Conducted in Cooperation with the City of Boise

Assessment of the Cross-Sectional Variability of Water-Quality Parameters in the Snake River as a Result of Measurement Location

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Water quality in the lower Boise River between Lucky Peak Dam and its confluence with the Snake River near Parma, Idaho is adversely affected by various agricultural and urban land- and water-use activities. The Snake River's Hells Canyon Reach spanning from the Oregon/Idaho border near Adrian, Oregon to the Brownlee Reservoir near Cambridge, Idaho is similarly affected.

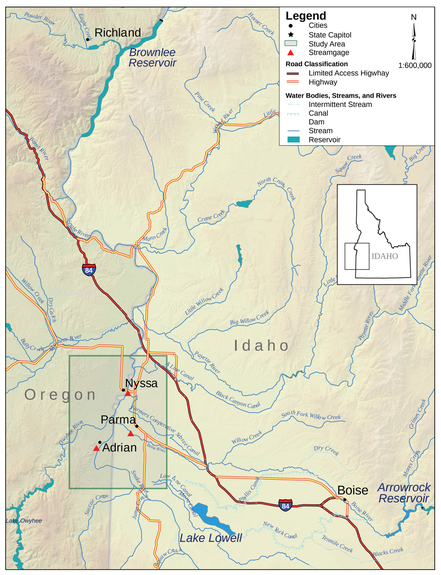
The relations between chlorophyll-a concentrations and phosphorus concentrations in the Snake River/Hells Canyon reach are poorly understood. Also in need of further investigation are the effects of nitrogen concentrations on algal production; effects of the algal communities on other key water-quality properties related to beneficial uses such as water clarity (turbidity), pH, and dissolved-oxygen concentration; and the significance of Boise River contributions of total phosphorus, total nitrogen, and chlorophyll-a to downstream water quality issues in the Snake River and Brownlee Reservoir. Intensive monitoring in the Boise and Snake Rivers is necessary to determine if concentrations of chlorophyll-a and total phosphorus are meeting established targets, and to address some of the unknown information and data variability issues discussed above.

Snake River near Adrian, OR

In October, 2008, the U.S. Geological Survey (USGS), in cooperation with the City of Boise, began conducting water-quality monitoring in the Snake River and the lower Boise River upstream of the Snake River. Three sites are included in the study: the Boise River near Parma, Idaho (Parma), just upstream of its confluence with the Snake River; the Snake River near Adrian, Oregon (Adrian), just upstream of its confluence with the Boise River; and the Snake River at Nyssa, Oregon (Nyssa), just downstream of its confluence with the Boise River.

One of the primary objectives of the project is to evaluate relations among continuously measured water-quality parameters, nutrients, and chlorophyll-a. A continuous water-quality monitor (CWQM) was installed at each of the three sites described above. The CWQMs record temperature, dissolved oxygen, pH, specific conductance, turbidity, and chlorophyll-a fluorescence (chlorophyll) at 15-minute intervals.

USGS scientists evaluated deployment locations for the CWQMs in October 2008 and determined that the downstream side of a bridge pier was the best deployment location at each of the Snake River sites to minimize equipment damage due to debris and high velocities. A bank-mounted installation at the Boise River near Parma site had been successfully used in previous studies and remained in use for this study. The methods described in this poster were used to evaluate whether data collected on the downstream side of a bridge pier are representative of channel conditions.



Methods

Field Methods

Data were collected to evaluate whether turbulence induced by a bridge pier would have a deleterious effect on recorded water-quality parameters. Table 1 summarizes data collection activities at each of the two sites evaluated.

Two CWQMs were deployed at the Adrian site to begin the tests. One was deployed at the bridge pier and one was deployed beside the bridge pier in open channel flow. The CWQM at the pier was deployed at an average depth of 3.2 feet and the CWQM beside the pier recorded an average depth of 2.5 feet. While these two CWQMs logged parameters at five-minute intervals, two horizontal profiles were completed at different mean times and a vertical profile was completed at both locations where CWQMs were continuously logging.

At the Nyssa site, limited availability of CWQMs disallowed simultaneous data collection at and beside the bridge pier. Instead, a CWQM logged water quality parameters for 20 minutes beside the bridge pier at an average depth of 1.0 foot before it was permanently installed at the pier. Water quality parameters logged beside the pier at Nyssa on October 29, 2008 were compared to water quality parameters logged at the pier at an average depth of 0.92 foot. Logistical constraints also prevented the completion of a second horizontal profile across the channel after vertical profiles were completed at and beside the bridge pier. Horizontal profiles at both sites were completed at depths between 0.5 and 1.5 feet.

