

CCHAB

Benthic algal mat signage design

April 30, 2020

CCHAB subcommittee

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Introduction

Benthic harmful algal blooms (HABs) have several differences from planktonic (suspended in the water column) HABs that affect how they are identified, sampled, and analyzed, and also impact the recommended precautions to reduce exposure. Benthic HABs are caused by algal and cyanobacterial (also known as blue-green algae) mats attached to substrates (boulders, cobble, sand, macrophytes, etc.) in the benthic (bottom) habitats of rivers or lakes. Though mats are usually dominated by one species, they are comprised of multiple species of micro and macro organisms forming a complex assemblage. Pieces of these mats can detach, float to the surface, and be transported with the current and wind to the shoreline.

Both algae and cyanobacteria can grow as benthic mats. Not all cyanobacterial species can produce toxins, and those that can do not always produce toxins. Therefore, when cyanobacteria are present in a mat, either as the dominant taxa or subdominant taxa within the assemblage, the benthic mat is potentially toxigenic. For example, cyanotoxins have been detected when cyanobacteria are at low relative abundance in mats dominated by non-toxic alga¹. Most cyanotoxins remain within the cells until the cells break open and die (lysis) therefore cyanotoxin concentrations in adjacent water samples may be low even when mat concentrations are elevated. The primary risk associated with mats is from ingesting the mat material rather than consuming the overlying water. Dogs and young children are most at risk from algal mats because they will directly consume the material.

To accurately evaluate the risk posed by mats, toxin concentrations in mats should be determined in the mat material ($\mu\text{g/g}$ mat), not the water column ($\mu\text{g/L}$). Currently the California Cyanobacteria and HAB Network (CCHAB Network) has [water column cyanotoxin trigger levels](#) expressed in micrograms per liter ($\mu\text{g/L}$) and does not have any toxin triggers for toxic mats. Collecting a water sample and comparing the water concentrations to the CCHAB cyanotoxin trigger level of cyanotoxin concentrations in water ($\mu\text{g/L}$) does not address the potential health risks from mats. Note that water samples may include some particles of cyanobacteria (visible colonies, small amounts of scum or dislodged mats) but this does not substitute for collection of mat samples.

In 2012, the Office of Environmental Health Hazard Assessment (OEHHA) published cyanotoxin action levels² that included mat toxin concentrations in milligrams toxins per kilogram dry weight. California

¹ Kelly et al. 2019 Multiple cyanotoxin congeners produced by sub-dominant cyanobacterial taxa in riverine cyanobacterial and algal mats
PLoS ONE 14(12):e0220422 <https://doi.org/10.1371/journal.pone.0220422>

² California Office of Environmental Health Hazard Assessment. *Toxicological summary and suggested action levels to reduce potential adverse health effects of six cyanotoxins*. May 2012.
<https://oehha.ca.gov/risk-assessment/document/toxicological-summary-and-suggested-action-levels-reduce-potential-adverse>

could improve risk assessment for toxic mats, if dry weight was calculated for mat samples collected by the FHABs program, and if CCHAB was to adopt mat trigger levels.

In addition to the sample and analysis differences, the messaging and advisories for benthic mats are also different from those developed for planktonic blooms, including the current CCHAB signs. Planktonic blooms can limit water visibility, cause visible discolorations, and be expansive, while benthic mats can grow in clear and pristine looking water and be sparsely distributed in a waterbody. The mat material can also detach from the bottom, float to the water surface, and be transported away from the source population, further complicating the messaging. As noted above, the primary risk associated with mats is ingesting mat material rather than overlying water. Due to these different characteristics between planktonic and benthic HABs, specific messaging and advisories are needed for each growth form.

A CCHAB subcommittee was formed to develop signage specifically for situations where cyanobacteria are present in benthic mats. This document describes the decisions the subcommittee considered in creating the signs, the content of the signs, and how they are intended to be used. If the CCHAB Network accepts these algal mat signs and procedures, the subcommittee proposes to add them to the California (CA) HABs Portal, share in future outreach material, and include in response communication if benthic mats occur at a reported waterbody.

