Study of Tiered Monitoring for Benthic Cyanobacterial Blooms in the Klamath Basin, 2025

February 2026

Freshwater Harmful Algal Bloom (FHAB) Monitoring and Response Program

North Coast Regional Water Quality Control Board

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SWAMP-MR-RB1-2026-0001

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This report should be cited as follows:

NCRWQCB 2026. Study of Tiered Monitoring for Benthic Cyanobacterial Blooms in the Klamath Basin, 2025. Freshwater Harmful Algal Bloom Monitoring and Response Program, North Coast Regional Water Quality Control Board, Santa Rosa, CA.

Introduction

In 2022, the North Coast Regional Water Quality Control Board (North Coast Water Board) released a report recommending the implementation of a tiered monitoring program to identify benthic cyanobacterial blooms in rivers for public health protection (Table 1) (NCRWQCB 2022a). The North Coast Water Board released a second report in the same year documenting the efficacy of Solid Phase Adsorption Toxin Tracking (SPATT) samplers to characterize benthic cyanobacteria and cyanotoxin conditions in a lotic system (NCRWQCB 2022b). In 2022 and 2023, the North Coast Water Board conducted a series of special studies demonstrating that the tiered approach, with incorporating SPATTs for early detection of benthic cyanobacterial blooms, can be an appropriate and cost-effective methodology to inform recreational posting recommendations for northern California rivers (NCRWQCB 2024).

Table 1. Tiered approach for monitoring benthic cyanobacterial blooms in rivers.

Tier	Monitoring Approach	Recommendations
1	SPATT deployment	Deployed as sentinel samplers to document increases in cyanotoxin trends, which indicates increasing benthic cyanobacteria and toxicity
2	Visual Assessment	Conducted once SPATT cyanotoxins increase to determine the presence and percent cover of benthic cyanobacterial genera of concern
3	Benthic mat collections	Conducted to confirm toxicity of cyanobacterial mats once a benthic bloom is identified and deliverability[1] has increased

To make informed decisions for public health protection, it is critical to gather, review, and communicate accurate and timely information about cyanotoxin concentrations. To that end, the North Coast Water Board recommends a tiered monitoring program that incorporates weekly SPATT deployments to document seasonal trends in cyanotoxins; these trends then determine when benthic cyanobacterial coverage and toxicity are increasing in the river system. Weekly SPATT deployments are preferred to capture any rapid changes in cyanotoxin production; however, biweekly SPATT deployments can still provide valuable information although response time is delayed accordingly. These monitoring protocols and public health recommendations are incorporated into the California Cyanobacteria Harmful Algal Bloom (CCHAB) Network's revised benthic guidance (CCHAB 2025). This guidance includes thresholds for posting health advisories based on cyanotoxin concentrations in SPATTs as well as percent cover of benthic cyanobacteria (Table 2). As outlined in a North Coast Water Board memorandum (https://mywaterquality.ca.gov/cyanohab/docs/toxic-algal-mats-guidance-appendix-c.pdf) in the guidance package, these threshold values were derived by comparing SPATT concentrations to concurrent measurements of cyanobacteria percent cover and cyanotoxins in benthic mats.

[1] Deliverability is defined as the potential for detachment and accumulation of benthic mats resulting in greater exposure to humans and animals.

Table 2. Revised benthic guidance indicators, metrics, and thresholds.

Indicator	Metric	Threshold
Cyanobacteria	Percent cover	Visual assessment of benthic mats include >15% genera of concern within 150 ft reach
Cyanotoxin	SPATT concentrations	Cyanotoxin of concern >100 ng/g -or- 8-fold increase in samples taken no more than two weeks apart where toxin levels are >10 ng/g
Cyanotoxin	Benthic mat concentrations	No threshold provided; supporting evidence to confirm bloom toxicity

Over the past 16 years, the Klamath Tribal Water Quality Consortium[2] (hereafter Tribal Consortium) has monitored the Klamath River for planktonic cyanobacteria and a common class of cyanotoxins, microcystins, sourced from upstream reservoirs. During that time, the largest funding source for this monitoring was PacifiCorp, the owner and operator of the upstream dams and reservoirs, as part of the Klamath Hydroelectric Settlement Agreements (KHSA). This funding ceased following the completion of dam removal in 2024. Removal of the dams has changed river dynamics as the system transitioned from a series of controlled releases to a more natural and connected flow regime that is dependent upon annual and seasonal changes in environmental conditions. The North Coast Water Board suspects that dam removal will potentially alter nutrient dynamics with the movement of historic reservoir sediments and the release of hypereutrophic water from Upper Klamath Lake. Given these conditions, there is a need to transition from monitoring impacts of planktonic cyanobacteria and microcystins sourced from upstream reservoirs to monitoring benthic cyanobacterial blooms growing in the river.

The North Coast Water Board presented at the Fall 2024 Klamath Basin Monitoring Program (KBMP) meeting and met with the Tribal Consortium to share guidance on monitoring for benthic cyanobacteria for the protection of public health. As with other partners in the North Coast Region, the North Coast Water Board has recommended the tiered monitoring approach. The North Coast Water Board received funding from the State Board Freshwater & Estuarine Harmful Algal Bloom (FHAB) Program to conduct a partner monitoring project in 2025 that incorporated the tiered approach and implemented the revised CCHAB Network benthic guidance. Project partners include the Karuk, Hoopa, and Yurok Tribes as well as the Quartz Valley Indian Reservation (QVIR).

