Water Quality Report for the mid-Klamath, Salmon, Scott, and Shasta Rivers: May-Dec 2009

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1 BACKGROUND

The Karuk Tribe is the second largest Tribe in California, with over 3,500 Tribal members currently enrolled. The Karuk Tribe is located along the middle Klamath River in northern California. Karuk Ancestral Territory covers over 90 miles of the mainstem 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 populations of toxic algae, and pandemic fish diseases, in addition to the extreme limitations and burdens applied 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 Fish and Wildlife Service (USFWS), the United States Geological Survey (USGS), and the Yurok Tribe.

In 2009, the Karuk Tribe's Water Quality Program (KTWQP) added to its baseline water quality by collecting water quality data at locations along the mid-Klamath River and at the mouth of three major tributaries. The work combined several projects and objectives, and they will be presented in this report together. The monitoring was done collaboratively with the Klamath Tribal Water Quality Workgroup (KTWQWG), the Yurok Tribe, and the Klamath Hydroelectric Agreement in Principle (AIP) Water Quality Working Group. Funding was provided by a variety of sources including EPA Region IX 106 Tribal Water Pollution Control, KTWQWG, and through the AIP Measure 15.

2 METHODS

The Karuk Tribe monitored water quality at nine stations between May and December of 2009. The stations are located along the mid-Klamath spanning approximately 150 miles of river (Figure 1). Six of the sites are along the mainstem Klamath. The uppermost site, Iron Gate (IG), is located directly below Iron Gate Reservoir, the most downstream dam on the Klamath Hydroelectric Project (KHP). The flow at IG is regulated by releases from the dam with the only unregulated flow coming from a small tributary, Bogus Creek. As you move downriver, more of the flow at the sites is from tributary inputs. The three tributary sites are located in major tributaries within a mile of the mouth of the tributary.

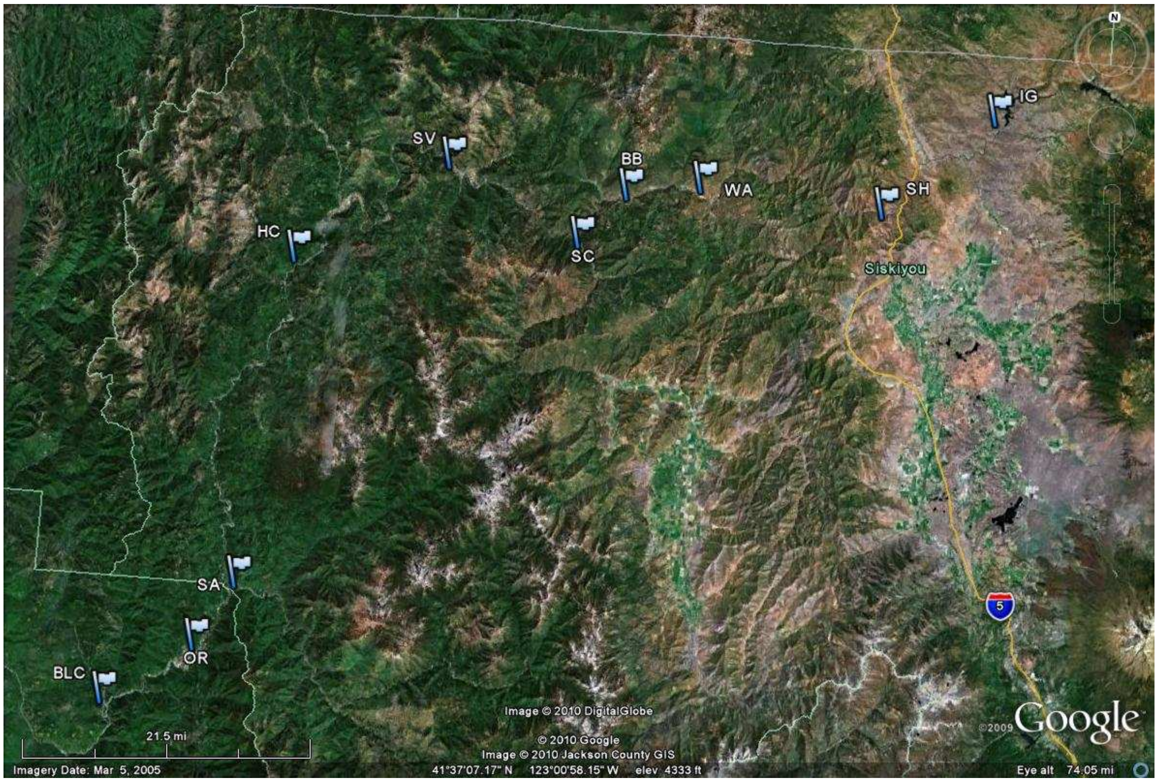

Figure 1. Over view of the Karuk Tribe's water quality monitoring locations along the Klamath River in 2009.

Type of data collected varied by site and is detailed in Table 1. Baseline monitoring data was collected at (from upstream to downstream) Iron Gate (IG), Walker Bridge (WA), Seiad Valley (SV), Happy Camp (HC), and Orleans (OR) in the mainstem Klamath and at Shasta River (SH), Scott River (SC), and Salmon River (SA) for the major tributaries. Baseline monitoring data consisted of continuous and discrete monitoring. For the continuous monitoring, parameters collected included temperature, dissolved oxygen (DO), pH, conductivity, and blue-green algae using a phycocyanin probe. Parameters were collected every half hour using YSI 6600 V2 multiparameter probes. IG, SV, and OR sites were linked to satellites to allow real time monitoring via the internet.

Table 1- 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 monitoring with a multiprobe instrument, and public health designates surface grab sampling for phytoplankton and algal toxins.

2009 Locations and Parameters Monitored						
Site ID	Latitude	Longitude	Nutrient Suite	Sonde	Public Health	Location
OR	N 41 18.336	W 123 31.895	X	X	X	Klamath River at Orleans at USGS Gage
SA	N 41	W 123	X	X		Salmon River at USGS Gage

	22.617	28.633				
HC	N 41 43.780	W 123 25.775	X		X	Klamath River downstream of Happy Camp
SV	N 41 50.561	W 123 13.132	X	X	X	Klamath River downstream of Seiad Valley
SC	N 41 46.100	W 123 01.567	X	X		Scott River at Johnson's Bar
BB	N 41 49.395	W 122 57.718	X		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
IG	N 41 55.865	W 122 26.532	X	X		Klamath River below Iron Gate Hatchery Bridge

The continuous monitoring was conducted from May-October in 2009. Water quality monitoring sites utilizing multiparameter probes were visited at biweekly intervals. At this time audits were performed with a YSI 6820 V2-2 multiparameter sonde. The audits allowed field personnel to compare readings from the two sondes taken before and after calibration. Calibration of the YSIs was performed in the field to minimize the amount of time the instruments were out of the water and thus not collecting data. Water quality probes were calibrated and serviced according to Karuk Quality Assurance/Quality Control protocol adopted from USFWS, USGS, and Yurok Tribe protocols. These calibrations followed the specific manufacturer's instructions as outlined in the section 2.6.1 ***Calibration Procedures***[1] of the YSI manual. During these regular visits, data was downloaded from the probes, bought back to the office, and reviewed.

Discrete grab samples were collected at varying intervals dictated by several different project sampling plans (Table 2). At most sites, grab samples were collected from May-October biweekly and monthly in November and December. At each sampling event, a suite of nutrients was collected which included: total nitrogen (TN), ammonia, nitrate-nitrite, total phosphorous (TP), SRP, TSS, VSS, alkalinity, TOC, DOC. In addition, we collected chlorophyll, phaeophytin, phytoplankton for species identification and enumeration, and the cyanotoxin microcystin. Public health surface grab samples were also collected from May-October. The details of that data collection effort and the results are detailed in a separate report.

[1] YSI Incorporated. "Calibration Procedures. "6-Series Environmental Monitoring Systems Operations Manual.

Table 2-2009 discrete grab sampling events by site and date.

