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Natural Resource Stewardship and Science

Southeast Alaska Network Freshwater Water Quality Monitoring Program

2013 Annual Report

Natural Resource Technical Report NPS/SEAN/NRTR—2014/840

ON THE COVER
Swans take flight on the Dyea flats of the Taiya River, Klondike Gold Rush National Historical Park
Photograph by: Christopher J. Sergeant, Southeast Alaska Network, National Park Service

Southeast Alaska Network
Freshwater Water Quality Monitoring Program

2013 Annual Report

Natural Resource Technical Report NPS/SEAN/NRTR—2014/840

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Executive Summary

Freshwater water quality is an indicator of aquatic and terrestrial ecosystem health and one of twelve priority Vital Signs in the National Park Service's Southeast Alaska Network (SEAN). In 2013, hourly water temperature, specific conductance, dissolved oxygen, and pH data were collected in the Salmon River (Glacier Bay National Park and Preserve) from April 29 through November 18, and in the Indian River (Sitka National Historical Park) from April 30 through November 7. The same parameters plus turbidity were collected in the Taiya River (Klondike Gold Rush National Historical Park) from April 16 through October 2.

Annual reports are concise data summaries that establish a regular and timely product for park staff, managers, superintendents, and other interested parties. This fourth annual water quality report from the SEAN represents the continuation of a long-term, high resolution water quality dataset in Southeast Alaska National Parks. All annual reports and data products are publically available at the SEAN freshwater water quality website:

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

Compared to previous monitoring seasons, 2013 was an exceptional year for minimum and maximum water temperatures in the Salmon and Indian Rivers. Daily mean temperature in the Salmon River ranged from 1.6 to 11.8°C and peaked on September 7, while the Indian River ranged from 3.3 to 10.7°C and peaked on August 31. Both rivers demonstrated higher than recent average summer temperatures. From mid-April through early June, water temperature trends in the Taiya River were much colder than 2011-2012. After early June, water temperatures appeared similar to the past two summers, likely reflecting the influence of glacial melt water buffering the variability of the summer thermal regime. Daily mean temperature ranged from 1.2 to 6.7°C, peaking on July 27. In the Taiya River, turbidity ranged from 0 to 390 NTU and appeared synchronized with high flow events.

Patterns in the medians and distributions of specific conductance, dissolved oxygen, and pH in the Salmon and Taiya Rivers were generally similar to previous years. While 2013 pH and specific conductance measurements from the Indian River remained similar to previous years, dissolved oxygen levels were the lowest ever observed since the start of SEAN water quality monitoring, reaching a minimum of 1.7 mg/L on August 29. During August 2013, a combination of warmer than average air and water temperatures, low stream discharge, and extremely high abundance of spawning salmon created poor Indian River water quality conditions.

No observed values or trends such as abnormally high specific conductance signaled point source pollution or a change to the fundamental water quality of the Salmon or Taiya Rivers. The Indian River should be monitored closely in future years to determine the frequency of low dissolved oxygen events during the summer.

Acknowledgments

This work could not be accomplished without the annual support of park staff. K. Doran, T. Kucerovy, C. Murdoch, E. Noyd, K. Rain, J. Rodstrom, and J. Wilbarger efficiently conducted field work and transmitted data for processing. 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 and Abbreviations

°C	Degrees Celsius
cfs	Cubic feet per second
DO	Dissolved oxygen
GLBA	Glacier Bay National Park and Preserve
KLGO	Klondike Gold Rush National Historical Park
m^3/s	Cubic meters per second
mg/L	Milligrams per liter
mS/cm	Milli-Siemens per centimeter
NPS	National Park Service
NTU	Nephelometric Turbidity Units
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; Figure 1) 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 (specific conductance, dissolved oxygen, pH, and water temperature; plus turbidity in the Taiya River) for at least one river in each SEAN park unit

- 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 (Sergeant et al. 2013) includes an extended description of each water quality parameter in Section 1.6. Briefly, specific conductance measures the ability of water to conduct an electrical current at a standardized temperature of 25°C, with higher values generally representing groundwater influence and lower values representing rain and snow runoff. Dissolved oxygen (DO) is a measure of the amount of microscopic oxygen bubbles in water and is essential for aquatic organism respiration. DO is mainly regulated by temperature, but fluctuations in DO can be caused by other factors such as organic matter loading, biological decomposition, and water aeration. The pH of water is a unit-less measure of hydrogen ion concentration reflecting relative acidity or alkalinity and affects aquatic organism respiration, salt exchange, and many biogeochemical processes. Turbidity is a measure of water clarity.

This report concisely summarizes results from the 2013 sampling season and compares it with past data. After the completion of the 2014 field season, a five-year synthesis report will present more in-depth trend analyses and broadened discussion. Guidance for annual report formatting and analysis is described in Standard Operating Procedure (SOP) 10 of the water quality monitoring protocol (Sergeant et al. 2013).

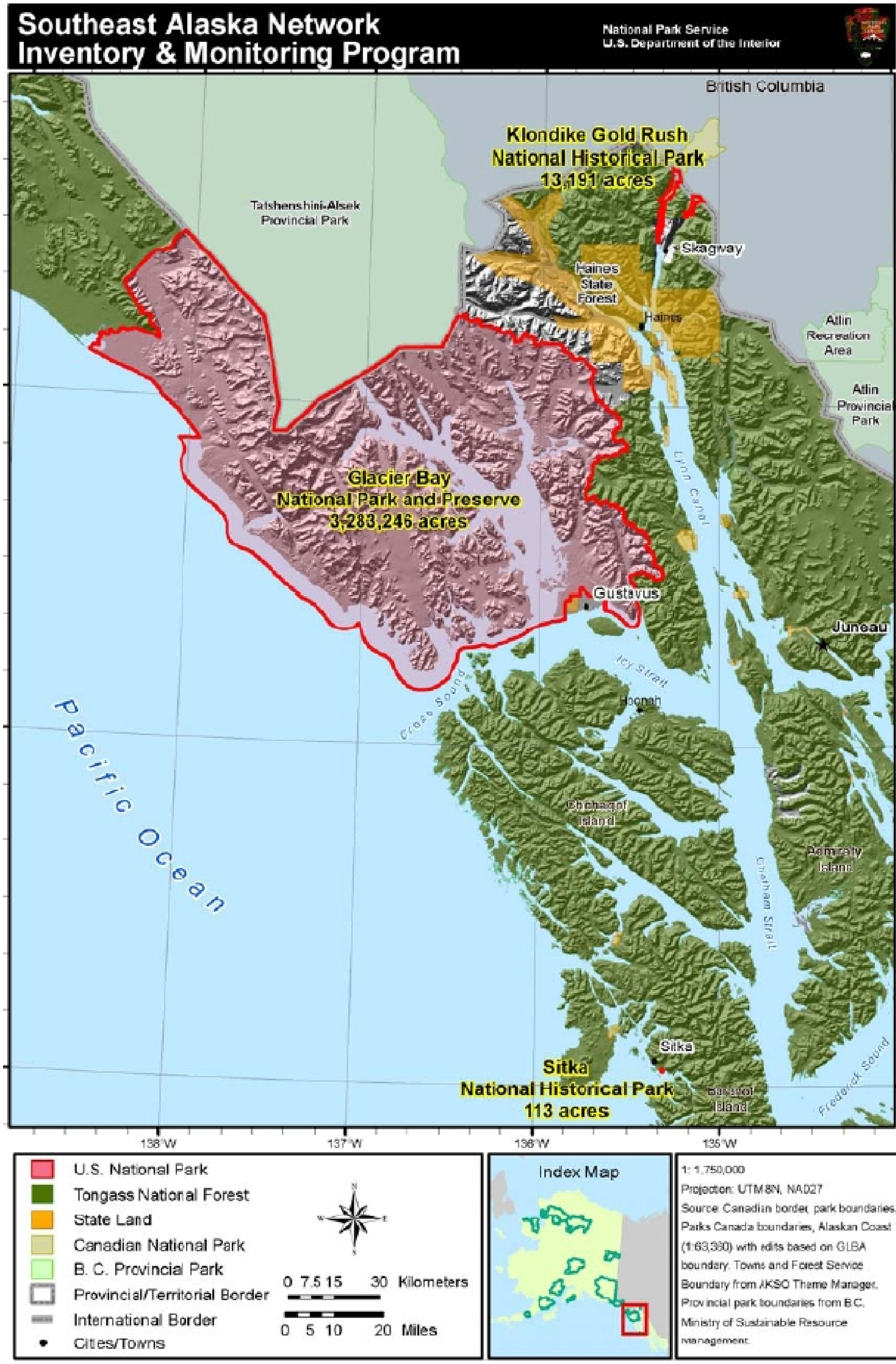

Figure 1. SEAN park locations and surrounding lands.

