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Legislative Policy and
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Harmful Algal Blooms Work Group

Final Report

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EXECUTIVE SUMMARY

The Harmful Algal Blooms work group was established by Representative Ken Helm at the end of the 2019 legislative session and tasked with studying Oregon’s response to harmful algal blooms in order to maintain a safe water supply for Oregonians. The work group members represent state agencies, municipalities, local water districts, and other interested organizations. The work group met 14 times, surveyed over 500 stakeholders, and agreed on the recommendations listed below.

This report compiles work that has been done by the work group and by the Legislative Policy and Research Office to support work group efforts.

Recommendations

1. Improve coordination by hiring appropriate staff and ensuring agencies work together.
2. Develop and implement a statewide, proactive monitoring program.

PROCESS

The Harmful Algal Blooms (HABs) work group was formed prior to the end of the 2019 legislative session to review the issue and develop recommendations for potential legislation for consideration in 2020 and/or 2021. The Work Group created three sub-groups (Treatment Technology, Monitoring and Prediction, and Response and Mitigation), which met independently and reported back to the full work group periodically for updates. The group held a total of 14 full work group and subgroup meetings. The full work group made its final recommendations to Chair Ken Helm, Rep. Marty Wilde, and Rep. Jack Zika, members of the House Committee on Water.

The HABs work group made four primary recommendations for legislative consideration during the 2020 session: compiling a comprehensive list of existing programs; creating an expert advisory council; funding for additional equipment, seasonal staff, and supplies; and funding for an outreach coordinator to small utilities.

As part of the first recommendation, the goal was to assemble an expansive list of all existing federal, state, local, and stakeholder programs that play a role in preventing, monitoring, and addressing exposure to cyanoHABs, with the following objectives:

- identifying gaps;
- identifying areas of potential collaboration;
- identifying key deficiencies;
- identifying relevant agencies, current and past programs, and funding and research needs;
- conducting a literature review of Oregon-based academic research; and
- outlining a set of effective strategies related to cyanoHABs for consideration during the 2021 Session.

To facilitate this effort, the work group considered two options. The first option was to submit a funding request during the 2020 session to contract with a consulting service; the second option was to designate the Legislative Policy and Research Office (LPRO) as “consultant services” in addition to overall project manager. Legislation introduced in 2020 to consider the recommendations of the work group (House Bill 4071) did not include a reference to the comprehensive study, as a decision was made prior to the session that the second staffing option would be selected and that LPRO would be directed to coordinate.

Chair Ken Helm wrote a letter officially requesting LPRO work with members of the HABs work group to address these objectives. The letter is included as Appendix A, the literature review is included as Appendix B, and a survey addressing the first four bullets above is included as Appendix C.

SURVEY

The Legislative Policy and Research Office (LPRO) administered a survey to support the Harmful Algal Blooms (HABs) Work Group in developing a better understanding of some of the key gaps and deficiencies in the state's work to address harmful algae and the resulting toxins, as well as identify areas of potential collaboration and other needs. The survey was intended to complement the work group's efforts and is an additional tool to help understand issues related to HABS. Detailed survey results are in Appendix C.

In July 2020, a draft survey designed to identify gaps; potential areas of collaboration; key deficiencies; and relevant agencies, programs, funding, and research needs was developed by LPRO staff with preliminary input from the leads of the three sub-groups of the HABs work group.

The draft was shared with members of the full work group for review, and feedback was incorporated into the final survey. A link to the survey was emailed to work group participants and their partners August 3, 2020. The survey was administered via Qualtrics, an online survey platform, and consisted of 18 open-ended questions and 8 yes/no and multiple-choice questions. The survey closed August 20, 2020.

LPRO staff estimate the survey reached nearly 500 people. Over 100 responses were received from representatives of 81 organizations, which included local government and government collaboratives (40), state government (15), private and nonprofit organizations (14), academia (8), federal government (3), and tribal government (2).

Results. Survey respondents identified a number of gaps and provided recommendations for more effectively addressing HABs in Oregon. Themes included:

1. **Communication and timing.** Multiple respondents expressed the need for more communication among groups working on HABs, including between agencies and utilities, and among treatment plants, test sites, and volunteer groups. Respondents also expressed a need for improved timing in dissemination of knowledge of new testing methods such as qPCR (quantitative Polymerase Chain Reaction).
2. **Coordination and flexibility.** Similar to communication and timing, respondents expressed a need for greater coordination and flexibility in work among agencies, utilities, and the three major testing labs in the state, in the uniform testing of lakes, and in tribal collaborations. The vast majority of respondents' organizations rely on information and data from other agencies, and respondents suggested promoting interjurisdictional relationships, including more organizations in coordinated efforts, and continuing work group collaboration.
3. **Prediction.** Respondents emphasized that, due to lack of funding, a key gap in HABs mitigation is prediction. In describing the organizations' budgets, 20

respondents noted having zero budget and zero staff for prediction work. This theme was the most popular, behind communication and coordination.

4. **Testing.** Respondents want to see more testing, including testing covering a greater geographic area, recreational water bodies, and pre- and post-bloom analysis. Twenty-eight respondents mentioned the need for funding for projects related to testing for HABs.
5. **Education.** Education of the public, local governments, board members, and emerging organizations that have a stake in mitigating HABs. Respondents suggested timely updates on new technologies and restoration work would be beneficial.
6. **Outreach**. Respondents suggested greater involvement by the legislature in projects and research, more education to the general public and to utilities, more volunteer options, and specific outreach to communities in the wake of 2018 HABs concerns. While connected to other recommendations, this category of responses appeared to be focused on trust and communication.
7. **Centralized data repository.** Several respondents brought up the need for a centralized data repository, such as a website that could include an interactive GIS map of lakes and water bodies experiencing HABs or exposed to cyanotoxins. Respondents offered that research articles, lessons learned from treatment plants and labs, and advisories for the public could be posted here, along with a database of types of cyanobacteria and cyanotoxins that have been identified in Oregon.
8. **Research.** Respondents described research needs, including prevention methods and techniques, pre/post bloom analytics, harm on humans at the current rates of detection, genetic sequencing, impacts of toxins, frequency and driver research, nonpoint source contribution, research effects on fisheries, birds, amphibians, aquatic life, climate change effects, recreational contact, and ecological issues.
9. **Upgrading equipment and process.** Upgrades mentioned by respondents included more robust analytical equipment, better shipping logistics, leveraging current infrastructure for optimal performance, and a more mainstream outreach system.
10. **Balancing short-term and long-term needs.** Respondents seemed to have conflicting views on the importance of short-term and long-term responses and techniques. For example, there appears to be a tradeoff between short-term efforts and long-term needs, and respondents were not in agreement on which to prioritize. Examples include funding prevention techniques versus response funding, rapid response capability versus the remediation of water bodies to slow HABs, long-term sustained action versus treatment and monitoring capabilities. Responses did not provide clear direction for allocating funding among options.

RECOMMENDATIONS

Improve Coordination

Improve state-level coordination to reduce risks to human and animal health and local economies from HABs, both in terms of reducing the potential for HABs formation and exposure to humans and animals once formed. Additional elements of alignment include multiple observations about the need for enhanced outreach, engagement, and public education related to HABs.

a. Hiring a Harmful Algal Blooms Coordinator (OHA)
b. Hiring a permanent Natural Resource Specialist 3 (DEQ)
c. OHA and DEQ shall develop and maintain a coordinated harmful algal bloom monitoring and response strategy. This includes development of enhanced communication strategies to establish clear lines of communication with monitoring partners, identifying key roles and responsibilities of state and local partners, and developing enhanced protocols for issuing advisory alerts to the public and impacted stakeholders in the occurrence of HABs.
d. OHA, in combination with DEQ, shall interpret and disseminate timely and high-quality data about the level of risk of harm or injury to public health and water bodies, including the relationship from recent wildfires on both short- and long-term impacts.
e. OHA will collaborate with DEQ to develop a prioritization monitoring framework of water sources that are susceptible to harmful algal blooms and that are sources of domestic and municipal drinking water; bodies of water accessed by the public for recreational use; and sources used for agricultural purposes.
f. Provide enhanced public education and outreach related to harmful algal blooms to the public, local governments, tribal members, and emerging organizations that have a role in mitigating HABs, through digital media and other forms of strategic communications.
g. Create a technical advisory committee among interested HABs stakeholders to further support the role and mission of OHA and DEQ in addressing HABs, which would meet at least annually to review progress to-date, discuss areas for needed support or further evaluation, help identify and recommend additional resources for legislative consideration, and generally provide input in an effort to support a state-wide framework for HABs monitoring, response, and mitigation.

