# Summary

# Harmful Algal Bloom Science Forum

**Date / time:** Tuesday, 3 June 2025, 9:00am to 1:00pm (ACST)

**Location:** South Australian Aquatic Sciences Centre and Microsoft Teams

## Acknowledgement of Country

*"We acknowledge and respect the traditional custodians whose ancestral lands we are meeting upon here today. We acknowledge the deep feelings of attachment and relationships of Aboriginal peoples to country. We also pay respects to the cultural authority of Aboriginal people attending from other areas of Australia present here."*

## Participants

The forum was open to the scientific community and brought together leading scientists from State and Federal government agencies, national research institutes and universities, and the private sector. Experts from New Zealand on harmful algal blooms (HAB) also provided valuable insight.

A full list of participants is provided in Appendix 1.

## Presentations

- Summary of remote sensing and oceanography (Mark Doubell, SARDI)
- Impacts on environment: fish kills on Kangaroo Island (Paul Rogers, Southern Fishery & Ecosystem Solutions)
- South Australian Shellfish Quality Assurance Program: Brevetoxin Response (Clinton Wilkinson, SASQAP)
- Overview of fish-killing HABs in Australia with a focus on *Karenia* (Shauna Murray, University of Technology, Sydney)

- A New Zealand perspective of dealing with fish-killing HABs and *Karenia* (Tim Harwood and Kirsty Smith, Cawthron Institute, New Zealand)
- Reoccurring HABs in Western Australia - identification, toxin studies, annually monitoring (Jeff Cosgrove, Department of Biodiversity Conservation and Attractions in WA (DBCA)
- Early detection using real time sensors, forecasting and the value of big data for future R&D (Mark Doubell, SARDI)
- Remote sensing and forecasting systems (Nagur Cherukuru, CSIRO)

# Background

South Australia is currently experiencing a Harmful Algal Bloom (HAB) of unprecedented scale, duration and impact across a wide range of marine industries and coastal communities.

The HAB was first detected in mid-March in the waters around the Fleurieu Peninsula in South Australia, particularly near Waitpinga and Parsons Beach. Testing has revealed the HAB impacting South Australia is dominated by the dinoflagellate *Karenia mikimotoi*, potentially mixed with other harmful algae species.

Daily satellite measures of chlorophyll-a levels, an indicator of algae concentrations, with connectivity to the HAB bloom identified off the Fleurieu Peninsula in mid-March, have been used to track the bloom (Figure 1).

