

The Environmental Case Management of Persons Exposed to Harmful Algal Bloom and Cyanobacteria

Guidelines for Public Health Officers

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Executive summary

These guidelines provide advice to public health officers on the environmental case management of people who may have been exposed to harmful algae or cyanobacteria in recreational water in New Zealand.

Background

Algae and cyanobacteria are an essential part of food webs in aquatic ecosystems, but at times they can produce biotoxins that pose a health hazard for humans and animals. Both algae and cyanobacteria exist in planktonic environments (free-floating in water) and benthic environments (mat-forming or attached to the substrate of rivers, lakes, estuaries, and other bodies of water). When potentially hazardous algae or cyanobacteria grow too fast or bloom, they are termed harmful algal blooms (HABs).

Biotoxin producing microalgae such as dinoflagellates and diatoms occur in marine environments. Cyanobacteria can occur in both fresh water and marine environments. Many of the health effects from recreational exposure to fresh, brackish, and marine cyanobacteria are similar to those from exposure to marine algae. Therefore, public health risk management for recreational water is similar for both marine and freshwater HABs.

The most significant exposure route for marine HABs is via food (not covered in any detail in this guidance). Internationally there are also reports of dermal, accidental water ingestion, and aerosolised exposure to marine HAB biotoxins – although such reports are generally associated with less serious consequences than toxic seafood poisoning.

Hazard identification

Freshwater cyanobacterial blooms often contain a mixture of toxin and non-toxin producing strains and their relative proportions may vary during the bloom. The factors that affect toxin production is not well understood, making it difficult to predict how much biotoxin will be produced in a bloom. Additionally, not all species form blooms or scums visible to the naked eye.

Cyanobacteria produce a range of cyanotoxins with different mechanisms of action. In New Zealand these biotoxins include microcystins, nodularins, anatoxins, saxitoxins, and cylindrospermopsins. Marine cyanobacterial species that produce lyngbyatoxins have also been identified in New Zealand.

Environmental conditions, such as wind or turbulence in water, can affect human exposure to HABs in recreational water depending on where and when HABs accumulate or dissipate.

Changing environmental conditions can present challenges with sampling, quantifying, or specifying biotoxins that would have been present during exposure events.

Other challenges include the coexistence of multiple potential biotoxins and the potential for exposure to previously unidentified biotoxins or biotoxin producing species. Many of the existing observational studies acknowledge challenges with attributing causation, but there is a reasonable body of literature demonstrating associations between adverse health effects and biotoxin exposures. Some observational studies also show an association between increased dose and route of exposure with adverse health effects, although this is more evident in animal studies.

As evidence regarding toxic strains of cyanobacteria and marine microalgae continues to evolve, a clear cause of symptoms may not be obvious at times and the potential for new biotoxin-producing strains may need to be investigated.

Exposure and health effects

It can be difficult to determine the type of biotoxin that caused illness based on self-reported symptoms and multiple exposure routes. Symptoms associated with exposure to HABs include dermal, eye, ear, and allergy symptoms from direct contact with contaminated water or from touching algal mats. Respiratory, nose, and throat symptoms can be associated with inhalation of contaminated water spray or aerosolised toxins. Vomiting and diarrhoea are common following recreational water cyanotoxin exposure. Swallowing contaminated water containing high concentrations of HAB species could cause neurological, gastroenterological, and liver symptoms.

The duration of time from exposure to symptom onset varies depending on the type of biotoxin. Usually, symptoms will appear within 24 hours of exposure. Neurotoxins such as anatoxins and saxitoxins are quick acting (within minutes to hours). Gastrointestinal and skin symptoms typically occur within three to five hours.

Children and people who have underlying health conditions are likely to be more vulnerable to the adverse effects of biotoxins. Māori and Pacific peoples disproportionately carry an increased burden of underlying co-morbidities perpetuated by the social determinants of health. People whose lifestyle or occupation predisposes them to more frequent contact with recreational water could lead to repeated exposures to HABs.

Most of the symptoms reported in recent epidemiological studies of acute health risks from short-term recreational exposure to low levels of cyanobacterial blooms were mild and self-limiting. This is likely because the dose from recreational exposures is lower than from other exposures. However, there are multiple indicators of the toxicity of some of these biotoxins via other exposure routes, such as toxic seafood poisoning, drinking water, or historic tragedies of contaminated haemodialysis water. Animal deaths associated with biotoxins also indicate the toxic potential of biotoxins.

Public health investigation and management of HAB exposure

All suspected cases of biotoxin poisoning from HABs must be notified to the public health system as they are classified as poisoning arising from chemical contamination of the environment under Schedule 2 of the Health Act 1956.

Case investigation of exposure to HABs requires a detailed history of the exposure and the timing of subsequent symptoms to determine the likelihood that symptoms are associated with HAB exposure in recreational water. Other potential causes of illness should be considered during the investigation.

Most cases, with a plausible exposure and clinical history will likely be classified as probable cases, as there is not yet any clinical laboratory testing available to confirm a non-foodborne cyanobacterial or marine HAB biotoxin poisoning diagnosis in humans. Cases can be classified as confirmed if several criteria are met. This includes that there is more than one affected person exposed to the same recreational waterbody and laboratory tests of the water confirm levels of HABs or HAB biotoxins that are associated with adverse health effects.

Additional environmental testing is not routinely required for classifying a case of HAB poisoning. However, if there is more than one person potentially exposed to HAB biotoxins or if there is probable public health risk at a recreational water site (not already known about) then further testing may aid public health risk assessment.

Case management involves communicating the public health risk to the exposed person and their whānau with the intention to prevent further HAB exposures and advising them to seek medical advice from their usual health care practitioner. It is important to understand the exposed person's cultural and social context and to ensure advice and public health responses are tailored to the person.

There are no contact tracing requirements as there is no person to person spread of illness from HABs. However, there may be other people exposed to HABs at the same recreational waterbody who may benefit from public health advice about HABs. It is important to understand if other people were exposed to the same waterbody and whether they became unwell, as it is likely to influence the public health risk assessment.

If case investigation, reports of animal deaths, or water monitoring and surveillance indicates HAB or HAB biotoxin levels meet the threshold for potential adverse health effects then a public health officer must alert the community of the public health risk.

The New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters (Ministry for the Environment & Ministry of Health 2009) provide two three-tier alert-level frameworks that identify monitoring thresholds for public health action based on increasing potential exposure risks from planktonic and benthic freshwater cyanobacteria. The frameworks are based on indicators of increased potential exposure risk such as greater biomass or cyanotoxin concentrations, dictating the need for increased frequency of monitoring and depending on the threshold, public

health action to communicate the health risk. There is no alert level framework for HABs in recreational marine water to guide safe recreation.

Communicating the public health risk via media releases, warning signs, engaging with primary care, and engaging and partnering with iwi and hapū are important for encouraging the public to avoid exposure to HABs in recreational water. Once monitoring shows HAB levels have reduced to meet lower alert levels and there are no other public health risks, then public health alerts can be downgraded.

Surveillance and monitoring of recreational freshwater is the responsibility of local councils under the *National Policy Statement for Freshwater Management* (Ministry for the Environment 2020), with advice from local public health officers. The Ministry for Primary Industries (MPI) is the lead agency for issuing and directing warnings for HAB biotoxins at recreational shellfish harvesting areas.

Monitoring and surveillance do not guarantee a waterbody is safe for recreation as environmental conditions and subsequently HAB biotoxin activity can change between monitoring intervals and other (unmonitored) environmental hazards may exist.

Public health advocacy for longer-term management of HABs

Given the toxic potential of HAB biotoxins in recreational water, preventing them occurring is key, otherwise alerts and advisories to avoid contact with recreational water are required.

Whilst cyanobacteria and microalgae are naturally occurring, they are greatly exacerbated by human activities such as nutrient runoff from agriculture and reduced water flows from extraction or drought and climate change. There is considerable scope for reducing the risk in the first place, which is the most important step in the hierarchy of controls.

In te ao Māori | the Māori world, connection to te taiao | the environment is of deep and spiritual importance to tangata whenua. Te Mana o Te Wai is a mātauranga | Māori knowledge concept that describes the importance of freshwater. It recognises that water is a taonga with its own mauri | lifeforce and recognises the interconnectedness of water and the wider ecosystem.

Te Mana o Te Wai highlights the importance of protecting the health and wellbeing of freshwater, to contribute to the protection of the health and wellbeing of people. Preventative action provides an opportunity for meaningful partnership and shared decision making with Māori to focus on both environmental and health outcomes.

Introduction

Purpose and scope

The purpose of this document is to provide guidance to public health officers on the environmental case investigation and management of people exposed to harmful algal blooms (HABs) in recreational water. It outlines the public health risks and management principles associated with recreational exposure to HABs, in marine and freshwater environments in New Zealand – although freshwater cyanobacteria are the main focus of this guidance.

Toxin-producing marine cyanobacteria and microalgae also pose a health risk to recreational water users but guidance material for this setting is currently limited and foodborne exposures pose a potentially more significant public health risk in that setting.

This document covers direct dermal contact, inhalation, and accidental ingestion exposure to HABs from recreational water, but not exposures through drinking water or foodborne ingestion. Guidance on cyanobacteria and drinking water is provided by Taumata Arowai (2020).

Information on food borne exposure to HAB biotoxins is provided by the Ministry for Primary Industries (MPI), though currently, MPI focus on marine algal toxins and shellfish.

This guidance is intended for use by public health officers (eg, Medical Officers of Health and Health Protection Officers) to investigate suspected exposure to harmful algae/cyanobacteria and manage subsequent public health risks. This guidance does not apply to clinical management of ill people, occupational exposures, nor animal exposures.

Background

Terminology

Cyanobacteria (also referred to as blue-green algae) are prokaryotic organisms that inhabit rivers, lakes, reservoirs, brackish, marine, and terrestrial environments. Cyanobacteria are technically bacteria but are often grouped with algae as they perform some of the same ecological functions as algae, such as using chlorophyll to produce energy through photosynthesis (Land, Air, Water Aotearoa (LAWA) 2021).

Microalgae are usually found in aquatic environments, including freshwater, salt water, and brackish water (a mixture of salt- and fresh-water). Like cyanobacteria, microalgae also harvest light from the sun to produce energy but are eukaryotes (have an enclosed nucleus) and have organelles (structures) such as chloroplasts. Diatoms and dinoflagellates are common types of microalgae.

Phytoplankton is a term that is commonly used in reference to cyanobacteria and microalgae – microscopic, single-celled photosynthetic organisms that live suspended in water. Periphyton refers to benthic mats made up of photosynthetic organisms as well as many other microbes. Both microalgae and cyanobacteria encompass both planktonic (free-floating in water) and benthic / epiphytic (mat-forming or attached to / associated with the substrate of rivers, lakes, estuaries, and other bodies of water) environments.

Harmful algal blooms

When biotoxin-producing microalgae or cyanobacteria grow too abundant, they can be harmful to human and animal health and such events are termed harmful algal blooms (HABs) (Centers for Disease Control and Prevention 2022b). For these guidelines, HAB refers to any potentially harmful growth of microalgae or cyanobacteria, in fresh, brackish, or marine environments.

Microalgae and cyanobacteria themselves are not a health hazard and are an essential part of the food web for aquatic life. However, some cyanobacteria and microalgae can produce toxins, termed biotoxins or phycotoxins, which are hazardous to human and animal health.

The public health risks from microalgae and cyanobacteria exposure are greatest during blooms when there are greater cell densities and potentially greater production of biotoxins (Taumata Arowai 2020; Wisconsin Department of Health Services Division of Public Health 2018).

Marine versus freshwater environments

Generally, toxin producing microalgae, such as dinoflagellates and diatoms, occur in marine environments whereas cyanobacteria occur in both freshwater and marine environments.

Many of the health effects from fresh, brackish, and marine cyanobacteria are similar to those from marine microalgae, excluding effects mediated through food consumption (Carmichael & Boyer 2016). Therefore, public health risk management principles for recreational water are similar for marine or freshwater HABs.

Marine HABs can affect the colour of the water, often turning it red or brown (termed red tides) or green or produce surface scums (Centers for Disease Control and Prevention 2022b). However, scums occur less frequently in marine waters than in fresh waters (World Health Organization 2021). When HABs die off, biotoxins can be released into the environment and the degradation process of the bloom can also cause aquatic animal deaths due to low oxygen levels.

Cyanobacteria

The biotoxins produced by cyanobacteria are called cyanotoxins. Cyanotoxins are made (biosynthesised) and stored in cyanobacterial cells. When cyanobacterial cells die, and rupture (lyse) cyanotoxins are released into the water. However, some species of cyanobacteria, like cylindrospermopsin-producing *Raphidiopsis*

raciborskii, can release cyanotoxins into the water without cell death or rupture (Chiswell et al. 1999; United States Environmental Protection Agency 2022b). Anatoxin-producing *Microcoleus autumnalis*, has also been shown to continuously release toxins into the surrounding water (Wood SA et al 2018). Thus, at the end of a bloom, there can be high concentrations of cyanotoxins, even if the bloom looks like it is subsiding.

Both planktonic and benthic cyanobacterial species are widespread in New Zealand. Cyanobacterial blooms can be identified visually in water by the presence of filaments, mats, blue, brown, or green discolouration of water and/or scum on the surface of the water. However, cyanotoxins can be present despite no visible bloom as not all species form blooms or scums visible to the naked eye (Ministry for the Environment & Ministry of Health 2009).

Some benthic cyanobacteria can be visually confused with freshwater algae groups. Furthermore, in California, toxin-producing cyanobacteria have been found growing amongst other benthic cyanobacteria and algal mats that would not traditionally be considered as dangerous (Kelly et al 2019).

Consequently, it is important that surveillance and monitoring of recreational water includes a component of microscopic examination (World Health Organization 2020b) or the measurement of cyanobacteria-specific pigments such as phycocyanin (Thomson-Laing et al 2020). Sampling of other periphyton besides cyanobacteria-dominated mats could be considered in an outbreak situation if clinical symptoms and environmental sampling results are mismatched.

To date, there is limited information on toxic metabolites or health impacts from freshwater microalgae, but the detection of new toxin-producing microalgae in freshwater environments is a possibility that may need to be investigated in serious outbreaks where other illness causing organisms cannot be identified.

Anthropogenic acceleration of HABs

It is useful to understand conditions in which HABs occur to prioritise monitoring and surveillance and to support risk assessments (Chorus & Welker 2021). The conditions for HABs are complex and although they can occur naturally, HABs can be accelerated by human activity.

