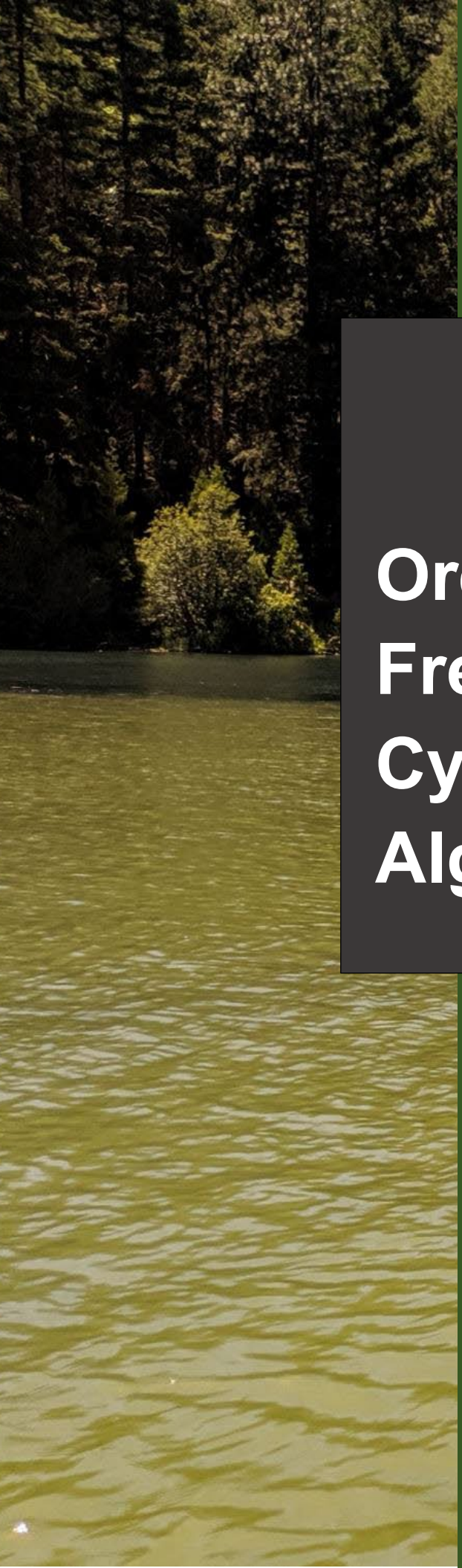

Oregon DEQ Freshwater Cyanobacteria Harmful Algal Blooms Strategy

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List of Acronyms

Acronym	Title
BEACH	Beach Environmental Assessment Communication and Health
BMP	Best Management Practices
CWA	Clean Water Act
CyanoHAB	Cyanobacteria harmful algal bloom
DEQ	Department of Environmental Quality
DWP	Drinking Water Protection
DWS	Drinking Water Services
DMAs	Designated Management Agencies
EP	Entry Point
EPA	U.S. Environmental Protection Agency
EQC	Environmental Quality Commission
FIFRA	Federal Insecticide Fungicide and Rodenticide Act
FPA	Forest Practices Act
FTE	Full Time Equivalence
GIS	Geographical Information Systems
HCB	Harmful Cyanobacterial Bloom
IMD	Internal Management Directive
LA	Load Allocation
LEAD	Laboratory Environmental Assessment Division
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
OAR	Oregon Administrative Rule
ODA	Oregon Department of Agriculture
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
OHA	Oregon Health Authority
OWEB	Oregon Watershed Enhancement Board
PWS	Public Water System
QAPP	Quality Assurance Project Plan
RP	Responsible Person
RUV	Recreational Use Value
SAP	Sampling Analysis Plan
SRF	State Revolving Fund
SWA	Source Water Assessment
TMDL	Total Maximum Daily Load
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
WLA	Waste Load Allocation
WMS	Watershed Management Section
WQA	Water Quality Assessment
WQP	Water Quality Permits
WQS	Water Quality Standards
WPCF	Water Pollution Control Facilities
WQMP	Water Quality Management Plan

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Overview and purpose

Freshwater Cyanobacteria Harmful Algal Blooms

Microscopic freshwater organisms that perform photosynthesis, otherwise known as algae, provide important food resources for aquatic food webs in lakes, reservoirs, streams, and rivers. However, under certain conditions, algal populations can grow at an accelerated rate and result in a "bloom." In some cases, these algal blooms can create harmful conditions by degrading water quality, producing toxins dangerous to humans and animals, or a combination of both.

Harmful blooms of a particular type of aquatic bacteria that has been historically grouped with algae-cyanobacteria-pose specific threats to water quality and human health in freshwater ecosystems. Cyanobacteria Harmful Algal Blooms (CyanoHABs; also referred to as HCBs) can impair water quality by degrading pH and dissolved oxygen conditions and produce a class of compounds known as cyanotoxins. Cyanotoxins threaten humans, wildlife, livestock, and fisheries because these compounds can cause a variety of sicknesses, and possibly death, from exposure or ingestion. The frequency, extent, and magnitude of CyanoHABs in waterbodies can respond to a variety of individual and combinations of factors, including changes in water temperature, nutrient loading, and hydrologic conditions within watersheds.

This document focuses on freshwater CyanoHABs and does not address harmful algal blooms that occur in estuarine and marine environments. However, concepts and actions identified in this document could eventually be used to address blooms in these waters. Appendix A: Marine HABs provides background on cyanobacteria and other types of harmful algal blooms in estuarine and marine ecosystems.

CyanoHABs in Oregon

Public concern over freshwater CyanoHABs has increased in Oregon since the early 2000s. From 2007 to 2023, 189 recreational advisories were issued by the Oregon Health Authority (OHA) for elevated cyanotoxins in waterbodies across the state (Oregon Health Authority, Cyanobacteria Advisory Archive, 2022). In 2018, a CyanoHAB in Detroit Reservoir caused the city of Salem to issue a "Do Not Drink" advisory for vulnerable populations (the young, elderly, and immunocompromised) due to elevated cyanotoxins in finished drinking water.

In 2010, the Department of Environmental Quality (DEQ) started to include waters with documented CyanoHABs on its list of impaired waters, as required under Section 303(d) the Clean Water Act (US EPA, Clean Water Act Section 303(d): Impaired Waters and Total Maximum Daily Loads (TMDLs), 2021)). These waterbodies do not meet water quality standards and thus do not support designated beneficial uses (drinking water, recreation, or agricultural/livestock use). The listing of a waterbody as impaired by a CyanoHAB requires DEQ to determine the cause(s) and establish a plan known as a Total Maximum Daily Load, or TMDL, for meeting water quality standards. At the time of the development of this strategy, the

current EPA-Approved 2022 Integrated Report lists 53 waterbodies as water quality impaired by CyanoHABs (Oregon Department of Environmental Quality, 2022 Final Integrated Report, 2022). Seven of the 53 waterbodies have established TMDLs for addressing CyanoHABs (Category 4A) and one has a Category 4B Alternative Plan in place.

The 2023 DEQ CyanoHAB strategy described here documents DEQ's actions to support the statewide monitoring, response, assessment, and management of CyanoHABs in Oregon. This strategy provides significant updates to the DEQ HABs strategy presented in 2011 (Oregon Department of Environmental Quality, Oregon DEQ Harmful Algal Bloom (HAB) Strategy, 2011). Recommendations in the 2023 strategy support continued implementation of several of the actions proposed in 2011 and identifies additional needs to support and expand current operations. Recommendations described in the strategy may require additional funding from state, federal, or other applicable sources.

Goals and objectives

The goal of this strategy is to outline the approach DEQ takes to detect, monitor, assess, and manage CyanoHABs as an agency and in coordination with partner agencies and interested parties. In the process of working toward this goal, we have identified gaps and have developed recommendations to improve and expand the DEQ CyanoHABs strategy.

Objectives of this strategy include:

- Describe the specific ways in which DEQ works with OHA and other state, federal, and external partners to detect, monitor, and manage CyanoHABs in drinking water sources and recreational waterbodies
- Describe the process by which DEQ identifies, lists, examines, monitors, and manages CyanoHABs within the framework of the Clean Water Act
- Provide decision points, process steps, data needs, and flow diagrams for how different subprograms work on CyanoHABs within DEQ
- Identify and quantify DEQ resources used on efforts to address CyanoHABs in Oregon

Purpose

The purpose of DEQ's CyanoHAB Strategy is to protect public health and the environment. The primary audience for this 2023 strategy is the State of Oregon and DEQ management and staff and is intended to function as an operational manual. However, the strategy can also be used by other government agencies and the public to understand decision points, processes, and responsible programs in the various components of the strategy. The overall effort to address CyanoHABs involves a broad partnership of federal, state, and local partners. Implementation of statewide actions to address CyanoHABs requires strong collaborations among all partners.

This strategy document does not contain in-depth background information, current areas of research, or policy positions on CyanoHABs. Background and policy information can be

accessed from the 2011 DEQ HABs strategy (Oregon Department of Environmental Quality, Oregon DEQ Harmful Algal Bloom (HAB) Strategy, 2011), from the US EPA's CyanoHABs website (US EPA, Cyanobacterial Harmful Algal Blooms (CyanoHABs) in Water Bodies, 2023), and the Interstate Technology Regulatory Council's Harmful Cyanobacteria Bloom website (Interstate Technology Regulatory Council, 2022).