Study areas

The sampling goal of this monitoring program is to track water quality status and trends in at least one river in each of the three SEAN parks. In 2010, sonde locations were finalized for the Salmon (GLBA) and Indian (SITK) Rivers. The Taiya River (KLGO) was added in 2011. Sampling sites were chosen based on individual park interest and dependable long-term site access. Until the SEAN freshwater water quality monitoring program began, no consistent or long-term data were available for these three rivers (Eckert et al. 2006a; Eckert et al. 2006b; Hood et al. 2006).

Salmon River (GLBA)

GLBA, the largest park unit in the SEAN, has more than 310 streams (Soiseth and Milner 1995) flowing for over 3,380 km through a diverse landscape. The Salmon River is 32.7 km long within an 11,552 ha watershed that 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 observed in the river but not formally reported (C. Soiseth, personal communication). The water quality monitoring site is located on the river left bank at approximately river km 9.0 (Figure 2) several meters upstream of the NPS boundary.

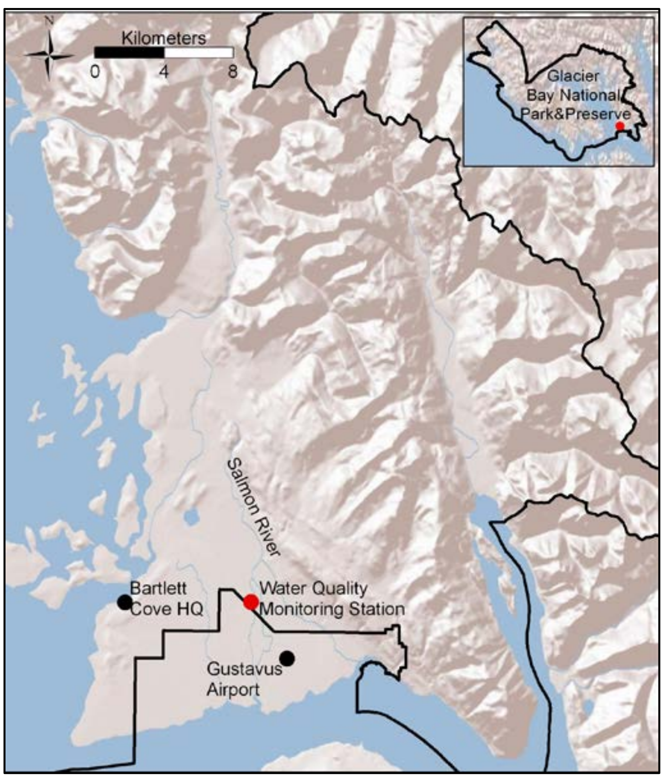

Figure 2. Monitoring station on the Salmon River in GLBA (red circle near S edge of map). The black line denotes park boundary.

Taiya River (KLGO)

The Taiya River, located west of Skagway and one of two major drainages within KLGO boundaries, is approximately 25.7 km long and drains a watershed of approximately 46,361 ha (Hood et al. 2006). The water quality monitoring site is located on the river left bank slightly downstream of the Taiya River Bridge (Figure 3) and adjacent to the USGS streamflow gaging site. From 1970 to 2012, the annual mean discharge from the Taiya River has ranged from a minimum of 24.9 m^3/s (880 cfs) in 1973 to 40.3 m^3/s (1,424 cfs) in 2004. Peak flows typically occur in August and September (USGS website for Taiya River gage 15056210: http://waterdata.usgs.gov/nwis/nwisman/?site_no=15056210&agency_cd=USGS).

Skagway is notably drier than other Southeast Alaska communities, averaging 69 cm of precipitation per year, in comparison to 142 cm in Gustavus and 217 cm in Sitka (Western Regional Climate Center Data: http://www.wrcc.dri.edu/summary/Climsmak.html). The glacial influence on the Taiya watershed is unique among streams currently monitored in the SEAN. As of 2001, approximately 36% of the watershed was covered by glaciers (Sergeant and Nagorski 2013 *submitted manuscript*). Glacial outburst events have led to large flooding events and created a highly dynamic physical environment (Hood et al. 2006). The Taiya watershed supports chum, pink, and coho salmon populations, as well as Dolly Varden. Eulachon (*Thaleichthys pacificus*) have been reported to run up the Taiya River in the spring (Hood et al. 2006).

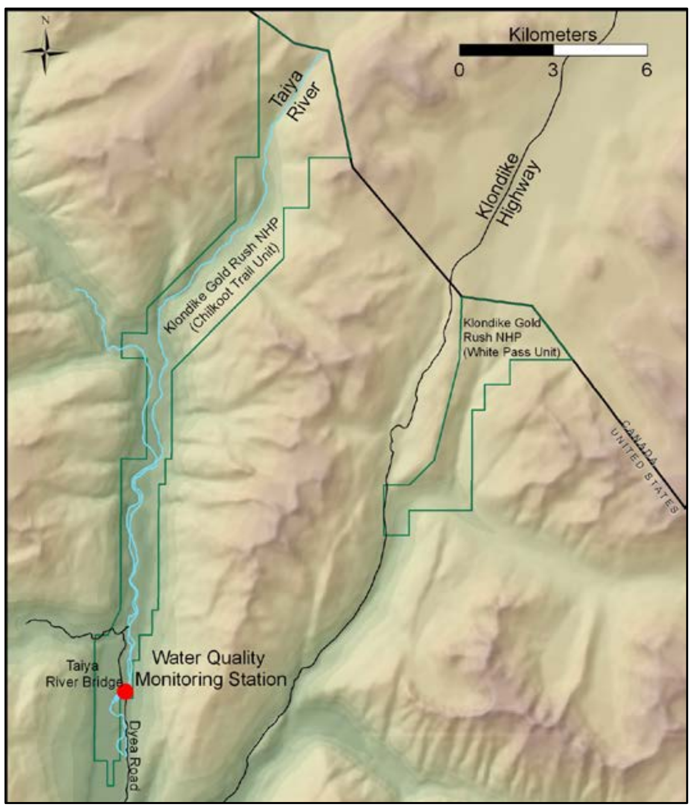

Figure 3. Monitoring station on the Taiya River in KLGO (red circle near SW corner of map). The green lines denote park boundaries (the park units are not contiguous).

Indian River (SITK)

The lowest 1 km of the Indian River is the only significant riverine habitat within the SITK boundary and can be characterized as a low gradient alluvial channel with gravel-cobble substrate that supports anadromous fish species, including coho, pink, chum, and Chinook salmon (*O. tshawytscha*), steelhead, Dolly Varden, and non-anadromous species such as resident rainbow trout (*O. mykiss*), 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 4).

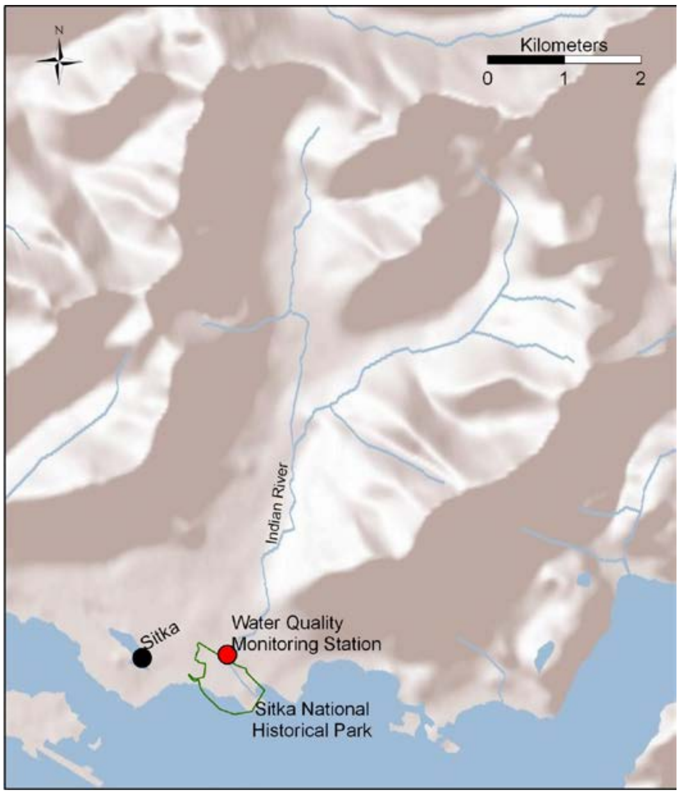

Figure 4. Monitoring station on the Indian River in SITK slightly upstream of park boundary (red circle near SW corner of map). The green line denotes park boundaries.