Signage overview

Before creating the signs, the members of the subcommittee reviewed the HABs webpages for all states in the USA and Australia, all Canadian provinces, and all New Zealand Regional Councils. We documented whether benthic mats were included in these entities' HAB advisories and if there were benthic specific signs. Only New Zealand had advisories explicitly related to benthic mats and overall, fewer than 10 webpages mentioned benthic mats at all. Most visual guides for HABs did not include images of benthic taxa or mats. The subcommittee concluded that there were few resources to consult in considering benthic mats, and that New Zealand had the most developed messaging and advisory structure for addressing benthic mats.

The subcommittee decided to create two signs (Figs. 1 and 2) related to toxin producing benthic mats, a general awareness sign and a trigger level sign. Many entities in California already post general awareness signs at both lakes and rivers. These signs are not tailored for benthic mats, so the subcommittee agreed that there was a need for a benthic-focused general awareness sign alerting the public to watch for potential benthic mats at a location. There are also situations where there is a known potentially toxigenic benthic mat issue, so the subcommittee also created a trigger level sign to be used after benthic mats have been confirmed at a location.

The subcommittee chose to include pictures on the signs for three reasons. First, the subcommittee felt that most members of the public are less familiar with benthic algal mats than with planktonic harmful algal blooms. Second, much of the existing messaging and visual guides focus on planktonic bloom characteristics. Third, the patchy spatial distribution and diverse morphologies of benthic mats further complicates communication to the public. The subcommittee thought that adding images would help overcome these communication challenges for benthic mats. Many of the algal mat advisory and awareness signs in New Zealand include images of mats and the subcommittee thought this was an effective method to improve the clarity of information presented to the public.

Language choices

Toxic: “Toxic” was chosen over “harmful” because the subcommittee thought that the phrase “harmful algal mats” was too similar to “harmful algal blooms” (HAMs versus HABs). We wanted the language describing benthic mats to be distinct from planktonic blooms.

Algal mats: Algal was chosen instead of cyanobacteria, because the public is more familiar with the term algae. The phrase “algal and cyanobacterial” was too long and potentially confusing. The phrase harmful algae is more familiar to people than cyanobacteria. We did not want to introduce a new esoteric word to people. New Zealand also uses “toxic algae” to describe their mats.

Benthic: “Benthic” was not used on the signs, because the subcommittee thought it was too technical for, and unfamiliar to, the general public. The term “algal mats” was used instead, as noted above.

Potentially toxigenic benthic mats: Not all benthic algae and cyanobacteria produce toxins. Potentially toxigenic mats are mats where cyanobacterial taxa capable of producing toxins have been visually identified, either microscopically or in the field.

May be present: Potentially toxigenic benthic mats could be occurring at this waterbody; used with general awareness sign.

Are present: Potentially toxigenic benthic mats have been confirmed visually at this waterbody; used with trigger level sign.

Advisories

The subcommittee included advisories on the signs for the two populations most at risk from cyanotoxins in benthic mats – young children and dogs. The subcommittee determined children and dog advisories were the highest priorities given past incidents and the higher probability of mat contact and ingestion for these two populations. The advisories focus on consumption and contact with algal mats, rather than drinking overlying water, because, as stated above, cyanotoxin concentrations within mats can be very high while dissolved cyanotoxins produced by the mats are rarely detected in the water column at concentrations above Warning and Danger advisory levels. We also chose to focus on the primary exposure routes, ingestion of, and contact with, mat material rather than inhalation of aerosols or fish or shellfish consumption.

Two icons are associated with the children and dog advisories. The icons on the CCHAB planktonic signage were not used because those icons do not clearly represent the advised behaviors or actions on the benthic signs. Instead, the subcommittee chose an open hand icon for the human advisory. This is designed to communicate, “do not touch.” The subcommittee thought this was simple and universally interpretable. Some New Zealand Regional Councils use a hand to communicate “do not touch.” A “no dog” icon was chosen for the dog advisory since multiple behaviors (drinking water and eating mats) are included in the advisory and potentially hard to convey in a small icon.