Agricultural intensification resulting in run-off from fertilisers and manure spread on agricultural areas and other human activities such as wastewater discharges can increase the concentrations of nutrients and minerals, particularly phosphate and nitrogen, in rivers, lakes, and marine environments. This process is known as eutrophication and can subsequently exacerbate HABs. However, some species of cyanobacteria can store phosphate and nitrogen, so cyanobacterial growth can still occur for a period after dissolved nutrient levels in the water have reduced (Chorus et al 2021; Chorus & Welker 2021).

It is well established that marine and freshwater ecosystems are warming, acidifying, and deoxygenating due to anthropogenic climate change (Gobler 2020; Griffith & Gobler 2020). The effects of climate change on cyanobacterial blooms are strongly

dependent on the conditions in the particular waterbody and the species of cyanobacteria present (Chorus et al 2021).

Warmer temperatures and reduced river flows in New Zealand related to climate change and water extraction could plausibly promote increased growth of freshwater cyanobacteria if nutrient concentrations are optimal for cyanobacterial growth (Puddick, Kelly, et al 2022). Other factors which affect the rate of growth of freshwater cyanobacteria include intensity of daylight, water alkalinity and pH, and atmospheric carbon dioxide (Taumata Arowai 2020). Warming ocean temperatures are also likely to increase the occurrence and intensity of marine microalgae and cyanobacteria (Rhodes & Smith 2022).

HABs usually occur during the summer months into autumn in New Zealand. However, with climate change induced warmer temperatures this may mean the peak season for blooms may last longer. Climate change may also result in different biotoxin producing cyanobacteria and microalgae being introduced to New Zealand and different HAB species being observed in regions where they have not previously grown.

The importance of the environment in te ao Māori

In te ao Māori | the Māori world, connection to te taiao | the environment is of deep and spiritual importance to tangata whenua (Harmsworth & Awatere 2013; Ministry for the Environment 2021). Whakapapa | ancestral lineage and connection encompasses personal relationships with mountains, rivers, land, the surrounding ecosystem and the species that inhabit them (Ministry for the Environment 2021; Te Aho 2018).

Māori models of health promotion, such as Te Pae Mahutonga are holistic and emphasise the connection between wai ora (healthy physical environments) and healthy people (Durie 1999). Pae ora is the overarching aim of He Korowai Oranga: Māori Health Strategy and includes three interconnected elements: mauri ora | healthy individuals, whānau ora | healthy families and wai ora | healthy environments. Wai ora acknowledges the importance of Māori connections to te taiao and the significant impact te taiao and access to resources (eg, healthy housing, air, water and food) has on the health and wellbeing of individuals, whānau, hapū, iwi and Māori communities (Ministry of Health 2014).

Whakamaua: Māori Health Action Plan 2020 – 2025 describes intended outcomes and priority actions that will contribute to pae ora. Enabling Māori health and wellbeing aspirations continues to be a condition for achieving pae ora.

Māori have the right to manage their own health and wellbeing aspirations. This requires changes to systems (such as addressing racism and including mātauranga Māori and Māori leadership) that better enable Māori to thrive, create healthy and sustainable environments and communities in which to live and raise children. Amongst other priority actions, Whakamaua highlights the importance of cross-sector action to address the broader determinants of health and to ensure Māori have access to healthy environments (Ministry of Health 2020).

Te Mana o Te Wai is a mātauranga Māori | Māori knowledge concept that describes the importance of freshwater. It recognises that water is a taonga with its own mauri | lifeforce and recognises the interconnectedness of water and the wider ecosystem.

Te Mana o Te Wai highlights the importance of protecting the health and wellbeing of freshwater, to contribute to the protection of the health and wellbeing of people. The *National Policy Statement on Freshwater 2020* requires that management of freshwater must give effect to Te Mana o Te Wai through active engagement with tangata whenua and communities (Ministry for the Environment 2020). Shared decision-making power and meaningful co-governance of te taiao with Māori is also a vitally important part of upholding crown obligations under Te Tiriti o Waitangi.

The importance of prevention

The hierarchy of controls is an approach to risk management. Eliminating the hazard is the most effective control, followed by substitution, engineering controls, administrative controls and personal protective equipment (Centers for Disease Control and Prevention 2022c).

In line with the concept of elimination as the most effective control, human activity should not exacerbate proliferation of HABs in the first place. If HABs do occur, preventing exposure to the hazard eg, communicating the health risks to the population, via alerts and warnings to avoid water with HABs, is the next priority along with ongoing public education about avoiding exposure to HABs.

The use of personal protective equipment for those who do have contact with the hazard also contributes to mitigating the exposure. If exposures occur before controls can be implemented, the next priority is to prevent future human exposures to the hazard.

Other guiding principles

The precautionary principle can be valuable in environmental health decision management especially when the evidence base is still evolving. The four components to this have been described as:

1. Take preventive action until risks are better understood.
2. Ensure that the burden of proof rests with the proponents of risk.
3. Explore alternatives to the risk.
4. Use participatory approaches to decision-making (David et al 2001).

The principle of proportionality is also useful to complement the precautionary principle, such that preventative actions during uncertainty are still proportional to the potential risk.

Key concepts in this guidance

The key concepts that will be outlined in this guidance include hazard identification, exposure assessment and reducing the public health risk, which includes case investigation and management, and risk communication to the public. The roles and

responsibilities of local organisations involved in immediate public health risk management are also considered as well as longer term prevention of HABs.

Hazard identification

Biotoxins associated with risk to public health from recreational water exposure

Marine biotoxins – dinoflagellates and diatoms

Common biotoxins produced by marine HABs include: saxitoxins, brevetoxins, azaspiracids, ciguatoxins, and the okadaic acid group of biotoxins. These biotoxins are produced by dinoflagellates and are associated with paralytic shellfish poisoning (PSP), neurotoxic shellfish poisoning, azaspiracid shellfish poisoning, ciguatera poisoning, and diarrhetic shellfish poisoning, respectively. Domoic acid is a common marine biotoxin produced by diatoms and is associated with domoic acid poisoning and amnesiac shellfish poisoning (Centers for Disease Control and Prevention 2022e).

The main exposure route for humans to marine HABs in recreational water is via food. Biotoxins can bioaccumulate up the food chain in fish or bivalve molluscan shellfish, which filter large quantities of water and can concentrate contaminants from the water column in which they grow (Lee et al 2008).

Internationally there are reports of dermal, accidental water ingestion, and aerosolised exposure to marine HAB toxins (Centers for Disease Control and Prevention 2022e; Durando et al 2007; Fleming et al 2009; O’Keeffe 2022; Todd 2002). However, these exposure routes are generally associated with less serious consequences than toxic seafood poisoning, probably due to the ability of shellfish and fish to concentrate the toxins.

Overall, marine seafood poisoning is typically caused by dinoflagellate blooms rather than cyanobacterial blooms, although cyanotoxin accumulation in marine organisms does occur (BPAC 2020). The biotoxin group of most concern in New Zealand in the marine environment is saxitoxins, which can be produced by both marine dinoflagellates and freshwater cyanobacteria and are discussed in more detail below.

Cyanotoxins

Most species of cyanobacteria consist of both toxin and non-toxin producing strains. As a result, cyanobacterial blooms often contain a mixture of toxin and non-toxin producing strains, with their relative proportions varying during the bloom. The factors that affect toxin production is not well understood making it difficult to predict whether toxin producing strains will produce toxin, or how much toxin will be in a bloom (Taumata Arowai 2020).

However, testing for the biotoxin itself or genes related to the production of the biotoxin can determine whether a bloom is toxic.

Marine cyanotoxins

There is a lack of research on marine cyanobacteria in Aotearoa New Zealand and internationally. Not much is known about the toxins produced by marine cyanobacteria in New Zealand. However, international data includes studies on lyngbyatoxins produced by *Moorea producens* – previously *Lyngbya majuscula* (Osborne et al 2001). Marine cyanobacterial species that produce microcystins, anatoxins and saxitoxins have also been reported in marine environments internationally (Carmichael & Li 2006; Kerbrat et al 2011; Mohamed & Al-Shehri 2015).

Freshwater cyanotoxins

Freshwater cyanobacteria produce a range of cyanotoxins with different mechanisms of action. In New Zealand these include microcystins, nodularins, anatoxins, and saxitoxins. Cylindrospermopsins have been detected at times in New Zealand (Wood et al 2006). The main exposure routes for humans to cyanotoxins are direct contact, inhalation, or ingestion of water (cyanotoxins can accumulate in freshwater organisms but HAB food poisoning is more commonly due to marine seafood exposure) (BPAC 2020).

WHO recreational guideline values

The World Health Organization (WHO) has derived provisional guideline values for recreational water exposure to microcystins, cylindrospermopsins and anatoxins based on no-observed-adverse-effect levels (NOAEL) identified from animal toxicological data. The WHO guideline value for saxitoxins is based on a lowest observed-adverse-effect level (LOAEL) derived from human poisoning data.

Guideline values are used for assessing the health risks from exposure to recreational water. In New Zealand, the WHO guideline values have been used to develop cell concentration alert-level thresholds for freshwater planktonic cyanobacteria.

Biotoxin quota data (the amount of toxin produced per cell) were used to estimate the cell concentrations of toxin producing cyanobacteria that would lead to health-adverse levels of cyanotoxins in a waterbody. This provides a more user-friendly means of evaluating the potential risk rather than routinely measuring biotoxin concentrations in samples from recreational freshwaters (Puddick, Wood, et al 2022).

Microcystins

Microcystins are commonly occurring cyanotoxins produced by a range of both planktonic and benthic cyanobacterial species. Microcystins are cyclic peptides and are hepatotoxic, ie toxic to the liver (Ministry for the Environment & Ministry of Health 2009). There are marked differences in toxicity depending on the structural variant, but many microcystin variants (congeners) are highly toxic (Bouaicha et al 2019), for example, microcystin-LR (TOXINZ 2011).

In animal studies intra-peritoneal and intranasal microcystin exposure was more toxic than oral exposure, this may be relevant for potential inhalation exposures from contaminated water spray (Ministry for the Environment & Ministry of Health 2009).

Based on animal toxicity data, the no observed adverse effect level (NOAEL) for microcystin- LR has been determined as 40 µg/kg body weight per day (Carmichael & Boyer 2016; Weirich & Miller 2014). This NOAEL was the basis for the tolerable daily intake (TDI) of 0.04 µg/kg body weight per day (World Health Organization, 2020c).

Nodularins

Nodularins are primarily found in brackish water where they are commonly produced by *Nodularia spumigena* (a bloom-forming planktonic cyanobacterium). However, nodularins have also been detected in benthic cyanobacteria from New Zealand and Australia (McGregor & Sendall 2017; Wood SA et al 2012a; Wood et al 2012b). Nodularins have a similar structure and mechanism of action to microcystins and are also hepatotoxic (Ministry for the Environment & Ministry of Health 2009). Aerosolised nodularin toxin has been detected at Lake Forsyth | Wairewa but only at low levels that were not deemed to be a health risk (Wood S et al 2018).

There is insufficient toxicological information to establish a NOAEL or TDI for nodularins, but nodularins can be treated as a part of the microcystin load in a waterbody due to their similar structure, mode of action and toxicity.

Cylindrospermopsins

Cylindrospermopsin-producing cyanobacteria are predominately found in freshwater environments (World Health Organization 2020b). Cylindrospermopsin inhibits protein synthesis causing extensive damage to the liver and kidney and to a lesser extent thymus, spleen, heart, and gastrointestinal tract lining (Weirich & Miller 2014). It may be several days after exposure before symptoms become apparent, this makes it more difficult to determine a cause–effect relationship.

Contamination of a local drinking water supply in Australia with a cylindrospermopsin producing cyanobacteria resulted in a significant human gastroenteritis outbreak in 1979. Cylindrospermopsin has also been deemed the cause of some cattle deaths (Ministry for the Environment & Ministry of Health 2009).

When present, cylindrospermopsin can persist in the water for weeks after the cylindrospermopsin producing cyanobacteria is no longer detected in the water and toxin testing is recommended for determining when the health risk has subsided (World Health Organization 2021).

A NOAEL of 30 µg/kg body weight per day has been established, based on increases in relative kidney weight in an 11-week mouse study. This NOAEL was the basis for the tolerable daily intake (TDI) of 0.03 µg/kg body weight per day (World Health Organization 2020b).

Anatoxins

Anatoxins are produced by both benthic and planktonic cyanobacterial species, some of which have an intermediate propensity to form surface scums (World Health Organization 2020a). Anatoxins are fast-acting neurotoxins that disrupt signalling at neuromuscular junctions causing over stimulation of muscles resulting in muscle fatigue and paralysis.

Anatoxins are small molecules, so they are rapidly absorbed when ingested orally (Ministry for the Environment & Ministry of Health 2009).

While anatoxins (and saxitoxins, see below) are not volatile, exposure via inhalation is possible through spray from cyanotoxin contaminated water. However, there is insufficient data on the concentration of cyanotoxins in sprays to develop risk assessments on the risks to human health from inhalation (World Health Organization 2020a).

Anatoxins include anatoxin-a (ATX) and its methyl derivative homoanatoxin-a (HTX) and dihydro-derivates of ATX and HTX (dhATX and dhHTX) and dihydro-derivates of ATX and HTX (dhATX and dhHTX). Anatoxin-a is often linked with animal and wildfowl poisonings but there have not been reported human fatalities (World Health Organization 2020a).

There is insufficient information to develop a chronic health-based guidance value for anatoxins. A conservative short-term NOAEL of 98 µg/kg body weight per day was established, based on a 28-day mouse study (World Health Organization 2020a).

Guanitoxin / Anatoxin-a(S)

Anatoxin-a(S), now called guanitoxin is structurally different to anatoxin-a but has a similar neurotoxic effect, although more potent and has been found to cause salivation in animals (Weirich & Miller 2014). Anatoxin-a(S) has not yet been detected in New Zealand (Ministry for the Environment & Ministry of Health 2009; Wood S, et al., 2018).

No health-based guidance values have been established for guanitoxin / anatoxin-a(S) to- date.

Saxitoxins

There are many variants (congeners) of saxitoxins which are produced by cyanobacteria as well as marine dinoflagellates (a type of microalgae) which can accumulate in shellfish and cause paralytic shellfish poisoning (PSP). For this reason, saxitoxins are sometimes referred to as paralytic shellfish toxins (PSTs). Food and drinking water exposures to saxitoxins are more common than recreational exposures.