Methods

Station instrumentation

The Salmon, Taiya, and Indian Rivers were sampled hourly for specific conductance (mS/cm), dissolved oxygen (mg/L), pH, and water temperature (°C). Additionally, turbidity (NTU) was measured in the Taiya River. Multi-parameter water quality sondes (Table 1) collected and logged data at single fixed sites in the Salmon River from April 29 through November 18, the Taiya River from April 16 through October 2, and the Indian River from April 30 through November 7 (Figures 2-4; Table 2). Each year, sampling is scheduled to occur from at least May 1 through October 31, and extends into November if ice conditions and staff resources allow.

Table 1. YSI, Inc. instruments used for 2012 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
Optical turbidity sensor	6136

In all three rivers, a sonde was mounted inside a perforated 4-inch ABS pipe. In the Salmon River the pipe was attached to an angle-iron rod set in the streambed, while in the Taiya and Indian Rivers the 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 sondes were installed, Park Leads visited the sondes approximately once per month to check calibration for each sensor and clean components, as needed. These calibration checks were used to assess data quality and ensure that the water quality instruments were functioning properly.

Table 2. Summary of 2013 freshwater water quality sampling effort.

	Month								
River	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Core parameters collected?
Salmon									Y[1]
Taiya									Y[2]
Indian									Y

Full month

Partial month

[1] from 5 May to 31 May, conductivity, pH, and DO are not accurate (see Results)

[2] After June 3, recalibration forced DO to be 0.7 mg/L lower than actual reading

Data processing

The protocol narrative and SOPs 1 through 3 describe the data collection, calibration checks, and data processing in detail (Sergeant et al. 2013). Park and SEAN staff generally conducted calibration checks monthly at each water quality station from May through November (Table 3). On the Indian River, the October calibration check did not occur due to staffing limitations, but a subsequent check in November demonstrated that sensor readings remained accurate (Table 3).

The 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 dataset. Data with '0' (no question of accuracy) or '1' (determined useable by Project Leader despite potential mistakes in precisely following protocols) quality ratings were used for analysis. SOP 13 of the water quality protocol (Sergeant et al. 2013) describes each data rating in detail. Comments contained in the water quality database are available on the SEAN website (http://science.nature.nps.gov/im/units/sean/FQ_Main.aspx) and contain explanations for each assigned rating other than zero.

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. The SEAN does not correct (adjust) data values based on calibration checks (as described in Wagner et al. 2006), but sensor values from calibration checks are available by downloading field sheets from the SEAN website (http://science.nature.nps.gov/im/units/sean/FQ_Main.aspx) and can allow data users to perform corrections if deemed appropriate.

The final datasets were analyzed and summarized according to the guidelines in SOP 10 (Sergeant et al. 2013).

Results

Data collection

While 2013 water quality measurements were generally high quality, several issues were encountered with data collection on the Salmon and Taiya Rivers. From May 5 to May 31, unusually high flow in the Salmon River caused the sonde to slide out of its mount and into river sediment. During this period, temperature data were deemed reliable, but due to artificially high sediment loading, specific conductance, DO, and pH were deemed inaccurate. Due to a fault in conducting monthly error checking, pH data grades are not available from May 31 to July 1, although subsequent error checks demonstrate that the measurements were likely to be quite accurate (all other monthly checks rated, ‘Excellent’; Table 3).

From June 3 to October 2 on the Taiya River, a calibration adjustment using the 650 handheld unit appears to have forced DO readings to be artificially high by 0.7 mg/L for all subsequent measurements. Due to staffing limitations, no monthly maintenance visits were performed after September 25, but due to failed batteries, no data was collected by the sonde between October 2 and mid-November, when the sonde was pulled for the season. Typically, sondes do not run out of battery power during the field season, so this issue will be examined by YSI during annual maintenance. Turbidity quality grades for the Taiya River ranged from Poor to Excellent. While the observed values were within reasonable sensor accuracy expectations, turbidity values are best used for relative seasonal trends in water clarity and less appropriate as absolute individual measurements.

Table 3. Summary of 2013 freshwater water quality data grades. E = Excellent, G = Good, F = Fair, P = Poor. Definitions for each grade are found in SOP 2 (Sergeant et al. 2013) and are based on USGS recommendations (Wagner et al. 2006). Shaded areas represent periods when data grades are not available.

		Date ranges						
River	**Parameter**	**4/29 - 5/31**	**5/31 - 7/1**	**7/1 - 7/30**	**7/30 - 9/4**	**9/4 - 9/30**	**9/30 - 11/4**	**11/4 - 11/18**
Salmon	Conductivity (mS/cm)	G	G	P	G	E	G	G
	Dissolved Oxygen (mg/L)	G	E	E	E	E	E	E
	pH	E		E	E	E	E	E
	Temperature (°C)	E	G	E	P	G	P	F
		Date ranges						
		4/16 - 5/2	**5/2 - 6/3**	**6/3 - 7/1**	**7/1 - 8/5**	**8/5 - 9/10**	**9/10 - 9/25**	**9/25 - 10/2**
Taiya	Conductivity (µS/cm)	G	G	G	G	F	E	
	Dissolved Oxygen (mg/L)	E	G	E	E	E	G	
	pH	E	E	E	E	E	E	
	Temperature (°C)	G	F	F	G	F	F	
	Turbidity (NTU)	G	P	E	F	P	E	
		Date ranges						
		4/30 - 6/12	**6/12 - 7/1**	**7/1 - 8/6**	**8/6 - 9/3**	**9/3 - 11/7**		
Indian	Conductivity (µS/cm)	E	E	G	G	G		
	Dissolved Oxygen (mg/L)	G	E	E	E	E		
	pH	E	E	E	E	E		
	Temperature (°C)	G	F	G	F	F		

Comprehensive time series data

Hourly time series data for all water quality parameters in all three rivers are included in Appendix A. Daily average streamflow time series data from the Taiya River is compared to daily average water quality data in Appendix B. Streamflow data was collected in the same location as water quality data. At this time, the Salmon River is not monitored for streamflow and Indian River streamflow data was not yet available.

Salmon River

Temperature

Based on previous monitoring results, 2013 appeared to be an exceptional year for minimum and maximum water temperatures. While May was a cool month in comparison to 2012, from late June through September, Salmon River water temperature was warmer than the past three years' average (Figure 5). In 2013, the daily mean water temperature in the Salmon River ranged from 1.6 to 11.8°C and peaked on September 7 (2012 peak was August 7; 2011: July 23; 2010: August 6). Median daily mean water temperature during the monitoring period was 7.7°C. Monthly mean daily average temperatures ranged from 3.8 to 10.5°C (Table 4). Variation in May, June, and September daily mean temperatures was high in comparison to other months (SD = 1.3 to 1.5; Figure 5 and Table 4).