Develop and Implement Proactive Monitoring Program

Develop and implement an increasingly proactive monitoring program for waterbodies susceptible to HABs (municipal and domestic drinking water; and recreational). Collect and analyze cyanotoxin and water quality data to provide needed information to interpret public health risks and to use with remote sensing data for developing plans to mitigate adverse impacts of HABs.

h. Analyze cyanotoxin samples collected in response to OHA testing requirements for vulnerable public water systems.
i. Collect and analyze cyanotoxin samples to provide OHA with information they need to interpret recreational risks to the public.
j. Provide more robust assessments and timely analysis of available data to support OHA's ability to issue and lift health advisories.
k. Collect and analyze water temperature, nutrient and other water quality samples to assist in the development of watershed-based plans to manage and mitigate HABs.
l. Provide HABs data via publicly accessible clearinghouse.
m. Analyze water quality data, weather data, and watershed attributes for the development of watershed-based plans to manage, mitigate, and reduce the frequency, severity, and duration of HABs.
n. Purchase an additional cyanotoxin analyzer instrument and associated services, supplies and equipment needed for its operation and maintenance.
o. Purchase a nutrient analyzer and associated services, supplies and equipment needed for its operation and maintenance.
p. Hire a permanent Chemist 2 to assist with analysis of water samples and collection of water samples during peak season periods when harmful algae blooms are most prominent.
q. Hire a permanent Natural Resource Specialist 1 to collect cyanotoxin samples in recreational waterbodies and to collect discrete and continuous water quality samples for use in the development of watershed management plans to mitigate the severity and duration of HABs.
r. Hire a permanent Natural Resource Specialist 3 to analyze water quality and satellite information in the development of watershed management plans to mitigate the severity and duration of HABs.

APPENDIX A

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February 11, 2020

Misty Mason Freeman, Interim Director
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RE: Request for continued support for the Harmful Algal Blooms workgroup

Dear LPRO Director:

The Harmful Algal Blooms (HABs) workgroup was formed at my request on behalf of the House Committee on Energy and Environment prior to the end of the 2019 Legislative Session. The workgroup was charged to take an in-depth look into the issue and develop recommendations for potential legislation related to HABs for consideration in 2020 and 2021. The workgroup created three sub-groups (Treatment Technology; Monitoring and Prediction; and Response and Mitigation), which met independently, reported back to the full workgroup in September, and presented final recommendations for the House Committee on Water on November 5, 2019. All told, there were a total of 14 full workgroup and subcommittee meetings, with robust discussion and exceptional enthusiasm from stakeholders.

Among the recommendations delivered by the workgroup to the House Committee on Water was the development and evaluation of a list of existing HABs programs. This effort would include comprehensive identification of all existing federal, state, local, and stakeholder programs that play a role in preventing, monitoring, and addressing exposure to HABs. Once compiled, an evaluation of the list would have the following objectives:

- Identifying gaps;
- Identifying areas of potential collaboration;
- Identifying key deficiencies; and,
- Identifying relevant agencies, current/past programs, and funding/research needs.

Additional activities needed to evaluate current HABs programs include:

- Conducting a literature review of Oregon-based academic research;
- Outlining a set of effective strategies related to HABs for consideration during the 2021 Session; and,
- Identifying best practices among agencies and utilities.

To that end, I would like to designate the Legislative Policy and Research Office (LPRO) as the project manager for this effort. Specifically, I request that assigned staff from LPRO work closely with the existing HABs workgroup members to identify existing HABs-related programs and compile them into a document, database, or other appropriate format. Once the list is complete, I request that LPRO staff facilitate an evaluation and related activities bulleted above, in coordination with subject matter experts from the HABs workgroup. Meetings with stakeholders may be held as necessary.

Finally, I request that LPRO provide its findings, including any proposed legislative concepts from HABs stakeholders, to the House Committee on Water by no later than September 1, 2020.

Sincerely,

Kenneth D. Helm

Representative Helm, Chair
House Committee on Water
Oregon State Legislature

APPENDIX B: LITERATURE REVIEW

Summary

The following is a review of literature on harmful algal blooms, sometimes referred to as HABs or cyanoHABs, the latter referring to the cyanotoxin that makes such blooms dangerous to humans and animals. Sources cited in this review were submitted for inclusion as part of a stakeholder survey conducted August 2020 and augmented with sources relevant to freshwater cyanoHABs in Oregon.

Intro

Cyanobacteria are a group of organisms (bacteria and algae) that can be found in almost all terrestrial and aquatic habitats. When cyanobacteria form colonies in calm, non-turbulent, and warm waters that are rich in nutrients like nitrogen or phosphorous, they are able to outcompete other organisms and their populations grow in size excessively, causing so-called "algal blooms." Algal blooms affect the entire ecosystem in which they occur in many ways, one of them being their natural ability to release cyanotoxins, most problematically neurotoxins, into the water.

Key Areas of Concern

CyanoHABs are an issue throughout Oregon; however, there are several bodies of water experiencing HABs particularly difficult to manage. For example, from 1997 to 2006, there have been five health advisories regarding Tenmile Lake, and the Lake has been on the state's Clean Water Act Section 303(d) list of impaired water since the 1980's (Hall, 9). Also, every year from 2009 through 2014 (excluding 2012) Tenmile Lake has been placed under health advisories for 40 days or more (Hall, 10).

The major species of cyanobacteria found in this lake are also some of the most commonly observed throughout Oregon: Microcystis aeruginosa, Aphanizomenon flos-aquae, and Dolichospermum planctonicum (formerly Anabaena) (Hall, 9). These cyanobacteria and their associated toxins have been found in waterbodies in Klamath, Multnomah, Marion, and Linn counties prompting health advisories every year. Since 2013, the most common cyanobacteria causing HABs has been Microcystin. Prior to 2013, the most common cyanobacteria causing HABs was Anabaena, or Dolichospermum, according to the Oregon Health Authority's Cyanobacteria Advisory Archive. Cyanotoxins can have neurotoxic, hepatotoxic, cytotoxic, and endotoxic effects and thus affect the nervous, hepatopancreatic, cellular, digestive, endocrine, and dermal systems (Pearl, 996) and can lead to death in the most severe cases of exposure.

Exposure

People can be exposed to cyanotoxins via skin contact, inhalation, or ingestion. The following are generalized lists that demonstrate exposure risk based on activities related to lake recreation:

- High Risk: Swimming/wading, Diving, Water skiing/Wakeboarding, Windsurfing, Jet skiing
- Moderate Risk: Fish/shellfish consumption, Canoeing, Rowing , Sailing, Kayaking, Motor boating (cruising)

- Low/No Risk: Catch and release fishing, Hiking, Picnicking, Sightseeing (Stone, 139).

Due to the popularity of fishing in Oregon, consumption of fish and shellfish is a great concern. In particularly harsh blooms, fish and shellfish can become contaminated. Usually toxins are found in the liver bile and guts of fish, but it is possible for them to penetrate edible portions of the organisms (Drobac, 309). One study has shown that a fillet can contain up to 25 times the tolerable daily intake value for microcystin (Stone, 140). To make matters worse, microcystins are heat-stable and are not broken down via cooking (Stone, 140).

Drivers

Cyanobacteria growth is exacerbated by several factors including nutrient loading, temperature, water turbidity, and sunlight availability. Nutrients found in watersheds and nearby soils, as well as warmer water temperatures are major contributors to cyanoHABs (Pearl, 998). Most cyanobacteria reach their optimum growth rate in waters that range from 27-32 degrees C, or 80-90 degrees F (Pearl, 999). Changing climate leads to two distinct reasons for increased cyanoHABs accumulation. First, warmer weather contributes to a greater growth rate for cyanoHABs due to increases in water temperature. Secondly, with larger storms from altered weather patterns, more nutrients are swept up by rainfall and runoff into freshwater and marine ecosystems. Winter and spring storms transport a greater amount of water and this suspends more nitrogen and phosphorus that is then discharged into a lake, sound, or reservoir. The extra nutrients during periods of summer drought will be subject to increased temperatures, vertical stratification, and longer water residence times, which contribute to a greater risk of cyanoHABs (Pearl, 999). Due to droughts and hotter weather, some freshwater bodies can potentially become more brackish and more nutrient-rich. This can potentially lead to the occurrence of cyanoHABs as many cyanobacteria are able to adapt to brackish waters. For instance, Anabaena and Anabaenopsis species can withstand salinities up to 45 percent of sea water salinity.