DEQ Freshwater CyanoHAB Strategy components

DEQ's strategy for addressing Freshwater CyanoHABs includes three main components:

- Drinking Water CyanoHABs: Monitoring and Public Health Response
- Recreational Freshwater CyanoHABs: Public Health Response
- Clean Water Act Freshwater CyanoHABs: Assessment and Actions

Detailed schematics and explanations of the collaborative process among DEQ, OHA, and other local, state, and federal partners can be accessed through the links above. For two of these components - drinking water and recreational use advisories - DEQ coordinates with OHA to monitor, sample, and analyze water quality samples for cyanotoxins. OHA issues and lifts public drinking water and recreational use advisories for freshwater CyanoHABs. OHA maintains a drinking water and recreational website that shows these advisories and links to other general information regarding CyanoHABs (Oregon Health Authority, Oregon Drinking Water Services, 2022; Oregon Health Authority, Cyanobacteria Blooms, 2022). DEQ maintains a list of waterbodies impaired by CyanoHABs that can be accessed from the Water Quality Assessment Integrated Report website (Oregon Department of Environmental Quality, 2022 Final Integrated Report, 2022).

Drinking Water CyanoHABs: Monitoring and Public Health Response

This section describes the ways in which DEQ works with the OHA Drinking Water Services (DWS) and other partners to address CyanoHABs in Public Drinking Water Systems (PWSs). Under an interagency agreement, the TMDL and Drinking Water Protection (DWP) programs and LEAD provide technical assistance and laboratory analysis to OHA DWS and as part of voluntary actions by PWSs. These administrative rules comprise Oregon's directives for cyanotoxin monitoring that apply to select PWSs and establish minimum requirements for monitoring and public notification. The Drinking Water CyanoHABs figure below highlights the roles and responsibilities each agency and partners have for monitoring and public health response. Details for each of the schematic components are described subsequently. Table **2** describes specific activities and subprograms currently active or needed for addressing drinking water issues related to CyanoHABs in Oregon freshwaters.

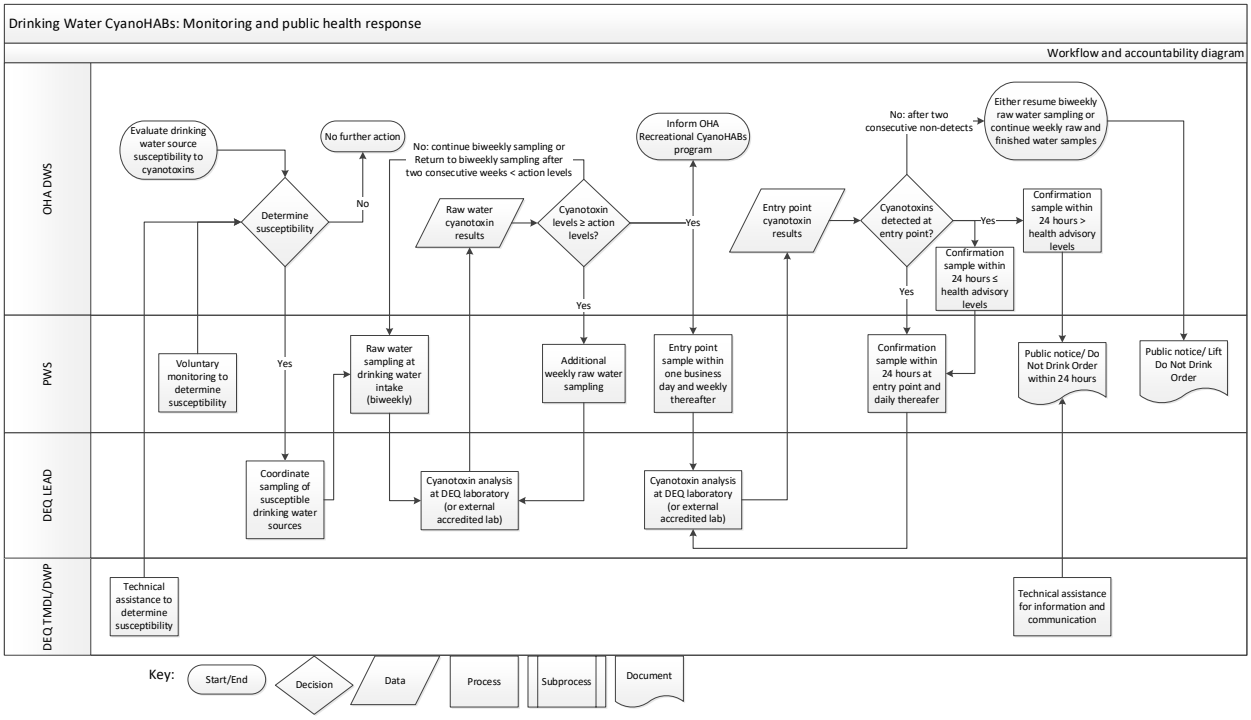

Figure 1. Workflow and accountability diagram for DEQ and partners describing monitoring of and response to CyanoHABs in Oregon's drinking water sources.

Starting point: Evaluate drinking water sources susceptible to cyanotoxins

Decision point: Determine susceptibility

OHA DWS decides if a drinking water source is susceptible to contamination by cyanotoxins with technical assistance from the TMDL and DWP programs. A drinking water source is considered susceptible to cyanotoxins if it uses a surface water source that:

- has had a documented CyanoHAB or cyanotoxin detection in the past
- is downstream from a waterbody with past CyanoHAB or cyanotoxin detections
- is determined to be susceptible to cyanotoxins as determined by WSA in the Integrated Report (algae and aquatic weeds)

Susceptible drinking water sources can also be identified based on the characteristics of the source (e.g., slow-moving or stagnant water, temperature, excess nutrient loading, water quality data, satellite imagery, presence of microcystin- or cylindrospermopsin-producing genes, or other relevant information).

Additionally, a PWS is considered susceptible and subject to OARs 333-061-0510 to 333-061-0580 if a PWS purchases and supplies water from a source deemed susceptible according to the criteria described above.

OHA DWS can approve voluntary cyanotoxin monitoring upon request by PWS if factors in the watershed indicate potential susceptibility (i.e., a potential bloom in an upstream waterbody). If cyanotoxins are detected, the drinking water source meets the definition of susceptible and the public water system them becomes are subject to the cyanotoxin rules (OARs 333-061-0510 to 333-061-0580**).**

The DWP and OHA DWS have created Source Water Assessments for most PWSs in Oregon (Oregon Department of Environmental Quality, About Drinking Water Protection, 2023). Using these and other resources, DEQ provides technical support to OHA for the identification and confirmation of susceptible drinking water sources.

If a drinking water source is deemed susceptible, OHA DWS coordinates with the DEQ Laboratory and Environmental Assessment Division (LEAD) on communicating and scheduling seasonal (May – October) biweekly sampling of cyanotoxin levels in raw water from the source by the PWS. If deemed not susceptible, no further actions or sampling are required. However, the PWS may sample raw water voluntarily. The flowchart OHA DWS uses for sampling and decision points for susceptible water sources is consistent with the flow diagram presented in this section (Oregon Health Authority, Cyanotoxin Monitoring Requirements For Sources Determined to be Susceptible, 2023).

Raw water sampling at intake (biweekly)

PWSs deemed as susceptible to CyanoHAB by OHA DWS must sample raw water every two weeks from May 1 to October 31 each year or until the system is no longer considered susceptible. Cyanotoxin samples must be analyzed at a laboratory accredited by the Oregon Environmental Laboratory Accreditation Program or by LEAD (which most PWS currently use). The DEQ Harmful Algal Blooms: Drinking Water Cyanotoxin Monitoring page has guidance for water systems needing to sample (Oregon Department of Environmental Quality, Harmful Algal Blooms: Drinking Water Cyanotoxin Monitoring, 2023).

Decision point: Are cyanotoxins in raw water above action level?

Biweekly sampling of cyanotoxins in raw water continue from May 1 to October 31 for susceptible PWS unless concentrations of total microcystins ≥ 0.20 µg/L or cylindrospermopsin ≥ 0.30 µg/L. Upon detection of total microcystins ≥ 0.20 µg/L or cylindrospermopsin ≥ 0.30 µg/L in raw water:

- The PWS must immediately increase raw water monitoring to weekly and sample finished water within one business day and weekly thereafter. If cyanotoxins are detected in finished water, finished water must be sampled daily.
- Exceeding a health advisory level in a sample collected from an entry point or a distribution sampling point requires additional monitoring and public notification (OAR 333-061-0540 and OAR 333-061-0570).

- The OHA Recreational HABs program must be notified to determine if a recreational advisory is needed.

If total microcystins are < 0.20 µg/L or non-detect and cylindrospermopsin are < 0.30 µg/L or non-detect in two consecutive weeks of raw water sampling and there is no upstream recreational CyanoHABs advisory, sampling of raw water returns to biweekly intervals at the PWS.

Decision point: Are cyanotoxins in finished water above health advisory levels?

Following the first detection of total microcystins ≥ 0.20 µg/L or cylindrospermopsin ≥ 0.30 µg/L in raw water, a sample from the entry point of the finished drinking water entering the distribution system must be taken within one business day. If two consecutive samples of finished water from the entry point and two consecutive raw water samples have total microcystins < 0.20 µg/L or non-detect and cylindrospermopsin < 0.30 µg/L or non-detect, then the sampling schedule returns to biweekly sampling of raw water at the PWS intake (OAR 333-061-0510).

OHA DWS has implemented health advisory levels for cyanotoxins in finished drinking water established by the EPA (Table 1).

Table 1. Health advisory thresholds for cyanotoxins in finished drinking water established by OHA.

Cyanotoxin	Vulnerable People (µg/L or ppb)	For Everyone (µg/L or ppb)
Total Microcystins	0.3	1.6
Cylindrospermopsin	0.7	3

If a sample from finished drinking water at the entry has detectable levels of cyanotoxins, regardless of concentration level, a sample must be taken within 24 hours and sampling at the entry point must be conducted daily. If a cyanotoxin concentration is confirmed to exceed the levels listed in Table 1, the PWS and any purchasing distributor must issue a “Do-Not-Drink” order for that source within 24 hours (for the water system and any purchaser) and sampling of finished water at the entry point of the distribution system continues daily thereafter. In order to lift the order, two consecutive water samples from finished water and the distribution system must be at or below the health advisory levels for vulnerable people, defined as children younger than six, pregnant women, the elderly, and those with pre-existing conditions (Table 1). Once an order is lifted, the PWS must monitoring for the rest of the year according to rule requirements.

