

KARUK TRIBE

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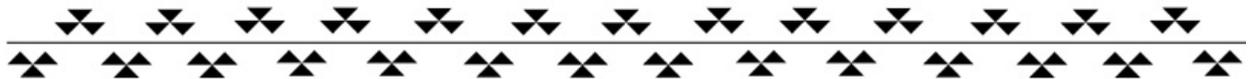


2021

Annual Monitoring Report



**KLAMATH RIVER, SALMON RIVER, SCOTT
RIVER, AND SHASTA RIVER**



Karuk Tribe

Annual Monitoring Report
2021

Prepared by
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1 Background

The Karuk Tribe is the second largest Tribe in California, with over 3,700 Tribal members currently enrolled and over 4,900 descendants. The Karuk Tribe is located along the middle Klamath River in northern California. Karuk Ancestral Territory covers over 90 miles of the main stem Klamath River and numerous tributaries. The Klamath River system is central to the culture of the Karuk People, as it is a vital component of our religion, traditional ceremonies, and subsistence activities. Degraded water quality and quantity has resulted in massive fish kills, increased occurrences of toxic algae, and outbreaks of fish diseases. Impaired water quality conditions also apply extreme limitations and burdens to our cultural activities.

The Karuk Tribe's Department of Natural Resources has been monitoring daily water quality conditions in the Klamath River since January of 2000 and tributaries to the Klamath River since 1998. The Karuk Tribe has been collaboratively involved in maintaining water quality stations along the Klamath River and its tributaries with the United States Environmental Protection Agency (USEPA), the United States Geological Survey (USGS), the Bureau of Reclamation (BOR), the Yurok Tribe, Quartz Valley Indian Reservation, the Hoopa Tribe, Resighini Rancheria, Oregon State University, Stanford University, and PacifiCorp. The following tables summarize waters within the aboriginal territory, tribal uses and goals of these waters, and impairments to these uses and goals (Tables 1-2).

Table 1 Atlas of Tribal Waters within Karuk Ancestral Territory

Atlas of Tribal Waters Within Ancestral Territory	
Total number of Klamath River miles	90
Total number of perennial stream miles	1,900
Total number of lake acres	442
Total number of wetland acres	UNKNOWN

Table 2 Designated uses, tribal goals and parameters measured to analyze impairments to tribal uses and goals

Making Assessment Decisions	
Designated Beneficial Uses and Tribal Goals	Parameter(s) to be Measured to Determine Support of Use of Goal
Rare, Threatened, or Endangered Species (RARE)	Temperature, DO, pH, Conductivity
Subsistence Fishing (FISH)	Temperature, DO, pH, Conductivity, Microcystin
Cold Freshwater Habitat (COLD)	Temperature, Turbidity
Cultural Contact Water (CUL-1)	Temperature, Phosphorus, Nitrogen, Microcystin
Cultural Non-Contact Water (CUL-2)	Temperature, Phosphorus, Nitrogen
Fish Consumption (FC)	Temperature, Phosphorus, Nitrogen
Water Contact Recreation (REC-1)	Temperature, Phosphorus, Nitrogen, Microcystin
Non-Contact Water Recreation (REC-2)	Temperature, Phosphorus, Nitrogen
Spawning, Reproduction, and/or Early Development (SPWN)	Temperature, DO, pH, Conductivity, Turbidity

2 Program Purpose

The overarching mission of the Karuk Tribe is to protect, promote, and preserve the cultural resources, natural resources, and ecological processes upon which the Karuk People depend. This mission requires the protection and improvement of the quality and quantity of water upstream and flowing through Karuk Ancestral Territory and Tribal trust lands.

The Karuk Tribe Water Quality Program (KTWQP) is currently evaluating the overall condition of water quality on Karuk Ancestral Territory, monitoring the extent to which water quality changes over time, and identifying impacts to beneficial uses. Data the KTWQP collects are indispensable in monitoring water quality conditions within the Klamath River Basin and providing valuable

information to ongoing water quality management processes. The information produced allows the Karuk Tribe to give valuable input in land management decisions and demonstrates the Tribe's commitment to sound resource management.

The Klamath River in California is listed as an impaired water body under the Clean Water Act (CWA) Section 303(d) list for temperature, nutrients, dissolved oxygen (DO), sediment, and microcystin (NCRWQCB, 2009). The mid-Klamath River can have elevated water temperatures, low dissolved oxygen levels, elevated sediment loads, loading from organic matter, and high levels of the cyanotoxin, microcystin. These detrimental conditions are caused by a variety of factors including the presence of Iron Gate and Copco Reservoirs, hydrological modification, agricultural use, timber harvesting, mining activities, cannabis cultivation, and fire suppression (NCRWQCB, 2009). Some of the beneficial uses that are important to the Karuk Tribe and impacted by poor water quality conditions are cultural use (CUL); subsistence fishing (FISH); cold freshwater habitat (COLD); recreation (REC-1 and 2); commercial and sport fishing (COMM); shellfish harvesting (SHELL); rare, threatened, or endangered species (RARE); migration of aquatic organisms (MIGR); spawning, reproduction, and/or early development (SPWN); and wildlife habitat (WILD) (NCRWQCB, 2007).

The data that the KTWQP collects are useful to Tribes, state and federal processes, and restoration efforts to assess current and past water quality conditions in the mid-Klamath River. For example, the North Coast Regional Water Quality Control Board (NCRWQCB) developed and began implementing Total Maximum Daily Loads (TMDLs) for the Klamath, Shasta, Scott, and Salmon Rivers. KTWQP data were used in the development of the technical portion of the TMDLs. Compliance points for tracking water quality improvements through TMDL implementation were placed at KTWQP long-term monitoring locations. On February 18, 2010, forty-eight entities signed on to the Klamath Hydroelectric Settlement Agreement (KHSA) to remove the four lower dams of the Klamath Hydroelectric Project (KHP). For this agreement, water quality monitoring will occur to establish baseline water quality conditions before the dams are removed in 2023.

The Karuk Tribe has established water quality standards for waters within Karuk Ancestral Territory. The details of these standards are outlined in the Karuk Tribe Water Quality Monitoring Plan (Karuk Tribe, 2002/2014).

3 Collaboration and Coordination

The KTWQP has found that the key to a successful water quality program in the Klamath region is to build collaborative relationships and coordinate with other entities in the basin. This adds credibility to our data sets, builds trust in our monitoring techniques, stretches water quality dollars by combining and coordinating monitoring efforts whenever feasible, and increases the Tribe's ability to conduct research and monitoring in the mid-Klamath. Our partners include: the Yurok Tribe, the Klamath Tribes, the Hoopa Tribe, Quartz Valley Indian Rancheria, Resighini Rancheria, Humboldt State University, Oregon State University, UC Berkeley, Stanford University, U.S. Fish and Wildlife Service, EPA Region IX, EPA Region X, Oregon Department of Environmental Quality, North Coast Regional Water Quality Control Board, State Water Resources Control Board, U.S. Forest Service (USFS), USGS, Humboldt County, Salmon River Restoration Council, Mid Klamath Watershed Council, Institute for Fisheries Resources, Pacific Coast Federation of Fishermen's Associations, and Klamath Riverkeeper.

The KTWQP participates in many collaborative workgroups. We currently attend meetings, provide constructive feedback, help set research and monitoring priorities, work in technical subgroups, look for and provide support for others' grant proposals, and conduct monitoring and research. Some of the workgroups we participate in include the Klamath Blue Green Algae Workgroup, California Cyanobacteria Harmful Algae Bloom Workgroup, Klamath Basin Monitoring Program, Klamath Tribal Water Quality Consortium, and the Klamath Fish Health Assessment Team.

4 Karuk Water Quality Program Design

The purpose of the Karuk Tribe's water quality monitoring program is to evaluate the quality of water flowing into, through, and out of Karuk Ancestral Territory and Tribal trust lands. We have combined the Karuk Tribe's goals with those of our collaborators listed above to establish a network of monitoring stations. We have established monitoring stations both within and above Karuk Ancestral Territory. These stations form a longitudinal profile of water quality conditions along the mid-Klamath River and associated major tributaries.

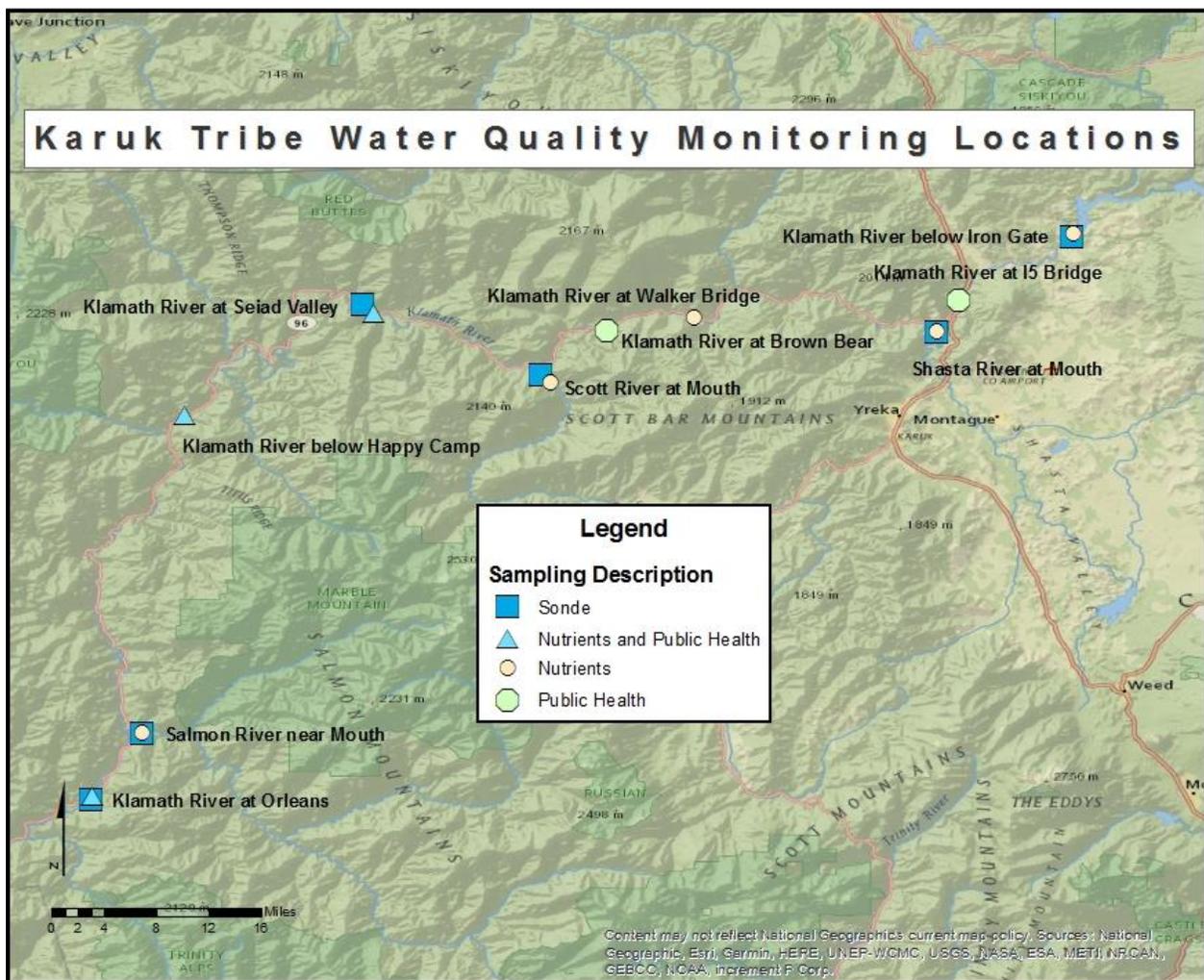


Figure 1 Overview of the Karuk Tribe's water quality monitoring locations along the Klamath River in 2021

Nutrient grab samples and phytoplankton are collected both in the Klamath River and the major tributaries, whereas public health monitoring for algal toxins occurs just in the main stem (Table 3). During the winters of 2007-2021, turbidity monitoring occurred at the Salmon River and Iron Gate sites. Iron Gate winter monitoring evaluates turnover in Iron Gate reservoir and influence on dissolved oxygen and pH. The Orleans (OR), Salmon River (SA), Seiad Valley (SV), Shasta River (SH), and Iron Gate (IG) continuous water quality monitoring stations are located at USGS gauging stations. This sampling is focused around the summer base flow (the growing season), which is generally from May-October. This is when water quality impairments stress beneficial uses. However, grab sampling continues throughout the year to help establish annual baseline load conditions and turbidity monitoring occurs in the winter when impairments are typically observed.

The frequency at which sampling occurs is dependent on resources and monitoring objectives. We focus on increasing a parameters collection frequency when the dynamics are changing at the greatest rate. For example, nutrient and phytoplankton dynamics are in flux more over the growing season than during the rest of the year. Therefore, grab samples may be collected approximately bimonthly (2x/month) during the growing season (May-October) and monthly the remainder of the year. Another example is our toxic algae and toxin sampling; it is aimed at being able to inform the public of health threats and is therefore collected at an increased frequency when threats are highest, in August and September (Kann and Corum, 2009).

Table 3 Site codes and locations of Karuk sampling stations for nutrients, algal toxins, and sondes. Nutrient Suite indicates collecting nutrients, algal toxins, and phytoplankton. Sonde indicates real time monitoring, and public health designates surface grab sampling for phytoplankton and algal toxins.

