during this period ranged from 4.7°C at T2MC to 5.9°C at T2LB (Table 1). The highest mean (SD) riverbed temperature for an individual monitoring location during the spawning period was 16.1°C (1.4°C), recorded at T2LB (Table 1). During the incubation period (January 1 through May 15, 2008), riverbed temperatures remained elevated compared to river temperatures through mid-April, after which seasonal warming caused river temperatures to became warmer than the riverbed (Figures 3 through 5). Mean riverbed temperatures were still elevated relative to the river during the incubation period, with differences ranging from 2.6°C at T2MC to 3.6°C at T1LB and T2LB. However, the difference between riverbed and river temperatures was substantially smaller than during the spawning period (Table 1). Composite mean temperature for all sites during the incubation period was 10.5°C in the riverbed and 7.2°C in the river.

Table 1. Mean temperature within the riverbed and river at Ives Island chum salmon spawning areas during spawning and incubation

		Mean Temperature (SD), °C		
Sampling Period	Sample Location	T1LB	T2LB	T2MC
Spawning (November 15–December 31, 2007)	Riverbed	12.6 (1.3)	16.1 (1.4)	14.9 (1.4)
	River	7.8 (1.4)	10.2 (2.7)	10.2 (1.7)
Incubation (January 1–May 15, 2008)	Riverbed	10.0 (0.7)	10.7 (1.1)	10.8 (0.9)
	River	6.4 (2.4)	7.1 (2.3)	8.2 (1.8)

5.0 References

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Appendix A

Temperature Sensor Location Information

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Temperature Sensor Location Information

Name	$\Delta L^{(a)}$ (cm)	$X^{(b)}$	$Y^{(b)}$
T1LB	58.0	578121	5053018
T2LB	58.4	578197	5053041
T2MC	58.0	578193	5053055

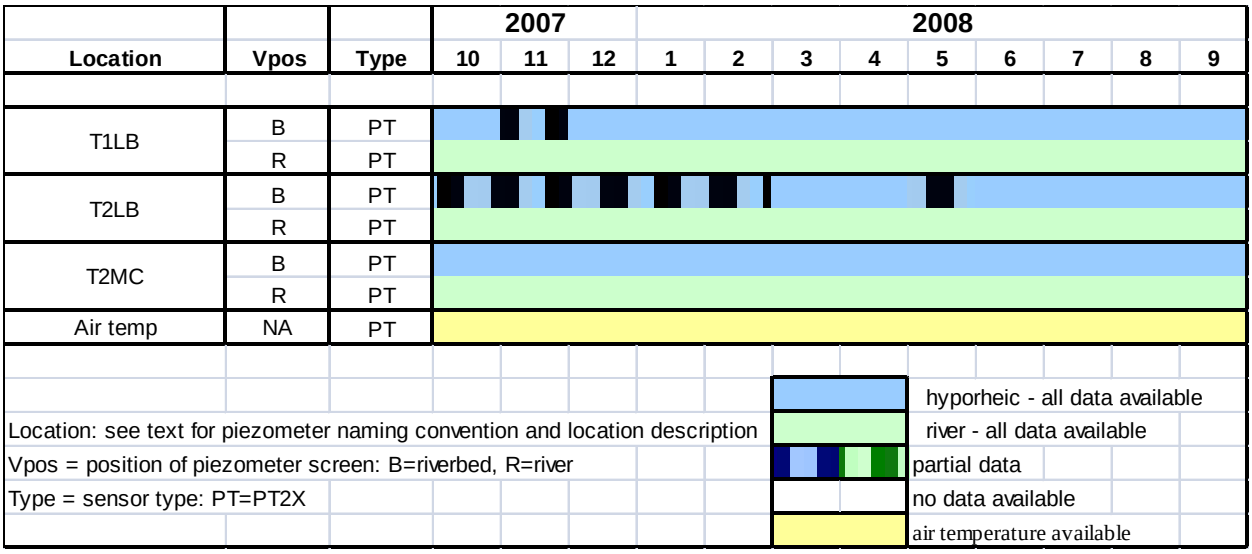
(a) ΔL= depth of riverbed sensor below the riverbed.
(b) Horizontal coordinate system UTM Zone 10 North, Datum NAD 83.

Appendix B

Temperature Data Collected Downstream from Bonneville Dam in the Ives Island Area, FY 2008

Appendix B

Temperature Data Collected Downstream from Bonneville Dam in the Ives Island Area, FY 2008



Appendix C

Temperature Data Compendium

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(Electronic file provided to BPA; please insert hyperlink here.)

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