Technical assistance

The TMDL and DWP programs can provide both OHA DWS and PWSs technical assistance in determining system susceptibility to CyanoHABs, interpretation of cyanotoxin monitoring results, and communication of cyanotoxin results to the general public. The DWP program for SWA maintains information on CyanoHABs on its program website (Oregon Department of Environmental Quality, About Drinking Water Protection, 2023).

Table 2. Specific actions and subprograms identified as currently part of or needed for addressing drinking water related issues related to CyanoHABs in Oregon freshwaters.

DEQ Program(s)	Action/subprogram	Currently active?	Recommendation(s)
LEAD/DWP/TMDL	Develop and implement a joint DEQ/OHA strategy to identify PWSs susceptible to CyanoHABs and provide technical assistance for testing, treatment alternatives, and protection	Yes	Continue with updates as needed
DWP	Partnership between OHA and DEQ to ensure consistent evaluation of cyanotoxin contamination risks for PWS	Yes	Continue
DWP	Conduct source assessments of PWSs for potential contaminants, including cyanotoxins, using water quality data, remote sensing, and landscape models	Yes	Continue with updates as needed
DWP/TMDL	Provide protection assistance and grant support to PWSs identified as susceptible to CyanoHABs	Yes	Continue
TMDL	Develop a nutrient strategy to assess sources of and reduction strategies for nutrient loading to watersheds and surface waters	Yes	Continue and expand as resources allow
DWP	Assess susceptibility of unregulated domestic drinking water sources to CyanoHABs	No	Implement as resources allow

DEQ Program(s)	Action/subprogram	Currently active?	Recommendation(s)
DWP/TMDL	Provide technical assistance and grant support to areas with domestic drinking water sources susceptible to CyanoHABs	No	Implement as resources allow
TMDL	Enact pollution reduction strategies in areas susceptible to CyanoHABs for both public and private domestic water sources	Yes	Continue and expand as resources allow
DWP	Recommend to local authorities and OHA potential restrictions on public and domestic drinking water sources affected by frequent CyanoHABs	No	Implement as resources and priorities allow
DWP	Leverage resources, share water quality and GIS data analyses, and assist other programs related to CyanoHAB-susceptible drinking water sources	Yes	Continue with updates as needed
TMDL/DWP	Conduct source assessments of potential factors contributing to CyanoHABs in PWSs to develop statewide policy and drinking water protection strategies	Yes	Continue and expand as resources and competing TMDL priorities allow
LEAD/TMDL	Collect monitoring data to assess the susceptibility of PWSs to CyanoHABs	Yes	Continue and expand as resources allow
TMDL	Issue TMDLs for PWS contaminated by CyanoHABs	No	As competing TMDL priorities allow

Recreational Freshwater CyanoHABs: Public Health Response

This section describes how DEQ works with OHA and other partners to address CyanoHABs in recreational waterbodies. The OHA Recreational HABs program is responsible for issuing, lifting, and communicating about public health advisories for cyanotoxins in recreational waterbodies. DEQ is an active partner tasked with cyanotoxin monitoring and water sampling and, independently, can investigate CyanoHABs in recreational waterbodies for Clean Water Act purposes. DEQ provides satellite imagery, coordinates monitoring internally and with OHA and external partners, and conducts laboratory analyses for cyanotoxins according to accredited methods. If there is not a clearly identified partner for water quality monitoring, DEQ may provide monitoring staff to collect, preserve, and transport samples. An interagency agreement between OHA and DEQ has been developed to define and partially fund joint OHA-DEQ activity. The Recreational Freshwater CyanoHABs figure highlights the roles each agency and external partners occupy for monitoring and public health responses. Details for each of the schematic components are described subsequently. Table **4** describes specific activities and subprograms currently active or needed for addressing recreational use issues related to CyanoHABs in Oregon freshwaters.

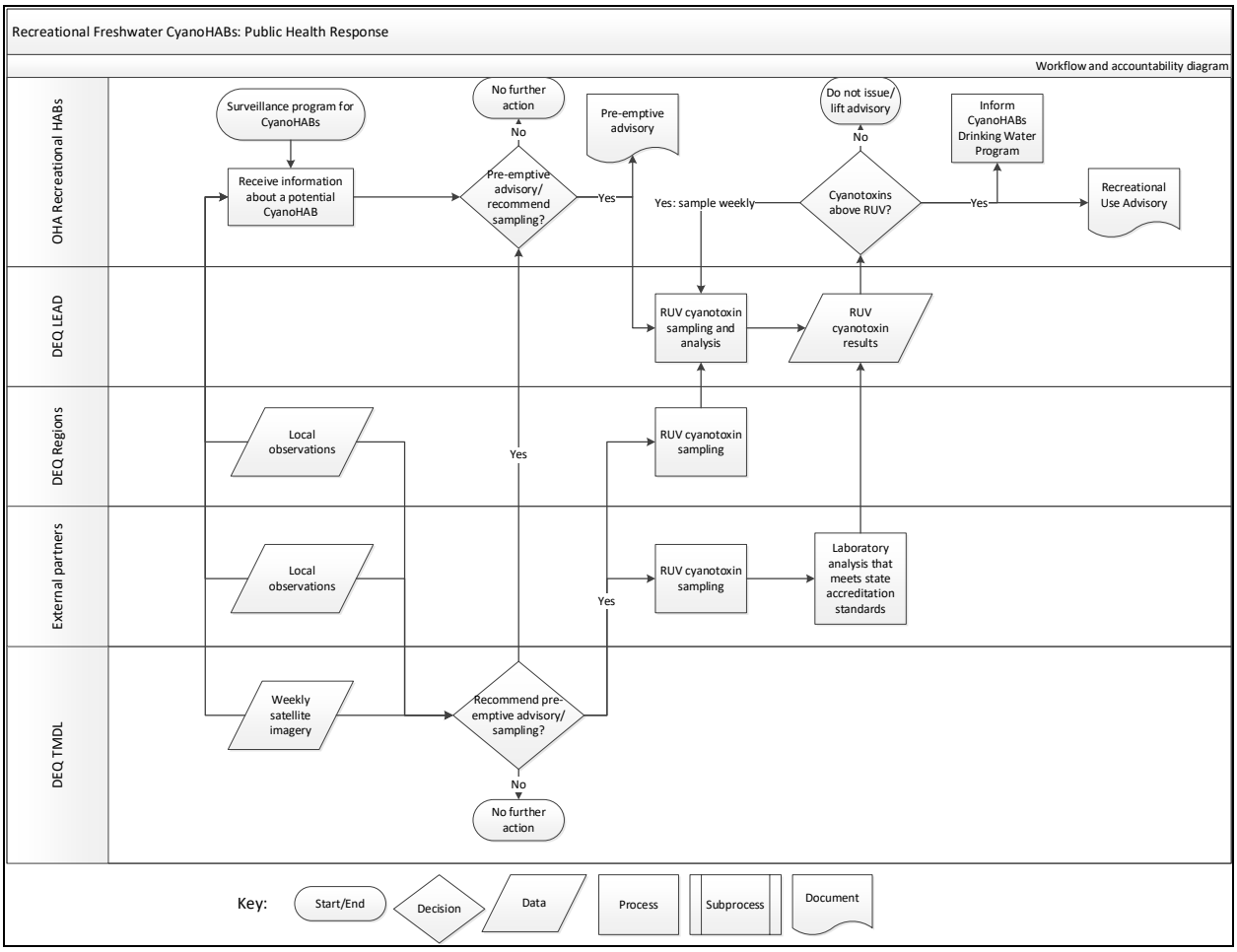

Figure 2. Workflow and accountability diagram for DEQ and partners describing the roles and responsibilities for responding to CyanoHABs in Oregon's recreational waterbodies.

Starting point: Surveillance program for CyanoHABs

To support decisions for public health advisories in recreational waterbodies, OHA operates a recreational HABs program. The program provides resources for partner agencies, waterbody managers, and the public to evaluate and monitor for CyanoHABs. Based on guidance provided by these documents, EPA, the Interstate Technological Regulatory Council, external partners such as federal agencies, lake managers, the general public, regional DEQ staff, and staff from the TMDL program provide OHA with information and recommendations about potential CyanoHABs in waterbodies across the state. OHA consults with DEQ staff and regional partners about issuing a pre-emptive advisory based on visual observations and recreational use level. OHA also consults with LEAD about the need for sampling to determine cyanotoxin levels.

Decision point: Pre-emptive advisory/recommend sampling

OHA may issue a pre-emptive recreational use health advisory when:

1. Visible scum with supporting photographs and cyanotoxin analysis will be performed within one business day. Scum is defined as a visible mass of cyanobacteria identified in the water body; or
2. Submitted samples by external partners or DEQ are above OHA's Recreational Use Values (RUVs) (Table 3).

Table 3. RUV thresholds for triggering a health advisory in Oregon.

Cyanotoxin	Microcystin	Anatoxin-a	Saxitoxin	Cylindrospermopsin
RUV (µg/L)	8	15	8	15

The DEQ Watershed Management Section may recommend a pre-emptive advisory and additional sampling to OHA based on analysis of information provided by DEQ regions and/or external partners, including, but not limited to, satellite imagery, visual observations of "scum", water quality samples for cyanotoxins, or other information describing cyanobacteria communities. If a pre-emptive advisory is not issued by OHA, the TMDL program may still request additional samples be taken by LEAD or external partners funded through the TMDL or NPS programs.

