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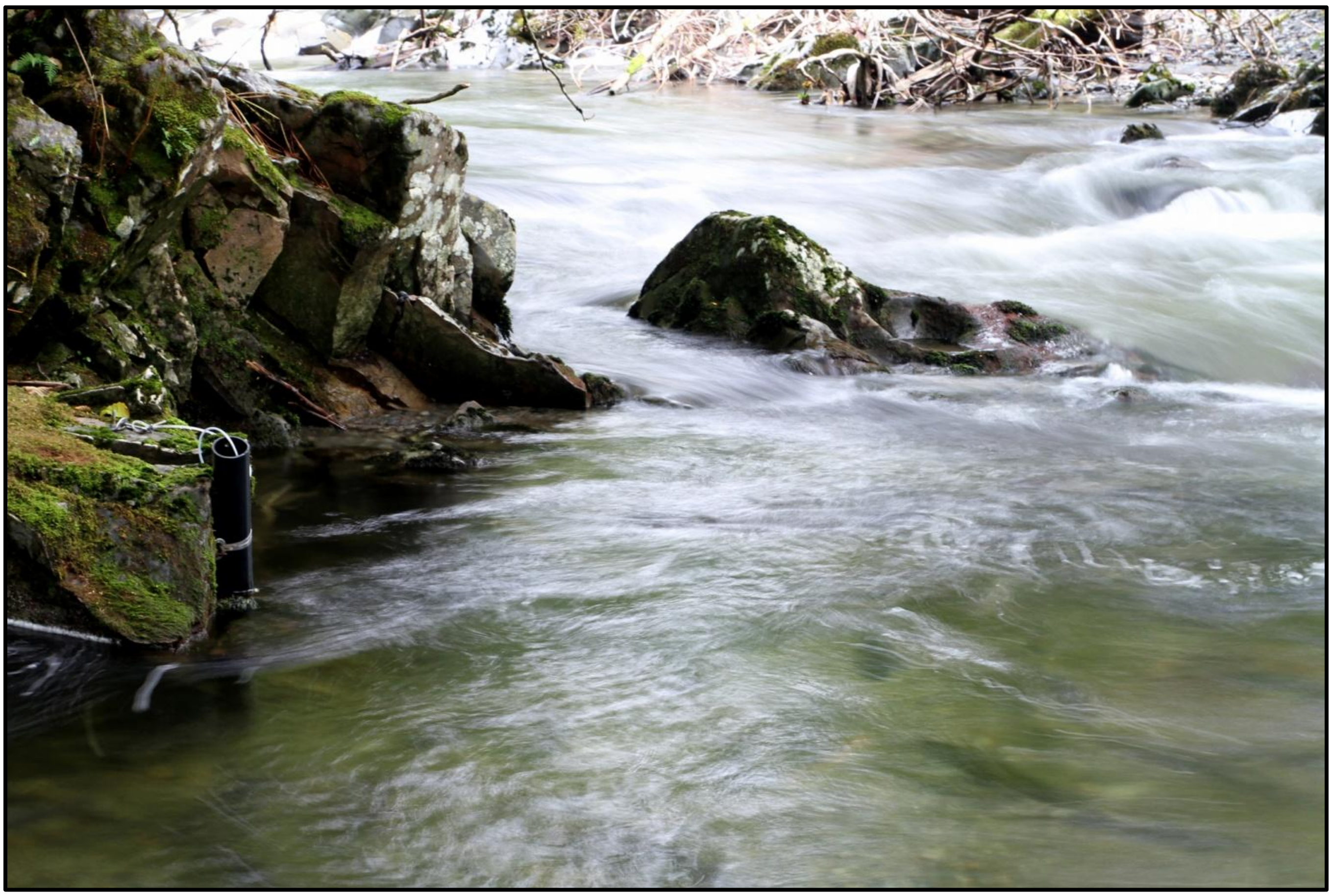
Natural Resource Stewardship and Science

Southeast Alaska Network Freshwater Water Quality Monitoring Program

2010 Annual Report

Natural Resource Technical Report NPS/SEAN/NRTR—2012/547



ON THE COVER
Indian River water quality monitoring site
Photograph by: Christopher J. Sergeant, Southeast Alaska Network, National Park Service

Southeast Alaska Network
Freshwater Water Quality Monitoring Program

2010 Annual Report

Natural Resource Technical Report NPS/SEAN/NRTR—2012/547

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February 2012

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

This report is available from the Southeast Alaska Network (http://science.nature.nps.gov/im/units/sean) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

Please cite this publication as:

Sergeant, C. J., W. F. Johnson, and B. J. Moynahan. 2012. Southeast Alaska Network freshwater water quality monitoring program: 2010 annual report. Natural Resource Technical Report NPS/SEAN/NRTR—2012/547. National Park Service, Fort Collins, Colorado.

NPS 953/112861, February 2012

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Executive Summary

Freshwater water quality is an indicator of ecosystem health and one of twelve priority Vital Signs monitored in the National Park Service's Southeast Alaska Network (SEAN). In 2010, hourly water temperature, conductivity, dissolved oxygen, and pH data were collected in the Salmon River (Glacier Bay National Park and Preserve) from June 4 through November 9, and in the Indian River (Sitka National Historical Park) from May 26 through September 23. Future annual reports will include data from the Taiya River in Klondike Gold Rush National Historical Park, first installed in 2011.

This is the first annual water quality report from the SEAN, representing the beginning of a sustained effort to collect long-term, high resolution water quality data in Southeast Alaska National Parks. Annual reports are concise but thorough summaries of the previous season's data that establish a regular product for park staff, managers, superintendents, and other interested parties. The 2010 report will establish the current water quality status of the Salmon and Indian Rivers and provide a broad comparison of water resource conditions between the two streams. In later years, annual report results will become more park-specific and describe trends within each river. All annual reports and data products are available at the SEAN freshwater water quality website:

http://science.nature.nps.gov/im/units/sean/FQ_Main.aspx

Both rivers demonstrated similar seasonal temperature trends in 2010. Daily mean water temperature in the Salmon River ranged from 4.0 to 11.0°C, peaking on August 6, while the Indian River ranged from 6.6 to 9.8°C, peaking on August 18. Median seasonal values for conductivity, dissolved oxygen, and pH were significantly different between systems. Compared to the Indian River, the Salmon had higher medians and non-overlapping ranges of values for conductivity and pH. Median DO in the Salmon River was significantly lower than the Indian, but the observed range of values overlapped throughout the season. These results were consistent with expectations for a mostly groundwater-influenced system (Salmon River) versus a mostly surface water-influenced system (Indian River).

Short-term snapshots of hourly data viewed over five to ten-day periods demonstrated that directional water quality trends during cool/wet weather periods were generally opposite of trends during warm/dry periods. For example, during a warm/dry period on the Salmon River, conductivity values tended to rise consistently, signifying the increasing contribution of groundwater contributions; during a cool/wet period, conductivity values generally dropped and were cyclical in response to rain events.

Both rivers demonstrated similar water quality characteristics in 2010 as those seen in past studies from the same systems or similar watersheds in Southeast Alaska. No 2010 observed water quality parameter values exceeded regulatory thresholds set by the Alaska Department of Environmental Conservation, and no observed values or trends appeared to signal point source pollution or a change to the fundamental water quality of the Salmon or Indian Rivers. Throughout the monitoring period, both rivers exhibited water quality conditions within expected normal ranges.

Acknowledgments

K. Fraley, C. Murdoch, G. Smith, and C. Soiseth conducted field work and transmitted data for processing. C. Smith and C. Soiseth reviewed and commented on the draft report. The SEAN Vital Signs program is supported by funding from the NPS National Inventory and Monitoring Program and the NPS Water Resources Division.

List of Acronyms

DO:	Dissolved oxygen
NPS:	National Park Service
GLBA:	Glacier Bay National Park and Preserve
NIST:	National Institute of Standards and Technology
SEAN:	Southeast Alaska Network
SITK:	Sitka National Historical Park
SOP:	Standard Operating Procedure
USGS:	United States Geological Survey

Introduction

Water quality is an indicator of aquatic and terrestrial ecosystem health in Southeast Alaska, a rainforest landscape dominated by a wet and mild maritime climate. The Southeast Alaska Network (SEAN) of the National Park Service (NPS) has prioritized Freshwater Water Quality as one of 12 Vital Signs for long-term ecological monitoring based on its vulnerability to alteration by human stressors and sensitivity for detecting fundamental environmental changes (Moynahan et al. 2008). Trends in water quality can signify chronic or developing watershed issues within national parks.

