Background information on freshwater and marine microalgae and harmful algal blooms (HABs)

1 Purpose and scope

This document provides background information on freshwater and marine microalgae and harmful algal blooms (HABs).

2 Associated documents

Biological assessment:

- *Sampling freshwater and marine microalgae and harmful algal blooms (HABs)*
- *Physical and chemical assessment - Chlorophyll a sample collection methods*

3 Introduction

Freshwater and marine microalgae, also known as phytoplankton, are an important group of microscopic plants for monitoring water quality because of their sensitivity to environmental changes. Microalgae are therefore good indicators of aquatic health because they reflect changes in water quality and/or environmental degradation.

In general, the greater the diversity of phytoplankton in a water sample, the better the health of the water body. If the number and diversity of phytoplankton genera and species is seen to decline during a routine monitoring program, this could be either the result of natural seasonal fluctuations or indicate that the water quality is declining in that water body.

There are many types of phytoplankton (Figure 1 and Figure 2) which can be divided into four main groups—the blue-green algae (cyanobacteria, which are not strictly algae), green algae, diatoms and flagellates (the latter including dinoflagellates and raphidophytes).

(a) (b)

Figure 1: Green microalgae (a) *Chroococcus turgidus* (b) *Micrasterias*. Photo credits: Glenn McGregor, DES

(a) (b) (c)

Figure 2: Blue-green algae (a) *Tolypothrix* sp. (b) *Anabaena* sp. (c) *Dolichospermum circinale.* Photo credits: Glenn McGregor, DES

Algae are important components of any aquatic environment because they are the primary producers at the base of all aquatic food chains. In addition to this, being photosynthetic “plants” they utilise dissolved CO_2 in the water and release oxygen, which meets the respiration needs of aquatic animals.

A number of environmental factors (including nutrients, light, water temperate, pH, salinity and turbidity) influence the growth of phytoplankton in aquatic environments. In some instances when excessive nutrients are available, phytoplankton can proliferate and form large algal blooms that are usually visible on the surface of a waterbody (Figure 3). Phytoplankton biomass in a water sample can be estimated by the photosynthetic pigment chlorophyll a which is found in all phytoplankton cells.

Algal blooms may occur under natural conditions and many are beneficial to aquatic environments by providing food sources for other organisms. However, increased frequency and intensity of algal blooms may be attributed to increased nutrient levels entering the water from either diffuse or point-source discharges (e.g. sewage treatment plants, agricultural irrigation, industrial effluents and domestic activities). Although phytoplankton/microalgae produce oxygen during photosynthesis and take up nutrients, large algal blooms can result in poor water quality. This is because the cells of the algal bloom eventually die and the subsequent microbial decomposition has the potential to deplete oxygen dissolved in the water. If oxygen concentrations drop low enough, it can lead to the death of other aquatic organisms, including fish and macroinvertebrates. Any bloom of sufficient biomass relative to the size of the waterbody can produce this harmful effect. This is an example of a non-specific harmful algal bloom (as it can be caused by species that are otherwise harmless).

4 Harmful algal blooms- freshwater blue-green algae (cyanobacteria)

Harmful Algal Blooms (HABs) are common, sometimes seasonal phenomena that occur throughout Queensland in fresh, estuarine and coastal marine waters. Their occurrence has the potential to seriously degrade water quality. When the total cell counts reach excessively high numbers they become evident as discoloured water, usually green or blue-green in colour, frequently with a strong musty odour and visible thick surface scums (Figure 4).

The organisms largely involved in these harmful outbreaks include cyanobacteria (such as *Microcystis*, *Dolichospermum*, *Nodularia*, *Cylindrospermopsis,* and *Chrysosporum*). Harmful algal blooms may produce toxins that pose a direct threat to human and animal health, or otherwise adversely affect water quality through the production of taste and odour compounds that reduce the suitability of water for direct consumption or recreational activities. Consequently, harmful algal blooms may have economic impacts from increased costs of water treatment or the need to use an alternative water supply, as well as social impacts through disruptions to the recreational use of the waterway. Toxin-producing HABs may also have deleterious effects on aquatic ecosystems.