Increases in nutrients, like phosphorous, contribute to an increased amount of cyanobacteria within a given watershed. Research suggests that higher levels of nitrogen can also be an active contributor to cyanobacteria as well. (Pearl, 997).

To complicate matters further, nitrogen-fixing cyanobacteria such as Anabaena need not rely on nitrogen dissolved in water (such as ammonia) and can pull it from the atmosphere (Pearl, 997). In Oregon, there has been regulation and oversight over how much phosphorous enters into a system, however, levels of nitrogen have not been regulated with the same frequency. When it comes to which types of cyanobacteria are more prevalent in Oregon, the non-nitrogen fixer Microcystis has dominated ecosystems since 2013 (OHA Archive), preceded by the nitrogen fixer Anabaena. Furthermore, Microcystis grows somewhat faster than nitrogen-fixing cyanobacteria, especially at higher temperatures (Chapra, 8396). The abundance of Microcystis for the past seven years implies that there is more than enough nitrogen available for non-nitrogen fixers to thrive. The regulation around point source water is usually on par with limiting the amounts of nutrients being added into a water system, but most of the nutrient content comes from nonpoint source loadings (Pearl, 1004). Nonpoint source loadings are also more difficult to regulate than point source.

Detecting/Notifying

Prior to 2004, alerts were not posted for Oregon lakes until the lakes reached a toxigenic cell density threshold exceeding 20,000 cells/mL. In 2005, the alert system was changed to require two triggers, one for visible scum on the top of the water, and the other for when cell density reached 100,000 cells/mL (unless the bloom contained Microcystis or Planktothrix) (Stone, 142). If the bloom had Microcystis or Planktothrix, then the threshold was 40,000 cells/mL. These were advisories, however, not lake closures, and they were dispersed through press releases to various media. This system was in place until 2014, and now we have the current system of advisories denoted by parts per billion.

This year, the state of Oregon has also implemented a new method of detection, qPCR (quantitative Polymerase Chain Reaction), for variations of microcystin producers in order to predict toxin production. This detection system is important because microcystin has been the most abundant cyanotoxin in Oregon since 2013. qPCR can reflect the levels of biomass, variation, bloom development, and toxin which leads to a better prediction of future cyanoHABs, especially of Microcystis (Lu, 10). qPCR is a method being implemented in addition to the state's use of Enzyme-linked immunosorbent assay (ELISA) testing and Solid Phase Adsorption Toxin Tracking (SPATTS) testing methods. This can be beneficial because the ELISA testing method can at times produce false positives.

Other methods of testing for cyanoHABs are by measuring Adenosine Triphosphate (ATP) levels, hyperspectral remote sensing, and monitoring alerts from the Environmental Protection Agency's (EPA's) new prototype CyAN app. One recent study by the Southern Nevada Water Authority (SNWA) shows the value of testing ATP to determine how much cyanobacteria is found within a sample taken. This test is low cost and results can be obtained in 10 minutes or less. However, this method is unable to determine which cyanobacteria is present (Greenstein, 178). SNWA conducted this test using water samples from Lake Mead as well as lab-cultured M. aeruginosa (Greenstein, 172). Next, the United States Geological Survey (USGS) has created a dataset that is a collection of hyperspectral imagery profiles of 13 common algae associated with cyanoHABs. It has been suggested that using satellite data to identify blooms in remote areas can be beneficial, especially having hyperspectral characterization keys, but these areas of remote sensing would need further testing to confirm the presence of cyanobacteria. Finally, the EPA has developed a prototype app called EPA CyAN that can track current HABs locations and cell counts. This can be a useful tool in notifying both the public and officials of blooms.

Long-Term Remedies/Prevention

Long-term remedies are explored in-depth in studies geared towards restoration of ecosystems, such as increasing the amount of aquatic plants within a watershed to absorb nutrients. This is a long-term strategy to decrease the amount of nutrients deposited into a waterbody such as a lake or reservoir (Haggard, 14). The more aquatic plants, the more sediment and nutrients that get caught and absorbed for fuel (Hall, 2). Also, as wetlands have been subject to urbanization and drainage, there has been removal of aquatic plants and foliage in Oregon. With less foliage and no wetlands to brace the amount of water that is carried from rainfall/winter runoff, water moves faster through these areas increasing the amount of sediment and nutrient deposits that reach freshwater or marine ecosystems (Hall, 11).

Next, one study provides that moving closer to a system of proper functioning conditions (PFC) of watersheds could be a more optimal, proactive way to prevent cyanoHABs. "PFC refers to how well the physical processes within a stream and wetland riparian area can sustain a state of resiliency" (Hall, 4), specifically, resiliency to changes in the stream and sediment/nutrient introduction to the riparian system. This study provides steps for long-term mitigation of cyanoHABs through "managing ecological functions to reduce transport of excess nutrients, thus preventing potential CyanoHABs," (Hall, 15). This is all a part of PFC for riparian ecosystems, to provide the self-healing needed to restore sediment deposition and nutrient sequestration, and the assimilation processes that are important in improving water quality (Hall,15).

Short-Term Remedies/Treatment

Short-term remedies are steps that we can take now in order to help prevent future cyanoHABs. One way to mitigate and slow cyanoHABs in the short term is to mitigate the amount of nutrients discharged into a watershed. In the case of Lemolo Lake, switching from clear-cutting forests in the mid 1990's to timber thinning by 2005 provided the ecosystem with a greater capacity to absorb phosphorous, and decreased the rate of flow from the upland areas (Hall, 7). The lower rate of flow allows for greater deposit of sediments and phosphorous along with it. As for Tenmile Lake, increased logging and urbanization leading to the drainage of wetlands increased both the amount of nutrients and the flow of water within a watershed (Hall, 10). These conditions improve the chances of cyanoHABs. As stated above, most nutrients come from nonpoint sources of water including agriculture and urban settings, and nitrogen limits in Oregon are not as strict as phosphorous limits. Setting guidelines for nitrogen and nonpoint sources are critical for preventing excess nutrients in a watershed.

Furthermore, some aquatic plants can suppress certain cyanobacteria in the short term. A study conducted in Upper Klamath Lake demonstrates that barley straw releases antimicrobial compounds, which, when faced with pressures from disease, killed and/or suppressed the cyanobacteria Aphanizomenon flos-aquae (A. flos-aquae) which are known to produce neosaxitoxin and saxitoxin (Sivonne, 12). The introduction of barley straw as well as other wetland plant material can increase suppression and mortality rates of A. flos-aquae, but adding these plants can also increase the amount of phosphorous within a system (Haggard, 21). The use of barley straw is a double-edged sword, but with mitigation of phosphorous from nonpoint sources could result in mitigating cyanoHABs.

A recent study also finds that the addition of aluminum sulfate and ammonium nitrate may help to reduce the amount of cyanobacteria within a body of water through creating larger N:P ratios (Harris, 91). Researchers found that by adding these two compounds to a water body, the total amount of phosphorous was decreased, whereas the nitrogen levels increased, creating a short-term fix to remove some cyanobacteria (Harris, 91). However, this short-term treatment is not without consequence. By N-loading a water body to increase the N:P ratio, it increases the toxicity and ammonia levels of the water body and adding chemicals such as these into the ocean is also undesirable (Harris, 88). The goal would be to nudge the N:P ration just over the limit of 50. Further, this treatment would be applied on an as-needed basis and may not be right for all water bodies and will require a permit for N-loading (Harris, 90).

