Submission to the Senate Inquiry into Algal Blooms in South Australia

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About The Biodiversity Council

The Biodiversity Council brings together leading experts, including Indigenous knowledge holders to promote evidence-based solutions to Australia's biodiversity crisis. The Council was founded by 11 universities with the support of Australian philanthropists.

Introduction

Australia is facing one of the worst marine disasters in living memory: a catastrophic harmful algal bloom (HAB) stretching across more than 4,000 square kilometres of South Australia's coastal waters,[1] devastating marine life and threatening iconic and economically important species and ecosystems. The bloom began in March 2025 on the Fleurieu Peninsula and has since been drawn through Backstairs Passage into the St Vincent Gulf and the lower half of the Spencer Gulf, and has not yet dissipated.

This submission draws on and adds to the Biodiversity Council's July 2025 report *Key actions needed to respond to South Australia's catastrophic toxic algal bloom*, and has been prepared with input from fourteen experts in marine ecology, climate change biology, algal blooms, fish and cephalopod biology, aquatic nutrient cycling, marine social science, marine and coastal ecosystem restoration and mental health from seven Australian universities.

Summary of recommendations

Recommendation		Category
a. Contributing environmental, land management or water quality factors		
1	Undertake research to definitively identify the diversity and dominance of species causing the blooms.	Research & Monitoring
2	Undertake lab and field studies to determine environmental and ecological preferences, the presence of cysts in sediments, toxic effects, and toxicological diversity of the most dominant *Karenia* species in the blooms.	Research & Monitoring
3	Undertake dissolved carbon and nutrient balance studies to determine the relative importance of ocean upwelling and other coastal and terrestrial sources of nutrients and dissolved carbon. Quantify the significance of key human-influenced nutrient and dissolved carbon pollution sources.	Research & Monitoring
4	Address major sources of nutrient and human-influenced nutrient and dissolved carbon (Guided by 3). This may reduce the likelihood of future coastal blooms, it would also provide benefits to the health of receiving waters, such as the Coorong and Lower Lakes.	Management response
b. Ecological, economic, cultural and social impacts of algal blooms		
5	Urgently undertake impact assessments for the species and groups listed in section biii, supported by field verification and population monitoring as required to fill knowledge gaps.	Impact assessment
6	Increase resourcing for the monitoring of temperate marine species, including non-charismatic and not commercially important species, including macroalgae and invertebrates. Design the monitoring to support conservation assessments.	Research & Monitoring

[1] https://www.abc.net.au/news/2025-05-08/size-of-sa-algal-bloom-revealed/105264168

Recommendation		Category
7	Assess the risk of the HAB to the giant Australian cuttlefish and potential interventions to avert a complete wipeout of the population if that becomes likely. (Note: This is underway led by the South Australian Government).	Impact assessment
d. The coordination of state and federal government responses		
8	Develop effective cross-jurisdictional 'playbooks' to plan for and respond effectively when catastrophic natural disasters occur, including HABS and marine heatwaves.	Management response
e. The current support and recovery arrangements for impacted industries and communities		
9	Undertake research to support the development of community level programs focused on enhancing wellbeing and resilience of affected communities in the face of increasing natural disasters and the resulting ecological grief and anxiety.	Research & Monitoring
10	Investment at least $20 million immediately to fund in situ scientific research to improve our understanding of biodiversity impacts, economic and community impacts, and potential management response (see eiii for specific research needs).	Research & Monitoring
11	Scale up the restoration and protection of marine ecosystems — particularly shellfish reefs, kelp, saltmarshes, mangroves, and seagrass — that naturally draw down nutrients and support biodiversity to help it bounce back after blooms.	Management response
12	Identify priority areas for ecosystem restoration.	Management response
13	Invest in adaptive research to refine seagrass and seaweed restoration techniques.	Research & Monitoring
f. The adequacy of long-term monitoring, forecasting and prevention strategies		
14	Monitor water quality, algal bloom and nutrient concentrations in South Australian coastal waters through a network of regular water sample collection; use molecular methods needed to determine the species of *Karenia* present and their abundances.	Research & Monitoring
15	Establish a long-term coordinated and multi-jurisdictional monitoring program for the Great Southern Reef, modelled on the $40 million, 10−year Great Barrier Reef's Reef Integrated Monitoring and Reporting Program (RIMReP).	Research & Monitoring
g. Any related matters		
16	Accelerate Australia's decarbonisation efforts and become a global leader in climate action.	Management response
17	Convene an expert panel to develop a standardised monitoring and data collection approach focusing on human responses to ecological change; provide funding support and a home within a governmental agency for a long-term initiative to collect and house the relevant data.	Research & Monitoring
18	Identify and support long-term adaptation and resilience-building measures for social-ecological sustainability informed by best available evidence (Guided by 16).	Management response

a. Contributing environmental, land management or water quality factors

It is well recognised that globally harmful algal blooms (HABs) are now occurring more often, in new and different places, often lasting longer, and with a range of toxicities.[2]

In general, marine harmful algal blooms can occur when certain species of microalgae grow or are concentrated faster than their rate of removal. Microalgal accumulation rates are affected by many factors, including water temperatures, salinity,[3] dissolved oxygen and macro and micro-nutrient and light availability, as well as predation and interactions with other phytoplankton, some of which can produce compounds that can impede the growth of co-occurring microalgal species. Physical processes that may concentrate algal cells include the action of water currents and water stratification due to temperature or salinity. Mechanisms of removal include consumption by grazers and filter feeders and by being flushed from the ecosystem by storms or currents.

HABs can occur in a very wide range of water temperature, nutrient, light and water column conditions. Although ideal growth conditions vary between algal species, warmer water, still conditions and greater nutrient availability have been shown to favour the formation of algal blooms of some species[4]. This means that climate change is likely to lead to an increase in algal blooms, especially where nutrient pollution is present and algal cells (cysts) are dormant in the sediments.[5] Climate change is itself likely to increase one potent source of nutrient pollution: ash-filled runoff following bushfires.[6] [7]

In the case of the South Australian HAB, according to reported South Australian Government testing, the composition of the bloom is understood to include a mix of algal species, dominated by *Karenia* species and including the harmful dinoflagellate *Karenia mikimotoi.*

While the exact confluence of drivers that initiated the South Australian HAB may never be determined, and is likely to have been a combination of multiple simultaneous factors, there is a consensus among experts that the drivers of the bloom are likely to include some of the following factors:

- Above-average seawater temperatures sustained during 2024/2025, which are part of a much broader marine heatwave. Water temperatures in the region were 1 to 2.5 °C above the long-term

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[2] Glibert, P. M., & Burford, M. A. (2017). Globally Changing Nutrient Loads and Harmful Algal Blooms: Recent Advances, New Paradigms, and Continuing Challenges. *Oceanography*, **30**(1), 58–69. http://www.jstor.org/stable/24897842

[3] R.J. Lukatelich, A.J. McComb. (1986) Nutrient levels and the development of diatom and blue-green algal blooms in a shallow Australian estuary, *Journal of Plankton Research*, **8**(4), 597–618, https://doi.org/10.1093/plankt/8.4.597

[4] Glibert, P.M. et al. (2018). Key Questions and Recent Research Advances on Harmful Algal Blooms in Relation to Nutrients and Eutrophication. In: Glibert, P., Berdalet, E., Burford, M., Pitcher, G., Zhou, M. (eds) Global Ecology and Oceanography of Harmful Algal Blooms . Ecological Studies, vol 232. Springer, Cham. https://doi.org/10.1007/978-3-319-70069-4_12

[5] Liu, Y., Hu, Z., Deng, Y., & Tang, Y. Z. (2020). Evidence for Production of Sexual Resting Cysts by the Toxic Dinoflagellate Karenia mikimotoi in Clonal Cultures and Marine Sediments. *Journal of Phycology*, **56**(1), 121-134. https://doi.org/10.1111/jpy.12925

[6] Ladd T. M., Catlett D., Maniscalco M. A., Kim S. M., Kelly R. L., John S. G., Carlson C. A. and Iglesias-Rodríguez M. D. (2023) Food for all? Wildfire ash fuels growth of diverse eukaryotic plankton *Proc. R. Soc. B*. **290**(2010) http://doi.org/10.1098/rspb.2023.1817

[7] Alexandra, J., & Finlayson, C. M. (2020). Floods after bushfires: rapid responses for reducing impacts of sediment, ash, and nutrient slugs. *Australasian Journal of Water Resources*, **24**(1), 9–11. https://doi.org/10.1080/13241583.2020.1717694

average for many months, and created optimal conditions for particular harmful microalgal species to proliferate
- Prolonged calm sea conditions and delay of winter storms, with minimal water mixing or flushing, which allowed the algae to accumulate.

These two factors are linked to human-induced climate change. The marine heatwave was predicted by CSIRO seasonal ocean forecasting in early December 2024.[8]

Algal blooms require food, though the amount and nutrient composition varies between algal species. Two unusual events delivered large amounts of nutrients to the region:

- Floodwaters from the Murray floods in November 2022 and February 2023[9]
- A prolonged coastal upwelling of deep, nutrient-rich waters in early 2025.

However, the coastal environment in this region may have had adequate background levels of nutrients for a bloom to form without those irregular sources. These background levels are contributed to by:

- Periodic upwelling (Bonney, Kangaroo Island and Eyre Peninsula upwellings).
- River discharges, including floodwaters. These can contain excess fertiliser run off from agriculture, and nutrient-rich bushfire ash and sediment from catchments, channels and lakes and disturbed soils (including coastal wetlands).
- Atmospheric deposition.
- Stormwater and treated wastewater generated from Adelaide.
- Loss of oyster reefs, which would have filtered over half a trillion litres of seawater daily.[10]

Harmful algal blooms can cause toxicity and fish kills in multiple ways, including the production of toxins or reactive oxygen species, which can damage gills and skin cells, and lead to water deoxygenation. *Karenia mikimotoi* does not produce toxins but does produce reactive oxygen species that can damage gills. *Karenia brevis* produces brevetoxin that not only kills fish, marine mammals, and other animals, but also causes Neurotoxic Shellfish Poisoning and respiratory distress in humans. The lipid-soluble brevetoxin can biomagnify up the food chain through fish to top carnivores like dolphins, killing them.[11] Some toxicity testing has been reported for this HAB, such as fish gill assays, however testing for each potential toxicity pathway, has not been publicly reported, and so the contributing modes of toxicity are not fully understood.

Once conditions cause the mortality of marine life, the decay of the animals killed can fuel the bloom further. Some *Karenia* species are mixotrophic (including *K. mikimotoi* and *K. brevis*), meaning they can obtain energy from photosynthesis (obtain energy from light) or from ingesting organic material, such as decaying organic matter —creating a self-reinforcing feedback loop for the bloom's persistence and severity. The species is also tolerant of both low and high light conditions, giving it a competitive advantage.

The sheltered conditions of the St Vincent and Spencer Gulf mean that their waters are typically warmer and calmer than other South Australian marine environments in the open ocean, making it harder for a bloom to disperse once formed.

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[8] https://www.csiro.au/en/news/All/Articles/2025/August/Marine-heatwave-planning
[9] https://soe.epa.sa.gov.au/environmental-themes/river-murray/state-of-the-murray/2022-23-river-murray-flood
[10] McAfee, D., & Connell, S. (2025, August 19). How could we clean up the algal bloom? The Conversation. Retrieved August 22, 2025, from https://theconversation.com/how-could-we-clean-up-the-algal-bloom-262749
[11] Brand LE, Campbell L, Bresnan E. (2012) *Karenia*: The biology and ecology of a toxic genus, *Harmful Algae*. **14**, 156-178. https://www.sciencedirect.com/science/article/pii/S156898831100148X

These coastal environments have also experienced a substantial reduction in the extent of habitats that filter and store nutrients such as kelp, mangroves, seagrass and shellfish reefs. The destruction of these habitats releases their stored nutrients, which can contribute to algal blooms.