The SEAN water quality monitoring program has the following objectives:

- Track the status and trends of each core water quality parameter (conductivity, dissolved oxygen, pH, and water temperature)
- Describe the timing and magnitude of seasonal and annual variation for each core water quality parameter
- Evaluate whether state and/or federal water quality standards are met or exceeded

The SEAN water quality monitoring protocol (Nagorski et al. 2012) includes an extended description of each water quality parameter (Sections 1.3-1.7) and a discussion of future priorities for expanding the monitoring program (Section 7.0). We expect future monitoring to include an expanded stream temperature monitoring component and additional water quality sondes in more rivers within the SEAN.

This report summarizes results from the 2010 sampling season and compares historical data in the same rivers or similar systems, where data was available. Some comparisons between rivers are made to provide a broader context for the range of water resources within the SEAN. In later years, annual report results will become more park-specific and describe trends within each river. It should be noted that the 2010 report was written in early 2012 after data management processes were finalized. Guidance for report formatting and analytical techniques is described in Standard Operating Procedure (SOP) 10 of the water quality monitoring protocol (Nagorski et al. 2012). Every five years, beginning in 2014, a five-year synthesis report will present more in-depth trend analyses and broadened discussion.

Study Areas

The initial sampling goal of the monitoring program was to track water quality status and trends in at least one river in each of the three SEAN parks. In 2010, sondes were installed in the Salmon (GLBA) and Indian (SITK) Rivers. The Taiya River (KLGO) was added in 2011. Sampling sites were chosen based on park prioritization and dependable site access.

Salmon River (GLBA)

The Salmon River is 32.7 km long within an 11,552 ha watershed and collects most of its water from Excursion Ridge. The lowermost portion of the river (river km 0.0 to 9.0) is outside of NPS boundaries and within the town of Gustavus. The Salmon River has gravel riverbed habitat and supports populations of gamefish species such as pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*O. keta*), coho salmon (*O. kisutch*), steelhead (*O. mykiss*), cutthroat trout (*O. clarkii*), and Dolly Varden (*Salvelinus malma*; Eckert et al. 2006a). Staghorn (*Leptocottus armatus*) and coastrange sculpin (*Cottus aleuticus*) have been documented in the river but not formally reported (C. Soiseth personal communication). Although there is no direct evidence from past data, it is possible due to local septic system design and proximity that sewage input from Gustavus residents affects Salmon River water quality downstream of the park boundary and sampling site. The water quality monitoring site is located on the river left bank at approximately river km 9.0, several meters upstream of the NPS boundary (Figure 1). GLBA, the largest unit in SEAN, has more than 310 streams (Soiseth and Milner 1995, NPS 2005) flowing for over 3,380 km through a diverse landscape, making this park a priority area for future water quality monitoring program expansion.

Figure 1. Monitoring station on the Salmon River in GLBA (large red circle near SE corner of map).

Indian River (SITK)

The lowest 1 km of the Indian River is the only significant riverine habitat within SITK boundaries and can be characterized as a low gradient alluvial channel with gravel-cobble substrate (Eckert et al. 2006b) that supports anadromous species, including coho, pink, chum, and Chinook salmon (*O. tshawytscha*), steelhead, Dolly Varden, and non-anadromous species such as resident rainbow trout (*O. mykiss*), resident cutthroat trout (*O.* clarkia), three-spine stickleback (*Gasterosteus aculeatus*), and coastrange sculpin (Eckert et al. 2006b). The Indian River is approximately 19.8 km long within a steep and well-drained 3,185 ha watershed. The water quality monitoring site is located on the river right bank approximately 60 m upstream of park boundaries at river km 0.8 (Figure 2).

Figure 2. Monitoring station on the Indian River in SITK (large red circle near NE corner of map).

Methods

Station instrumentation

2010 marked the first year of continuous freshwater water quality monitoring in the SEAN. Both the Salmon and Indian Rivers were sampled hourly for conductivity (specific conductance; mS/cm), dissolved oxygen (mg/L), pH, and water temperature (°C). Multi-parameter water quality sondes (Table 1) collected and logged data at single fixed sites (Figures 1 and 2) in the Salmon River, from 4 June 2010 through 9 November 2010, and in the Indian River from 26 May 2010 through 23 September 2010 (Table 2). In following years, sampling is planned to occur from May 1 through October 31, possibly into November if ice conditions and staff availability allow.

Table 1. YSI, Inc. instruments used for 2010 water quality sampling.

Equipment description	Model number
Multi-parameter water quality logger	6920V2-2
Multi-parameter display system	650
Conductivity/temperature probe	6560
pH probe	6561
Optical oxygen sensor	6150

In both rivers, the sonde was mounted inside a perforated 4-inch ABS pipe. In the Salmon River the pipe was attached to an angle-iron rod set into the streambed, while the Indian River pipe was bolted to a large boulder in the stream channel. A bolt mounted through the ABS pipe set the sonde height in the water column. After initial installation, Park Leads generally visited the sondes once a month to check calibration for each sensor and clean components, as needed. These calibration checks were used to grade data quality and ensure that the water quality instruments were functioning properly.

Table 2. Summary of 2010 freshwater water quality sampling effort. Lightly shaded boxes represent a full month of sampling, while darker boxes represent a partial month.

	Month							
River	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Core parameters collected?**
Salmon								Y
Indian								Y

Data processing

Calibration checks were conducted on the Salmon River within the first three days of each month from July to October until instrument removal on November 10. On the Indian River, calibration checks were conducted June 30, August 2, and August 31 before instrument removal on September 23. The protocol narrative, SOP 1, and SOP 2 describe the data collection, calibration checks, and data processing in detail (Nagorski et al 2012).

SEAN has established data ***ratings*** and ***grades*** to describe overall data quality. ***Ratings*** denote unusable data for reasons such as the sonde being out of water during a calibration check or a spurious value due to instrument error. Before analysis, data with a ‘2’ or ‘3’ quality rating were removed from the analyzed data set. No data with ‘0’ (no question of accuracy) or ‘1’ (determined useable by Project Leader despite potential mistakes in following protocols) data quality ratings were deleted from the data summaries. SOP 13 of the water quality protocol (Nagorski et al. 2012) describes each data rating in detail. Comments contained in the processed CSV files available on the SEAN website (http://science.nature.nps.gov/im/units/sean/FQ_Main.aspx) also contain justification for each rating.

Data ***grades*** refer to the point-in-time accuracy of each water quality sensor during regular calibration checks and range from 'Poor' to 'Excellent'. The grades determined by these point checks were back dated to the previous calibration check and applied to all data during that time period. Currently, SEAN does not correct (adjust) data values based on calibration checks (as described in Wagner et al. 2006), but will develop a proposal for future consideration of data correction procedures around early 2013.

The final data sets were analyzed and summarized according to the guidelines in SOP 10 (Nagorski et al. 2012).

Comparison of cool/wet versus warm/dry periods

Hourly readings from short time periods were used to compare fine-scale water quality trends during warm/dry versus cool/wet periods. To determine warm and cool periods, daily mean air temperature data were taken from Sitka and Gustavus airports. Dry and wet periods were determined using total precipitation data from the Sitka airport for the Indian River and the Hoonah airport for the Salmon River. The Hoonah airport is approximately 40 km from Gustavus, but is the nearest reliable source of precipitation data.

Results

Data collection

Once sondes were installed for the season, no data collection problems caused significant data gaps. During limited periods in the Salmon and Indian Rivers, water temperature readings were graded 'poor,' (Table 3). This grade is given when the difference between the sonde water temperature sensor reading and an NIST-certified thermometer is greater than 0.8°C (see SOP 2). But, in general, sonde water temperature readings are dependable and it is believed that a poorly performing electronic NIST-thermometer provided flawed comparisons with the sondes' temperature sensors during the season. At no time was the sonde temperature sensor more than 1°C different from the NIST thermometer.

Table 3. Summary of 2010 freshwater water quality data grades. E = Excellent, G = Good, F = Fair, P = Poor. Definitions for each grade are found in SOP 2 (Nagorski et al. 2012) and are based on USGS recommendations (Wagner et al. 2006).

		Date ranges				
River	**Parameter**	**6/4 to 7/2**	**7/2 to 8/2**	**8/2 to 9/3**	**9/3 to 10/1**	**10/1 to 11/10**
Salmon	Conductivity (mS/cm)	E	E	E	E	E
	Dissolved Oxygen (mg/L)	G	G	P	E	E
	pH	E	E	E	E	E
	Temperature (°C)	E	P	E	F	E
		Date ranges				
		5/26 to 6/30	**6/30 to 8/2**	**8/2 to 8/30**	**8/30 to 9/23**	
Indian	Conductivity (µS/cm)	P	E	E	E	
	Dissolved Oxygen (mg/L)	G	E	E	E	
	pH	E	E	E	E	
	Temperature (°C)	F	P	P	F	

Temperature

Both systems demonstrated similar seasonal temperature trends (Figure 3), but the Salmon River was, on average, warmer and more variable than the Indian River. Daily mean water temperature in the Salmon River ranged from 4.0 to 11.0°C, peaking on August 6, while the Indian River ranged from 6.6 to 9.8°C, peaking on August 18. The range of monthly averages for daily mean water temperatures was greater in the Salmon, while the Indian River monthly averages were relatively stable (Table 4). Minimum temperature comparisons during the fall are not possible because Indian River sampling ended September 23. The Salmon River began dropping toward its minimum observed temperatures beginning October 20.