Information and Databases

There are currently several datasets and general information relating to cyanoHABs in various places in Oregon. Data reports given by the Deschutes River Alliance have water quality reports of the river, but these reports are not limited to just cyanoHABs. Next, the Clackamas River Basin has a partnership in monitoring water quality with PGE and they have compiled reports of water quality as well. This is a management strategy that could potentially be used by other water providers with limited funding resources. Another database is the data from long-term monitoring of the upper Klamath Basin. It is a long-term water quality monitoring program conducted by USGS and boasts a continuous monitoring network of the upper basin. These three databases all have different datasets and reports that are not uniform and are posted to different websites, making them difficult to find for the public and officials unaware of these resources. The final database comes from the Oregon Health Authority (OHA). They have compiled a database of cyanotoxins that have been found in drinking water since 2018. The database includes the distribution system, entry point, source, and common header and can be separated by county and agency.

Additionally, there are two resources that can be helpful in the future as tools to predict and monitor cyanoHABs. First is The Prediction Lab, that made predictions of cyanoHABs in Detroit Lake for the 2019 season that were fairly on par with the blooms that occurred there and accurately predicted the crests and trophs of cyanobacterial development. Another potential tool to look at is the California government’s water quality monitoring website that specifically deals with HABs. This site can be used as a potential blueprint for an Oregon website for monitoring and notifying the public of cyanoHABs.

Lastly, the Oregon Department of Environmental Quality’s HABs Strategy has general information and management practices that the state is undergoing to combat cyanoHABs and gives a great overview of everything studied and management until 2011.

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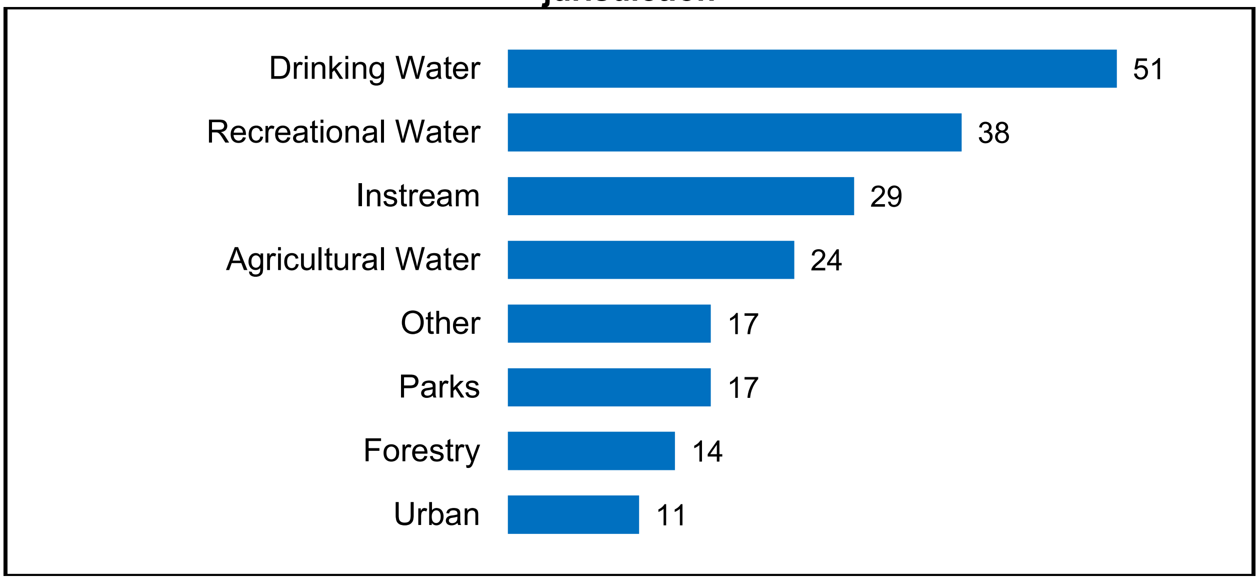
APPENDIX C

Overview of characteristics of organizations represented in survey responses
Drinking water was the category of water most of the respondents selected as the category their organization has jurisdiction over or generally coordinates with when considering harmful algal blooms (HABs), followed by recreational water. Instream water was selected by 29 respondents and agricultural water was selected by 24 (Figure 1). Reservoirs not providing drinking water, wetlands, wildlife habitats, private intakes of drinking water, hydropower, and water used in production were mentioned in the Other category of jurisdiction.

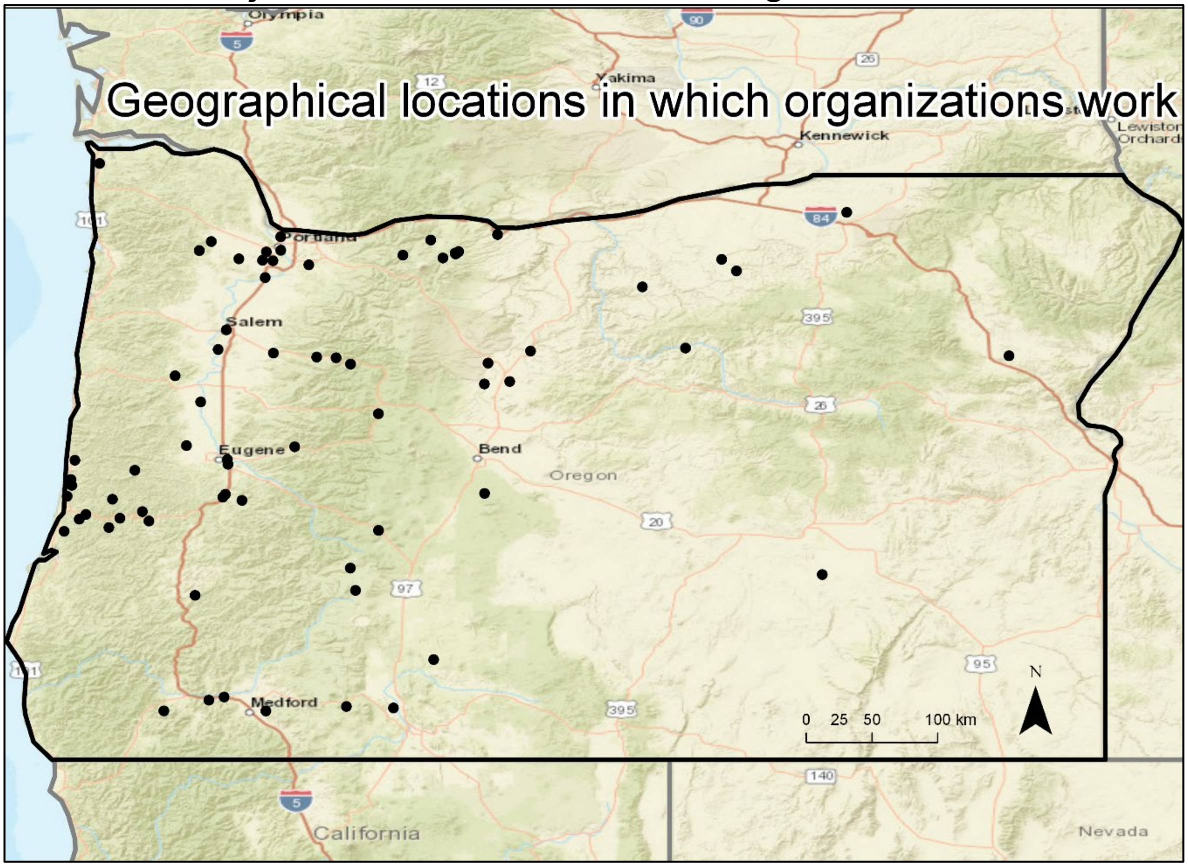
Figure 1. Categories of water over which respondents' organizations have jurisdiction



Source: Legislative Policy and Research Office

The specific geographic locations in which the respondents' organizations or agencies work are represented in Figure 2 below, while 27 organizations represented in the survey reported to work on HABs statewide.