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[2] Partners from the Klamath Tribal Water Quality Consortium that participated in this project include the Hoopa, Karuk, and Yurok Tribes as well as the Quartz Valley Indian Reservation. The Pulikla Tribe, formerly the Resighini, also conducts planktonic monitoring in the Klamath Basin.

Methods

The Klamath Basin is a much larger river system than most systems in the North Coast Region with many major tributaries impacting water quality. Therefore, a large spatial distribution of SPATTs was needed to better understand the dynamics and risks inherent to the basin, especially since historical benthic cyanobacteria data are limited. There currently is no guidance regarding the spatial distribution of SPATTs to characterize a watershed, so best professional judgment of project team members was used to identify 12 stations across the Klamath Basin. Stations were located in the Klamath, Trinity, Salmon, and Scott Rivers as well as Kidder Creek (Table 3, Figure 1). Most of these stations have been monitored historically for other parameters and represent specific stretches of the river or areas with Tribal and recreational use.

Table 3. Station information for tiered benthic monitoring in the Klamath Basin, 2025.

Station	Waterbody	Description	Tribe	Latitude	Longitude
KR1760	Klamath River	at I-5 Rest Area	Karuk	41.85695	-122.57085
KR1575	Klamath River	at Brown Bear River Access	Karuk	41.82342	-122.96181
105SC3110	Scott River	at Indian Scotty	QVIR	41.63561	-123.07732
KDDR	Kidder Creek	above Adventure Camp	QVIR	41.524921	-122.968316
KR1285	Klamath River	below Seiad (Sluice Box)	Karuk	41.842464	-123.22012
KR1084	Klamath River	below Happy Camp	Karuk	41.77402	-123.39635
105SA0561	Salmon River	near Somes Bar	Karuk	41.37849	-123.47554
105KL2802	Klamath River	at Orleans (USGS)	Karuk	41.30289	-123.53452
106TR1038	Trinity River	at Southern Boundary (Tish Tang)	Hoopa	41.021284	-123.63491
106TR0008	Trinity River	near Mouth	Yurok	41.18462	-123.70662
KR0385	Klamath River	below Trinity River (Tulley Creek)	Yurok	41.22662	-123.77241
KR0060	Klamath River	near Klamath (Terwer)	Yurok	41.51001	-123.97944

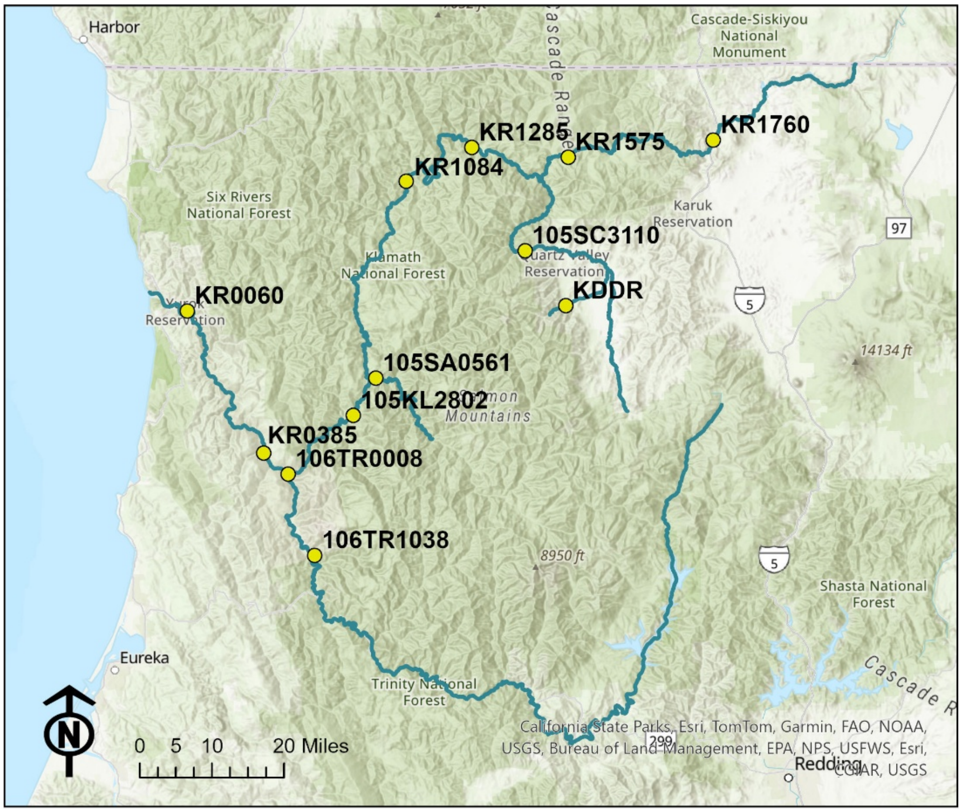

Figure 1. Map of monitoring stations in the Klamath Basin, 2025.