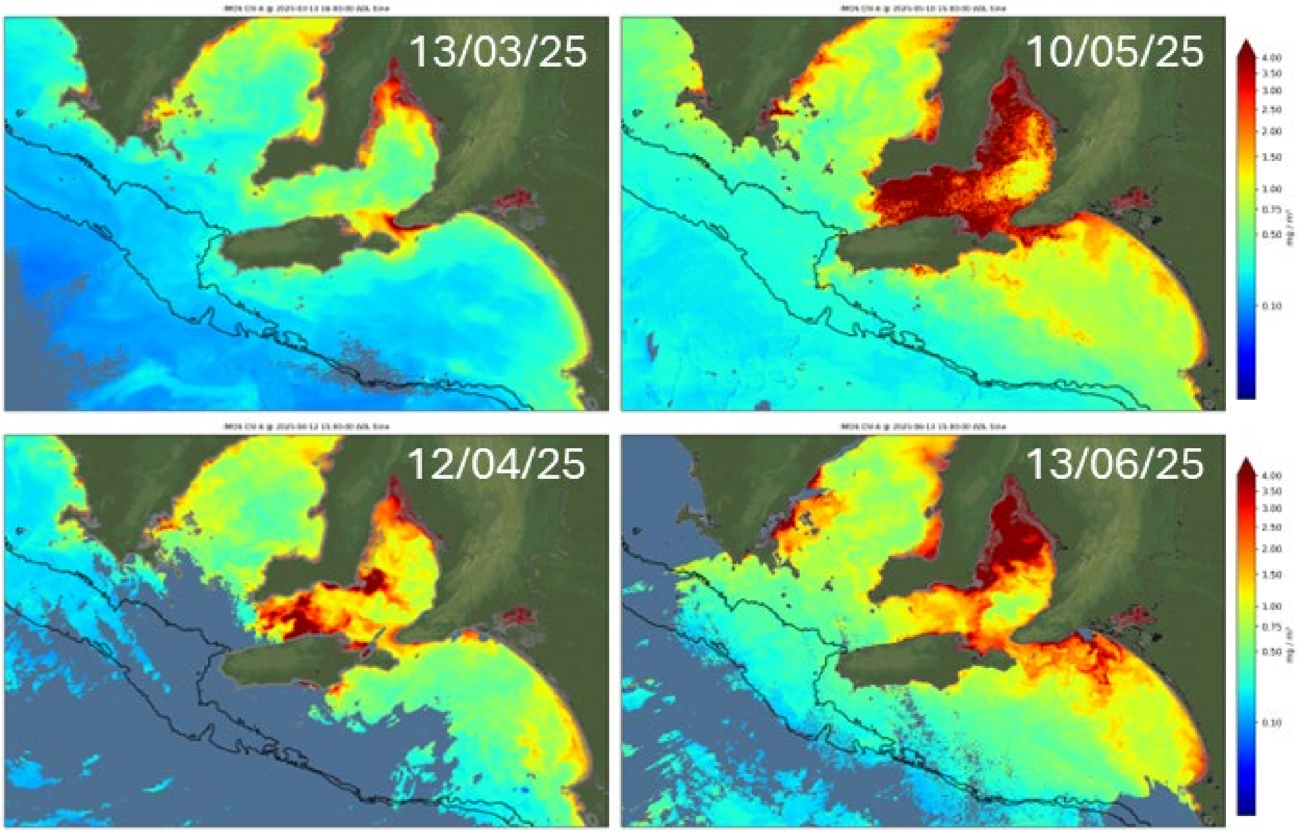

Figure 1. Examples maps of the daily sea surface chlorophyl a (chla) maps used over the period March to June 2025 to track the spatial dynamics of the bloom. Red shading indicates areas of high chla biomass. Regions where no data is available due to cloud cover are shaded in grey-blue. *Source: https://oceancurrent.aodn.org.au/*

Satellite measures of chla concentrations (Figure 1) in shallow waters (i.e. <30 m depth) can be affected by optical issues (e.g. bottom reflectance, seagrass detection) which can lead to the over-estimation of chla levels. To remove these biases maps showing daily increases and decreases in chla relative to the median conditions observed over the previous ten days have been produced (Figure 2). These maps have provided a useful product to determine areas of active chla increases and decreases, noting areas of high chla do not necessarily confirm the presence of the specific *Karenia mikimotoi*. Combined with in-situ surveillance, and forecasts of the ocean circulation provided by the eSA-Marine ocean modelling system, the maps have provided a useful tool to inform the potential presence and trajectory of the HAB.