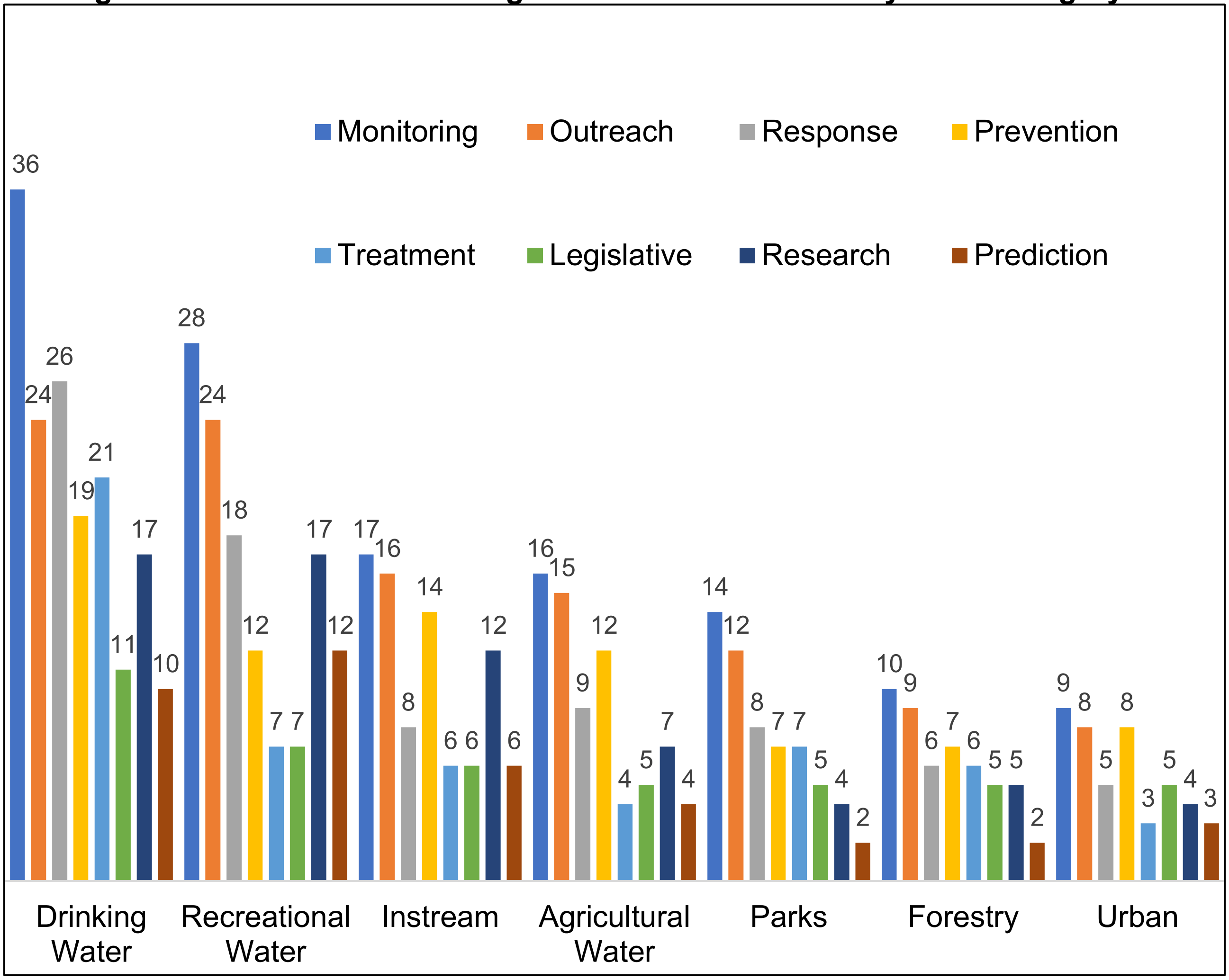
Figure 2. Map of the geographical locations over which organizations have jurisdiction to address Harmful Algal Blooms



Source: Legislative Policy and Research Office

Respondents categorized the activities of their organizations regarding harmful algal blooms, and Figure 3 represents the activities undertaken for the different categories of water the organizations work on. The most prevalent activity in all categories is monitoring, followed by outreach. Prevention, research, and legislative actions are the least frequent activities undertaken across all categories.

Figure 3. Activities in which organizations are involved by water category



Source: Legislative Policy and Research Office

The specific activities undertaken by the organizations are visualized in the word cloud below (Figure 4). The most frequent activity was monitoring (26 respondents). Outreach was the next most frequent activity undertaken by organizations represented in the survey (eight respondents), followed by treatment, prevention, and sampling (four respondents each). Research and legislative activities were undertaken by three organizations each as per survey respondents.

Figure 4. A word cloud representation of the specific activities undertaken by organizations, where the size of each word indicates its frequency

Source: Legislative Policy and Research Office

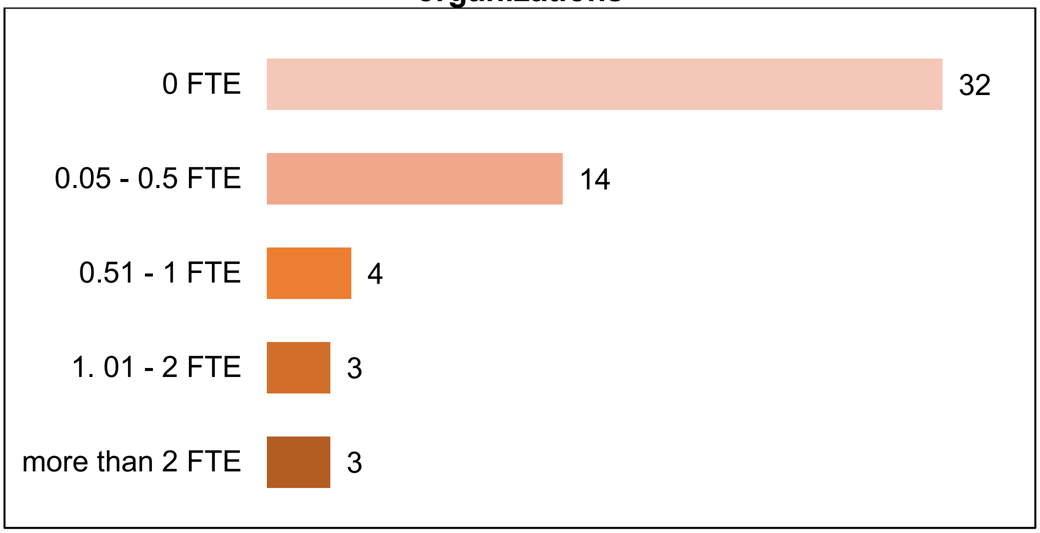
Based on the respondents' answers, 24 of the organizations represented in the survey have been engaged in HABs efforts for over 10 years, 17 have been working in this area for five to 10 years, and 19 have been engaged in the specific activities for less than five years (Fig 5).

Figure 5. Length of time organizations have been engaged in HABs efforts

Source: Legislative Policy and Research Office

Among the organizations represented in the survey, three of them utilized more than two full time equivalent (FTE) positions specific to HABs in their approximate overall 2019 budget, while 32 had 0 FTE specifically dedicated to HABs (Fig 6).

Figure 6. FTEs dedicated specifically to HABs in the 2019 budgets of organizations

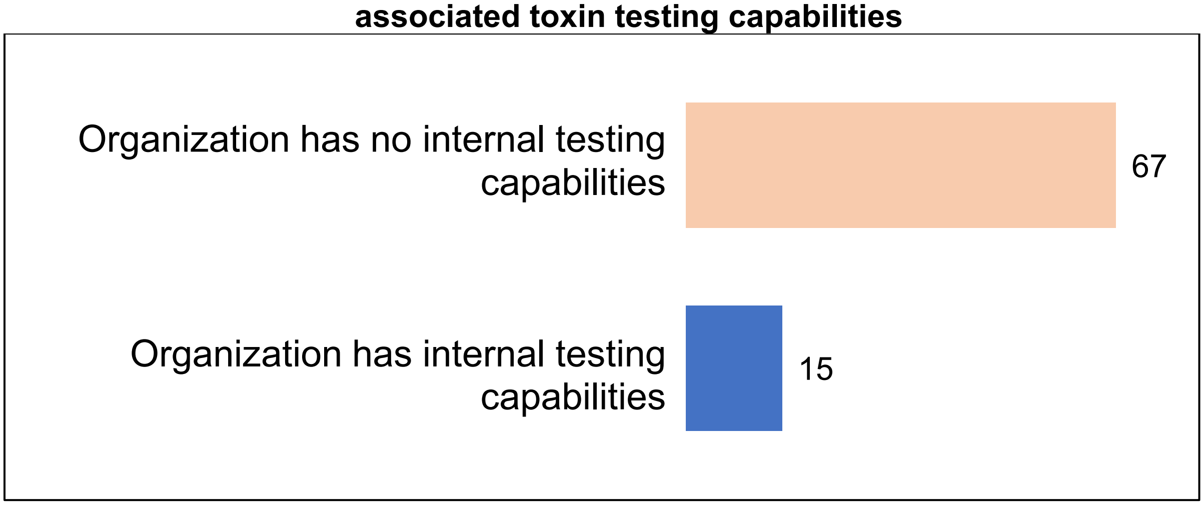


Source: Legislative Policy and Research Office

Testing capabilities

Sixty-seven (67) respondents answered that their organization did not have internal cyanoHABs or associated toxin testing capabilities, while 15 said their organizations do have cyanoHABs or associated toxin testing capabilities (Figure 7).