Issuing and lifting recreational use advisories

An interagency agreement between OHA and DEQ has been developed to define and partially fund joint OHA-DEQ activity. If requested by OHA, the DEQ laboratory may conduct laboratory analysis for cyanotoxins of water quality samples submitted by external partners or may conducted water quality sampling and laboratory analysis for cyanotoxins when external partners have not been identified. LEAD may provide monitoring staff to collect, preserve, and transport samples.

External partners, including OHA defined partners, federal agencies, other state agencies, local governments, and the public, may conduct independent observations and sampling for potential CyanoHABs. These partners may consult, but are not required to, with DEQ and OHA on designing and implementing a monitoring study to assess cyanotoxins in relation to RUVs and may report potential CyanoHABs to DEQ and OHA.

LEAD conducts analyses for cyanotoxins using accredited methods according to OAR Chapter 333 Division 64. External partners are required to sample and analyze samples using the same accredited methods. External Partners contract with laboratories accredited according to the

OHA approved list of laboratories for recreational and drinking water sampling or LEAD to perform the required analyses (Oregon Health Authority, Cyanobacteria Blooms, 2022).

If the subsequent cyanotoxin sample collected within one business day is below all RUVs, OHA will lift the pre-emptive advisory. However, if cyanotoxins levels are above one or more cyanotoxins RUVs (Table 3), LEAD or an external partner informs OHA immediately and a recreational use advisory is issued. Weekly sampling of cyanotoxins then commences. OHA lifts the advisory when two consecutive samples fall below the RUVs.

Additional technical support from DEQ

The TMDL program provides routine seasonal technical support to OHA and other federal, regional, and local partners for the identification and analysis of potential CyanoHABs in recreational waterbodies. General support includes expert consultation, analysis of water quality data, modeling, and interpretation of field and remotely sensed data.

The TMDL program has worked with the EPA and NASA to compile weekly imagery of cyanobacteria abundance in large (>1 km^2) Oregon waterbodies. Images are compiled weekly from May to October and compiled on an interactive website (Oregon Department of Environmental Quality, Satellite Estimates of Cyanobacteria in Oregon Lakes and Reservoirs, 2023). Weekly emails are distributed to DEQ regional staff, OHA, and external partners. Additional satellite imagery and images from other sources may be included on the website in the future.

When specific waterbodies show potential CyanoHABs formation based on satellite imagery or other information, the TMDL program follows up with DEQ regional contacts and OHA recommended actions, including the issuance of a pre-emptive advisory and cyanotoxin sampling.

DEQ regional staff may be available to support CyanoHAB monitoring in recreational waterbodies through on-site observations, feedback from the public, and examination of satellite imagery. Historically, LEAD has supplied regional staff with CyanoHABs sampling kits in advance of CyanoHABs season.

Regional staff must be notified by OHA or LEAD in a timely manner if a potential CyanoHAB is reported within their basin of responsibility from external partners or internal agency sampling. If LEAD will conduct cyanotoxin sampling at the request of OHA, it must notify the appropriate staff from the region and TMDL program prior to sampling and report field conditions at time of sampling and sample results.

When a local partner cannot be identified for addressing a potential CyanoHABs, DEQ regional staff may assume the local partner role upon request. Upon identification of a potential CyanoHABs through observations of visible scum or other evidence, regional staff may

coordinate with OHA, LEAD, or the TMDL program to conduct additional investigations or sampling. They are also available to aid in cyanotoxin sampling and field observations as requested by LEAD or OHA.

Table 4. Specific activities and subprograms identified as currently active or needed for addressing recreational use issues related to CyanoHABs in Oregon freshwaters.

DEQ Programs	Activity/subprogram	Currently Active?	Recommendation(s)
LEAD	Participation in CyanoHAB monitoring program with OHA and other local partners	Yes	Continue and expand as resources allow
LEAD	Work with OHA to review and refine monitoring methods for cyanotoxins	Yes	Continue and update as needed
LEAD/TMDL	Partner with OHA, Oregon State University, and other groups to host an annual stakeholder meeting to review and discuss CyanoHABs	Yes	Continue
LEAD/TMDL/Regions	Maintain a DEQ CyanoHAB response team for responding to CyanoHAB events reported by agencies or the public	Yes	Continue and expand as resources allow
LEAD/TMDL	Conduct annual review following CyanoHABs monitoring season for process improvements and data maintenance	Yes	Continue
TMDL	Develop a DEQ CyanoHABs website to provide access to the CyanoHAB strategy, Satellite analysis, other DEQ CyanoHAB related info, links, and other available information	Yes	Continue and update
LEAD/TMDL	Develop Memorandum of Agreements among state agency partners to better define roles and responsibilities for addressing CyanoHABs	Partially Yes	Expand beyond OHA

DEQ Programs	Activity/subprogram	Currently Active?	Recommendation(s)
LEAD/TMDL	Incorporate genetic sampling, satellite analyses, and water quality modeling for proactive issuance of recreational advisories	Yes	Continue and expand as resources allow
LEAD/DWP/TMDL/ Regions	Form Oregon CyanoHABs Task Group (state, federal, local agencies, academics) to discuss, plan, develop and coordinate actions in Oregon to improve multi-agency response to CyanoHABs and ultimately prevent and control CyanoHABs	Partially Yes	Continue, update, and expand as resources allow

Clean Water Act Freshwater CyanoHABs: Assessment and Actions

This section describes how DEQ identifies, assesses, and determines appropriate actions for protecting and restoring Oregon waterbodies impaired by CyanoHABs. DEQ is responsible for implementing and managing the Clean Water Act in Oregon. Figure 3 highlights the roles each DEQ water quality subprogram and external partners have for identifying, developing, and implementing the actions. The process starts with the assessment for beneficial use supported and ultimately ends with the implementation of actions to restore beneficial uses through a TMDL or an alternative plan. As of the 2022 Integrated Report cycle, seven waterbodies have approved TMDLs for CyanoHABs (Category 4A) and one has an approved Alternative Plan (category 4B) (Oregon Department of Environmental Quality, 2022 Final Integrated Report, 2022). Table 5 describes specific activities and subprograms currently active or needed for addressing Clean Water Act issues related to CyanoHABs in Oregon waterbodies.

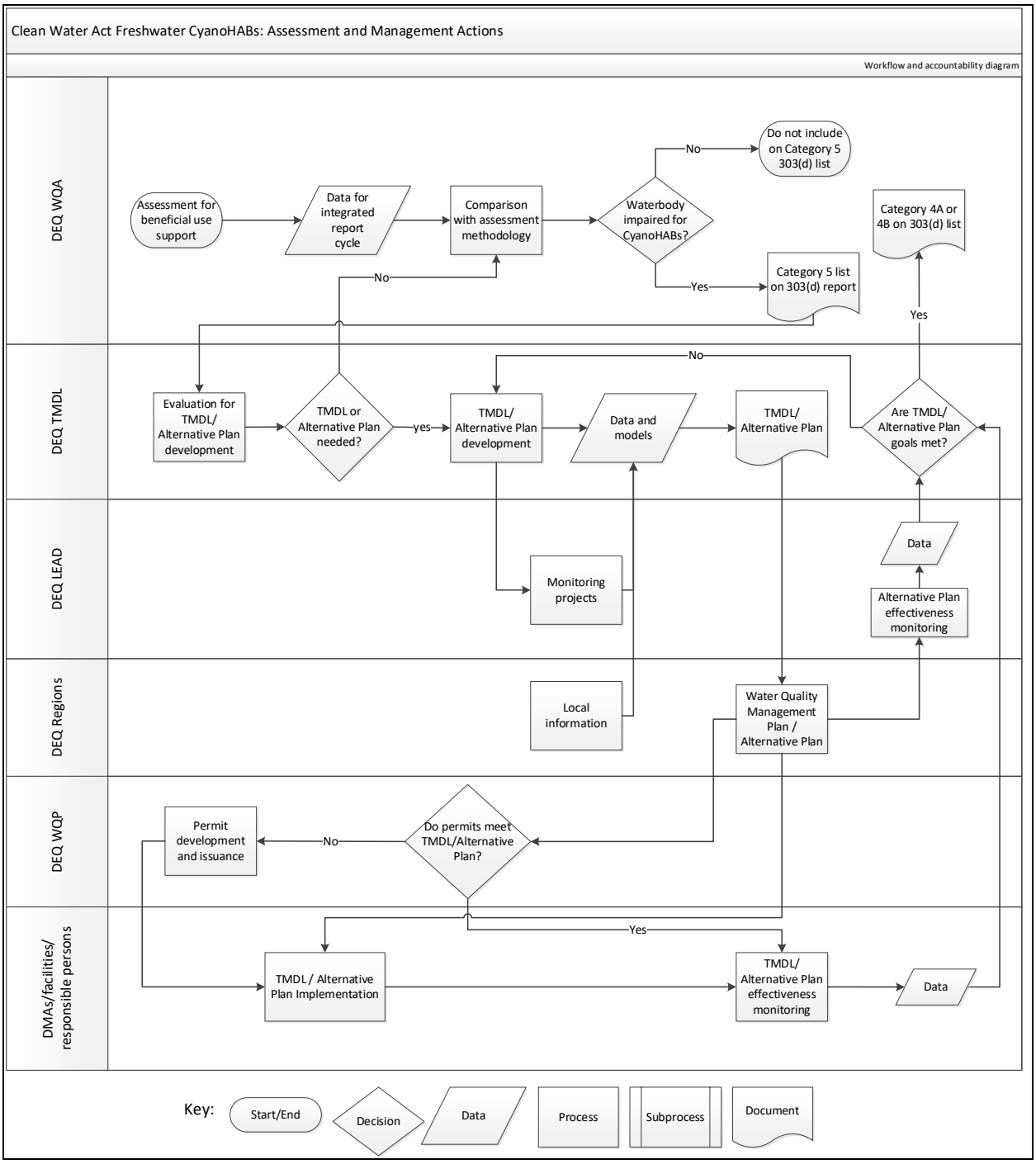

Figure 3. Workflow and accountability diagram for DEQ and partners describing the roles and responsibilities for assessing and managing CyanoHABs under the Clean Water Act.