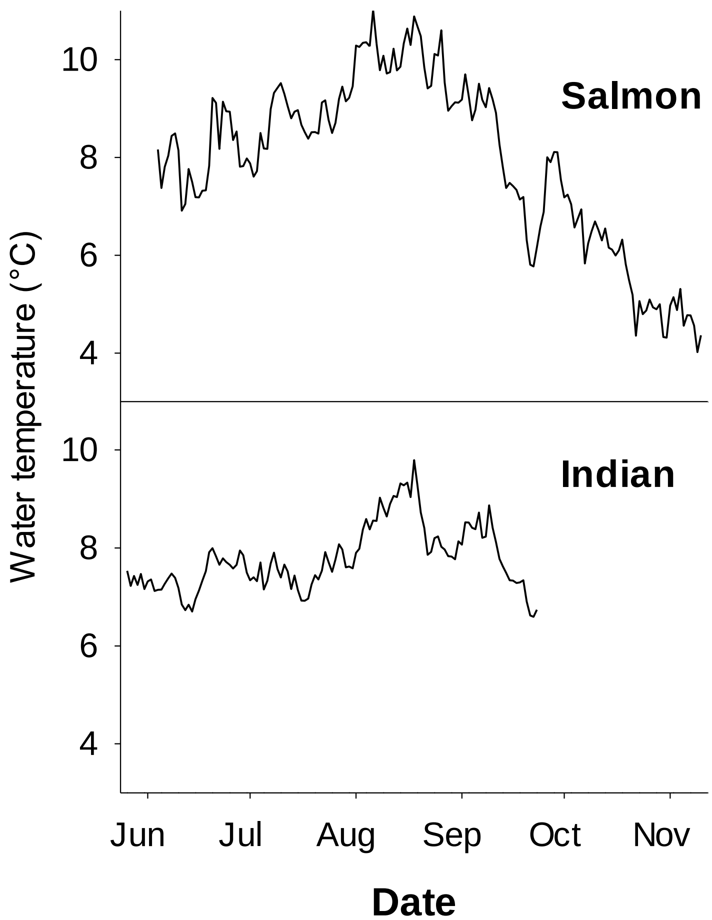

Figure 3. Daily mean water temperature for the Salmon and Indian Rivers in 2010.

Table 4. Monthly mean, minimum daily mean, and maximum daily mean water temperature for the Salmon and Indian Rivers in 2010. See the methods section for sonde installation dates for each river.

	Salmon			Indian		
Month	**Mean daily average (SD)**	**Min**	**Max**	**Mean daily average (SD)**	**Min**	**Max**
June	8.0 (0.8)	6.9	9.2	7.4 (0.6)	6.7	8.0
July	8.8 (0.6)	7.6	9.5	7.5 (0.5)	6.9	8.1
August	10.0 (0.7)	8.9	11.0	8.5 (0.7)	7.8	9.8
September	7.9 (1.2)	5.8	9.7	7.8 (0.8)	6.6	8.9
October	5.8 (0.9)	4.3	7.2			

Conductivity, DO, and pH

Median values for specific conductance, dissolved oxygen (DO), and pH were significantly different between the Salmon and Indian Rivers (two-sample Wilcoxon rank-sum test; $p < 0.001$ for all comparisons). Box plots summarizing the seasonal distribution of values for each water quality parameter illustrate distinct differences between systems (Figure 4). Compared to the Indian River, the Salmon had higher conductivity and pH. Median DO in the Salmon River was significantly lower than the Indian, but the observed range of values had some overlap throughout the season.

Full season hourly time series data for all water quality parameters are included in Appendix A. Preliminary daily average streamflow time series data from the Indian River are provided with daily average water quality data in Appendix B. Streamflow data were collected in close proximity to water quality data, but streamflow data are considered preliminary until the SEAN streamflow monitoring protocols and data management procedures have been finalized.

Plots for warm/dry periods versus cool/wet periods provide a general summary of high-resolution, short-term water quality trends in each system (Figures 5 to 8). Each figure displays the same scales for consistent trend comparisons across times and locations. In general, monotonic directional trends for each water quality parameter during each weather snapshot were quite small, but statistically significant using the Mann-Kendall non-parametric test for trend. For each river, these figures demonstrate that directional trends for individual parameters typically switched between warm and cool periods. These trends should be interpreted cautiously, as they are calculated from short-term data sets that were chosen strictly for illustrative purposes.

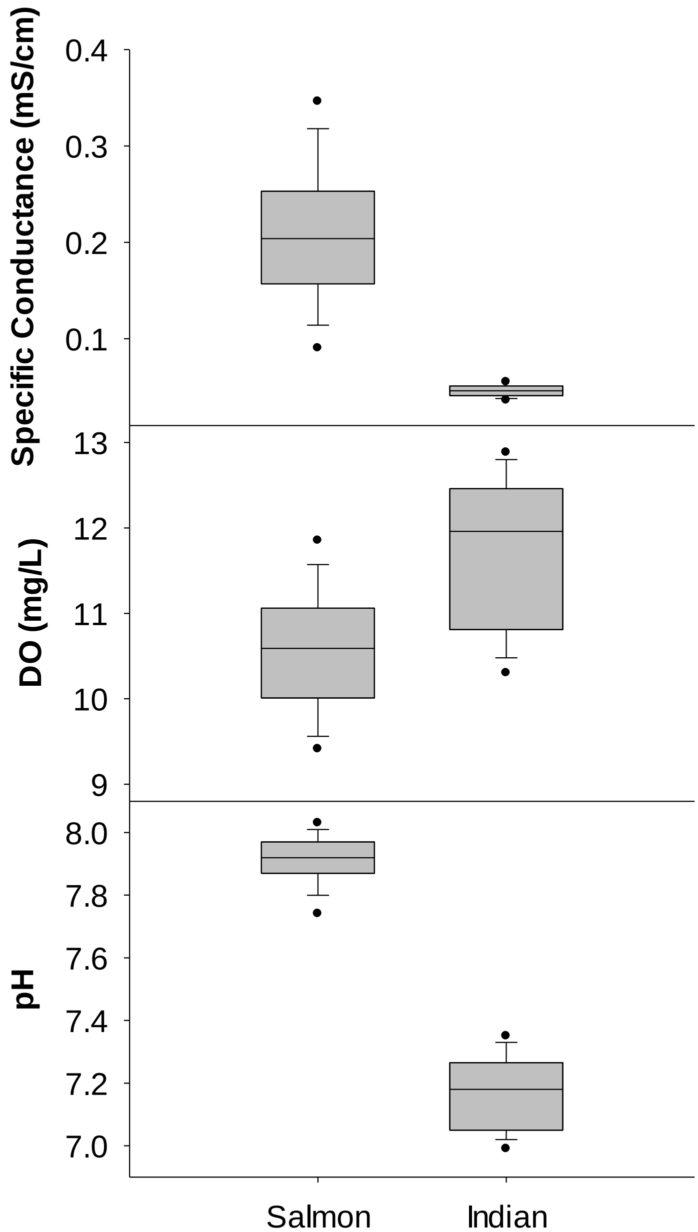

Figure 4. Box plots summarizing seasonal values for pH, dissolved oxygen (DO), and specific conductance for the Salmon and Indian Rivers in 2010. The central horizontal line within each box indicates median values, horizontal lines bounding the upper and lower portion of the boxes represent 25th and 75th percentiles, lower and upper whiskers represent 10th and 90th percentiles, and single points represent 5th and 95th percentiles.

During a warm/dry period on the Salmon River from August 11 through August 16 (Figure 5), water temperature and DO demonstrated the greatest diel variation. Values for pH had slight diel periodicity. Median water temperature, conductivity, and pH rose slightly during this period (Mann-Kendall test; $p < 0.001$), while median DO levels dropped slightly ($p < 0.001$). Conductivity values rose consistently as the dry period continued.