	DATE													
SITE	5/14	5/28	6/11	6/25	7/9	7/23	8/6	8/20	9/3	9/17	10/1	10/15	11/12	12/10
OR	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SA	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HC		X		X		X		X		X		X	X	X
SV	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SC	X	X	X	X	X	X	X	X	X	X	X	X	X	X
WA	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SH	X	X	X	X	X	X	X	X	X	X	X	X	X	X
IG	X		X		X		X		X		X			

QA/QC

The Department of Natural Resources Water Quality Program developed an EPA-approved Quality Assurance Project Plan (QAPP) to ensure that data generated from environmental measurement studies are technically sound and legally defensible. The QAPP summarizes procedures to be followed in administering federally funded programs that involve measurement of environmental parameters. The QAPP applies to special water quality studies involving surface and ground water bodies, as well as to surveillance and compliance monitoring of discharges.

Briefly, the QAPP requires that (a) physical and professional capabilities be adequate to perform the analysis for all parameters in the sampling plan; (b) sample collection, handling, and preservation be conducted according to EPA manuals; (c) time-sensitive samples be transported and analyzed within specific holding times; (d) sample integrity be provided for a legal chain of custody of samples collected for support of enforcement actions; (e) analytical methods be in accordance with standardized methods; and (f) analytical quality control procedures be established for intra-laboratory checking of reference samples. Laboratory records including reference sample results are to be available for EPA.

A detailed description of our QA/QC is available in our QAPP; however a brief summary for our YSI monitoring data follows. For monitoring with YSIs, QA/QC was performed in both the field and the office. Every two weeks in the field, probes were examined, cleaned, and calibrated. In the office, data was reviewed to help locate failed probes or other malfunctions in a timely manner. Daily values (based on at least 46 of 48 measurements since data was collected in ½ hour intervals) were obtained utilizing an Excel spreadsheet. If there were less than 46 measurements for a 24-hour period that day’s data was not used in the daily maximum, mean, and minimum calculations. All data collected has gone through QA/QC, outliers and instances of improper calibration were removed from further analysis.

3 WATER QUALITY PARAMETERS

Water quality data collected included water temperature, dissolved oxygen, pH, specific conductivity, BGA, total nitrogen, total phosphorus and turbidity. These parameters are outlined and described below. Karuk tribal water quality standards are included where applicable.

3.1 Water Temperature

Water temperature varies both seasonally and diurnally (within a twenty-four hour period). Elevated temperatures may lead to increased metabolic rates in organisms, algal growth, and increased fish susceptibility to disease. Many factors can affect stream temperature, including discharge, air temperature, the amount of shaded cover (which significantly influences smaller streams), contribution of snow melt and springs (or cold water tributaries), aspect, amount of runoff from human influenced areas, smoke cover from summer wildfires, and the length the stream must travel.

Temperature has an impact on many beneficial uses in the Klamath River, including cold-water fish, subsistence fishing, cultural use, and recreational use. A common method to assess water temperature for streams that support salmonid populations is to compare sustained water temperatures to an acute and chronic temperature standard. The acute standard represents the lethal temperature for salmonids. The chronic temperature designation represents the maximum weekly average temperature (MWAT), which is the upper limit for optimum growth for salmonids. The Karuk Tribe's water quality objectives have set the maximum temperature threshold at 21°C and MWAT of 15.5°C[2].

3.2 Dissolved Oxygen

Dissolved oxygen (DO) varies both seasonally and diurnally, particularly in the summer when photosynthesis adds oxygen to the system during the day and respiration consumes it at night. In cold water, oxygen is more soluble; therefore the amount of available oxygen for salmonids is greater. Oxygen levels lower when water temperatures are elevated and more photosynthesis is occurring. A supersaturated (very high DO) environment may exist during daytime hours, but at night DO levels may drop to lethal levels due to microbial respiration and lack of photosynthesis.

The Karuk Tribe's water quality objectives have established minimum DO levels for waters designated as Cold Freshwater Habitat (COLD) in the Karuk Tribe Water Quality Control plan, to be 6.0 mg/l. Areas providing Spawning, Reproduction, and/or Early Development habitat (SPWN) need to maintain a minimum DO of 9.0 mg/l for tribal trust

[2] Tripp, Sandi, and Susan Corum. Karuk Tribe of California. Department of Natural Resources. Water Quality Control Plan. Orleans, CA: 2002.

fish species. The Basin plans specific water quality objectives state that the Klamath River below Iron Gate shall maintain a minimum DO of 8.0 mg/l, the Shasta and Scott River shall maintain a minimum DO of 7.0 mg/l and the Salmon River 9.0 mg/l[3]. These DO objectives are currently in a review processes under the California Environmental Quality Act (CEQA).

3.3 pH/Alkalinity

The pH level or alkalinity of water refers to the concentration of hydrogen and hydroxide ions in the water. Water becomes more acidic with higher concentrations of hydrogen ions and lower concentrations of hydroxide ions, likewise water will be more basic if there are more hydroxide ions present than hydrogen ions. Water temperature has a significant impact on the concentrations of these ions in water. As water temperatures rise, algae and plant photosynthesis increases, leading to a daily fluctuation of pH. Photosynthesis extracts dissolved CO_2 from the water column, which was previously in the form of carbonic acid, H_2CO_3. High levels of photosynthesis cause the pH to rise during the day and lower at night when respiration is occurring. High pH levels cause ammonium ions to go from an ionized state to a de-ionized form that is vastly more toxic to fish. The Klamath River has abundant ammonium ions due, in a large part, to agricultural runoff and nitrogen fixation by algae within the reservoirs. The pH or alkalinity also determines the solubility and biological availability of nutrients and other chemicals in water. Changes in pH can greatly influence how much of a nutrient or chemical is available for use by aquatic organisms. The Karuk Tribe has established a minimum pH objective of 6.5 and a maximum of 8.5. Changes in normal ambient pH levels shall not exceed 0.5 units within the range specified above in fresh waters with designated COLD or WARM beneficial uses[4].

3.4 Nutrients

The Klamath River is 303(d) listed for nutrient impairment. The Klamath River has elevated levels of both nitrogen and phosphorous. It is important to assess levels of nutrients in the basin, including organic and inorganic forms. Ideally, samples are taken at multiple time points throughout the year and at strategic locations along the river to allow for analysis of spatial and temporal variability. For a discussion of nutrient parameters selected for the 2009 sampling season, see the 2009 AIP Monitoring Plan[5].

3.5 Blue-Green Algae (BGA)

[3] State of California. North Coast Regional Water Quality Control Board. Water Quality Control Plan For The North Coast Region January 2007. Santa Rosa, California: GPO, 2007.

[4] Tripp, Sandi, and Susan Corum. Karuk Tribe of California. Department of Natural Resources. Water Quality Control Plan. Orleans, CA: 2002.

[5] Full Document available at http://www.swrcb.ca.gov/northcoast/water_issues/programs/tmdls/klamath_river/klamath_river_khsa_monitoring/

Blue-Green Algae data was collected at the three mainstem sites. YSI Phycocyanin probes were used to determine a cell per milliliter estimate. The use of these probes coupled with real time results available on the internet allows timely assessment of public health threats from toxigenic algal species.

In grab samples, phytoplankton samples were collected to enumerate potentially toxigenic species of cyanobacteria. Samples of the cyanotoxin microcystin were also collected and analyzed by ELISA. California has guidance for harmful algal blooms with action to avoid contact at levels over 40,000 cells/ml of *Microcystin aeruginosa* (MSAE), 100,000 cells/ml of cyanobacteris, and/or 8 µg/L microcystin. Due to the public health nature of this issue, the results of the sampling for MSAE and microcystin are detailed in another report.

4 RESULTS AND DISCUSSION

4.1 Temperature

The sonde data presented in Figures 2-8 shows seasonal trends at mainstem Klamath River monitoring sites. In 2009, Seiad Valley (SV) and Orleans (OR) monitoring locations had similar thermographs when looking at daily averages. The Iron Gate (IG) site had less variability in average temperature fluctuations than SV or OR, and average temperatures were generally lower from July-September (Figure 2). The IG site is just below Iron Gate dam, and the dam release seems to have a moderating effect on water temperature. The Tribally adopted temperature standard has 21C as the acute standard over which temperatures may be lethal for salmonids and 15.5C for a maximum weekly average temperature (MWAT) above which chronic temperature issues are a concern (Karuk, 2002)[6]. All sites exceed the maximum 21C and the 15.5C for chronic MWAT and are impaired for water temperature.