Saxitoxins are fast acting neurotoxins which block nerve transmission causing muscle weakness, paraesthesia (tingling or numbness), loss of motor control, twitching and in severe cases convulsions or respiratory paralysis and death

(Weirich & Miller 2014; World Health Organization 2020d). If a person fully recovers from acute PSP, there does not appear to be any lasting health effects (Metcalf et al 2021; World Health Organization 2020d).

A lowest observed adverse effect level (LOAEL) of 1.5 µg/kg body weight has been established for saxitoxins from review of human cases of PSP. As some cases are asymptomatic at higher dose levels, it was assumed that this dose level was close to the NOAEL and an acute reference dose (ARfD) of 0.5 µg/kg body weight was established (World Health Organization 2020d).

Lyngbyatoxins

Lyngbyatoxins are a severe skin irritant and can cause smooth muscle contraction. The symptoms of lynbyatoxin exposure include skin, eye, and respiratory irritation (Weirich & Miller 2014), as well as gastric irritation if ingested (Osborne & Shaw 2008). Lyngbyatoxins can be produced by freshwater or marine cyanobacteria and have caused animal deaths (Chorus & Welker 2021; Weirich & Miller 2014).

The marine cyanobacterium *Moorea producens* (previously *Lyngbya majuscula*), which produces a wide range of lynbyatoxins, has been identified at times at Ōmana Beach (Auckland region) and reported from Waiheke Island to Hawke's Bay. It is most prevalent in warm temperate to tropical regions (Biessey 2023; Nelson et al 2015; Tricklebank & Hay 2007). No health-based guidance values have been established for lyngbyatoxins.

Lipopolysaccharides

Lipopolysaccharides, also called endotoxins, are part of the cell walls in cyanobacteria and other gram-negative bacteria. Lipopolysaccharides are less well studied than other cyanotoxins but lipopolysaccharides from cyanobacteria may be linked to skin rashes and eye irritation (Pilotto et al 1997; Torokne et al 2001). Although cyanotoxins and gram-negative bacteria such as *Escherichia coli* may be more toxic than cyanobacterial lipopolysaccharides (Chorus & Welker 2021; Keleti & Sykora 1982; Ministry for the Environment & Ministry of Health 2009; Weirich & Miller, 2014).

In New Zealand, the potential risk of health effects from lipopolysaccharides is managed through a total biovolume threshold for all freshwater planktonic cyanobacteria in a waterbody (Ministry for the Environment & Ministry of Health 2009).

β-N-methylamino-l-alanine

β-N-methylamino-l-alanine (BMAA) is a non-proteinogenic amino acid produced by some cyanobacteria, as well as by diatoms and dinoflagellates. There has been some concern that exposure to BMAA could contribute to neurodegenerative diseases such as amyotrophic lateral sclerosis (a form of motor neurone disease) / Parkinsonism – dementia through accumulation in the food chain or proximity to freshwater. However, this link has not yet been confirmed and the methods used to

quantify BMAA in environmental and human tissue samples in some research studies have not been specific enough (Centers for Disease Control and Prevention 2022d; Chorus et al 2021; Chorus & Welker 2021). Further research into BMAA is warranted. No NOAELs have been established for BMAA due to a lack of toxicological data (Jiang et al 2014; Ministry for the Environment & Ministry of Health 2009; Weirich & Miller 2014).

Further information on freshwater cyanotoxins

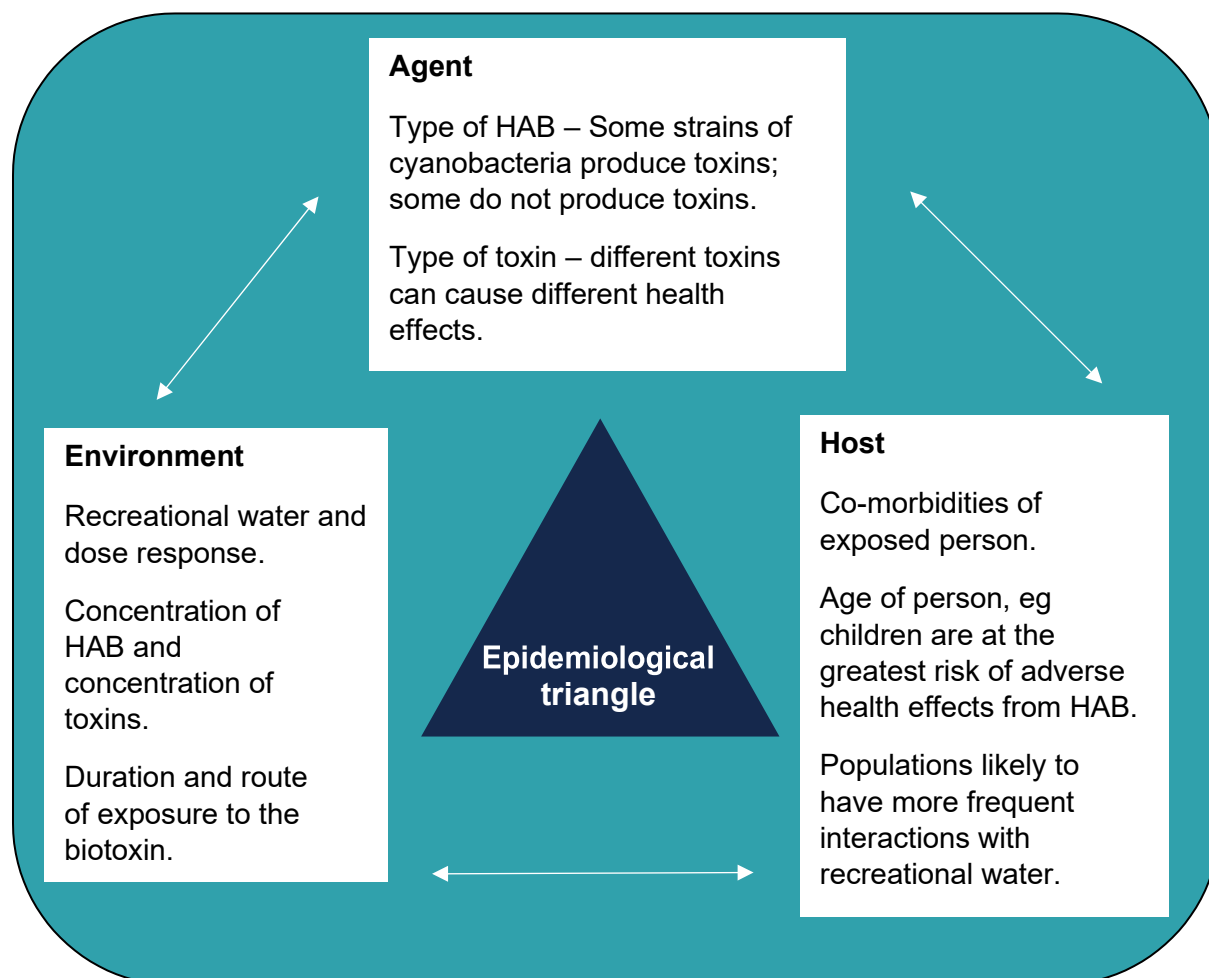
A summary of the cyanotoxins discussed in this section, their health effects and genera known to produce these toxins is provided in [Appendix B](#).

For further information please refer to The New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters for a list of freshwater cyanotoxin-producing species and their prevalence in New Zealand and more in-depth information on freshwater cyanotoxins and their measurement (Ministry for the Environment & Ministry of Health 2009).

Exposure and health effects

When considering potential health impacts of exposure to HABs it is useful to think about the person's underlying health and behaviour as well as the dose and type of biotoxin from the biomass. Figure 1 shows how all three components (agent, host, and environment) interact and contribute to health outcomes for HAB exposure.

Figure 1 Epidemiological triangle for harmful algal blooms



Exposure assessment

It is useful to consider the environmental conditions and site of the biotoxin exposure event. Cyanobacterial scums can represent extremely high concentrations of cyanobacterial cell populations (World Health Organization 2003). Cyanobacterial blooms that accumulate surface scums in bays or at points of entry to recreational water bodies are likely to provide maximal exposure to the cyanobacterial bloom especially if gentle wind has caused large accumulations of surface scums, which can result in 1000-fold increases in toxin concentrations (Chorus et al 2021; Ministry for the Environment & Ministry of Health 2009). High winds can increase the aerosolisation of HAB toxins.

The health risks associated with benthic cyanobacteria are less well researched and quantified than for planktonic species. Turbulence can cause mats to detach from the riverbed. Detached mats can pose higher risks to health compared to attached mats, through proximity of mats to shorelines (increasing the chances of exposure) and lysing of cells releasing more toxins (increasing the dose) (Ministry for the Environment & Ministry of Health 2009).

Routes of exposure and signs and symptoms

Assessing the amount and type of exposure can assist with biotoxin case investigation. Primary contact with recreational water is when users are in direct contact with water and can fully immerse their body and swallow water – for example, while swimming, diving, and water skiing. Secondary contact with recreational water is where there is direct contact but swallowing water is unlikely – for example activities such as wading, boating, and fishing (Cressey 2016). Exposure to biotoxins can be via direct contact, inhalation, or ingestion.

Direct contact

Direct contact occurs from touching algal mats or direct contact with contaminated water, for example, when swimming or boating.

Direct contact with biotoxin contaminated water can cause urticaria, dermatitis, perioral and perinasal blisters, other types of rashes, eye irritation such as conjunctivitis and photosensitivity, ear canal irritation and earache (BPAC 2020; Centers for Disease Control and Prevention 2022a).

Clinical investigations have confirmed that hypersensitivity reactions (inappropriate immune response to an allergen or antigen) can occur with exposure to certain freshwater cyanobacteria. Although it is still unknown which constituents of cyanobacterial cells cause allergic reactions (Chorus & Welker 2021).

Dermatological symptoms associated with direct contact with marine cyanobacteria are reported to be more severe than those from freshwater cyanobacterial exposure (Chorus & Welker 2021). Marine dinoflagellates can also cause dermatitis (Moreira-Gonzalez et al 2021).

Some anecdotal reports by researchers in the USA described a reversible clinical syndrome of symptoms including memory loss, confusion, and acute skin burning after occupational direct exposure to suspected toxin-producing *Pfiesteria* or *Pfiesteria*-like dinoflagellates.

Further research to identify the possible toxin produced by *Pfiesteria* is ongoing (World Health Organization 2003).

Inhalation

Inhalation can occur when exposed to spray of contaminated water or aerosolised biotoxins, for example from the wake of boats, storms, or irrigation (BPAC 2020).

Biotoxins from many microalgae and cyanobacteria (eg, microcystins, nodularin, anatoxins brevetoxins, and biotoxins from *Ostreopsis* spp eg, palytoxins) can be inhaled through aerosolised spray from contaminated water (Abdullah et al 2022; Berdalet et al 2015; Centers for Disease Control and Prevention 2022a; Durando et al 2007; Fleming et al 2009; Genitsaris et al 2011; World Health Organization 2020c and 2021).

The effects of inhaled biotoxins or fragments of biotoxins may be related to mechanical irritation of the respiratory tract, tissue damage due to toxins, or subsequent secondary infections with associated microorganisms (Chorus & Welker 2021). Additionally, the size of the biotoxin producing microalgae or cyanobacteria could affect which part of the respiratory tract it can infiltrate and evoke symptoms (Wisniewska et al 2020).

Inhalation of aerosolised biotoxins is predominately associated with respiratory symptoms related to bronchospasm (asthma like symptoms such as wheeze, shortness of breath, cough, chest tightness, and difficulty breathing), severe allergic reactions, pneumonia, rhinitis and sore throat (BPAC 2020). The possibility of anaphylaxis related to some benthic cyanobacteria has been raised (Chorus & Welker 2021). Other symptoms such as neurological or liver symptoms can occur depending on the biotoxins in the spray from contaminated water if inhaled and systemically absorbed.

Accidental water ingestion

This guidance considers ingestion via accidental swallowing of small amounts of contaminated recreational water during swimming. An adult swimmer could ingest up to 100-200 mLs of water in one session, a child 250 mLs, and a water-skier will likely ingest more water than a swimmer (World Health Organization 2003). This guidance does not pertain to the consumption of biotoxin contaminated foods or drinking water.

Cyanotoxins

Swallowing contaminated freshwater containing cyanobacteria can cause neurological, gastroenterological, and liver or kidney symptoms. Vomiting and diarrhoea are common following recreational water cyanotoxin exposure and can result in dehydration (TOXINZ 2011).

Symptoms of liver and kidney toxicity can include nausea, vomiting, diarrhoea, a bad taste in the mouth, acute hepatitis, jaundice, blood in urine or dark urine, malaise, lethargy, headache, fever, and loss of appetite. Liver and kidney toxicity can be caused by microcystins and nodularins (Centers for Disease Control and Prevention 2022a).

Symptoms associated with neurotoxins, such as anatoxins and saxitoxins, can include sensory symptoms like paraesthesia, and motor symptoms like muscle twitching. High doses may lead to increasing muscle paralysis, including, potentially, of respiratory muscles (Centers for Disease Control and Prevention 2022a). Seizures

are uncommon and have only been documented after haemodialysis fluid was contaminated with cyanotoxins (TOXINZ 2011).

Marine biotoxins

There is no evidence of significant human health impacts caused by direct ingestion of HAB affected marine recreational water, although marine animal deaths may have been due to ingestion or inhalation of marine biotoxins such as brevetoxins (World Health Organization 2021).

Biotoxins and challenges with correlation to signs and symptoms

Determining the specific biotoxin or HAB species causing symptoms is complicated for the following reasons:

1. Several biotoxins can co-exist along with other known or unknown compounds in HABs.
2. People are likely to have more than one route of exposure. For example, if they have been swimming, they may have direct contact, inhalation, and ingestion, thus potential exposure to a variety of biotoxins and routes.
3. It can be difficult to determine the type of biotoxin that caused illness based on self-reported symptoms without confirmatory water samples (Centers for Disease Control and Prevention 2022a).
4. There is a large crossover of symptoms caused by biotoxins. For example, most of the biotoxins are associated with gastrointestinal symptoms.
5. Although biotoxins are broadly classed by their predominant mode of action, reported symptoms in observational studies are diverse and some researchers suggest that biotoxins may act more broadly (Metcalf et al 2021).
6. Other potential health hazards such as faecal pathogens may also be present in the water which further complicates the attribution of cause (Taumata Arowai 2020; Weirich & Miller 2014).