Many different benthic algal and cyanobacteria taxa, as well as mixed assemblages of potentially non-toxic and toxic species, can co-occur in California. Therefore, the subcommittee determined that signs would be too complicated or confusing if the emphasis were placed on avoiding only certain taxa. Therefore, the advisories on the proposed signs state that all algal mats should be avoided, not just toxigenic cyanobacterial mats. This is also consistent with advisories in other regions (e.g. New Zealand

and Wisconsin) where the signage recommends that people not consume any material in the water, rather than singling out cyanobacteria.

General awareness sign description

The general awareness sign (Fig. 1) is designed to:

- 1) inform people that potentially toxigenic benthic mats MAY be present,
- 2) provide them with information about how to identify benthic mats, and
- 3) advise people on preventative practices to reduce the risk of exposure to benthic mats.

Trigger level: There is no trigger level associated with posting the general awareness sign. This sign can be displayed to increase overall awareness, even when no potentially toxigenic benthic mats are present.

Overview: The general awareness sign can always be posted at waterbodies where potentially toxigenic benthic mats are likely to occur. In situations where a planktonic bloom is more likely, we recommend using the US EPA infographics customized for California ([abbreviated sign](#) and [detailed sign](#) versions available), which were designed for planktonic blooms. In some lakes there could also be seasonal shifts within a waterbody in the types of cyanobacteria that grows. For example, in summer planktonic blooms could occur, while in winter there could be potentially toxigenic benthic mats that grow. In these cases, planktonic and benthic signage could be swapped out depending on which form of bloom (benthic or planktonic) was most likely to grow in a given season.

Trigger level sign description

The trigger level sign (Fig. 2) is designed to:

- 1) inform people that potentially toxigenic benthic mats ARE present
- 2) provide them with information for how to identify benthic mats and
- 3) advise people on preventative practices to reduce the risk of exposure to benthic mats.

Trigger level: There are two triggers for posting this sign, 1) presence of potentially toxigenic benthic mats, floating mat material, or stranded mats on the shoreline at a site, or 2) detection of cyanotoxins or cyanotoxin genes within mat material. Either trigger can result in a signage posting and this sign does not require cyanotoxin detections prior to posting (see [CCHAB guidance for posting jurisdictions](#)). If potentially toxigenic benthic mats are observed at a site (either in the field or microscopically) by a qualified observer, then the trigger level sign can be posted. The subcommittee deemed that the presence or absence of potentially toxigenic benthic mats is an acceptable trigger, rather than an additional metric such as percent cover of a sampling area. This is due to the challenges of consistent percent cover measurements between observers, time and training involved to make percent cover measurements, and the mobile nature of detached benthic mats. The additional visual indicators of potentially toxigenic floating mat material or stranded mats were included to address situations where mats have detached, been transported by wind or flow, and are floating or stranded at a different location.

As mentioned in the introduction, there are currently no CCHAB trigger levels for benthic mats, and mat samples are not typically analyzed by the method and in units comparable to OEHHHA's 2012 crust and mat action levels. Meaning at this time the subcommittee cannot establish cyanotoxin concentration triggers for posting signs. Therefore, the subcommittee decided that the presence of toxins or toxin producing genes (via qPCR) in the mat material (not overlying water) is an acceptable trigger level.

Overview: The advisories associated with the trigger level sign are similar to the CCHAB “Caution” sign. The coloration and language of the trigger level sign communicate more risk due to the confirmed presence of potentially toxigenic benthic mats. Yellow was chosen as the color for this sign, due to the similar advisories with CCHAB “Caution” sign. The trigger level sign is posted after the trigger level conditions described above (visual observation or toxins in mat material) have been met. The subcommittee concluded that this sign is complementary to either the benthic general awareness sign or a planktonic general awareness sign (such as the [US EPA infographics](#)). Once potentially toxigenic benthic mats are confirmed then the trigger level sign can be posted alongside the general awareness sign because the signs are designed to offer complementary messaging. Alternatively, the trigger level sign can be posted alone if no general awareness sign was previously posted at a location.

Some lakes may experience a planktonic bloom and have potentially toxigenic benthic mats also growing in the lake at the same time. The subcommittee agreed that in these cases where both a toxic planktonic bloom and potentially toxigenic benthic mats are present, the CCHAB planktonic signs would be most protective of public health. For example, the planktonic signs have more advisories than the general awareness sign. Specifically, they advise people to avoid scums, and any detached floating benthic mats would fit into this category, and so the planktonic sign would protect against benthic material. Therefore, in the event of a planktonic bloom, the trigger level sign is not intended to replace the current CCHAB planktonic signage, nor water column trigger levels.