Starting point: Assessment for beneficial use support

DEQ must assess water quality for beneficial use support and report to EPA on the condition of Oregon's waters. Every two years, the Water Quality Assessment Program (WQA) prepares an Integrated Report to meet the requirements of Federal Clean Water Act Sections 305(b) and 303(d). The report cycle begins with a public call for data.

Data for Integrated Report cycle

CyanoHABs monitoring data and CyanoHABs advisory information are evaluated every two years to assemble the Integrated Report. Data may come from:

- DEQ's Ambient Water Quality Monitoring System
- EPA's Water Quality Portal
- DEQ's Volunteer Monitoring Program
- OHA public health drinking water advisories list.
- OHA public health recreational advisories issued and lifted throughout the season for monitored and sampled water bodies.

Comparison with assessment methodology

CyanoHABs monitoring data and advisory information compiled during the Integrated Report cycle call for data are assessed using DEQ's most current Integrated Report assessment methodology. Based on the current data window defined in the methodology, a waterbody may be classified into the following assessment categories for CyanoHABs:

- **Category 2**: Available data and information indicate that some designated uses are supported and the water quality standard is attained.
- **Category 3**: Insufficient data to determine whether a designated use is supported. Oregon further subclassifies Category 3 as:
    - **3B**: Insufficient to determine use support but some data indicate non-attainment of a criterion
    - **3C**: Potential concern when data are insufficient to determine full use support
    - **3D**: Insufficient data to determine use support because numeric criteria are less than quantitation limits.
- **Category 4**: Data indicate that at least one designated use is not supported but a TMDL is not needed to address the pollutant cause. This includes:
    - **4A**: TMDLs that will result in attainment of water quality standards and beneficial use support have been approved.

    - **4B**: Other pollution control requirements are expected to address pollutants and will result in attainment of water quality standards.
    - **4C**: Impairment caused by pollution, not by a pollutant (e.g., flow or lack of flow are not considered pollutants).
- **Category 5**: Data indicate a designated use is not supported or a water quality standard is not attained and a TMDL or Alternative Plan is needed. This category constitutes the Section 303(d) list that EPA will approve or disapprove under the Clean Water Act.

Decision point: Is the waterbody impaired by CyanoHABs?

To be placed on the Category 5 list as impaired by CyanoHABs, a waterbody must have had a public health advisory issued by OHA, in conjunction with other federal, state, county, city or local agencies, within the data window which:

- is a permanent advisory
- has reoccurred for two or more HABs seasons
- only occurred once but had cyanotoxin values above OHA guidelines for water contact recreation (Table 3)
- finished water exceeds the advisory for vulnerable people AND where the waterbody is the source of water for a public water system (Table 1)
- where there is a livestock watering use, only occurred once but had a microcystin value above livestock watering levels of 2.3 µg/L
- Recreational advisories shall be associated with impairments of the water contact recreation use. Drinking water advisories shall be associated with impairments of the domestic water supply use. Exceedance of the reference concentration for livestock shall be associated with impairment of the livestock watering use.

A waterbody is classified as Category 3B based on the data window if it has had a single season public health advisory issued by the OHA, in conjunction with other federal, state, county, city or local agencies, with no associated toxin data; or if it had raw source water exceeding drinking water values for vulnerable people only for water bodies with known drinking water intakes. Categories 3C and 3D do not apply to CyanoHABs.

A waterbody is placed on the Category 4 list when data indicate that at least one designated use is not supported as a result of a CyanoHAB and a TMDL is not needed because:

- 4A: a TMDL has been developed and approved
- 4B: Other pollution controls are in place (alternative plan), or
- 4C: Impairment caused by pollution not by a pollutant, such as low water flow

To be delisted from the 303(d) list, a waterbody must be free of an OHA health advisory for more than three consecutive seasons and have supplemental data consistent with OHA's

advisory lifting procedures (photos, cell counts and toxin data below OHA guidelines) for at least two of those seasons.

These criteria for listing and delisting are current for the 2022 Integrated Report (Oregon Department of Environmental Quality, 2022 Final Integrated Report, 2022). Criteria are subject to change and may be updated in future Integrated Report cycles.

Evaluation for TMDL development / Alternative Plan

The federal Clean Water Act requires Oregon or the EPA to develop a TMDL or execute an enforceable Category 4B Alternative Plan for every pollutant/waterbody combination on the Integrated Report Category 5 303(d) list impaired by CyanoHABs to ensure that state water quality standards are met and beneficial uses are protected. The required elements for developing a TMDL are identified in the Federal Code of Regulations at 40 CFR § 130.7 and in OAR 340-042-0040.

TMDL development projects are prioritized based on a variety of factors including risk to beneficial use, court ordered schedules, and permit issuance priorities. TMDL development priorities are documented in the Integrated Report and in the Performance Partnership Agreement between DEQ and EPA.

After a waterbody is listed as impaired by CyanoHABs, the TMDL program evaluates existing and additional data to better understand the condition of the waterbody, if the impairment is caused by pollutants or other conditions, and if a TMDL or Alternative Plan needs to be developed in light of the data analysis.

Decision point: Is a TMDL/Alternative plan needed?

If the initial data review and analysis indicate that a TMDL or Alternative Plan for CyanoHABs in a waterbody is not needed, the TMDL program recommends that the DEQ Water Quality Assessment Program re-evaluate the 303(d) category listing. This may include listing the waterbody as Category 4C (impairment not caused by a pollutant) or delisting the waterbody.

If the initial data review and analysis determines that a TMDL or an Alternative Plan is needed, the TMDL program works with regional basin coordinators and the laboratory, to develop, implement, and monitor a TMDL or an Alternative Plan for pollutants contributing to the CyanoHAB impairment.

Total Maximum Daily Load (TMDL)

A TMDL is the maximum amount of pollutant that can be present in a waterbody while still meeting water quality standards. A TMDL is set to the loading capacity for any identified pollutants and consists of:

- Waste Load Allocations allocated to permits for point sources regulated under the federal Water Pollution Control Act 402 33 USC Section 1342.
- Load Allocations allocated to existing nonpoint sources including runoff, deposition, soil contamination and groundwater discharges, or to background sources.
- Reserve Capacity to allocate for increases in pollutant loads from future growth and new or expanded sources. The TMDL may allocate no reserve capacity and explain that decision.
- Margin of Safety to account for uncertainty related to the TMDL and, where feasible, quantifies uncertainties associated with estimating pollutant loads, modeling water quality and monitoring water quality. The TMDL will explain how the margin of safety was derived and incorporated into the TMDL.

To develop a TMDL for CyanoHABs, the TMDL program, in consultation with the Regional Basin Coordinator and LEAD, conducts analyses and/or modeling to determine:

- Pollutant identification: the pollutant(s) causing the impairment addressed in the TMDL
- Water quality standards and beneficial uses: For the waterbody/basin, relevant water quality standards and beneficial uses will be identified and those most sensitive to impairment by the pollutant(s) will be specified. For CyanoHABs, the standards assess are based on the criteria for a Category 5 listing and the beneficial uses include:
    - Domestic water supply
    - Irrigation
    - Livestock watering
    - Water contact recreation
- Loading capacity: the amount of a pollutant or pollutants that a waterbody can receive and still meet water quality standards.
- Excess load: the difference between the actual pollutant load and loading capacity
- Sources or source categories: actual pollutant loading from identified sources.
- Seasonal variation: the seasonal variation and critical conditions in stream flow, sensitive beneficial uses, pollutant loading so that water quality standards will be attained and maintained during all seasons of the year
- The Water Quality Management Plan (WQMP): the framework of management strategies to attain and maintain water quality standards.

Category 4B Alternative Plans

A Category 4B Alternative Plan is intended to meet water quality standards in a reasonable period of time using other pollution control requirements not necessarily included in a TMDL (Monschein & Reems, 2009).If an Alternative Plan is determined to be appropriate, the TMDL program works with the Regional Basin Coordinator and LEAD to develop, implement, and

monitor the plan. According to EPA guidance, an Alternative Plan must include these six elements (Monschein & Reems, 2009):

- Identification of segment and statement of problem causing the impairment
- Description of the pollution controls and how they will achieve WQS, including a description of the pollutant loads needed to meet WQS and a description of the requirements under which the controls will be implemented
- An estimate or projection of the time when WQS will be met
- Schedule for implementing pollution controls
- Monitoring plan to track effectiveness of pollution controls
- Commitment to revise pollution controls, as necessary

Water Quality Management Plan

A WQMP, or framework, to guide how to reduce pollution to those waters impaired by CyanoHABs, is issued with every DEQ-developed TMDL**.** The WQMP along with the Assessment and Monitoring Strategy connects the planning and development for implementation and monitoring. OAR 340-042-0040 (Establishing TMDLs) identifies the elements of a WQMP.

LEAD, in consultation with the TMDL program and DEQ regional staff, designs additional monitoring for informing the analysis and development of a TMDL or alternative plan for a waterbody impaired by CyanoHABs. This process develops a Quality Assurance Project Plan (QAPP) and Sampling Analysis Plan (SAP) for TMDL/Alternative Plan development monitoring projects. Laboratory staff coordinate and execute field sampling and water quality analysis for the projects.

Decision point: Do permits meet TMDL/Alternative Plan?