Recommendations

1. Undertake research to definitively identify the diversity and dominance of species causing the blooms.
2. Undertake lab and field studies to determine environmental and ecological preferences, the presence of cysts in sediments, toxic effects, and toxicological diversity of the most dominant *Karenia* species in the blooms.
3. Undertake dissolved carbon and nutrient balance studies to determine the relative importance of ocean upwelling and other coastal and terrestrial sources of nutrients and dissolved carbon. Quantify the significance of key human-influenced nutrient and dissolved carbon pollution sources.
4. Address major sources of nutrient and human-influenced nutrient and dissolved carbon. (Guided by 3). This may reduce the likelihood of future coastal blooms, it would also provide benefits to the health of receiving waters, such as the Coorong and Lower Lakes.

b. Ecological, economic, cultural and social impacts of algal blooms with particular reference to:

i. Tourism, commercial and recreational fishing industries

Losses to fisheries and aquaculture, as well as marine-based and regional tourism, are occurring as species mortality affects catches, biodiversity values, iconic marine species, and visitor experiences both directly and indirectly by deterring the public. The bloom threatens the giant cuttlefish (*Ascarosepion apama*) aggregation near Whyalla, a National Heritage–listed site and major tourism drawcard. Beach and natural values uses[12] are extremely high in the areas hit by the HAB and there may be long-lasting economic effects.[13]

ii. Regional and coastal communities

The death of marine species and degradation of coastal ecosystems affect the economic and social well-being of regional communities dependent on healthy marine environments for livelihoods, recreation, and local identity. The profound grief experienced by many due to the large loss of life also has significant mental health implications.[14] [15]

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[12] Loch A., Scholz G., Auricht C., Sexton S., O'Connor P., Imgraben S. (2023) Valuing Protected Area Tourism Ecosystem Services Using Big Data *Environmental Management*, **71** (2), pp. 260 - 273, https://link.springer.com/article/10.1007/s00267-022-01746-0

[13] Manero, A., Yusoff, A., Lane, M., & Verreydt, K. (2024). A national assessment of the economic and wellbeing impacts of recreational surfing in Australia. *Marine Policy*, **167**, 106267. https://doi.org/10.1016/j.marpol.2024.106267

[14] Cunsolo, A., Ellis, N.R. Ecological grief as a mental health response to climate change-related loss. Nature Clim Change 8, 275–281 (2018). https://www.nature.com/articles/s41558-018-0092-2

[15] Webster, N., Bluff, L., Moir, M. L., Marsh, J. R., Teixeira, D., Gray, J., ... & Woinarski, J. C. (2023). Of grief, spirit and hope: personal reflections of the 2019–20 wildfires. Australia's Megafires: Biodiversity Impacts and Lessons from 2019-2020, 442. https://books.google.com.au/books?hl=en&lr=&id=eS-pEAAAQBAJ&oi=fnd&pg=PA442&dq=ecological+grief+black+summer+and+texeira&ots=Ehd84RPIjC&sig=dErejgRIDkSfJI0OZgKnX-h6oU8#v=onepage&q&f=false

Economic impacts on land values, which have been shown to drop by 4-12% for several years as a consequence of lost confidence after natural disasters.[16]

iii. Marine biodiversity and ecosystem health

Citizen scientists have collected more than 33,000 records of more than 480 species affected to date. This represents only a small proportion of animals killed, as most will rot on the sea floor. The records include dolphins, sharks, stingrays, leafy sea dragons, sea lions, sea turtles, cuttlefish, a wide range of fish species, and many smaller invertebrate species such as gastropods, bivalves, crabs, sea cucumbers, and worms. Some shellfish communities have experienced high mortality, such as pen shells (razorfish) and cockles, whereas other bivalves appear resilient and are feeding on the harmful species, such as native flat oysters and farmed Pacific oysters. While there are substantial data gaps, this collection of citizen science data provides a window into understanding the broader environmental impact. Research that provides insight into what proportion of total mortalities are observed on beaches would make the job of understanding the effects of this and future blooms easier.

The area impacted by the HAB includes parts of the Great Southern Reef, a temperate reef which is globally unique; 70% of Great Southern Reef species are endemic, meaning they occur nowhere else.

Research shows that species endemic to Australia's temperate reefs were already facing unprecedented, climate-driven threats prior to this HAB.[17] A study of population trends of 626 common shallow reef species at 869 sites around Australia from 1992 to 2024 found that 36% of assessed species met IUCN threatened criteria; most were Australian endemics and nearly all temperate.[18] The study also found that 63% of endemic echinoderms (which include starfish and sea cucumbers) are experiencing population declines nationally, making this group particularly vulnerable to additional stressors. A second study of 1,057 common shallow reef species at 1,636 sites around Australia over the past decade found that almost all had declined and more than 30% of shallow invertebrate species in cool latitudes exhibited high extinction risk.[19] Prior to the HAB the endemic southern Australian weedy seadragon had already experienced a documented decline of 59% from 2011 to 2021.[20]

This longer-term trend of climate stress and declining populations of temperate marine species will reduce the resilience of many species to recover after the HAB.

Threatened species impacted include the Endangered Australian sea lion and Vulnerable white shark; threatened ecological communities affected include the Endangered giant kelp community. However, although many temperate marine species are in trouble, they are not well represented in conservation planning frameworks. High access costs and difficulties obtaining population and distribution data mean

[16] Fletcher, C. S., Ganegodage, K. R., Hildenbrand, M. D., & Rambaldi, A. N. (2022). The behaviour of property prices when affected by infrequent floods. Land Use Policy, 122, 106378. https://doi.org/10.1016/j.landusepol.2022.106378

[17] Edgar, G. J., D., R., Heather, F. J., Barrett, N. S., Turak, E., Sweatman, H., Emslie, M. J., Brock, D. J., Hicks, J., French, B., Baker, S. C., Howe, S. A., Jordan, A., Knott, N. A., Mooney, P., Cooper, A. T., Oh, E. S., Soler, G. A., Mellin, C., . . . Bates, A. E. (2023). Continent-wide declines in shallow reef life over a decade of ocean warming. *Nature*, **615**(7954), 858-865. https://doi.org/10.1038/s41586-023-05833-y

[18] Johnson, O. J., Heather, F. J., Stuart-Smith, J., Stuart-Smith, R. D., Mellin, C., & Edgar, G. J. (2025). Macroalgae and mobile reef invertebrates face high extinction risk. *Biological Conservation,* **305**, 111052. https://doi.org/10.1016/j.biocon.2025.111052

[19] Edgar et al. 2023

[20] Ibid.

marine species are poorly represented on EPBC and IUCN threatened lists due to data deficiency, limiting their usefulness for guiding action.

For example, reef monitoring data sets, containing records of 3,412 mobile species greater than 2.5cm in size, only 626 species (18%) had sufficient information to undertake a meaningful conservation assessment.[21]

Macroalgae and macro-invertebrate species are particularly underrepresented in conservation assessments.[22] This is because very little baseline data exists for these groups. The loss of kelps is of particular concern due to their importance as ecosystem foundation species, which provide breeding, sheltering and foraging habitat for other species, including leafy and weedy seadragons and cuttlefish. While macro-invertebrates also play vital roles in ecosystems, including through nutrient cycling and food sources for larger species.