Statistical Comparisons

At the Adrian site, continuous water-quality data collected at the pier were compared with data collected beside the pier (open channel) and in the horizontal profiles using statistical hypothesis tests. Measures of central tendency for each parameter were compared using the parametric T-Test (to compare means) and non-parametric Mann-Whitney U test (to compare medians). Data collected at the same time at and beside the pier were also compared as paired values using the parametric paired T-test and non-parametric Wilcoxon Signed-Ranks test. In addition, variances in the data sets were compared using the Modified-Levene Equal Variance test, and distributions were compared using the Kolmogorov-Smirnov test. In all cases, the chosen statistical level of significance, or alpha, was 0.05.

Statistical comparisons at the Nyssa site were identical to those at the Adrian site, except that the data at and beside the pier could not be compared using paired-t or Wilcoxon Signed-Ranks tests because they were collected at different times.

Data Collected	Time Completed Adrian	Time Completed Nyssa
Continuous water quality parameters logged beside bridge pier in open channel flow	~4 hours Mean time: 1356	~30 min Mean time 1446
Continuous water quality parameters logged at bridge pier		~1 hour Mean time: 1601
Vertical profile at the bridge pier	1246	1428
Vertical profile beside bridge pier in open channel flow	1345	1410
Equal width horizontal profile across channel at time 1	1240	1324
Equal width horizontal profile across channel at time 2	1429	none

Table 1

Results

Figures 1-3 illustrate comparisons of horizontal profiles to continuously logged values at and beside the pier at both sites.

At Adrian, the completion of two horizontal profiles enabled comparison of high, low, and mean values at each point across the channel. At Nyssa, parameters measured at each point in a single horizontal profile were compared to standard deviation measured across the same profile. Horizontal profiles were compared to continuously logged values at and beside the pier at both sites.

Adrian | **Nyssa**

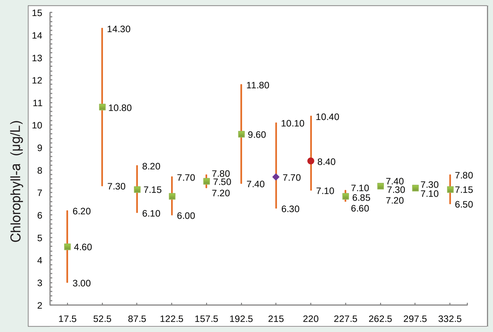


Figure 1a

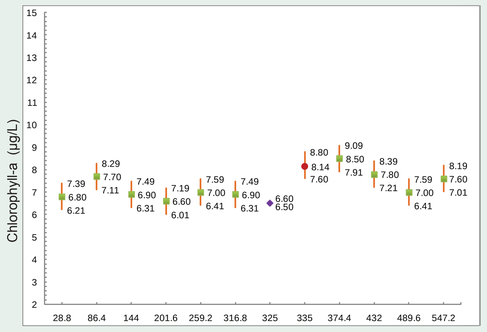


Figure 1b

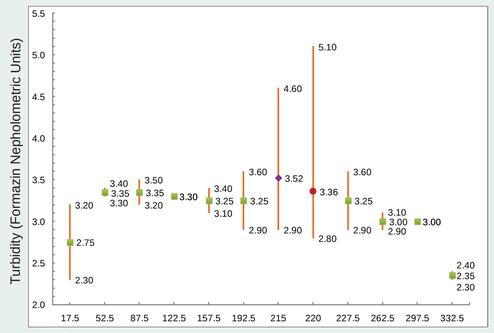


Figure 2a

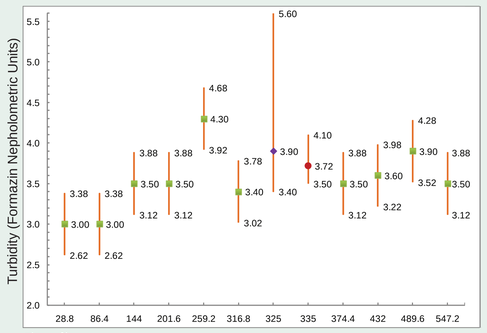


Figure 2b

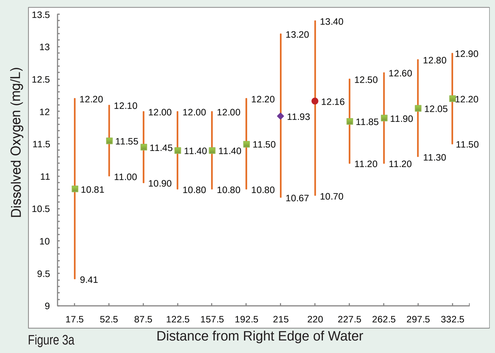


Figure 3a

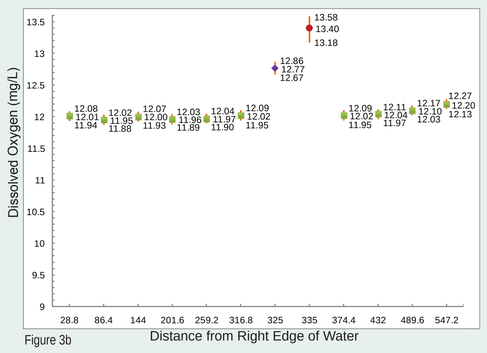


Figure 3b

Explanation

High Value Measured at Location
Mean Value Measured at Location (Two Horizontal Profiles)
Low Value Measured at Location
Mean Value Measured at CWQM Continuously Logging beside Bridge Pier
Mean Value Measured at CWQM Continuously Logging at Bridge Pier