Overall, as evidence regarding toxic strains of cyanobacteria continues to evolve and new toxic strains continue to be identified, using the precautionary principle means that all cyanobacteria should be regarded as potentially toxic until proven otherwise (Ministry for the Environment & Ministry of Health 2009).

Knowing the exact biotoxin becomes more important if it will change the public health risk management strategy. However, the data may also add to the limited knowledge base of the clinical impact of the different biotoxins.

Population groups at risk

There are population groups that are at greater risk of both exposure to HABs as well as to adverse health effects if exposed.

- Children are at greater risk of adverse health effects associated with biotoxin exposure because of their exploratory behaviours, stage of development, and smaller size relative to their amount of exposure as they swallow more water compared to adults (Hilborn et al 2014; Weirich & Miller 2014).
- Young men are also prone to risk taking behaviour such as swimming in potentially hazardous environments.
- The health effects of biotoxin exposure in pregnancy are not yet quantified. The health effects of biotoxins on human foetal development are unknown but adverse health effects have been seen in animal foetal development (Weirich & Miller 2014).
- Wai | water is of great cultural significance in te ao Māori. People who live next to water bodies, work with water, or have strong social-cultural ties to water may have more opportunities to have repeated contact with potentially contaminated water.
- People who have underlying health conditions, such as chronic hepatitis B infection, respiratory conditions, for example asthma, are likely to be more vulnerable to the adverse effects of biotoxins that exacerbate those symptoms. Māori and Pacific peoples disproportionately carry an increased burden of underlying co-morbidities perpetuated by the social determinants of health, including institutional racism (Gurney et al 2020).

Dose response

The principles of toxicology are that adverse effects will increase in prevalence and/or severity with increasing exposure dose. The nature of this relationship is termed a dose- response relationship. Consequently, accidental ingestion of small amounts of water or inhalation of small amounts of aerosolised biotoxins are more likely to result in milder health effects compared to greater exposures such as ingesting large amounts of contaminated drinking water, consuming seafood in which toxins have bioaccumulated, or exposure via a route that reaches the systemic circulation rapidly, such as contaminated haemodialysis fluid (TOXINZ 2011).

Well-defined dose response curves are not available nor representative for human exposure to most biotoxins in recreational water. For saxitoxins, dose and severity information is available for several hundred cases of PSP (European Food Safety Authority 2009) while for other biotoxins considered in these guidelines dose-response information is mainly from a limited number of laboratory studies in animals.

Some observational studies have reported an association between human exposure and symptoms. In a review of CDC's Waterborne Disease and Outbreak Surveillance System in the USA in 2009–2010, there were 11 outbreaks associated

with cyanobacteria which affected 61 people and resulted in 2 people being hospitalised.

The outbreak with the more severe gastrointestinal and neurological symptoms was associated with the highest concentrations of cyanotoxins (Chorus & Welker 2021). Individuals in an epidemiological survey who were exposed to cyanobacterial cell surface areas of more than 12 mm²/mL in recreational water were more likely to report symptoms, particularly respiratory symptoms, compared to individuals exposed to lower cyanobacterial cell surface areas (2.4 mm²/mL) (Stewart, Webb, Schluter, Fleming, et al 2006).

An observational study investigating lyngbyatoxin exposure found that while those who had primary contact, rather than secondary contact with water were more likely to report skin and eye symptoms, only a small proportion of symptoms were serious (Osborne et al 2007).

In a Canadian study, gastrointestinal symptoms were associated with secondary contact with cyanobacterial contaminated recreational water as participants avoided primary contact during proliferations of blooms but continued with secondary contact (Levesque et al 2014). This highlights that although the literature indicates an association between dose and response, symptoms from secondary contact are still plausible.

Severity

Most of the symptoms reported in recent epidemiological studies of acute health effects from short term recreational exposure to low levels of cyanobacterial blooms were mild and self-limiting (Chorus & Welker 2021).

However, severe acute effects on human health from recreational cyanotoxin exposure have been reported, although they appear to be rare (Weirich & Miller 2014). A young Argentinian jet ski rider exposed to microcystins was treated in intensive care with respiratory symptoms and hepatic insufficiency, and a child in Uruguay presented with acute liver failure associated with repeated recreational exposure to microcystins. Although causal links between the exposures and the illnesses were not conclusive, they were highly plausible (Chorus & Welker 2021; Vidal et al 2017).

Although not recreational contact, exposure to cyanotoxins, in particular microcystins, via contaminated dialysis water has sadly resulted in human deaths in Brazil in 1996 (Azevedo et al 2002; Carmichael & Boyer 2016).

Animal illnesses as sentinel events

The deaths of other organisms, particularly livestock, dogs, birds, fish, and invertebrates (eg, crustaceans, starfish, sea urchins) are important as they indicate the toxic potential of biotoxin-containing waterbodies and indicate the potential for human health risks (Chorus & Welker 2021; Hilborn & Beasley 2015).

Chronic effects of cyanobacterial exposure

Chronic microcystin exposure has been linked to liver injury and promotion of tumour growth in the liver. The International Agency for Research on Cancer (IARC) has classified microcystin-LR as a possible carcinogen to humans (Ministry for the Environment & Ministry of Health 2009).

Evidence regarding long-term or repeated human exposure to cyanotoxins is still evolving. There are no human studies of long-term anatoxin, saxitoxin, or cylindrospermopsin exposure. Although there is currently no evidence of health effects from long term exposure to saxitoxin, the World Health Organization (WHO) still recommends a precautionary approach to avoiding long-term exposure from drinking water sources (World Health Organization 2020a, 2020b and 2020d).

Time on onset

The duration of time from exposure to onset of symptoms varies depending on the type of biotoxin. However, usually onset of symptoms will be within 24 hours of exposure (BPAC 2020). Neurotoxins such as anatoxins and saxitoxins are fast-acting (onset is approximately minutes to hours) while some biotoxins are slower acting, eg, cylindrospermopsins, and it may take several days after exposure for symptoms to occur (Ministry for the Environment & Ministry of Health 2009).

Gastrointestinal and skin symptoms typically occur within three to five hours. After high exposures to biotoxins, neurological and hepatic symptoms also typically develop within hours (Osborne & Shaw 2008; TOXINZ 2011). Tingling or numb lips from mild paralytic shellfish poisoning usually occurs within 30 minutes (World Health Organization 2020d).

Burden of Disease

It is challenging to quantify the burden of disease associated with HAB exposure in recreational water. Attributing causation to biotoxins can be challenging because of the changing nature of the water, weather, and the natural environment.

It is likely that adverse human health affects related to HAB exposure are underreported. If the exposure was brief and symptoms mild or non-specific, the person may not have sought professional health advice or identified the link with recreational water exposure even if the illness resulted in absence from work (Hilborn et al 2014; Stewart, Webb, Schluter, & Shaw 2006; Weirich & Miller 2014; Young et al 2020). This makes estimating the true burden of disease difficult. However, many people experiencing mild illness can add up to a substantial burden of disease.

Reporting cases to public health authorities is important to improve understanding of the public health impact of recreational water exposure to HABs as well as to trigger public health action to prevent further exposures and illnesses (Chorus & Welker

2021). The burden of disease which has likely been prevented though public health action is also unquantified.

Between 2005 and 2022 there have been three probable cases and two cyanobacterial poisoning outbreaks notified in New Zealand, which included one outbreak with two cases and another with 18 cases of gastroenteritis reported to the National Public Health Service. These case numbers are too small to disaggregate by demographics (BPAC 2020; Environmental Health Intelligence New Zealand 2022).

Public health reporting and surveillance of chemical poisoning from the environment is currently the responsibility of Environmental Health Intelligence NZ. From 2005–2012, reporting and surveillance was provided by the Institute of Environmental Science and Research (ESR) (BPAC 2020). Hospitalisations or health sector interaction data are not readily available for HAB poisoning related to recreational water exposure.

For perspective, the health impacts of biotoxins are likely to be lower than from microbial pathogens. For example, infectious microorganisms in drinking water cause a more substantial burden of disease via diarrhoeal illness than toxic chemicals (Chorus et al 2021; Chorus & Welker 2021). Additionally, recreational exposures are often associated with lower doses and less harmful exposure routes than food or drinking water exposures.

Limitations

The limitations of the scientific literature surrounding the health impacts of HABs have been referred to throughout this document. The guidelines are based on a rapid review of available evidence. The evidence base regarding HABs and health risks is still evolving and many data gaps still exist.

The evidence of health impacts is primarily based on a few epidemiological studies of recreational exposures, case reports of extreme human exposure events, and animal studies. The evidence detailing longer-term health impacts is even less clear with studies ongoing (Centers for Disease Control and Prevention 2022a).

Risk reduction – environmental case investigation and management

Notification

All suspected or confirmed cases of biotoxin poisoning must be notified to the National Public Health Service in New Zealand.

Health professionals and testing laboratories are legally responsible for reporting all injuries or diseases caused by a notifiable disease to their local medical officer of health. This legal responsibility is stipulated in Schedule 2 of the Health Act 1956. Although HABs and cyanobacteria are naturally occurring, they can be toxic and are classified as poisoning arising from chemical contamination of the environment.

Notifications can be made to the medical officer of health via the Hazardous Substances Disease and Injury Reporting Tool (HSDIRT) from general practice management systems (BPAC 2020; Environmental Health Intelligence New Zealand 2021a). In addition, the public may self-notify HAB exposures to their local office of the National Public Health Service.

Public health surveillance

Once investigated and actioned, local offices of the National Public Health Service submit case investigation reports to the national office of the National Public Health Service, via the HSDIRT national surveillance database, managed by Environmental Health Intelligence New Zealand (EHINZ) at Massey University.

EHINZ receives anonymised data to perform analysis and produces surveillance information to inform environmental health policy and prevention activities (Environmental Health Intelligence New Zealand 2021b).

New Zealand case definitions and classification

Laboratory testing

There is currently no clinical laboratory testing available to confirm a cyanotoxin or marine HAB biotoxin poisoning diagnosis in humans.

Case investigation

Timely case investigation is important for preventing additional exposures. The steps outlined below provide general guidance for how to approach a case investigation and are based on expert advice from New Zealand, and international guidance (Centers for Disease Control and Prevention 2021; Environmental Health Intelligence New Zealand 2021a; Wisconsin Department of Health Services Division

of Public Health 2018). The questions outlined in [Appendix A](#) can be used to investigate the exposure and clinical context.

Consider the clinical context

1. Review the information provided by the health care professional, including the presumptive diagnosis and clinical findings or any laboratory tests.
2. Take a detailed history from the person about their symptoms and determine if they are consistent with harmful algal bloom poisoning (eg, gastroenterological, respiratory, dermal, neurological, or hepatic signs and / or symptoms). See [Appendix C](#).
3. Find out about the exposed person's current and past health status and consider groups at higher risk of adverse health outcomes.
4. Consider any other obvious potential causes of their symptoms, such as microbial pathogens, eg, *Escherichia coli* identified in stool sample.

Consider the exposure context

Weigh up the potential exposure type, time, and likelihood of the waterbody containing biotoxins by considering the following.

1. There is a suitable timeline (eg, the exposure occurred hours to days before symptoms). Consider repeated chronic exposure.
2. There is a compatible dose and mechanism of exposure (eg, accidental swallowing of water) or long enough duration of direct contact with water (eg, minutes rather than seconds in the water).
3. It is plausible that there is a HAB in the recreational water? Factors to consider could include:
 - a. Visual reports or photos from the water body by those present at the time are consistent with the presence of harmful algae (eg, water discoloration, surface scum, odour, visible algae in the water or algal mats).
 - b. Monitoring of the waterbody at the time (within a week) of exposure confirms the presence of harmful algae and no other pathogens. Algal bloom surveillance and monitoring is the responsibility of regional councils as per the roles and responsibilities section of these guidelines. Exceedances are reported to the relevant local office of the National Public Health Service as outlined in the [alert level framework](#) . Alerts for maritime HAB food collection areas are issued by MPI.
 - c. If no specific monitoring has been conducted, consider guidance in the *New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters* (Ministry for the Environment & Ministry of Health 2009). This includes a decision tree that summarises the major environmental variables important in the development of cyanobacterial blooms and benthic mats, and the selection of specific genera.¹ The decision tree can help to estimate whether there is a high or low probability of cyanobacteria bloom or mat in the water

¹ [Refer to Figure 5, page 32, of the guidelines.](#)

- body reported. For example, low river flows, high water temperatures and eutrophic conditions, make the presence of cyanobacteria more likely.
- d. Any coinciding significant animal health issues that were reported by veterinarians to be caused by harmful algae.

Probable case definition

1. A clinically compatible illness suggestive of HAB poisoning (eg, gastrointestinal, respiratory, dermal, neurological, or hepatic signs and/or symptoms), **AND**
2. other diagnoses have been excluded, **AND**
3. the illness is associated with a probable history of exposure to a HAB bloom in recreational water in the week before illness.

Probable exposure history is defined as any one of the following (as reported by the person exposed or by first-hand knowledge):

- Visual evidence of a HAB (eg, water discoloration, surface scum, visible algae in the water or algal mats) at the time of exposure, **OR**
- Public health alerts or warning signage related to HABs in place at the time and location of the exposure based on regular monitoring results, **OR**
- Documented elevation of HAB levels or algal biotoxin levels through laboratory testing of water samples within a week of exposure.

Confirmed case definition

Clinical laboratory testing is usually required to confirm a case. However, cases can be classified as confirmed if:

1. There is more than one affected person, **AND**
2. the affected people were exposed to the same recreational waterbody within a similar time period (usually within 24 hours of each other, but it could be up to a week), **AND**
3. They have a clinically compatible illness consistent with HAB poisoning (eg, gastrointestinal, respiratory, dermal, neurological, or hepatic signs and/or symptoms), **AND**
4. Other diagnoses have been excluded, **AND**
5. A health practitioner has diagnosed the case as HAB bloom poisoning, **AND**
6. Their symptoms occurred within a plausible time frame (eg, usually within 6 hours of exposure to the recreational waterbody, but could be up to 24 hours since exposure), **AND**
7. Laboratory testing of the recreational water sampled at a similar time to the exposure confirms there are elevated levels of harmful algae or the presence of algal biotoxins.