The HAB may represent a catastrophic loss of endemic biodiversity that cannot be fully understood without targeted surveys of these understudied but highly vulnerable species groups. This knowledge is also needed to guide future proactive management options. Species that are narrowly restricted or have low swimming capabilities with small home ranges, or key habitat or breeding grounds within the area impacted by the HAB are likely to be at particular risk from this HAB. Some species restricted to Spencer Gulf and Gulf St Vincent may now qualify for national threatened status based on their small range and the likelihood that this event has substantially reduced their population size.

While the giant Australian cuttlefish is widespread, the population in the Upper Spencer Gulf is globally unique due to its mass aggregation breeding behaviour. It is the only cuttlefish population in the world known to do this. The HAB currently poses a potential threat to the eggs in the breeding ground around Point Lowly. If the HAB were to wipe out these eggs, it may wipe out the entire population and its behaviour.[23] The South Australian Government has commenced an assessment of the risk of the HAB to the population.

Species recommended for assessment, due to likely susceptibility:

Fish Species

- Red velvetfish (*Gnathanacanthus goetzeei*)[24]
- Weedy and leafy seadragons (*Phyllopteryx taeniolatus, Phycodurus eques*) [25]
- Pipefish species with restricted ranges
- Endemic seahorse species
- Prowfish species (*Pataecus spp.*)
- Weedfish species (*Heteroclinus spp*.)
- Anglerfish species with limited distributions
- Cowfish species (*Aracana spp.*)

[21] Johnson et al. 2025
[22] Johnson et al. 2025
[23] Doubleday, Z. (2025, July 30). The giant cuttlefish's technicolour mating display is globally unique—an SA algal bloom could kill them all. The Conversation. Retrieved August 23, 2025, from https://theconversation.com/the-giant-cuttlefishs-technicolour-mating-display-is-globally-unique-the-sa-algal-bloom-could-kill-them-all-262108
[24] Edgar, G. J. (2024). IUCN Red List criteria fail to recognise most threatened and extinct species. *Biological Conservation*, **301**, 110880. https://doi.org/10.1016/j.biocon.2024.110880
[25] Edgar et al. 2023

Mobile Invertebrates[26]

Echinoderms

- Biscuit seastars (*Tosia australis*)
- Ocellate Seastar (*Nectria ocellata*)
- Gunn's Six-armed Star (*Meridiastra gunnii*)
- Short-spined Sea urchin (*Holopneustes porosissimus*)
- Purple urchin/short-spined urchin (*Heliocidaris erythrogramma*)
- Inflated egg urchin (*Holopneustes inflatus*)

Gastropods

- Staircase Abalone (*Haliotis scalaris*)
- Common Pheasant Shell (*Phasianella ventricosa*)

Macroalgae

- *Macrocystis pyrifera*

Recommendations

5. Urgently undertake impact assessments for the species and groups listed above, supported by field verification and population monitoring as required to fill knowledge gaps.
6. Increase resourcing for the monitoring of temperate marine species, including non-charismatic and not commercially important species, including macroalgae and invertebrates. Design the monitoring to support conservation assessments.
7. Assess the risk of the HAB to the giant Australian cuttlefish and potential interventions to avert a complete wipeout of the population if that becomes likely. (Note: This is underway led by the South Australian Government).

c. The cultural and economic impacts on Indigenous communities, including any loss of access to traditional fishing

While specific monitoring data is not available, the scale of species mortality and habitat loss is likely to affect Indigenous communities through loss of access to culturally significant fishing areas, sea country, and species, and by diminishing opportunities for marine-based economic and cultural activities. A poignant example is the impact on the traditional cockle fishing grounds of the Ngarrindjeri People.

d. The coordination of state and federal government responses, including support, industry engagement and scientific advice

There are two key elements to address; the response to this HAB and also Australia's general preparedness for natural catastrophes.

With regard to this event, the commitment of $14 million each from the Australian and South Australian Governments in July, followed by an additional $2.25 million from the Australian Government in August was

[26] Johnson et al. 2025

a welcome start. The total of $30.25 million is unlikely to be sufficient to provide for the immediate and longer-term needs of the community, biodiversity and impacted industries. Considerably greater investment will be required to support immediate research needs and long-term monitoring and ecological and socio-economic recovery plans.

In August the South Australian Government convened a scientific advisory panel to guide responses to the bloom, and a separate panel to assess the risk to the globally unique aggregating giant Australian cuttlefish population in the Upper Spencer Gulf. Both of these panels include relevant leading experts from across Australia, including those from within Australian universities, and were an essential step in developing effective responses. However, it is important to bring the community and affected stakeholders into planning processes to address the impacts of the current bloom.

With regard to the timing of both the resourcing announcement and advisory panel commencement, which occurred 5 and 6 months after the start of the bloom, the long delays means valuable time has been lost to assess risks, plan and act to support industry, community and the environment.

Natural catastrophes should be anticipated in Australia. Extreme bushfires, floods, cyclones, droughts, marine heatwaves and harmful algal blooms, which harm biodiversity, industries and communities, are all inevitable in the face of climate change, and as natural ecosystems lose resilience due to climate change and other ongoing threats, such as habitat destruction and degradation, invasive species and pollution. Extreme events require increasingly costly response packages. It is essential that we anticipate, plan for, and are ready to respond rapidly to these events, as that can significantly affect outcomes for nature and people and the economic impact of these events.

Cross-jurisdictional coordination and planning processes need to be established now to ensure that we are ready to respond promptly when natural disasters occur. Australia needs 'playbooks' for natural disasters with adaptive plans that outline key stakeholders, potential actions, responsibilities, and funding sources. Their development needs the input of scientists, government agencies and the community. Engaging stakeholders and the community before extreme events would enable discussion of relative priorities and trade-offs, thereby building community support. Use scenario planning, or other futures approaches, to help people work through the range of possibilities that we may be confronted with, and to develop flexible yet effective responses.

These playbooks could build on Adaptlog[27] recently developed by CSIRO and the NESP Climate Systems hub. They must also learn from past experiences in Australia (such as the devastating *Lyngbya* bloom in Moreton Bay in the mid-2000s,[28] which impacted turtles and dugongs and other species, when drought interacted with implicated nutrient enrichment) and overseas (the USA has a long history of HABs in key tourism and fisheries spots). As well as from current risk assessment and planning experiences, such as the NSW marine heatwave response plan, and marine heatwave and HAB risk assessments for species such as the red handfish in Tasmania and the Spencer Gulf giant Australian cuttlefish population. Equally important will be a review of plans after events, to assess outcomes and identify key operational and knowledge limitations or gaps, in order to improve future plans.

[27] CSIRO. (2024). Adaptation Catalogue for Conservation (AdaptLog). Retrieved August 23, 2025, from https://adapt-log.csiro.au/

[28] Osborne, N., Shaw, G., & Webb, P. (2007). Health effects of recreational exposure to Moreton Bay, Australia waters during a Lyngbya majuscula bloom. *Environment International*, **33**(3), 309-314. https://doi.org/10.1016/j.envint.2006.10.011

Recommendation

8. Develop effective cross-jurisdictional 'playbooks' to plan for and respond effectively when catastrophic natural disasters occur, including HABS and marine heatwaves.

e. The current support and recovery arrangements for impacted industries and communities, including:

i. Financial support for fishing, aquaculture, tourism and other impacted businesses

Current financial assistance is limited in scale compared to previous natural disasters that have had major impacts on wildlife. For example, following a mass fish kill in the Lower Darling River system between December 2018 and January 2019, the Australian Government committed $70 million to preventing future fish kills in the Murray-Darling Basin, including at least $30 million on measures focused on improving water flows and $20 million for water and environmental research.[29] And following the 2019–2020 Black Summer bushfires, the Australian Government invested $2 billion in the National Bushfire Recovery Fund, and spent more than $200 million on the response for wildlife, including $53.4 million for immediate wildlife rescue and recovery, followed by $150 million on the longer-term recovery of wildlife and habitat.[30]

The joint $28 million commitment from the South Australian and Australian Governments marks an important step in supporting businesses affected by the 2025 algal bloom. While this assistance provides immediate relief, for many operators it is unlikely to be sufficient to ensure long-term economic viability. Most businesses are eligible for grants of up to $10,000, with larger amounts of up to $100,000 available to the hardest-hit harvesters. These measures are welcome, yet they exclude employees of affected businesses who have lost their income. Beyond the immediate financial strain, the bloom is expected to generate medium- to long-term disruption across supply chains and workforce availability. Consequently, although government support may ease short-term pressures, the prospects for recovery remain uncertain. The industry's dependence on ecosystems that may take years to recover—and the possibility of similar events recurring—raises serious questions about the sustainability of business as usual in South Australia's seafood sector.

ii. Community resilience and ecosystem services

There is a need to consider how the current algal bloom impacts the wider community. This includes the economic viability of coastal businesses, flow-on effects for regional economies, less tangible aspects of the relationship of communities with the marine environment, and the mental health of people living along the coast and experiencing severe damage to the places they value. The distress the algal bloom is causing local

[29] Smail, S. (2019, April 10). Federal government announces big spend to prevent more fish kills. ABC News. https://www.abc.net.au/news/2019-04-10/federal-govt-announces-big-spend-to-prevent-more-fish-kills/10986120

[30] Australian National Audit Office. (2023). Wildlife and Habitat Bushfire Recovery Program (Auditor-General Report No. 2 2023–24). Australian National Audit Office. https://www.anao.gov.au/work/performance-audit/wildlife-and-habitat-bushfire-recovery-program

residents is well documented in the media.[31] Such environmental degradation can trigger widespread ecological grief, distress, and depression.[32] Different terms are in use for this, including eco-anxiety and solastalgia. There has been no large-scale program reported for targeted wellbeing or recovery services for affected communities. We know little about the best ways to support community wellbeing in the face of such disasters, and new, collective approaches that do not individualise or medicalise the distress are crucial. A solely mental health service response will not be appropriate or feasible given the likely scale of distress in the communities.

Human-nature interactions are constantly changing and developing. Significant disturbance events have the potential to break existing feedbacks between people and nature, changing the ways in which people understand, interpret, and ultimately benefit from ecosystems and natural resources. The devastating effects of the algal bloom have the potential, for example, to reduce local and regional engagement with nature and interest in biodiversity conservation and ecotourism. Changes in demand for nature-based experiences can force local businesses to either find alternative sources of income, change the location or focus of their product, or go out of business.[33] Experiences from algal blooms in other places, Covid and coral bleaching events have shown that many small businesses lack the capital to survive long periods of being unable to operate, and larger tourism and fishing businesses often have sunk costs in the form of infrastructure (e.g., boats, moorings, pontoons) that are impossible to recover if the business becomes financially unviable. The impacts of significant perturbations are therefore spread unevenly across different community members and sectors. A strategic approach is needed to identify vulnerable individuals and businesses, provide short and potentially longer-term support, and minimise the impacts of the algal bloom on the social and economic stability of affected regions. In the longer term, a focus on building adaptive capacity that enhances the capacity to cope with extreme environmental events will be critical for the resilience of coastal communities.[34]

Recommendation

9. Undertake research to support the development of community level programs focused on enhancing wellbeing and resilience of affected communities in the face of increasing natural disasters and the resulting ecological grief and anxiety.

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[31] See Le Busque, B. (2025, August 11). When a beach walk feels like grief: Disasters like SA's algal bloom cut us off from nature when we need it most. The Conversation. https://theconversation.com/when-a-beach-walk-feels-like-grief-disasters-like-sas-algal-bloom-cut-us-off-from-nature-when-we-need-it-most-262705
Sweet, M., & Barrett, A. (2025, July 25). Experts sound health alarm on algal bloom crisis, calling for climate action and comprehensive responses. Croakey Health Media. https://www.croakey.org/health-experts-sound-alarm-on-algal-bloom-crisis-calling-for-climate-action-and-comprehensive-responses/
Sweet, M., & Baum, F. (2025, August 15). From the beaches of South Australia, a cry for climate action. Croakey Health Media. https://www.croakey.org/from-the-beaches-of-south-australia-a-cry-for-climate-action/
https://theconversation.com/when-a-beach-walk-feels-like-grief-disasters-like-sas-algal-bloom-cut-us-off-from-nature-when-we-need-it-most-262705

[32] Patrick et al. (2023) Prevalence and determinants of mental health related to climate change in Australia. *Aust N Z J Psychiatry,* **57**,710-24
Albrecht G, Sartore G-M, Connor L, et al. (2007) Solastalgia: The Distress Caused by Environmental Change. *Australasian Psychiatry* **15**(1_suppl),S95-S98. https://doi.org/10.1080/10398560701701288