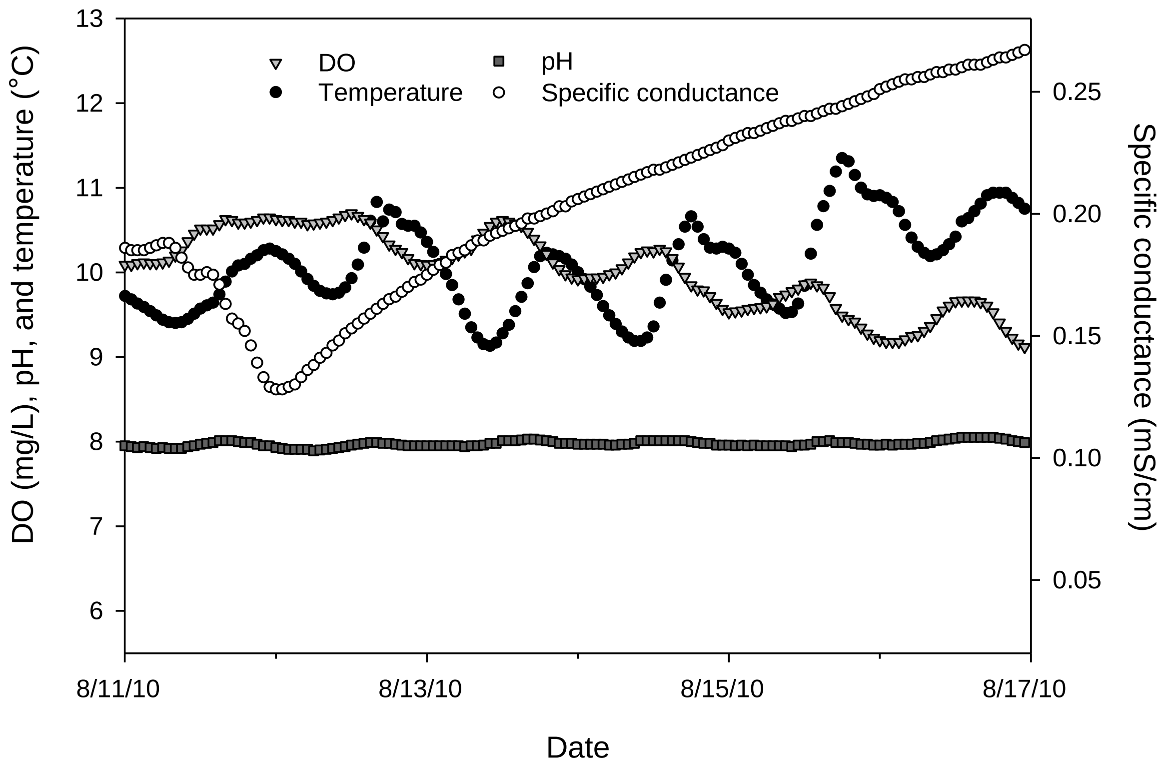

Figure 5. Hourly water quality readings of DO, pH, water temperature, and conductivity for the Salmon River during a representative 2010 warm/dry period. During this date range, no rainfall was recorded at the Hoonah airport (surrogate) and average daily air temperatures ranged from 14-18°C at the Gustavus airport. Note the second axis for specific conductance values.

The short-term directional trend of each water quality parameter switched during a cool/wet period on the Salmon River from October 9 through October 17 (Figure 6). The highest daily total precipitation recorded at the Hoonah airport during the field season occurred on October 12 and appears to correspond with a large drop in conductivity and rise in DO. Diel variation was apparent among all water quality parameters, and in general variation during the cool/wet period in the Salmon River was greater than the warm/dry period. Median water temperature, conductivity, and pH dropped slightly during this period ($p < 0.001$), while median DO rose slightly ($p < 0.001$). During this cool/wet period, DO and conductivity demonstrated a stronger inverse relationship than during warm/dry days.

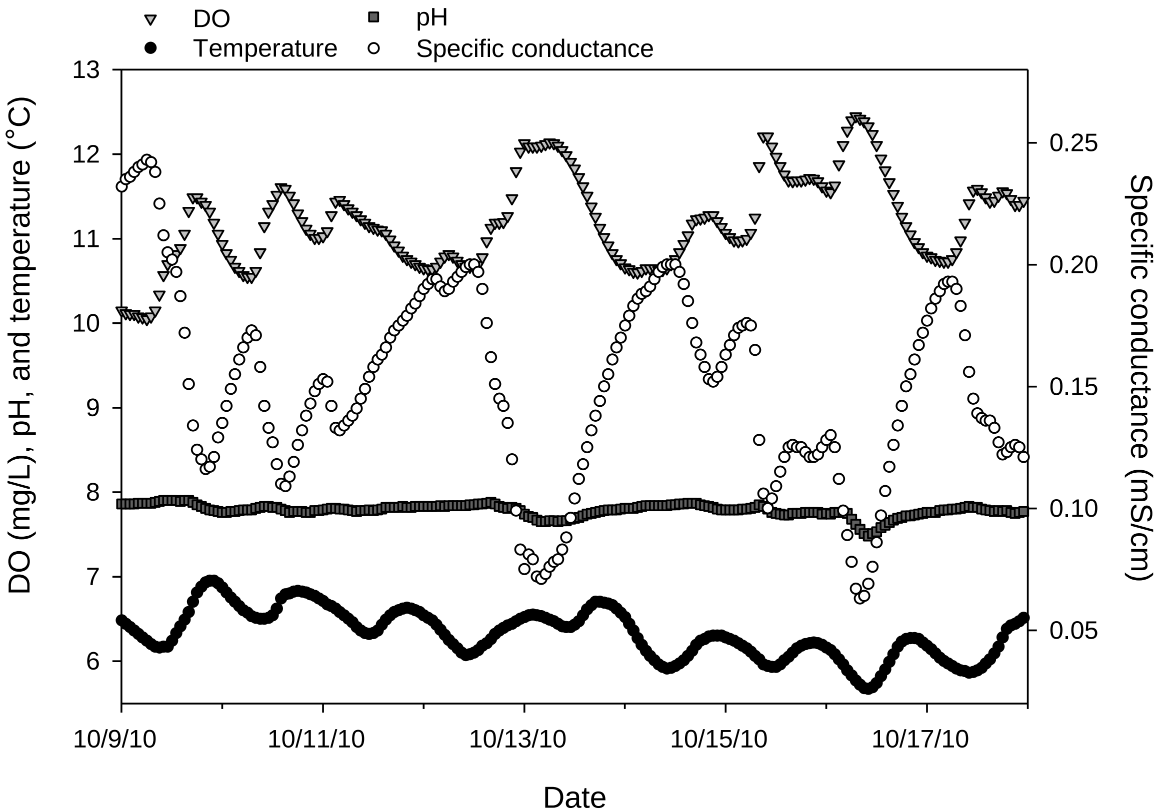

Figure 6. Hourly water quality readings of DO, pH, water temperature, and conductivity for the Salmon River during a representative 2010 cool/wet period. During this date range, total daily precipitation at the Hoonah airport (surrogate) ranged from 0.07 to 3.89 cm and average daily air temperatures ranged from 6-9°C at the Gustavus airport. Note the second axis for specific conductance values.

During a warm/dry period on the Indian River from August 12 through August 16 (Figure 7), water temperature and DO demonstrated the greatest diel variation. Median water temperature and conductivity rose slightly during this period ($p < 0.001$), while median DO and pH levels dropped slightly ($p < 0.001$). The direction and magnitude of warm/dry trends for DO, pH, and water temperature were similar between the Salmon and Indian rivers, but considerably different in magnitude for conductivity. While both systems demonstrated rising conductivity during warm/dry periods, the Indian River exhibited a smaller proportional and absolute increase.