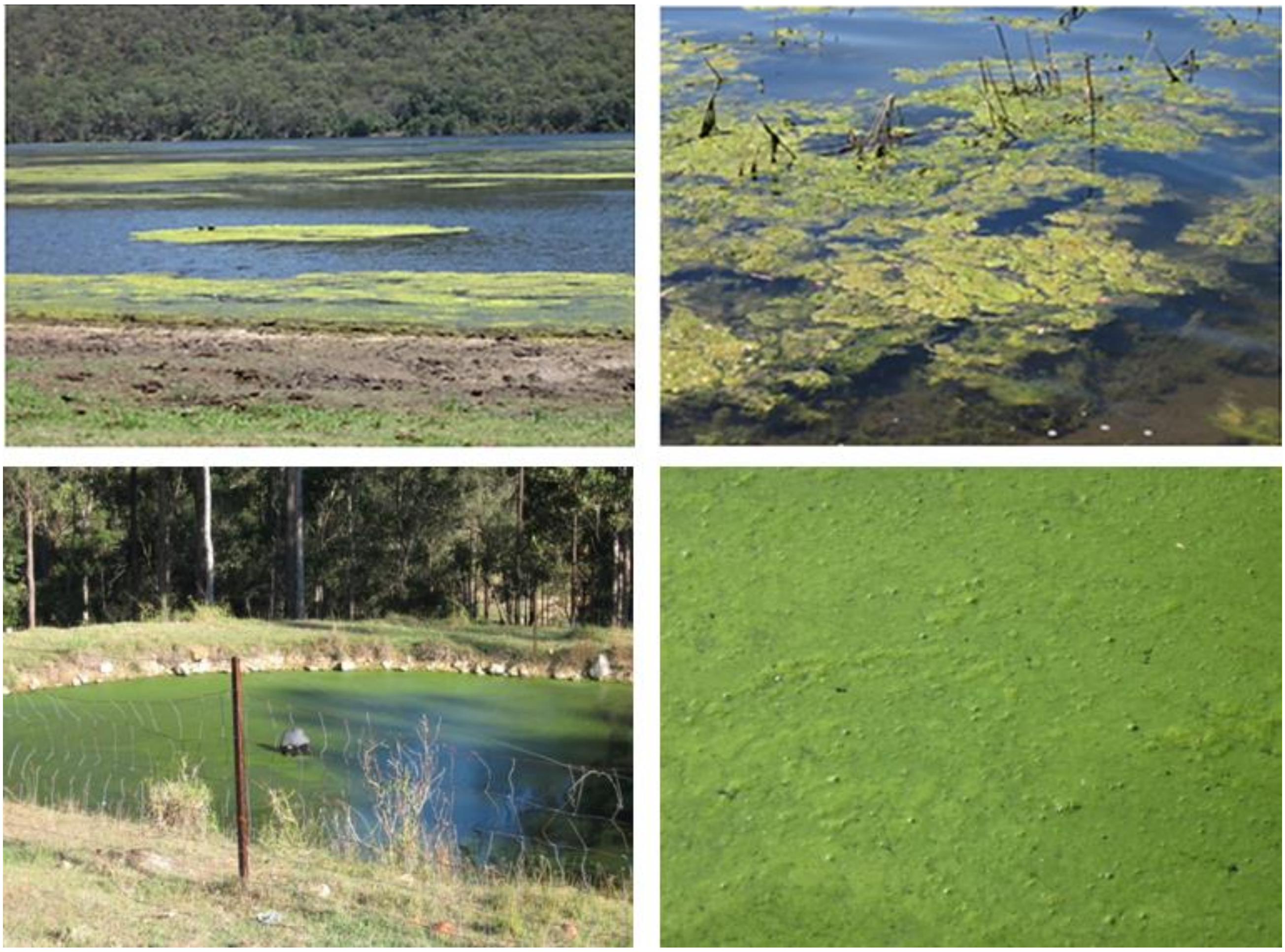

Figure 3: Photographs of fresh water algal blooms in lakes and a small farm dam. Photo credits: Philippa Uwins, DES

Figure 4: Fresh water cyanobacteria blooms. Photo credits: Glenn McGregor, DES

Recent research has also linked a neurotoxin known as BMAA (β-methylamino-ʟ-alanine) that can be produced by a range of cyanobacteria (as well as some marine diatoms and dinoflagellates) as a possible contributing factor to neurodegenerative disease (Cox et al. 2016).