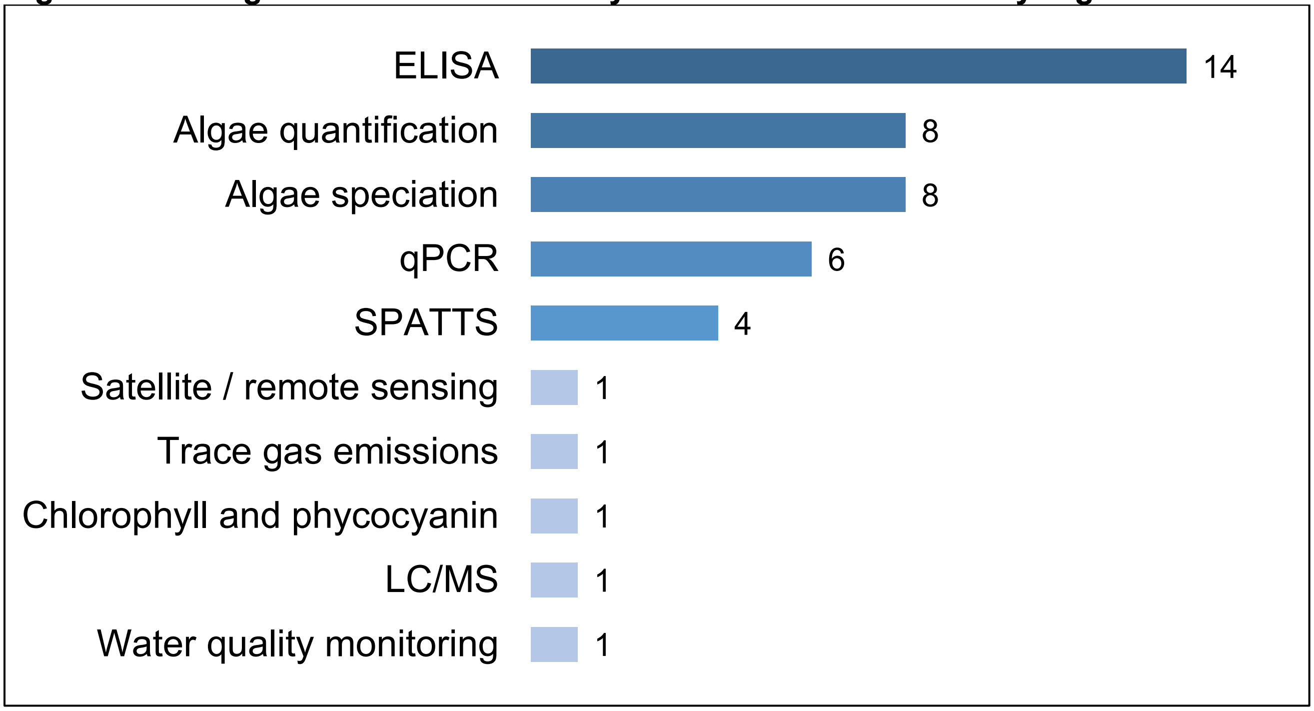
Figure 7. Number of organizations with and without internal cyanoHABs or associated toxin testing capabilities



Source: Legislative Policy and Research Office

The organizations that do have internal cyanoHABs or associated toxin testing capabilities described their testing and mechanisms able to be used to conduct cyanoHABs testing (Figire 8). The most commonly used was ELISA (14 respondents), followed by algae quantification and speciation (eight respondents).

Figure 8. Testing and mechanisms for cyanoHAB detection used by organizations



Source: Legislative Policy and Research Office

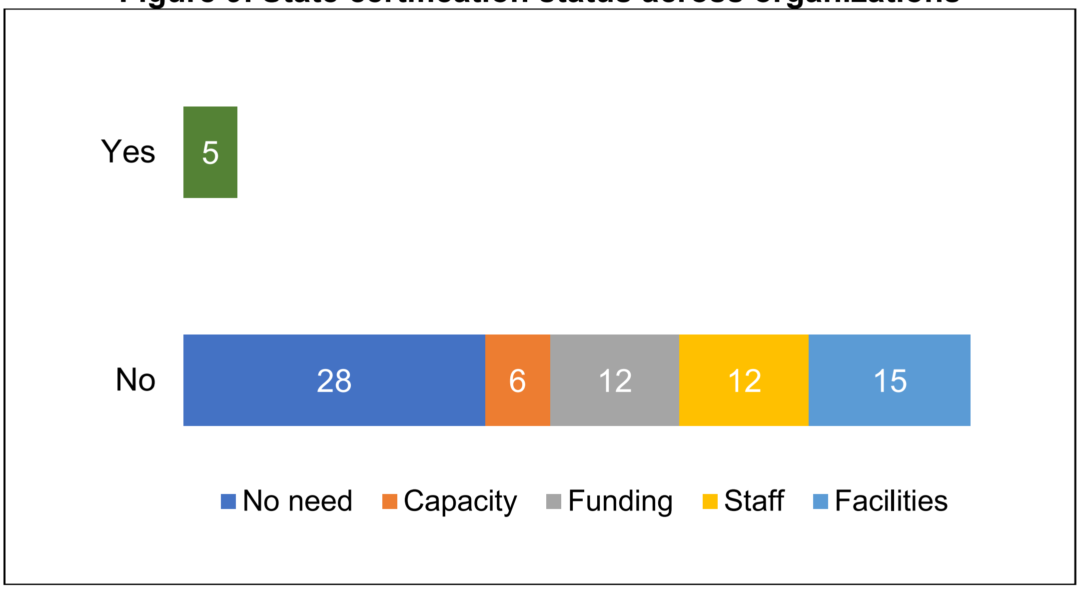
Table 1 describes the specific testing and mechanisms used to conduct cyanoHABs testing by the organizations represented in the survey.

Table 1: Specific testing and mechanisms used to conduct cyanoHABs testing

ELISA	Algae Speciation	Algae Quantification	qPCR	SPATTS	Other
• DEQ18-LAB-0050-SOP • EPA Standard Method 546 • In-house ELISA testing for microcystin and cylindrospermopsin • Cyanotoxin automated assay system • Water samples • Abbraxis kits • Measuring levels of cyanotoxins	• Contract with BSA Environmental for algae ID • Microscopic evaluation • Send to outside lab to ID species found in HABs • Microscopic identification and sequencing filter samples for 16s sequence • FlowCam	• Contract with BSA Environmental for algae enumeration • Utermohl chamber • Chlorophyll-a biomass • Send to outside lab to quantify number of cells per species • Contract to various labs combined with multiparametric and other statistical analysis • Counting cells and fluorometric measurements of chlorophyll-a • FlowCam	• Phytoxigene CyanoDTec kits and SYBR qPCR and RT-qPCR on a portable thermocycler and a Fluidigm Biomark HD system • RT-qPCR & phytoxigene, • OH USGS lab • Send to outside lab for IDing toxin potential production	• Partnership w/USGS • Research on SPATT results compared with grab samples of aquatic and benthic algae • Measuring the prevalence of cyanotoxins in select water bodies	• Continuous data monitoring of water quality and pigments associated with cyanoHABs • EPA Standard Method 545 • Real-time WQ probes installed in sondes downstream of reservoirs, in river, and elsewhere in watershed for early warning • Proton transfer reaction mass spectrometry

Only five of the organizations represented in the survey were state-certified for testing for cyanoHABs or associated toxins (Figure 9). Of those organizations not state certified for testing for cyanoHABs or associated toxins (73), 28 reported that their organizations have not pursued certification because it is not a necessity for the work they are doing, while the rest faced barriers to certification such as lack of facilities and equipment (15), lack of trained staff (12), lack of funding (12), or no in-house capacity, such as time and space, to run a testing program (5).