Explanation

Standard Deviation above Measured Value at Location
Value Measured at Location (Single Horizontal Profile)
Standard Deviation below Measured Value at Location
Mean Value Measured at CWQM Continuously Logging beside Bridge Pier
Mean Value Measured at CWQM Continuously Logging at Bridge Pier

Statistical Tests

Summary statistics and comparisons for both sites are presented in Tables 2 and 3. At both Adrian and Nyssa, there was no significant difference in turbidity and specific conductance data collected at the pier and in the horizontal profile.

At Adrian, higher dissolved oxygen at the pier can be attributed to some minor turbulence and air entrainment induced by the pier. At Nyssa, the difference could be due to air entrainment and a difference in time periods measured. This turbulence may also serve to concentrate phytoplankton populations at the pier, resulting in slightly higher chlorophyll concentrations. The differences in chlorophyll concentrations are not critical, as the data are calibrated to the local phytoplankton population measured in periodic samples.

Standard deviation for most parameters at Adrian were lower in the data set at the pier than beside the pier. The lower standard deviation may be advantageous when analyzing trends in the data. Unfortunately, higher standard deviations were measured in data at the pier compared with data measured beside the pier at Nyssa. This may be due to different time periods measured and merits further investigation.

Means and Standard Deviations of Continuous Water-Quality Data Measured at the Pier, beside the Pier, and in Horizontal Profiles

Key: mg/L = milligrams per liter, FNU = Formazin Nepholometric Units, °C = degrees Celsius, mS/cm = microSiemens per centimeter, % = percent]

Snake River near Adrian, OR

Parameter	Chlorophyll-a Fluorescence			Turbidity			Temperature			Specific Conductance			pH			Dissolved Oxygen		
Units	mg/L			FNU			°C			mS/cm			Standard Units			mg/L		
	At Pier	Beside Pier	Horizontal	At Pier	Beside Pier	Horizontal	At Pier	Beside Pier	Horizontal	At Pier	Beside Pier	Horizontal	At Pier	Beside Pier	Horizontal	At Pier	Beside Pier	Horizontal
Mean	8.4	7.7	7.5	3.4	3.5	3.1	12.1	12.2	12.2	545	561	548	8.7	8.7	8.7	12.2	11.9	11.6
Standard Deviation	0.64	0.72	2.28	0.39	0.41	0.38	0.17	0.17	0.09	1.4	1.9	9.5	0.056	0.060	0.030	0.80	0.78	0.46

Snake River at Nyssa, OR

Parameter	Chlorophyll-a Fluorescence			Turbidity			Temperature			Specific Conductance			pH			Dissolved Oxygen		
Units	mg/L			FNU			°C			mS/cm			Standard Units			mg/L		
	At Pier	Beside Pier	Horizontal	At Pier	Beside Pier	Horizontal	At Pier	Beside Pier	Horizontal	At Pier	Beside Pier	Horizontal	At Pier	Beside Pier	Horizontal	At Pier	Beside Pier	Horizontal
Mean	8.1	6.6	7.3	3.7	3.9	3.5	11.1	10.9	10.6	545	547	547	8.7	8.6	8.5	13.4	12.8	12.0
Standard Deviation	0.44	0.17	0.59	0.23	0.95	0.38	0.060	0.030	0.04	0.84	0.55	2.50	0.013	0.0084	0.01	0.16	0.074	0.07

Table 2

Statistical Comparisons of Continuous Water-Quality Data

[All statistical tests were run at a significance level (alpha) of 0.05; Example: If "lower" is displayed below the column for beside pier, this means that the parameter of interest (e.g., mean) was statistically lower in the beside pier data than in the at-pier data;
Key: mg/L = micrograms per liter, mg/L = milligrams per liter, FNU = Formazin Nepholometric Units, °C = degrees Celsius, mS/cm = microSiemens per centimeter, % = percent, N/A = not applicable]