[33] Bartelet, Henry A., Michele L. Barnes, and Graeme S. Cumming. Microeconomic adaptation to severe climate disturbances on Australian coral reefs, *Ambio* **52** (2), 285-299.https://doi.org/10.1007/s13280-022-01798-w

[34] Elrick-Barr, C.E., Thomsen, D.C. and Smith, T.F., 2024. Governance innovations in the coastal zone: Towards social-ecological resilience. *Environmental Science & Policy*, **153**, 103687 https://doi.org/10.1016/j.envsci.2024.103687

iii. Research, monitoring and restoration efforts

Monitoring is covered in section f

Research

There are still major knowledge gaps regarding the bloom and its impacts. Research is needed to assess which species are affected by the bloom, by how much, and across what spatial and temporal scales, and to monitor species and ecosystem recovery. The knowledge generated will tell us which species can recover on their own and which cannot, and which require immediate or long-term assistance, such as through fishing closures, reduced fish catches, or catch size restrictions or more targeted immediate interventions. Understanding how species respond is valuable to inform efforts to build future resilience, including through habitat restoration and emergency interventions.

It is very possible that numbers of some species that only or mainly occur in the St Vincent and Spencer Gulfs may have now dropped so low that they meet the criteria to be listed as threatened under national environmental law. Listing species that are at risk of extinction can be an important first step in their recovery, if listing generates good planning and investment in management.

However, assessing marine species against listing criteria is often difficult due to a lack of suitable data - most marine species would be too widespread and abundant to meet many listing criteria, and so instead the evidence needed to demonstrate their extinction risk relies on understanding population trends over 10-year or 3-generation periods (whichever is longer). Regular and fit-for-purpose monitoring data are crucial. At present, commercially significant fisheries species are likely to have the best data, where metrics such as catch per unit effort can be used to estimate population trends. Investing in scalable and robust methods to monitor population dynamics of non-commercial species and ecological communities would be very helpful for future conservation assessments, including benthic habitat-forming species. Such monitoring could form part of the proposed Great Southern Reef monitoring program, outlined in section f.

Dead marine animals washed up on beaches are only a fraction of the animals killed. However, citizen scientists collected records of these dead animals may be able to be used to provide an understanding of the broader environmental impacts. Research that provides insight into what proportion of total mortalities are observed on beaches would make the job of understanding the effects of this and future blooms easier. However, there may be no suitable methods to estimate this in the short term - it is more likely that signals of the impact will be seen in future genetics studies, especially if pre-impact genetic samples are available.

In addition to research focused on ecological outcomes and responses, a much higher and more consistent level of investment is needed into understanding how human societies perceive and respond to environmental perturbations and the ways in which ecological events impact critical elements of human wellbeing, such as local livelihoods and cultural benefits. This understanding will be critical to guiding policy and management responses to emerging crises and efforts to mitigate their impacts on coastal communities.

Nutrients have been considered a likely contributor to the initiating factors of this bloom, and addressing human-mediated sediment sources is one of the policy approaches likely to be considered within future HAB prevention strategies. A critical piece of knowledge required to assess the likely benefit and inform the design of any pollution reduction strategies is a nutrient balance study, which quantifies contributions from human and natural sources. This knowledge would be essential to design cost-effective pollution reduction strategies, aimed at reducing impacts on receiving waters and the likelihood of future blooms. The research

should involve a catchment-to-coastlines process,[35] involving agricultural stakeholders and upstream catchment and riparian management.

Recommendations

10. Investment at least $20 million immediately to fund in situ scientific research to improve our understanding of:

    a) Biodiversity impacts
        - Determining if the proportions of animals killed wash up on beaches can provide any indication of overall impact
        - Assessing which species are affected by the bloom, how much, and where, and monitor their recovery
        - Identifying species in need of emergency conservation or fisheries-regulation actions
        - Assess if any species appear highly imperilled or qualify for threatened status
    b) Economic and community impacts
        - Assessing the economic impact of the bloom and where impacts are most acute
        - Measuring eco-anxiety to monitor local community impacts and recovery
    c) Management response
        - Developing short-term and targeted methods that reduce or mitigate bloom spread, or protect vulnerable populations

Restoration

The clearing and degradation of large expanses of South Australia's coastal habitats has left marine ecosystems vulnerable. Shellfish reefs, seagrass meadows, kelp forests, saltmarshes and mangroves once filtered nutrients, stabilised sediments and provided habitat over thousands of coastal kilometres. Today, these systems are degraded and shellfish reefs formed by oysters are functionally gone.[36]

For example, when Europeans arrived in South Australia shellfish reefs occurred across >2,630 square kilometres of South Australia's coastal waters (for comparison, the total area of the ACT is 2,358 km²). They were sustainably managed by Indigenous communities as sources of food, material, and culture. Subsequent human causes of reef loss and degradation include commercial harvesting of oyster reefs by hand and dredging, including dredging the calcium-rich reefs for lime and construction materials, and seafloor trawling fisheries practices. The loss of these filter-feeding reef ecosystems resulted in reduced water quality and nutrient cycling, while the loss of reef substrate that is required for natural shellfish recruitment meant that these reefs have not naturally regenerated, requiring active restoration efforts to revive these ecosystems. It is estimated that 98% of flat oyster (*Ostrea angasi*) reefs, 50—75% of hammer oyster (*Malleus meridianus*) reefs and 25-75% of razor clam (*Pinna bicolor*) reefs have been lost within South Australia.[37]

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[35] Wurtsbaugh, W. A., Paerl, H. W., & Dodds, W. K. (2019). Nutrients, eutrophication and harmful algal blooms along the freshwater to marine continuum. *WIREs Water,* ***6***(5), e1373. https://doi.org/10.1002/wat2.1373

[36] Gillies, C. L., Castine, S. A., Alleway, H. K., Crawford, C., Fitzsimons, J. A., Hancock, B., Koch, P., McAfee, D., McLeod, I. M., & Zu Ermgassen, P. S. (2020). Conservation status of the Oyster Reef Ecosystem of Southern and Eastern Australia. *Global Ecology and Conservation*, **22**, e00988. https://doi.org/10.1016/j.gecco.2020.e00988

[37] Martin, B., Huveneers, C., Reeves, S., & Baring, R. (2025). Reviving shellfish reef socio-ecological histories for modern management and restoration. *Ocean & Coastal Management*, **261**, 107540. https://doi.org/10.1016/j.ocecoaman.2025.107540

The loss of 6,200 ha of seagrass off the Adelaide metropolitan coast since 1949 has had substantial implications for beach management, fisheries and biodiversity.[38] The primary causes of loss are generally considered to be the overgrowth of seagrass by epiphytic algae that thrived in nutrient-rich conditions created by anthropogenic nutrient inputs, and to a lesser extent, turbidity associated with storm-water runoff. In South Australia, historical losses of saltmarshes have been estimated at 8,400 ha since the 1930s[39] and 300 ha of mangroves since the 1950s[40] mostly due to change in landuse and bunding of tidal waters.