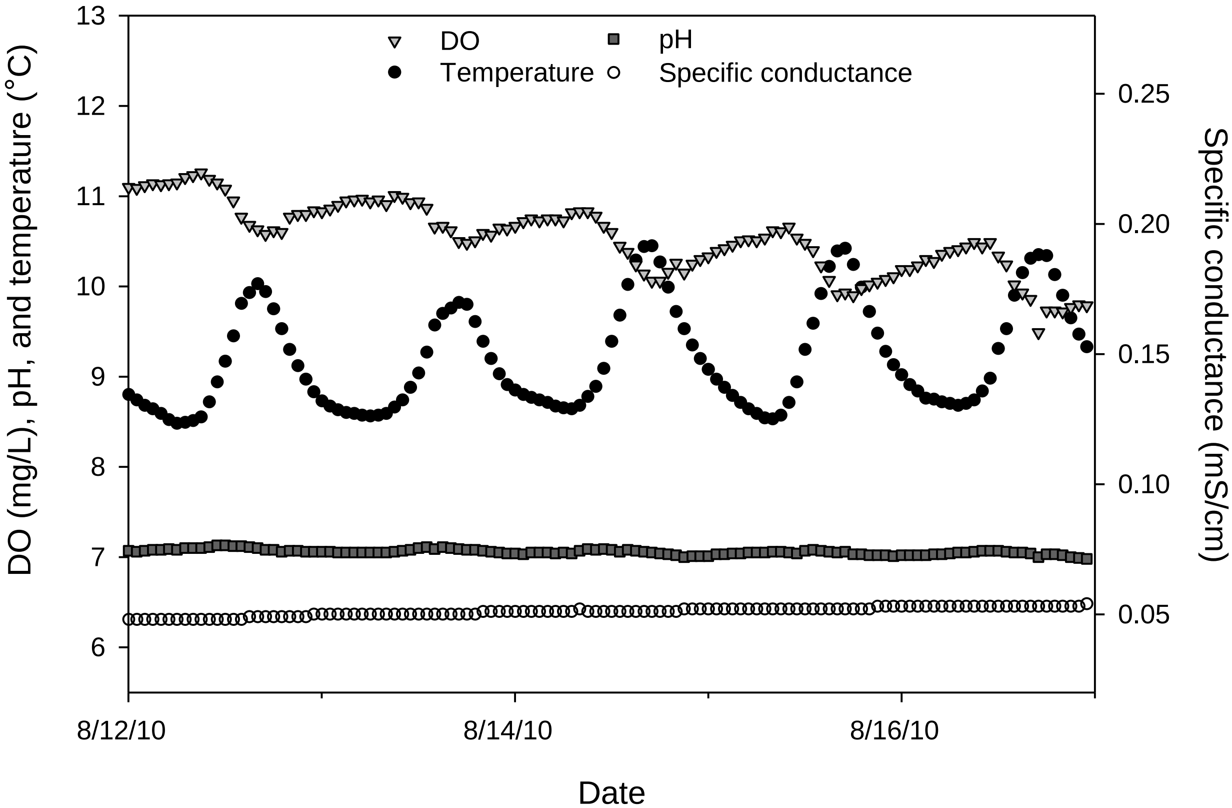

Figure 7. Hourly water quality readings of DO, pH, water temperature, and conductivity for the Indian River during a representative 2010 warm/dry period. During this date range, no rainfall was recorded at the Sitka airport and average daily air temperatures ranged from 14-17°C. Note the second axis for specific conductance values.

The short-term directional trends for conductivity and DO switched during a cool/wet period on the Indian River from June 30 through July 5 (Figure 8). Median water temperature did not change significantly during this period ($p = 0.392$). Conductivity and pH dropped slightly during this period ($p = 0.024$ and $p < 0.001$, respectively), while median DO rose slightly ($p = 0.032$). Variation in DO and conductivity values during cool/wet periods were much more muted in the Indian River in comparison to the Salmon.

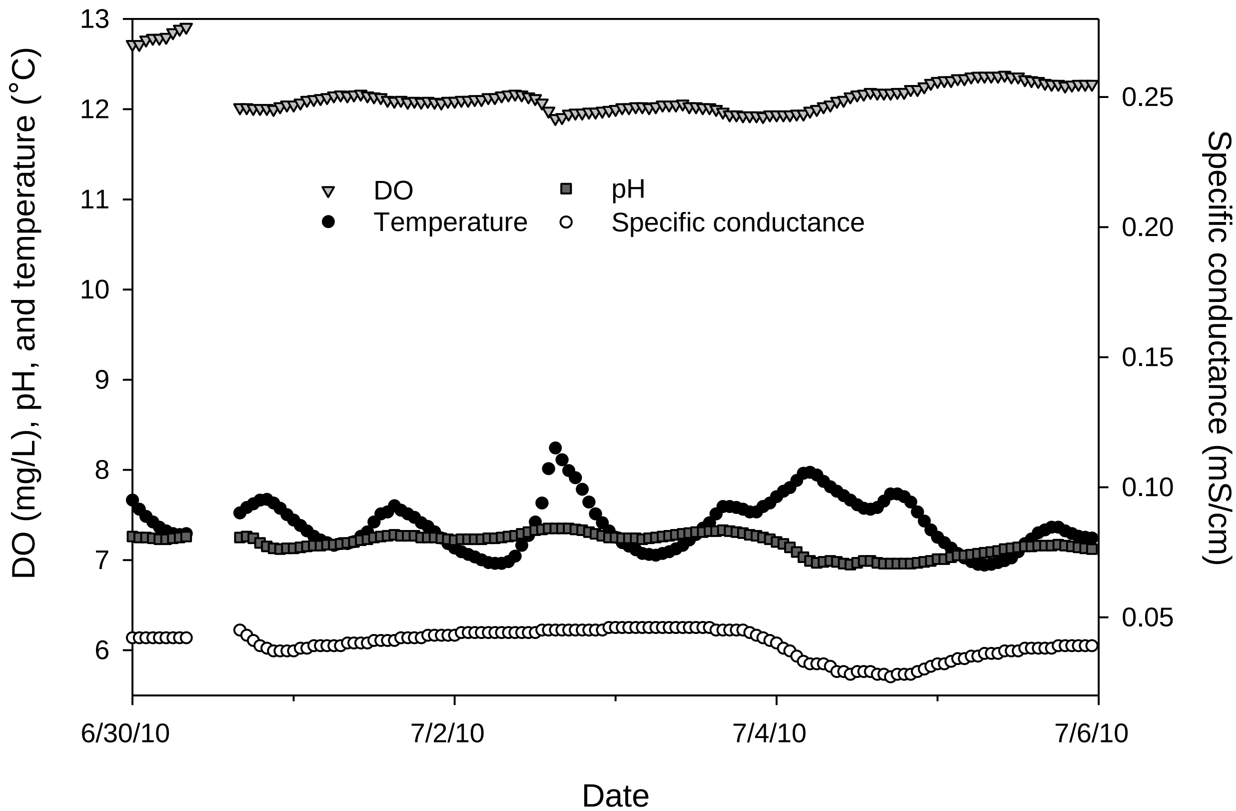

Figure 8. Hourly water quality readings of DO, pH, water temperature, and conductivity for the Indian River during a representative 2010 cool/wet period. During this date range, total daily precipitation at the Sitka airport ranged from 0.00 to 2.13 cm and average daily air temperatures ranged from 9-12°C. Note the missing values on June 30 when the sonde was out of water for servicing and the second axis for specific conductance values.

Compliance with water quality standards

2010 observations (Table 5) never exceeded Alaska Department of Environmental Conservation water quality standards (Table 6; ADEC 2011) and generally never approached regulatory thresholds. On August 6, the Salmon River was greater than 12°C for approximately seven hours, which begins to approach salmonid spawning thresholds (Table 6), but the weekly average from August 1 to 7 was 10.4°C.

Table 5. Period of record and summary statistics for all freshwater water quality collected and reported by the SEAN.

				Summary statistics				
River	**Parameter**	**Period of Record**	**Number of observations[1]**	**Median**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Salmon	Conductivity (mS/cm)	4 June 2010 to 9 November 2010	3810	0.20	0.21	0.07	0.05	0.39
	Dissolved Oxygen (mg/L)		3810	10.6	10.6	0.7	9.0	13.0
	Dissolved Oxygen (% Sat)		3810	89.4	89.1	6.5	73.3	105.9
	pH		3810	7.9	7.9	0.1	7.4	8.1
	Temperature (°C)		3810	8.2	7.9	1.8	3.8	12.4
Indian	Conductivity (µS/cm)	26 May 2010 to 23 September 2010	2864	0.05	0.05	0.01	0.03	0.06
	Dissolved Oxygen (mg/L)		2864	12.0	11.7	0.9	9.5	13.2
	Dissolved Oxygen (% Sat)		2864	100.2	98.0	6.7	82.2	108.8
	pH		2864	7.2	7.2	0.1	6.8	7.4
	Temperature (°C)		2864	7.7	7.8	0.8	5.9	10.5

[1] Data graded '2' or '3' were not counted as observations; Please see SOP 13 of the Freshwater Water Quality protocol (Nagorski et al. 2012) for descriptions of these record quality ratings

Table 6. Alaska Department of Environmental Conservation (ADEC) water quality standards (ADEC 2011). Standards listed below are the most stringent for each parameter. Superscript numbers denote regulatory categories for each standard.