The project took place from July through November 2025 with deployments occurring biweekly for a total of eight maximum deployments for each Tribal partner. Overall, deployments totaled 97 SPATTs, which included one quality assurance duplicate for research level purposes. SPATTs were attached to metal stakes at mid-depth in well-mixed zones of the river reach and were analyzed via Enzyme-Linked Immunosorbent Assay (ELISA) for anatoxins and microcystins (microcystins analysis includes detection of nodularins, reported herein as microcystins/nodularins). For analysis purposes, results below the ELISA method detection limit (MDL) were recorded as zeros, and means rather than medians were used to describe central tendencies (see NCRWQCB 2022b).

During the project, the North Coast Water Board requested that Tribal partners conduct visual assessments to estimate percent cover if benthic cyanobacteria were present. If benthic cyanobacteria percent cover was >15%, Tribes were requested to collect a composite benthic mat sample following standard operating procedures (https://mywaterquality.ca.gov/cyanohab/docs/toxic-algal-mats-guidance-appendix-a.pdf) and using the field data sheet (https://mywaterquality.ca.gov/cyanohab/docs/printable-field-data-sheet.pdf) provided in the revised benthic guidance package. Paired data are useful for determining the relationship between measured SPATT toxin concentrations, percent cover, and benthic mat toxicity in a larger system where dilution may impact passive sampler results. On the final collection date, Tribes were asked to conduct a visual assessment and collect one composite benthic mat sample per station if cyanobacteria were present. All mat samples were analyzed via ELISA for anatoxins and microcystins/nodularins. Most mat samples collected by QVIR were identified to genus-level via microscopy. If possible, all other identifications were done macroscopically in the field.

The North Coast Water Board provided a project training for Tribal partners on July 10, 2025, that reviewed the revised benthic guidance and all aspects of tiered benthic monitoring, including SPATT deployment, visual assessments, composite mat sampling, paperwork, and sample storage and shipping. Posting recommendations were made during the monitoring period based on exceedances of SPATT and percent cover thresholds (see Table 2 above). See revised benthic guidance [posting recommendations](https://mywaterquality.ca.gov/cyanohab/docs/toxic-algal-mats-guidance-appendix-d.pdf) (https://mywaterquality.ca.gov/cyanohab/docs/toxic-algal-mats-guidance-appendix-d.pdf) or more information[3].

Results

SPATTS

The range of anatoxins concentrations in SPATTs varied per station and river (Table 4). Anatoxins remained below SPATT thresholds except for Scott River at Indian Scotty Campground (105SC3310), which measured anatoxins at 122.04 ng/g in mid-September. In general, all sites exhibited non-detects earlier in the study with detections occurring in the September to November timeframe (Figure 2). The complete dataset for SPATT anatoxins can be found in the Appendices.

Table 4. Summary statistics for anatoxins (ATX) in SPATTs.

Station	Not Analyzed	Non-Detects	ATX Min (ng/g)	ATX Max (ng/g)
KR1760	1	6	ND	1.93
KR1575	1	5	ND	1.95
105SC3310	0	2	ND	122.04
KDDR	0	7	ND	1.76
KR1285	1	6	ND	1.85
KR1084	2	5	ND	1.54
105SA0561	2	5	ND	2.25
105KL2802	4	3	ND	1.99
106TR1038	1	5	ND	3.62
106TR0008	0	5	ND	6.21
KR0385	0	5	ND	1.91
KR0060	0	6	ND	2.96

[3] In the posting recommendations table, SPATT concentrations are “high” if they exceed thresholds, i.e., cyanotoxin of concern >100 ng/g -or- 8-fold increase in samples taken no more than two weeks apart where toxin levels are >10 ng/g. Low concentrations are below the SPATT thresholds.

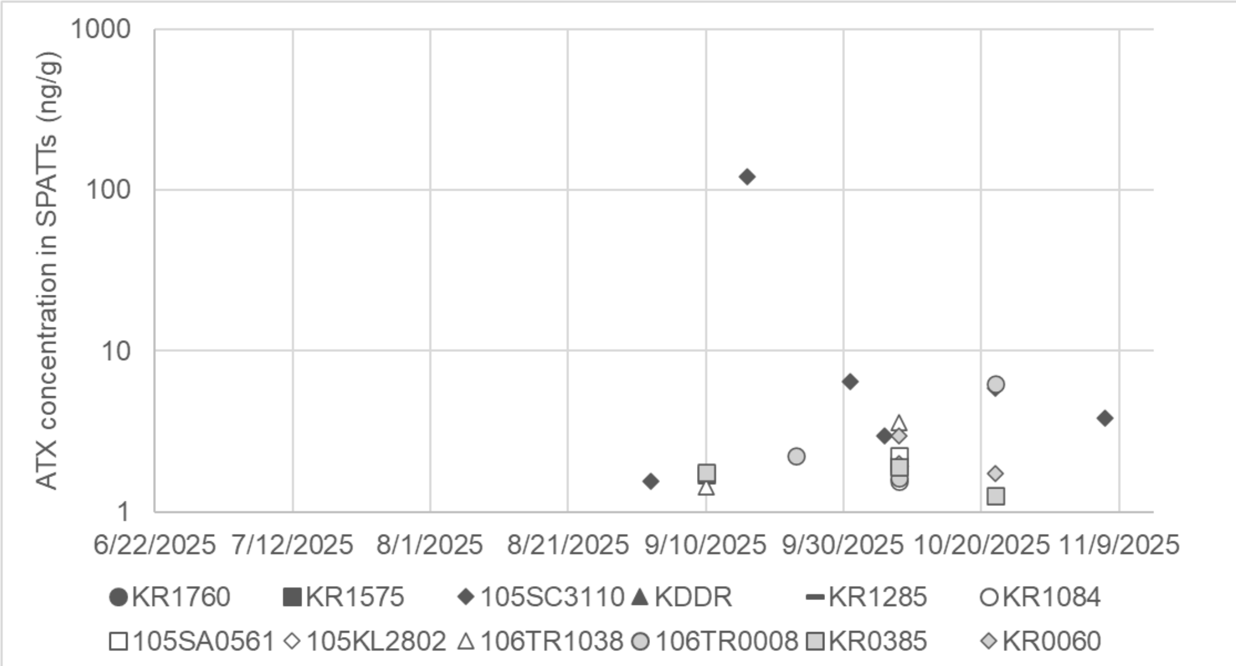

Figure 2. Anatoxins (ATX) in SPATTs recovered at each station.

Microcystins/nodularins were also measured in SPATTs, however, they are typically not considered a cyanotoxin of concern for benthic blooms in northern California rivers (NCRWQCB 2022a, 2024) (Table 5). Microcystins/nodularins remained below SPATT thresholds and were sporadically detected throughout the study (Figure 3). There were no detections of microcystins/nodularins at Salmon River near Somes Bar (105SA0561). There were consistent detections in the Trinity River at Southern Boundary (106TR1038) except for one SPATT that was not analyzed. The complete dataset for SPATT microcystins/nodularins can also be found in the Appendices.

Table 5. Summary statistics for microcystins/nodularins (MCY) in SPATTs.

Station	Not Analyzed	Non-Detects	MCY Min (ng/g)	MCY Max (ng/g)
KR1760	1	5	ND	16.35
KR1575	1	5	ND	4.03
105SC3310	0	8	ND	ND
KDDR	0	1	ND	16.39
KR1285	1	2	ND	24.38
KR1084	2	2	ND	17.44
105SA0561	2	6	ND	ND
105KL2802	4	1	ND	16.0
106TR1038	1	0	1.83	6.12
106TR0008	0	5	ND	8.06
KR0385	0	1	ND	5.88
KR0060	0	4	ND	27.02

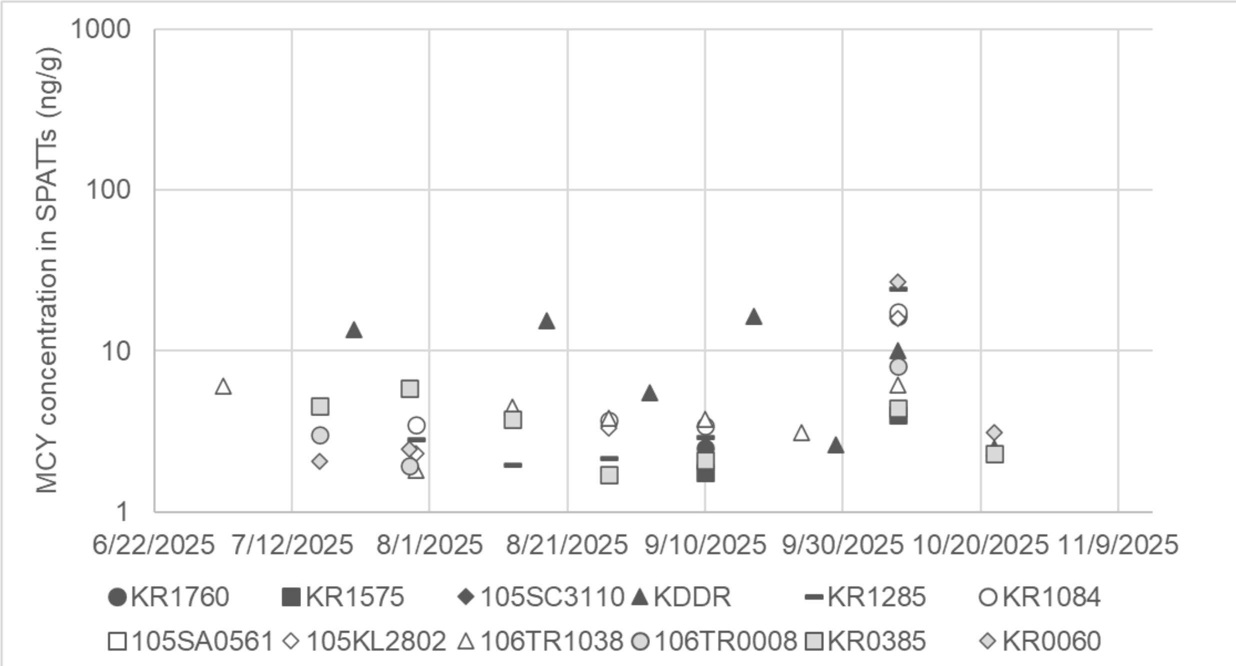

Figure 3. Microcystins/nodularins (MCY) in SPATTs recovered at each station.

Visual Assessments

Visual assessments were conducted when cyanobacteria of concern were present and on the final collection date (Table 6). Cyanobacteria were present above the 15% benthic threshold at Klamath River at Brown Bear River Access (KR1575) in late September, however, the benthic bloom dissipated by the final collection date that occurred two weeks later. Benthic cyanobacteria also exceeded the coverage threshold in Kidder Creek (KDDR) during two visual assessments in late September and October, however, these estimates included a mixed assemblage of cyanobacteria and non-toxic filamentous green algae. Benthic coverage was also recorded above 15% at Trinity River near Mouth (106TR0008) and Klamath River below Trinity River (KR0385) on the final collection date in late October, however, cyanobacteria field identification was not made at that time, and the estimates included a mixture of filamentous green algae. Visual assessments were limited or not possible at some stations (e.g., 105SA0561, KR0060) due to high water and the inability to wade instream.

Table 6. Percent coverage estimates of benthic cyanobacteria.

Station	Date	Percent Cover	Notes
KR1760	10/8/2025	0	No cyanobacteria observed (final date)
KR1575	9/24/2025	>15	*Oscillatoria* dominant
KR1575	10/8/2025	0	No cyanobacteria observed (final date)
105SC3310	11/7/2025	<15	*Microcoleus* dominant
KDDR	9/29/2025	>15	Mixed cyanos and algae
KDDR	10/22/2025	>15	Mixed cyanos and algae
KR1285	9/24/2025	<15	*Microcoleus* dominant
KR1285	10/8/2025	0	No cyanobacteria observed (final date)

Station	Date	Percent Cover	Notes
KR1084	10/8/2025	0	No cyanobacteria observed (final date)
105SA0561	10/8/2025	0	Only shoreline assessment (final date)
105KL2802	10/8/2025	0	No cyanobacteria observed (final date)
106TR1038	10/8/2025	0	No cyanobacteria observed (final date)
106TR0008	10/22/2025	>15	Mixed cyanos and algae (final date)
KR0385	10/22/2025	>15	Mixed cyanos and algae (final date)
KR0060	10/22/2025	---	No visual assessment (final date)

Benthic Mats

Composite algal mat samples were collected if cyanobacteria were present, as well as on the final collection date (Table 7). As part of their own research and monitoring, QVIR collected additional mat samples throughout the study period that were analyzed for common cyanotoxins, including anatoxins and microcystins/nodularins. Some QVIR mat samples were also analyzed for anatoxin-producing genes via quantitative polymerase chain reaction (qPCR) since previous research in the watershed suggests a positive correlation between anatoxin concentrations and anatoxin-producing gene copies (Genzoli et al. 2024). Analysis of these qPCR results is beyond the scope of this study, and the CCHAB Network benthic guidance on posting decisions does not include toxin gene enumeration by qPCR, so these data are interpreted by the sampling entity for research purposes.

Table 7. Cyanotoxin and qPCR concentrations in composite benthic mat samples.

Station	Date	ATX (ug/L)	ATX qPCR (copies/mL)	MCY (ug/L)
KR1760	---	---	---	---
KR1575	9/24/2025	ND	---	ND
105SC3310*	7/21/2025	---	16,234,018	---
105SC3310*	8/18/2025	1.31	28,667	0.65
105SC3310*	9/2/2025	7.94	60,109	0.51
105SC3310*	9/16/2025	198.03	1,609,617	0.29
105SC3310*	10/1/2025	19.15	830,263	0.42
105SC3310*	10/6/2025	12.84	2,147,896	ND
105SC3310*	10/22/2025	29.84	254,084	0.63
105SC3310*	11/7/2025	---	---	---
KDDR*	7/21/2025	---	ND	---
KDDR*	8/4/2025	---	ND	---
KDDR*	8/18/2025	---	ND	---
KDDR*	9/2/2025	---	ND	---
KDDR*	9/17/2025	---	267,480	---
KDDR*	9/29/2025	---	2,258,070	---
KDDR*	10/6/2025	---	3,141,667	---
KDDR*	10/22/2025	---	2,254,440	---
KDDR*	11/12/2025	---	---	---

Station	Date	ATX (ug/L)	ATX qPCR (copies/mL)	MCY (ug/L)
KR1285	9/24/2025	ND	---	ND
KR1084	---	---	---	---
105SA0561	---	---	---	---
105KL2802	---	---	---	---
106TR1038	---	---	---	---
106TR0008	10/22/2025	1.89	---	ND
KR0385	10/22/2025	0.49	---	2.72
KR0060	---	---	---	---

**QVIR stations with additional mat sampling.*

The QVIR dataset provides a fuller picture of cyanotoxin production, particularly at Scott River at Indian Scotty (105SC3310) where peak concentrations of anatoxins in benthic mats (198.03 ug/L) coincides with peak SPATT anatoxins (122.04 ng/g) in mid-September (Figure 4). Microcystins/nodularins in benthic mats remained very low in the Scott River, which corresponds to the non-detects in SPATTs throughout the study.

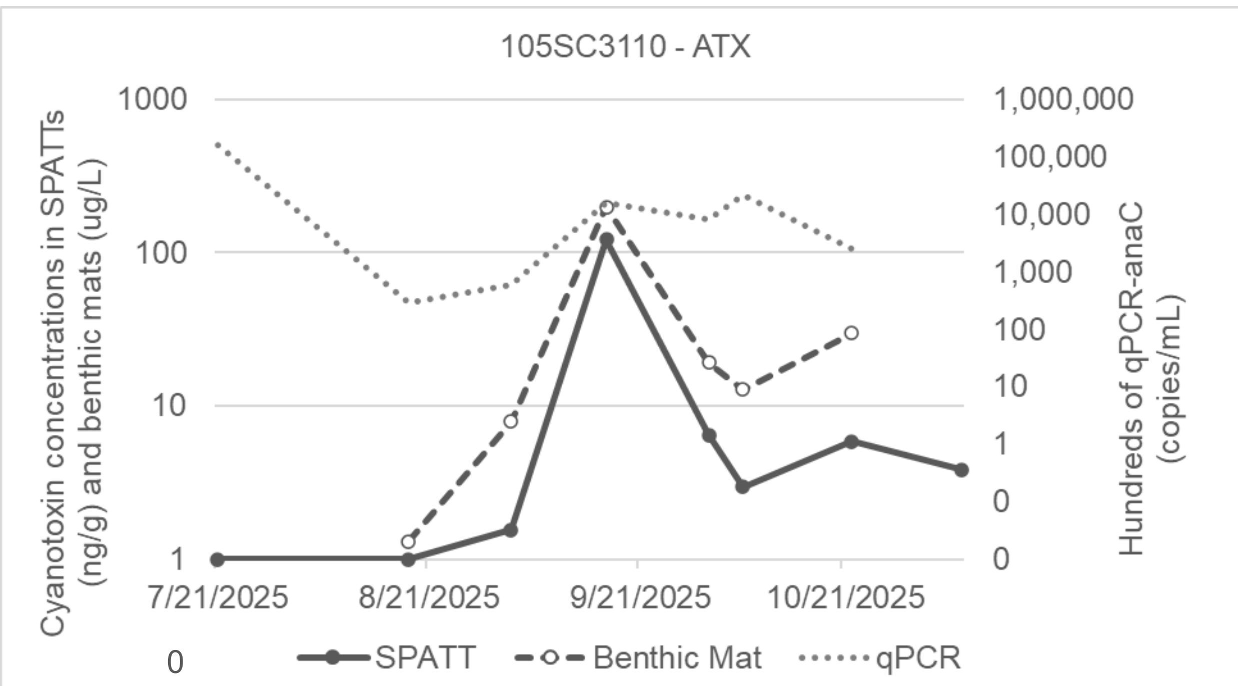

Figure 4. Anatoxins (ATX) concentrations in SPATT samplers (solid line with closed circles) and benthic mat samples (dashed line with open circles) as well as qPCR-anaC (dotted line) in the Scott River at Indian Scotty.

At other stations in Table 7, anatoxins and microcystins/nodularins were low in benthic mats, which corresponds to the low concentrations observed in SPATTs (<100 ng/g). As indicated with "---," composite mat samples were not collected at several stations where cyanobacteria were not observed, or a visual assessment was not conducted.

Posting Recommendations

Following the tiered approach and using thresholds in the revised benthic guidance, five Toxic Algae Alert postings were recommended during the study period (Table 8).

Table 8. Posting recommendations during study period.

Station	Date	Justification
KDDR	8/11/2025	QVIR posted Toxic Algae Alert once results from 8/4/2025 mat sampling were received, which included qPCR detections for saxitoxins at 22,513 copies/mL. SPATT concentrations remained low (<100 ng/g) throughout the study period; however, a posting would have been recommended by the Water Board when percent cover exceeded 15% on 9/29/2025.
105SC3110	9/16/2025	SPATT anatoxins rapidly increased to 122.04 ug/L on 9/16/2025, which exceeded the 100 ng/g threshold and resulted in a Toxic Algae Alert recommendation. Benthic mats collected on the same date also exhibited a rapid increase to 198.03 ug/L. Cyanobacteria percent cover never exceeded 15% during the study period.
KR1575	9/24/2025	Percent cover *Oscillatoria* exceeded 15% threshold, however, concurrent SPATT and mat results were ND for anatoxins and microcystins/nodularins. A Toxic Algae Alert was recommended due potential for cyanobacteria to start producing toxins and heightened potential for exposure due to elevated percent coverage (i.e., increased deliverability). Posting lifted after follow-up monitoring determined the benthic bloom had dissipated.
106TR0008	10/22/2025	Percent cover cyanobacteria exceeded 15% threshold on 10/22/2025, however, concurrent SPATT and mat results remained low for anatoxins and microcystins/ nodularins. A Toxic Algae Alert was recommended per CCHAB Network guidance.
KR0385	10/22/2025	Percent cover cyanobacteria exceeded 15% threshold on 10/22/2025, however, concurrent SPATT and mat results remained low for anatoxins and microcystins/ nodularins. A Toxic Algae Alert was recommended per CCHAB Network guidance.

Discussion

Evaluation of Tiered Benthic Monitoring

Overall, tiered benthic monitoring was an effective approach for identifying benthic cyanobacterial blooms in the Klamath Basin. Note that in early August, QVIR posted a Toxic Algae Alert for Kidder Creek (KDDR) based on qPCR results, which is beyond the scope of this study. However, based on the cyanobacteria percent cover threshold in the revised benthic guidance (Table 2), a posting would have been recommended for KDDR in late September when coverage exceeded 15% and mat deliverability increased. Deliverability is defined as the potential for detachment and accumulation of benthic mats resulting in greater threat of exposure to humans and animals.