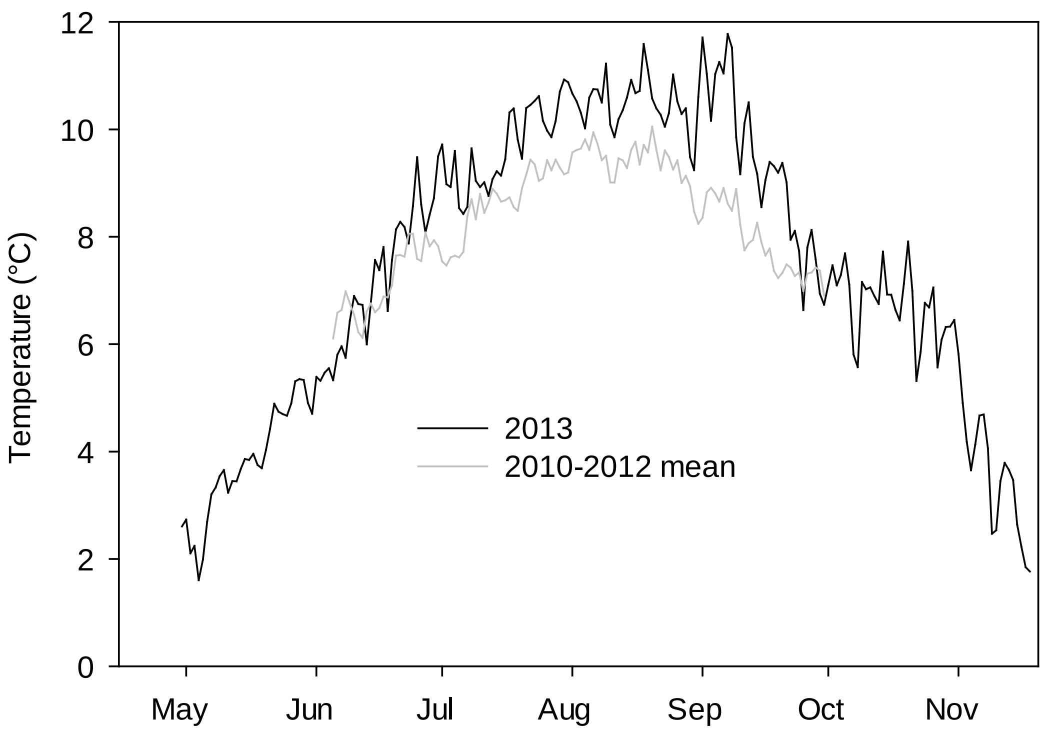

Figure 5. Daily mean water temperature for the Salmon River in 2013 and averaged across commonly measured dates in 2010-2012.

Table 4. Monthly mean, minimum daily mean, and maximum daily mean water temperature for the Salmon, Taiya, and Indian Rivers in 2013. See the Methods section for sonde installation dates for each river.

	Salmon			Taiya			Indian		
Month	**Mean daily average (SD)**	**Min**	**Max**	**Mean daily average (SD)**	**Min**	**Max**	**Mean daily average (SD)**	**Min**	**Max**
May	3.8 (1.3)	1.1	7.2	3.3 (1.5)	0.3	8.3	4.7 (0.9)	3.2	7.5
June	7.2 (1.5)	4.6	10.9	5.3 (1.2)	2.8	8.4	7.0 (1.2)	5.1	9.9
July	9.7 (0.9)	8.1	11.8	5.9 (0.9)	4.3	8.8	8.0 (0.8)	6.8	10.7
August	10.5 (0.7)	8.8	12.8	5.9 (0.8)	4.6	8.3	9.5 (0.5)	8.5	10.9
September	9.3 (1.5)	6.1	12.2	5.4 (0.5)	3.8	7.1	8.5 (1.3)	6.3	12.0
October	6.7 (0.7)	5.0	8.2				7.0 (0.4)	6.0	8.5

Specific conductance, DO, and pH

The 2013 ranges for specific conductance and pH values in the Salmon River (Figure 6) were generally similar to 2012, which had a similar data collection time frame. In 2013, DO had a greater range of values than 2012, but the median remained similar. In 2013, individual specific conductance measurements ranged from 0.00 to 0.45 mS/cm with a median of 0.18 mS/cm. DO ranged from 7.9 to 15.5 mg/L with a median of 10.3 mg/L. DO dropped slightly but steadily from May through mid-August (most likely in response to warming water temperature) and reached the minimum observed value on August 16 (Appendix A; Figure 11). Values for pH ranged from 7.2 to 8.1 with a median of 7.9. Through mid-August, pH values were relatively stable but began demonstrating greater variation through the remainder of the monitoring season.

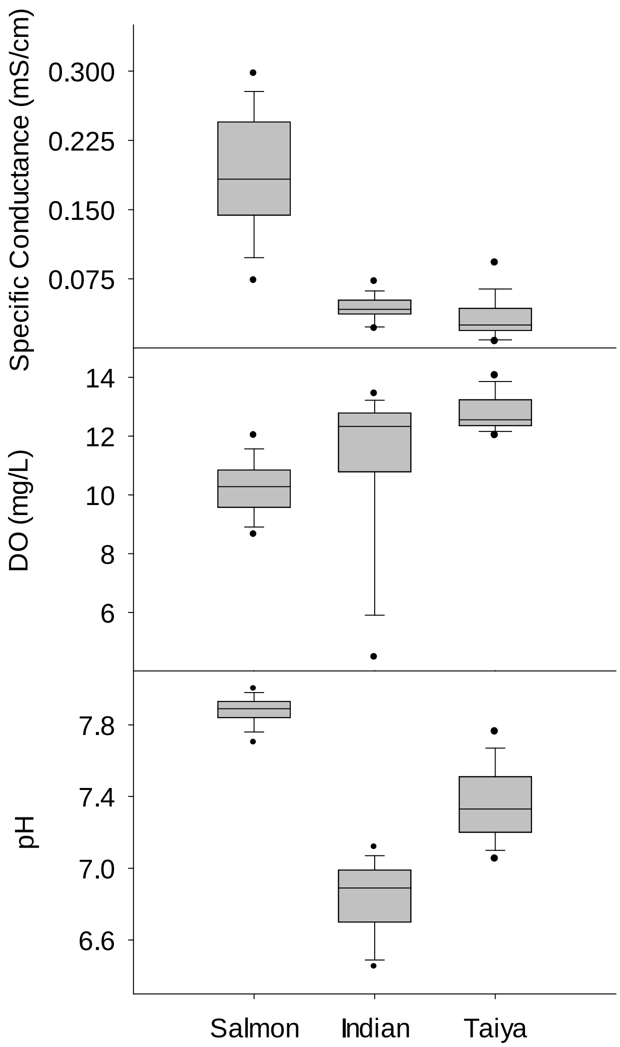

Figure 6. Box plots summarizing all valid measurements for pH, dissolved oxygen (DO), and specific conductance for the Salmon, Taiya, and Indian Rivers in 2013. The central horizontal line within each box indicates median values, horizontal lines bounding the upper and lower portion of the boxes represent 25th and 75th percentiles, lower and upper whiskers represent 10th and 90th percentiles, and single points represent 5th and 95th percentiles. Taiya River measurements may be slightly low due to a calibration adjustment that forced DO measurements to be 0.7 mg/L lower than actual readings.

Taiya River

Temperature

From mid-April through early June, 2013 water temperature trends in the Taiya River were much colder than 2011-2012 (Figure 7). After early June, water temperatures appeared similar to the past two summers, likely reflecting the increasing influence of glacial melt water, which buffers the variability of the summer thermal regime. Daily mean temperature ranged from 1.2 to 6.7°C, peaking on July 27. Monthly mean daily average temperatures ranged from 3.3 to 5.9°C (Table 4).

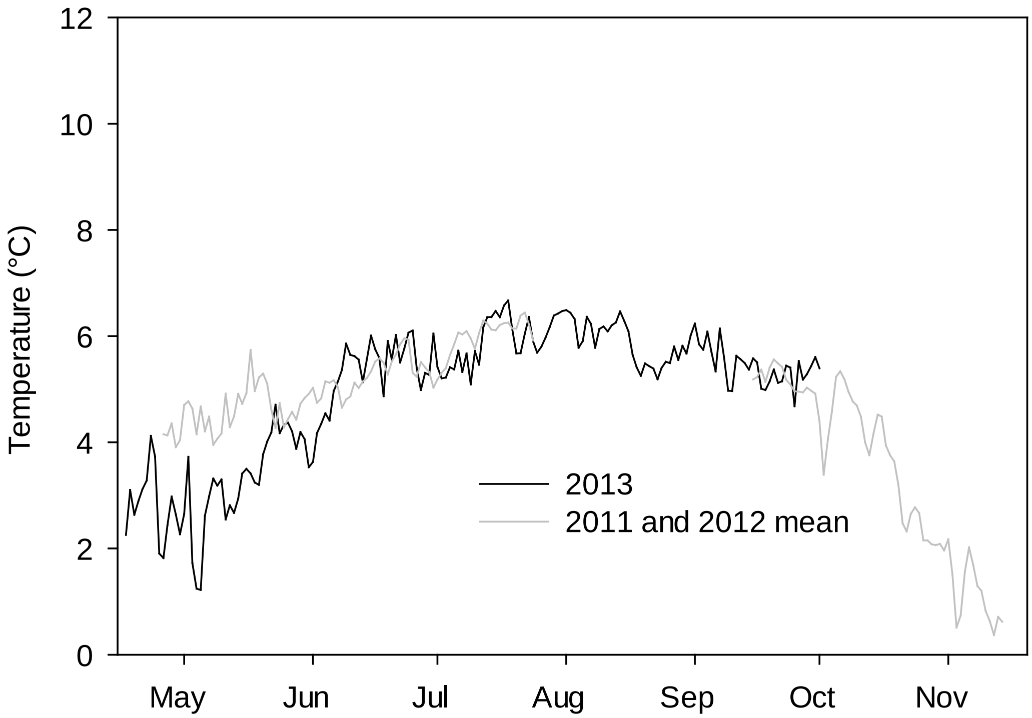

Figure 7. Daily mean water temperature for the Taiya River in 2013 and averaged across commonly measured dates in 2011 and 2012.