Notes for confirmed case definition:

- For the meaning of 'health practitioner' refer to 5(1) of the Health Practitioners Competence Assurance Act 2003. Ideally, confirmed cases should have been diagnosed by a health practitioner.
- A plausible time frame is usually within 6 hours of exposure but could be up to 24 hours since exposure. The shorter the time period between exposure and the onset of symptoms characteristic of harmful algae poisoning, the more likely that algal biotoxins are the cause in the absence of other known causes of the symptoms and/or signs. Seek technical expert advice for classifying confirmed cases if symptom onset was more than 24 hours post exposure using ESR's analysis and advice service for the National Public Health Service. A longer time between onset and exposure could be considered plausible if technical advice or scientific literature indicates that the signs and/or symptoms and biotoxins or species of harmful algae are compatible with a longer onset time, such as cylindrospermopsin-producing species.
- Water sampling (and subsequent laboratory testing) of recreational water should usually be conducted within 24 hours of exposure but could be up to a week since exposure if environmental and weather conditions remain stable.
- Elevated levels of freshwater cyanobacteria are defined as at least meeting the amber level threshold in the [alert level framework](#), but more likely will meet the threshold for red levels.
- Toxin levels are not specified, but the presence of a biotoxin known to produce similar effects to the symptomology observed provides strong evidence for harmful algal bloom poisoning.

Outbreak definition

An outbreak is classified as two or more confirmed cases related to the same recreational water exposure within a similar time period (usually within 24 hours of each other but could be up to a week).

Under investigation

A case which has been notified but information is not yet available to classify it as 'probable' or 'confirmed' is 'under investigation'.

Not a case

The classification 'not a case' is used when a case has been investigated and is deemed to not be a case based on the exposure and clinical history.

Decision to conduct environmental investigation and testing

If symptoms are consistent with HAB exposure, consider whether environmental testing is required to help quantify exposure to harmful algae and algal biotoxins, see Table 1 below. Further environmental analysis for harmful algae algal biotoxins in samples from the site of exposure would be useful information to support case

classification in addition to the exposure and clinical history. However, this is rarely possible or practical, especially if the bloom has finished, plus there is the additional time and cost of extra testing (Weirich & Miller 2014).

Review local HAB monitoring results to determine if there is already a notified HAB reported at the location. Contact your regional council to find out if there is any additional recent information for the waterbody the case was exposed to. Find out when the waterbody was last monitored.

While data from samples collected within a few hours to 24 hours of the exposure is the most useful, data from within a week is still relevant unless weather conditions have changed substantially since the exposure. Strong winds or high rainfall events could affect the environmental monitoring to such a degree that conditions may be vastly different to the conditions when the exposure occurred. Surface blooms or scums can disperse within a few hours (Chorus & Welker 2021).

Check MPI shellfish biotoxin alerts for any current marine HAB locations (note: these alerts do not include all types of HABs but only HABs that cause illness from contaminated shellfish consumption).²

Discuss decisions to conduct environmental testing with the medical officer of health and see Table 1. If further water testing or a site visit is required to aid the environmental case investigation and public health risk assessment, contact your regional council to conduct the sample collection and arrange testing. Guidance for maintaining human and ecological safety whilst taking potentially contaminated water samples can be found in the *New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters* (Ministry for the Environment & Ministry of Health 2009).

Table 1 Considerations for further environmental testing

Further testing may be useful	No further testing
More than one person exposed at the same waterbody.	Minimal or no compatible illness.
Accurate description of large quantities of HABs not already known about.	Minimal or no exposure to waterbody
Compatible illness and undetermined/unquantified exposure (not all HABs are visible).	Exposure was more than one week ago.
	Compatible illness and confirmed HAB exposure – HAB monitoring already in place and confirmed at waterbody Other causes are more likely than HAB poisoning, eg known faecal indicator bacteria are present in water and compatible with illness or/and human laboratory test such as stool samples.

² [MPI posts alerts on its website.](#)

Further testing may be useful

No further testing

Competing health system priorities, eg separate concurrent significant outbreak with high burden of disease consequences.

Case management

The focus of public health case management is education, risk communication, and the prevention of future exposures to HABs.

Any people exposed to HABs should be advised to seek medical advice from their usual health care practitioner. Treatment for cyanobacterial-related illness is supportive, with the focus on managing symptoms. There is no specific antidote to cyanotoxin poisoning (BPAC 2020; Centers for Disease Control and Prevention 2022a; TOXINZ 2011).

There are no contact tracing requirements as there is no person-to-person spread of illness from HABs, including cyanobacteria. Illness from biotoxins requires exposure to the biotoxin. However, it is useful to find out about any other people (or animals) that were exposed to the same recreational waterbody as the case was. Such information can inform public health risk characterisation and management decisions relating to the recreational waterbody.

Cultural and social

It is important to understand the exposed person's cultural and social context and to ensure advice and public health responses are tailored to the person, acknowledging their beliefs and practices. How this looks will vary from person to person but should include consideration of the individual's:

- age or generation
- gender
- sexual orientation
- occupation and socioeconomic status
- cultural or community background
- religious or spiritual belief
- health and disability level.

Request an interpreter if required.

Risk communication / education

If there is a HAB, risk communication is an important component of preventing further exposures. All exposed cases and their whānau should be provided information about HABs, their health consequence, what to do if exposed, and how to avoid future HAB exposure, including advice about food-collection/mahinga kai and where to find more information.

Public health services also have a role in longer term public health education about HABs. This could include explaining what HABs can look like, the environmental conditions under which they occur, the limitations of relying solely on visual appearance, and caveats around monitoring intervals especially if weather and environmental conditions change.

It is important to note that the community perception of risk is not based on technical risk assessment alone. Public recognition of risks, in contrast to risk assessment based on probabilities prepared by experts, includes intuitive risk perception. The characteristics of such perceptions are related to concepts of fairness, familiarity, future and present ‘catastrophic potential’, and outrage at involuntary exposure to hazards not of their making.

The public may perceive that cyanobacteria pose a lower risk to health compared to other hazardous substances because cyanobacteria are thought of as “naturally-occurring” (Chorus & Welker 2021). Low risk may be conflated with no risk. Therefore, it is important that the exposed person and their whānau understand the risks associated with HABs and other potential hazards associated with recreational water.

Information provided needs to be accessible, including for those with disabilities or those from Culturally and Linguistically Diverse (CALD) communities. Provide the exposed person and their whānau / family with written information for their future reference. Land, Air, Water Aotearoa (LAWA) provides public information on HABs, see [Factsheets – Toxic algae](#).

Overall, risk communication needs to be a two-way process and ongoing, as described in some detail in the USEPA’s *Risk Communication in Action: The risk communication workbook* (Reckelhoff-Dangel & Petersen 2007). The goal of risk communication is to establish trust and credibility. It needs to be done in such a way that people are well informed and guided in the actions they can take, while knowing that the experts are also taking account of, and acting on, people’s concerns.

Reporting

Data Sovereignty

All data collection and reporting should adhere to the key principles set out by Te Mana Raraunga, Māori Data Sovereignty Network (Te Mana Raraunga 2022). In addition to comprehensive case notes, enter case details into HSDIRT, please refer to the HSDIRT user guide produced by EHINZ for further information.

Occupational case reporting

Medical officers of health are required to advise WorkSafe New Zealand of work-related notifiable disease or hazardous substances injury (under section 199 of the Health and Safety and Work Act 2015).

If a case is notified arising from occupational exposure, consent is needed from the individual to notify identifiable information to WorkSafe New Zealand. If the case meets the definition of 'serious harm', the employer is required to inform WorkSafe New Zealand under the Health and Safety at Work Act 2015 and the Hazardous Substances and New Organisms Act 1996. The Medical Officer of Health should inform the case (and the employer if the case agrees) of this obligation.

To notify WorkSafe, please use the form provided at [Appendix C – "Notifications under section 199 of the Health and Safety at Work Act 2015 Notifications by Medical Officers of Health"](#) Please email the notification to: healthsafety.notification@worksafe.govt.nz.

Future exposure risk characterisation

Categorisation of the risk of future HAB exposures at the recreational waterbody is based on the public health case investigation and/or environmental testing.

Public health officers should discuss taking immediate public health management with the medical officer of health if there are any of the following.

- The recreational waterbody is the exposure site of a probable or confirmed case of exposure to a HAB without an existing public health warning in place.
- The recreational waterbody is the exposure site of an animal death confirmed as being caused by exposure to a HAB without an existing public health warning in place.
- Surveillance and monitoring of the freshwater recreational waterbody shows the threshold for action (red) mode in the [alert level framework](#) is met either by cyanobacterial biovolume, cell concentration of toxin-producing cyanobacteria, cyanotoxin concentrations, consistent scum presence, detaching mats or the percentage of benthic cyanobacteria mat coverage.

Risk reduction – immediate public health management of recreational water with a HAB

Alert level framework for freshwater cyanobacteria

New Zealand guidance uses three separate tier alert-level frameworks for planktonic and benthic cyanobacteria documented in detail in the *New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters* (Ministry for the Environment & Ministry of Health 2009). The frameworks define increased frequencies of monitoring for increasing potential exposure risk, as well as defining thresholds for additional public health actions such as risk communication.

- **Green: Surveillance mode** – weekly or fortnightly visual inspections and sampling of water bodies where cyanobacteria are known to proliferate between spring and autumn.
- **Amber: Alert mode** – requires notification to and consultation with the local office of the National Public Health Service and other stakeholders, and increased frequency of sampling, to at least weekly across multiple sites.
- **Red: Action mode** – contact with the specified recreational water should be avoided and the public are notified of a potential risk to health from exposure to the recreational water. Monitoring continues and if potentially toxic cyanobacterial taxa are present, testing for cyanotoxins is considered (Ministry for the Environment & Ministry of Health 2009; World Health Organization 2021).

For benthic cyanobacteria, the potential recreational exposure risk is assessed by measuring the percentage of benthic mat covering the riverbed or the presence of detached mats.

For planktonic cyanobacteria, action mode red alert levels are determined by any of the following ways: cell concentration thresholds for toxin producing cyanobacteria, total biovolume of all cyanobacteria, cyanotoxin concentration thresholds, or consistent cyanobacteria scums.

Biotoxin concentration thresholds are based on the 2020 World Health Organization guideline values for cyanotoxins in recreational waters (anatoxins, cylindrospermopsins, microcystins and saxitoxins). The WHO recreational guideline values are based on a worst-case exposure situation of a 15 kg toddler swallowing 250 mL of water.

Other local criteria may also be established to contribute to the alert level framework such as prolonged time (weeks) between flushing flows in rivers and low river flows.

The frameworks can be used for routine monitoring of HABs or unexpected detection of blooms. Cases of cyanobacterial poisoning where clinical history and or

environmental investigation ascertain relevant cyanobacterial exposure will also trigger action to prevent further exposures.

Marine recreational water

There is no alert level framework for HABs in recreational marine water to guide safe swimming.

MPI test shellfish and seawater for toxic algae every week from popular shellfish gathering areas around New Zealand as the greatest public health risks from marine HABs are via seafood. If the shellfish are not safe to eat, MPI issue public health warnings and put up signs at affected beaches (Ministry for Primary Industries 2022b).

MPI set toxigenic phytoplankton levels in seawater that trigger testing of commercial bivalve molluscan shellfish (Ministry for Primary Industries 2022a).

Activating a public health alert – communicating the public health risk

If the public health risk assessment based on the case investigation of an exposed person to a HAB or monitoring of recreational water finds HAB levels meet the threshold for (red) action mode in the alert level framework, then it is vital to communicate the health risk to the public as well as hapū and iwi in a timely way.

The roles and responsibilities section of these guidelines outlines the roles of the public health officers in the National Public Health Service, territorial authorities, and regional council, all of whom engage with their local rūnanga or hapū or iwi regarding HABs.

Engagement with iwi and hapū

Discuss the health risks and risk mitigation of HABs through existing relationships with the local rūnanga. Te Arawhiti have some useful resources for crown engagement with Māori. Items to discuss (as part of these existing relationships) could include:

- Do they want to be informed when a case has been confirmed?
- Do they want to be involved in the collection of environmental samples (if required)?
- The best way to provide the results and interpretation of them.
- Agree ways to work in partnership on any response.

Media release and social media

Issue a media release providing information on HABs, their health consequence, what to do if exposed and how to avoid HAB exposure, including advice about food-collection | mahinga kai and where to find more information. Where available, social media platforms allow the dissemination of public health information to engaged

members of the public and provides a convenient opportunity for them to share it with their own networks. Templates for warning signs and media releases are found in the *New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters* (Ministry for the Environment & Ministry of Health 2009).

Warning signs

Temporary health warning signs should be erected at recreational waterbodies with cyanobacteria levels meeting the action mode (red) alert level thresholds.

Some waterbodies may have a long-term or permanent warning applied to them where there is evidence of frequent HAB activity. It may be useful to think about how to convey long-term warnings so they remain up to date and are reviewed regularly, for example, by adding dated comments that the warning remains in place.

As HABs can change more rapidly than they may be monitored, it is important that recreational water users know what conditions to avoid when making their own risk assessment. For example, it is especially important to avoid contact with surface scums as well as algal mats or water with pronounced green turbidity (World Health Organization 2020b).

Consider additional communication methods depending on the public health risk and primary users of the waterbody, including telephone messaging, mailbox drops, direct connection with relevant businesses, clubs, and organisations. Consider the cultural safety and accessibility of all communication, including for people with disabilities and people from Culturally and Linguistically Diverse (CALD) communities.

Communication with primary care

In addition to media releases and public signage it is appropriate to provide information to primary care regarding the health consequences of exposure to HABs and information on how to notify public health. Consider issuing communications to primary care at the start of the HAB season or if notified of a probable or suspected case in the local area (World Health Organization 2003). Refer primary care to the Best Practice Advocacy Centre New Zealand (BPAC) guidance *Consider blue-green algal blooms this summer: Identifying and managing suspected cyanotoxin poisoning in primary care* (BPAC 2020).

Downgrading a public health alert

As well as timely initiation of public health alerts it is prudent to ensure health alerts are rescinded when the public health risk has reduced to surveillance (green) levels as per the alert level framework. Robust monitoring plans are imperative because although there are potential health consequences of HABs, being overcautious with alerts and warnings may lead people to become complacent, resulting in them ignoring warnings (Stewart, Webb, Schluter, Fleming et al 2006).

Additionally, there are potential negative health impacts of people choosing to avoid green and blue spaces based on out-of-date risk communications, as cultural and spiritual connections to natural environments may be impacted. Additionally, avoiding nature can limit the mental health benefits of connections to nature, opportunities for physical activity during outdoor recreation, or participating in income generating activities such as tourism (Carmichael & Boyer 2016; Mackay & Taylor 2020; Martin et al 2020).