Though it is unlikely that dissolved cyanotoxins from benthic mats will exceed water column concentrations to trigger a CCHAB Warning or Danger planktonic advisory, an anatoxin-a Caution advisory could be more easily triggered. Since anatoxin-a is frequently produced in mats, the CCHAB anatoxin-a Caution advisory was set at any detection of anatoxin-a because if there is anatoxin-a in the water column there might be mats nearby and dogs and children are at high risk to toxigenic benthic mats³. When the trigger level was developed, there had been cases where dogs had been harmed by very low water column concentrations of anatoxin-a in the water, likely due to ingesting mat material. The low anatoxin-a trigger level was designed to protect dogs and children from the ingestion of mat material not consumption of open water, given the lack of mat specific advisories and signage at the time.

Due to the low anatoxin-a trigger level, it may happen that benthic trigger levels are met (visual confirmation of potentially toxigenic mats or cyanotoxins detected within mats), and anatoxin-a is detected in a water column sample, triggering a planktonic Caution advisory. In this case where both signs are triggered, we recommend placing both the planktonic Caution sign and the benthic trigger level sign. Since potentially toxigenic mats are confirmed, it is important to have the benthic trigger level sign posted, so that the public knows that the greatest risk is posed by the mats, and not the open water column. Only placing a planktonic Caution sign would not accurately communicate risk to the public.

³ Appendix A. CCHAB 2016 Cyanotoxin Advisory Levels Guidance Document. https://mywaterquality.ca.gov/habs/resources/habs_response.html#trigger_levels

Posting guidelines

General awareness sign

1. Posting general awareness sign

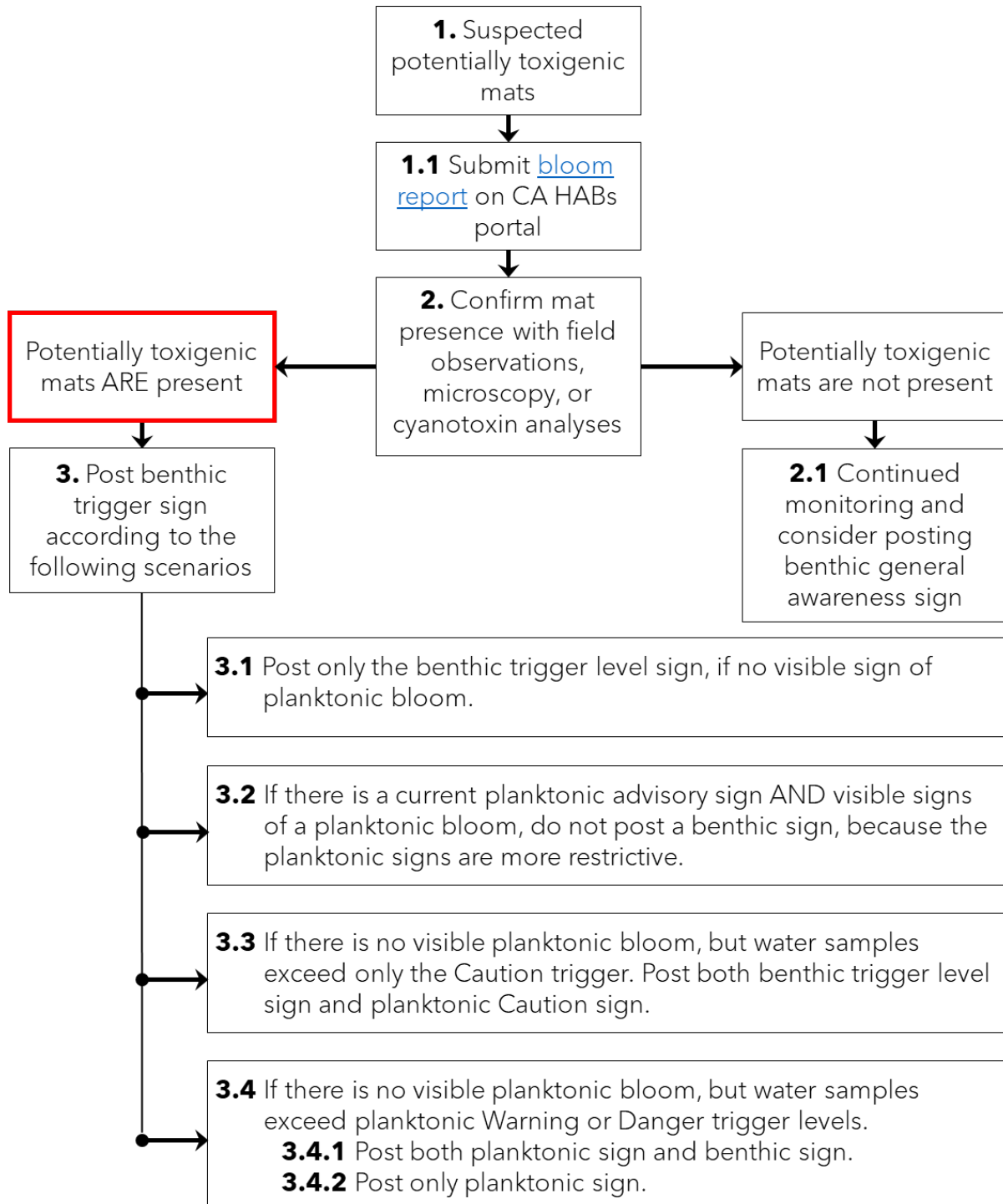
- 1.1.** If you suspect that potentially toxigenic benthic mats are likely to occur at a waterbody, then the general awareness sign can be posted prior to any visual confirmation of mats being present.
 - 1.1.1.** Waterbody managers can decide if they would like to post a general awareness sign.
 - 1.1.2.** The general awareness sign does not need any authorization from the Water Boards or County Health staff.
- 1.2.** Signs can be posted seasonally or remain in place all year.
- 1.3.** If a general awareness sign is posted, and a planktonic bloom occurs, then the CCHAB advisory can replace the benthic general awareness sign or be posted concurrently with the benthic general awareness sign.