[6] Tripp, Sandi, and Susan Corum. Karuk Tribe of California. Department of Natural Resources. Water Quality Control Plan. Orleans, CA: 2002.

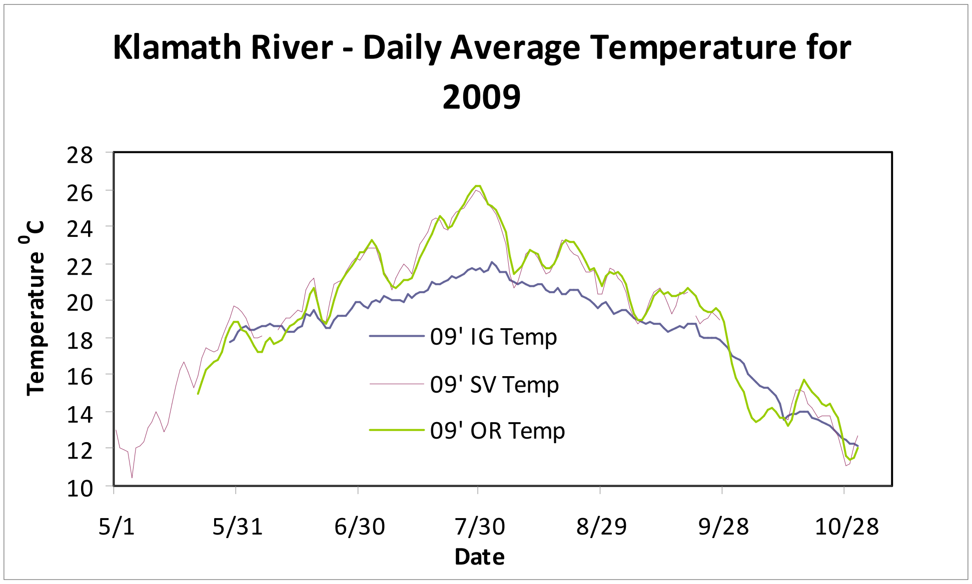

Figure 2. Daily average temperatures for 3 mainstem Klamath River sites in 2009: below Iron Gate dam (IG), Seiad Valley (SV), and Orleans (OR).

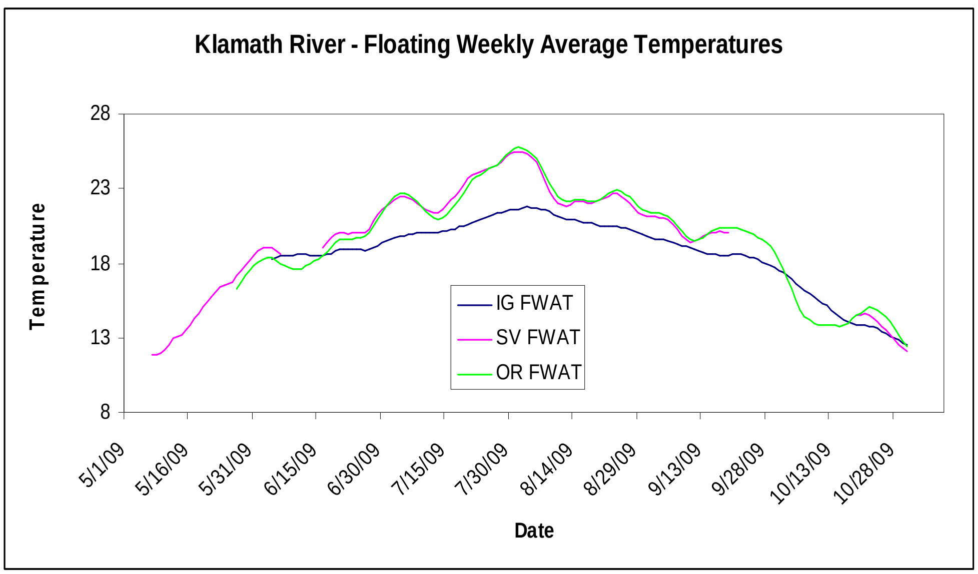

Figure 3. Floating weekly average temperatures for 3 mainstem Klamath River sites in 2009: below Iron Gate dam (IG), Seiad Valley (SV), and Orleans (OR). Karuk Water Quality Standard for temperature is a maximum weekly average temperature (MWAT) of 15.5.

In 2009, the KTWQP monitored three major Klamath tributaries with datasondes: the Shasta, Scott, and Salmon Rivers. Each of the tributaries has some similar seasonal trends in regards to water quality parameters. In 2009, all monitored tributaries had highest daily average temperatures in late July and early August, followed by a drop in temperature around the first week of August (Figures 4-5). These water temperatures correlate with high air temperatures in July, followed by isolated summer thunderstorms in early August. At all sites in 2009, water temperatures started to decline steadily in early October. All sites exceeded the acute and chronic temperature threshold of 21C and 15.5C, respectively, in the Karuk Tribe's adopted water quality standards (Karuk Tribe, 2002). Differing among sites was the water temperature towards the beginning of summer. For the first week of July, temperatures were above 20C at Shasta, around 20C at Scott, and less than 20C at Salmon.

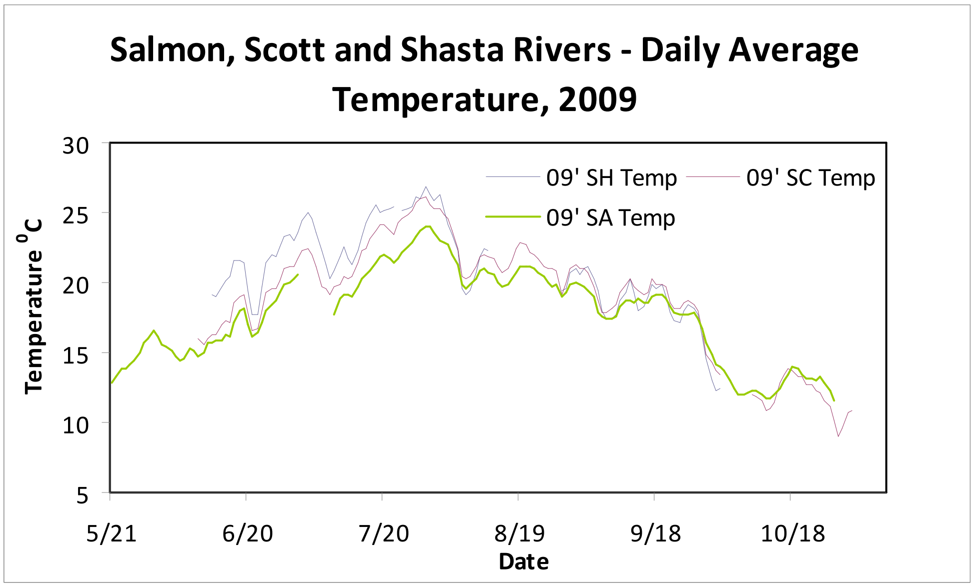

Figure 4. Daily average temperatures for 3 Klamath River tributary sites in 2009: Shasta River (SH), Scott River (SC), and Salmon River (SA).