Locations and Parameters Monitored in 2021							
Site ID	Latitude	Longitude	Nutrient Suite	Sonde	Public Health	Winter Turbidity	Location
OR	N 41 18.336	W 123 31.895	X	X	X	X	Klamath River at Orleans
SA	N 41 22.617	W 123 28.633	X	X		X	Salmon River at USGS Gage
HC	N 41 43.780	W 123 25.775	X		X		Klamath River downstream of Happy Camp

Locations and Parameters Monitored in 2021							
Site ID	Latitude	Longitude	Nutrient Suite	Sonde	Public Health	Winter Turbidity	Location
SV	N 41 50.561	W 123 13.132	X	X	X	X	Klamath River downstream of Seiad Valley
SC	N 41 46.100	W 123 01.567	X	X			Scott River near mouth
BB	N 41 49.395	W 122 57.718			X		Brown Bear River Access on Klamath River
WA	N 41 50.242	W 122 51.895	X				Klamath River at Walker Bridge
SH	N 41 49.390	W 122 35.700	X	X			Shasta River at USGS Gage
IB	N 41 51.424	W 122 34.245			X		Klamath River at I-5 Bridge
IG	N 41 55.865	W 122 26.532	X	X		X	Klamath River below Iron Gate Hatchery Bridge

Further discussion of monitoring protocols and procedures can be found in the KTWQP's Annual Monitoring Reports (formerly Water Quality Assessment Reports), the Mid-Klamath River Nutrient, Periphyton, Phytoplankton and Algal Toxin Sampling Analysis Plan, and the Karuk Tribe Quality Assurance Protocols and Procedures document (QAPP) (Karuk Tribe, 2000-2002, 2006-2020; Karuk Tribe, 2009; Karuk Tribe, 2018).

5 Data Interpretation and Management

The Karuk Tribe purchased Aquatic Informatics (AI) Time-Series software in 2015 to manage, QA/QC, and in conjunction with AI's Webportal software disseminate our continuous data. Raw data and data that have under-gone further QA/QC are automatically archived separately. Metadata associated with each data type are also stored within the system and can be easily accessed when questions arise. Phytoplankton and algal toxin data are entered into Excel spreadsheets that are checked for accuracy by the Project Manager and backed up onto the KTWQP network and an external hard drive system that is maintained offsite.

Data are compiled using spreadsheets, R, and the AI Time-Series software. Graphical and statistical analyses are used to assess the current status and trends of monitored water bodies. In addition, comparisons between sites can also be made. Overall, water quality is evaluated using standards put forth in the Karuk Tribe's Water Quality Control Plan and QAPP. Assessment of data also includes the evaluation of field methodology and data quality. Data collected are then submitted electronically to EPA via the California Environmental Data Exchange (CEDEN), cross walked to EPA's Water Quality Exchange (WQX), and made publicly available. Data may be utilized by other Tribes, agencies, and entities to help direct water resource management actions.

6 2021 Water Quality Results

6.1 Main Stem Klamath

The sonde data presented in Figures 2-13 depict seasonal temperature, dissolved oxygen, and pH trends at main stem Klamath River monitoring sites.

6.1.1 Main Stem Temperature

Monitoring locations at Seiad Valley (SV) and Orleans (OR) have similar thermographs when comparing daily averages in 2021 (Figure 2). The site below Iron Gate dam (IG), however, has less variability both in the short-term and throughout the year including a lower peak temperature in July and August (Figure 2). These trends are reinforced by comparing the aggregated 15-year aggregated daily averages 2007-2021 (Figure 3). Water released from the Iron Gate reservoir has a moderating effect on temperature, reducing summer highs and raising winter lows as compared to historic conditions and upstream un-impounded tributary contributions. Furthermore, the effect of the Iron Gate "curtain" can be seen in mid-May when the sites diverge as water begins to be drawn from the lower depths of the reservoir. Water temperatures in 2021 were slightly higher than previous years (Figures 2 and 3).

Klamath River Daily Average Temperature, 2021

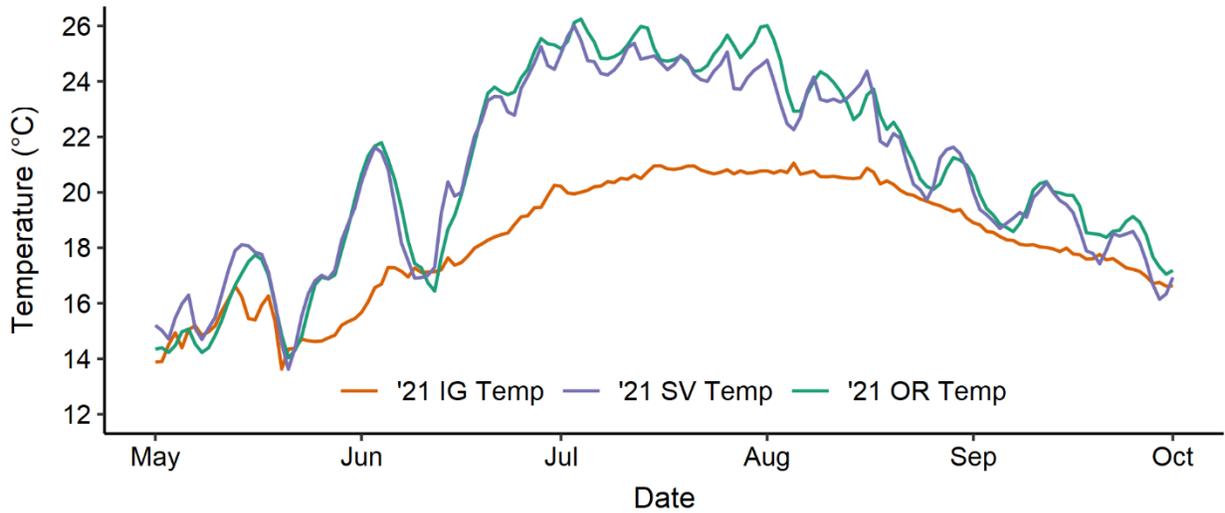


Figure 2 Daily average water temperatures in 2021 at three main stem Klamath River sites: below Iron Gate dam (IG), Seiad Valley (SV), and Orleans (OR)

Klamath River 15 Year Average Daily Temperature

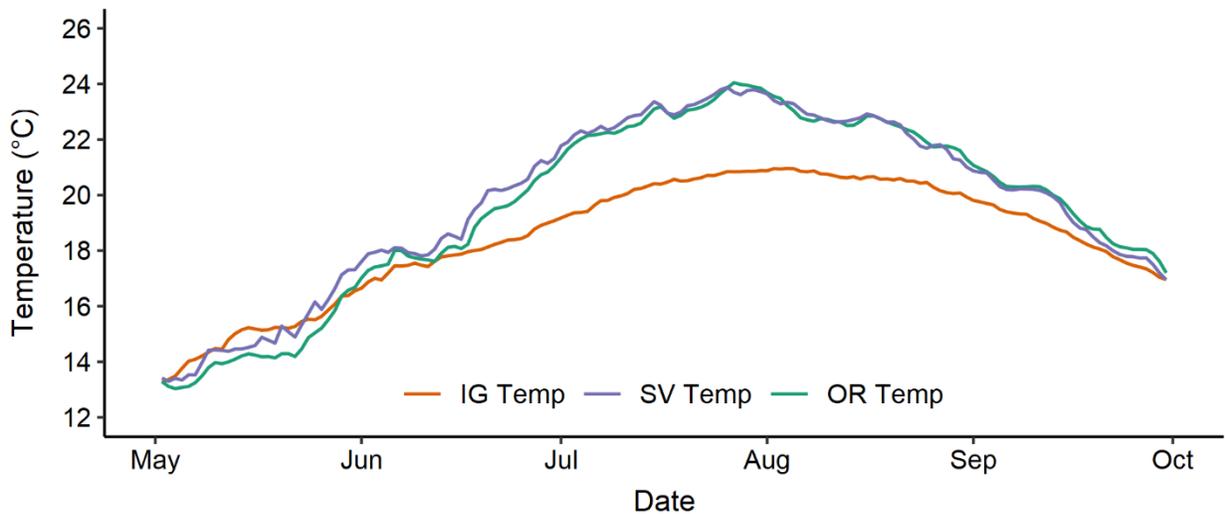


Figure 3 Aggregated daily average water temperatures from 2007-2021 at main stem Klamath River sites: below Iron Gate dam (IG), Seiad Valley (SV), and Orleans (OR)

6.1.2 Main Stem Dissolved Oxygen

Iron Gate dam has a negative impact on dissolved oxygen levels from mid-August through the end of data collection, dropping while downstream sites rise (Figures 4-7). This timing overlaps with fall-run salmonid migration and impairs beneficial use. This is also true when comparing to the 15-year historical record; spring levels are also lower than downstream sites. The Orleans and Seiad Valley sites have similar profiles and conform with their historical averages (Figure 8). Dissolved oxygen levels at the three sites converge during the summer when water temperatures are highest (Figures 3 and 8). Again, the impact of the curtain can be seen in depressed dissolved oxygen levels beginning in mid-May when it is deployed and water released from the dam comes from deeper, anoxic reservoir waters (Figures 4 and 7). The most impaired site according to the North Coast Regional Water Quality Control Board (NCRWQCB) is Iron Gate, followed by Seiad Valley and then Orleans. This demonstrates the dam's negative influence on dissolved oxygen, which is mitigated by distance and other inputs downstream.

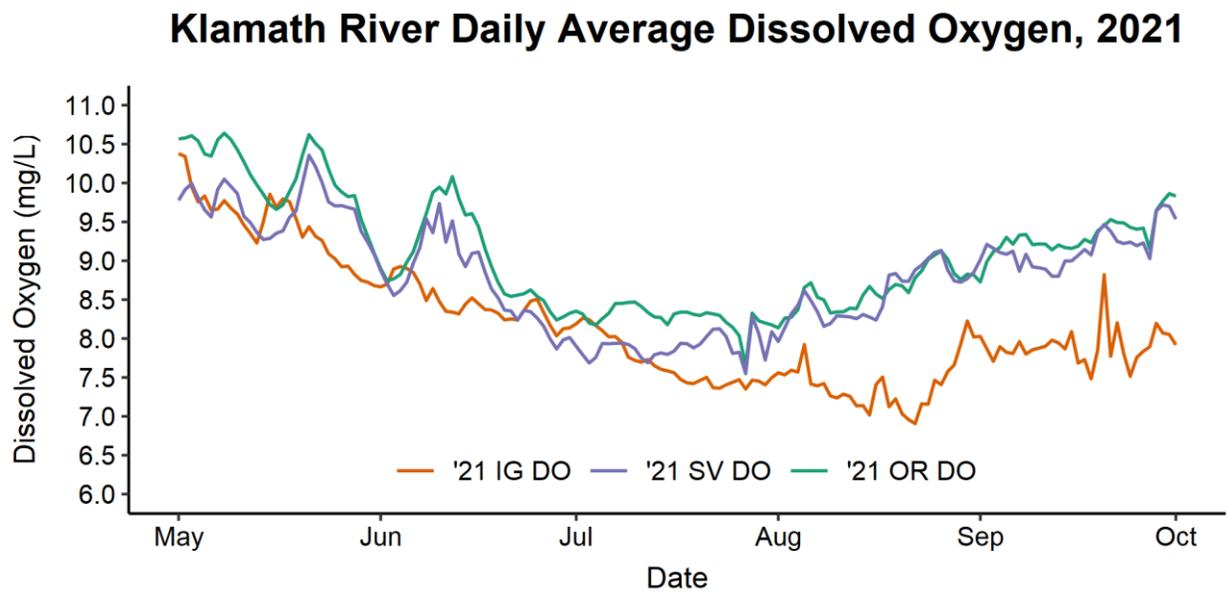


Figure 4 Daily average dissolved oxygen levels in 2021 at mainstem Klamath River sites: below Iron Gate dam (IG), Seiad Valley (SV), and Orleans (OR)

Klamath River at Orleans Dissolved Oxygen Saturation, WY 2021

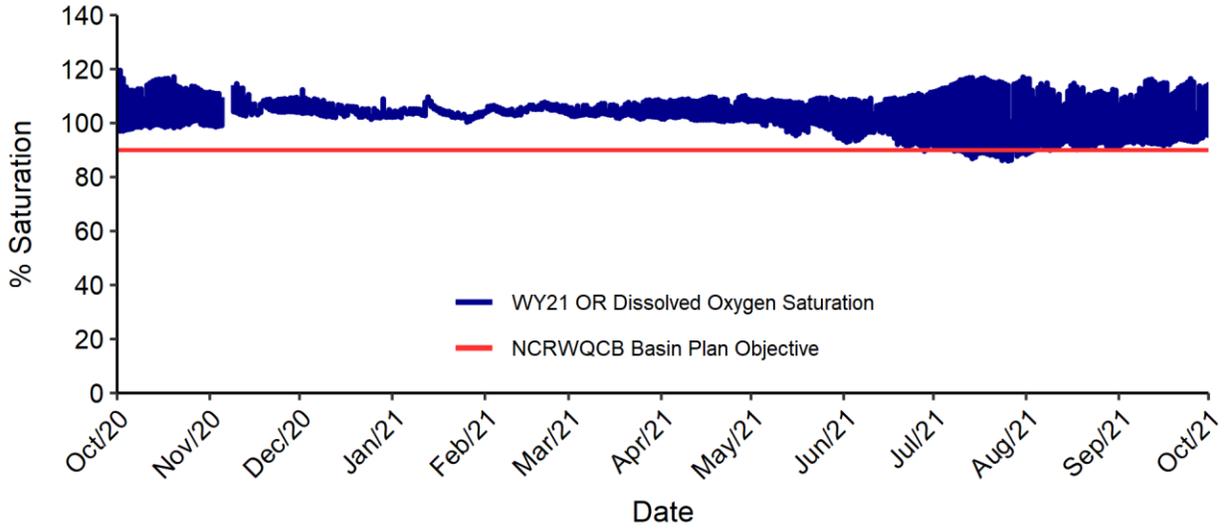


Figure 5 Dissolved oxygen saturation readings recorded instantaneously every 15 minutes in 2021 at the Klamath River at Orleans (OR) and the NCRWQCB Basin Plan Klamath River site-specific dissolved oxygen water quality objective: > 90% saturation year-round from the Scott River confluence to Hoopa