An American study found that lake visitors were willing to drive long distances to avoid sites with HAB warnings, lasting up to six days after warnings were lifted, although avoidance reduced towards six days post warnings (Boudreaux et al 2023).

When surveillance and monitoring results indicate a HAB has abated, cyanotoxin testing results can support the decision making and risk assessment when considering downgrading a public health alert. Although cyanotoxin concentrations can change over the duration of a bloom, in slow moving waterbodies, such as lakes, blooms are unlikely to become non-toxic within a few days. Therefore, it is recommended that alert levels should not be reduced until two consecutive results, taken more than seven days apart, from representative samples, have been reviewed (Ministry for the Environment & Ministry of Health 2009).

Additionally, seek advice from local monitoring experts regarding the monitoring parameters that indicate a HAB and/or HAB biotoxins have reduced to a lower alert level.

Surveillance and monitoring of waterbodies

Monitoring for HABs in all rivers, lakes, estuaries, and coastlines in New Zealand would be entirely impractical. Therefore, criteria for monitoring are determined regionally. Regional councils have a responsibility to monitor regularly used recreational freshwater bodies for their risk to human health (Ministry for the Environment 2020).

The *New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters* recommend that the regional council, territorial authority, and local public health service agree and document general areas to be included in routine monitoring programmes in partnership with the local rūnanga (Ministry for the Environment & Ministry of Health 2009). MPI are responsible for monitoring seafood (kai moana) gathering locations.

HABs are more common in summer. Therefore, routine monitoring of water bodies with frequent recreational activity should occur during warmer months and months corresponding with increased recreational activity. Local longer-term HAB trends and results can be useful in determining the seasonal monitoring period.

The monitoring season may need to be reviewed on a local basis and potentially extended with future climate change induced warmer temperatures. Warmer temperatures may also affect the geographic distribution of waterbodies affected by

HABs, with new waterbodies becoming affected as the climate changes (Puddick, Kelly, et al 2022; Rhodes & Smith 2022).

Determining monitoring intervals is complex as blooms and benthic proliferations may change rapidly (within days or even hours for surface scums) affecting biotoxin concentrations and therefore changing the health risk. Therefore, flexibility is needed to adjust monitoring to respond to environmental conditions (Ministry for the Environment & Ministry of Health 2009).

Recreational water site visits to conduct visual assessment for turbidity, water discolouration, or scums can trigger increased surveillance and monitoring vigilance if HABs are observed (World Health Organization 2020b). Monitoring programmes should be adaptive, so that sampling and analyses are increased when there is evidence of increasing amounts of harmful algae as per the alert level framework (World Health Organization 2020b).

Satellite remote sensing of cyanobacteria can augment monitoring programmes especially in areas where there is a need for multiple sampling points. However, there are a range of limitations with satellite imagery. For example, the density of HABs does not necessarily correlate with the amount of toxins in the bloom. Therefore, it is important that satellite results are validated with field measurements (Chorus & Welker 2021; Von Tress et al 2021; Whitman et al 2022).

Public information about monitoring

LAWA provides a useful website (www.lawa.org.nz) which documents weekly summer monitoring results and the long-term water quality status of common swimming sites in New Zealand. Some councils may also report monitoring data on their own websites.

Caveats

Monitoring and surveillance do not guarantee a body of water is safe for recreation, as localised sites are assessed rather than the entire waterbody. Algal bloom and cyanotoxin activity can change between monitoring intervals and other (unmonitored) environmental hazards may exist (Australian Government 2008). Additionally, absence of reported HABs may be due to a lack of monitoring rather than the absence of HABs and absence of reported health symptoms associated with HABs may be due to under reporting rather than absence of HAB exposure related illness.

Risk reduction – longer-term public health risk management

The *National Policy Statement for Freshwater Management 2020* (Amended December 2022) sets out targets for improving the proportions of specified rivers and lakes that are suitable for recreational activities. This includes targets for reducing the concentration of biovolume of all cyanobacteria and potentially toxic cyanobacteria. There are also targets for volume of algae, periphyton, and phytoplankton. Additionally, regional councils may impose conditions on resource consents to achieve targets (Ministry for the Environment 2020).

To reduce HAB occurrence and the potential for human exposure and adverse health outcomes, it is essential to prevent anthropogenic acceleration of HABs. Public health officers can advocate for health promoting environmental management strategies and collaborate or provide advice or submit on environmental policy and regional council's long-term plans.

Long-term river catchment management is a key solution to reduce HABs. It is important to reduce nutrient and sediment runoff from land entering waterways to prevent eutrophication and subsequent HAB proliferation. In general, reducing nutrient loads entering waterways can be addressed by avoiding excessive use of fertilisers and manure on agricultural land within the catchments and maintaining riparian vegetation to provide shade (block light) and reduce soil erosion into waterways. It is also important to remove nitrogen and phosphorus and treat sewage before it enters waterways (Chorus & Welker 2021; Water NSW 2022; World Health Organization 2021).

Implementation and monitoring of integrated coastal management plans can be useful levers to control nutrient discharges into marine environments (Australian Government 2008). Additionally, climate change mitigation is vitally important for a myriad of health and ecological reasons, including that warming temperatures are likely to promote HAB proliferation (World Health Organization 2021).

It is useful to understand the local species and human factors driving proliferation of HABs to address them. Seeking appropriate expertise should be included in catchment management plans. Additionally, every local authority must actively involve tangata whenua (to the extent they wish to be involved) in freshwater management and giving effect to Te Mana o te Wai (Ministry for the Environment 2020).

One example of a tool that may facilitate a shared understanding of water management is The Cultural Health Index (CHI) for rivers and streams. The CHI is a tool that is based on mātauranga Māori and cultural values that Māori can use to assess and manage waterways in their area. The CHI can provide a framework by which iwi can communicate with water managers in a way that can be understood and integrated into environmental management processes (Tipa & Teirney 2006a, 2006b).

Roles and responsibilities

Local authorities

Local Authorities are territorial authorities, regional councils, and unitary authorities. Section 35 of the Resource Management Act 1991 (RMA) outlines the duties of local authorities to gather information, monitor, and keep records.

This requirement includes monitoring of freshwater and marine water (including natural thermal waters). Therefore, local authorities are responsible for maintaining recreational water monitoring programmes and carrying out reviews of compliance with consent conditions.

Regional Councils

Regional councils also have functions as defined in section 30 of the RMA and some of these relate to water bodies.

Regional councils can set policies, establish rules in plans, and issue resource consents. They must produce regional policy statements and may produce regional plans including a regional coastal plan, regional freshwater plan, and others. They also issue resource consents (including for applications to discharge to water), infringement notices, abatement notices and enforcement orders.

Regional Councils undertake (or contract out) the water quality sampling for the recreational bathing during the summer months in lakes, rivers, and the beaches. Regional councils will also have the results of the sampling tests on their websites. Lab analysis of samples can sometimes take up to a few days to process, so the results can be three to four days behind initial exposure, which poses a risk to the public as people can already be exposed to contaminated water.

Territorial authorities

Territorial authorities (eg, district and city councils) also have functions as defined in section 31 of the RMA. They can set policies, establish rules in plans, and issue resource consents relating to land use and can issue infringement notices, abatement notices, and enforcement orders.

Under the Health Act 1956 territorial authorities must ensure health nuisance conditions are identified and abated and to endeavour to ensure that such conditions are not created.

Health NZ considers that the nuisance provisions in the Health Act apply to all fresh and marine waters (along with swimming pools such as school pools). Therefore, territorial authorities' responsibilities can include the following.

- Assessing all recreational waters for the presence of nuisance conditions.
- Securing the abatement of nuisances or removal of nuisance conditions.

- Acting to abate sources of pollution of recreational water sites.
- Where abatement is not practicable, communicating the risks associated with specific sites (eg, through temporary and permanent signage and contact with key groups).
- Maintaining permanent standardised warning signs where necessary.
- Maintaining sufficient stocks of standardised signs for temporary warnings against swimming and/or the collection of shellfish in contaminated areas (these could be shared between authorities in some situations).
- Providing reports to the medical officer of health when requested under section 23 of the Health Act 1956.
- Administering any relevant bylaws.

National Public Health Service

The National Public Health Service provides operational public health services and employs public health officers. It works with the lead agencies (local authorities) to provide sound technical and professional advice on public health issues relating to recreational waters.

Public health services do not have a role in monitoring of recreational water bodies, but may use the results of sampling and surveys to advise local authorities of public health implications and how this could impact on their obligations. The National Public Health Service oversees analysis and surveillance information of notified cases of human exposures to HABs. Long-term surveillance data can be used to inform environmental health policy and prevention activities. This work is currently contracted to EHINZ at Massey University.

The National Public Health Service undertakes a number of activities in relation to recreational waters.

- Providing information and advice to other agencies, organisations, and the public on the health effects of recreational water.
- Maintaining effective recreational water advocacy activities.
- Maintaining information systems on regional recreational water quality issues.
- Supporting local authorities in responding to public health events.
- Investigating cases of disease linked to recreational water.
- Supporting local government implementation of national policy statements and national environmental standards, including awareness of the responsibilities of other agencies in regard to recreational water quality and the need to carry out surveillance to ensure that the public health aspects of those responsibilities are met (in particular those matters outlined in sections 23 and 29 of the Health Act 1956 and section 35 of the Resource Management Act 1991).
- Making submissions on national and regional plans and policies, district plans and policies and applications for resource consents to ensure that public health aspects of recreational water quality management are considered.

- Taking appropriate action to minimise risks and to protect public health from environmental hazards and environmental exposures to contaminated water.
- Monitoring territorial authorities' actions on these issues to ensure health impacts are minimised.

Collaborating with other stakeholders is a key part of the work related with recreational swimming. And as each region has their own specific water quality issues it is emphasised that building and maintaining a working relationship with all stakeholders is vital for an effective public health response.

Other agencies

Taumata Arowai have the responsibility for addressing drinking water related issues and the Ministry for Primary Industries is responsible for food safety issues (including mahinga kai, wild foods and commercial foods).

Local agreements

Roles and responsibilities should be confirmed and documented for both routine monitoring and responding to an unexpected HAB exceedance or exposure. Local level agreements should include local offices of the National Public Health Service, local government, and local rūnanga / iwi / hapū. These agreements could be based on the framework in Table 2 (see below), which is adapted from the *New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters* (Ministry for the Environment & Ministry of Health, 2009).

In general, regional councils and territorial authorities are responsible for all recreational water except for shellfish harvesting areas.

It is important that roles and responsibilities are agreed and documented for:

- freshwater recreational food gathering sites | mahinga kai /
- marine recreational waterbodies that are not food gathering sites | mahinga kai .

Table 2 Example roles and responsibilities framework for routinely monitored HAB sites.

Activity	NPHS (local offices) – Health NZ	Territorial authority (TA)	Regional Council (RC)	Rūnanga / iwi / hapū
Monitoring	Reviews the effectiveness of the monitoring and reporting strategy.	If required / requested to, undertakes nuisance monitoring.	Coordinates the monitoring, sample analysis, and reporting strategy.	Engages with RC and / or PHU regarding any relevant information / concerns about local HABs. Involved in sampling to

Activity	NPHS (local offices) – Health NZ	Territorial authority (TA)	Regional Council (RC)	Rūnanga / iwi / hapū
				extent they wish to be.
Case investigation	Investigates notified human exposures to HABs.			
Action / issuing alerts	Issues public health alerts / risk communication when public health action is required according to the Alert Level Framework, in partnership with rūnanga, TA, and RC.	If required / requested to by RC, removes or abates the nuisance.	Implements surveillance and alert-level monitoring and provides NPHS with the results.	Are involved (to the extent they wish to be) in decision making regarding issuing public health alerts.
Warning signs	Requests that TA erect warning signs at affected waterbodies.	At the direction of the NPHS erects warning signs at affected water bodies.		Are involved (to the extent they wish to be) in erection of warning signs at affected water bodies.
Action and advice	Provides public health advice, where requested, to help rūnanga, TA and / or RC undertake necessary actions.	Takes action based on advice received.	Uses advice provided to implement appropriate surveillance.	Communicates advice and information regarding public health alerts to their community. Can provide advice to TA, RC and or NPHS on relevant cultural matters.
Rescinding alerts	Downgrades alert levels in accordance with the Alert Level Framework and in		Informs NPHS and TA if monitoring indicates HAB levels	Are involved (to the extent they wish to be) in decision making regarding

Activity	NPHS (local offices) – Health NZ	Territorial authority (TA)	Regional Council (RC)	Rūnanga / iwi / hapū
	partnership with rūnanga, TA, RC.		have reduced as per the Alert Level Framework.	rescinding public health alerts.
Long term surveillance	Advocates for health promoting environmental management strategies and collaborates / submits on environmental policy.	Actively involves rūnanga in freshwater management giving effect to Te Mana o te Wai.	Collates information for state of the environment reporting and a review of management policies.	Are actively involved (to the extent they wish to be) in freshwater management.

Recreational shellfish harvesting areas

- The local offices of the National Public Health Service investigate and report all foodborne exposures to HABs.
- MPI is the lead agency for monitoring, issuing, and directing warnings for the main recreational shellfish harvesting areas in New Zealand. The MPI shellfish monitoring programme involves regularly testing shellfish for toxins and sea water for toxic algae.
- Close communication and collaboration between agencies involved in recreational water and food safety is beneficial for long term public health risk management as the two activities often occur at the same time (recreational bathing and recreational food harvesting). For example, public health warnings at freshwater recreational sites should also include information about food gathering | mahinga kai.

Glossary

Acute reference dose (ARfD) – an estimate of the amount of a substance in food or drinking water that can be ingested over a short period of time, usually during one meal or one day, without appreciable health risk to the consumer.

Anatoxins – a group of neurotoxic alkaloids produced by some cyanobacterial genera.

Alkaloids – a class of basic, naturally occurring organic compounds that contain at least one nitrogen atom.

Benthic – the bottom substrate of a waterbody.

Benthic cyanobacteria – cyanobacteria that live in the benthic zone, mat-forming or attached to the substrate of rivers, lakes, oceans, and other waterbodies.

Biotoxin – a poisonous substance produced by a living organism.

Brackish water – water that is saltier than fresh water, but not as salty as seawater.

Catchment – is the entire land area from which rain, snowmelt, or groundwater drain into a waterbody, typically delineated by the crests of the hills or mountains that form water divides; synonyms include “watershed”, “river basin” and “drainage area”.

Chlorophyll – any of several related green pigments that are involved in photosynthesis and are found in cyanobacteria, algae, and plants.