A required component of a TMDL is identifying and quantifying pollutant contributions from point sources. Wasteload allocations (WLAs) are allocated to permits for point sources regulated under the federal Clean Water Act section 402. For the purposes of CyanoHABs, the most relevant permits are National Pollutant Discharge Elimination System (NPDES) permits. Water Pollution Control Facilities (WPCF) permittees do not discharge to surface waters; however, WPCF permits allow land-based discharge of pollutants that may eventually enter surface waters through runoff and groundwater discharge. The TMDL WQMP plan identifies the point sources evaluated for the TMDL and how WLAs in a TMDL will be implemented for those sources subject to permit requirements in ORS 468B.050 (water quality permit).

Permit development and issuance

If one or more existing permits does not meet the TMDL WLA or Alternative Plan requirements or a facility/entity applies for a new permit, DEQ develops and issues a new permit as outlined

OAR 340-045-005. Waste Load Allocations and other Alternative Plan management strategies are incorporated into the permit by the WQP Program during permit development for new issuance or renewal.

Nutrients are a primary focus of NPDES Permits addressing water quality impairments by CyanoHABs. Several categories of permits support the control of nutrients or surrogate pollutants, most notably:

- NPDES permits for discharges of wastewater (sewage treatment plants, industries such as pulp and paper mills, stormwater runoff, pesticide application, and Confined Animal Feeding Operations); and
- WPCF permits for the prevention of discharges (onsite sewage disposal systems (septic) and land irrigation as part of Confined Animal Feeding Operations).

Effluent limits in permits must be consistent with the assumptions used to develop TMDL WLAs. In the absence of a TMDL, such as Category 4B Alternative Plans, DEQ must assess the need for effluent limits based on water quality standards and where necessary, develop effluent limits.

Permit meets wasteload allocations

Water quality-based discharge limits in NPDES permits must be consistent with the assumptions and requirements of WLAs in approved TMDLs or Alternative Plans. If the existing permit meets the requirements for the effluent-based discharge of pollutants identified in the TMDL, the permittee continues to follow the requirements for discharge, treatment, best management practices, and monitoring described in the active permit.

TMDL/Alternative Plan implementation

DEQ Regional staff work with TMDL staff, LEAD, DMAs, facilities, or RPs to implement the requirements of the TMDL or Alternative Plan. The TMDL/Alternative Plan implementation process starts with the development and issuance of a WQMP or an Alternative Plan for CyanoHABs and the identified surrogate measures. A WQMP identifies the WLAs (point sources) and LAs (nonpoint sources) evaluated for the TMDL and how the allocations in a TMDL will be implemented by DMAs, facilities, or RPs for those sources. A Category 4B Alternative Plan is designed to attain water quality standards on a faster schedule than a TMDL, defers or bypasses the development of a TMDL, and is implemented upon DEQ approval.

TMDL/Alternative Plan Effectiveness Monitoring

DEQ Regional staff work with TMDL program staff, LEAD staff, Designated Management Agencies (DMAs), facilities, or responsible persons (RPs) to design effectiveness monitoring for a waterbody impaired by CyanoHABs where TMDL or Alternative Plans are implemented. This includes development of a QAPP and SAP. DMAs, facilities, RPs, or the DEQ laboratory (Alternative Plans only) conduct field sampling and water quality analyses for pollutants and

surrogate measures identified that influence the frequency, magnitude, and extent of CyanoHABs. Water quality data collected from the projects are evaluated according to quality assurance/quality control criteria described in the developed QAPPs and SAPs and are posted to the DEQ Ambient Water Quality Monitoring System.

Decision Point: Are TMDL/Alternative Plan goals met?

Water quality data and surrogate measures collected as part of effectiveness monitoring are used to evaluate progress toward meeting water quality standards and management targets described in the approved WQMP or Alternative Plan. When a TMDL is issued for a CyanoHAB, the waterbody is placed on the 303(d) list Category 4A (TMDL developed and approved). DEQ, DMAs, RPs, and others continue periodic monitoring to evaluate progress towards meeting TMDL allocations and surrogates. These data contribute to a DEQ publication on water quality status and trends analysis each year. The analysis informs DEQ, other state and federal agencies, and the public on the condition of waters and if TMDL targets are being achieved, if water quality is improving or degrading, the pace of improvement or degradation, what actions, if any, are being taken to improve water quality, and where water quality data are and are not being collected.

Based on the expected timeline in the WQMP or Alternative Plan, DEQ will update the Integrated Report (305(b) and 303(d) lists) in the subsequent cycle when monitoring data show the water body attains water quality standards. The assessment status is changed from Category 4A to Category 2; however, the TMDL or Alternative Plan remains in effect.

If monitoring data do not indicate acceptable progress towards water quality targets, TMDL allocations, or surrogate measures, the DEQ WMS reevaluates the approved TMDL or Alternative Plan, including allocations and surrogate measures. The DEQ Watershed Management Section, DEQ regional staff, the DEQ laboratory, DMAs, RPs, and others re-engage to update the targets in the WQMP or Alternative Plan and the effectiveness monitoring strategy. This cycle of development, monitoring, and evaluation fits within the broader adaptive management process, which allows DEQ and implementing entities to course-correct towards achieving water quality standards.

Table 5. Specific activities and subprograms identified as currently active or needed for addressing Clean Water Act issues related to CyanoHABs in Oregon waterbodies.

DEQ Program	Activity/subprogram	Currently Active?	Recommendation(s)
WQA	List waterbodies as impaired (Category 5) by CyanoHABs based on current Integrated Report Methodology	Yes	Continue and update as needed
WQA	List other waters based on data showing cyanotoxin thresholds were exceeded but a recreational advisory was not issued	No	As resources allow
WQA/TMDL	IMD for Antidegradation Policy Implementation for nonpoint sources	Yes	Continue
WQA/TMDL	Evaluate the potential for numeric nutrient criteria development during the next triennial review	No	As resources allow
WQS	Develop water quality criteria for cyanotoxins	No	As resources and priorities allow
TMDL/Regions	Improve regional coordination among DEQ and partners for addressing CyanoHABs related water quality impairments	Yes	Continue and expand
TMDL/Regions	Develop TMDLs or Alternative Plans for CyanoHAB listed waters	No	As resources and priorities allow
TMDL	Dedicate a TMDL analyst to specialize in CyanoHABs analysis and management	No	As resources and priorities allow
TMDL/Regions	Develop regional or basin-specific approaches to managing CyanoHABs	No	As resources and priorities allow
TMDL/Regions	Consider alternatives to TMDLs, such as Watershed Based Plans, as appropriate	No	As resources and priorities allow
TMDL/WQP	Develop loading capacities for pollutants that are identified to cause CyanoHABs in waterbodies	No	As resources and priorities allow
TMDL/Regions	Address nutrient, sediment, and other CyanoHAB related LAs through DMA implementation plans, Agriculture Water Quality Rules and Plans, and FPA	Yes	Continue and expand as resources allow

DEQ Program	Activity/subprogram	Currently Active?	Recommendation(s)
TMDL/Regions	Evaluate effectiveness of DMA management plans, Agriculture Water Quality Rules and Plans, and FPA in meeting LAs	Yes	Continue and expand as resources allow
TMDL/Regions	Add CyanoHABs-related work in Interagency Agreements to facilitate other agencies to develop CyanoHAB collaborative approaches	No	As resources and priorities allow
TMDL/Regions	Work with ODFW, USFWS, USFS, USBOR, USACE, EPA and others to address the role of fisheries in lake eutrophication and CyanoHABs	No	As resources and priorities allow
Regions/Onsite	Continue and promote use of local authorities to require on-site system evaluations where needed	Yes	Continue with updates as needed
Regions/Onsite	Explore ways to provide Clean Water SRF or other funding to assist with repair or replacement of on-site systems	Yes	Continue and expand as resources and priorities allow
Regions/Onsite	Work with local government to implement on-site system evaluations near waterbodies with CyanoHABs	No	As resources and priorities allow
Regions/Onsite	Consider requiring periodic inspections of on-site systems	No	As resources and priorities allow
WQP	Continue no discharge of wastewater to lakes/reservoir rule	Yes	Continue
Regions/WQP	Clarify ability to use herbicides and other chemicals for CyanoHAB treatment – either through conformance with FIFRA labeling or through permit	Yes	As resources and priorities allow
WQP	Continue to address CyanoHABs through the 401 process including certification conditions	Yes	Continue and update as needed

Synthesis and recommendations

DEQ's CyanoHABs strategy provides information on the multifaceted ways in which the agency addresses CyanoHABs in freshwater ecosystems of Oregon. The strategy also describes how DEQ works with other government agencies and stakeholders, particularly OHA and drinking water providers, to respond to CyanoHABs affecting water supplies and recreational activities. Throughout the development of the strategy, we have documented additional needs to improve DEQ's approach to detecting, monitoring, assessing, and managing CyanoHABs. In this section, we discuss the importance of incorporating concepts and approaches related to climate change and environmental justice into the strategy. We also outline current resource limitations and funding needed to sustain and improve the agency's strategy. We conclude with the near- and long-term outlook for CyanoHABs management and prevention in Oregon.

Climate Change

The degree to which climate change has contributed to increased frequency, extent, and magnitude of CyanoHABs remains intensely debated. Recent work has claimed both that CyanoHABs in freshwater ecosystems have grown more frequent, extensive, and severe around the world due to climate change (Ho, Michalak, & Pahlevan, 2019) and while other research suggests the incidence of algal blooms has remained stable over the past several decades (Oliver, et al., 2017). The lack of long-term data does not allow an assessment of how characteristics of CyanoHABs have changed over time in Oregon.

Despite the lack of specific data characterizing long-term trends, DEQ has reason to believe that environmental conditions favorable for increased frequency, extent, and severity of CyanoHABs will become more prevalent across the state in the foreseeable future (Oregon Department of Environmental Quality, Oregon DEQ Harmful Algal Bloom (HAB) Strategy, 2011). A report issued by the Oregon Climate Change Research Institute provides evidence that human activities have been primarily responsible for the 1.5°F increase in average annual temperatures over the past century (Dello & Mote, 2010). For the remainder of the 21st century, average annual temperatures are expected to increase at a rate of 0.2-1.0°F per decade, summer precipitation will decrease 14% by the 2080s, and increases in extreme precipitation events are likely. These types of climatic shifts have led to conditions favorable for cyanobacterial growth in other regions (Paerl & Huisman, 2008).

In 2020, DEQ established a new Climate Protection Program focused on reducing greenhouse gas emissions. However, the program currently does not describe how DEQ will address and mitigate environmental effects of climate change such as CyanoHABs. Based on the updated CyanoHAB strategy, we recommend the DEQ programs work together to take the following actions to address climate change effects on CyanoHABs in Oregon waterbodies:

- Identify waterbodies at risk for developing CyanoHABs due to effects of climate change

- Develop strategies to mitigate effects of climate change in waterbodies currently experiencing CyanoHABs
- Expand forecasting and monitoring modalities for CyanoHABs
- Educate the public on how different aspects of climate change can increase the frequency, severity, and extent of CyanoHABs in Oregon waters
- Work with other state agencies and partners to provide resources to lake managers and residents to mitigate effects of climate change on CyanoHABs

As this strategy undergoes updates in the future, other actions may be identified and prioritized.

Environmental Justice

DEQ is committed to the principles of Environmental Justice. In the original staff report to the EQC on Environmental Justice in Oregon, exposure to water pollution is singled out as a topic requiring improved coordination, sampling, and communication with affected communities (Oregon Department of Environmental Quality, Environmental Justice, 2022).

To inform the exposure risk and to develop an equitable approach for CyanoHAB management and prevention in waterbodies used by marginalized communities for dietary, cultural, and recreational practices in Oregon, DEQ proposes the following measurable actions:

- Enhance public participation in DEQ's actions and monitoring decisions to ensure the meaningful involvement of people who may be affected by CyanoHABs
- Identify racial, ethnic, and socioeconomic groups that may bear a disproportionate share of negative health, cultural, and environmental consequences resulting from CyanoHABs and include these in prioritization for actions.
- Build stronger relationships with Oregon tribes to understand the impact of CyanoHABs on Indigenous peoples
- Work with OHA DWS to identify underserved or marginalized populations served by PWSs that have had or currently have disproportionate risk to contamination from pollutants
- Develop an agency plan to address language access disparities related to CyanoHAB notifications and advisories, including ways the agency can provide important environmental and public health information to people with limited English proficiency

Funding

Funding for current DEQ CyanoHAB monitoring, analysis, and mitigation measures comes from several sources. Several of these sources are targeted for specific activities and projects while others provide overall funding to agency positions and resources. The main sources include:

- State General Fund and Lottery Fund appropriations (e.g., agency budget and policy bills)
- Legislative, for monitoring activities, technical assistance, analytical support, and data management services for recreational and drinking water programs

- National Lakes Assessment Federal Monitoring Initiative Grants under Section 106 of the Clean Water Act
- Federal CWA Section 319 Funds

The degree to which different funding sources support monitoring, laboratory analysis, and data analysis varies over time. Funding allocations within DEQ can be broken down into staff time for field sampling, monitoring equipment, laboratory analysis equipment, laboratory staff time, data analytical resources, and data analysis staff time. LEAD, and the TMDL and DWP subprograms are primarily involved with CyanoHABs related efforts, although WQP can be involved sporadically through NPDES permits, 401 Certification, and general permits for pesticide/herbicide applications.

Overall, LEAD currently receives the most dedicated resources at DEQ to address CyanoHABs through several funding mechanisms and collaborations with state and federal agencies. Resources for LEAD staff, both in terms of FTE and laboratory equipment for analysis of cyanotoxins and nutrients, have increased since the implementation of OAR 333-061-0510 in 2019. LEAD also received additional staffing and equipment resources following the 2021 Oregon legislative session to improve monitoring of recreational waterbodies and other areas upstream of drinking water sources that may be contributing to CyanoHAB blooms. In terms of collaborations, LEAD has an interagency agreement with OHA work on special projects related to cyanotoxin monitoring. Most recently (2020), OHA provided DEQ funding to investigate the utility of quantitative polymerase chain reaction (qPCR) to protect public water supplies. In 2017 DEQ received supplemental EPA funding to monitor lakes across Oregon as part of the National Lakes Assessment (US EPA, National Lakes Assessment, 2021). These funds supported the collection of chemical, biological, and habitat indicators at 29 lakes including cyanotoxins. This program was funded again in 2022 and DEQ monitored 23 lakes as part of the study.

In general, the TMDL, DWP, and WQP programs in the Water Quality Division receive little dedicated funding and resources to address CyanoHABs. However, individual projects or responses to emergencies have received dedicated resources as needed under specific circumstances. Support for staff time spent on CyanoHABs in the Water Quality Division programs comes from State and General and Lottery Fund appropriations, EPA 319 funding for nonpoint source issues, and interagency agreements (i.e., OHA DWS support of DWP activities). Funding from the 319 Program has been used to address to address the restoration and protection needs of priority lakes, ponds, and reservoirs with approved TMDLs for CyanoHABs in Oregon (Oregon Department of Environmental Quality, 2022 Final Integrated Report, 2022). Funding and resources for CyanoHABs related efforts also are embedded in standard business expenses and general CWA activities, including Integrated Report development, issuance of NPDES permits, 401 certifications, and nonpoint source implementation activities, among others.

Current and projected funding for sustaining and enhancing the strategy remain insufficient to meet objectives outlined in each component of the DEQ CyanoHAB Strategy (Tables 2Table **2**. Specific actions and subprograms identified as currently part of or needed for addressing drinking water related issues related to CyanoHABs in Oregon freshwaters., 4, and 5). Other states, including Table 1Washington, California, Minnesota, Wisconsin, Nebraska, and New

Hampshire have used funding mechanisms such as registration fees, grants, or loans. Regardless of the approaches or mechanisms utilized, additional funding and resources will be required for DEQ to fully implement the agency's strategy.

Conclusions

The updates provided to the DEQ CyanoHABs strategy here reflect the ways in which the agency works internally and with partners to detect, monitor, assess, and manage CyanoHABs across Oregon. DEQ has made significant progress towards achieving goals on objectives outlined in the original DEQ HABs Strategy, with 65% of activities listed originally currently implemented or under development (Oregon Department of Environmental Quality, Oregon DEQ Harmful Algal Bloom (HAB) Strategy, 2011). However, as detailed in this document, expanded work and funding are still needed to fully realize and implement the strategy.

We intend the strategy to be updated regularly to assess progress towards meeting recommended actions detailed in Tables 2Table **2**. Specific actions and subprograms identified as currently part of or needed for addressing drinking water related issues related to CyanoHABs in Oregon freshwaters., 4, and 5 to identify emerging issues surrounding CyanoHABs in Oregon. DEQ expects that CyanoHABs will continue to impact water quality in Oregon freshwater ecosystems for the foreseeable future. While most past and current DEQ activities have focused on lakes and reservoirs, a growing body of evidence suggests CyanoHABs in rivers and streams could also significantly affect human health and downstream ecosystems (Interstate Technology Regulatory Council, 2022). Implementing the current strategy and working towards the recommendations outlined in this document will allow DEQ to meet the capacity to monitor, manage, and prevent CyanoHABs in freshwater ecosystems throughout Oregon.

Appendix A: Marine HABs

The 2011 DEQ HABs strategy only focused on HABs that occurred in the freshwater environment and did not address blooms that occur in estuarine and marine environments (Oregon Department of Environmental Quality, Oregon DEQ Harmful Algal Bloom (HAB) Strategy, 2011). Harmful Algal Blooms have been responsible for closures of shellfish and crab fisheries off the Oregon coast in recent years, resulting in negative social and economic impacts for coastal communities and across the state. Although these blooms largely occur in the open water habitats off the Oregon coast, the effects of HABs are often most felt along the shorelines. In response, the state of Oregon and the National Oceanic and Atmospheric Association have been engaged in efforts to research and monitor the potential causes and extent of HABs to better understand the risks ((Oregon Ocean Information, 2023).

Marine HABs are typically caused by types of phytoplanktonic algae which produce biotoxins that accumulate throughout the marine food web. The two most common biotoxin producing phytoplankton genus that occur off the Oregon coast are: (1) dinoflagellate blooms from the genus *Alexandrium* which produce saxitoxin, a neurotoxin that causes paralytic shellfish poisoning in humans and (2) diatom blooms from the genus *Pseudo-nitzchia* which produce domoic acid that causes amnesic shellfish poisoning in humans (Oregon Department of Fish and Wildlife, 2023).

In 2006, ODFW in collaboration with Oregon State university, University of Oregon and the NOAA Northwest Fisheries Science Center were awarded a 5 year nearly $2.3 million competitive grant from the NOAA CSCOR Monitoring and Event Response for a Harmful Algal Bloom (MERHAB) research program to develop an integrated HAB monitoring and event response program. This program, MOCHA, begun collecting data in 2007. ODFW staff, in conjunction with ODA monitored 10 sites along the coast of Oregon for any potential signs of the phytoplankton that cause Domoic Acid (*Pseudo-nitzschia* sp.) and Paralytic Shellfish Poisoning (*Alexandrium* sp.) (Oregon Conservation Strategy, 2023).

While HABs are often localized events, research suggests that the frequency and spatial extent of HABs off the west coast has increased over the last several decades. A geographically extensive and long lasting bloom of *Pseudo-nitzchia* that affected marine wildlife and fisheries along the west coast began in the spring of 2015. The bloom stretched from Alaska to California and persisted for longer than what is considered normal (Oregon Conservation Strategy, 2023).