Parameter	**Criteria**
Conductivity	None listed by ADEC
Dissolved oxygen (DO)[1]	DO must be greater than 7 mg/l in waters used by anadromous or resident fish. In no case may DO be less than 5 mg/l to a depth of 20 cm in the interstitial waters of gravel used by anadromous or resident fish for spawning (see note 2). For waters not used by anadromous or resident fish, DO must be greater than or equal to 5 mg/l. In no case may DO be greater than 17 mg/l. The concentration of total dissolved gas may not exceed 110% of saturation at any point of sample collection.
pH[1]	May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH unit from natural conditions.
Temperature[1,2]	May not exceed 20°C at any time. The following maximum temperatures may not be exceeded, where applicable: Migration routes 15°C Spawning areas 13°C Rearing areas 15°C Egg & fry incubation 13°C For all other waters, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms.

[1] Growth and propagation of fish, shellfish, other aquatic life, and wildlife
[2] Water supply/aquaculture

Discussion

Before the 2010 field season, no known long-term water quality records existed for the Salmon River (Eckert et al. 2006a). Falls Creek, located on the east side of Gustavus, is a similar watershed with some available data collected during the design of a hydroelectric facility. During spot measurements taken in August 1999, November 1999, and February 2000, Falls Creek pH ranged from 7.9 to 8.2, and DO ranged from 8.5 to 12.2 mg/L (FERC and NPS 2004). These ranges are very consistent with the observed 2010 Salmon River data (Table 5).

Data were collected through a USGS-NPS partnership from January 2001 to September 2002 near the current Indian River monitoring site. Those data characterized Indian River water resources as high quality and relatively pristine, despite the potential for pollution from urban runoff and continued development (Eckert et al. 2006b; Neal et al. 2004). During this period, water temperature ranged from 2.0 to 8.5°C, DO from 11.4 to 14.1 mg/L, pH from 6.5 to 8.1, and specific conductance from 0.036 to 0.053 mS/cm. While the 2010 maximum observed water temperature (10.5°C) was higher and the minimum DO (9.5 mg/L) slightly lower, all other observed water quality parameter values fell within the range of the Neal et al. study (Table 5).

Based on preliminary Indian River streamflow data, flow patterns generally mirror precipitation events, which on average peak during September through November (Eckert et al. 2006b). In 2010, the highest daily average flows occurred in July (Appendix B). The influence of surface waters are also seen in the extremely low conductivity values compared to the Salmon River. Low values are typically seen in rainfall because it contains small amounts of dissolved ions that would increase observed conductivity values. Combined, the flow and conductivity data strongly suggest that surface water is the main driver of flow patterns for the Indian River.

Water quality observations in 2010 were consistent with the expected results for a more groundwater and mature wetland-influenced system (Salmon River) versus a mostly surface water-influenced system (Indian River). Both rivers generally demonstrated similar water quality patterns in 2010 as those seen in past studies from the same systems or similar watersheds in Southeast Alaska (Hood and Berner 2009).

No 2010 observed water quality parameter values exceeded regulatory thresholds set by the ADEC (Table 6), and no observed values or trends appeared to signal point source pollution or a change to the fundamental water quality of the Salmon or Indian Rivers. Throughout the monitoring period, both rivers exhibited water quality conditions within expected normal ranges.

Considerations

Readers interested in accessing SEAN water quality data can download data from the SEAN Freshwater Water Quality webpage: http://science.nature.nps.gov/im/units/sean/FQ_Main.aspx

Currently, SEAN does not correct (adjust) data values based on calibration checks (see Wagner et al. 2006), but will develop a proposal for considering future data correction procedures around early 2013. If data customers decide that analyses may benefit from data correction, all data necessary to develop correction procedures are available on the SEAN website (e.g., site visit worksheets including calibration check results).

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Appendix A: Hourly time series data for all water quality parameters

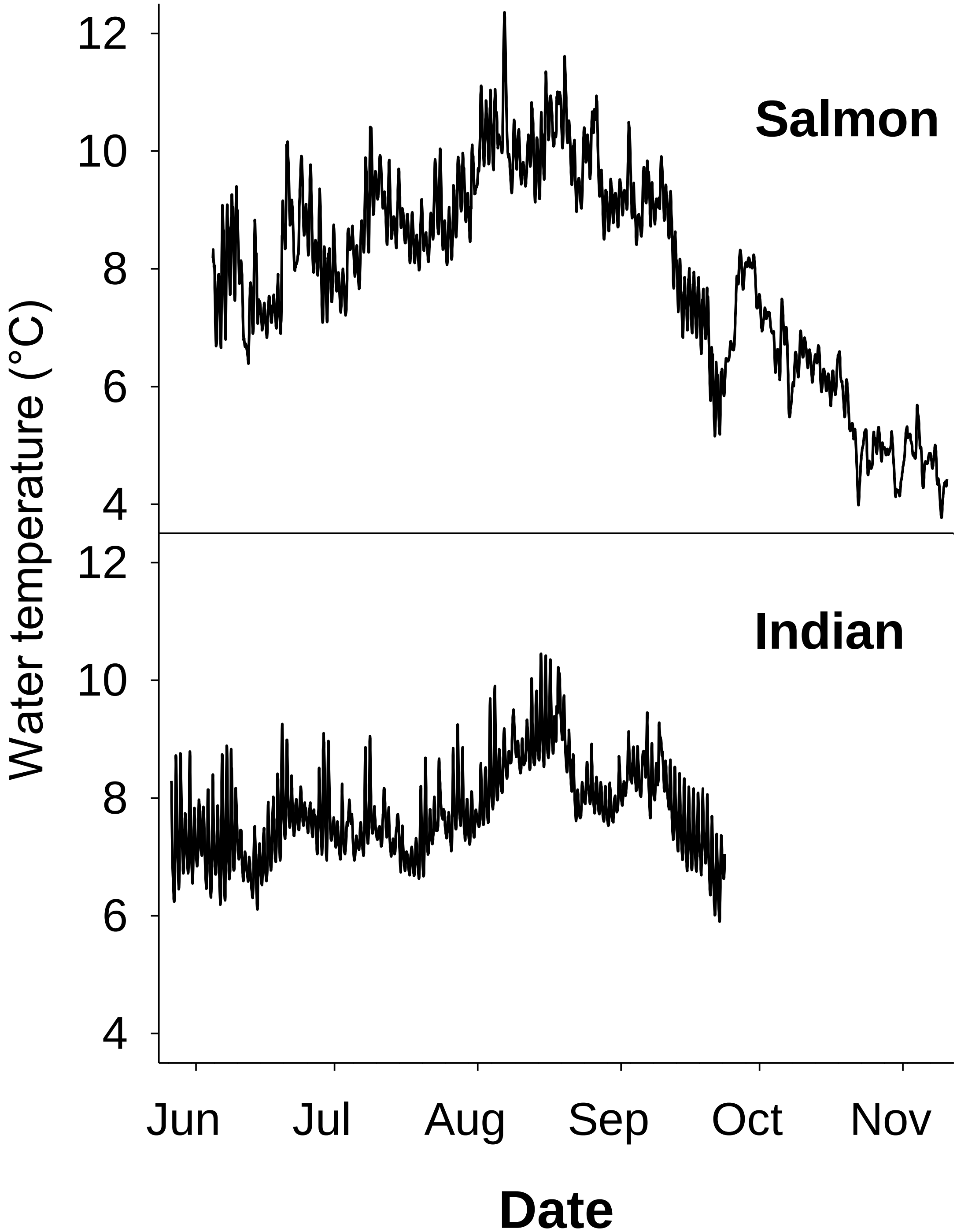

Figure 9. Hourly water temperature data for the Salmon and Indian Rivers in 2010.