Chloroplast – a structure (a type of membrane-bound organelle) within plant and algal cells that contains chlorophyll and is the site of photosynthesis.

Compound – a substance made up of two or more elements that are chemically bonded together.

Congener – members of the same taxonomic genus.

Cyanobacteria (also known as blue-green algae) – a phylum of bacteria that obtain their energy through photosynthesis.

Cylindrospermopsin – a hepatotoxic alkaloid produced by a variety of cyanobacterial genera.

Cytotoxic – toxic to cells.

Dermatotoxic – toxic to the skin.

Diatoms – a type of microalgae comprising several diverse genera. Their cell walls are made from silica, and they occur in both marine and freshwaters and can be planktonic or benthic.

Dinoflagellates – a type of microalgae that are primary unicellular and motile (they possess flagellar). Dinoflagellates occur mostly in marine habitats but also exist in freshwaters. They can be planktonic or epiphytic/benthic.

Endotoxin – components of the outer membrane of the cell wall of gram-negative bacteria; also called Lipopolysaccharides.

Epiphytic – an organism that grows on the surface of a plant.

Eukaryote – an organism whose cells have a nucleus enclosed within a nuclear envelope.

Eutrophication – degradation of water quality due to enrichment by nutrients such as nitrogen and phosphorus, which can result in excessive algal growth and decay, and is often associated with low dissolved oxygen in the water.

Exposure – contact of a chemical, physical or biological agent with the outer boundary of an organism (eg, through inhalation, ingestion or dermal contact).

Genus – A genus is a class or group of something. In biology, a genus is a taxonomic group covering more than one species. Genera is the plural of genus.

Hazard – a biological, chemical, physical, or radiological agent that has the potential to cause harm.

Hepatotoxic – toxic to the liver.

LOAEL – lowest observed adverse effect level – the lowest level of a substance found by experiment or observation that causes an adverse effect.

Macroscopic – large enough to be seen by the unaided eye.

Microcystins – a group of hepatotoxic cyclic peptide cyanotoxins produced by a range of cyanobacteria.

Neurotoxic – toxic to nerves or nerve tissue.

Nodularin – a hepatotoxic cyclic peptide cyanotoxin commonly produced by the planktonic cyanobacterium *Nodularia spumigena*.

NOAEL – no observed adverse effect level - level of exposure, found by experiment or observation, at which there is no adverse effects.

Organelle – a specialised subunit or structure, usually within a cell, which has a specific function.

Organic compound – a type of compound that contains a carbon atom.

Peptide – short chains of amino acids linked by chemical (peptide) bonds.

Periphyton – the mixture of algae, cyanobacteria, heterotrophic microbes, and detritus found attached to submerged surfaces in most aquatic ecosystems.

Phycotoxins – toxins produced by algae or seaweeds.

Phylum – a level of biological classification or taxonomic rank below kingdom and above class.

Phytoplankton – mostly microscopic, single-celled photosynthetic organisms that live suspended in water.

Plankton – a diverse collection of organisms found in water that are unable to propel themselves against a current

Planktonic – cyanobacteria and microalgae that are free-floating (drifting) in the water body.

Primary contact – users are in direct contact with recreational water and can fully immerse their body and could swallow water

Prokaryote – an organism whose nucleus is not clearly defined (bacteria and cyanobacteria, but not animals, plants, or fungi).

Riparian – area at the interface between land and a river or stream

Saxitoxin – a neurotoxin produced by cyanobacteria and some marine microalgae. Also known as paralytic shellfish toxin and causes paralytic shellfish poisoning.

Secondary contact – there is direct contact with recreational water, but swallowing water is unlikely.

Secondary metabolite – organic compounds that are not directly involved in the primary metabolic pathways of normal cell growth, development, or reproduction.

Sign – objective evidence of disease observed by a health practitioner.

Species – basic unit of classification and a taxonomic rank of an organism, as well as a unit of biodiversity.

Strain – a genetic variant, a subtype or a culture within a biological species.

Substrate – the surface on which an organism (e.g., plant, fungus, or animal) lives

Symptom – a subjective report by a patient that may indicate illness or disease.

Tolerable daily intake (TDI) – the daily amount of a substance that has been estimated as safe for human health on long-term basis.

Toxic – poisonous.

Toxicity – the degree to which a chemical substance or a particular mixture of substances can damage an organism.

Toxigenic – toxin-producing.

Appendix A: Environmental case management report form

This is an example case investigation report form that can be used for reporting exposure to harmful algal blooms in recreational water as chemical poisoning of the environment to HSDIRT.

At the start of the interview introduce yourself, explain why you are contacting the person, relevant privacy policies, and identify if the person has any accessibility needs.

A.1 Case investigator details

Local NPHS office responsible for case investigation:

Name of case investigator:

Date of investigation:

A.2 Notifier details

Referrer / reporting source:

General Practitioner Hospital based practitioner Laboratory

Self-notification Outbreak investigation Other

Name of reporting source:

Contact phone:

Date reported:

Case's usual GP:

GP address:

A.3 Case demographic information

Name of case:

If person is younger than 16 years parent / guardian / caregiver:

NHI:

Current address:

Phone:

Email:

Date of Birth:

Gender: Male Female Another gender

Occupation:

Ethnic groups the case belongs to? (Tick all that apply)

Follow the [Ethnicity Data Protocols](#) by saying “I am going to read out a list of ethnic groups. Can you tell me which ethnic group or groups you belong to?” Read out each of the categories and wait for a yes/no answer to each. When an answer is given, the interviewer continues asking the rest of the list until it is completed.

- New Zealand European
- Māori
- Samoan
- Cook Island Māori
- Tongan
- Niuean
- Chinese
- Indian
- Other e.g., Dutch, Japanese, Tokelauan, please state:

A.4 Exposure event history

Date of recreational water exposure:

Repeated exposures: No Yes if yes, specify

Other recent recreational water exposures:

Detailed location of exposure:

Exposure route: Ingestion Inhalation Skin contact Eye contact (tick all that apply)

Exposure duration:

Did the exposure occur at work: No Yes

Was the exposure intentional? Unintentional Intentional Unknown

Activity: (eg, boating, fishing, swimming)

Exposure intensity (how much contact did the case have with recreational water):

- No water contact (eg, stayed on bank of river)
- Splash / spray (water on hands / feet / head)
- Full emersion
- Partial emersion (not head)
- Consumed food gathered from exposure site, e.g., trout, shortfin eel, kākahi (freshwater mussels) or kai moana (eg, shellfish)

Clothing worn during exposure: (eg, wetsuit, swimming costume, gloves, waders, normal clothes)

Decontamination processes: (eg, did they rinse their skin and activity gear with clean/non contaminated water afterwards?)

Visual signs of water contamination at time of exposure reported by case: (attach any photos)

- Surface scum
- Algal mats on shore
- Discoloured water
- Visible algae in water
- Odour
- Public health warning signs

A.5 Exposure site monitoring information (internal use)

Date of most recent environmental monitoring for the recreational water exposure site: Harmful algal bloom present at time of contact: (can refer to LAWA website)

No Yes Unknown

Harmful algal bloom upstream of exposure location at time of contact:

No Yes Unknown

Weather conditions at time of exposure:

A.6 Other people/animals exposed

Were there any other whānau with similar contact to the same waterbody at the same time? No Yes if yes, how many people?

Are any of them unwell? No Yes if yes, describe their symptoms, symptom onset and record their names and contact details:

Are any animals with contact to the same waterbody unwell?

A.7 Clinical presentation

Symptoms (please describe symptoms and include severity, date and time of onset and time since exposure and duration):

Clinical signs and symptoms	Yes/No/Unknown	Onset date and time (or time since exposure)	Duration and description (and severity)
Ear / nose / throat symptoms, eg, sore/irritated/burning			
Eye symptoms eg, irritated, conjunctivitis			
Skin effect eg, rash, itch			
Cough			
Breathing difficulties (eg, short of breath, wheeze)			
Stomach pain/ abdomen cramps			
Nausea			
Vomiting			
Diarrhoea (+/- blood)			
Fever			
Headache			
Fatigue			
Tingling/ numbness/ altered sensation			
Muscle twitching			
Dizziness			
Drowsiness			
Altered speech or coordination			
Urinary symptoms (eg, dark urine, +- blood)			
Other symptoms eg, joint or muscle ache.			

Basis on which medical practitioner made diagnosis eg:

- clinical and exposure history
- clinical examination
- laboratory tests – stool sample, bloods - liver function, kidney function (attach results)

Are the symptoms consistent with HAB exposure?

Did the case require time off work? No Yes

Admission/Presentation to hospital: No Yes if yes, dates admitted and discharged

A.8 Relevant past medical history

Any relevant medical conditions? (eg, immunocompromised, history of respiratory, skin, gastrointestinal, kidney, liver, psychological or neurological conditions)

Is the person pregnant?

Any known allergies:

Any relevant medications:

A.9 Exclude other causes

Have other causes of illness been excluded in the week prior to illness? eg

Overseas travel: No Yes if yes, dates

Animal contact: No Yes if yes, dates

Other food or water-borne risk factors eg:

- duck or swimmers itch (Avian cercariae),
- known E.coli, Shigella or other gram negative bacteria in recreational waterbody,
- collection and consumption of mahinga kai shellfish/fish (marine or freshwater) e.g., *Vibrio parahaemolyticus*, mushrooms
- untreated drinking water,
- risk factors for other enteric diseases such as, undercooked meat, unwashed salad, unpasteurised foods.

Any other infectious illnesses risk factors:

(eg, contact with infectious person at pre-school/school such as Norovirus)

A.10 Case classification of harmful algal bloom poisoning from exposure to recreational water (internal use)

Outbreak

Confirmed case

Probable case

Under investigation

Not a case

Rationale for case classification:

A.11 Case investigation management actions taken

- Public health risk communication to case
- Educational information on swimming and harmful algal blooms provided (eg, LAWA website, MPI alerts, advised to contact health provider if unwell)
- Any other exposed people requiring contacting? No Yes provide rational:
- Additional environmental testing required No Yes provide rational:
- Public health alert issued by Medical Officer of Health in partnership with and rūnanga? Yes No provide rational:
- Other public health actions taken (please describe):

Appendix B: Table of biotoxins produced by marine and freshwater HABS

Biotoxin	Health effect(s)	Examples of known toxin-producing genera	Habitat(s)
Anatoxin-(S) / Guanitoxin	Neurotoxin. Acetylcholinesterase inhibitor.	Cyanobacteria: <i>Dolichospermum</i> , <i>Sphaerospermopsis</i> .	Planktonic freshwater
Anatoxins	Neurotoxin. Agonist of nicotinic acetylcholine receptors.	Cyanobacteria: <i>Aphanizomenon</i> , <i>Arthrospira</i> , <i>Cuspidothrix</i> , <i>Cylindrospermum</i> , <i>Dolichospermum</i> , <i>Geitlerinema</i> , <i>Microcoleus</i> , <i>Microcystis</i> , <i>Oscillatoria</i> , <i>Phormidium</i> , <i>Planktothrix</i> , <i>Raphidiopsis</i> , <i>Tychonema</i> .	Benthic freshwater, Planktonic freshwater
Aplysiatoxins	Dermatoxin. Protein kinase C activator. Skin irritant ('Swimmers itch' or 'seaweed dermatitis'). Carcinogen.	Cyanobacteria: <i>Moorea</i> (previously <i>Lyngbya</i>), <i>Phormidium</i> , <i>Schizothrix</i> .	Benthic marine
Azaspiracid	Gastrointestinal discomfort. Azaspiracid shellfish poisoning (from the consumption of contaminated shellfish)	Dinoflagellate: <i>Azadinium</i> .	Planktonic marine
Brevetoxins	Neurotoxin. Binds to voltage	Dinoflagellate: <i>Karenia</i> .	Planktonic marine

Biotoxin	Health effect(s)	Examples of known toxin-producing genera	Habitat(s)
	<p>sensitive sodium channels.</p> <p>Neurotoxic shellfish poisoning (from the consumption of contaminated shellfish)</p> <p>Respiratory irritant when aerosolised</p>		
Ciguatoxins	<p>Neurotoxin.</p> <p>Lower the threshold for opening excitatory voltage-gated sodium channels.</p> <p>Ciguatera poisoning (from the consumption of contaminated food).</p>	<p>Dinoflagellate: <i>Gambierdiscus</i>.</p>	Benthic marine.
Cylindrospermopsins	<p>Hepatotoxin.</p> <p>Protein synthesis inhibitor.</p> <p>Genotoxicity.</p>	<p>Cyanobacteria: <i>Aphanizomenon</i>, <i>Chrysochlorum</i>, <i>Dolichospermum</i>, <i>Microseria</i>, <i>Rhaphidiopsis</i>, <i>Phormidium</i>, <i>Umezakia</i>.</p>	Benthic freshwater, Planktonic freshwater.
Domoic acid	<p>Neurotoxin.</p> <p>Glutamate receptor activator.</p> <p>Amnesic shellfish poisoning (from the consumption of contaminated shellfish, sardines and anchovies).</p>	<p><u>Diatom</u>: <i>Pseudo-nitzschia</i>.</p>	Planktonic marine.
Lyngbyatoxins	<p>Dermatoxin.</p> <p>Skin irritant ('Swimmers itch' or 'seaweed dermatitis').</p> <p>Carcinogen.</p>	<p>Cyanobacteria: <i>Moorea</i> (previously <i>Lyngbya</i>).</p>	Benthic marine.

Biotoxin	Health effect(s)	Examples of known toxin-producing genera	Habitat(s)
Microcystins	Hepatotoxin. Protein phosphatase inhibitor (that accumulates in the liver). Liver tumour promoter.	Cyanobacteria: <i>Anabaena</i> , <i>Anabaenopsis</i> , <i>Annamia</i> , <i>Aphanocapsa</i> , <i>Coelosphaerium</i> , <i>Dolichospermum</i> , <i>Fischerella</i> , <i>Geitlerinema</i> , <i>Gloeotrichia</i> , <i>Hapalosiphon</i> , <i>Heteroleibleinia</i> , <i>Leptolyngbya</i> , <i>Limnothrix</i> , <i>Microcoleus</i> , <i>Microcystis</i> , <i>Nostoc</i> , <i>Oscillatoria</i> , <i>Phormidium</i> , <i>Planktothrix</i> , <i>Plectonema</i> , <i>Pseudoanabaena</i> , <i>Pseudocapsa</i> , <i>Radiocystis</i> , <i>Rhaphidiopsis</i> , <i>Rivularia</i> , <i>Schizothrix</i> , <i>Scytonema</i> , <i>Snowella</i> , <i>Synechococcus</i> , <i>Synechocystis</i> , <i>Tolypothrix</i> , <i>Woronichinia</i> .	Benthic freshwater, Planktonic freshwater, Benthic marine, Terrestrial.
Nodularins	Hepatotoxin. Protein phosphatase inhibitor (that accumulates in the liver). Liver tumour promoter.	Cyanobacteria: <i>Nodularia</i> , <i>Iningainema</i> , <i>Nostoc</i> .	Benthic freshwater, Planktonic freshwater, Terrestrial.
Oakadaic acid / Dinophysistoxins	Gastrointestinal discomfort. Diarrheic shellfish poisoning (from the consumption of contaminated shellfish). Protein phosphatase	Dinoflagellate: <i>Dinophysis</i> , <i>Prorocentrum</i> .	Planktonic marine, Benthic marine.