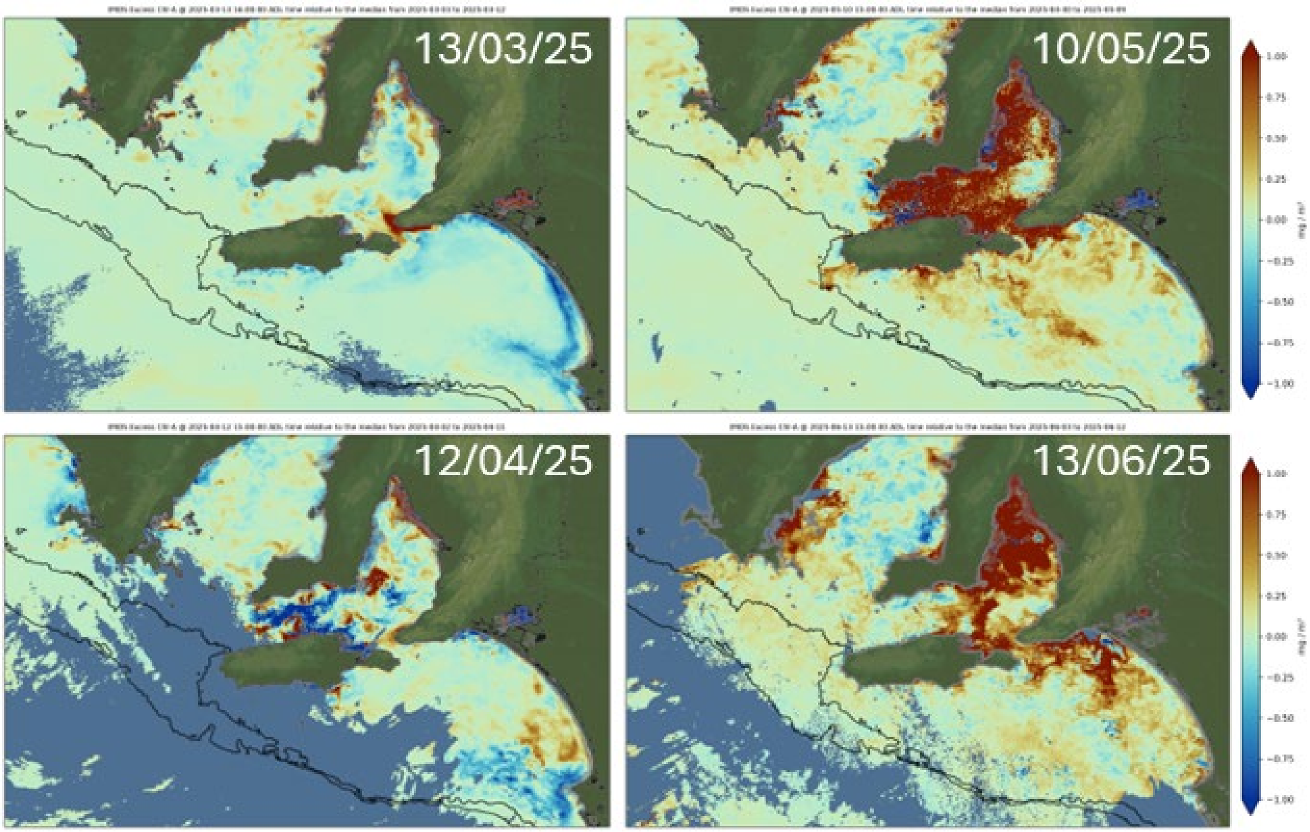


Figure 2: Maps showing daily increases and decreases in chla over the bloom course. Regions where no data is available due to cloud cover are shaded in grey-blue. Source: SARDI Oceanography.

Currents efforts to monitor the HAB have included using satellite measures of chla (Figures 1 and 2) and water sampling. Water samples are collected and sent to microalgal taxonomists to confirm what algal species are present and in what concentration via light microscopy. Additional water samples for more accurate determination of species using molecular methods have been undertaken but have long turnaround times before results are received. Real-time HAB indicator sensors, being trialled by SARDI in Port Lincoln, have been effective in providing early detection but are still undergoing validation to determine their accuracy and resolution.

Brevetoxins, a group of neurotoxins produced by *Karenia* species, have been identified as part of this bloom event for the first time in Australian waters. *Karenia mikimotoi* is not known to produce brevetoxins, providing further evidence that other *Karenia* spp. are likely involved.

The detection of brevetoxins has been managed in line with Australia's standard procedures for managing biotoxin detections. Its detection demonstrates that the program in place is robust and effective.

PIRSA's SASQAP program (the South Australian Quality Assurance Program) specifically monitors South Australian classified waters that are approved for harvesting and commercially harvested shellfish are exclusively sourced from these monitored waters.

SARDI prepares regular HAB Situation Updates (~two times a week) which are made accessible on the PIRSA website.

# Current knowledge

## General

Harmful algae refers to specific species of marine phytoplankton that have a negative impact on marine ecosystems, and this can be via the production of harmful toxins. Toxin-producing algae constitute only a small fraction of marine phytoplankton, are naturally occurring, and found globally.

Toxins are species-specific (even strain-specific), with different toxin types having different effects and levels of threat to both marine systems and humans (e.g. some kill fish and others accumulate in shellfish). SASQAP regularly monitors waters around shellfish harvesting areas to address the human health risk presented by toxic algal species and the marine biotoxins they produce.

Fish-killing HABs occur everywhere in the world, with *Karenia mikimotoi* and other *Karenia* species, *Karlodinium* (another genus of dinoflagellates) and a range of raphidophytes being significant contributors.

