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Environment Institute of Australia and New Zealand Inc.

22 August 2025

EIANZ-SA Division submission to the Environment and Communications References Committee – Inquiry into Algal Blooms in South Australia

Dear Committee,

Thank you for the opportunity to provide feedback on the Terms of Reference for the Inquiry into algal blooms in South Australia.

The Environment Institute of Australia and New Zealand (EIANZ) is Australasia's peak body for environmental professionals. We represent around 4,000 members and certified environmental practitioners in our region and are part of a global network of over 100,000.

Our members come from a diverse range of technical professions, including scientists, policymakers, engineers, lawyers and economists. They are at the forefront of issues such as impact assessment, biodiversity, climate change, and nature positive. EIANZ represents environmental practitioners at all stages of their career, from student and early career practitioners to senior leaders.

The EIANZ South Australian Division is pleased to provide feedback on the Terms of Reference. Our submission has been led by EIANZ Fellow, David Wiltshire.

We thank the Senate Standing Committees on Environment and Communications for engaging in discussion regarding the Inquiry into Algal Blooms in South Australia. EIANZ would welcome the opportunity for continued involvement.

Yours sincerely,

Sally O'Neill
SA Division President, on behalf of the EIANZ SA Division

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Environment and Communications Reference Committee Inquiry into Algal Blooms in South Australia

Submission by The Environment Institute of Australia and New Zealand (EIANZ), South Australian Division

About EIANZ

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This submission has been prepared by the South Australian Division, and led by EIANZ Fellow, David Wiltsire.

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EIANZ-SA Division Submission

Submission scope

This submission will address the following aspects of the Terms of Reference.

The causes, frequency, scale and duration of recent algal blooms in South Australian marine and coastal environments are addressed, with particular reference to:

a. contributing environmental, land management or water quality factors;

f. the adequacy of long-term monitoring, forecasting and prevention strategies, including funding and institutional support for marine science and environmental data collection.

Contributing environmental, land management or water quality factors

Context

The unprecedented bloom of *Karenia mikimotoi* in the coastal waters of South Australia during 2025 has occurred within the context of:

- a marine heatwave during summer 2024-25 in which local coastal waters were consistently up to 2-3^{o}C higher than normal;
- a long period of calm seas during the on-set of the bloom;

- the 2022-23 River Murray floods that discharged large amounts of freshwater, silt and nutrients into the local marine environment;
- a nutrient upwelling off the south coast of South Australia during the summer of 2024-25;
- areas of significant ongoing nutrient enrichment associated with human activities within Spencer Gulf and Gulf St Vincent.

Key ecological features of Karenia mikimotoi

The phytoplankton responsible for the South Australian algal bloom, *K. mikimotoi*, is a toxic dinoflagellate. Regular blooms of *K. mikimotoi* have occurred in other parts of the world, including China, Japan, Europe and North America, and have generally been correlated with nutrient enrichment (e.g. Chen Baohong et al. 2021).

Marine plants, including phytoplankton, typically require light and carbon dioxide for photosynthesis, and the nutrients nitrogen and phosphorus, as well as micro-nutrients iron and silicate, to grow. In situations where there is sufficient light, their growth will generally be limited by a deficiency in one or more nutrients. In South Australian coastal waters, the growth of marine plants has been found to be typically limited by insufficient nitrogen (i.e. ammonia, ammonium, nitrite and nitrate) (Gaylard 2014).

An unusual aspect of *K. mikimotoi* is that it is mixotrophic, meaning that it is able to use both photosynthesis and ingestion of prey micro-organisms, including bacteria, diatoms and ciliates, for its energy needs (Qing-Chun Zhang et al. 2013). *K. mikimotoi* is thought to be very adaptable and able to use a variety of dissolved nutrients and prey organisms. This may provide it with a competitive advantage over other species of phytoplankton, which it may also consume (Qing-Chun Zhang et al. 2013, Zhao Y et al. 2017).

Laboratory studies have shown that growth of *K. mikimotoi* is promoted by both dissolved inorganic nitrogen (i.e. ammonium, nitrite and nitrate) and dissolved organic nitrogen (i.e. urea and amino acids)(Yan Zhao et al 2017). Furthermore, culturing *K. mikimotoi* using urea, which is usually associated with human activity, has been found to produce algae that is much more toxic than culturing using ammonium (Yan Zhao et al 2017).

When conditions are unsuitable, dormant cysts of *K. mikimotoi* are produced and can remain in the sediment for long periods until conditions improve and further blooms are able to occur (Zhao Y et al. 2017).