The *Queensland Harmful Algal Bloom Response Plan* (DNRM 2014) outlines the contingency plan for responding to HABs within the capacity of local response agencies such as the Department of Natural Resources, Mines and Energy (DNRME), Department of Environment and Science (DES), Department of Health (DoH), Department of Agriculture and Fisheries (DAF), local governments and water storage operators.

As described above, blue-green algal blooms form clearly visible surface scums which can be highly toxic. In view of this, extreme care should be taken when sampling water (e.g. the use of implements to collect samples, wearing protective long sleeved safety gloves etc.) in order to avoid any body contact (See detailed procedures in *Sampling freshwater and marine microalgae and harmful algal blooms* document for harmful algal bloom sample collection and handling).

Reporting blue-green algal blooms is particularly important because of the wide range of users that can be affected. Rapid reporting to the responsible water authority will allow the authorities to alert their aquatic plant experts to verify the identification and perform a cell count of the numbers of organisms, so that control procedures can be implemented and appropriate signage put up to alert the public.

5 Marine harmful microalgae

Around the world a range of marine microalgae can cause harmful algal blooms and these are sometimes known as ‘red tides’, although most blooms don’t have a red colour. The most commonly occurring harmful marine algae in coastal Queensland is *Lyngbya majuscula* (a large filamentous cyanobacterium or blue-green algae) (Figure 5). Toxicological tests from Moreton Bay have identified toxins that may occur separately or in combination in *Lyngbya majuscula* populations. The toxins identified from Queensland populations are Lyngbyatoxin A and Debromoaplysiatoxin.

Another potentially harmful group of marine cyanobacteria that commonly occur in Queensland waters are species of *Trichodesmium,* which have been linked to skin irritations in humans. Large, floating drifts of *Trichodesmium* are commonly seen on the surface of estuarine and coastal Queensland waters during periods of calm weather (Figure 6).

The other main group of microalgae responsible for marine HABs around the world are flagellates, especially dinoflagellates and raphidophytes. Certain species of these groups have been responsible for fish kills on a large scale. In addition, toxins produced by some species of dinoflagellate (and diatom) can accumulate in seafood (especially shellfish) to cause human poisoning. In Queensland, the most common form of seafood poisoning caused by marine microalgae is ciguatera, from consumption of normally edible species of fish contaminated with ciguatoxins. Ciguatoxins are produced by benthic dinoflagellates belonging to the genus *Gambierdiscus* (Holmes et al. 2014). *Gambierdiscus* are common epiphytes of seaweeds on coral reefs along the coast of Queensland (Gillespie et al. 1985) and the ciguatoxins they produce can accumulate through marine food chains into normally edible species of fish.

(a) (b)

Figure 5: (a) Large blooms of *Lyngbya majuscula* smothering seagrass beds in Moreton bay. Photo credit: DES, Queensland Government Wetland Info. (b) *Lyngbya* bloom washed onto foreshores in Deception Bay and smothering mangrove roots (Photo credit: Moreton Bay Regional Council)

Figure 6: *Trichodesmium* bloom

6 Shellfish poisonings caused by HABs

Shellfish can accumulate and concentrate phytoplankton toxins from a range of marine dinoflagellate and diatom species. To date, such shellfish poisonings have been rare in Queensland. Different HAB species produce different toxins that cause different types of seafood poisonings such as Diarrhetic Shellfish Poisoning (DSP), Paralytic Shellfish Poisoning (PSP), Neurotoxic Shellfish Poisoning (NSP) and Amnesic Shellfish Poisoning (ASP). In some cases, shellfish can become poisonous when relatively low numbers of HAB species are present in the water.

7 Stock and wildlife affected by harmful microalgae

Stock animals are often affected by algal blooms through the consumption of freshwaters contaminated with cyanotoxins (toxins produced by blue-green algae). All animal species are potentially susceptible. Fatal cases are on record for cattle, sheep, horses, pigs, dogs and birds. Wildlife most commonly affected by harmful algae are fish (Figure 7) and water birds.

A range of marine flagellate species can also produce toxins that can kill fish and other wildlife. The flagellate species most often associated with fish kills are certain dinoflagellate and raphidophyte species.

(a)

(b)

Figure 7: (a, b) Algal bloom, Caboolture River with fish kill

8 References and additional reading

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