Restoring shellfish reefs, seagrass meadows, kelp forests, saltmarshes and mangrove habitats is essential to:

- Filter and absorb excess nutrients
- Provide habitat for marine species, including nursery habitat
- Increase coastal resilience to climate shocks

Research in Japan and the United States also suggests that protecting and restoring native seagrasses and seaweeds in coastal marine environments could specifically assist in the suppression of HABs, as the seagrass and seaweeds produce high densities of algicidal and growth-inhibiting bacteria which are effective in suppressing certain HAB species.[41]

Coastal ecosystem restoration efforts are underway in some locations — but much more is needed. Coastal and marine ecosystem restoration must be scaled up as part of our national biodiversity and water quality strategy. Increasing the amounts and health of these ecosystems can help to boost the numbers of the species that depend on them, some of which are commercially important. When species start with larger populations, more individuals are likely to survive, which generally enhances the ability of the population to recover as bigger populations maintain more genetic variation and ability to adapt.

Effective methods for oyster reef restoration are established and have been successfully demonstrated within South Australian waters, including 1.1 km of reefs along the Yorke Peninsula, two 5-hectare reefs on the Adelaide metropolitan coast, and reefs at Kangaroo Island. Results can be rapid; the original 2 ha reef constructed at Glenelg Beach supported a restored functional oyster community within 2.5 years of reef construction, which was filtering millions of litres of water per day. Oyster reef restoration is an effective and low-risk strategy to draw down nutrients, improve water quality and provide other biodiversity benefits.

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[38] Tanner, J. E., Irving, A. D., Fernandes, M., Fotheringham, D., McArdle, A., & Murray-Jones, S. (2014). Seagrass rehabilitation off metropolitan Adelaide: A case study of loss, action, failure and success. *Ecological Management & Restoration*, **15**(3), 168-179. https://doi.org/10.1111/emr.12133

[39] Macreadie, P. I., Ollivier, Q. R., Kelleway, J. J., Serrano, O., Carnell, P. E., Ewers Lewis, C. J., Atwood, T. B., Sanderman, J., Baldock, J., Connolly, R. M., Duarte, C. M., Lavery, P. S., Steven, A., & Lovelock, C. E. (2017). Carbon sequestration by Australian tidal marshes. *Scientific Reports*, **7**, 1–10. https://doi.org/10.1038/srep44071

[40] Scientific Working Group. (2011). The vulnerability of coastal and marine habitats in South Australia. Marine Parks, Department of Environment, Water and Natural Resources South Australia.

[41] Imai, I., Inaba, N. & Yamamoto, K. (2021) Harmful algal blooms and environmentally friendly control strategies in Japan. *Fish Sci* **87**, 437–464 https://doi.org/10.1007/s12562-021-01524-7
Research Outreach. (2022, October 10). A new biological approach to control harmful algal blooms. https://researchoutreach.org/articles/new-biological-approach-control-harmful-algal-blooms/
Sylvers, L. H., & Gobler, C. J. (2021). Mitigation of harmful algal blooms caused by Alexandrium catenella and reduction in saxitoxin accumulation in bivalves using cultivable seaweeds. *Harmful Algae*, **105**, 102056. https://doi.org/10.1016/j.hal.2021.102056

There have also been successes in the restoration of native seagrasses and seaweeds, including near Adelaide.[42] Most observed changes in seagrass and seaweed have been passive recoveries linked to improved wastewater treatment efforts to reduce nitrogen inputs, as opposed to active restoration transplants.[43] Although passive recovery has been successful in deeper waters (>10 m),[44] large areas in shallow water remain bare. This indicates that further adaptive research trials are needed for seagrass and seaweed restoration.

Tidal restoration of saltmarsh and mangrove ecosystems in South Australia has proven successful, delivering measurable gains for biodiversity and carbon sequestration.[45] In 2024 a South Australia tidal reconnection project became the second nationally to register with the Clean Energy Regulator.[46] To capitalise on these proven benefits, restoration efforts now need to be scaled up and expanded across the state's coastline.

Recommendations

11. Scale up the restoration and protection of marine ecosystems — particularly shellfish reefs, kelp, saltmarshes, mangroves, and seagrass — that naturally draw down nutrients and support biodiversity to help it bounce back after blooms.
12. Identify priority areas for ecosystem restoration.
13. Invest in adaptive research to refine seagrass and seaweed restoration techniques.

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[42] Tanner, J. E., Irving, A. D., Fernandes, M., Fotheringham, D., McArdle, A., & Murray-Jones, S. (2014). Seagrass rehabilitation off metropolitan Adelaide: A case study of loss, action, failure and success. *Ecological Management & Restoration*, **15**(3), 168-179. https://doi.org/10.1111/emr.12133

[43] Fernandes, M. B., Hennessy, A., Law, W. B., Daly, R., Gaylard, S., Lewis, M., & Clarke, K. (2022). Landsat historical records reveal large-scale dynamics and enduring recovery of seagrasses in an impacted seascape. *Science of The Total Environment*, **813**, 152646. https://doi.org/10.1016/j.scitotenv.2021.152646
McAfee, D., Alleway, H. K., & Connell, S. D. (2020). Environmental solutions sparked by environmental history. *Conservation Biology*, **34**(2), 386-394. https://doi.org/10.1111/cobi.13403

[44] Fernandes, M. B., Hennessy, A., Law, W. B., Daly, R., Gaylard, S., Lewis, M., & Clarke, K. (2022). Landsat historical records reveal large-scale dynamics and enduring recovery of seagrasses in an impacted seascape. *Science of The Total Environment*, **813**, 152646. https://doi.org/10.1016/j.scitotenv.2021.152646