Identification of the harmful algae species prevalent in the bloom is critical in understanding the toxic effects that are occurring or may occur. Some algal species become problematic at very low densities that cannot be detected by traditional remote sensing technologies, while other species need to achieve a higher biomass before impacts become significant.

Impacts from the HAB have potentially devastating implications for industries such as fisheries, aquaculture and tourism, aquatic recreation activities including fishing, coastal communities and human health as well as broader ecosystem health. However, challenges remain in understanding the full extent of the impacts and the resilience of marine ecosystems as well associated estuarine ecosystems (such as the Coorong in South Australia).

### Secondary effects of HABs

Depletion of dissolved oxygen has been associated with HABs, which generally occurs towards the end of the bloom when the algae start to die off and decompose, and bacterial consumption of dying algae takes place. The effects of deoxygenation will be more pronounced on fish in HAB events where the harmful algae have impacted the gills of fish. Salinity changes, stratification, or inputs of freshwater in the system can impact osmoregulation as well.

## This bloom

The north coast of Kangaroo Island has faced extensive impacts from the current HAB, with the HAB spreading across almost the entirety of Backstairs Passage and causing widespread mortalities among fish and invertebrates, particularly benthic and reef-associated species. There have been numerous reports of fish and invertebrates washing ashore. Many of these incidents have been brought to the attention of South Australia's National Parks and Wildlife (Department for Environment and Water), often by the public, with demersal species appearing to be particularly affected.

Following a recent storm (20 May 2025), chlorophyll-a concentrations have decreased in Investigator Strait, including along the western coast of Kangaroo Island, the southern foot of Yorke Peninsula, and the eastern side of Gulf St Vincent. Increases in chlorophyll-a concentrations have been observed along the western side of Gulf St Vincent, in Spencer Gulf from Louth Bay to Port Neill, and around Hardwicke Bay. The HAB is dynamic, and the distribution varies with changes to current environmental conditions.

The HAB is believed to be influenced by recent environmental conditions, including ongoing marine heatwaves under drought conditions and relatively calm weather conditions in South Australia since September 2024, although further research is needed to understand drivers. Other contributing factors may include nutrient influx from the Murray River floods in the summer of 2022/23 and a sustained upwelling event in the summer of 2023/24. Atmospheric dust and carbon from the recent bush fires, particularly on Kangaroo Island were also raised as potentially contributing.

It is considered likely that this HAB event will recur in the future. *Karenia* HABs have shown this recurrent behaviour in the Gulf of Mexico (Florida, USA and blooms of similar species such as *Karlodinium* (non-cyst forming) and *Alexandrium minutum / A. pacificum* (cyst-forming) have been observed to recur regularly once established. *Karenia* species, including *K. mikimotoi,* are not known to produce long-term resting cysts, but instead produce short-term cysts called pellicle cysts that are thought to provide advantage in extension of bloom sequences.

## The New Zealand *Karenia* experience

New Zealand has experienced a number of HAB events, including the catastrophic outbreak of *Karenia brevisulcata* in Wellington Harbour in 1998 that severely impacted marine organisms in the harbour at that time. Respiratory illness and skin rashes were reported with this HAB. Recovery period for the marine ecosystem was between 3 to 5 years.

New Zealand developed a monitoring and research program in response to blooms in the early 1990s. This includes developing thresholds for brevetoxins in shellfish and for *Karenia* species associated with recreational activities and protecting public health (e.g. swimming, surfing, etc.). Research programs were established to understand HABs. Seafood Safety Risks, a program operating since the mid-2000s, focuses particularly on risks from microbes. A newer program investigates how climate change affects HABs and explores the development of new monitoring methods, including remote sensing and *in-situ* monitoring. The health impact of HABs on wildlife is also being considered as part of an emerging aquatic disease program.

Rapid molecular tests, such as real-time qPCR assays, have been developed for high-risk algal species. These tests can provide results within hours of sample receipt. These are particularly important for *Karenia* species that are hard to identify under the microscope.

One limitation of this testing approach is its reliance on pre-existing assays, which means it cannot detect outbreaks of new species or mixed blooms. Consequently, there is a growing shift toward using high-throughput sequencing techniques to analyse the entire community within a sample.

New Zealand is actively researching toxins produced by *Karenia* species and aims to establish analytical methods for effective monitoring. While some toxic metabolites are currently detectable, others remain unidentified. Investigations are also underway to understand the effect of different toxins between and within a species.