Trigger level sign

The posting guidelines for the benthic trigger level sign follow a similar general framework as the planktonic advisories but are not associated with the planktonic cyanotoxin trigger levels. Regional or State Water Boards staff recommend HAB advisories based on the voluntary California guidelines to the local public and/or environmental health staff, water managers, and recreation managers. The local Health staff have the jurisdiction to issue public health advisories. A water manager or recreation manager is strongly recommended to coordinate posting with the local health agency and to contact the Water Boards to get assistance in coordinating the signage posting: cyanoHAB.reports@waterboards.ca.gov or 1-844-729-6466.

The flow-chart below summarizes the process for posting a benthic trigger level sign. A detailed description of the process follows the flow-chart.

Benthic trigger level sign posting process summary



Benthic trigger level sign posting detailed process

1. Suspected potentially toxigenic benthic mats are present

1.1. File a Bloom Report by either:

1.1.1. Filling out the [online bloom report form](#),

1.1.2. Emailing cyanoHAB.reports@waterboards.ca.gov

1.1.3. Calling 800-222-1222 (toll free).

1.2. Take photographs of the potentially toxigenic benthic mats and submit to cyanoHAB.reports@waterboards.ca.gov with Bloom Report ID number.

1.2.1. The online form will not support the uploading of photographs. After you submit the form, please send photographs of mats (attached, floating, or stranded) and any additional information.

1.3. Once the report is submitted, staff from the Regional Water Quality Control Boards or State Water Board will contact you to collect more information and coordinate additional sampling.

2. Visual confirmation or collection of mat samples

2.1. If potentially toxigenic benthic mats are not present, consider posting the general awareness sign and continue monitoring the site as needed.

2.2. If the presence of potentially toxigenic benthic mats can be confirmed based on field photographs, then the trigger level sign may be placed.

2.2.1. If the photographs are not clear to trained staff, then an additional site visit will be needed to obtain more information about the composition of mats and their potential for toxin production. Collection of samples for microscopy would be recommended in mixed assemblages where the presence of toxigenic species is difficult to visually determine in the field.