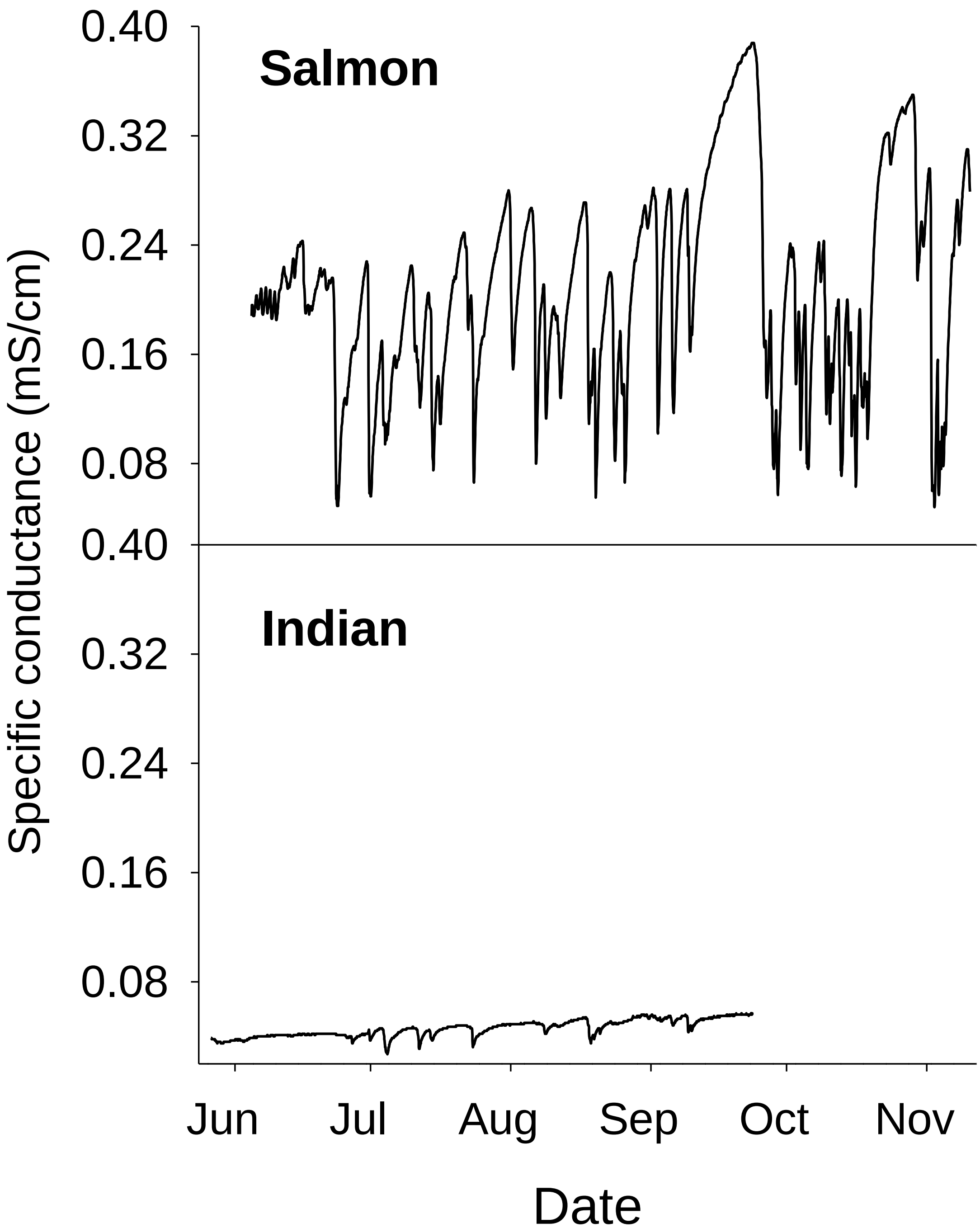

Figure 10. Hourly conductivity data for the Salmon and Indian Rivers in 2010.

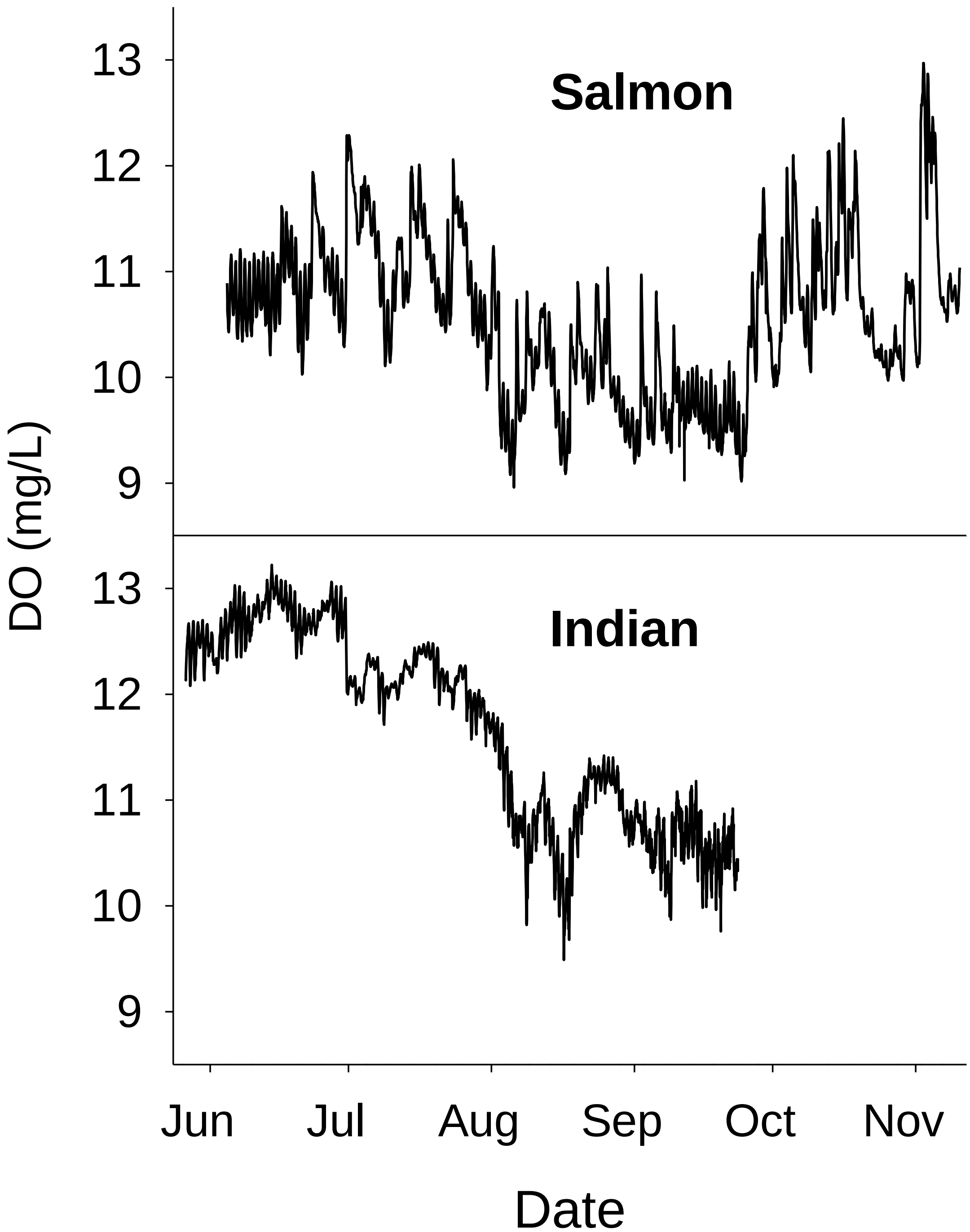

Figure 11. Hourly dissolved oxygen data for the Salmon and Indian Rivers in 2010.