Figure 9. State certification status across organizations



Source: Legislative Policy and Research Office

Research on benthic cyanobacteria

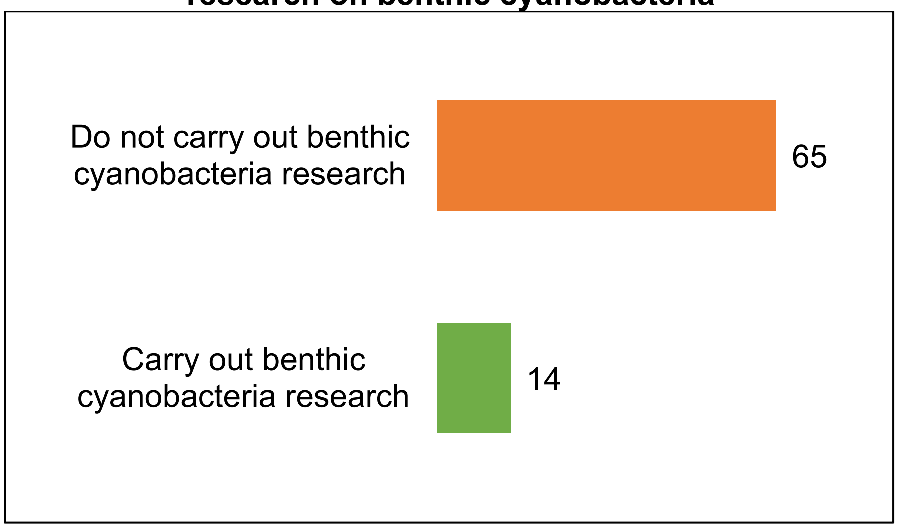
Of all the organizations represented in the survey, only 14 organizations research benthic cyanobacteria, and they study a variety of bodies of water - rivers, reservoirs, lakes, and waterbodies under development, such as:

- Billy Chinook Lake
- Blue River
- Clackamas River
- Cougar Reservoir
- Crooked River
- Detroit Reservoir
- Keizer Slough
- Lakes in Washington State (over 100)
- Lower Deschutes River
- McKenzie River
- N. Santiam River
- Ross Island Lagoon

- Santiam River
- South Fork
- Tualatin River
- Upper Klamath Lake
- Willamette River
- Confidential sites

Sixty-five (65) organization representatives responded that their organizations do not carry out research on benthic cyanobacteria (Figure 10).

Figure 10. Comparison of number of organizations that do and do not carry out research on benthic cyanobacteria



Source: Legislative Policy and Research Office

Detection of specific toxins and organisms
Respondents described where and how their organizations detected the presence of specific cyanobacteria or cyanotoxins, summarized in Table 2. The most common methods of detection were ELISA, LC/MS/MS, SPATT, UCMR-4: EPA 544,545 & 546, and genetic IDs.

Table 2: Locations of detection of specific cyanotoxins and cyanobacteria

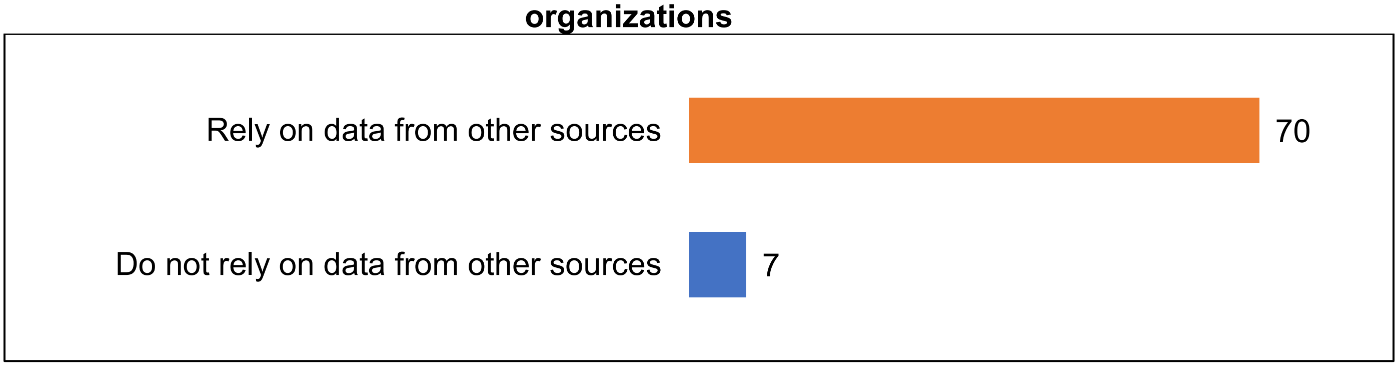
WHAT?	WHERE?
ANATOXIN A	Clackamas River, Detroit Reservoir, Santiam River, McKenzie River, Blue River Reservoir, S. Umpqua River, North Fork Res, Ross Island Lagoon, Tenmile Lakes, various Cascades rivers and lakes, Anderson Lake, Lone Lake, Fairview Lake

MICROCYSTIN	Detroit Reservoir, Odell Lake, Lake Selmac, Willamette River, Klamath Lake, South Umpqua potholes, Scoggins Reservoir, L. Carpenter Creek, Lake Billy Chinook, Lava Lake, Brownlee Reservoir, City of Stayton raw water intake, City of Gates raw water intake, City of Salem raw water intake, City of Salem distribution system, Clackamas River, Big Cliff Reservoir, Santiam River, Siltcoos Lake, McKenzie River, Powder River Arm of Brownlee, Blue Lake, Junipers Reservoir, Willow Creek Reservoir, Tenmile Lakes, Cullaby Lake, Green Lake, South Twin Lake, Miller Lake, Fairview Lake
SAXITOXIN	Detroit Reservoir, Clackamas River, Santiam River, McKenzie River, Powder River Arm of Brownlee Reservoir, Lemolo Lake, Dorena Reservoir, Fairview Lake, Middle Fork Willamette River, various Cascades rivers and lakes
CYLINDROSPERMOPSIN	Willamette River, Big Cliff Reservoir, Siltcoos Lake, Clackamas River, Santiam River, McKenzie River, Blue River Reservoir, Cougar Reservoir, Detroit Lake, Dexter Reservoir, Eckman Lake, Suttle Lake, Wickiup Reservoir, Ross Island Lagoon, Tenmile Lakes, various Cascades rivers and lakes, Fairview Lake, Timothy Lake
DOLICHOSPERMUM	Ross Island Lagoon; Lakes: Middle Erma Bell, Suttle, Odell, South Twin, Diamond, Paulina, Lava, Little Lava, Miller, Marion
GLOEOTRICHIA	Diamond Lake
MICROCYSTIS	Ross Island Lagoon

Data and information sources

Many organizations rely on information and data from other organizations/agencies (70), as seen in Figure 11.