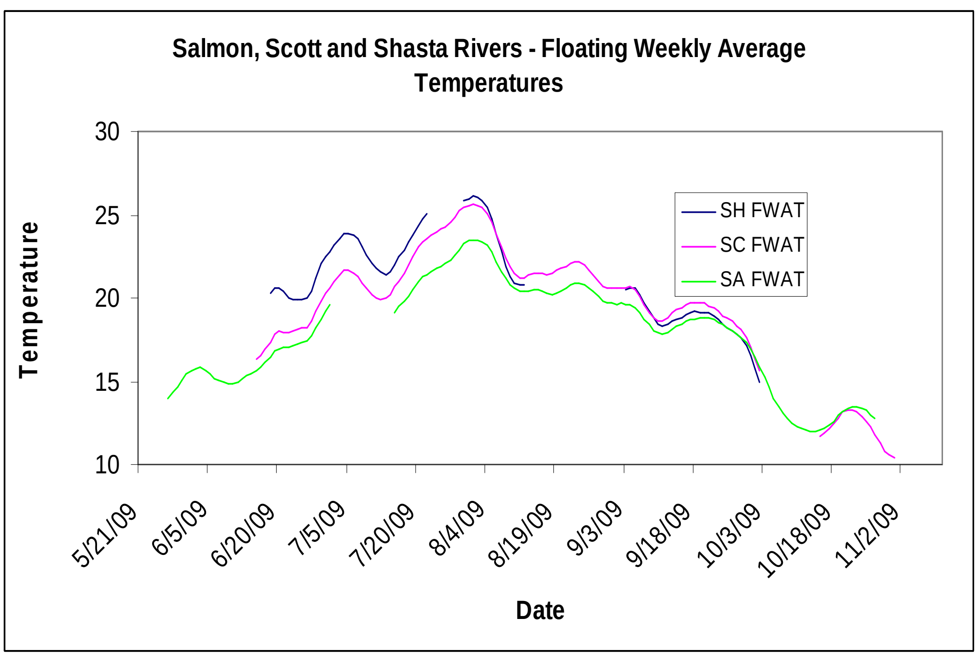

Figure 5. Floating weekly average temperatures for 3 Klamath River tributary sites in 2009: Shasta River (SH), Scott River (SC), and Salmon River (SA). Karuk Water Quality Standard for temperature is a maximum weekly average temperature (MWAT) of 15.5.

4.2 Dissolved Oxygen

Average daily dissolved oxygen (DO) levels are generally higher at OR and decrease at upstream sites in 2009 (Figure 6). Among the sites, the seasonal DO differences are less extreme in the middle of the summer when water temperatures are the hottest (Figure 6). Releases from IG appear to have a negative impact on DO levels in late September and October. At this time, DO levels are dropping, whereas at other locations along the Klamath River, the DO levels are increasing (Figure 6). This is of concern since this timing overlaps with fall-run salmonid migration and spawning.

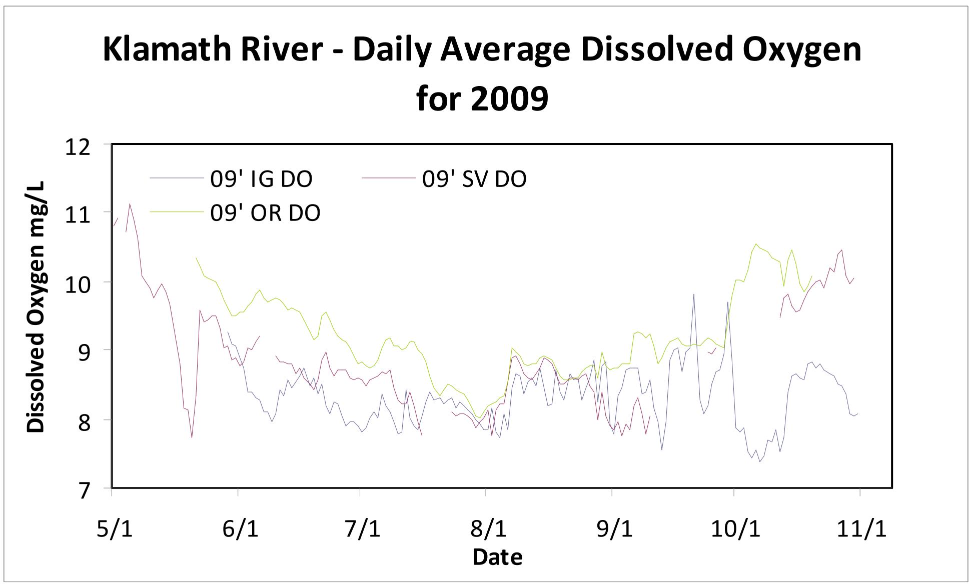

Figure 6. Daily average dissolved oxygen concentrations for 3 mainstem Klamath River sites in 2009: below Iron Gate dam (IG), Seiad Valley (SV), and Orleans (OR.

All tributary monitoring sites dropped below the Tribal standard of 8.0 mg/l in 2009 in late July and/or early August (Figure 7). Keep in mind that these figures are daily averages of DO, and a figure with daily minimums would show even greater exceedances. In 2009, the DO sag in later July and early August follows the high temperatures discussed above. Following the trend in the mainstem, DO levels in the tributaries visibly increased in late September/early October.

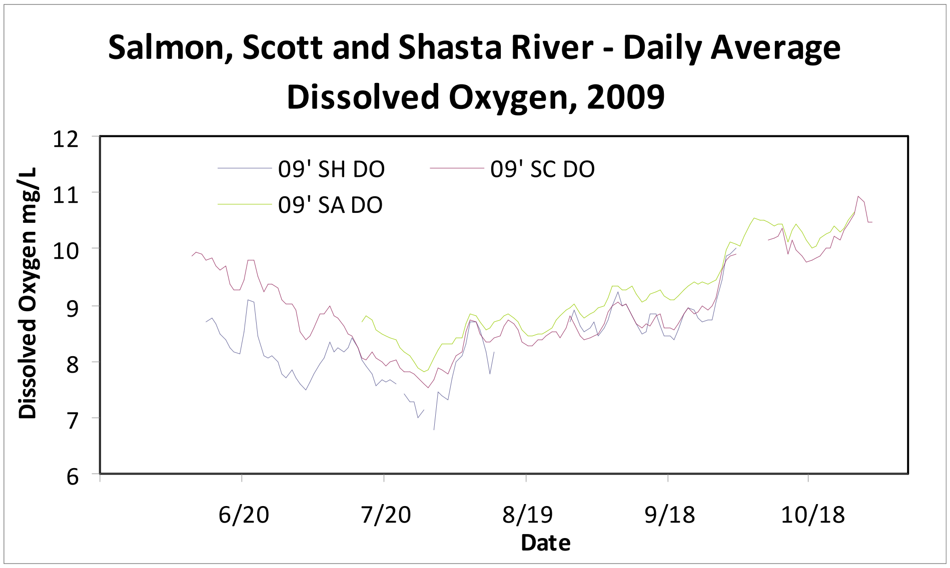

Figure 7. Daily average dissolved oxygen concentrations for 3 Klamath River tributary sites in 2009: Shasta River (SH), Scott River (SC), and Salmon River (SA).

4.3 pH

Average daily pH trends vary between mainstem sites (Figure 8). Orleans has the least seasonal variability, with daily average pH staying below 8.5. The Karuk Tribe has an adopted standard of 6.5<pH<8.5 (Karuk Tribe, 2002). In 2009, SV has an incomplete data set due to probe malfunction and improper calibration. The pH generally peaks in late July and August at SV, with exceedances above 8.5. Of all the mainstem sites, IG has the most extreme exceedances for the Tribal pH standard, with spikes in pH during the summer which can add stress to salmonids.