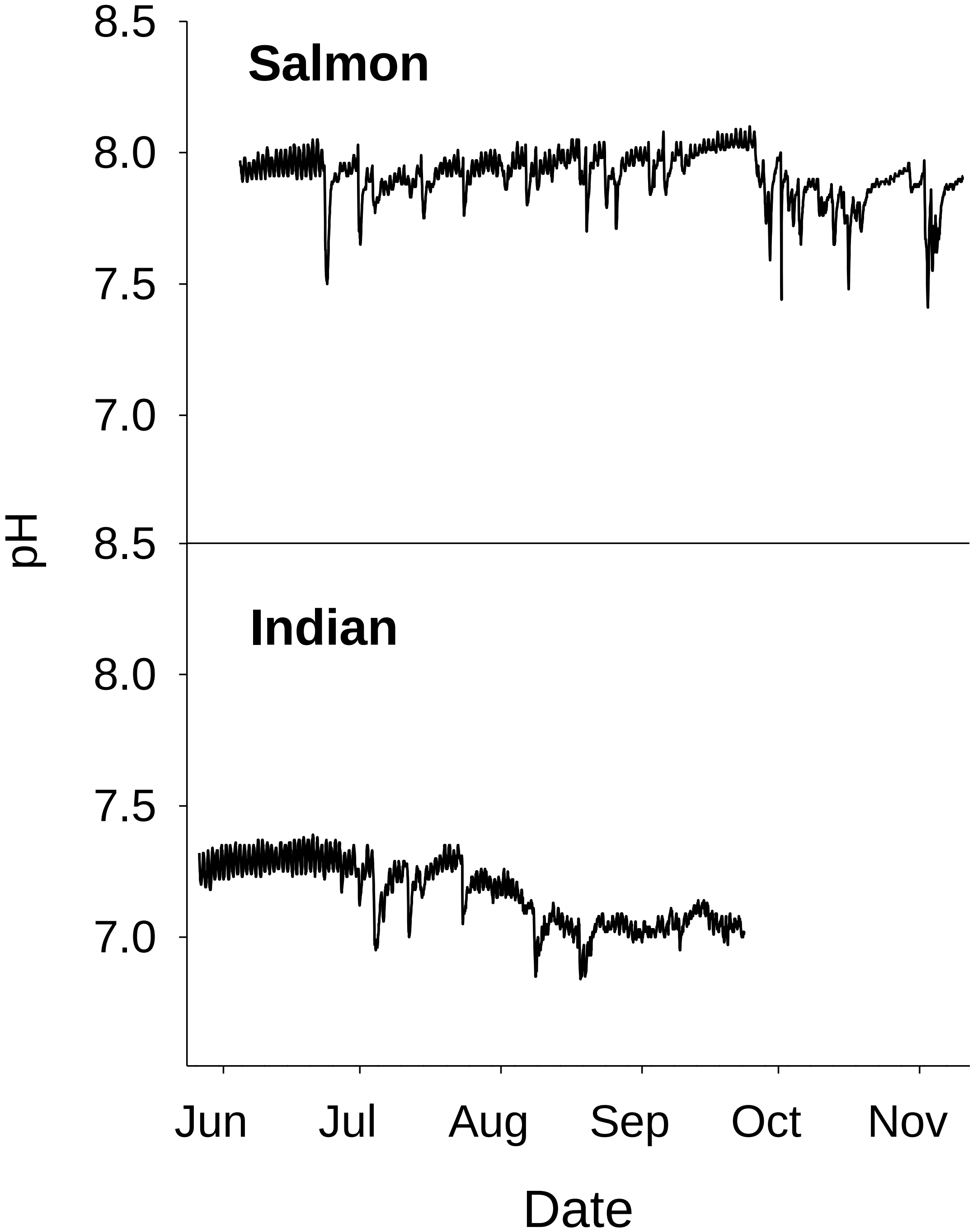

Figure 12. Hourly pH data for the Salmon and Indian Rivers in 2010.

Appendix B: Indian River streamflow time series versus all water quality parameters

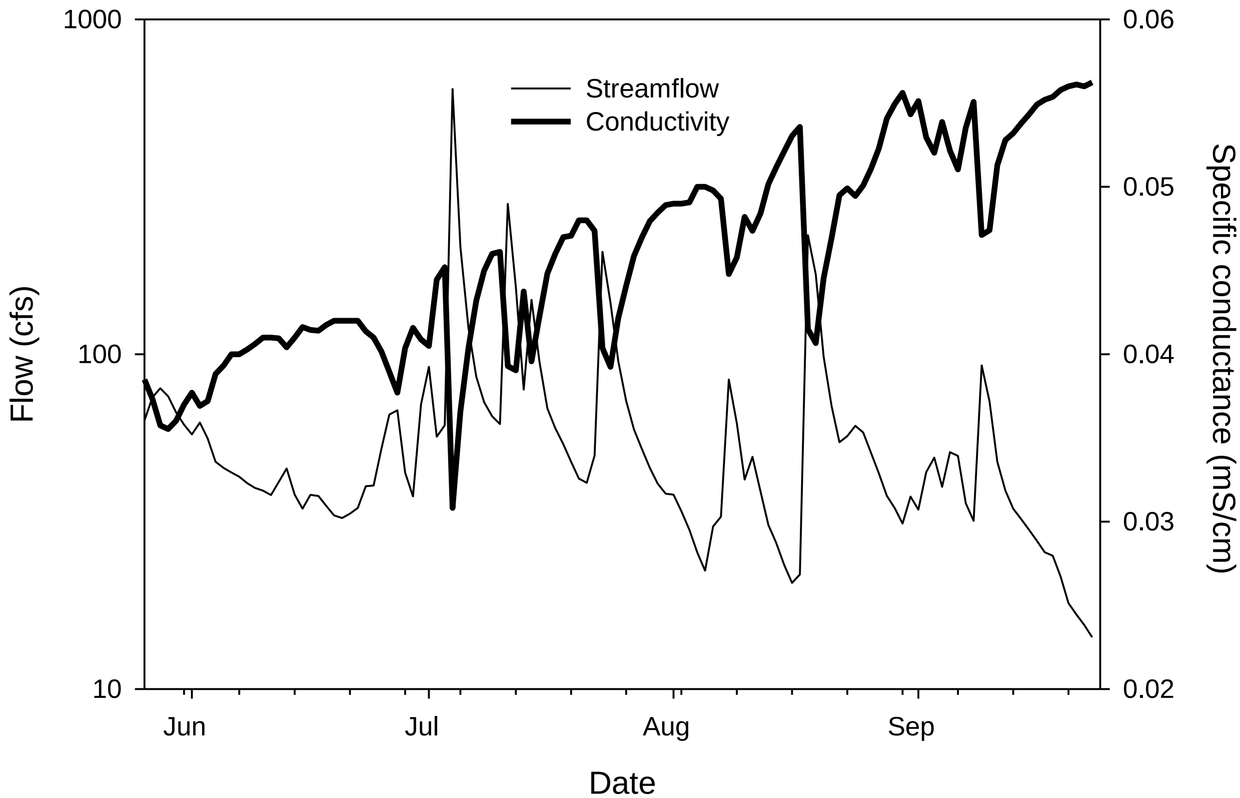

Figure 13. Daily average streamflow (log scale) versus daily average conductivity in the Indian River in 2010. Streamflow data collected at the same site as water quality data, but streamflow values are considered preliminary until the NPS streamflow monitoring program protocols have been finalized.

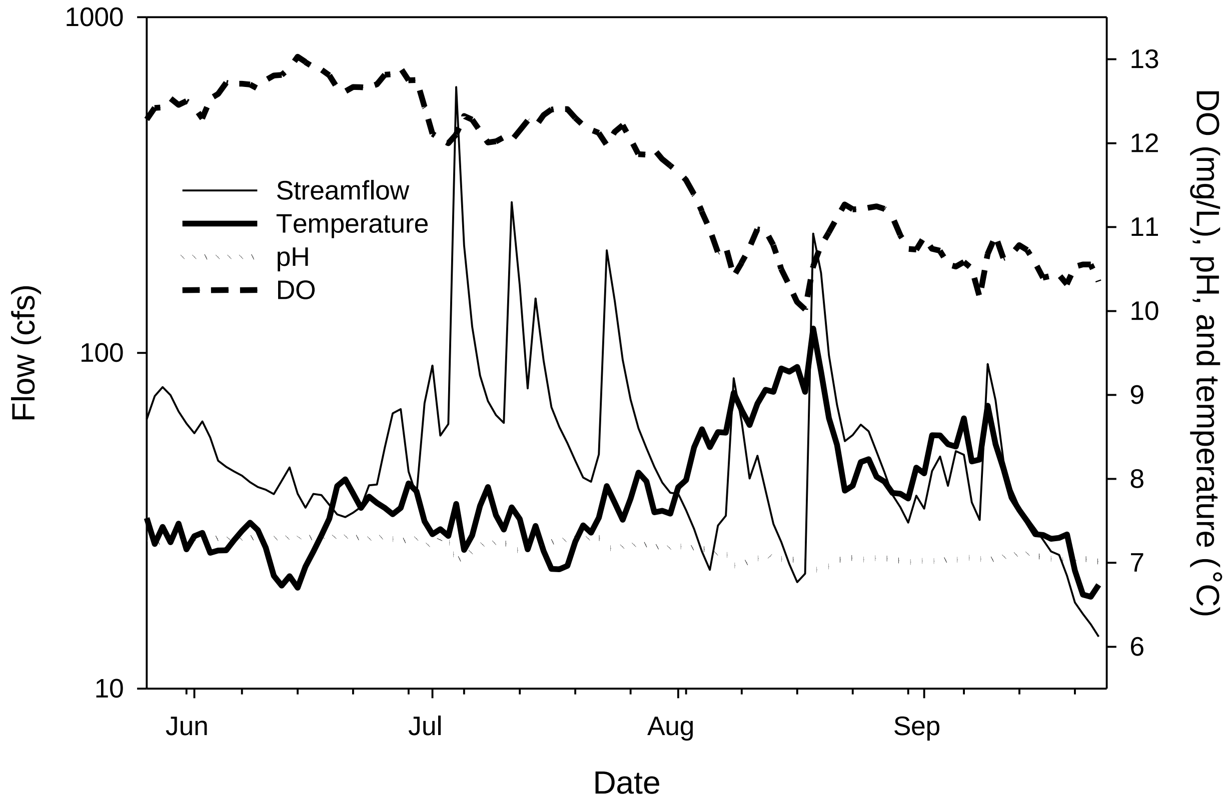

Figure 14. Daily average streamflow (log scale) versus daily average temperature, DO, and pH in the Indian River in 2010. Streamflow data collected at the same site as water quality data, but streamflow values are considered preliminary until the NPS streamflow monitoring program protocols have been finalized.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 953/112861, February 2012

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