2.3. If cyanotoxins or cyanotoxin synthesis genes (via qPCR) are detected in the mat material, then the trigger level sign should be posted at the site.

2.3.1. Note, mat samples for cyanotoxin or gene analyses are not required to post the trigger level sign but could be collected to gather additional information.

2.3.2. The SWAMP field guide includes an [SOP for collecting mat material](#).

3. Posting trigger level sign

Posting of trigger level signs should be coordinated with Water Boards staff, County Health staff, and waterbody managers. County Public or Environmental Health grants the authority to post a health advisory sign. All postings should be connected to a bloom report (see section 2.2). As with the CCHAB planktonic signs, the spatial extent covered by each advisory and posting is subject to the discretion of the waterbody manager, Water Boards staff, and County Health staff.

3.1. The trigger level sign could be placed next to a planktonic general awareness sign. It is up to the discretion of the waterbody manager on how to display general awareness and trigger level signs in order to best communicate risk to the public.

3.2. If there is visual evidence of a planktonic bloom and water concentrations exceed the planktonic Caution, Warning, or Danger trigger levels, even if benthic mats are also present, the appropriate planktonic advisory sign should be posted. Posting only the

benthic trigger level sign is not recommended, since this trigger sign is less restrictive and contains fewer advisories than the CCHAB planktonic signs.

3.3. If potentially toxigenic mats are present and there are no visual indicators of a planktonic bloom, but cyanotoxins are detected in the water column at levels above the Caution planktonic trigger, yet below Danger or Warning triggers, then triggers for both the benthic trigger level sign and the planktonic Caution advisory have been met, though it is likely that the source of the water column anatoxin-a is the benthic mats.

3.3.1. The benthic trigger level sign and the planktonic Caution sign should be placed at the water body

3.3.2. The planktonic Caution sign should not be posted alone because it does not adequately communicate the risk of mats to the public.

3.3.3. Note, it is not required to collect water column samples when there are no signs of a planktonic bloom and cyanotoxins are thought to be produced in mats.

3.4. In the rare circumstance that toxic benthic mats are confirmed and water column concentrations reach the CCHAB Warning or Danger level **without any visual evidence of a planktonic bloom**, we recommend coordination between the responding waterbody managers, Regional/Water Boards staff, and local Public Health staff to determine which of the following two signage options is most appropriate to protect public health for the given situation.. The two signage options are:

3.4.1. Post both the benthic trigger level and the appropriate CCHAB planktonic sign (Warning or Danger).

3.4.2. Only post the CCHAB planktonic sign.

4. Continued monitoring and de-posting

4.1. Once the trigger level sign is posted, then the site should be monitored for presence of benthic mats (attached, floating and detached, or stranded onshore).

4.2. Trigger level signs can be removed, if visual surveys do not identify potentially toxigenic benthic mats or mat samples have no cyanotoxin or cyanotoxin synthesis gene detections over a 2-week period ([consistent with the current CCHAB de-posting criteria](#)).


4.2.1. Local health officials should be notified of the changing advisory status when trigger level signs are removed, and the advisory status should be changed on the CA HABS Portal incident map by coordinating with the Regional or Water Boards staff.

Figure 1. General awareness sign.


CHECK FOR ALGAE


Toxic algal mats may be present in this water
Mats can be attached to the bottom, detached and floating, or washed up on shore

Common examples



If you see algal mats:

 **Do NOT let children or adults touch, eat, or swallow any algal mats.**

 **Do NOT let dogs eat algal mats or drink from the water.**

Call your doctor or veterinarian if you or your pet get sick after contacting or ingesting algae. For more information on toxic algae visit: mywaterquality.ca.gov/habs
For local information, contact:

Figure 2. Trigger level sign

TOXIC ALGAE ALERT

Toxic algal mats ARE present in this water

Mats can be attached to the bottom, detached and floating, or washed up on shore



Do NOT let children or adults touch, eat, or swallow any algal mats.



Do NOT let dogs eat algal mats or drink from the water.



Call your doctor or veterinarian immediately if you or your pet get sick after contacting or ingesting algae. For more information on toxic algae visit: mywaterquality.ca.gov/habs

For local information, contact:

Date posted: