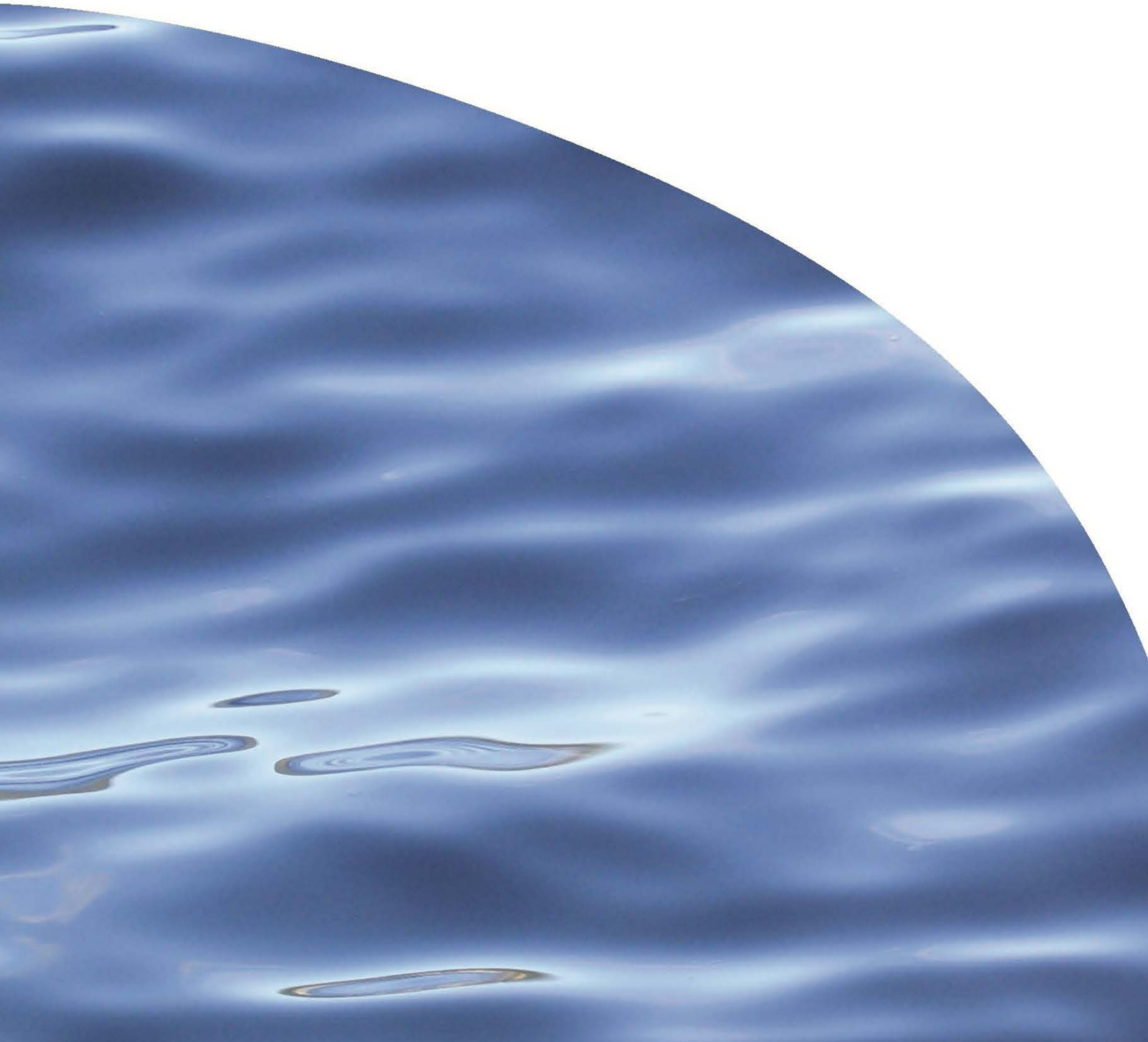
REPORT NO. 3075

ADVICE ON BENTHIC CYANOBACTERIA HEALTH RISKS AND COMMUNICATION STRATEGIES IN THE SOUTHLAND REGION



ADVICE ON BENTHIC CYANOBACTERIA HEALTH RISKS AND COMMUNICATION STRATEGIES IN THE SOUTHLAND REGION

SUSIE WOOD

Environment Southland

CAWTHRON INSTITUTE
98 Halifax Street East, Nelson 7010 | Private Bag 2, Nelson 7042 | New Zealand
Ph. +64 3 548 2319 | Fax. +64 3 546 9464
www.cawthron.org.nz

REVIEWED BY:
Xavier Pochon

APPROVED FOR RELEASE BY:
Roger Young

ISSUE DATE: 13 September 2017

RECOMMENDED CITATION: Wood SA 2017. Advice on benthic cyanobacteria health risks and communication strategies in the Southland region. Prepared for Environment Southland. Cawthron Report No. 3075. 19 p.

1. AIM OF THIS REPORT

Benthic cyanobacteria that produce toxins and form blooms have increased in prevalence in New Zealand rivers in the last decade. Extensive blooms and high toxin concentrations have been reported in several Southland rivers.

The aim of this report is to provide recommendations for:

- Improving communication on how health risks associated with benthic cyanobacteria should be reported to the public, particularly in relation to the consumption of fish and the provision of stock drinking water.
- Reporting frameworks to ensure that actions are efficient and effective.

2. BENTHIC CYANOBACTERIA AND HEALTH RISKS

2.1. What are benthic cyanobacteria and cyanotoxins?

Benthic cyanobacteria grow attached to substrates in aquatic systems. Benthic cyanobacteria occur in low concentrations in most aquatic ecosystems; however, when environmental conditions are favourable, cells can multiply rapidly and form benthic blooms.

Some cyanobacterial species produce natural toxins, known collectively as cyanotoxins. Cyanotoxins have a very broad range of toxicity mechanisms. Those currently described include hepatotoxic, neurotoxic, dermatotoxic and protein synthesis inhibition (Chorus and Bartram 1999). Based on their chemical structure, cyanotoxins can be divided into three broad groups; cyclic peptides (microcystins and nodularins), alkaloids (cylindrospermopsins, anatoxins and saxitoxins) and lipopolysaccharides. Cyanotoxins are a threat to humans when consumed in drinking water supplies or by contact during recreational activities. They can also have negative effects on terrestrial animals and aquatic organisms.

Benthic cyanobacteria in New Zealand are known to produce anatoxin-a and homoanatoxin-a (hereafter called anatoxins), microcystins, nodularin and saxitoxins (Table 1). A more detailed description of the national distribution of these toxins is given in Wood et al. (2015). By far the most common bloom-forming, toxin-producing benthic cyanobacteria in New Zealand is *Phormidium* (McAllister et al. 2016). *Phormidium* forms thick black-brown cohesive mats that may cover many kilometres of the riverbed and it commonly produces anatoxins. Although usually dominated by *Phormidium*, these mats also contain other organisms including bacteria, other cyanobacteria, diatoms and to a lesser extent, green algae (Harland et al. 2014; Brasell et al. 2015). *Phormidium* mats are commonly associated with cobble-bedded rivers in New Zealand; however, under stable flow conditions they also grow in rivers with fine substrate. Extensive mats have also been identified on the bottom of lakes (Wood et al. 2012a), and in farm ponds (Wood et al. 2016).

Anatoxin concentrations in *Phormidium* mats can vary dramatically both spatially and temporally. Wood et al. (2012b) demonstrated that this variability is partly due to differences in the relative abundance of toxic and non-toxic strains within a mat, and differences in the amounts of toxin each strain produces.

Table 1. Summary of known toxin-producing benthic cyanobacterial species in New Zealand. Taxa/cyanotoxin in bold letters are known toxin producers/toxins in the Southland region.

Genus/species	Cyanotoxin
Nostoc commune	Microcystins*[1]
Oscillatoria sp.	Anatoxin-a*[2],microcystins*[2]
***Phormidium* sp.**	Anatoxin-a*[3], homoanatoxin-a*[3], **dihydroanatoxin-a*[3], dihydrohomoanatoxin-a***[3]
***Planktothrix* sp.**	**Microcystins*[4]**
Scytonema cf. *crispum*	Saxitoxins*[5]
Unknown species	Nodularin*[6]

*This result was obtained from testing environmental samples. 1. Wood et al. 2006, 2. Hamill 2006, 3. Heath et al. 2010, 4. Wood et al. 2010, 5. Smith et al. 2012, 6. Wood et al. 2012a.

2.1.1. Benthic cyanobacteria in Southland

Sudden deaths of dogs were reported at the Mataura River (Southland) in 1999 and 2000. Benthic *Oscillatoria* sp. mats were collected and mouse bioassays confirmed their high toxicity (death within 5 minutes; Hamill 2001). Detailed taxonomic identification of the causative species was not undertaken. Oscillatoriales are notoriously difficult to identify based on morphology alone, and it is likely that the *Oscillatoria* sp. documented in this study was *Phormidium.*

Heath and Wood (2010) reviewed *Phormidium* cover and anatoxin data from five rivers (Oreti, Makarewa, Waikaia, Mataura, Aparima) that had been sampled weekly (Oreti, Makarewa) or monthly in the summer of 2009/10. Anatoxins were detected at the Oreti, Waikaia and Mataura sites. The highest were at the Oreti River (0.71 mg kg^{-1} dried weight [dw]).

Wood and Puddick (2017) collected samples from the Mataura River (at the Seaward Downs site) every two to three hours over a 26-hour sampling period. The following samples were collected: unfiltered water samples which were assessed for total anatoxins (i.e. including toxin contained within cells of *Phormidium* in the water column and dissolved toxins); filtered water samples which were analysed for dissolved toxins; Solid Phase Absorbent Tracking Technology (SPATT) bags which were used to collect time-integrated toxin samples; and 15 mat samples. At the time of sampling *Phormidium* mats covered > 50% of the substrate, and the bloom appeared to continue for many kilometres upstream from the sampling site (Figure 1A, 1B). Anatoxin concentrations in *Phormidium* mat samples were extremely high. The highest value (1,684 mg kg^{-1} dw]) was over twice that recorded previously in a nationwide collation of data (McAllister et al. 2016). Anatoxins were detected in all water and SPATT samples. The majority of the toxins detected in the water samples were dissolved, which corroborated the microscopic analysis where very few *Phormidium* cells were observed.

On the margins of the Mataura River at the Seaward Downs site where water velocity was slow, thin green cyanobacterial mats were observed (Figure 1C). Analysis of these samples showed they were dominated by *Planktothrix* sp. and contained microcystins (Wood and Puddick, unpublished data).

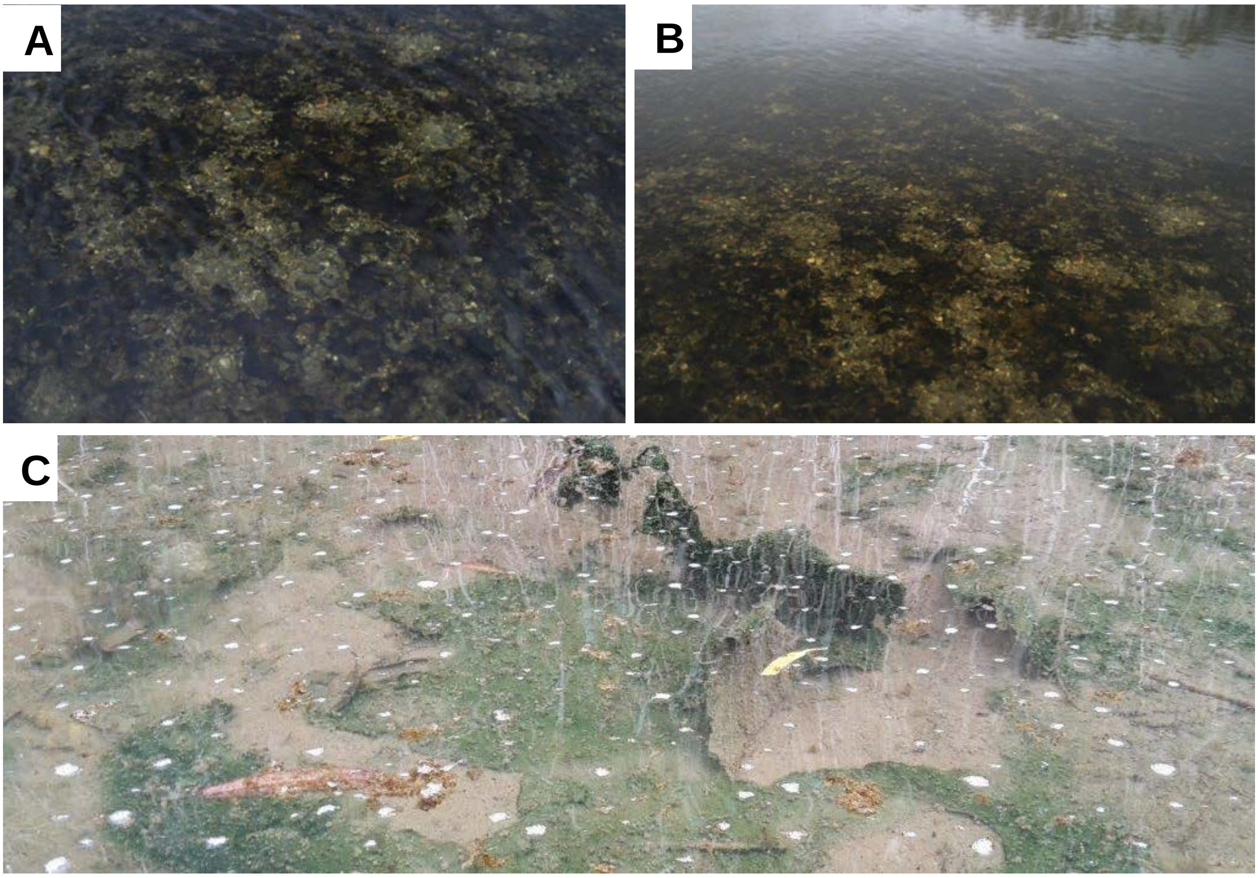


Figure 1. *Phormidium* sp. (A, B), and *Planktothrix* sp. (C) mats at the Seaward Downs sampling site at the Mataura River.

As part of the initial site selection for the Wood and Puddick (2017) study samples from three other sites were analysed. The data given here are presented in wet weight; all other data in this report are in dry weight. The values would be higher if the samples had been dried. Results were; Aparima River, no toxin were detected; Mataura River at Gore, total anatoxin = 2.4 mg kg^{-1} wet weight (ww); and the Mimihau Stream at Wyndham, total anatoxin = 0.003 mg kg^{-1} ww.

Wood and Puddick (2017) undertook a very preliminary assessment of the potential for anatoxin to bioaccumulate in three freshwater species at the Mataura River Seaward Down site; the mayfly *Deleatidium* sp., the freshwater snail *Potamopyrgus antipodarum*, and an unknown Platyhelminthes (flatworm) species. Specimens were maintained in river water for 24 hrs (to purge digestive tracts of food and possible *Phormidium* cells), and washed five times in Milli-Q water, and analysed for anatoxins. All samples were positive. Because the data are preliminary and the method is not yet validated they do not provide actual toxin concentrations.

2.2. Risks to recreational users and drinking water supplies

The remainder of this report focuses on *Phormidium* and anatoxins as these are currently considered the cyanobacteria/toxins that pose the greatest risk to humans and animals in Southland.

Anatoxins mimic the action of acetylcholine at neuromuscular nicotinic receptors of the post-synaptic membrane at the neuromuscular junction (Figure 2). During normal muscle activity, acetylcholine is released from vesicles of the motor neurons at the neuromuscular junction (axon terminal, Figure 2). It then binds to the acetylcholine-receptors on the postsynaptic muscle cell, opening sodium ion channels, allowing for sodium ion influx from the synaptic cleft and thereby triggering muscle cell contraction (Figure 2). Extracellular acetylcholinesterases degrade acetylcholine thereby preventing overstimulation of the muscle cells and consequent muscle fatigue. Anatoxins are not degraded by cholinesterase and in its presence muscle cells continue to be stimulated, causing muscular twitching, fatigue, and paralysis. Animals that have consumed the toxins usually die of respiratory arrest.

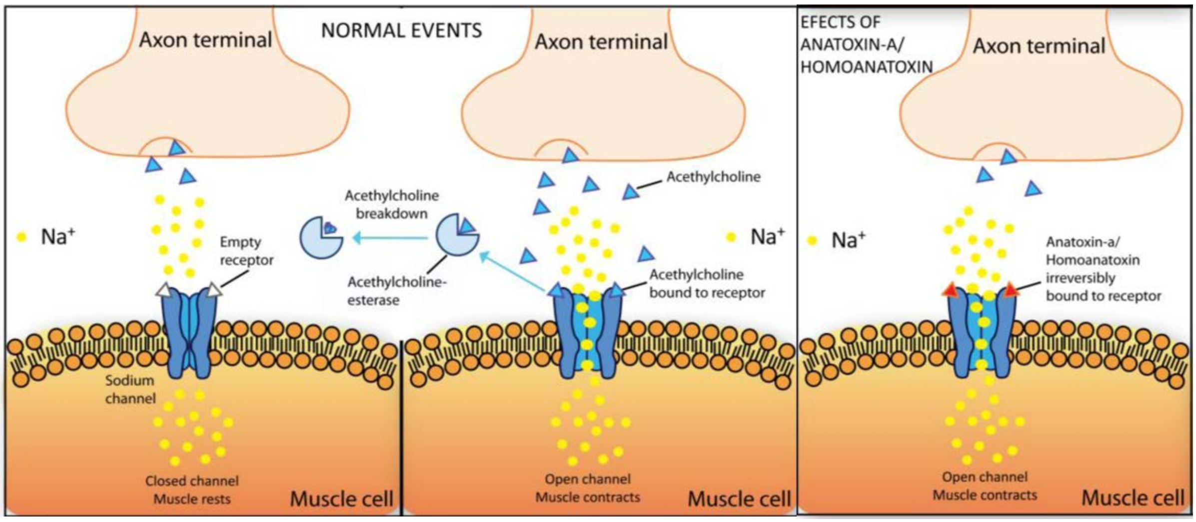


Figure 2. Schematic representation of the mode of action of anatoxin-a/homoanatoxin-a. From Valério et al*.* (2010).

The greatest risk to human and terrestrial animals comes from the ingestion of *Phormidium* mats. Although anatoxins are often detected in low concentrations in river water (Wood and Puddick 2017) large amounts would need to be consumed to ingest a lethal dose. In contrast, the toxins can be highly concentrated in the mats.

Although intentional ingestion of mats by adults is unlikely, small sections of well-developed mats continually slough off rocks, and float down the river. These could be accidentally ingested while partaking in recreational activities, i.e., swimming, in the river. Additionally, simultaneous mass autogenic detachment of *Phormidium* mats can occur. During these events, large sections of mats detach and float down river, often accumulating on the river's edge. The likelihood of contact and therefore ingestion of *Phormidium* mats will markedly increase during mass detachment events.

There are also certain user groups that may be more likely to come in contact with or ingest *Phormidium* mats than others, or the consequences for some groups may be more severe if they do. These groups include children, tourists or people from culturally and linguistically diverse backgrounds, and the elderly or those with existing medical conditions (NHMRC 2008).

Children usually spend more time in the water than adults and are therefore more likely to swallow water or benthic cyanobacterial mats, either intentionally or unintentionally (WHO 2003). A small number of children aged 1 to 6 have an eating disorder known as pica. This is characterised by persistent and compulsive cravings (lasting 1 month or longer) to eat non-food items, such children may be more prone to consuming *Phormidium* mats.

Tourists and people from culturally and linguistically diverse backgrounds may be unaware of the risks posed by *Phormidium* mats, and may not understand warning signs.

Although the likelihood of ingestion by elderly is not elevated, the consequence if they do consume *Phormidium* mats may be more severe. In regard to anatoxin, people with pre-existing peripheral or central nervous neuropathies or predispositions for neuropathies (e.g. familial Amyotrophic Lateral Sclerosis) may have a higher susceptibility than healthy individuals.

The following is recommended as advice to the public.

It is not safe to swim in rivers with toxic algae* mats. Avoid any skin contact with the water and avoid swallowing the water. The greater the amount of toxic algae and the longer the time spent in the water, the more severe the symptoms are likely to be. Wearing a wetsuit will not protect you and may cause severe irritation around the collar and cuffs. Be particularly vigilant with young children, especially when they are playing at the edge of rivers where floating mats may accumulate.

** It may be more appropriate to use the terms 'cyanobacteria' or 'toxic algae' rather than 'Phormidium' when providing advice to the public as this general terminology is easier to understand. The Greater Wellington Regional Council has found the use of 'toxic algae' is the easiest for the public to relate to.*

No data are available on the chronic oral toxicity of anatoxins. Because they appear to irreversibly bind to the nicotinic acetylcholine-receptors, chronic neurotoxicity is a potential risk. For this reason, although it is unlikely that a lethal dose will be consumed from drinking water, it is advisable to use alternative water supplies when toxic *Phormidium* mats are present. Anatoxins are not removed by boiling, by using normal filter systems, or by adding household disinfectants. There are a range of water treatment systems that can remove anatoxins, but a review of these is beyond the scope of this report.

The following is recommended as advice to the public.

It is not safe to drink water containing toxic algae. Toxins are not removed by boiling, using normal filter systems, or by adding household disinfectant.

2.3. Risks from consuming aquatic organisms

With the exception of the preliminary study in the Mataura River (Section 2.1.1), the accumulation of anatoxin in aquatic organisms has not been investigated in New Zealand. There is an urgent need to undertake further research to assess the effects of anatoxins on a variety of freshwater species, to validate the toxin extraction methods for use on freshwater species, and to investigate the accumulation of anatoxins in freshwater species, in particular edible taxa, e.g. trout.

An increasing number of overseas studies have demonstrated that anatoxin can accumulate in aquatic organisms. Osswald et al. (2007) placed juvenile carp (*C. carpio*) in water contaminated with extracts of an anatoxin-producing strain. After 96 hours of exposure, minor levels (0.005–0.073 µg g^{-1}) were found to have accumulated in the fish. In a similar experiment, blue mussels (*Mytilus galloprovincialis*) were exposed to water contaminated with extracts of an anatoxin-producing strain and accumulation and depuration monitored (Osswald et al. 2008). Anatoxin was detected in the digestive tract, muscles and foot. One day after beginning the depuration, no toxin could be detected, suggesting it is actively detoxified (Osswald et al. 2008).

Osswald et al. (2011) exposed juvenile rainbow trout (*Oncorhynchus mykiss*) to three concentrations of anatoxin for 96 hr. All fish accumulated the toxin. The fish body concentrations of the toxin were higher than the corresponding water concentrations. This suggest that rainbow trout can bioconcentrate anatoxin, even during short-term exposures and this process may considerably increase the risk of accumulating high levels of anatoxin in the natural environment through transfer up the food web. Further evidence to show that fish can accumulate anatoxin in the wild comes from a four-year study in a lake experiencing blooms containing anatoxin (Pawlik-Skowrońska et al. 2012). Anatoxins were detected in the liver and muscles of the omnivorous roach (*Rutilus rutilus*), Prussian carp (*Carassius gibelio*) and perch (*Perca fluviatilis*). The author suggests that the accumulation of anatoxin in fish muscles is likely through the food chain. The same research group also showed that anatoxin accumulate in the fly *Chironomus* sp. inhabiting a lake with a bloom of planktonic anatoxin-producing cyanobacteria (Oporowska et al. 2014).

The following is recommended as advice to the public.

Aquatic organisms from water bodies with toxic algal blooms should only be eaten occasionally (less than 1 meal per week). Consumers should avoid eating the liver and other organs, as this is where the accumulation of toxins may be greatest. Fish may taste earthy due to other compounds produced by the toxic algae; there is no relationship with taste and the concentration of toxins. Contact with the water should be avoided while fishing/harvesting and all organisms should be washed in clean water.

2.4. Risks to pets, wildlife and stock

Anatoxins have been associated with poisonings and deaths of livestock, dogs and ducks after ingestion of cyanobacterial material and/or exposure to water contaminated with anatoxins (Carmichael and Gorham 1978; Edwards et al. 1992; Faassen et al. 2012; Backer et al. 2013). Quantitative exposure data are not provided but clinical signs are generally reported as neurologic and deaths due to respiratory paralysis.

In New Zealand dogs seems particularly susceptible to poisoning possibly because they are attracted to the earthy musty smell of *Phormidium* mats. Dogs like to scavenge and play near water increasing the likelihood of coming in to contact with the mats and eating them.

To date no studies have been undertaken to investigate whether anatoxins accumulate in larger terrestrial animals. A study using the hepatotoxic cyanotoxin microcystin showed that when cattle consume sub-lethal doses of microcystins, the toxins could not be detected in their milk (Orr et al. 2001)

Where possible if the water supply for the stock drinking water contains toxic benthic *Phormidium* mats, an alternative water supply should be found. It is unlikely that a lethal dose will be consumed from dissolved toxins in the water, but small mat fragments may accumulate in the supply and either be consumed or die in the trough, releasing pulses of toxins into the water supply.

The following is recommended as advice to the public.

> Keep your dogs (and other pets) out of the water and most importantly, ensure they do not eat any algal material in the water or at the water's edge.

> Where possible find an alternative water supply for stock. Check stock drinking water regularly for the presence of toxic algal mats.

2.5. What to do if potential irritation or poisoning occurs

In humans, skin contact with *Phormidium* can cause irritation of the skin, eyes, nose and mouth, and if swallowed, can cause vomiting, diarrhoea, abdominal pain, cramps, nausea and potentially death if a lethal dose is consumed.

The following is recommended as advice to the public.

> Anyone who suspects they are experiencing a reaction due to contact with toxic algae should seek urgent medical attention and advise the doctor of the potential exposure to toxic algae and ask them to notify Regional Public Health.

If a dog or other animal is suspected to have consumed *Phormidium*, a vet should be contacted immediately. In extreme cases death can occur within 30 minutes after the first signs of poisoning appear. In some cases animals can be treated using activated carbon, stomach pumping and assisted respiration.

The following is recommended as advice to the public.

If a dog or other animal is suspected to have consumed toxic algae, a vet should be contacted immediately.

3. MONITORING

3.1. *Phormidium* monitoring

Regular monitoring should be undertaken at sites where *Phormidium* blooms are known to occur, where the public uses the river or adjacent land for recreational activities, or where the river is used as a drinking water supply.

It is recommended that the site survey method given in the New Zealand Guidelines for Managing Cyanobacteria in Recreational Fresh Waters (Ministry for the Environment and Ministry of Health 2009) be followed. Full details are given in the guidelines, but briefly it involves surveying four transects, positioned at right angles to the water's edge and extending to a depth of 0.6 m. The abundance of *Phormidium* mats is assessed at five points along each transect using a bathyscope. The average percent cover of *Phormidium* at each site is then calculated and used to identify the appropriate alert level (Table 2). At each level a series of monitoring and management actions are provided which regulators can use for a graduated response to the onset and progress of a cyanobacterial bloom or to respond to an unexpected cyanobacterial event.

Table 2. Alert-level framework for benthic cyanobacteria (adapted from Ministry for the Environment and Ministry of Health 2009).

Alert level[a]	Actions
Surveillance (green mode) Up to 20% coverage[b] of potentially toxigenic cyanobacteria attached to substrate.	• Undertake fortnightly surveys between spring and autumn at representative locations in the water body where known mat proliferations occur and where there is recreational use.
Alert (amber mode) 20−50% coverage of potentially toxigenic cyanobacteria attached to substrate.	• Notify the public health unit. • Increase sampling to weekly. • Recommend erecting an information sign that provides the public with information on the appearance of mats and the potential risks. • Consider increasing the number of survey sites to enable risks to recreational users to be more accurately assessed. • If toxigenic cyanobacteria dominate the samples, testing for cyanotoxins is advised. If cyanotoxins are detected in mats or water samples, consult the testing laboratory to determine if levels are hazardous.
Action (red mode) *Situation 1:* Greater than 50% coverage of potentially toxigenic cyanobacteria (see Table 1) attached to substrate; **or** *Situation 2:* up to 50% where potentially toxigenic cyanobacteria are visibly detaching from the substrate, accumulating as scums along the river's edge or becoming exposed on the river's edge as the river level drops.	• Immediately notify the public health unit. • If potentially toxic taxa are present then consider testing samples for cyanotoxins. • Notify the public of the potential health risks.

a The alert-level framework is based on an assessment of the percentage of river bed that a cyanobacterial mat covers at each site. However, local knowledge of other factors that indicate an increased risk of toxic cyanobacteria (e.g., human health effects, animal illnesses, prolonged low flows) should be taken into account when assessing a site status and may, in some cases, lead to an elevation of site status (e.g., from surveillance to action), irrespective of mat coverage.

b A description on how to undertake a site survey is provided in the guidelines.

4. COMMUNICATING RISK

After several years of developing a communication plan the Greater Wellington Regional Council (GWRC) has come to the conclusion that to communicate the health risks associated with *Phormidium* it is important to invest in publicising warnings and other information: *We can do all the monitoring in the world but if no one knows about the information being generated by it we might as well not do it at all* (quote from Summer Greenfield, GWRC).

4.1. Information and warning signs

Information and/or warning signs at key sites can be an effective method to educate and/or warn the public of potential risks. The extent of *Phormidium* blooms can vary rapidly; for example, they might be removed after heavy rain, and expand rapidly in summer. Additionally, it is not possible to monitor all sites on a regular basis. It also takes considerable resources to put up and remove signs. It is important to keep these up to date, otherwise the public becomes complacent, believing that the warning signs are always up even when there is no risk. For these reasons many regional councils now use information signs, or a combination of information and warning signs. The aim of the information sign approach is to educate the public on what to look for, and to help them make an informed decision on whether the waterbody is safe to use.

After several years of experimenting the GWRC now have a single information sign which is placed at key site with known *Phormidium* problems. Initially these signs included big red ‘warnings’ and ‘don’t swim’-type symbols. They noted that the public found these signs scary and it made them think that *Phormidium* was a problem all summer long (but in reality, in the Hutt River *Phormidium* is present < 15% of the time). Greater Wellington Regional Council has now changed the signs, removing the warning symbols (Figure 3). The aim of these is that when they are put in place during summer they would alert people to a potential risk and provide public advice on the latest warnings (i.e., in the GWRC case, the ‘summer check’ section of their website).

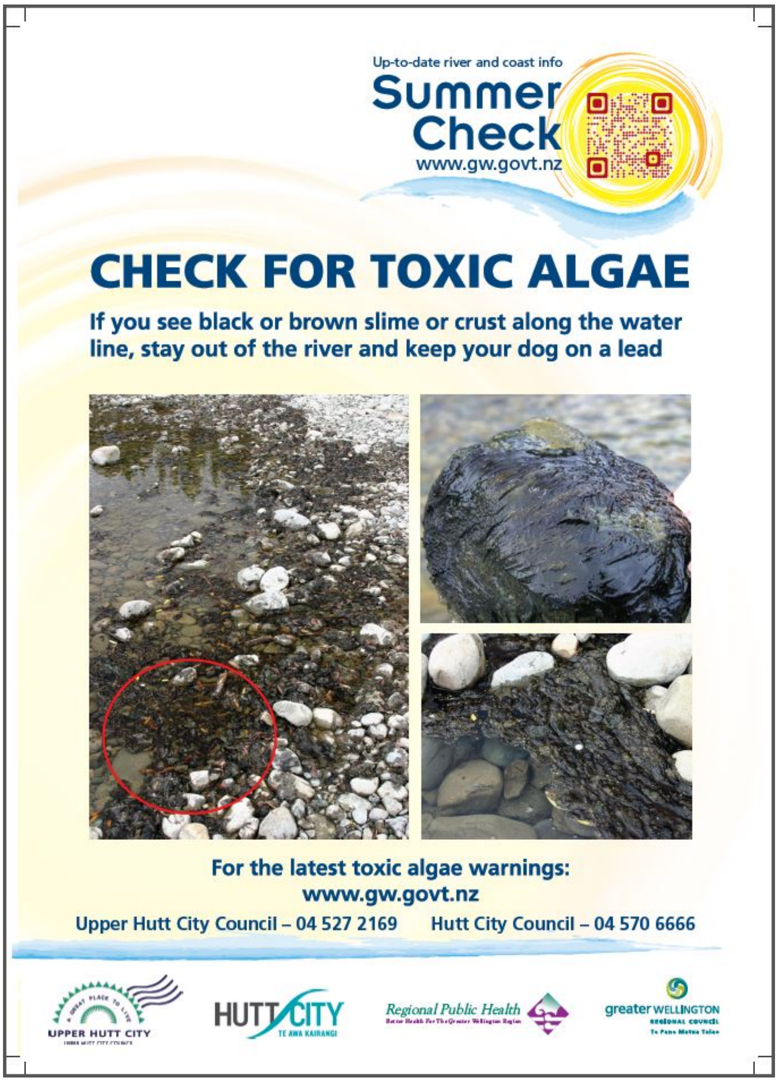


Figure 3. The Greater Wellington Regional Council toxic algae information sign used in 2016/2017.

Nelson has adopted a similar approach with permanent information signs placed at key sites along affected rivers (Figure 4), and warning signs are put up when cover exceeds the thresholds given in the New Zealand Guidelines for Managing Cyanobacteria in Recreational Fresh Waters (Ministry for the Environment and Ministry of Health 2009). At some sites in the Canterbury region (and other regions in New Zealand) the permanent signs include both information and a ‘fire warning’ alert system which is updated based on the most recent monitoring data (Figure 5).

Figure 4. The Nelson City Council toxic algae information (A), and warning (B) signs.

Figure 5. An example of a toxic algae information and warning sign used by Environment Canterbury.

4.2. Websites

Regional council websites contain a wealth of valuable information aimed at educating the general public on *Phormidium/*cyanobacteria, and it is recommended that Environment Southland develop a similar resource on their website.

The Greater Wellington Regional Council has a particularly good website that includes a description of cyanobacteria, frequently asked questions, photo gallery, links to several short videos, and an interactive map that allows users to see if there are any toxic algae warnings currently in place: http://www.gw.govt.nz/toxic-algae-faqs/.

Below are links to other Regional Council webpages, most of which include fact sheets, photos and locations of current warnings.

Environment Canterbury Regional Council
https://www.ecan.govt.nz/your-region/your-environment/water/cyanobacteria-warnings/

Nelson City Council
http://nelson.govt.nz/environment/water-3/toxic-algae/

Tasman District Council
http://www.tasman.govt.nz/environment/water/rivers/river-water-quality/toxic-algae-monitoring/

Bay of Plenty Regional Council
https://www.boprc.govt.nz/our-region-and-environment/rivers-and-drainage/river-algae-monitoring-and-warnings/

Hawkes Bay Regional Council
http://www.hbrc.govt.nz/hawkes-bay/swimming/swimminginhb/

Otago Regional Council
http://www.orc.govt.nz/Information-and-Services/Pest-Control/Plant-pests/toxic-algae/

4.3. Videos

Short videos are a particularly effective format to educate the public on the appearance and risks posed by *Phormidium*.

The GWRC has produce several short videos which are embedded in their website: http://www.gw.govt.nz/toxic-algae-faqs/

Their target audience was recreational water users within the greater Wellington region including; dog walkers, swimmers and those involved in water sports. The video's focus is on answering commonly asked questions in a clear, and accessible manner.

Cawthron has also produced a similar video that aims to show river users what *Phormidium* looks like, highlight the risks, and provide suggestions on where further information can be obtained. Environment Southland are welcome to embed this video in their website: https://vimeo.com/160826825.

4.4. Social and other media

The GWRC has been extremely proactive at informing the public of the risks posed by *Phormidium*. This section is based on their experiences and communication plan.

The GWRC trialled three different social media platforms: Twitter, Facebook and Neighbourly.

Twitter was used to update the public of new *Phormidium* blooms, and any changes to certain sites over time. The benefits of Twitter were that posts are easily and readily shared and engaged with. The limitations of Twitter are that it doesn't provide much room for explanation (140 characters maximum), additional information or ongoing engagement. Their posts related to toxic algae were highly engaged with over December 2015, January and February 2016

An example of their Twitter post in February 2016:

High toxic algae warning @ Hutt River Silverstream. Unsafe for swimming & dogs. Check #summercheck for latest alerts http://www.gw.govt.nz/summer-check/

GWRC found that Facebook was the most successful social media platform. It provided opportunities (and enough writing space) for answering questions, directing users to information sources (such as the GWRC website).

An example of a Facebook post in February 2015:

Toxic algae has been found in parts of the Waipoua River, near Masterton, so keep your dog on a lead and take care near the water.

Monitoring of the Waipoua River at Colombo Road shows that the amount of brown or black toxic algal mats growing on the river bed has reached moderate levels. With temperatures warming up it's providing ideal conditions for algae growth. If ingested it can kill livestock and dogs and contact can cause sickness in humans. Masterton

District Council has posted toxic algae information signs at key access points along the river.

Monitoring of Wellington waterways and coastal areas is carried out by Greater Wellington Regional Council, Regional Public Health and local authorities on a weekly basis over the summer months. Keep an eye on the #summercheck website for the latest monitoring results. (Image inserted)

Neighbourly is a social media platform for members of the public. Greater Wellington Regional Council directed posts to certain community groups depending on the location of the *Phormidium* blooms. They found that using this platform encouraged participants to have discussions amongst themselves. Because of the way Neighbourly is set up it was hard to measure the effectiveness of this platform in reaching the target audience.

Other media avenues that have been utilised by GWRC (and other councils) around New Zealand include:

- Producing an information pamphlet for pet owners, this is distributed to local veterinarian clinics.
- A text alert that goes out to registered dog owners at the start of each summer to remind owners to remain vigilant at certain sites.
- Booking radio advertising slots; for example, GWRC used approximately 300 radio spots in 2015/16 encouraging people to find out about the potential health risk from swimming at their favourite swimming spot and if there are warnings in place. The main aim was to encourage the public to make regular use of their interactive water quality map.
- Meetings with key stakeholders—e.g. local veterinarian Association Branches, community groups etc.

5. FINAL RECOMMENDATIONS

It is important the public is educated about the risks *Phormidium* poses, but that this is done in a manner that does not scare them away from using rivers.

Potentially toxic *Phormidium* are present at a number of sites in the Southland region. The concentrations of toxins at some sites are extremely high (i.e. the highest detected in New Zealand to date), and preliminary studies have shown that anatoxins accumulate in aquatic organisms at one site. Currently some of these sites are monitored as part of the State of the Environment periphyton programme (monthly).

The following actions are recommended:

- A review of the current *Phormidium* monitoring programme at specific recreational sites – some key sites may need more regular monitoring. The development of a site-specific model for predicting cover (an Envirolink project underway) may eventually elevate the need for regular monitoring at some sites, but the validation of this will take several years.
- Design and erect information signs at key sites.
- Develop a webpage promoting public awareness of *Phormidium* in the Southland region.
- Develop a *Phormidium*/cyanobacterial communication strategy.

6. ACKNOWLEDGEMENTS

This work was funded by an Envirolink Small Advice grant (1781-ESRC169). Mark Heath and Penny Fairbrother (GRWC) and Summer Greenfield (formerly GRWC) are thanked for sharing their benthic cyanobacterial communication strategies and other valuable information. Xavier Pochon and Roger Young (Cawthron) are thanked for their valuable suggestions during the review of this report, and Gretchen Rasch (Cawthron) for scientific editing.

7. REFERENCES

Backer L, Landsberg J, Miller M, Keel K, Taylor T 2013. Canine cyanotoxin poisonings in the United States (1920-2012): review of suspected and confirmed cases from three data sources. Toxins 5: 1597-1628.

Brasell K, Heath M, Ryan K, Wood S 2015. Successional change in microbial communities of benthic *Phormidium*-dominated biofilms. Microbial Ecology 69: 254-266.

Carmichael WW, Gorham PR, Biggs DF 1977. Two laboratory case studies on the oral toxicity to calves of the freshwater cyanophyte (blue-green alga) *Anabaena flos-aquae* NRC-44-1. Canadian Veterinary Journal 18: 71-75.

Chorus I, Bartram J 1999. Toxic cyanobacteria in water: a guide to their public health consequences, Monitoring and Management. London, E & F Spon.

Edwards C, Beattie KA, Scrimgeour CM, Codd GA 1992. Identification of anatoxin-a in benthic cyanobacteria (blue-green algae) and in associated dog poisonings at Loch Insh, Scotland. Toxicon 30: 1165-1175.

Faassen EJ, Harkema L, Begeman L, Lurling M 2012. First report of (homo)anatoxin-a and dog neurotoxicosis after ingestion of benthic cyanobacteria in The Netherlands. Toxicon 60: 378-384.

Hamill KD 2001. Toxicity in benthic freshwater cyanobacteria (blue-green algae): first observations in New Zealand. New Zealand Journal of Marine and Freshwater Research 35: 1057−1059.

Harland F, Wood SA, Broady P, Williamson W, Gaw S 2014. Polyphasic studies of benthic freshwater cyanobacteria in Canterbury, New Zealand. New Zealand Journal of Botany 52: 116-135.

Heath M, Wood SA, Ryan K 2010. Polyphasic assessment of fresh-water benthic mat forming cyanobacteria isolated from New Zealand. FEMS Microbiology 73: 95-109.

Heath MA, Wood SA 2010. Benthic cyanobacteria and anatoxin-a and homanatoixn-a concentrations in five Southland rivers. Prepared for Environment Southland. Cawthron Report No. 1841. 17 p

McAllister T, Wood SA, Hawes I 2016. The rise of toxic benthic *Phormidium* proliferations: a review of their taxonomy, distribution, toxin content and factors regulating prevalence and increased severity. Harmful Algae 55: 282-294

Ministry for the Environment and Ministry of Health 2009. New Zealand guidelines for managing cyanobacteria in recreational fresh waters – interim guidelines. Prepared for the Ministry for the Environment and the Ministry of Health by SA Wood, DP Hamilton, WJ Paul, KA Safi, WM Williamson. Wellington: Ministry for the Environment. 89 p.

National Health and Medical Research Council 2008. Guidelines for managing risks in recreational water. Australian Government National Health and Medical Research Council. https://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/eh38.pdf

Oporowska M, Pawlik-Skowronska B, Kalinowska R 2014. Accumulation and effects of cyanobacterial microcystins and anatoxin-a on benthic larvae of *Chironomus* spp. (Diptera: Chironomidae). European Journal of Entomology 111: 83-90.

Orr PT, Jones GJ, Hunter RA, Berger K, De Paoli DA, Orr CLA 2001. Ingestion of toxic by dairy cattle and the implications for microcystin contamination of milk. Toxicon 39: 1847-1854.

Osswald J, Azevedo J, Vasconcelos V, Guilhermino L 2011. Experimental determination of the bioconcentration factors for anatoxin-a in juvenile rainbow trout (*Oncorhynchus mykiss*). Proceedings of the International Academy of Ecology and Environmental Sciences 1: 77-86.

Osswald J, Rellán S, Carvalho AP, Gago A, Vasconcelos V 2007. Acute effect of anatoxin-a producing cyanobacteria on juvenile fish *Cyprinus carpio*. Toxicon 49:693-698.

Osswald J, Rellán S, Gago A, Vasconcelos V 2008. Uptake and depuration of anatoxin-a by the mussel *Mytilus galloprovincialis* (Lamarck, 1819) under laboratory conditions. Chemosphere 72: 235-1241.

Pawlik-Skowrońska B, Toporowska M, Rechulicz J 2012. Simultaneous accumulation of anatoxin-a and microcystins in three fish species indigenous to lakes affected by cyanobacterial blooms. Oceanological and Hydrobiological Studies 41: 53-65.

Smith F, Wood SA, Wilks T, Kelly D, Broady P, Gaw S 2012. Survey of *Scytonema* (Cyanobacteria) and associated saxitoxins in the littoral zone of recreational lakes in Canterbury (New Zealand). Phycologia 51: 542-551.

Valério E, Chaves S, Tenreiro R. 2010. Diversity and impact of prokaryotic toxins on aquatic environments: a review. Toxins 2: 2359-2410.

Wood SA, Stirling DJ, Briggs LR, Sprosen J, Holland PT, Ruck JG, Wear RG 2006. Survey of cyanotoxins in New Zealand waterbodies between 2001 and 2004. New Zealand Journal of Marine and Freshwater Research 40: 585-595.

Wood SA, Heath M, McGregor G, Holland PT, Munday R, Ryan K 2010. Identification of a benthic microcystin producing filamentous cyanobacterium (Oscillatoriales) associated with a dog poisoning in New Zealand. Toxicon 55: 987-903.

Wood SA, Kuhajek J, de Winton M, Phillips NR 2012a. Species composition and cyanotoxin production in periphyton mats from three lakes of varying trophic status. FEMS Microbiology Ecology 79: 312-326.

Wood SA, Smith FMJ, Heath MW, Palfroy T, Gaw S, Young R, Ryan KG 2012b. Within-mat variability in anatoxin-a and homoanatoxin a production among benthic *Phormidium* (Cyanobacteria) strains. Toxins 4: 900-912.

Wood SA, Hawes I, McBride G, Truman P, Dietrich D 2015. Advice to inform the development of a benthic cyanobacteria attribute. Prepared for Ministry for the Environment. Cawthron Report No. 2752. 91 p

Wood SA, Puddick J, Fleming R, Heussner AH 2016. Detection of anatoxin-producing *Phormidium* in a New Zealand farm pond and an associated dog death. New Zealand Journal of Botany 55:1-11.

Wood SA, Puddick J 2017. Assessment of anatoxin levels in the water of rivers affected by *Phormidium* blooms: Interim report. Prepared for Ministry of the Environment. Cawthron Report No. 3022. 23 p.

World Health Organization (WHO) 2003. Guidelines for safe recreational water environments. Volume 1: Coastal and fresh waters. WHO. 253 p.