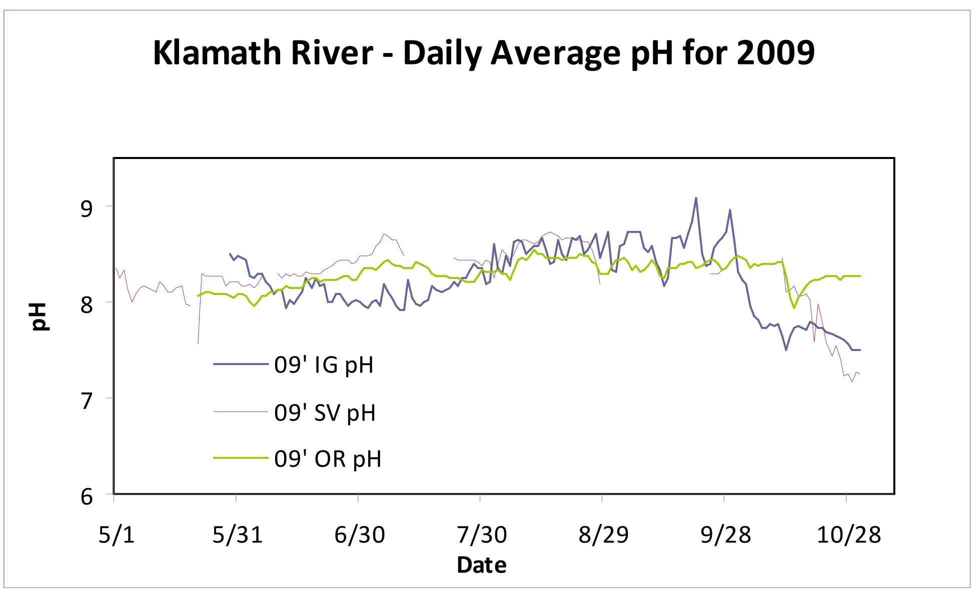

Figure 8. Daily average pH levels for 3 mainstem Klamath River sites in 2009: below Iron Gate dam (IG), Seiad Valley (SV), and Orleans (OR).

Average daily pH varies between tributary sites (Figure 9). The Salmon River site had a pH of around 8 for most of the season. For the Scott River site, pH increased above the Karuk standard around the beginning of August and stayed elevated through September. The Shasta River had the highest average pH of all three tributaries with levels above 8.5 from July-September.

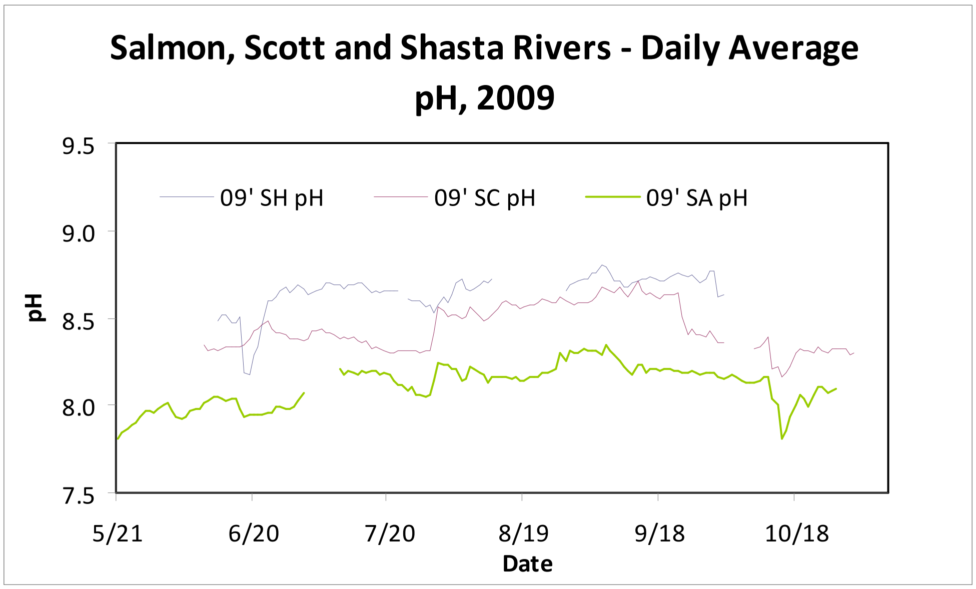

Figure 9. Daily average pH levels for 3 Klamath River tributary sites in 2009: Shasta River (SH), Scott River (SC), and Salmon River (SA).

4.4 <u>Nutrients</u>

Nutrient samples were collected by the KTWQP in 2009 from the mainstem Klamath and major tributaries. For total nitrogen (TN), mainstem concentrations were highest at the most upriver sites (IG and WA) (Figure 10). TN concentrations increased throughout the season, at least doubling between May and October. For TN, SH had higher levels than the other tributaries, with a decline in October. Overall, ammonia levels were highest and most variable at IG (Figure 11). All mainstem sites showed an increase in ammonia levels in the fall. For the tributaries, SH and SA levels stayed low and virtually the same all season, whereas SC exhibited some variability in August and September. For nitrate-nitrite, again SH and SA levels were generally nondetect for most of the year with little variability (Figure 12). The Scott River had low levels in May –June and then dropped for most of the year. However, in December all sites were at their highest level except for the Salmon River. The mainstem trend generally had IG with the highest levels and OR with the lowest levels.

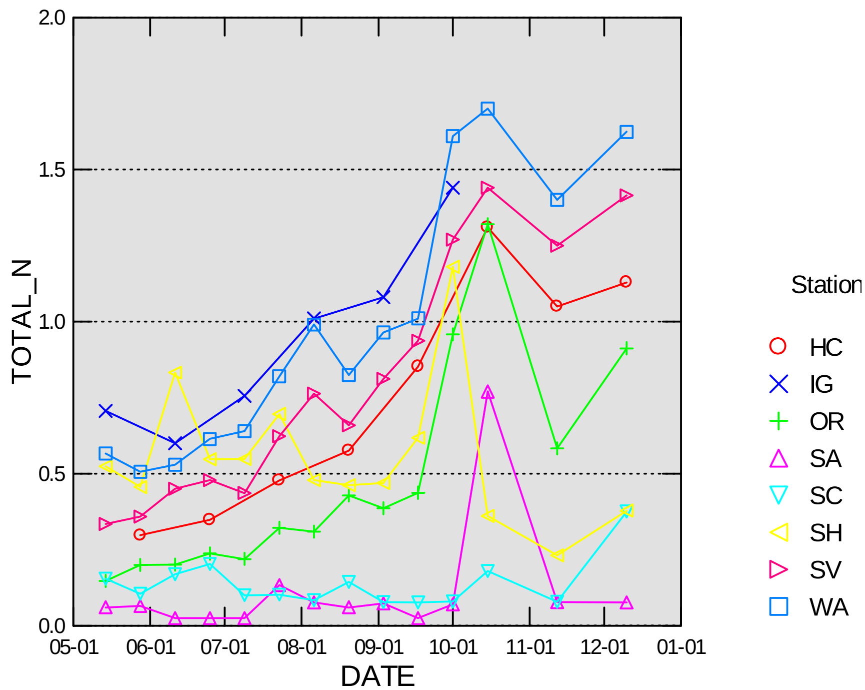

Figure 10. Total Nitrogen measured in mg/l for all monitored sites during 2009. Mainstem sites: Iron Gate (IG), Walker Bridge (WA), Seiad Valley (SV), Happy Camp (HC), Orleans (OR). Tributary sites: Shasta River (SH), Scott River (SC), Salmon River (SA).

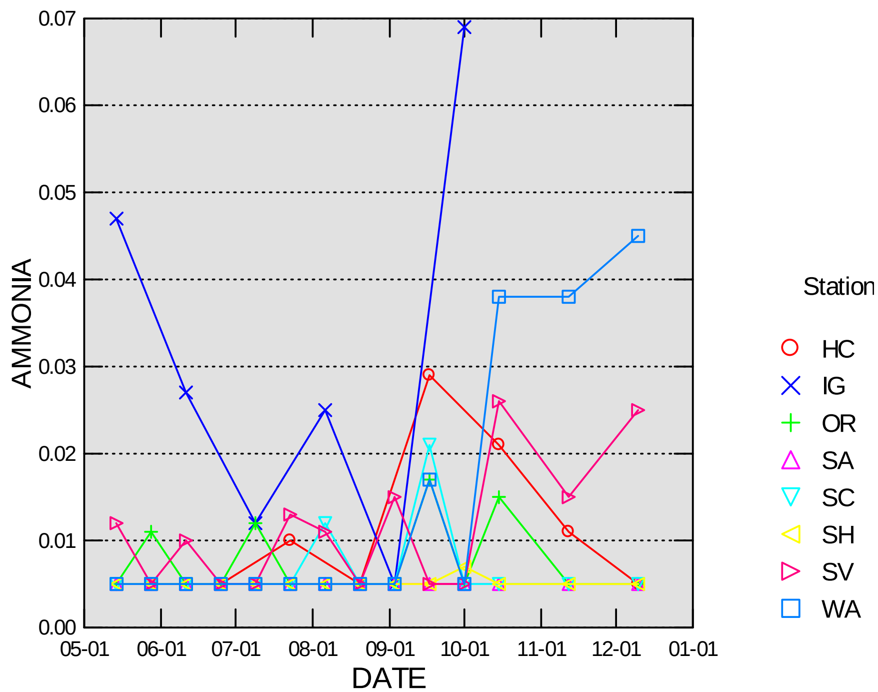

Figure 11. Ammonia measured in mg/l for all monitored sites during 2009.