Snake River near Adrian, OR

Parameter	Chlorophyll-a Fluorescence		Turbidity		Temperature		Specific Conductance		pH		Dissolved Oxygen	
Units	mg/L		FNU		°C		mS/cm		Standard Units		mg/L	
	At Pier Compared With:		At Pier Compared With:		At Pier Compared With:		At Pier Compared With:		At Pier Compared With:		At Pier Compared With:	
	Beside Pier	Horizontal	Beside Pier	Horizontal	Beside Pier	Horizontal	Beside Pier	Horizontal	Beside Pier	Horizontal	Beside Pier	Horizontal
Paired T-Test (Means and Medians)	lower	N/A	similar	N/A	higher	N/A	higher	N/A	lower	N/A	lower	N/A
T-test (Means and Medians)	lower	similar	higher	similar	similar	similar	higher	similar	lower	similar	similar	lower
Modified Levene Test (Variance)	similar	similar	similar	similar	similar	similar	different	different	similar	similar	similar	similar
Kolmogorov-Smirnov Test (Distributions)	different	different	similar	similar	similar	similar	different	different	similar	different	similar	similar

Snake River at Nyssa, OR

Parameter	Chlorophyll-a Fluorescence		Turbidity		Temperature		Specific Conductance		pH		Dissolved Oxygen	
Units	mg/L		FNU		°C		mS/cm		Standard Units		mg/L	
	At Pier Compared With:		At Pier Compared With:		At Pier Compared With:		At Pier Compared With:		At Pier Compared With:		At Pier Compared With:	
	Beside Pier	Horizontal	Beside Pier	Horizontal	Beside Pier	Horizontal	Beside Pier	Horizontal	Beside Pier	Horizontal	Beside Pier	Horizontal
T-test (Means and Medians)	lower	lower	similar	similar	lower	lower	higher	similar	lower	lower	lower	lower
Modified Levene Test (Variance)	similar	similar	similar	similar	similar	similar	similar	different	similar	similar	similar	similar
Kolmogorov-Smirnov Test (Distributions)	different	different	similar	similar	different	different	similar	similar	different	different	different	different

Table 3

Conclusions

Specific conductance continuously logged in the open channel at Adrian may have been significantly higher than values measured continuously at the pier and throughout the channel due to differences in instrument calibration. Specific conductance values measured across the channel at Adrian decreased from the right bank to the left bank and the mean value measured in the open channel was only one µS/cm higher than the highest values measured on the right bank. Regardless, specific conductance values measured continuously at the pier at both Adrian and Nyssa were representative of specific conductance values measured throughout the channel at each site.

Adrian CWQM Installation Process

Installed CWQM at Nyssa

Differences in temperature, pH, and dissolved oxygen values measured at different mean times at Nyssa are attributed an increase in solar radiation and a subsequent increase in temperature, pH, and dissolved oxygen concentrations. Because the time-span of continuous data collected at and beside the pier at Adrian bracketed the mean times of data collected at vertical and horizontal profiles, pH and temperature values at the pier are representative of values measured throughout the channel.

Dissolved oxygen measured at the pier at Adrian was higher than dissolved oxygen in the cross section. Higher dissolved oxygen at the pier could be due to turbulence or the fact that the mean time of data collected at the pier is slightly later than the mean time of both horizontal profiles. At Nyssa, large differences between dissolved oxygen values measured at the pier and those measured throughout the channel were attributed to relatively rapidly increasing dissolved oxygen values over short periods of time. When compared to data collected at the bridge pier at the same mean time on the following day, the mean dissolved oxygen value in Nyssa's horizontal profile was only 0.02 mg/L lower than the dissolved oxygen value recorded at the pier.

Chlorophyll and turbidity measured at the pier at both sites does not differ significantly from chlorophyll and turbidity measured throughout the channel. Because of the relatively small diurnal fluctuation and high short-term variance of these parameters, mean values are likely to fall within the range of values from any given data set providing the time-spans are similar.

Statistical Conclusions

Snake River near Adrian, OR: Dissolved oxygen was slightly higher behind the pier than the mean value measured in the horizontal profile. This is likely due to turbulence and air entrainment due to the presence of the pier. However, the difference was fairly small. All other parameters were statistically similar. This indicates that data collected at the pier, perhaps with the exception of dissolved oxygen, are representative of conditions throughout the cross-section. This will be verified at various flows.

Snake River at Nyssa, OR: Chlorophyll, temperature, pH, and dissolved oxygen were slightly higher at the pier than the mean value measured in the horizontal profile. The differences are attributed to the difference in time periods between the comparison data sets (13:14-13:34 for the horizontal profile vs. 15:31-16:31 at the pier). Future comparisons should be made with data from the same time period. There was no statistical difference in the central tendency and distribution of the turbidity and specific conductance data measured at the pier and in the horizontal profile.

USGS personnel will continue to collect data at a variety of flows and compare the data collected at the pier with data collected throughout the stream cross-section. Of particular interest is whether the differences remain constant or proportional over seasons and flows. Even though some parameters were statistically different, protecting equipment is paramount; therefore, the equipment was mounted on the downstream side of the pier at both sites.

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