## Western Australia

Phytoplankton monitoring in Western Australia is focused on the Swan Canning Estuary (Perth), as well as a number of other estuaries in the Southwest of the state. Monitoring in coastal waters is driven by industry, primarily wastewater treatment plant discharge and some aquaculture-associated WASQAP monitoring. For the coastal sampling programs, the non-WASQAP sampling is typically targeted to the Dec-Mar period only.

HAB Species of note in WA are *Karlodinium* cf. *veneficum, Karlodinium* cf. *armiger*, *Alexandrium minutum, Alexandrium pacificum, Dinophysis* spp., *Prorocentrum* spp., *Heterocapsa* spp., *Pseudonitzschia* spp. Though not known to have bloomed or been associated with mortality events in the past, monitoring has also detected a range of *Karenia* species, with the potential inclusion of *K. brevis.*

Though there is no conclusive evidence, it has been noted that bloom species can establish, or blooms become more intense, a couple of years after local flood events. The first major *Alexandrium* bloom event in the Swan Canning occurred during and in the vicinity of bridge construction works, with a tentative link to sediment disturbance (of cysts). In terms of overall phytoplankton biomass (chla), satellite imagery has shown pulses of high levels associated with marine heatwave events.

There has been a recent highlight of the need to develop capability for cell isolation and phylogenetic analysis to characterise species and look to develop locally applicable primers for qPCR analysis and investigate potential benefit and use of Nanopore sequencing. HAB species characterisation needs to include characterisation of toxins, and this potentially needs development of local skills and equipment.

There is an overall need to consider if current sampling techniques are suitable for these species (collection, preservative and storage), and to get better determination of ecological impacts of these HAB species.

## HAB monitoring

In Australia, monitoring for microalgae / HABs is typically reactive unless associated with a shellfish quality assurance program. HABs are generally reported by the public, and local authorities may establish an algal bloom response monitoring campaign and enhance public communications and warnings if needed.

Other areas of the world that more commonly experience destructive HABs with significant socioeconomic impacts employ advanced technology (real-time monitoring buoys, advanced genetic techniques, and models in combination with satellite data). However, Australia remains heavily reliant on phytoplankton taxonomists using light microscopy.

Satellite remote sensing can serve as an effective tool for monitoring moderate to high biomass blooms in across large spatial scales including remote areas. Satellite data can offer crucial insights into where monitoring and sampling efforts should be concentrated and act as an input for forecasting models. *In-situ* sensors, potentially fitted with plankton samplers or real-time HAB detection sensors, will also provide valuable data needed to improve satellite detection products and develop forecast models.

CSIRO is actively refining/validating these models using machine learning by ground-truthing them with *in-situ* data, while also exploring emerging technologies such as hyperspectral data from NASA satellites. Hyperspectral data are thought to provide enhanced precision in targeting phytoplankton. Water samples will be needed to validate the remote sensing and identify the algae to species level. This information can continue to be fed back into models.

The power of citizen science is employed in other countries, including the USA and UK, to monitor HAB species. Data from these programs being used to trigger more thorough investigation by authorities. Citizen science is being used in the community to monitor the current HAB.

## HAB control

Localised control options to contain HABs and reduce the impact of HABs on offshore aquaculture operations include:

- towing pens away (noting you need to consider licences and certifications, etc.);
- application of a perimeter or skirt especially for surface HABs;
- stop feeding fish to encourage fish to move lower in the water column to try and minimise exposure at the surface (not effective against species such as *Karenia mikimotoi* that occurs throughout the water column); and
- bubble curtains (noting there is a risk with fragile species, such as *Karenia*, that the cells can break and release toxins making them more potent);

Another option used internationally (particularly China and Korea) to control algal blooms threatening valuable fisheries resources includes application of clay minerals with additives mixed with water and sprayed on the water surface to bind and remove both HAB cells and toxins. The composition of the clay mixture needs to be targeted to the specific HAB species and water chemistry for best results to be achieved.

# Industry questions raised during the Science Forum

- *Is there a history of a HAB lasting this long in other parts of the world, and what is the timeframe and success of recovery of commercially fishable stocks?*

  There are examples of other *Karenia* blooms lasting this long in other parts of the world. *Karenia* is also well known to reoccur. The impacts and recovery are not well understood and need further investigation.