The evidence suggests that the availability of nitrogen based nutrients is likely to be one of the key drivers of *K. mikimotoi* blooms.

Nutrient enrichment of South Australian coastal waters

Prior to European settlement, South Australian coastal waters typically had very low concentrations of nutrients due to South Australia's old, nutrient poor soils, low rainfall and limited run off entering coastal waters. Over thousands of years, the local marine ecosystem became adapted to these very low nutrient conditions, with plants that were able to thrive in nutrient-poor waters, such as seagrasses, proliferating in gulf waters (Gaylard 2014). Phytoplankton levels in gulf waters are thought to be limited by the low nutrient concentrations, but have been found to be much more abundant outside the gulfs in areas where upwellings of nutrient rich oceanic water occurs (van Ruth 2008).

Food chains are thought to be largely driven by the decomposition of seagrass detritus in the gulfs, and phytoplankton in coastal waters outside the gulfs.

As nutrient levels gradually increased in South Australia's coastal waters as a result of human activities, thresholds were reached in the 1960s and 70s when significant ecological impacts became apparent. These impacts were initially confined to the loss of extensive seagrass communities in areas where nutrient rich wastewater was discharged to the marine environment such as off Adelaide (Shepherd et al 1989). Although the nutrient levels were elevated, they were still low compared with the Water Quality Guidelines, indicating the extreme sensitivity of the local ecosystem to nutrient enrichment and the potentially inappropriate nutrient thresholds in the guidelines.

Occasional harmful algal blooms, including *K. mikimotoi* blooms, have occurred in South Australia over the last 50 years, but they have generally been relatively small and of short duration (van Ruth 2014). It was suggested that growth-limiting factors were reducing phytoplankton biomass, and that low nutrient concentrations were probably preventing harmful algal species from occurring (van Ruth 2014).

The occurrence of the algal bloom in South Australia in 2025 suggests that the thresholds for one or more of the growth-limiting nutrients have now been exceeded.

Potential drivers of the algal bloom

Temperature, salinity and calm seas

The optimal seawater temperature and salinity for growth of *K. mikimotoi* appears to be 20 to 26^{o}C, and 20 to 35 ppt, respectively (Kaempf 2025). These temperatures are typical of summer water temperatures in South Australia, and 35 ppt is typical seawater salinity.

The data suggest that the growth of *K. mikimotoi* may be inhibited in the northern reaches of the gulfs where the salinity often exceeds 40 ppt, and during winter when water temperatures are 13 -16^{o}C.

Growth of *K. mikimotoi* may be promoted in brackish water where there is significant freshwater input to the sea, such as during the River Murray flood of 2022-23. However, this flood event occurred approximately two years before the algal bloom and is unlikely therefore to have promoted the bloom.

It was initially thought that the above average seawater temperature and ongoing calm conditions during late summer and autumn may have been the primary drivers of the bloom. However, the perseverance of bloom into winter, when seawater temperatures had declined and sea conditions had become rougher, suggests that elevated seawater temperature and calm conditions were not the primary drivers of the bloom.

Ballast water disposal

The bloom of *K. mikimotoi* in South Australia may have been initiated by the disposal of ballast water containing *K. mikimotoi* into an area of South Australia's coastal waters where conditions were conducive to a bloom developing.

Nutrient load

Human activities since European settlement have upset the nutrient balance in coastal waters and resulted in the load of nitrogen-based nutrients within the South Australian marine environment gradually increasing. The main sources have been tuna and kingfish aquaculture, wastewater treatment plants, agricultural runoff, industry and stormwater, with tuna and kingfish aquaculture being the largest source of nutrients in Spencer Gulf by an order of magnitude (Gaylard 2014). Average N nutrient concentrations in coastal water may finally have reached a threshold where they are now promoting algal blooms over wide areas rather than being growth-limiting.

Increased nutrient recycling

Most nutrients are stored and recycled within the marine environment via complex biological and chemical processes related to the decomposition of organic matter. Some of these biochemical processes transform organic nitrogen into soluble inorganic forms such as ammonia, ammonium, nitrite and nitrate that are available for uptake by phytoplankton and other marine plants (i.e. nitrification). Other biochemical processes transform nutrients into nitrogen gas that is released to the atmosphere (i.e. denitrification). These processes require very specific communities of bacteria and chemical conditions to operate (Gaylard 2014).

It is conceivable that changes in seawater chemistry related to climate change, such as increased acidity, are altering these biochemical processes and nutrients stored in organic matter are being more readily transformed into soluble forms that are available for uptake by phytoplankton.