Monitoring for these HABs and sampling shellfish for food safety have resulted in closures or opening delays for both recreational and commercial shellfish fisheries in Oregon. In its 2018 Integrated Report assessment (Anthony, 2020), DEQ concluded that since the entire Oregon Coast had a shellfish advisory for a minimum of one shellfish type (i.e. mussels, scallops, clams, razor clams, crabs and bay clams) in every year of the 10-year data window (January 1, 2008 through December 31, 2017), the entire Oregon coast would be listed as Category 5:Impaired for impairment of the Fishing: Shellfish consumption beneficial use.

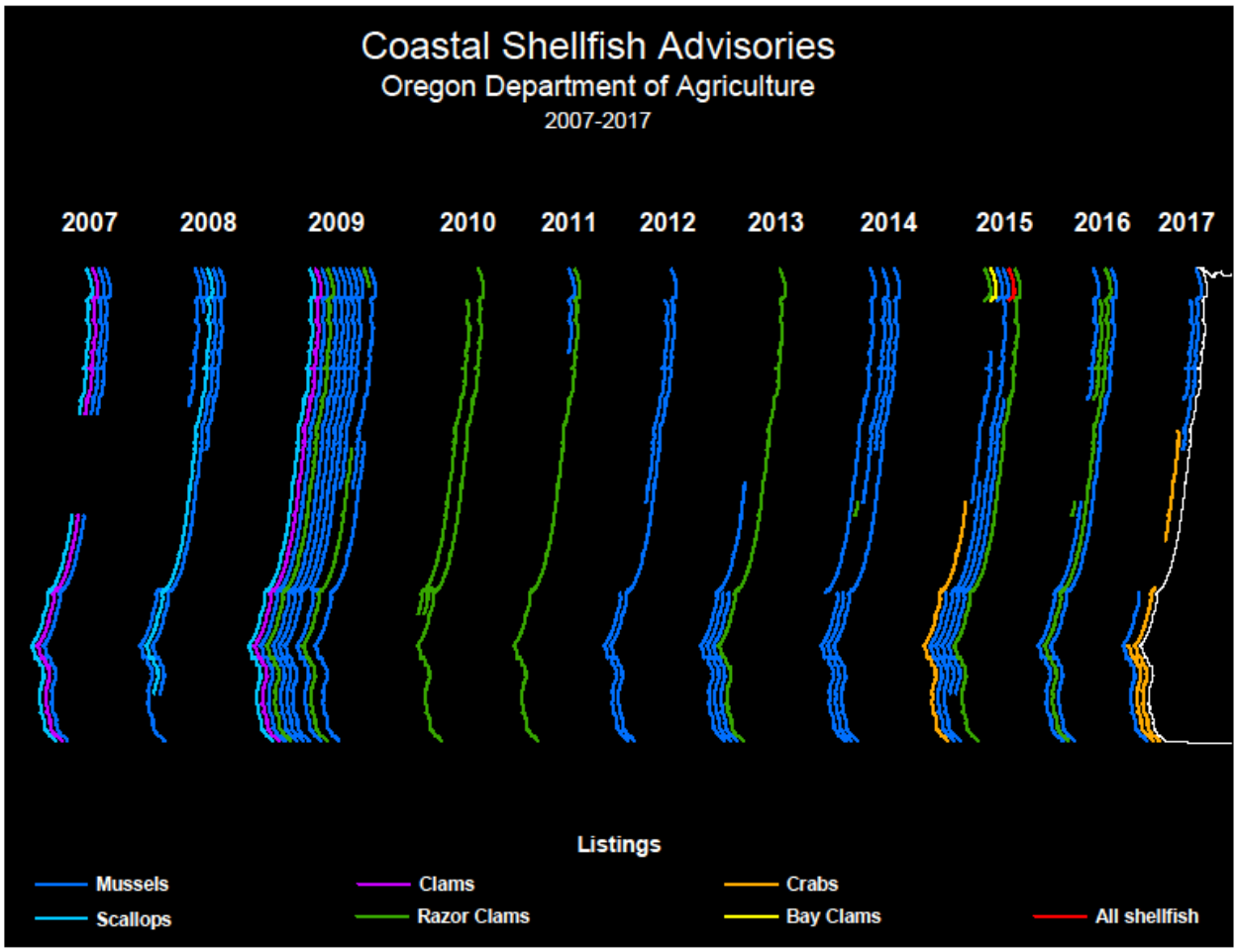

Figure 4. Schematic of Oregon coastal shellfish advisories by year from 2007-2017.

Monitoring for marine HABs is often conducted at two levels: sampling marine waters to monitor the phytoplankton for HABs and sampling organisms that consume phytoplankton to monitor for the accumulation of the disease-causing toxins. Oregon has not directly sampled its coastal waters for HABs since 2012 due to a lack of ongoing funding, however, Oregon Department of Agriculture continues to monitor selected bivalve shellfish species for biotoxins (Oregon Department of Fish and Wildlife, 2023).

References

Anthony, B. (2020). *Methodology for Oregon's 2018 Water Quality Report and List of Water Quality Limited Waters.* Portland, OR: Oregon Department of Environmental Quality. Retrieved from https://www.oregon.gov/deq/wq/Documents/wqa2018AssessMethodR.pdf

Dello, K. D., & Mote, P. W. (2010). *Oregon climate assessment report.* Corvallis, OR: Oregon State University.

Ho, J. C., Michalak, A. M., & Pahlevan, N. (2019, February 17). Widespread global increase in intense lake phytoplankton blooms since the 1980s. *Nature*, 667-670. doi:10.1038/s41586-019-1648-7

Interstate Technology Regulatory Council. (2022). *Strategies for Preventing and Managing Harmful Cyanobacterial Blooms (Benthic)*. Retrieved January 29, 2022, from https://itrcweb.org/teams/active/hcb

Monschein, E., & Reems, S. (2009). *Category 4b - Current National Status and Trends.* Washington, DC: US EPA.

Oliver, S. K., Collins, S. M., Soranno, P. A., Wagner, T., Stanley, E. H., Jones, J. R., . . . Lottig, N. R. (2017). Unexpected stasis in a changing world: Lake nutrient and chlorophyll trends since 1990. *Global Change Biology, 23*, 5455-5467. doi: https://doi.org/10.1111/gcb.13810

Oregon Conservation Strategy. (2023). Retrieved from Strategy spotlight: harmful algal blooms in marine waters: https://www.oregonconservationstrategy.org/success-story/strategy-spotlight-harmful-algal-blooms-in-marine-waters/

Oregon Department of Environmental Quality. (2011, June). *Oregon DEQ Harmful Algal Bloom (HAB) Strategy*. Retrieved January 27, 2022, from https://www.oregon.gov/deq/FilterDocs/HABstrategy.pdf

Oregon Department of Environmental Quality. (2022, September 1). *2022 Final Integrated Report*. Retrieved January 25, 2023, from https://rstudioconnect.deq.state.or.us/2022_IR_Database/

Oregon Department of Environmental Quality. (2022). *Environmental Justice*. Retrieved January 28, 2022, from https://www.oregon.gov/deq/about-us/Pages/Environmental-Justice.aspx

Oregon Department of Environmental Quality. (2023). Retrieved from About Drinking Water Protection: https://www.oregon.gov/deq/wq/programs/Pages/dwp.aspx

Oregon Department of Environmental Quality. (2023). *Harmful Algal Blooms: Drinking Water Cyanotoxin Monitoring*. Retrieved from https://www.oregon.gov/deq/wq/Pages/Drinking-Water-Cyanotoxin-Monitoring.aspx

Oregon Department of Environmental Quality. (2023). *Satellite Estimates of Cyanobacteria in Oregon Lakes and Reservoirs*. Retrieved from https://rstudioconnect.deq.state.or.us/Oregon-cyanobacteria-satellite-report/

Oregon Department of Fish and Wildlife. (2023). *Marine Resources: Commercial and recreational marine fisheries*. Retrieved from https://www.dfw.state.or.us/mrp/shellfish/razorclams/harmful_algae.asp

Oregon Health Authority. (2022). Retrieved January 27, 2022, from Oregon Drinking Water Services: https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/DRINKINGWATER/Pages/index.aspx

Oregon Health Authority. (2022). Retrieved January 27 2022, from Cyanobacteria Blooms: https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/RECREATION/HARMFULALGAEBLOOMS/Pages/index.aspx

Oregon Health Authority. (2022). *Cyanobacteria Advisory Archive*. Retrieved January 26, 2022, from https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/RECREATION/HARMFULALGAEBLOOMS/Pages/archive.aspx

Oregon Health Authority. (2023). *Cyanotoxin Monitoring Requirements For Sources Determined to be Susceptible*. Retrieved from https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/DRINKINGWATER/RULES/Documents/cyanotoxins/cyanotoxin-monitoring-flowchart.pdf

Oregon Ocean Information. (2023). Retrieved from Harmful Algal Blooms: https://www.oregonocean.info/index.php/ocean-issues/63-harmful-algal-blooms

Paerl, H. W., & Huisman, J. (2008). Blooms like it hot. *Science, 320*, 57-58.

US EPA. (2021). *319 Grant Program for States and Territories*. Retrieved January 28, 2022, from https://www.epa.gov/nps/319-grant-program-states-and-territories

US EPA. (2021, July 15). *Clean Water Act Section 303(d): Impaired Waters and Total Maximum Daily Loads (TMDLs)*. Retrieved January 26, 2022, from https://www.epa.gov/tmdl

US EPA. (2021). *National Lakes Assessment*. Retrieved January 28, 2022, from https://www.epa.gov/national-aquatic-resource-surveys/nla

US EPA. (2023). *Cyanobacterial Harmful Algal Blooms (CyanoHABs) in Water Bodies*. Retrieved from https://www.epa.gov/cyanohabs

Wisconsin Department of Natural Resources. (2021). *DNR Surface Water Grant Application Guide*. Retrieved 28 2022, January, from https://dnr.wi.gov/files/pdf/pubs/cf/cf0002.pdf