In the Scott River at Indian Scotty Campground (105SC3310), SPATT anatoxins rapidly increased from 1.56 to 122.04 ng/g in mid-September, which exceeded the 100 ng/g threshold (Figure 4). Concurrent results for benthic mats also exhibited a rapid increase in anatoxins to from 7.94 to 193.03 ug/L. Although cyanobacteria percent cover never exceeded 15%, these results support previous findings by the North Coast Water Board that SPATTs are an effective tool for determining when anatoxins production increases in benthic mats (NCRWQCB 2024). As a result, the SPATT threshold established in the revised benthic guidance was applied and demonstrated its appropriateness to inform public health postings (CCHAB 2025).

In the case of Klamath River at Brown Bear River Access (KR1575), SPATTs did not provide an early indication of increasing percent cover; however, benthic cyanobacteria were not producing cyanotoxins at the time, as evidenced by non-detects in both the SPATT and composite mat sample on 9/24/2025. Nonetheless, a Toxic Algae Alert was recommended due to exceedance of the 15% coverage threshold since deliverability had increased and cyanobacteria can rapidly switch to producing cyanotoxins. The station was de-posted the following sampling event as the benthic bloom dissipated, which was corroborated by low SPATT results for the final sampling date.

At Trinity River near Mouth (106TR0008) and Klamath River below Trinity River (KR0385), cyanobacteria percent cover exceeded the 15% threshold in late October, resulting in a Toxic Algae Alert recommendation, yet SPATT and composite mat sampling both exhibited low anatoxins and microcystins/nodularins throughout the study period. Like Klamath River at Brown Bear River Access (KR1575) above, this case shows the importance of conducting visual assessments and using the percent cover threshold to account for deliverability and potential cyanotoxin production in benthic mats. Postings based on percent cover thresholds are especially relevant when resources for cyanotoxin testing are limited.

Considerations for Future Monitoring

During the study, SPATT and benthic mat samples were analyzed for both anatoxins and microcystins/nodularins. Although microcystins/nodularins were consistently detected in SPATTs, concentrations remained below the threshold value and did not reflect increasing deliverability or bloom conditions observed in the field. Available data for microcystins/nodularins in benthic mats were also low and did not exhibit the sudden increases that were observed with anatoxins, notably in the Scott River. As concluded in previous reports (NCRWQCB 2022a, NCRWQCB 2022b, NCRWQCB 2024), the North Coast Water Board continues to recommend using anatoxins as an indicator for increasing benthic cyanobacterial coverage and toxicity in northern California rivers. Additional studies are needed to identify other cyanotoxins of concern in watersheds outside of these study areas.

Tiered benthic monitoring saves partner resources by utilizing SPATTs as an early detection tool. SPATTs inform when additional tiers or resources are needed rather than repeated use of staff time to survey river reaches and repeated mat collections to determine toxicity. Even so, the North Coast Water Board realizes that partner resources can be limited such that SPATT monitoring is not an option. In these cases, visual assessments provide valuable information on cyanobacteria presence and coverage and are a cost-effective option that can be compared against CCHAB Network's percent cover thresholds for public health protection (CCHAB 2025). As evidenced in this study, visual assessments are important for identifying potential health risks, especially when resource limitation does not support toxin analysis. Overall, having advisory thresholds for multiple indicators is valuable since staff may have varied levels of training and toxin production can rapidly change in a system.

Training is needed to successfully implement the tiered monitoring approach. Standard operating procedures and protocols are available for SPATT deployments, visual assessments, and composite mat sampling (see CCHAB 2025), however, techniques such as the correct identification of cyanobacterial genera of concern generally require nuanced field training that is better conveyed in person. Field identification is especially relevant when distinguishing between benthic cyanobacteria from other instream growths like non-toxic filamentous green algae. The North Coast Water Board continues to host annual field trainings and encourages partners to attend or request additional trainings as needed. Water Board staff are also available to review field photos to help partners determine if cyanobacteria of concern are present in a waterbody.

Stations for this study were selected to spatially characterize the river network and determine bloom conditions near areas of interest. Over the course of the study, visual assessments were not possible at several stations due to changing water levels or overall non-wadeable conditions. Future studies should consider accessibility and wadeability so all aspects of the tiered approach (e.g., visual assessment) can be implemented successfully. To address temporal variations, additional monitoring would be recommended in successive years since fluctuations in water years as well as changes in hydrogeomorphology due to dam removal could influence benthic cyanobacterial growth. Monitoring in successive years is especially relevant since this study occurred during the first year following dam removal; therefore, results may not be representative or predictive of future conditions when hydrogeomorphology settles and benthic cyanobacteria are potentially more established. Furthermore, extending the monitoring timeframe into November and December each year would provide valuable information on the fate of identified blooms, particularly when the recreation season is extended due to delayed precipitation events or scouring flows.