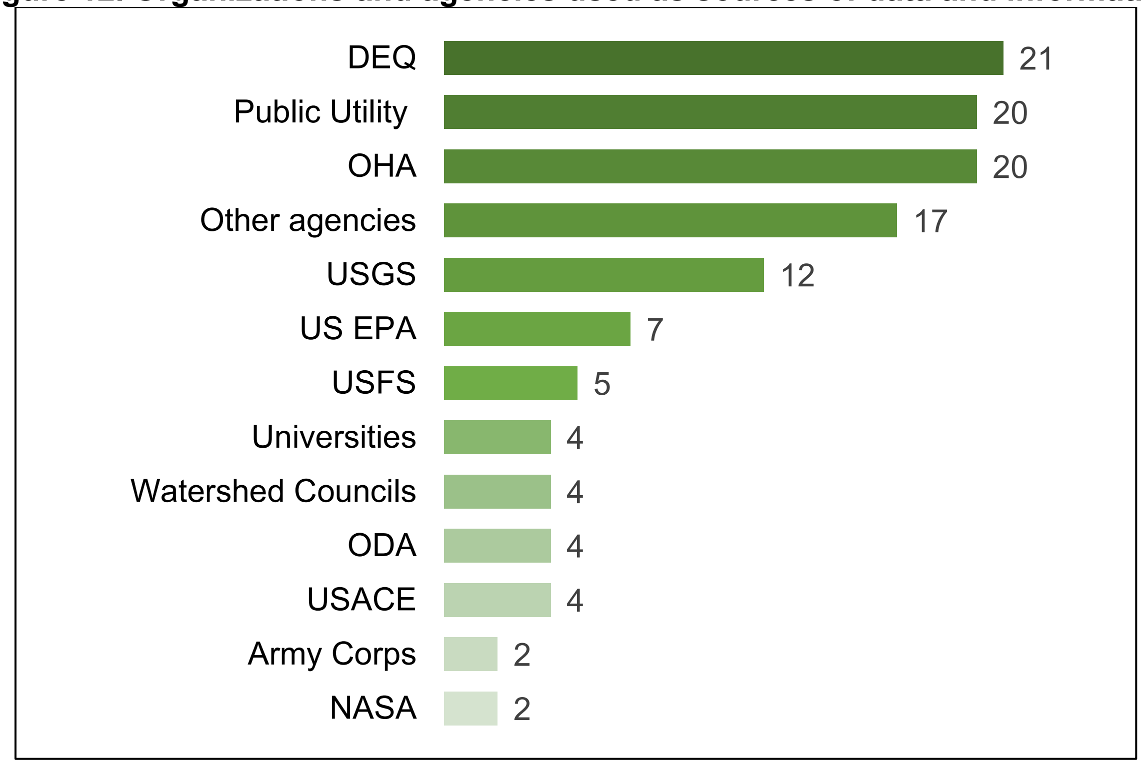
Figure 11. Organizations' reliability on other sources of data, like agencies or organizations



Source: Legislative Policy and Research Office

Most organizations used the DEQ, various public utilities, and OHA as sources of cyanoHABs information and data, followed by the USGS, US EPA, USFS, several Oregon universities and watershed councils, ODA, USACE, the Army Corps, and NASA.

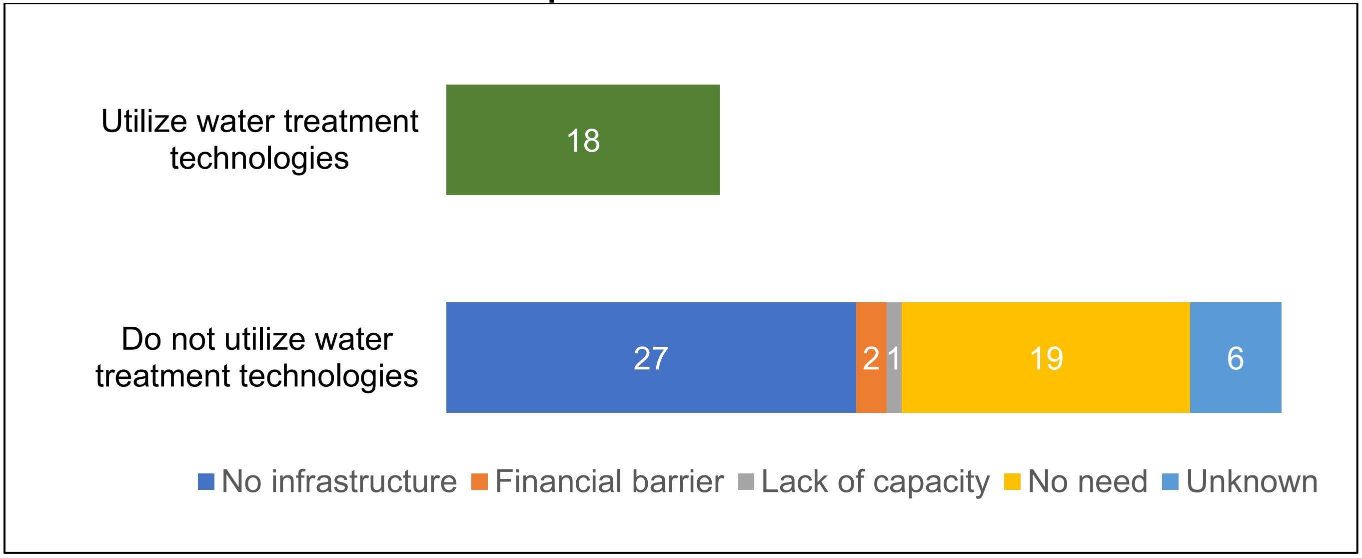
Figure 12. Organizations and agencies used as sources of data and information



Source: Legislative Policy and Research Office

Only 18 respondents reported that their organizations utilize water treatment technologies capable of addressing potential cyanotoxins from HABs (Fig 13). The organizations that currently do not utilize water treatment technologies capable of addressing potential cyanotoxins from HABs either did not have the infrastructure to implement water treatment and/or internal testing technologies (27) or this was not in the scope of their work (19). Three organizations noted that they would utilize water treatment technologies if they had the capacity to do so (presently, they are unable due to lack of funding and staff).

Figure 13. Utilization of water treatment technologies and barriers to implementation

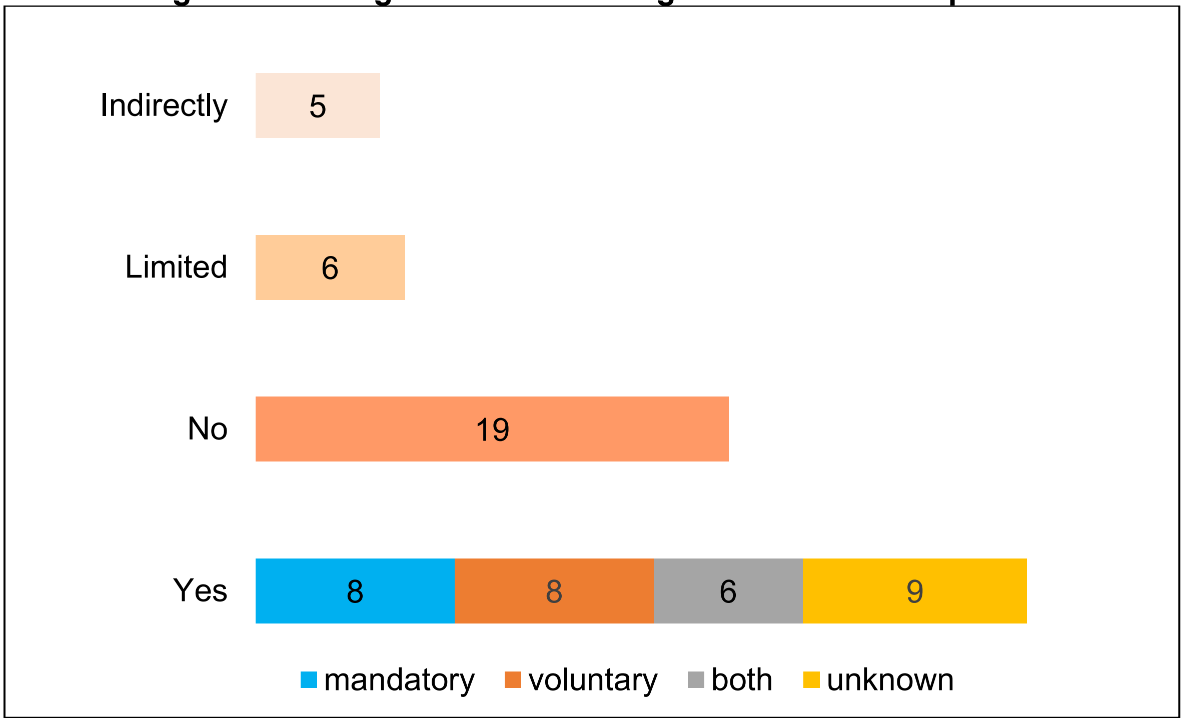


Source: Legislative Policy and Research Office

Disclosing advisories to the public

In terms of disclosing advisories to the public, 19 organizations represented in the survey did not disclose any advisories to the public and eight representatives said this does not apply to their organizations (Figure 14). Some organizations were only required or allowed to disclose advisories to the public in specific circumstances (6) or they did so indirectly via other organizations that they work with (6). Six organizations represented in the survey disclosed advisories both mandatorily and voluntarily, while eight did so mandatorily and another eight did so voluntarily.

Figure 14. Categories of disclosing advisories to the public



Source: Legislative Policy and Research Office