- *When will the current HAB end?*

  This is not known, and it is very difficult to predict. A change towards winter weather patterns of regular cold fronts, cooler water temperatures, and reduced nutrients may help dissipate the HAB.

- *How do we assess the extent of the losses from the HAB?*

  Further investigation of the impacts (environmental and to marine industries, local communities etc.) is needed.

  The general public and independent researchers along the coast are documenting the bloom by making contributions to iNaturalist, which is assisting in developing our understanding of the impacts. At this stage, anecdotal evidence appears to indicate that pelagic species are not as impacted as demersal species. This is consistent with similar events elsewhere (e.g.Swan Canning in WA), where a lot of pelagic species moved away during the event and returned soon after the end of the bloom. To get a better assessment of the impacts of this HAB, benthic fauna and habitat assessments, considering the broader ecosystem impacts, will need to be conducted over the next few years.

- *How can forecasting improve in the future to predict these HAB events?*

  Satellite remote sensing, combined with data from *in situ* sensors and results from water samples, can enhance monitoring and forecasting models. More research is needed to understand both the drivers of bloom formation and the drivers of bloom collapse.

- *Is there a correlation between recent events (upwellings, Murray Floods) and the HAB?*

  This is not yet clear, although a potential correlation between floods and HAB events has been noted in Western Australia. Other HAB bloom events have been noted after unseasonal hydrological patterns in other parts of the world.

- *How does the brevetoxin bioaccumulate in animals and across the food chain, specifically if affected sardines were fed to tuna?*

  Brevetoxins are known to bioaccumulate, especially in fatty organs such as the liver. Primarily this occurs in the standard manner, with planktivores and detritivores (bivalves, gastropods, etc.) directly uptaking toxins as they consume *Karenia*, then biotoxin levels accumulate with progression up the food chain until the toxin load reaches a lethal limit.  So yes, tuna fed with affected sardines would bioaccumulate higher levels of the toxin. Seabirds that eat fish and any animal that eats brevetoxin-laden wildlife (dead or alive) will then bioaccumulate the toxin. It is important to note that anecdotal evidence appears to indicate that pelagic species, such as sardines, are not being impacted in this bloom, and rather, it is the demersal species that are impacted. This is consistent with similar events reported elsewhere.

- *What is the expected long-term damage and timeframe for the rejuvenation of the habitats impacted, particularly areas in which there appears to be large scall die-offs in all areas of the food chain?*

  Further investigation is needed. In Wellington Harbour in New Zealand, the recovery timeframe was in the order of 3 to 5 years.

- *For the shellfish industry (Australia wide) it is critical to gain an understanding of the algae species. For example: In NSW they have previously observed* K. mikimotoi *and* K. papilionaceae *but have not detected* K.brevis*. Being able to identify the exact species of Karenia that is producing brevetoxins allows industry to respond appropriately to future Karenia detections.*

There is a need to build capacity in Australia to be able to accurately and rapidly identify harmful algal species both morphologically and genetically.

## Key Knowledge Gaps

- Limited understanding of the biological and ecological processes driving harmful algal blooms (HABs).
- Lack of rapid and reliable methods for HAB identification at species and community levels.
- Insufficient knowledge of the types of toxins produced by different HAB species and their impacts on various organisms, including humans, and the food web.
- Limited understanding of the long-term ecological effects of HABs, including recovery times and broader impacts on biodiversity, productivity and connectivity in marine and associated estuarine ecosystems.
- Limited capability to detect and forecast HABs in near-real time.
- Biosecurity risks associated with HABs, including disease impacts and invasive species.
- Limited understanding of effective and practical control measures for managing HABs.

## Identified needs

- Continue to collect live samples of harmful algae to isolate and culture algal species for immediate analysis.
- Establish a certified laboratory in Australia to accurately identify Brevetoxins, addressing a critical gap in scientific infrastructure.
- Develop better systems for phylogenetic analysis.
- Review HABs in Australia to understand their biology and ecology, including drivers.
- Develop monitoring and forecast programs for HABs in South Australia, including of remote regions. Monitoring methods should explore the integration of high resolution imagery,  satellite remote sensing, in situ real-time sensors which can detect (limited) HAB species to provide early detection, and microscopic and molecular methods.
- Develop standard national approach to genetic ID and monitoring with rapid turn-around time to allow for confident species level determination (semi-quantitative or quantitative) within wild, mixed species samples, when the target species is at very low cell concentrations.