Klamath River at Seiad Valley Dissolved Oxygen Saturation, WY 2021

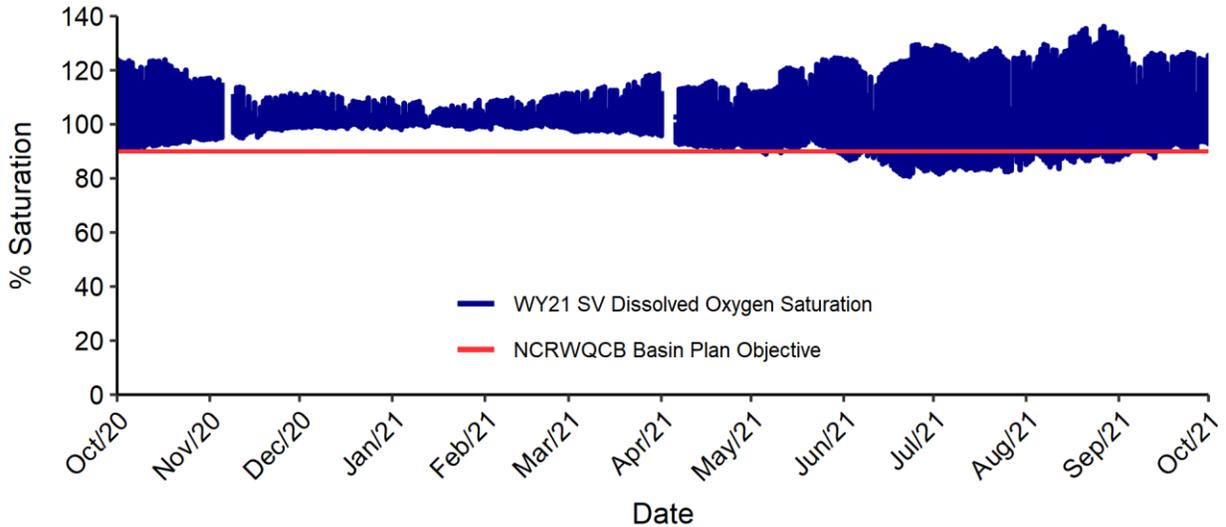


Figure 6 Dissolved oxygen saturation readings recorded instantaneously every 15 minutes in 2021 at the Klamath River at Seiad Valley (SV) and the NCRWQCB Basin Plan Klamath River site-specific dissolved oxygen water quality objective: > 90% saturation year-round from the Scott River confluence to Hoopa

Klamath River at Iron Gate Dissolved Oxygen Saturation, WY 2021

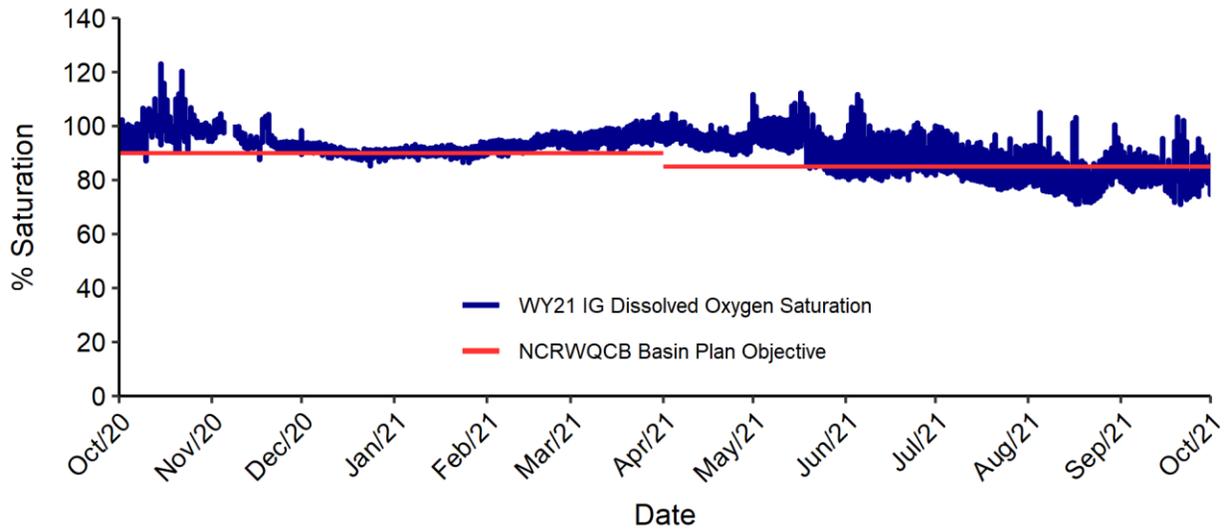


Figure 7 Dissolved oxygen saturation readings recorded instantaneously every 15 minutes in 2021 at the Klamath River below Iron Gate dam (IG) and the NCRWQCB Basin Plan Klamath River site-specific dissolved oxygen water quality objective: > 90% saturation Oct 1 – March 30 and > 85% saturation April 1 – Sept 30 from the OR/CA state line to the mouth of the Scott River

Klamath River 15 Year Average Daily Dissolved Oxygen

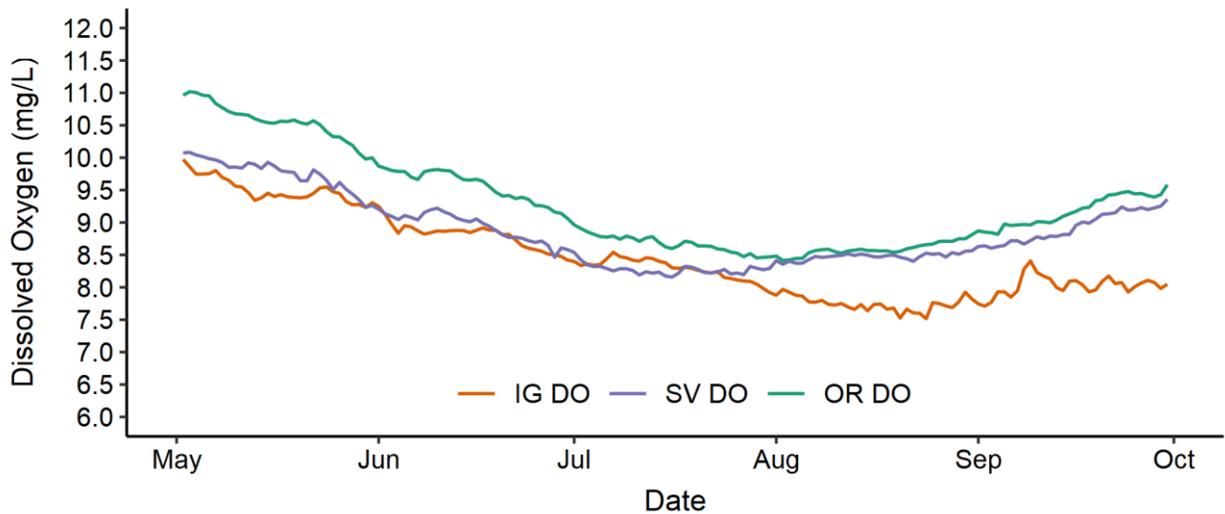


Figure 8 Aggregated daily average dissolved oxygen levels from 2007-2021 at main stem Klamath River sites: below Iron Gate dam (IG), Seiad Valley (SV), and Orleans (OR)

6.1.3 Main Stem pH

pH levels vary among sites, with Seiad Valley being the most basic and having the most exceedances of the NCRWQCB Basin Plan water quality objective for the Klamath River. However, exceedances at Iron Gate are the largest in magnitude (Figures 9-12). The Iron Gate pH levels are the most dynamic, owing to the use of the curtain beginning in mid-May which depresses pH levels followed by rapidly increasing productivity in the reservoir during warm summer months (Figures 9 and 12).

Historic 15-year trends are replicated this year with pH levels peaking between August and October and regular daily exceedances of the Basin Plan objective (Figures 9 and 13). This late summer pH increase coincides with the peak of in-river productivity and the lowest dissolved oxygen readings, indicative of water quality impairments associated with photorespiration.

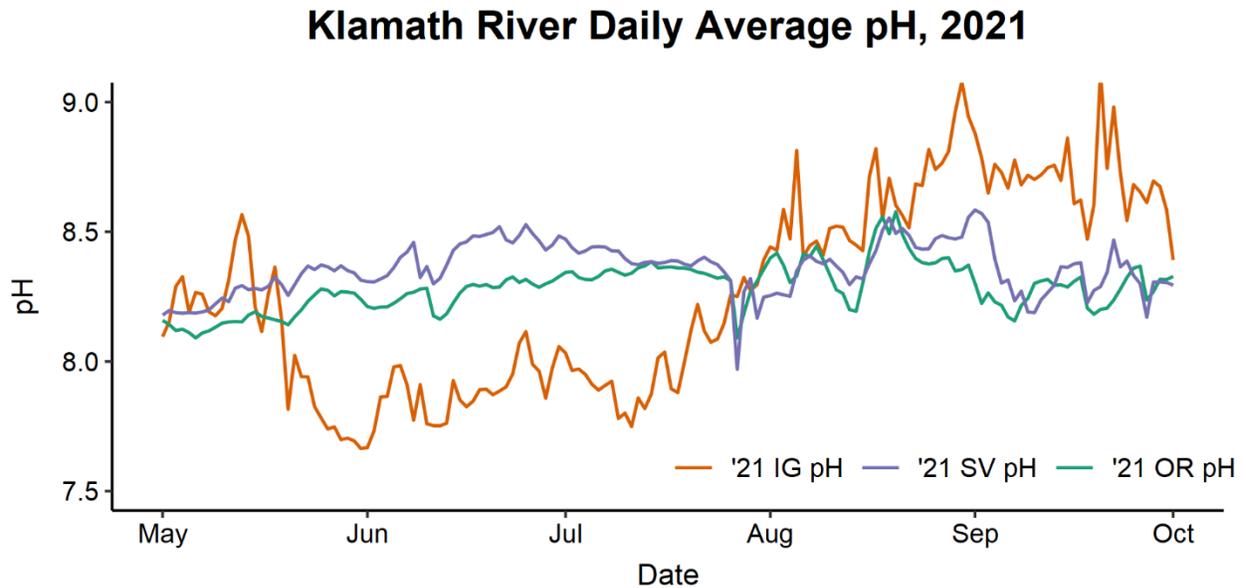


Figure 9 Daily average pH levels in 2021 at main stem Klamath River sites: below Iron Gate dam (IG), Seiad Valley (SV), and Orleans (OR)

Klamath River at Orleans pH, WY 2021

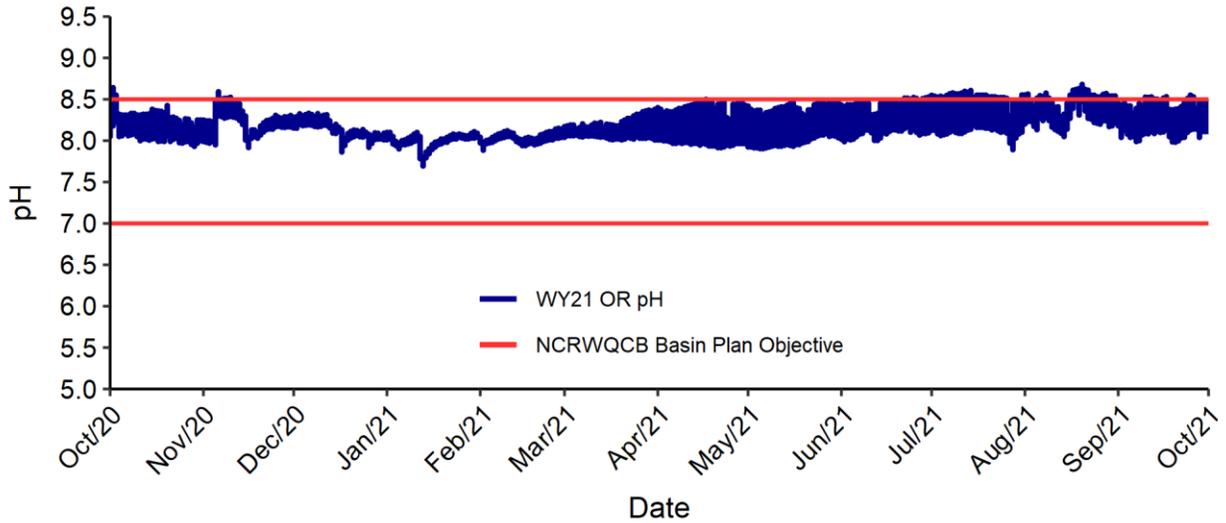


Figure 10 pH readings recorded instantaneously every 15 minutes water year 2021 at the Klamath River at Orleans (OR) and the NCRWQCB Basin Plan objective for the Klamath River: $7 < x < 8.5$