Turbidity

In 2012, Taiya River hourly turbidity measurements ranged from 0 to 390 NTU during the sampling season, with the largest peak events occurring in spring and early summer (Figure 8). Turbidity spikes began in May and continued through September until data collection ceased. Turbidity events were reliably timed with high flow events caused by greater glacial melt water input (Appendix B; Figure 14).

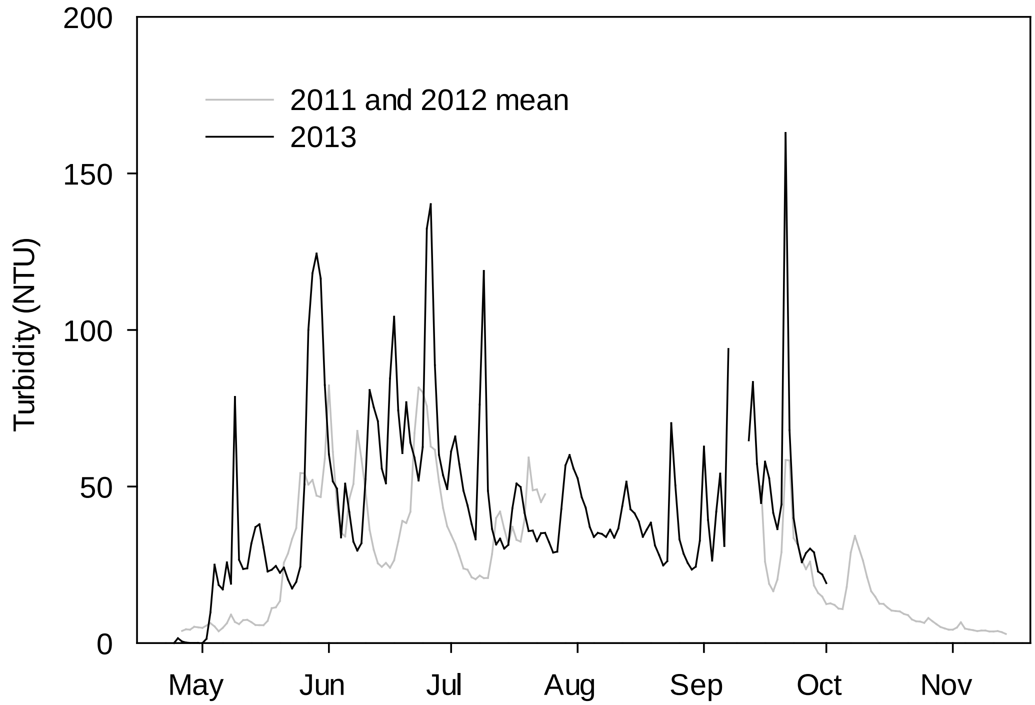

Figure 8. Daily mean turbidity for the Taiya River in 2013 and averaged across commonly measured dates in 2011 and 2012.

Specific conductance, DO, and pH

In the Taiya River in 2013, individual specific conductance measurements ranged from 0.00 to 0.10 mS/cm with a median of 0.03 mS/cm. From mid-April to mid-June, specific conductance steadily dropped, while after mid-September, values began steadily rising (Appendix A; Figure 12). DO ranged from 11.6 to 14.9 mg/L with a median of 12.6 mg/L. These DO summary values include some data graded ‘2’ (questionable) due to potential error associated with a calibration adjustment that may have artificially increased readings by 0.7 mg/L. Values for pH ranged from 6.5 to 8.0 with a median of 7.3. The range of observed pH values in 2013 was greater than 2012 (7.0-7.6), but the median remained similar.

Indian River

Temperature

Summer water temperatures on the Indian River in 2013 were much warmer than the previous three years’ average (Figure 9). In 2013, the daily mean water temperature in the Indian River ranged from 3.3 to 10.7°C and peaked on August 31 (2012: August 23; 2011: August 20; 2010: August 18). Median daily mean water temperature during the monitoring period was 7.5°C. Monthly mean daily average temperatures ranged from 4.7 to 9.5°C (Table 4).

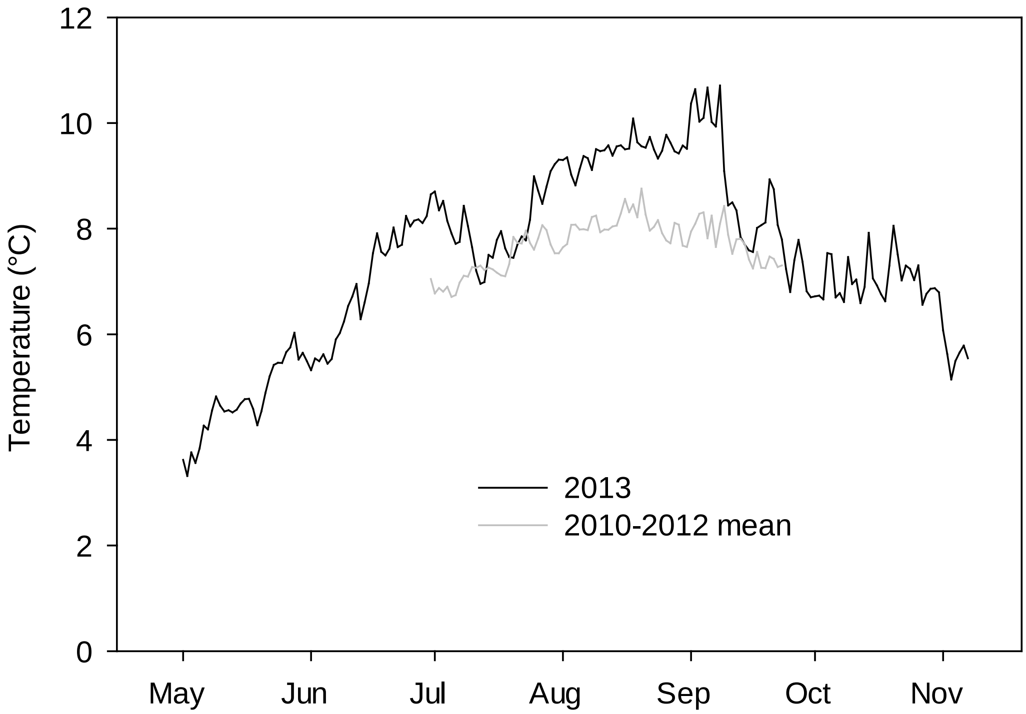

Figure 9. Daily mean water temperature for the Indian River in 2013 and averaged across commonly measured dates in 2010-2012.

Specific conductance, DO, and pH

Direct comparisons of specific conductance, DO, and pH values to past data in the Indian River are difficult due to differences in sampling windows, but the 2013 ranges of specific conductance and pH have remained relatively similar from 2010 through 2012. Hourly specific conductance measurements ranged from 0.01 to 0.08 mS/cm with a median of 0.04 mS/cm. In August 2013, DO levels reached the lowest ever observed since the start of SEAN water quality monitoring, and should be watched closely in coming years (Figure 6). DO ranged from 1.7 to 14.0 mg/L with a median of 12.3 mg/L (see Discussion section for expanded dialogue regarding low DO values). Values for pH ranged from 6.3 to 7.3 with a median of 6.9.

Compliance with water quality standards

In general, 2013 observations do not indicate any chronic exceedances of Alaska Department of Environmental Conservation water quality standards (Tables 5 and 6; ADEC 2012) and water quality values in the three rivers generally never approached regulatory thresholds. One exception is Indian River DO, in which a significant portion of August hourly measurements were below the 5.0 mg/L threshold for waters with spawning anadromous fishes (Table 6).

Table 5. Period of record and summary statistics for all freshwater water quality data collected and reported by the SEAN from 2010 through 2013.

				Summary statistics				
River	**Parameter**	**Period of Record**	**# obs.** [1]	**Median**	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Salmon	Conductivity (mS/cm)	Jun 04 2010 to Nov 18 2013	15,485	0.19	0.20	0.07	0.00	0.44
	Dissolved Oxygen (mg/L)		15,489	10.4	10.5	0.9	7.9	15.5
	Dissolved Oxygen (% Sat)		15,489	87.7	87.6	6.2	70.4	110
	pH		14,748	7.8	7.8	0.1	7.1	8.1
	Temperature (°C)		16,124	7.8	7.5	2.2	1.1	12.8
Taiya	Conductivity (mS/cm)	Apr 25 2011 to Oct 02 2013	12,868	0.04	0.04	0.02	0.00	0.09
	Dissolved Oxygen (mg/L)		9,979	12.5	12.6	0.7	10.7	14.9
	Dissolved Oxygen (% Sat)		9,979	97.0	96.9	3.5	79.8	110.5
	pH		12,655	7.4	7.4	0.2	6.5	8.0
	Temperature (°C)		12,868	5.0	4.7	1.7	0.0	9.6
	Turbidity (NTU)		12,732	24.1	29.9	27.9	-0.7 [2]	390.0
Indian	Conductivity (mS/cm)	May 26 2010 to Nov 07 2013	13,425	0.04	0.04	0.01	0.01	0.08
	Dissolved Oxygen (mg/L)		13,425	12.1	11.6	1.9	1.7	14.0
	Dissolved Oxygen (% Sat)		13,425	100.4	95.2	13.9	15.5	108.8
	pH		13,421	7.0	7.0	0.2	6.3	7.7
	Temperature (°C)		14,053	7.4	7.2	1.5	2.2	12.0

1 Data graded '2' or '3' were not counted as observations; Please see SOP 13 of the Freshwater Water Quality protocol (Sergeant et al. 2013) for descriptions of these water quality ratings.

2 Slightly negative turbidity values reflect inherent sensor imprecision

Table 6. Current Alaska Department of Environmental Conservation (ADEC) water quality standards (ADEC 2012; amended April 8, 2012). Superscript numbers denote the category of water quality standard.

Parameter	Criteria
Specific conductance	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. 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[1,2]	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.
Turbidity[3]	May not exceed 5 NTU above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU. May not exceed 5 NTU above natural turbidity for all lake waters.

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

Discussion

Salmon River

There were no notable differences in the 2013 ranges of observed Salmon River specific conductance, DO, or pH measurements in comparison to 2010-2012. Summer water temperatures were elevated in comparison to the previous three years, but no cause for concern. A previous SEAN annual report provides more detailed reporting of Salmon River water quality trends during relatively wet or dry periods (Sergeant et al. 2012a).

Taiya River

Water quality patterns observed during 2013 were similar to patterns observed in 2012. Notably, 2013 water temperature was cooler than average from mid-April to early June. In this glacially influenced river, the early and late monitoring months are most interesting due to their apparent inter-annual variability in comparison to summer water quality. Unfortunately, October and November data are not available this year because of battery power loss that was not detected until the sonde was removed in mid-November. Annual maintenance from YSI will determine whether this sonde is experiencing battery power issues and will resolve the issue before the start of 2014 sampling. A previous SEAN annual report provides more in-depth reporting of water quality trends during relatively wet or dry periods and compares recently observed water quality values with historical measurements (Sergeant et al. 2012b).

Indian River

A combination of warmer than average air and water temperatures, low stream discharge, and extremely high abundance of spawning salmon created poor Indian River water quality conditions during the month of August 2013. Although previous years have demonstrated a drop in DO during the annual spawning migration of tens of thousands of pink salmon in July and August (Alaska Department of Fish and Game, unpublished data), 2013 DO reductions were much more severe in comparison (Figure 10), and may have directly caused some mortality in other species such as Dolly Varden and juvenile coho salmon (S. Gende, unpublished data). Events such as these underline the importance of maintaining annual water quality and streamflow monitoring.

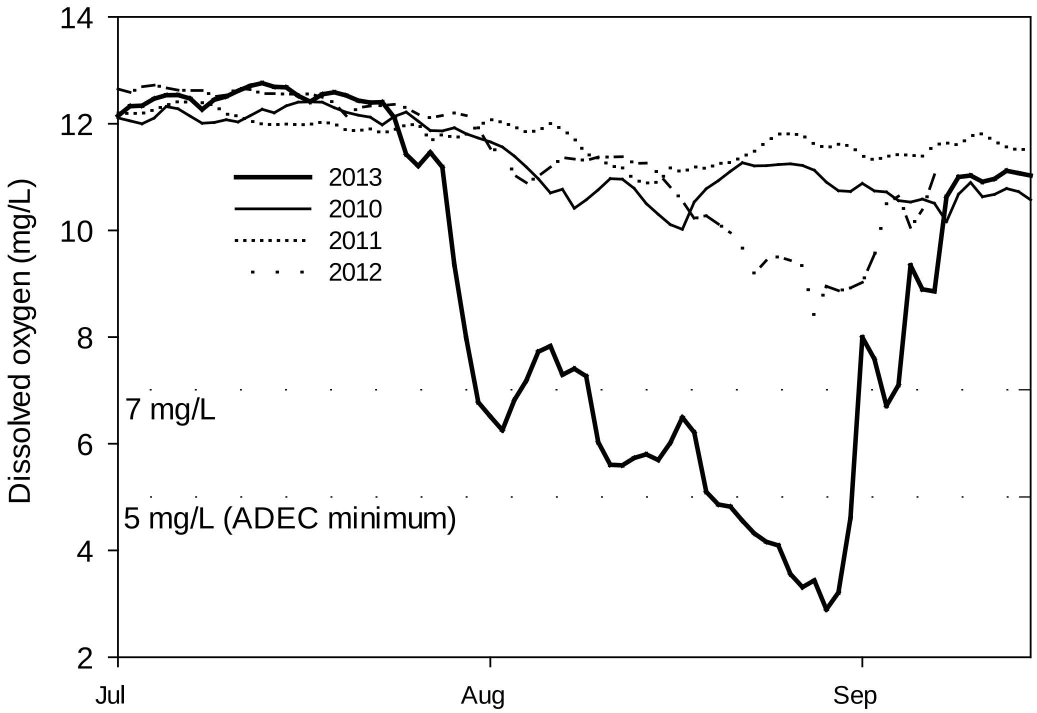

Figure 10. Depressed summer DO levels for the Indian River in 2013 versus 2010-2012. According to ADEC regulations, "DO must be greater than 7 mg/l in waters used by anadromous or resident fish. In no case may DO be less than 5 mg/l to a depth of 20 cm in the interstitial waters of gravel used by anadromous or resident fish for spawning."

A previous SEAN annual report provides more in-depth reporting of water quality trends during relatively wet or dry periods (Sergeant et al. 2012a).

Network-wide observations

A manuscript analyzing three years of SEAN water quality monitoring data was submitted in September 2013 to by SEAN staff and a cooperator (Sergeant and Nagorski 2013). The manuscript, which is still under review, attempts to demonstrate three points related to future NPS water quality monitoring:

1. In southeastern Alaska, the "core parameters" (water temperature, DO, pH, and specific conductance) adequately demonstrate the unique physical-chemical characteristics of each river. In the paper, we refer to these unique characteristics as a "water quality regime."

2. The medians and distributions of individual core parameter measurements are relatively similar when collected at weekly, twice monthly, and monthly intervals, but hourly measurements much more accurately characterize local minima and maxima. In general, the current hourly resolution collected by the SEAN appears justified for long-term monitoring, but it is important to note that lower resolution data from other systems may still do a good job of characterizing the water quality regime.

3. Multivariate analysis of the core parameters is a promising approach for illuminating emerging pollution, environmental anomalies, or slowly changing conditions over time.

In addition to this manuscript, a synthesis report will be drafted after the 2014 field season to comprehensively summarize 5 full years of water quality monitoring data and determine whether the current monitoring protocol is adequately fulfilling program objectives.

In 2013, no observed values or trends appeared to signal point source pollution or a change to the fundamental water quality of the Salmon or Taiya Rivers. The Indian River should be monitored closely during the summer months to determine the relative frequency of low DO conditions such as those observed in 2013.

Considerations

The pre-season field preparations for 2013 adequately addressed training needs and allowed for sufficient dialogue between the project lead and field leads to ensure the protocol was implemented consistently. The SEAN recommends continuing pre-installation meetings at the start of each season, even when previously experienced field leads are involved. Lack of staff capacity near the end of the field season (October/November) did cause two missed monthly maintenance checks and a loss of Taiya River data in the month of October, but the SEAN is working closely with parks to determine the best way to fulfill future needs.

Year-round temperature monitoring remains an important expansion opportunity for the SEAN water quality monitoring program. Due to the low cost of temperature logging sensors and ease of installation and maintenance, a network of temperature sensors across streams in all three parks is very feasible. To date, the development of several other Vital Signs programs has precluded the advancement of increased water temperature monitoring. With the help of community partners, the SEAN may be able to install and maintain several water temperature loggers in KLGO and SITK in 2014 as a pilot study. Freshwater water temperature is an important environmental driver in Southeast Alaska that is directly influenced by glacial melt and atmospheric temperature shifts due to climate change. The need for high resolution temperature data has been identified across the United States to properly document shifting temperatures, validate predictions of temperature changes due to climate change, and assess biological impacts such as changes in salmon growth and survival.

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Appendix A: Hourly time series by river for all water quality parameters

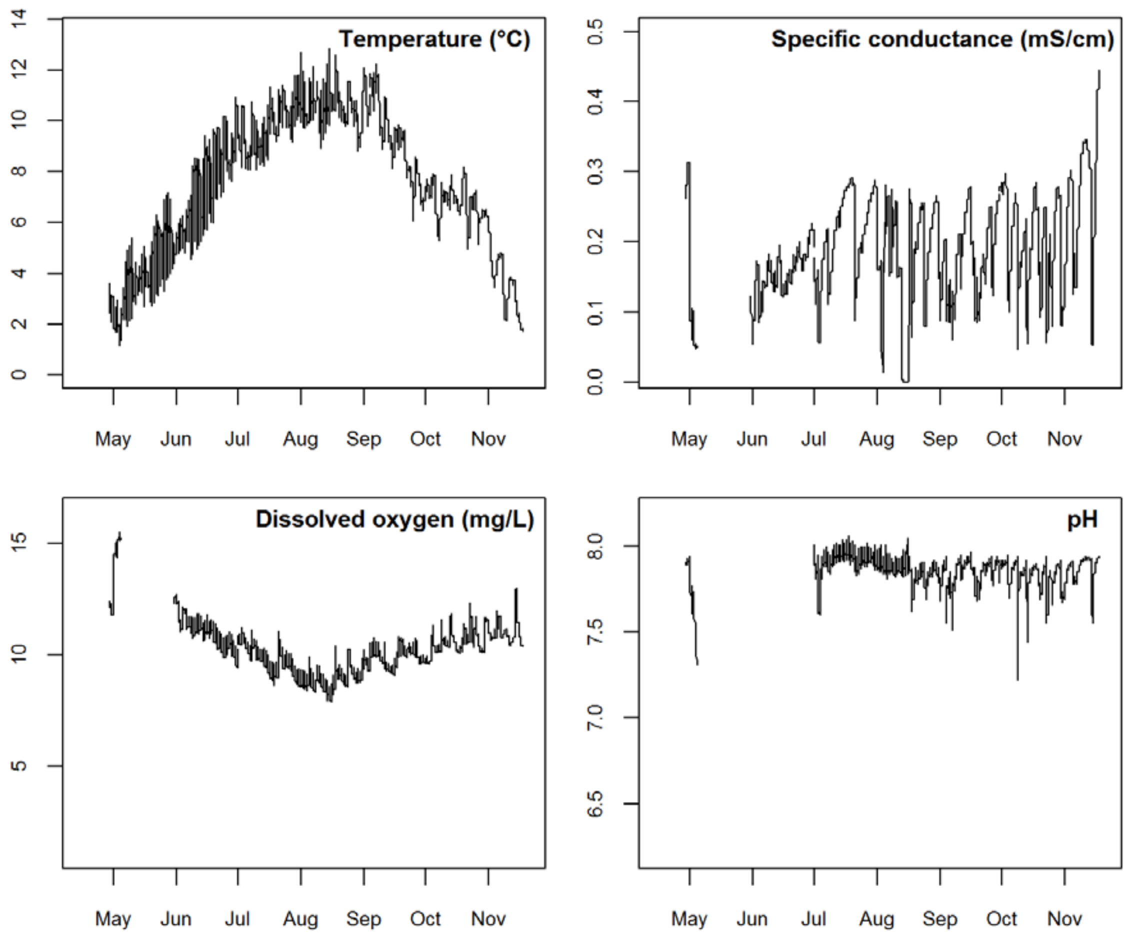

Figure 11. Hourly water quality data for the Salmon River in 2013. See ‘Data Collection’ within the Results section for more details regarding missing data.

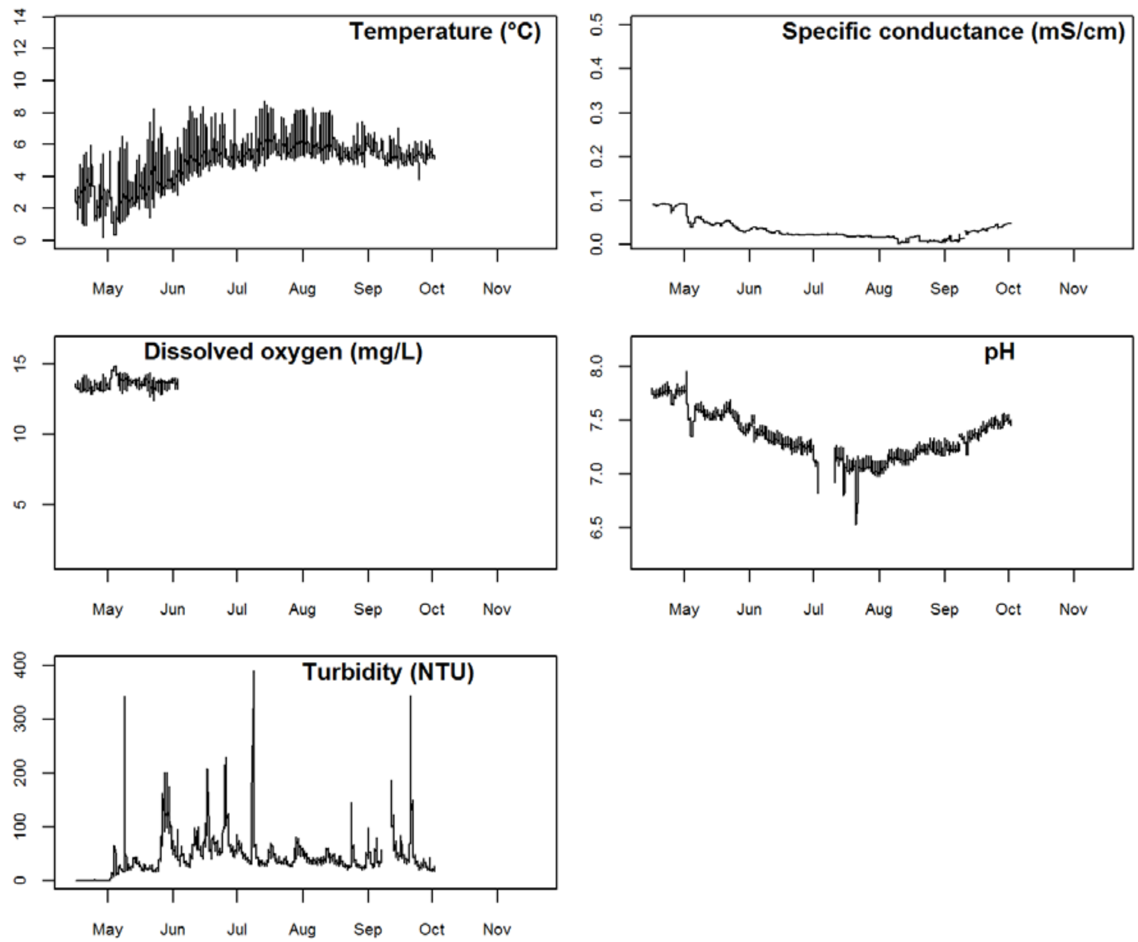

Figure 12. Hourly water quality data for the Taiya River in 2013.