Biotoxin	Health effect(s)	Examples of known toxin-producing genera	Habitat(s)
	inhibitor.		
Palytoxins and palytoxin-like compounds	Dermatoxin. Skin irritant.	Dinoflagellate: <i>Ostreopsis</i> .	Planktonic marine, Benthic marine.
	Respiratory irritant when aerosolised		
Saxitoxins	Neurotoxin. Voltage-gated sodium channel blocker. Paralytic shellfish poisoning (from the consumption of contaminated shellfish).	Cyanobacteria: <i>Aphanizomenon</i> , <i>Cylindrospermum</i> , <i>Geitlerinema</i> , <i>Microcystis</i> , <i>Microseria</i> , <i>Phormidium</i> , <i>Planktothrix</i> , <i>Rhaphidiopsis</i> , <i>Scytonema</i> . Dinoflagellate: <i>Alexandrium</i> , <i>Pyrodinium</i> , <i>Gymnodinium</i> .	Benthic freshwater , Planktonic freshwater, Planktonic marine.

Toxin production has been observed in New Zealand for the genera and habitats in bold type. New toxin-producing cyanobacteria and microalgae continue to be identified, and this list of toxin-producing genera should not be treated as comprehensive.

Appendix C: Examples of some symptoms and potential cyanotoxins

This is not a comprehensive list of symptoms but provides some examples of types of symptoms and possible exposure routes and potential toxins associated with those symptoms.

Symptoms	Exposure	Potential freshwater biotoxins	Potential marine biotoxins
Difficulty breathing, shortness of breath, chest tightness, wheezing	Inhalation of water spray	Microcystins Lyngbyatoxins	Lyngbyatoxins Brevetoxin Domoic acid Palytoxins
Pneumonia	Inhalation of water spray	Microcystins	
Nausea Diarrhoea (+-blood) Vomiting Loss of appetite	Ingestion of water / food	Microcystins Nodularin Cylindrospermopsin Saxitoxin	Brevetoxin Ciguatoxins Domoic acid Okadaic acid Azaspiracid Saxitoxin Palytoxins
Stomach pain	Ingestion of water / food	Microcystins	Brevetoxin Ciguatoxins Azaspiracid
Blistering around the mouth	Ingestion of water	Microcystins	
Sore throat, dry cough	Inhalation of water spray Ingestion of water	Microcystins	Brevetoxin Palytoxins
Skin rash, dermatitis – itchy skin, blistered skin	Direct contact with water	Multiple cyanobacteria (not necessarily toxin producing, due to lipopolysaccharides) Lyngbyatoxins	Aplysiatoxins Lyngbyatoxins Pinnatoxins and Portimines Palytoxins
Conjunctivitis Eye irritation	Direct contact with water Inhalation of water spray	Lyngbyatoxins	Lyngbyatoxins Brevetoxins Palytoxins
Anaphylaxis	Direct contact, Inhalation Ingestion of water	Unknown components in cyanobacteria	

Headache	Ingestion of water / food Inhalation of water spray	Saxitoxins Cylindrospermopsin	Saxitoxins Okadaic acid Brevetoxins Palytoxins Ciguatoxins
Fever	Ingestion of water / food	Cylindrospermopsin	Okadaic acid Palytoxins
Dizziness, Vertigo, visual disturbance	Ingestion of water / food	Saxitoxins Brevetoxin	Saxitoxins Brevetoxin Ciguatoxins
Altered sensation - Numbness or tingling of tongue, face, throat, lips of hands or feet	Ingestion of water / food	Saxitoxins Brevetoxin	Saxitoxins Brevetoxin Palytoxins Ciguatoxins
Difficulty distinguishing between hot and cold	Foodborne		Brevetoxin Domoic acid Ciguatoxins
Burning pain sensation (peripheries)	Ingestion of water / food	Saxitoxins Anatoxin	Saxitoxins
Drowsiness	Ingestion of water / food	Anatoxin	Domoic acid
Slurred / unclear speech Reduced motor coordination	Ingestion of water / food	Anatoxin Brevetoxin Saxitoxin	Saxitoxins Brevetoxin
Muscle twitching	Ingestion of water / food	Anatoxin Lyngbyatoxins Saxitoxins	Lyngbyatoxins Saxitoxins Palytoxins
Respiratory paralysis leading to death	Ingestion of water / food	Anatoxin Saxitoxin	Saxitoxins Ciguatoxins
Amnesia	Foodborne		Domoic acid

Appendix D: Work injury notification form

WORKSAFE
Mahi Haumarū Aotearoa

FORM

Notifications by medical officers of health

Notifications under section 199 of the Health and Safety at Work Act 2015

Email: healthsafety.notification@worksafe.govt.nz

Mandatory information

Pursuant to section 199 of the Health and Safety at Work Act 2015 (HSWA)

The following information is required by law to be provided to WorkSafe New Zealand. Individual/patient consent is not a prerequisite in supplying the information in this section.

Type of notification received:

- Section 74 of the Health Act 1956 of a notifiable disease (that you reasonably believe arises from work)
- Section 143 Hazardous Substances and New Organisms Act 1996 of an injury caused by a hazardous substance (that you reasonably believe arises from work)

Full name of person:

Nature of disease or injury:

Discretionary information Section 197 of HSWA

The following information is **not** required by law to be provided to WorkSafe. Provision of the below information to WorkSafe is **discretionary**. WorkSafe seeks this information in order to enable it to carry out its functions, duties or powers. If the information requested below is provided to WorkSafe, it must be provided with the relevant individual's consent.

Contact details of medical officer of health

This information is collected to enable WorkSafe to contact you if further information is needed from you, in order to enable WorkSafe to monitor and enforce compliance with health and safety legislation.

Name:

Mobile phone:

Work phone:

Public Health Unit:

Patient workplace information

This information is being collected by WorkSafe for purposes of monitoring and enforcing compliance with health and safety legislation.

Name of workplace:

New Zealand Business Number (NZBN): (if known)

Address of workplace:

Two or more cases in the workplace:

- Yes
- No
- Not sure/no information

Describe hazard present in the workplace:

WORKSAFE



Te Kāwanatanga o Aotearoa
New Zealand Government

worksafe.govt.nz 0800 030 040 1/2

Notifications by medical officers of health

Patient demographic information

This information is collected for purposes of research, and for purposes of analysing and publishing statistics in relation to work health and safety. The relevant individual will not be identified in any publication.

Date of birth: / /

Gender:

- Male Female Prefer not to say/not specified
 Another gender: (please advise)

Ethnic origin:

- NZ Pakeha/European Māori
 Other European Samoan
 Tongan Cook Island Māori
 Niuean Chinese Indian
 Other: (please advise)

Patient objected to providing some or all s197 information: Yes No

Information provided under s197 subject to any conditions

Conditions can relate to the storage and use of, or access to, anything provided; and the copying, returning, or disposing of copies of any documents provided. Yes No

If yes, specify conditions:

Type of work

Note In some situations more than one type of work may be applicable

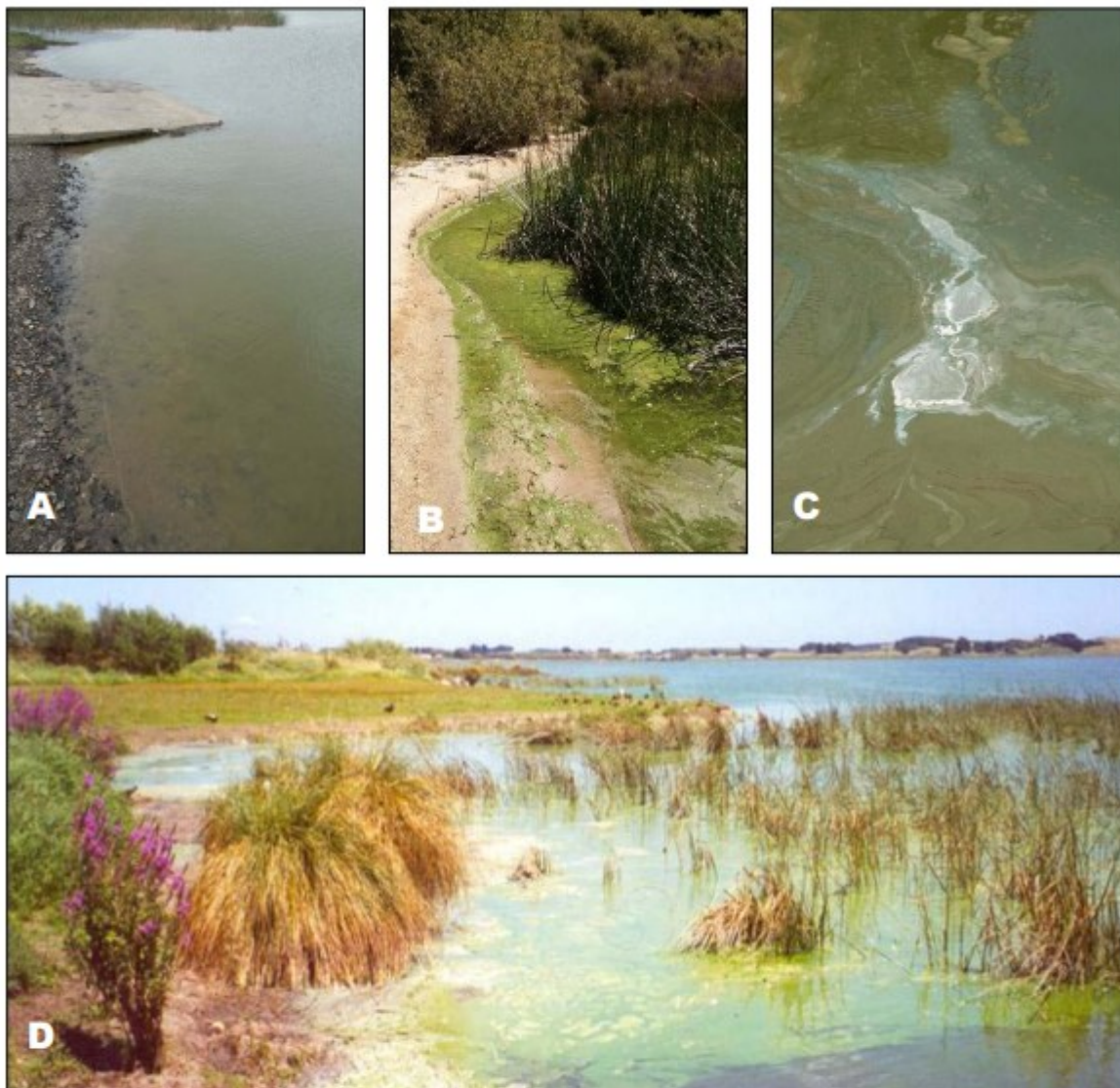
This information is collected for purposes of research, and for purposes of analysing and publishing statistics in relation to work health and safety. The relevant individual will not be identified in any publication.

Type of work: (select all that apply)

- Accommodation and Food Services
 Administrative and Support Services
 Agriculture
 Aquaculture
 Arts and Recreation Services
 Construction
 Diving
 Education and Training
 Electricity and Gas
 Financial and Insurance Services
 Fishing, Hunting and Trapping
 Forestry and Logging
 Health Care and Social Assistance
 Information Media and Telecommunications
 Manufacturing
 Mining – Minerals
 Mining – Petroleum
 Mining – Other Services
 Professional, Scientific and Technical Services
 Public Administration and Safety
 Rental, Hiring and Real Estate Services
 Retail Trade
 Transport, Postal and Warehousing
 Water and Waste Services
 Wholesale Trade
 Other services or types of work: (please specify)

Appendix E: Photographs of Planktonic Blooms

Images in this section are from the *New Zealand Guidelines for Cyanobacteria in Recreational Fresh Waters – Interim Guidelines* (MfE, 2009)



- (A) Toxic bloom of *Cylindrospermopsis raciborskii* (Lake Waahi, Waikato) of approximately 200,000 cells/mL. Cells were not visible macroscopically. The water had a slight brown tinge, but was not markedly different from the usual colour of this peat lake. Photo: S Wood, Cawthron.
- (B) Toxic bloom of *Microcystis panniformis* (Lake Rotoehu, Rotorua). Colonies were visible in the water and scum had formed along the shoreline. Photo: S Wood, Cawthron.
- (C) A non-toxic bloom of *Anabaena circinalis* and *A. lemmermannii* (Lower Karori Reservoir, Wellington). A thick surface scum covered large areas of the reservoir and filaments were clearly visible in the water. The light blue/white streak is decaying cells that are lysing and releasing their pigments. This is a common occurrence during bloom decline. Photo: S Wood, Cawthron.
- (D) Toxic bloom of *Microcystis* spp. (Lake Horowhenua, Levin). A thick scum had accumulated along the downwind shoreline. Photo: S Wood, Cawthron.



- (E) A non-toxic bloom of *Anabaena planktonica* (Lower Karori Reservoir, Wellington). This species rarely forms scums. Photo: S Wood, Cawthron.
- (F) Shoreline scum of toxic *Microcystis* spp. (Lake Wiritoa, Levin). Photo: S Wood, Cawthron.
- (G) Shoreline scum of toxic *Microcystis panniformis* (Lake Rotoehu, Rotorua). Photo: S Wood, Cawthron.



(H) Bloom of *A. lemmermannii* (Lake Waihola, Dunedin). Photo: J Milne, Greater Wellington Regional Council.

(I) Bloom of *A. lemmermannii* (Lake Waihola, Dunedin). Photo: J Milne, Greater Wellington Regional Council.

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