Klamath River at Seiad Valley pH, WY 2021

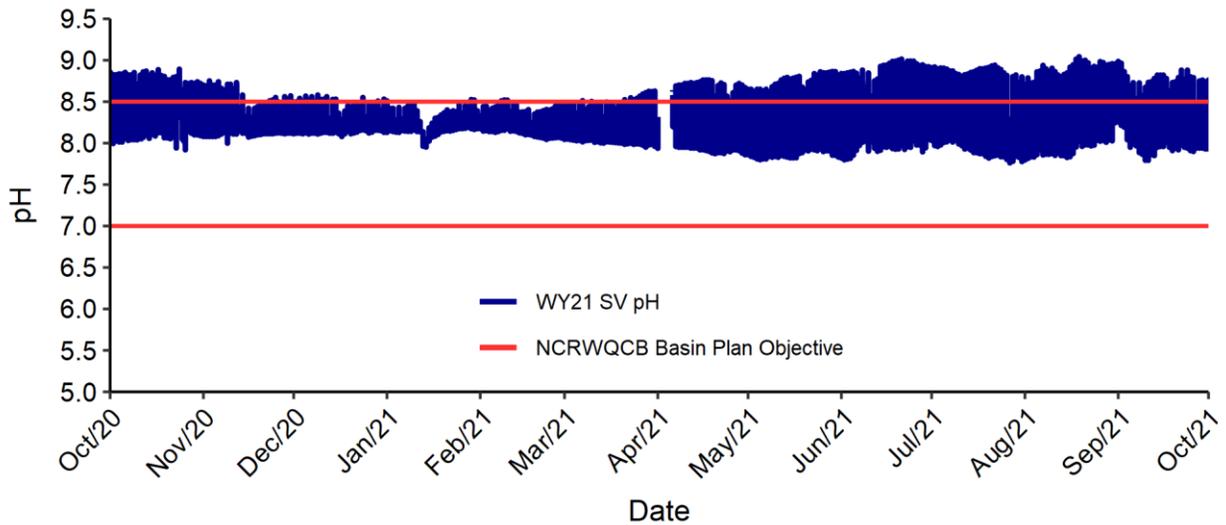


Figure 11 pH readings recorded instantaneously every 15 minutes in water year 2021 at the Klamath River at Seiad Valley (SV) and the NCRWQCB Basin Plan objective for the Klamath River: $7 < x < 8.5$

Klamath River at Iron Gate pH, WY 2021

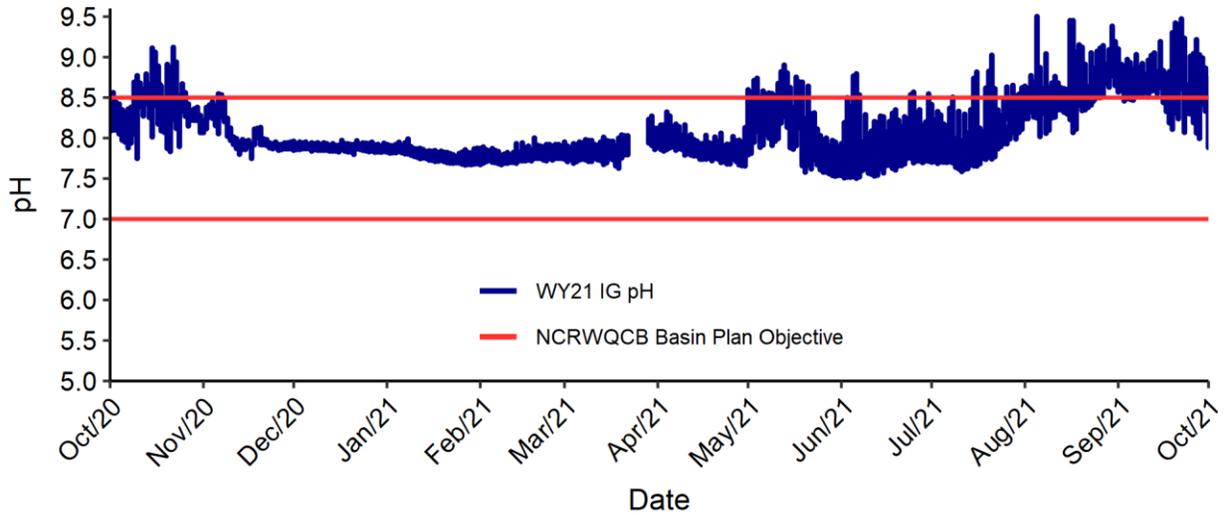


Figure 12 pH readings recorded instantaneously every 15 minutes in water year 2021 at the Klamath River below Iron Gate dam (IG) and the NCRWQCB Basin Plan objective for the Klamath River: $7 < x < 8.5$

Klamath River 15 Year Average Daily pH

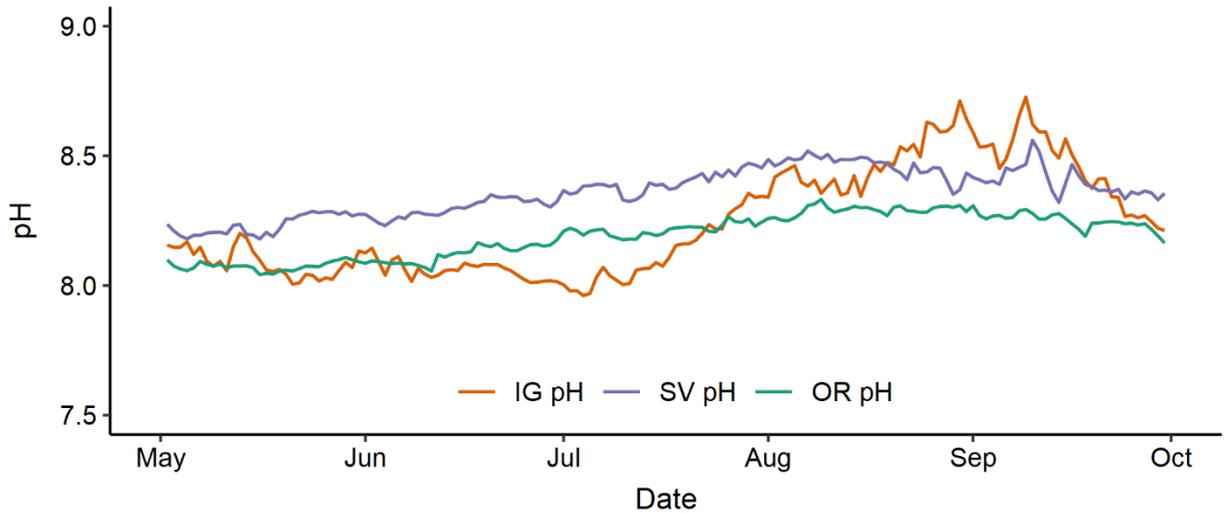


Figure 13 Aggregated daily average pH levels from 2007-2021 at main stem Klamath River sites: below Iron Gate dam (IG), Seiad Valley (SV), and Orleans (OR)

6.2 Tributaries

The Karuk Tribe Water Quality Program has monitored three major Klamath tributaries just upstream from their confluences with the Klamath since 2006: the Shasta, Scott, and Salmon Rivers. Each of the tributaries has similar seasonal water quality trends.

6.2.1 Tributary Temperature

Temperatures in spring are stratified among the tributaries due to variable input: the Shasta River is warmer due to groundwater influences which moderate temperature, the Scott River is intermediate with a mix of groundwater and snowmelt, and the Salmon River is the coldest with a snowmelt-dominated system. Over time, temperatures converge as solar radiation becomes the dominant driver (Figure 14). Individual thermographs show historic peak temperatures in July-August, with this year's temperatures reaching higher than the historic record at several points (Figures 15-17).

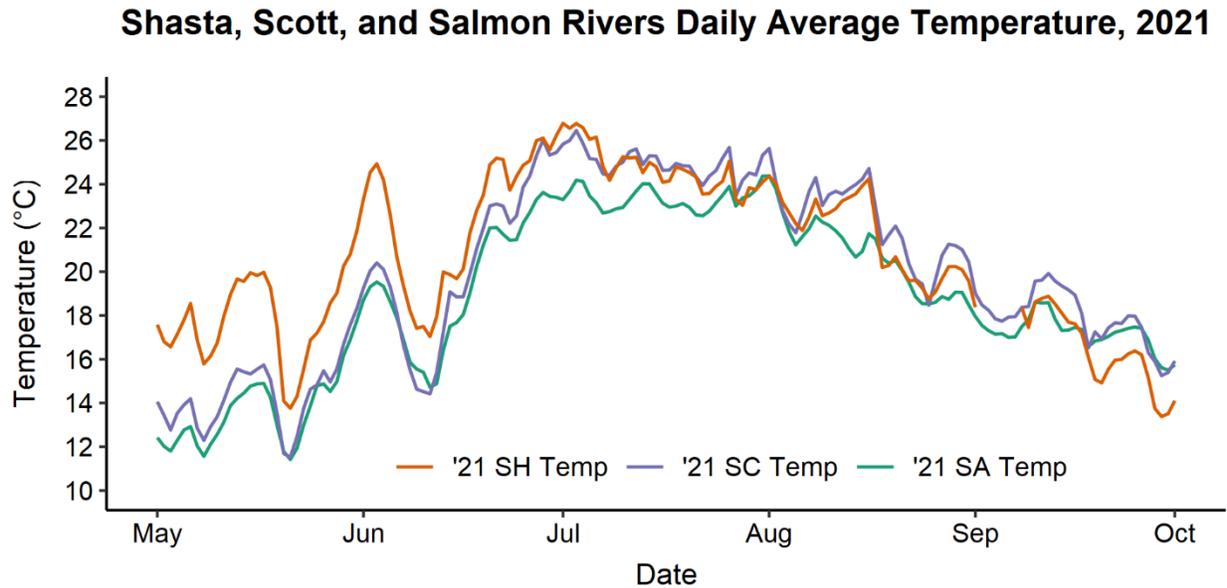


Figure 14 Daily average water temperature in 2021 at Shasta (SH), Scott (SC), and Salmon (SA) Rivers

Shasta River Daily Average Temperature, 2015-2021

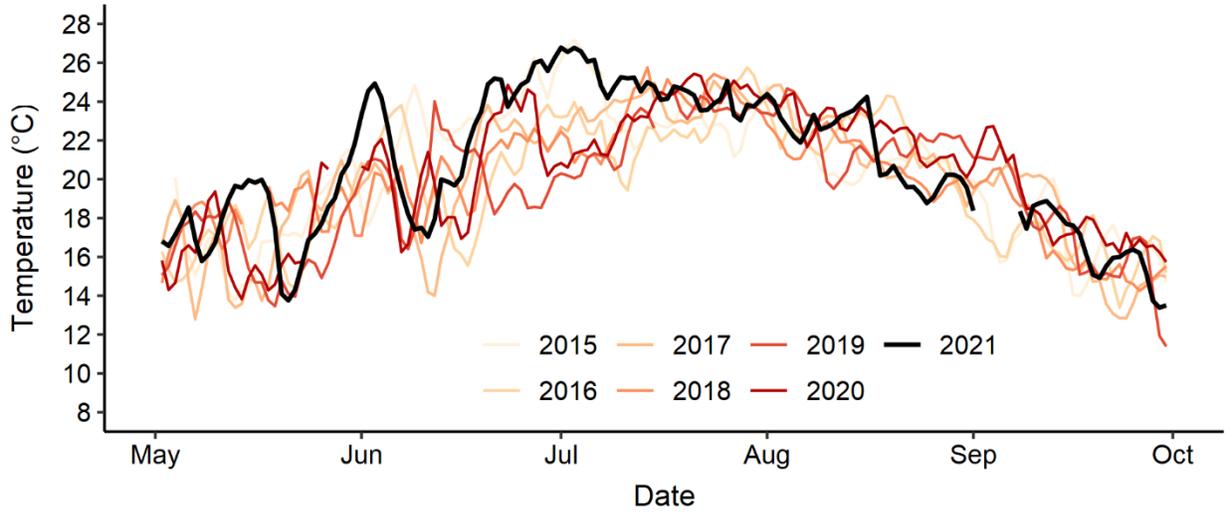


Figure 15 Daily average water temperatures from 2015-2021 at the Shasta River

Scott River Daily Average Temperature, 2015-2021

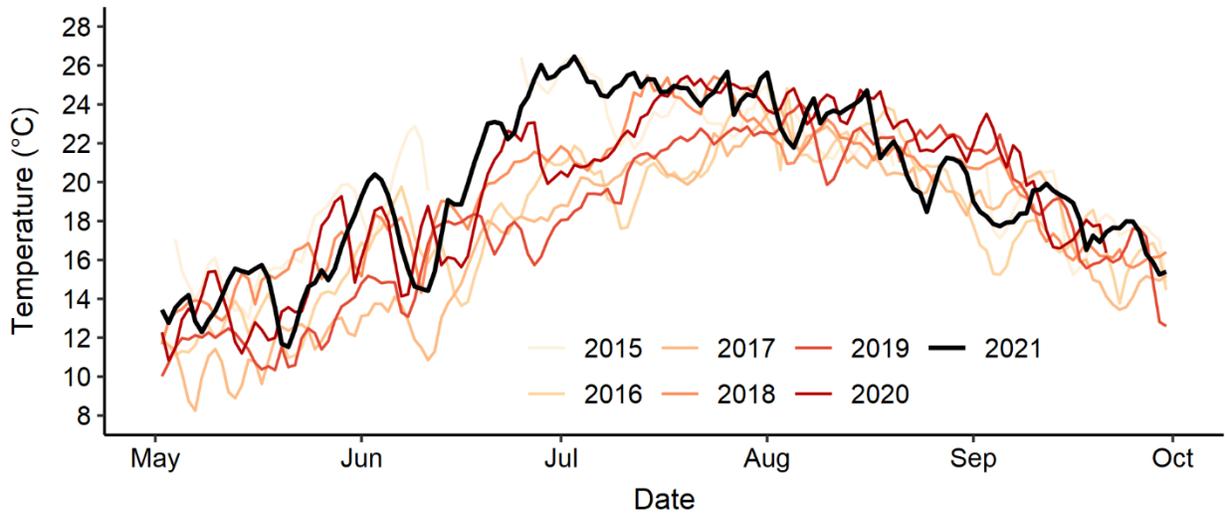


Figure 16 Daily average water temperatures from 2015-2021 at the Scott River

Salmon River Daily Average Temperature, 2015-2021

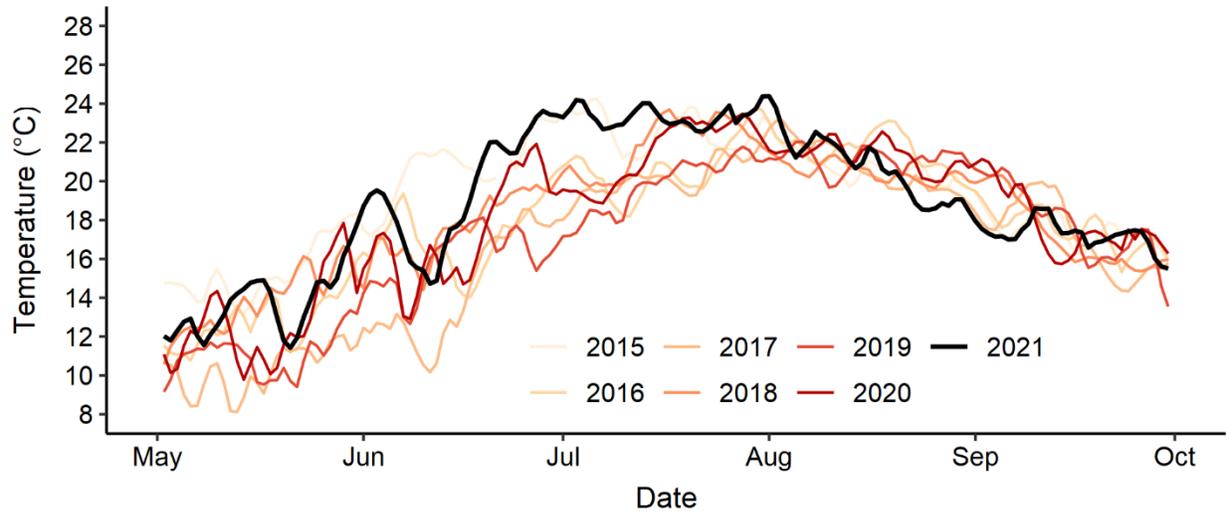


Figure 17 Daily average water temperatures from 2015-2021 for the Salmon River

6.2.2 Tributary Dissolved Oxygen

The relationship between dissolved oxygen and temperature is represented by the differing spring dissolved oxygen levels, with the Salmon River having the highest levels (and coldest temperature) and the Shasta River having the lowest levels (and warmest temperatures) (Figure 18). Lower spring dissolved oxygen temperatures than previous years reflect the higher-than-average temperatures discussed in the previous section (Figures 19, 21, and 23), particularly in spring.

The NCRWQCB Basin Plan establishes water quality objectives for each tributary based on instantaneous readings. The Shasta River was regularly impaired May-August (< 7 mg/L); the Scott River had the least deviation but was slightly impaired July-August (< 7 mg/L); and the Salmon River was significantly impaired July-September (< 9 mg/L) (Figures 20, 22, and 24).

Shasta, Scott, and Salmon Rivers Daily Average Dissolved Oxygen, 2021

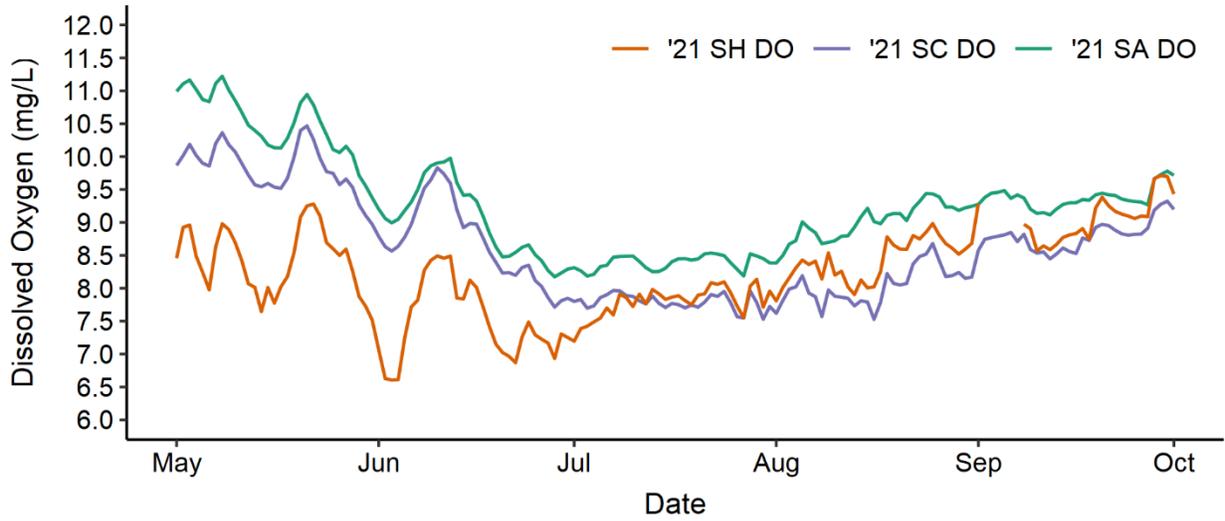


Figure 18 Daily average dissolved oxygen levels in 2021 at Shasta (SH), Scott (SC), and Salmon (SA) Rivers

Shasta River Daily Average Dissolved Oxygen, 2015-2021

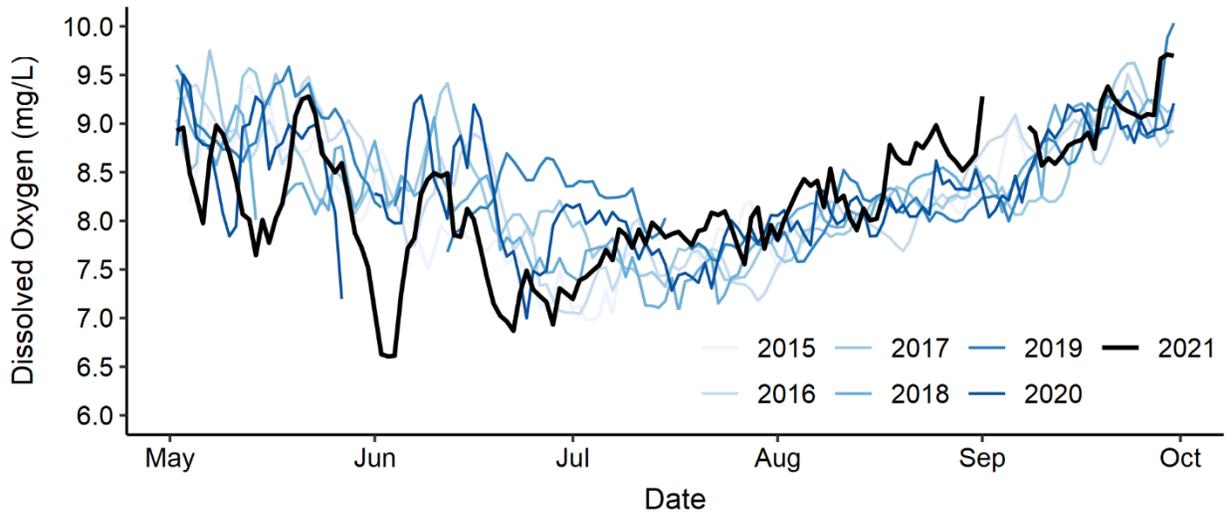


Figure 19 Daily average dissolved oxygen levels from 2015-2021 at the Shasta River

Shasta River Dissolved Oxygen, 2021

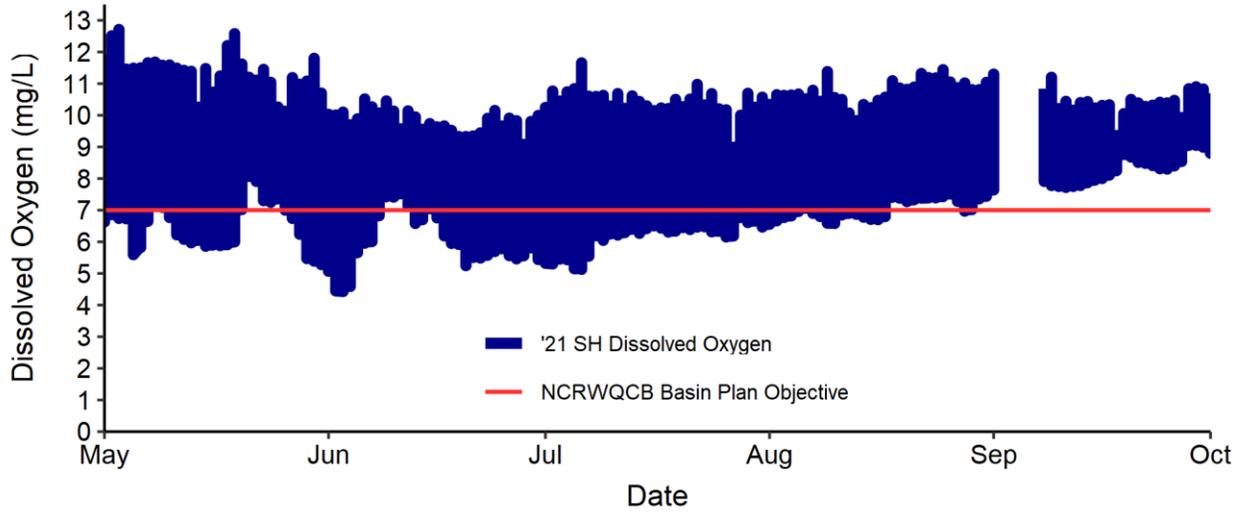


Figure 20 Dissolved oxygen readings recorded instantaneously every 15 minutes in 2021 at the Shasta River and the NCRWQCB Basin Plan site-specific water quality objective for the Shasta River, > 7 mg/L

Scott River Daily Average Dissolved Oxygen, 2015-2021

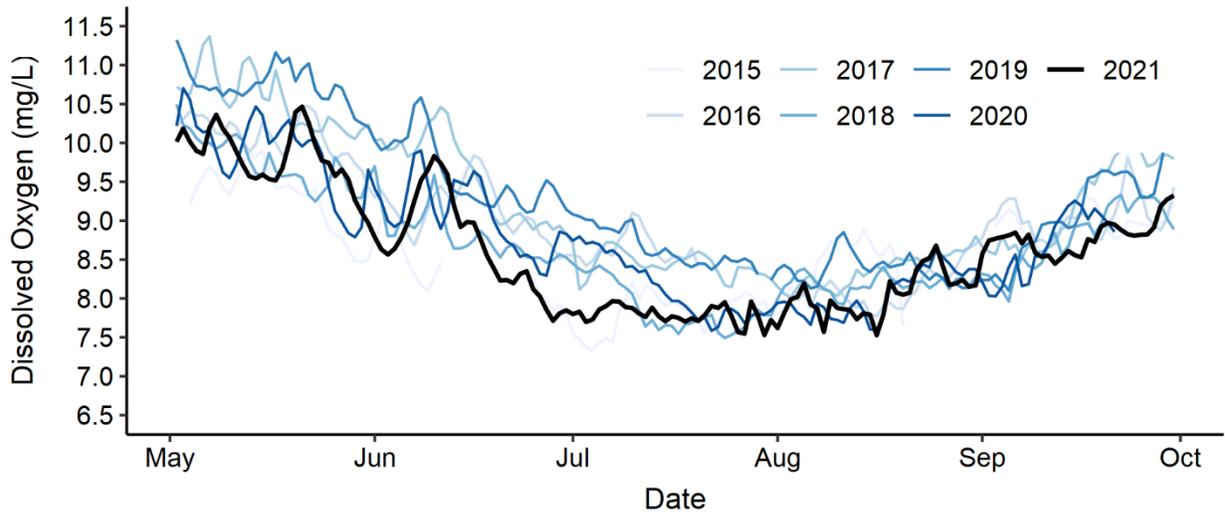


Figure 21 Daily average dissolved oxygen levels from 2015-2021 at the Scott River

Scott River Dissolved Oxygen, 2021

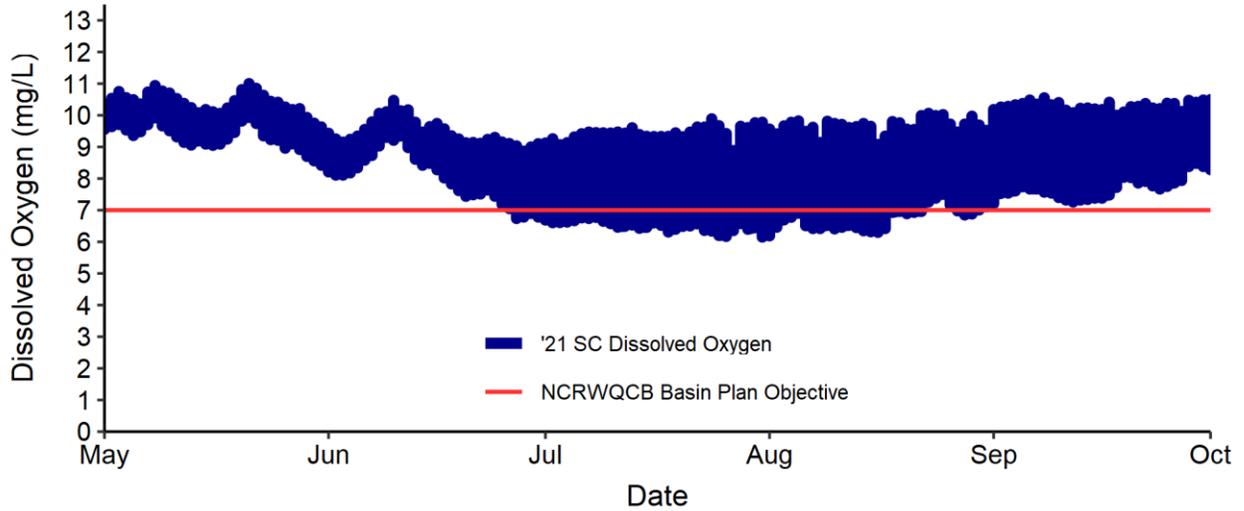


Figure 22 Dissolved oxygen readings recorded instantaneously every 15 minutes in 2021 at the Scott River and the NCRWQCB Basin Plan site-specific water quality objective for the Scott River, > 7 mg/L

Salmon River Daily Average Dissolved Oxygen, 2015-2021

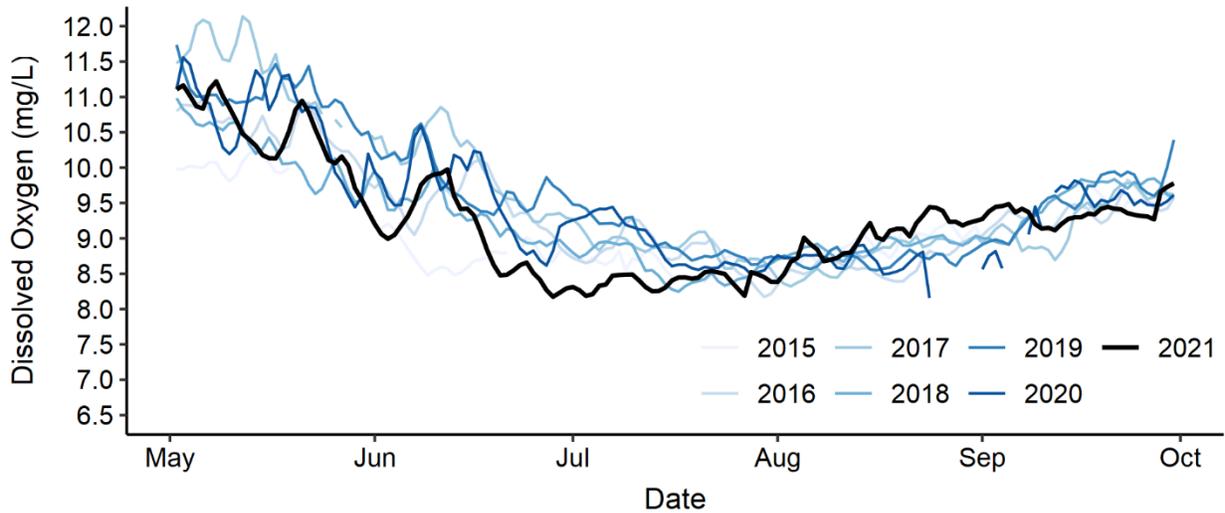


Figure 23 Daily average dissolved oxygen levels from 2015-2021 at the Salmon River

Salmon River Dissolved Oxygen, WY 2021

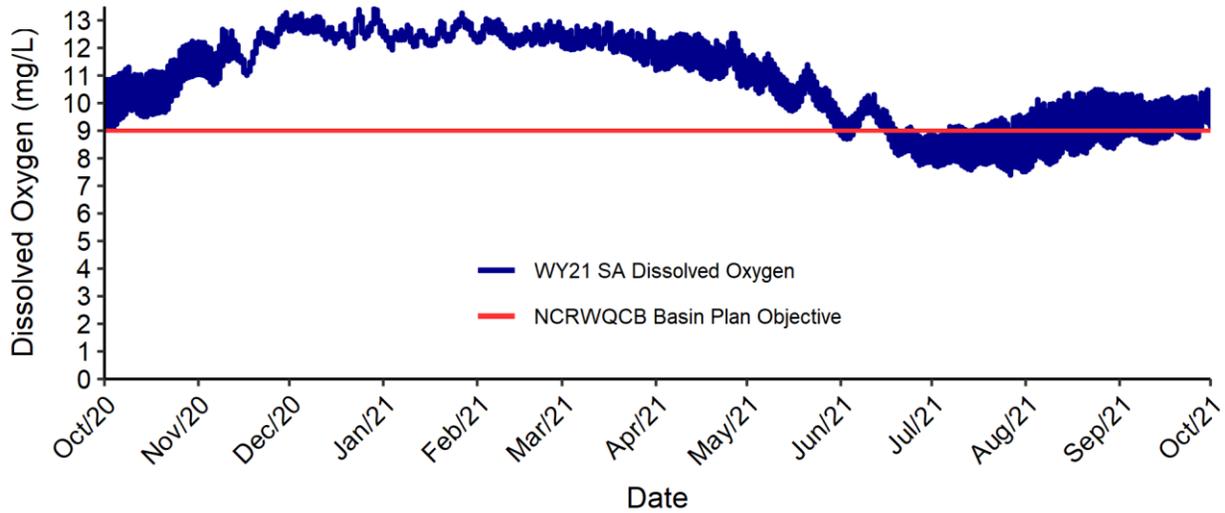


Figure 24 Dissolved oxygen readings recorded instantaneously every 15 minutes in water year 2021 at the Salmon River and the NCRWQCB Basin Plan site-specific water quality objective for the Salmon River, > 9 mg/L

6.2.3 Tributary pH

Daily average pH readings are stratified among tributaries, with Shasta River as the most basic due to groundwater input hardness and heightened productivity deriving from land use and Salmon River as the least (Figure 25). The Shasta and Scott River trends are generally stable throughout the year, while the Salmon River's pH climbs from spring to fall (Figures 26, 28, and 30). This, and the more frequent and severe drops in pH throughout the year, are tied to the distinct geology of the Salmon River that reflects its position lower in the Klamath basin. Steep topography and rapid releases of snowmelt result in larger flow peaks and stronger scour, which negatively impact benthic producers and lead to drops in pH. The Scott River shows a similar but lower magnitude trend, reflecting its intermediate position in the basin.

Comparison with earlier years shows similarity with levels in 2021 (Figures 26, 28, and 20). All three tributaries exceeded the NCRWQCB Basin Plan site-specific water quality objectives for pH in 2021. Magnitudes of exceedance matched their stratified pH levels, with the Shasta River most impaired in terms of pH and the Salmon River least. Notably, exceedances are confined to certain seasons at the Salmon River; are regularly exceeded by diurnal highs at the Scott River; and are the dominant state in the Shasta River except for nocturnal lows (Figures 27, 29, and 31).

Shasta, Scott, and Salmon Rivers Daily Average pH, 2021

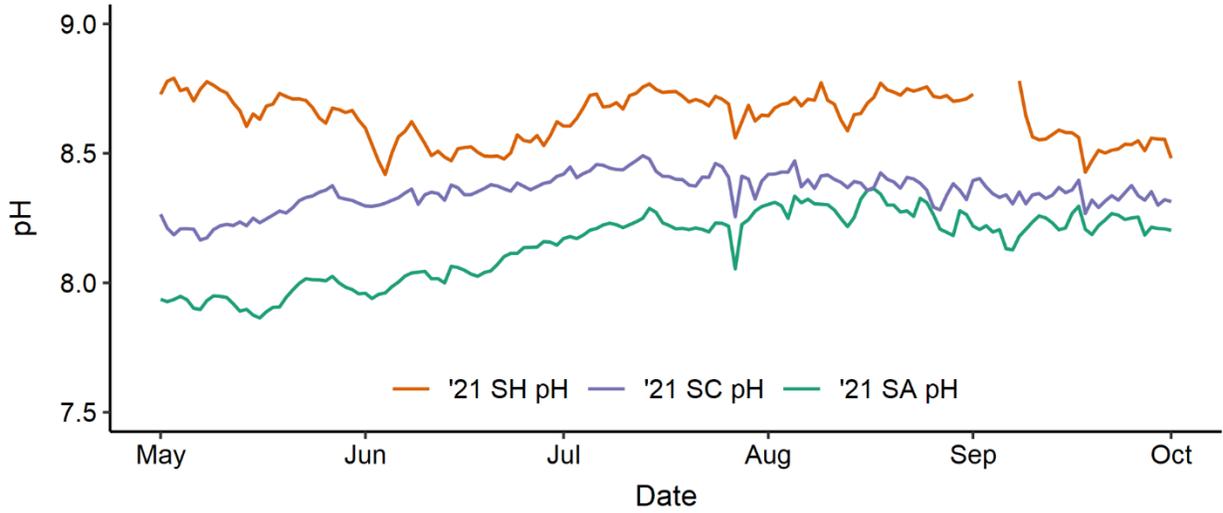


Figure 25 Daily average pH levels in 2021 at Shasta (SH), Scott (SC), and Salmon (SA) Rivers

Shasta River Daily Average pH, 2015-2021

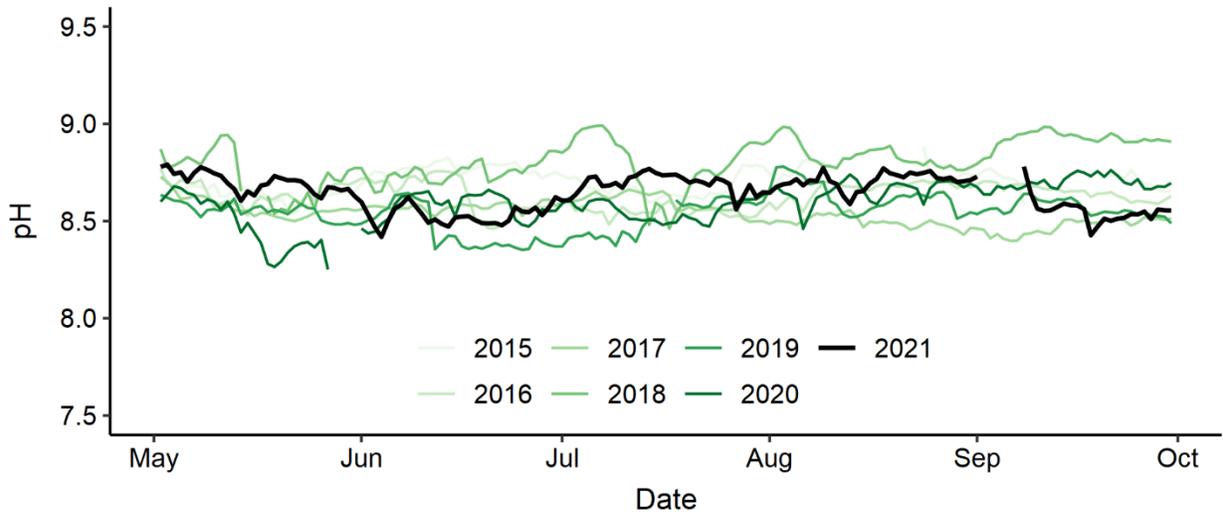


Figure 26 Daily average pH levels from 2015-2021 at the Shasta River

Shasta River pH, 2021

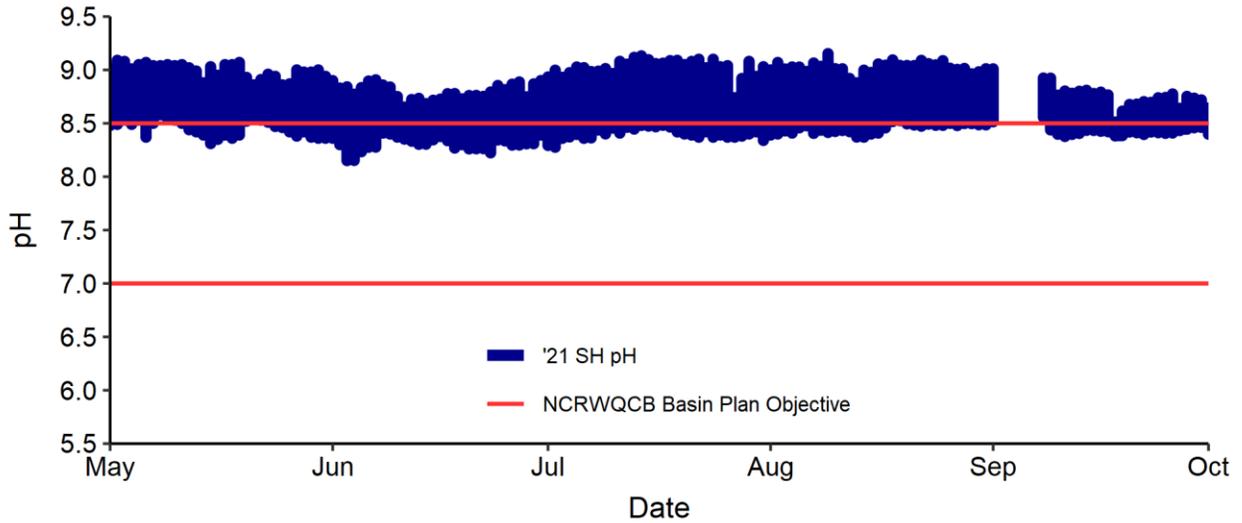


Figure 27 pH readings recorded instantaneously every 15 minutes in 2021 at the Shasta River and the NCRWQCB Basin Plan site-specific water quality objective for the Shasta River, $7 < x < 8.5$

Scott River Daily Average pH, 2015-2021

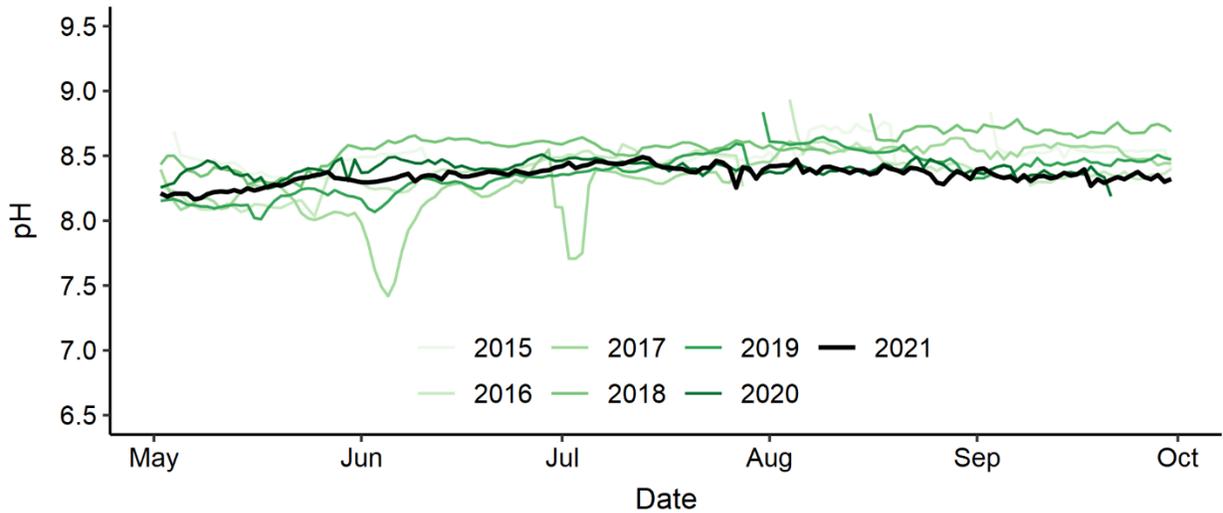


Figure 28 Daily average pH levels from 2015-2021 at the Scott River

Scott River pH, 2021

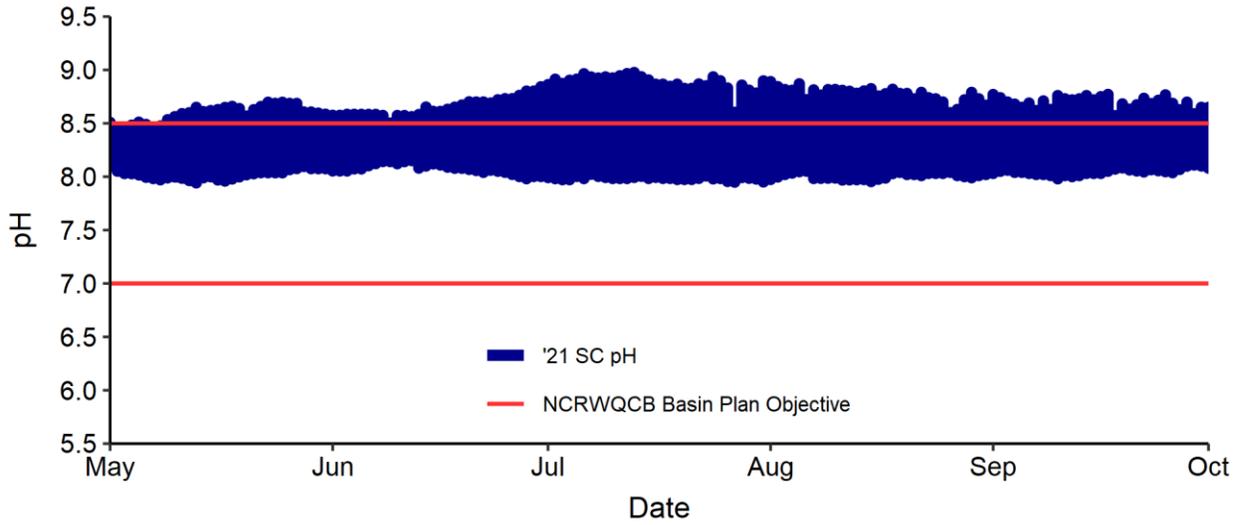


Figure 29 pH readings recorded instantaneously every 15 minutes in 2021 at the Scott River and the NCRWQCB Basin Plan site-specific water quality objective for the Scott River, $7 < x < 8.5$

Salmon River Daily Average pH, 2015-2021

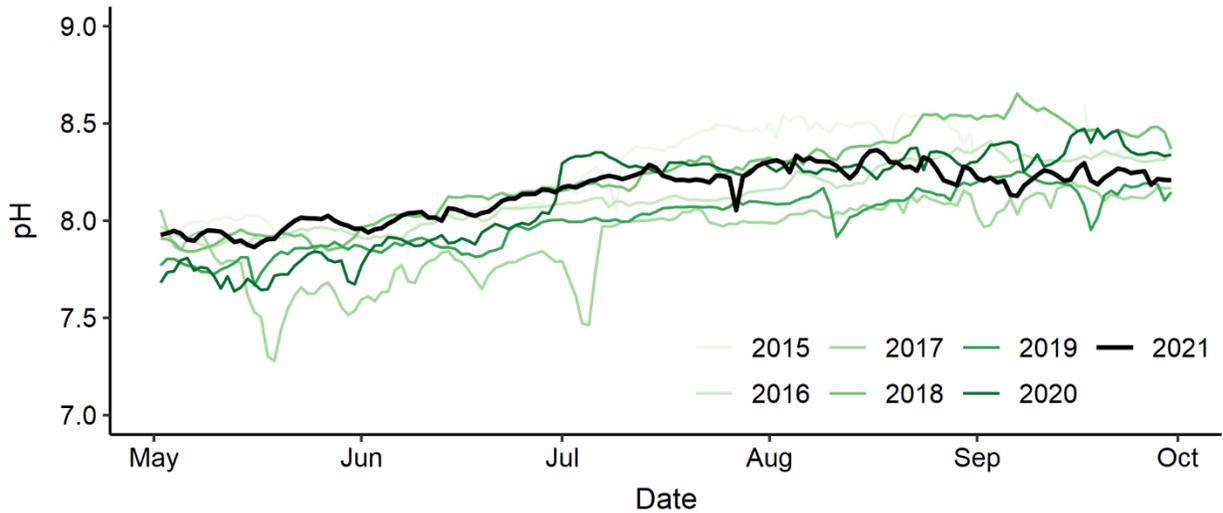


Figure 30 Daily average pH from 2015-2021 at the Salmon River

Salmon River pH, WY 2021

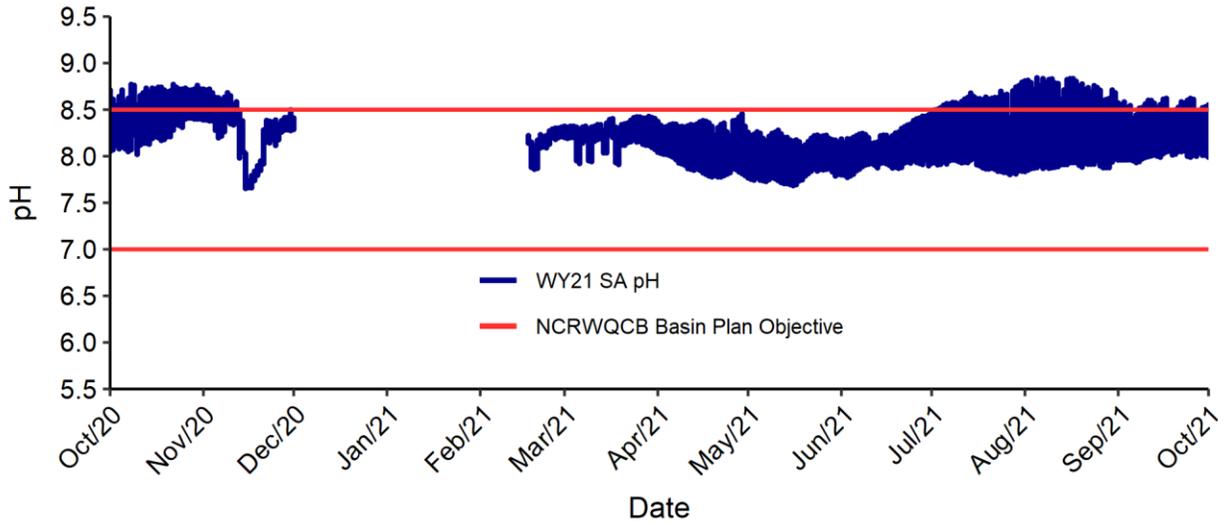


Figure 31 pH readings recorded instantaneously every 15 minutes in water year 2021 at the Salmon River and the NCRWQCB Basin Plan site-specific water quality objective for the Salmon River, $7 < x < 8.5$

6.2.4 Salmon River Turbidity

Turbidity data collected at the Salmon River show fewer spikes than previous years, with one major event in January. This reflects low precipitation in 2021 (Figure 32).

Salmon River Daily Average Turbidity, 2017-2021

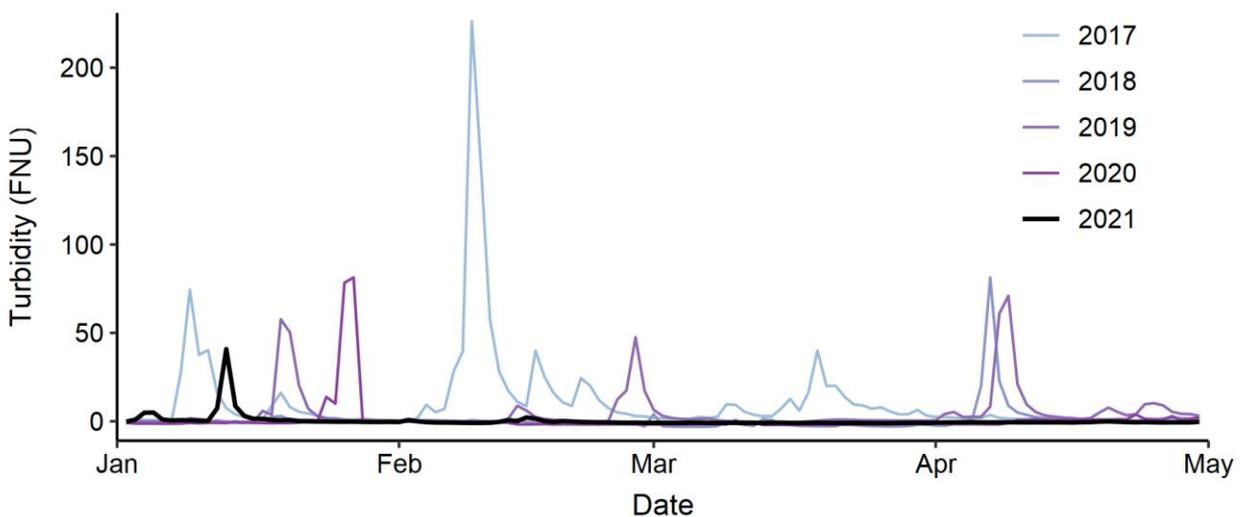


Figure 32 Daily average turbidity from 2017-2021 at the Salmon River

6.3 Nutrients

Nutrient samples were collected by the Karuk Tribe Water Quality Program from both the main stem Klamath and tributaries. Nutrient concentrations are largely driven by discharge and differing land use, with increases in both total phosphorus and, with larger magnitude, total nitrogen during lower-flow summer and fall months (Figures 33 and 36). Historical records show spikes in winter months as increasing precipitation leads to runoff and scour of sediment (Figures 34, 35, 37, and 38). These trends and nutrient concentrations in general are muted in the Scott and Salmon Rivers, and elevated in the Shasta River, with respect to main stem sites (Figures 33 and 36). This reflects a higher degree of nutrient inputs from agriculture in the Shasta River. In mainstem sites, there is a spatial trend of nutrient concentrations decreasing longitudinally in the downriver direction as they are processed metabolically (Figures 35 and 38). Overall, nutrient concentrations are within historic ranges and were lower than spikes of the past five years, with the exception of total phosphorus in the Shasta River, which reached a ten-year high and support its nutrient enrichment TMDL listing (Figures 34, 35, 37, and 38). Elevated nutrients also impact dissolved oxygen and pH by boosting productivity.

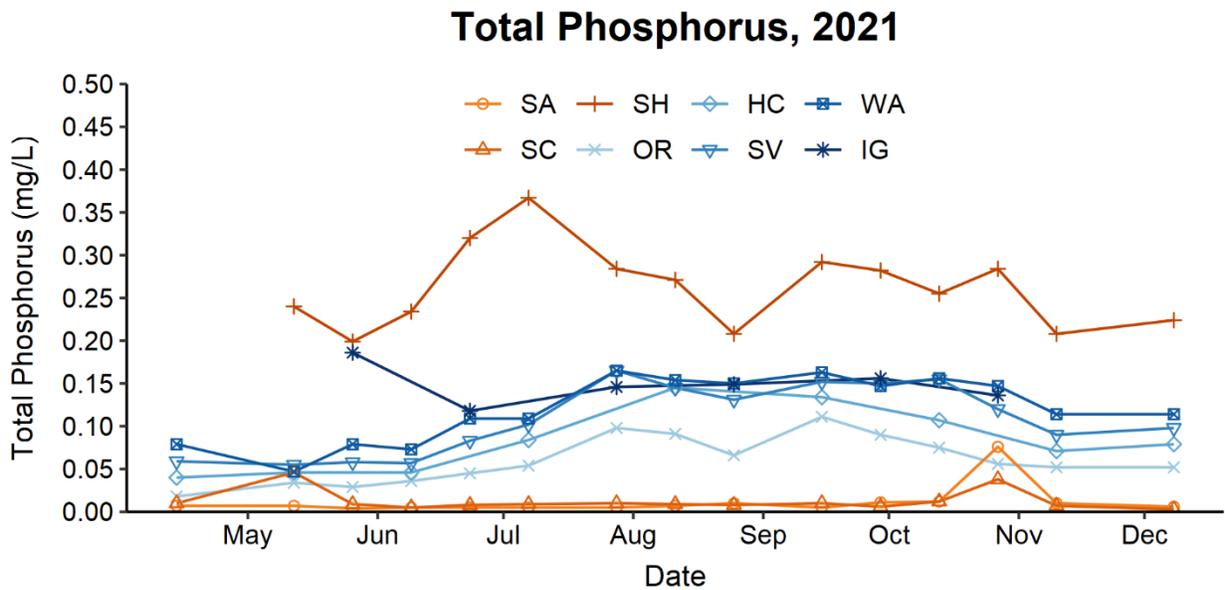


Figure 33 Total phosphorus measurements in 2021 at all monitored sites

Shasta, Scott, and Salmon Rivers Total Phosphorus, 2007-2021

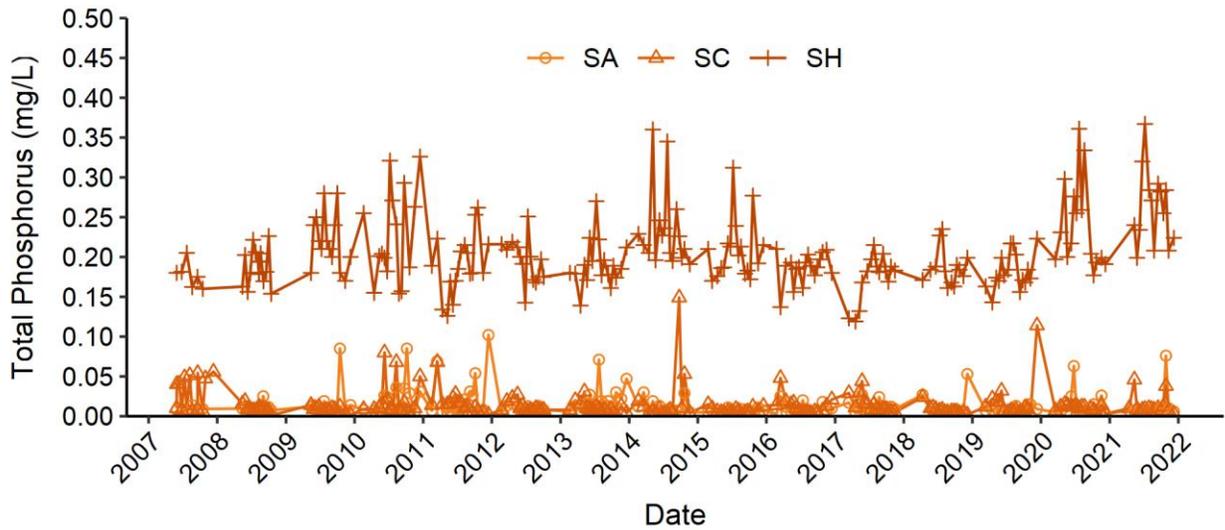


Figure 34 Total phosphorus measurements from 2007-2021 at the Salmon (SA), Scott (SC), and Shasta (SH) Rivers

Klamath River Total Phosphorus, 2007-2021

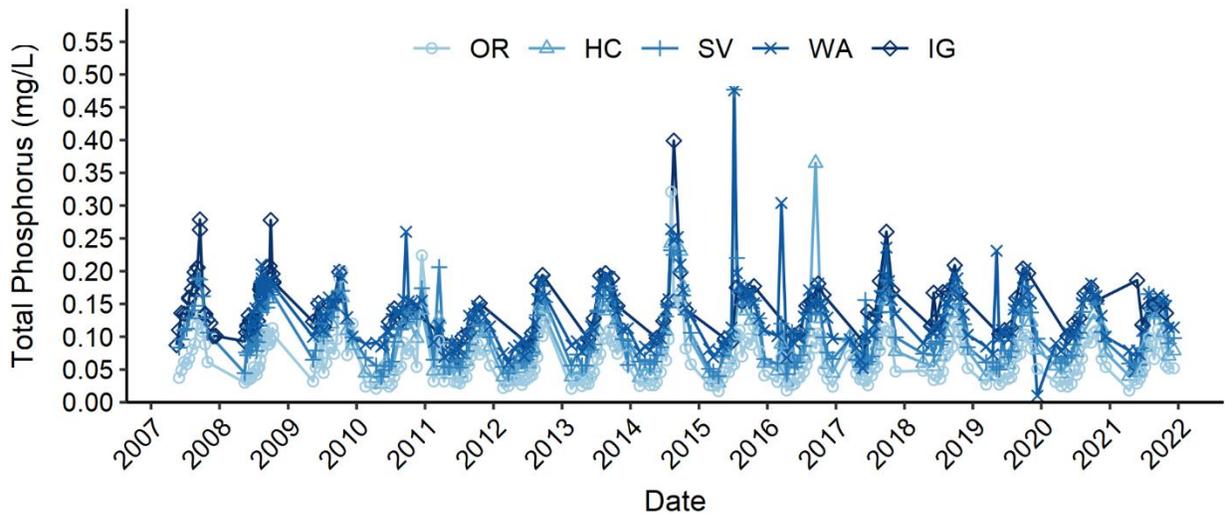


Figure 35 Total phosphorus measurements from 2007-2021 at main stem Klamath River sites: below Iron Gate dam (IG), at Walker Bridge (WA), at Seiad Valley (SV), at Happy Camp (HC), and at Orleans (OR)

Total Nitrogen, 2021

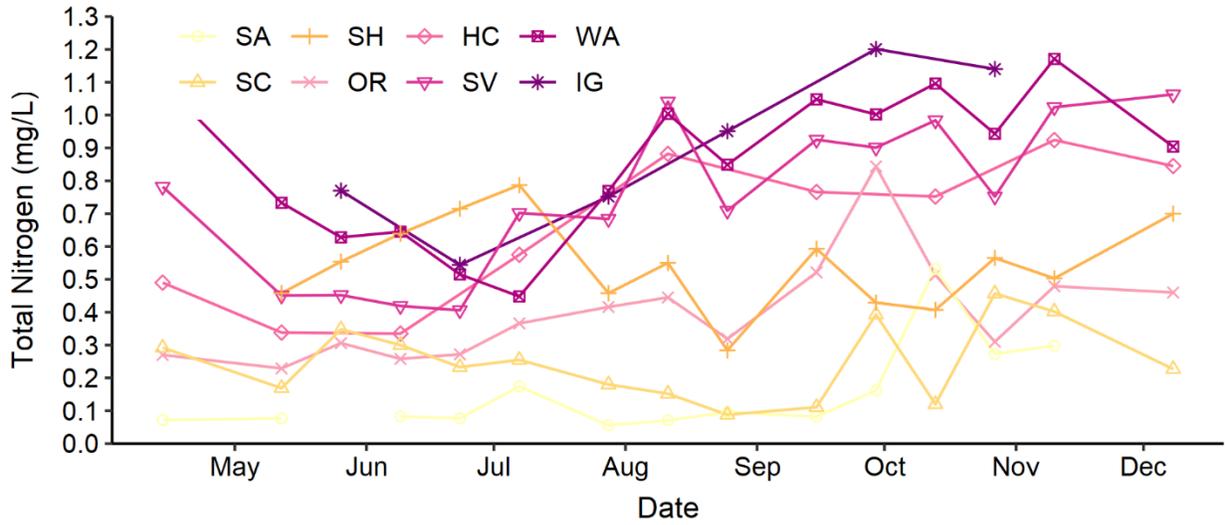


Figure 36 Total nitrogen measurements in 2021 at all monitored sites

Shasta, Scott, and Salmon Rivers Total Nitrogen, 2007-2021

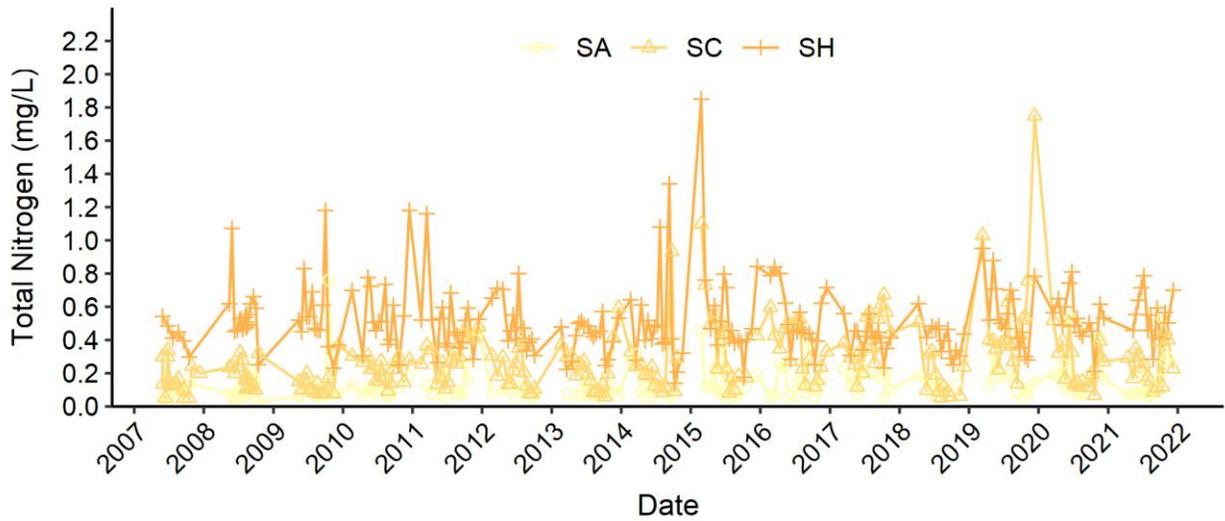


Figure 37 Total nitrogen measurements from 2007-2021 at the Salmon (SA), Scott (SC), and Shasta (SH) Rivers

Klamath River Total Nitrogen, 2007-2021

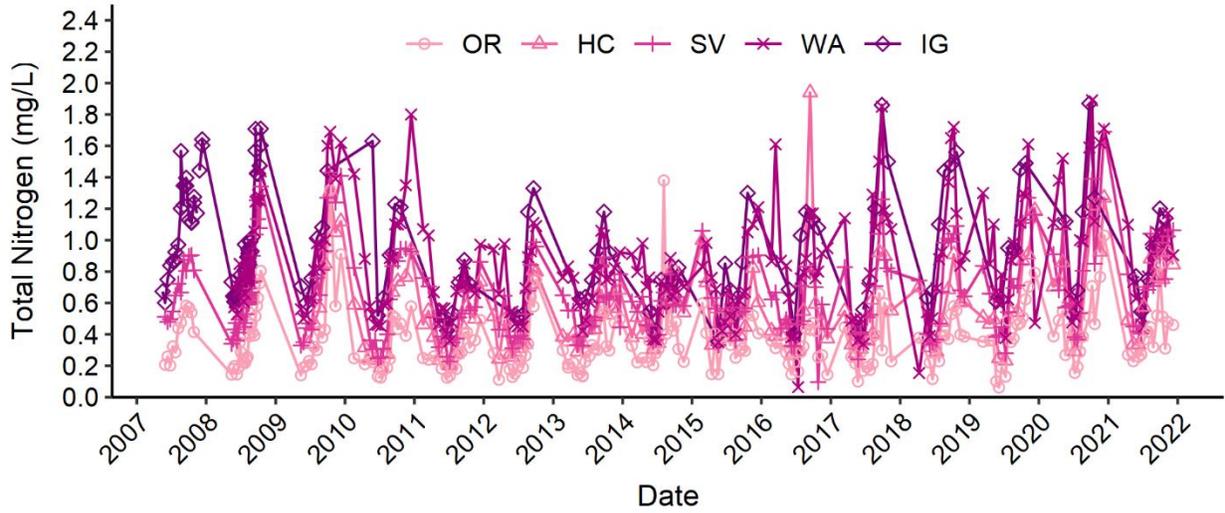


Figure 38 Total nitrogen measurements from 2007-2021 at main stem Klamath River sites: below Iron Gate dam (IG), at Walker Bridge (WA), at Seiad Valley (SV), at Happy Camp (HC), and at Orleans (OR)

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