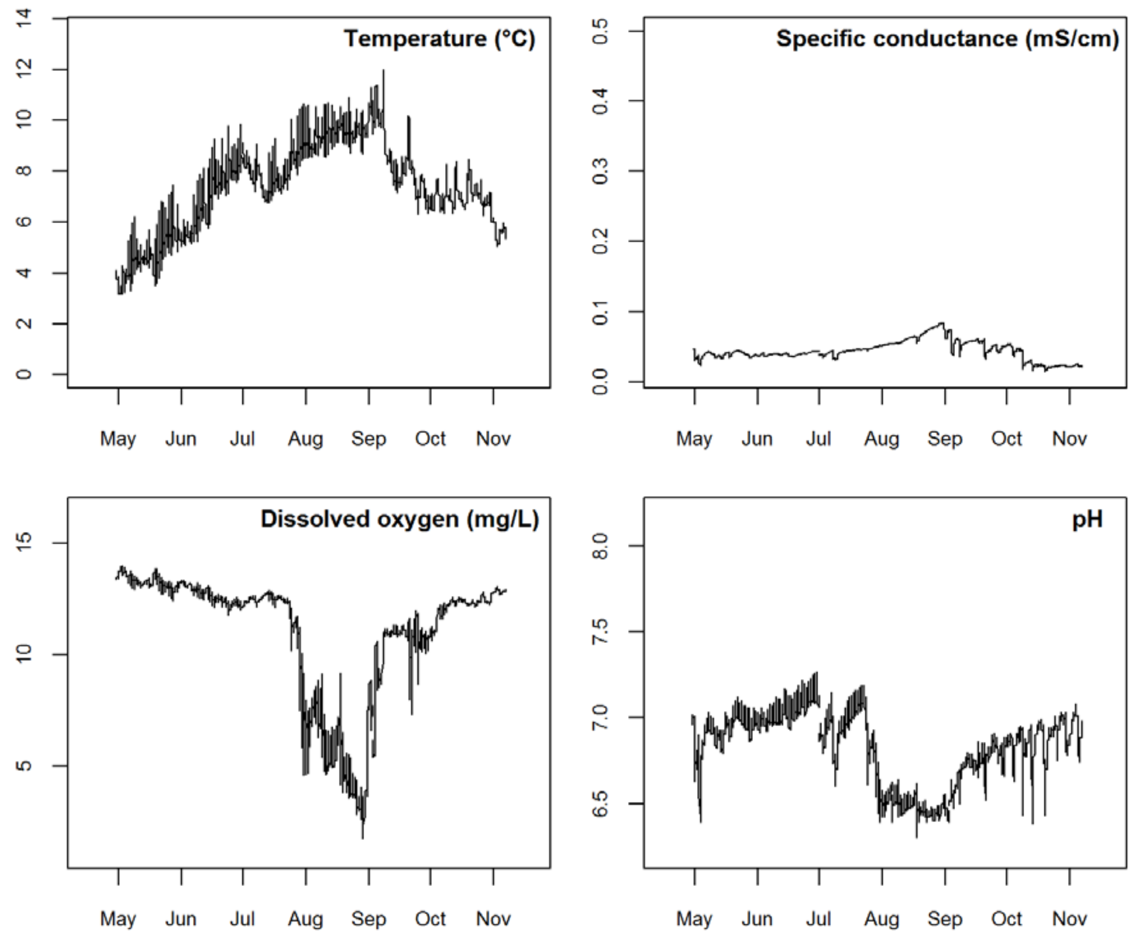

Figure 13. Hourly water quality data for the Indian River in 2013.

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

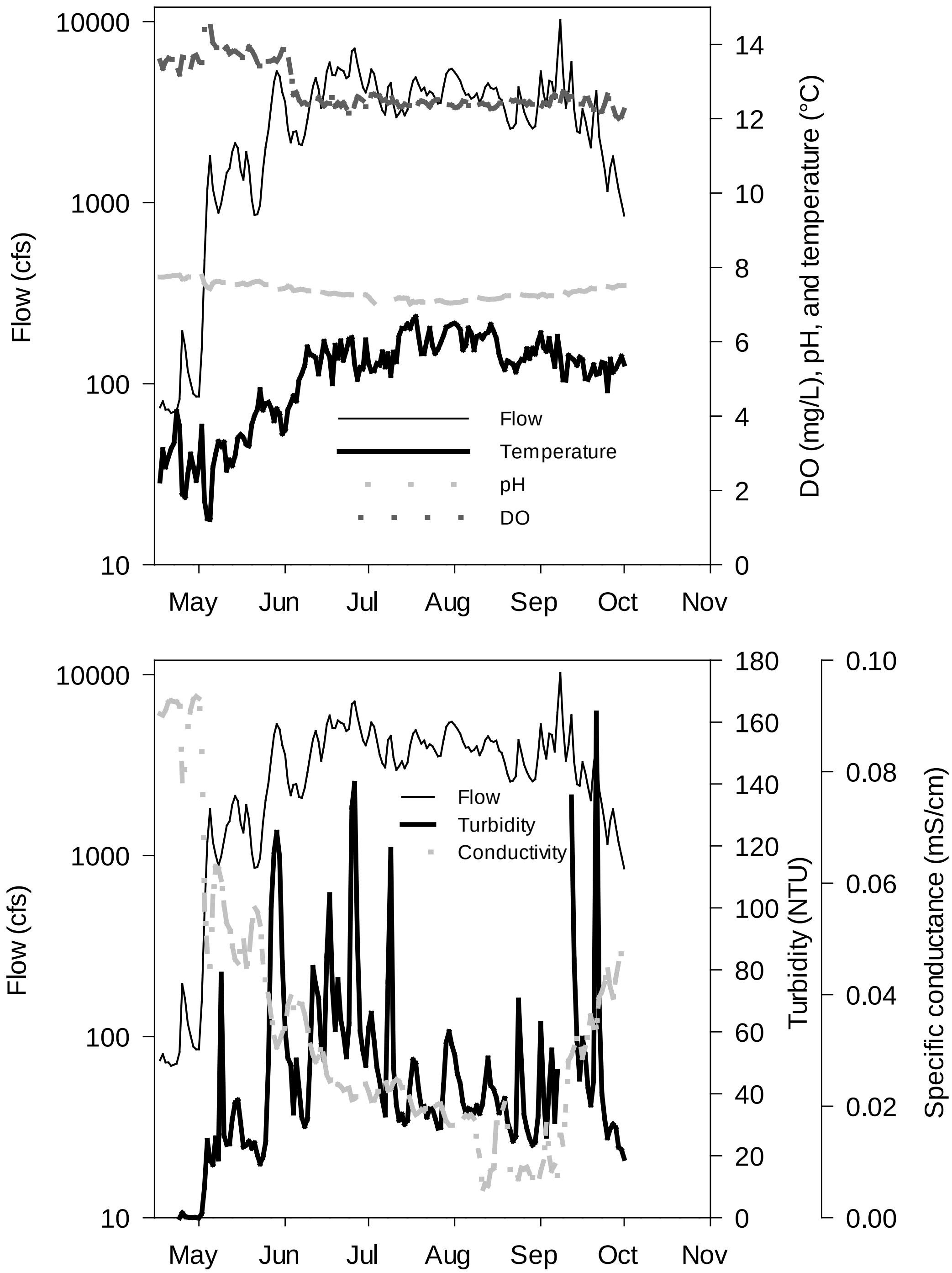

Figure 14. Daily average streamflow (log scale) versus daily averages for all water quality parameters in the Taiya River in 2013. Note the additional Y-axes on each panel. Streamflow data collected in the same location as water quality data and downloaded from the Taiya River USGS gage #1505621 website (http://waterdata.usgs.gov/ak/nwis/uv/?site_no=15056210&PARAmeter_cd=00065,00060).

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