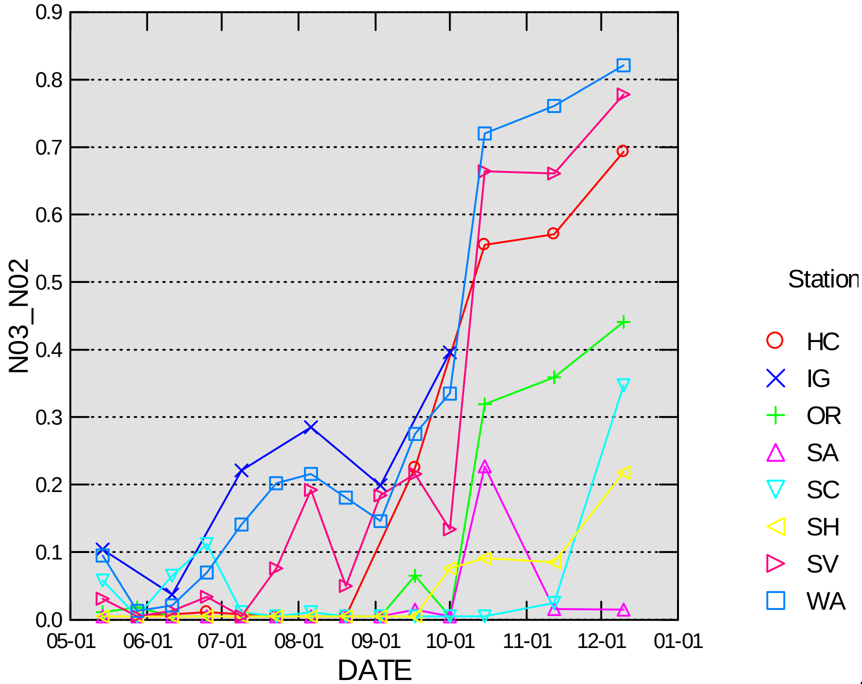

Figure 12. Nitrate-Nitrite measured in mg/l for all monitored sites during 2009.

Total phosphorus (TP) results for 2009 from the mainstem show the Iron Gate and Walker Bridge sites have the highest overall levels (Figure 13). TP levels decrease as one travels down river to SV, HC and OR sites. However, there was a shift in October where OR TP levels slightly exceed the upriver sites. Most sites peaked for TP in mid-October. The Shasta River had the highest levels of TP of all the sites, including mainstem sites, whereas the Scott and Salmon had the lowest levels of all the sites. Soluble reactive phosphorous (SRP) exhibited a similar trend both seasonally and longitudinally as TP (Figure 14).

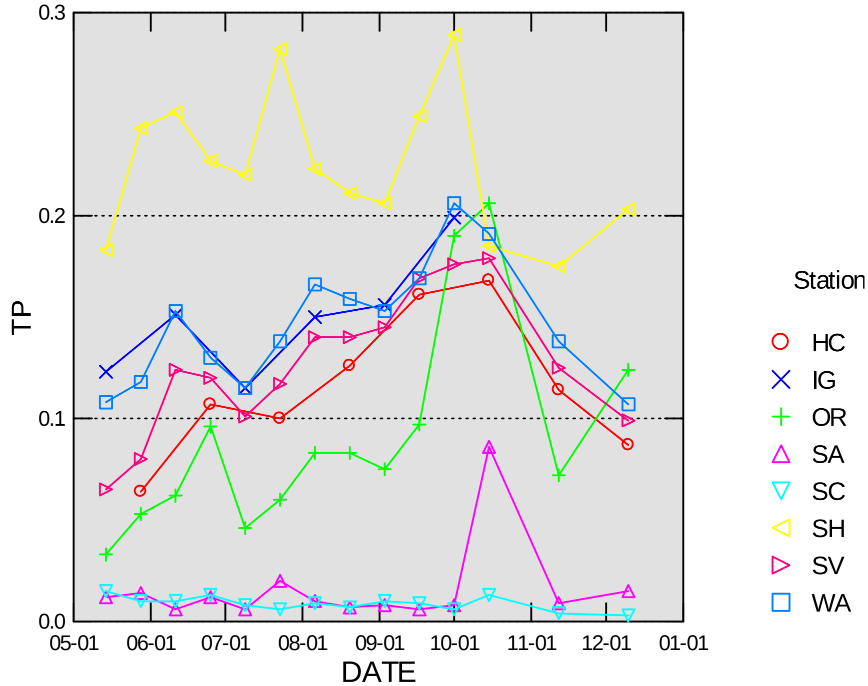

Figure 13. Total Phosphorus measured in mg/l for all monitored sites during 2009.

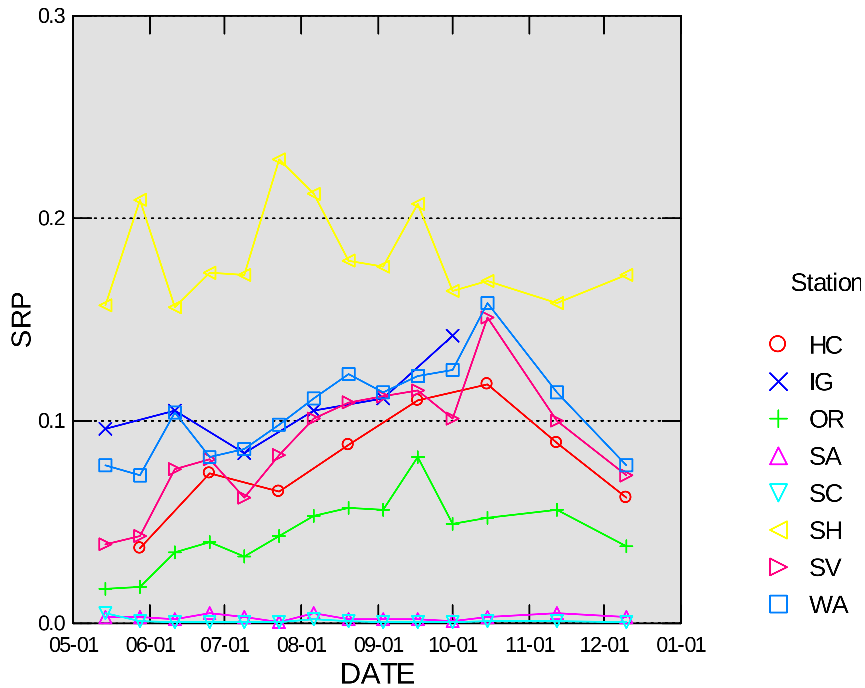

Figure 14. SRP measured in mg/l for all monitored sites during 2009.

Alkalinity levels in the mainstem Klamath River in 2009 did not very much between sites (Figure 15). Also, over the course of the monitoring season, the levels stayed constant. The variation in alkalinity levels was greatest when comparing tributaries. The Salmon had the lowest level. The Scott River had about twice the level of alkalinity of the

Salmon, and the Shasta had approximately 3 times the level of the Scott. The Shasta also displayed the most prominent seasonal decrease.