Conclusion

In conclusion, tiered benthic monitoring continues to allow for accurate and timely postings so the public can make informed decisions about their water activities. The revised benthic guidance establishes suitable thresholds that prevent premature postings when health risks are not present, which can lead to sign fatigue, public distrust, and economic loss to communities. When combined, the benthic guidance and tiered approach provide a comprehensive monitoring framework that integrates SPATTs with coverage assessments and toxin analysis. This approach is expected to reduce exposure incidents by identifying major proliferations of benthic cyanobacteria in riverine systems. Nonetheless, even the most robust monitoring program cannot guarantee that the public will be fully protected at any given time and location since isolated patches of cyanobacteria will always be present. Future monitoring is recommended for a dynamic system like the Klamath Basin, especially as the watershed ecosystem adapts to dam removal and re-establishes hydrogeomorphology.

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Appendix A. Compiled SPATT anatoxins data by station

Date	KR1760	KR1575	105SC3110	KDDR	KR1285	KR1084	105SA0561	105KL2802	106TR1038	106TR0008	KR0385	KR0060
7/2/2025	NS	NS	---	---	NS	NS	NS	NS	0	---	---	---
7/16/2025	0	0	---	---	0	NS	0	NS	NS	0	0	0
7/21/2025	---	---	0	0	---	---	---	---	---	---	---	---
7/29/2025	---	---	---	---	---	---	---	---	---	0	0	0
7/30/2025	0	0	---	---	0	0	0	0	0	---	---	---
8/13/2025	0	0	0	---	0	0	0	0	0	0	0	0
8/18/2025	---	---	---	0	---	---	---	---	---	---	---	---
8/27/2025	0	0	---	---	0	0	0	0	0	0	0	0
9/2/2025	---	---	1.56	0	---	---	---	---	---	---	---	---
9/10/2025	0	1.71	---	---	0	0	NS	NS	1.44	0	1.76	0
9/16/2025	---	---	122.04	---	---	---	---	---	---	---	---	---
9/17/2025	---	---	---	0	---	---	---	---	---	---	---	---
9/23/2025	---	---	---	---	---	---	---	---	---	2.25	0	0
9/24/2025	0	0	---	---	0	0	0	NS	0	---	---	---

Date	KR1760	KR1575	105SC3110	KDDR	KR1285	KR1084	105SA0561	105KL2802	106TR1038	106TR0008	KR0385	KR0060
9/29/2025	---	---	---	0	---	---	---	---	---	---	---	---
10/1/2025	---	---	6.44	---	---	---	---	---	---	---	---	---
10/6/2025	---	---	2.98	---	---	---	---	---	---	---	---	---
10/8/2025	1.93	1.95	---	1.76	1.85	1.54	2.25	1.99	3.62	1.64	1.91	2.96
10/22/2025	---	---	5.87	0	---	---	---	---	---	6.21	1.27	1.73
11/7/2025	---	---	3.85	---	---	---	---	---	---	---	---	---
11/12/2025	---	---	---	0	---	---	---	---	---	---	---	---

Abbreviations: “NS”, not sampled and analyzed due to SPATT loss, out of water, or hold times; “---“, date does not apply to station.

Appendix B. Compiled SPATT microcystins/nodularins data by station

Date	KR1760	KR1575	105SC3110	KDDR	KR1285	KR1084	105SA0561	105KL2802	106TR1038	106TR0008	KR0385	KR0060
7/2/2025	NS	NS	---	---	NS	NS	NS	NS	6.11	---	---	---
7/16/2025	0	0	---	---	0	NS	0	NS	NS	3.03	4.55	2.07
7/21/2025	---	---	0	13.68	---	---	---	---	---	---	---	---
7/29/2025	---	---	---	---	---	---	---	---	---	1.93	5.88	2.44
7/30/2025	0	0	---	---	2.84	3.51	0	2.29	1.83	---	---	---
8/13/2025	0	0	0	---	1.98	0	0	0	4.46	0	3.75	0
8/18/2025	---	---	---	15.4	---	---	---	---	---	---	---	---
8/27/2025	0	0	---	---	2.18	3.72	0	3.3	3.83	0	1.71	0
9/2/2025	---	---	0	5.55	---	---	---	---	---	---	---	---
9/10/2025	2.48	1.76	---	---	2.93	3.43	NS	NS	3.77	0	2.06	0
9/16/2025	---	---	0	---	---	---	---	---	---	---	---	---
9/17/2025	---	---	---	16.39	---	---	---	---	---	---	---	---
9/23/2025	---	---	---	---	---	---	---	---	---	0	0	0
9/24/2025	0	0	---	---	0	0	0	NS	3.1	---	---	---

9/29/2025	---	---	---	2.62	---	---	---	---	---	---	---	---
10/1/2025	---	---	0	---	---	---	---	---	---	---	---	---
10/6/2025	---	---	0	---	---	---	---	---	---	---	---	---
10/8/2025	16.35	4.03	---	10.14	24.38	17.44	0	16	6.12	8.06	4.44	27.02
10/22/2025	---	---	0	2.5	---	---	---	---	---	0	2.3	3.1
11/7/2025	---	---	0	---	---	---	---	---	---	---	---	---
11/12/2025	---	---	---	0	---	---	---	---	---	---	---	---

Abbreviations: “NS”, not sampled and analyzed due to SPATT loss, out of water, or hold times; “---“, date does not apply to station.