- Identify algal toxins (integrating genetic and chemical analysis), and their effect on different organisms (including humans) and ecosystems.
- Develop regional phytoplankton spectral libraries to improve remote sensing models for South Australian waters.
- Evaluate the impact of, and recovery from, HABs on marine ecosystems - including biodiversity, threatened species, trophodynamics and productivity. Consider the role of marine parks and potential refuges.
- Evaluate the impact and recovery from HAB in estuarine ecosystems, particularly the Coorong, including biodiversity, trophodynamics and productivity to inform management and potential restoration actions.
- Understand how HABs may affect nearby terrestrial wildlife and habitats.
- Understand the threat of HABs to commercial and recreational fisheries and development of locally relevant management options.
- Develop international linkages with regions that have experienced similar bloom events for knowledge exchange on bloom dynamics, monitoring and management.
- Develop coordinated risk assessments, response plans, communications plans and data management frameworks to better manage HABs in the future.
- Take learnings from the current HAB related use of citizen science and platforms/apps that can be applied for this, and develop protocols, guidance and systems to utilise this resource more effectively in future scenarios.
- Develop a national HAB response/ forum / network.

# Key actions

- Share information gathered during the Science Forum with the SA Government Interagency HAB Working Group to facilitate the prioritisation of research needs and the development of a Science Program aimed at addressing research gaps and future priorities. Funding options will also be evaluated as part of this process, which could include national natural disaster relief funds.
- PIRSA to organise an industry forum in the coming weeks to provide an update on the current situation and address industry concerns or queries.
- Circulate key communication steps and messages, once established to Science Forum participants.

# Appendix 1 – Participants

<u>In-person participants</u>
Gretchen Grammer, SARDI (Chair)
Angela Cassidy (PIRSA)
Benita Dillon (DEW)
Clinton Wilkinson (PIRSA Biosecurity)
Craig Styan (University of South Australia)
Danny Brock (DEW)
Gavin Begg (PIRSA)
Jane Ham (SARDI)
Justin Brooks (The University of Adelaide)
Keith Rowling (NMSC)
Kristian Peters (GA, DEW)
Mark Doubell (SARDI)
Matt Bansemer (PIRSA Fisheries and Aquaculture)
Matt Ward (DEW)
Nagur Cherukuru (CSIRO)
Paul Dowsett (PIRSA)
Rebecca Quin (DEW)
Sam Gaylard (EPA)
Sarah Catalano (SARDI)
Sarah Spurling (PIRSA Biosecurity)
Simon Goldsworthy (SARDI)
Sophie Leterme (Flinders University)
Stephan Pahl (SARDI)
Tamsyne Smith-Harding (Microalgal services)

<u>Online participants</u>
Adrianne Laird (FRDC)
Alessandra Palomino (PIRSA)
Alison Turnbull (UTAS)
Andreas Segar (UTAS)
Andrew Hutchinson (PIRSA)
Anthony Zammit (DPI, NSW)
Ben Night (Cawthron Institute, New Zealand)
Brad Martin (Oz Fish)
Carl Seubert (SmartSat CRC)
Chaojiao Sun (CSIRO)
David Cunliffe (SA Health)
Davina White (PIRSA)
Dominic Mcafee (The University of Adelaide)
Elizabeth Weeks (SmartSat CRC)
George Wood (UWA)
Gustaaf Hallegraeff (UTAS)
Ian Gibbins
Jeff Cosgrove (DBCA)
Justin Seymour (UTS)
Kirsty Smith (Cawthron Institute, New Zealand)

Martina Doblin (UTAS)
Michelle O'Connor (PIRSA)
Michelle Waycott (DEW)
Nagur Cherukuru (CSIRO)
Paul Rogers (Southern Fishery & Ecosystem Solutions, SFES)
Phil Baker (DPI, NSW)
Ruth Eriksen (CSIRO)
Ryan Baring (Flinders University)
Shauna Murray (UTS)
Simon Bryars (DEW)
Steve Brett (Microalgal services)
Valeria Torok (SARDI)