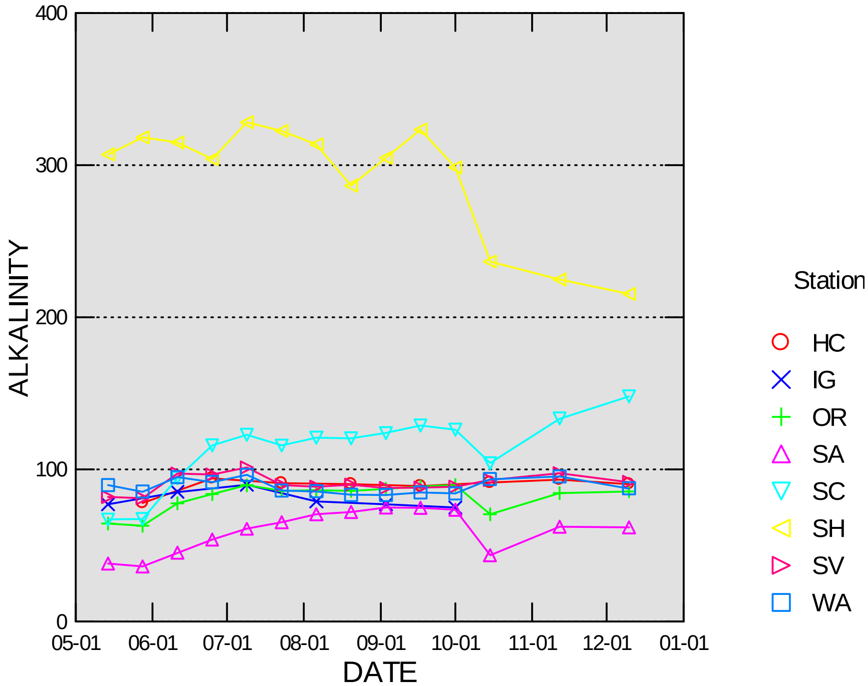

Figure 15. Alkalinity measured in mgCaCO3/L for all monitored sites during 2009.

In 2009 we measured both total organic carbon (TOC) and dissolved organic carbon (DOC) at all sites (Figures 16 and 17). The trend for both TOC and DOC was generally with the Shasta River having the highest levels. The most upstream mainstem sites (IG and WA) had the next highest levels and then the levels decreased as you move downstream. The Scott and Salmon had the lowest levels of all the sites and unlike the other sites except Walker, had peaks in October.

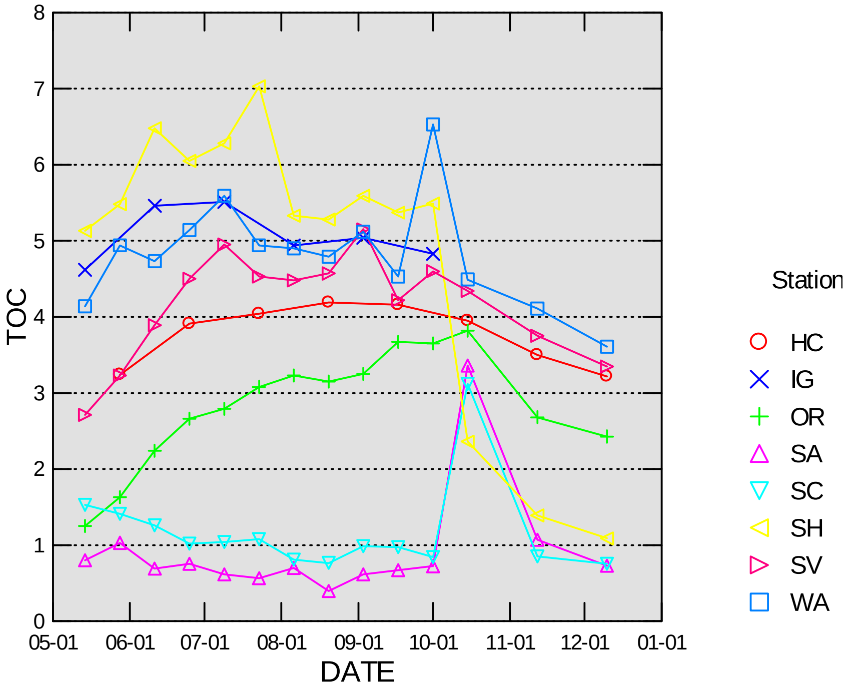

Figure 16. Total organic carbon (TOC) measured in mg/l for all monitored sites during 2009.

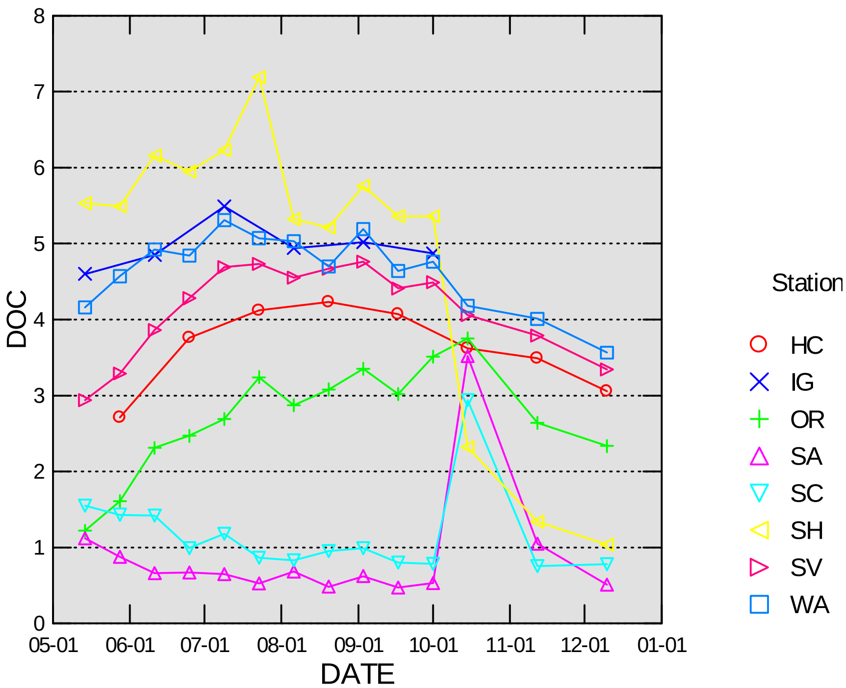

Figure 17. Dissolved organic carbon (DOC) in mg/l for all monitored sites during 2009.

Total suspended solids (TSS) levels were generally less than or near 10 mg/l for most of the monitoring season (Figure 18). The exception in late spring was in the Shasta where levels were >20 mg/l. In October, the Shasta and Orleans sites peaked above 50 mg/l, and the Salmon increased to over 30 mg/l. For volatile suspended solids (VSS), the levels at most sites were less than 4 mg/l (Figure 19). Again, the Shasta River was the exception earlier in the season with levels near 7 mg/l in June. The Shasta and Orleans had levels above 12 mg/l and the Salmon above 8 mg/l in October. Several other sites also increased above 4 but were less than 8 mg/l in October.

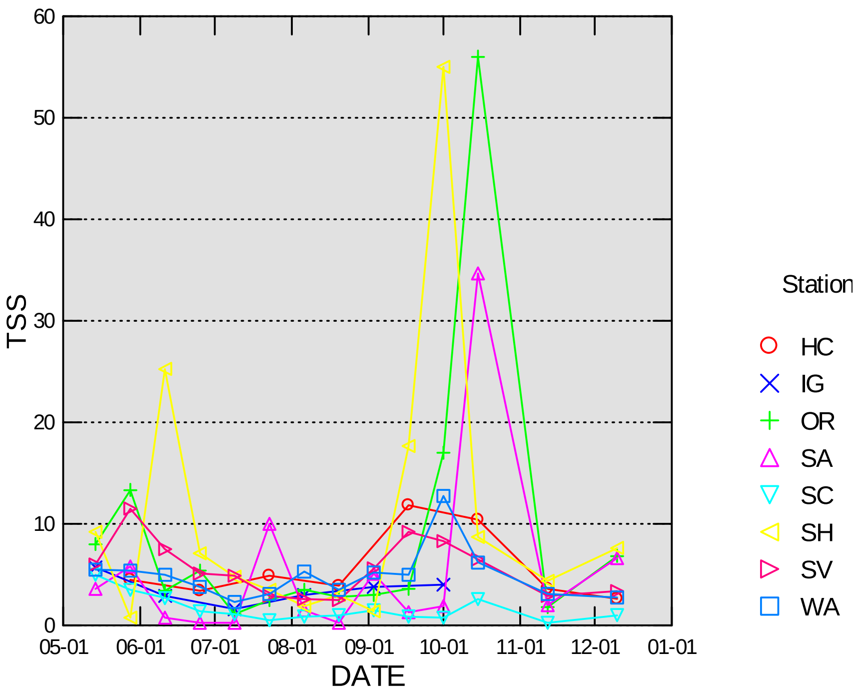

Figure 18. Total suspended solids (TSS) in mg/l for all monitored sites during 2009.