Increased nutrient upwellings

Increased nutrient concentrations in South Australia's coastal waters may also be related to increased nutrient upwellings along the South Australian coast. Although these upwellings are not well understood, they are thought to be driven by a variety of oceanographic and climatic factors, including ocean currents and prevailing winds, which may be changing as a result of climate change.

Iron

It is conceivable that the micro-nutrient iron may be implicated in the algal bloom, as it has been found to be the growth-limiting factor for phytoplankton in some situations. For example, as part of carbon sequestering studies, it has been shown that the addition of trace amounts of iron to oceanic waters that are otherwise nutrient-rich can stimulate large blooms of phytoplankton (Degraff 2025).

Significant sources of iron in South Australian coastal waters may be fugitive iron-rich dust from the ship loading activities in Spencer Gulf, the discharge of ballast water from magnetite/iron ore ships prior to entering Spencer Gulf to load magnetite off Whyalla.

Changes to seawater chemistry related to climate change, such as increased acidity, may also be transforming iron in the sediments from insoluble to soluble forms that may promote phytoplankton blooms.

The adequacy of long-term monitoring, forecasting and prevention strategies, including funding and institutional support for marine science and environmental data collection

Water quality guidelines

At present, the SA EPA is working towards amending the Water Quality Guidelines for South Australia (S. Gaylard, pers. comm., 15-8-2025). There is an urgent need to finalise the revision of the Guidelines to address issues associated with the ongoing nutrient enrichment of South Australia's coastal waters. In particular, more conservative thresholds are required for nitrogen-based nutrients to reflect the extreme sensitivity of the local marine ecosystem to elevated nutrient levels.

Ballast water disposal protocols

The potential introduction of *K. mikimotoi* into South Australia via ballast water highlights the need for ongoing strict biosecurity controls relating to the disposal of ballast water. Ballast water disposal locations and protocols should be reviewed and amended if appropriate.

Laboratory experiments

The growth requirements of *K. mikimotoi* should be investigated via laboratory/mesocosm experiments. In particular, the effects of dissolved inorganic and organic nitrogen, micro-nutrients such as iron, seawater temperature, salinity and pH on algal blooms should be investigated.

Nutrient inputs and cycles

Nutrient cycles within South Australia's coastal waters and sediments are poorly understood. In light of the human perturbations of the nutrient cycles, it is necessary to gain a better understanding of the complex biochemical processes driving the availability of nutrients in South Australia's coastal waters. A study of nutrient inputs, nutrient cycles and associated biochemical processes is likely to provide a better understanding of the nutrient enrichment of South Australia's coastal waters and the likelihood of future algal blooms.

Nutrient upwellings

The oceanographic and meteorological drivers of nutrient upwellings along the South Australian coast should be investigated to determine whether they are changing as a result of climate change. If feasible, nutrient upwellings should be modelled to enable predictions to be made concerning the location, magnitude and frequency of upwellings, and the likely input of nutrients to coastal waters.

Seawater and sediment quality

Seawater quality monitoring programs, focusing in particular on phytoplankton, bio-available N nutrients and physical parameters, should be expanded to provide comprehensive coverage of South Australia's coastal waters. Sediments should also be monitored to provide information on the load of insoluble nutrients stored in the sediment and the presence of dormant *K. mikimotoi* cysts.

Nutrient mitigation

Every opportunity to prevent nutrients from entering the marine environment in South Australia should be investigated. In particular, existing programs to re-use treated wastewater on land for irrigation, industrial, and urban uses should be investigated and, if possible, expanded.

'Integrated multi-trophic aquaculture' at Port Lincoln should be investigated, as tuna farms contribute by far the greatest load of nutrients to Spencer Gulf. Particulate organic nutrients can be removed from seawater via 'integrated multi-trophic aquaculture', whereby filter-feeding shellfish such as oysters and mussels are cultured near the tuna farms.

There may also be opportunities to remove dissolved nutrients from seawater at Port Lincoln by culturing the red macroalgae *Asparagopsis* near the tuna farms. There is an expanding market for *Asparagopsis* as a dietary supplement for cattle feed to reduce the production of methane, which is one of the most potent greenhouse gases.

Management and coordination

The complexity and magnitude of the issues associated with the algal bloom suggest the need for a dedicated government team to manage and coordinate investigations and responses by the various branches of government, research institutions and the community.

The need for such an approach is outlined in EIANZ's position statement on Natural Disaster Resilience (EIANZ 2024).

Conclusion

We thank the Senate Standing Committees on Environment and Communications for engaging in discussion regarding the Inquiry into Algal Blooms in South Australia. EIANZ would welcome the opportunity for continued involvement.

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