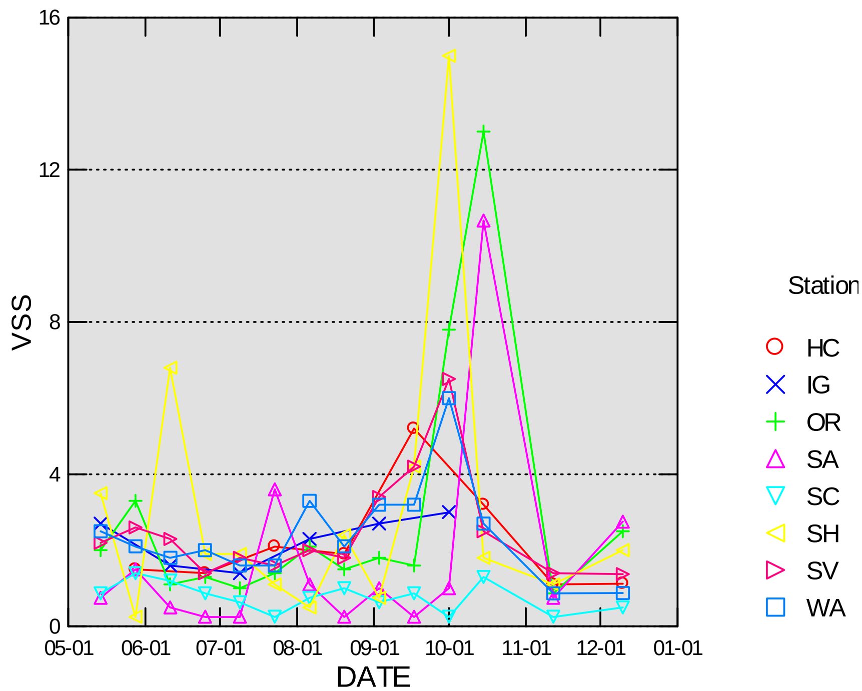

Figure 19. Volatile suspended solids (VSS) measured in mg/l for all monitored sites during 2009.

Like all the other samples collected in the nutrient suite, chlorophyll- *a* and pheophytin were collected below the surface of the water at approximately ½ m depth. Therefore, water sampled is representative of the mixed, flowing water column and not still, surface water. Surface grab samples were part of public health monitoring and discussed in that report. Through May and early July, most sites had chlorophyll-*a* levels less than 10 µg/l (Figure 20). In mid-July, levels start to rise in the mainstem most notably at IG where levels near 20 µg/l. In October, Orleans spiked and had the highest concentration overall at around 30 µg/l. For the tributaries, the Scott had low levels throughout the season, whereas the Shasta and Salmon had small spikes in the fall. All sites except for Orleans dropped below 10 µg/l in November with Orleans increasing in December. Phaeophytin levels remained less than 10 µg/l at all sites until mid-September when HC hit approximately 12 µg/l (Figure 21). In October, both SH and OR peaked to over 20 µg/l. Then all sites dropped below 10 µg/l for November and December.

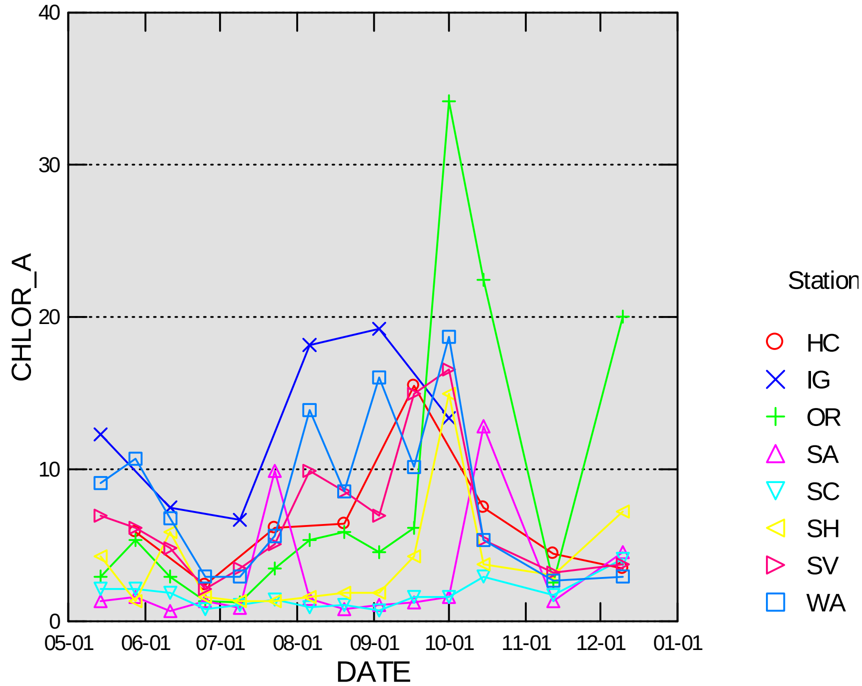

Figure 20. Chlorophyll- *a* measured in µg/l for all monitored sites during 2009.

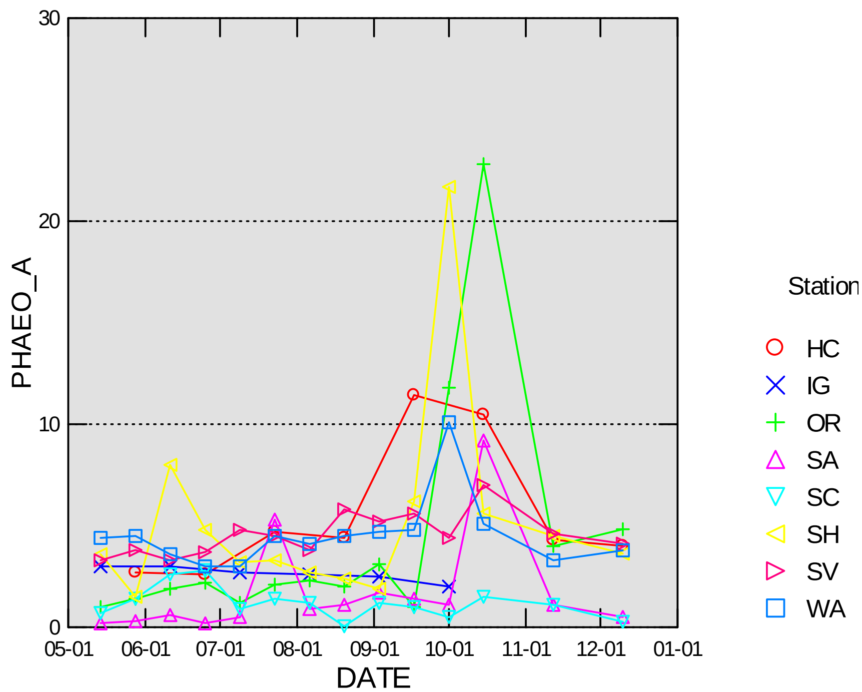

Figure 21. Pheophytin measured in µg/l for all monitored sites during 2009.

5 CONCLUSION

2009 was the first year that sampling was conducted as part of the KHSA AIP. Sampling is continuing again in 2010 and should occur until the dams are removed as part of the settlement agreement. Combining this data with monitoring results from the KTWQWG, Karuk monitoring, and other agency monitoring will provide high quality data that will lead to sound baseline datasets. This data will be useful to Tribes, agencies, and other entities for water quality analysis, modeling, and for directing management actions.