[45] Dittmann, S., Mosley, L., Beaumont, K., Clarke, B., Bestland, E., Guan, H., Sandhu, H., Clanahan, M., Baring, R., Quinn, J., Seaman, R., Sutton, P., Min Thomson, S., Costanza, R., Shepherd, G., Whalen, M., Stangoulis, J., Marschner, P., Townsend, M. (2019) From salt to C; carbon sequestration through ecological restoration at the Dry Creek Salt Field. Goyder Institute for Water Research Technical Report Series No. 19/28. https://goyderinstitute.org/wp-content/uploads/2023/06/goyder_trs_19-28_from_salt_to_c_carbon_sequestration.pdf
Dittmann, S., Mosley, L., Clanahan, M., Quinn, J., Crooks, S., Emmer, I., Min Thomson, S. and Seaman, R. (2019) Proof of concept for tidal re-connection as a blue carbon offset project. Goyder Institute for Water Research Technical Report Series No. 19/29 https://goyderinstitute.org/wp-content/uploads/goyder_trs_19-29_proof_of_concet_blue_carbon_project

[46] The Nature Conservancy Australia. (n.d.). Registration of Australia's largest blue carbon project. https://www.natureaustralia.org.au/newsroom/registration-blue-carbon-project/

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

Algal bloom monitoring and forecasting

Algal blooms can be detected and monitored from space[47] and remote sensing methods are advanced for assessment of *Karenia* blooms in other parts of the world.[48] Investment in high temporal and spatial remote sensing of the SA algal bloom, integrated with field sampling, could be a cost-effective monitoring option for assessing the scale of the bloom and changes in the bloom extent and intensity both due to management actions and ocean and climate conditions.

To understand the factors that drive future HABs, and potentially to inform early detection, water quality must be monitored and HAB species must be identified.This would involve setting up a network of regular (suggest fortnightly) water sample collection and using molecular methods to determine the species of *Karenia* present and their abundances, with triggers for more action.

Within Australia, research to improve the prediction of HABs is occurring.[49]

Monitoring of other marine flora and fauna is covered under section f.

Recommendation

14. Monitor water quality, algal bloom and nutrient concentrations in South Australian coastal waters through a network of regular (e.g. fortnightly) water sample collection; use molecular methods needed to determine the species of *Karenia* present and their abundances.

Great Southern Reef monitoring

The Great Southern Reef is a global biodiversity hotspot and contributes $11.5 billion to the Australian economy each year through tourism and fisheries — nearly double the economic value of the Great Barrier Reef. Yet, it is poorly studied, under-protected and lacks a well-designed coordinated long-term monitoring program.

The Australian Government should move urgently to establish a long-term monitoring program for the Great Southern Reef with funding at least equivalent to the Great Barrier Reef's Reef Integrated Monitoring and Reporting Program (RIMReP) which is $40 million over 10 years. Such an investment represents just 0.04% of the Great Southern Reef's annual economic value — a prudent step to protect one of our most important natural assets. The monitoring program could fill data gaps that are currently preventing species assessments as outlined in section e iii.

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[47] Roelfsema, C., Phinn, S., Dennison, W., Dekker, A., & Brando, V. (2005). Monitoring toxic cyanobacteria Lyngbya majuscula (Gomont) in Moreton Bay, Australia by integrating satellite image data and field mapping. *Harmful Algae*, **5**(1), 45-56. https://doi.org/10.1016/j.hal.2005.05.001

[48] Alexanin, A., Kachur, V., Khramtsova, A., & Orlova, T. (2022). Methodology and Results of Satellite Monitoring of Karenia Microalgae Blooms, That Caused the Ecological Disaster off Kamchatka Peninsula. Remote Sensing, **15**(5), 1197. https://doi.org/10.3390/rs15051197

[49] Hipsey, M. R., Carey, C. C., Brookes, J. D., Burford, M. A., Dang, H. V., Ibelings, B. W., & Hamilton, D. P. Integrating phytoplankton phenology, traits, and model-data fusion to advance bloom prediction. *Limnology and Oceanography Letters*. https://doi.org/10.1002/lol2.70052

The Great Southern Reef stretches 8,000 km from Western Australia to New South Wales, passing through the waters of every Australian state except Queensland. It is essential that monitoring is coordinated across the whole Great Southern Reef, rather than by individual state governments, as most species will have strong links to multiple regions through direct migration or the movement of their predators or prey. Significant changes in any one area could have cascading effects on others.

A Great Southern Reef monitoring program could be integrated with other national platforms like marine seasonal forecasts (formerly CSIRO, now BOM) to support:

- Advanced predictive capability for HABs
- Comprehensive environmental-economic modelling of the impacts of HABs and the cost-effectiveness of options to reduce their probability and mitigate their impact
- Adaptive fisheries and conservation management
- Targeted ecosystem restoration
- Early detection and response to future marine threats
- Monitoring of impacts of eco-anxiety on local populations and their productivity

Recommendation

15. Establish a long-term coordinated and multi-jurisdictional monitoring program for the Great Southern Reef, modelled on the $40 million, 10−year Great Barrier Reef's Reef Integrated Monitoring and Reporting Program (RIMReP).

g. Any related matters

Action to address and prepare for future events

The most important action Australia can take to reduce the risk of future marine catastrophes is to dramatically accelerate the decarbonisation of our economy. Marine heatwaves — now more frequent, longer-lasting, and more intense — contribute to the warm conditions in which many harmful algal blooms thrive, in addition to causing a wide range of other impacts such as coral bleaching and death, seagrass loss and direct mortality of organisms. Climate change is also increasing the risk and intensity of bushfires which can result in nutrient-rich ash being washed off catchments, and is intensifying storms and floods that flush pulses of freshwater, sediment, pollutants, and nutrients into our coastal waters. Climate change is further stressing marine species already struggling to cope with habitat loss, pollution and overfishing. Australia must not only cut emissions rapidly at home — we must also position ourselves as a global champion of climate action. This includes:

- Rapidly transitioning to renewable energy sources
- Ending fossil fuel subsidies and phasing out fossil fuel exports
- Investing in nature-based solutions that sequester carbon and protect biodiversity
- Supporting policies that place a fair price on greenhouse gas pollution

Future harmful algal blooms, marine heatwaves, floods and bushfires will become more frequent and intense under climate change. Scenario planning, monitoring and pre-event stakeholder engagement are essential to ensure readiness and community support for rapid, effective responses. The mental health impacts will continue to increase: a person born in the 2020s will experience 2–7 times more

climate-related disasters than a person born in the 1960s.[50] Community wellbeing will need to be thoughtfully addressed, and appropriate community-based responses designed, evaluated, and resourced. Physical health will also be severely affected, such as through increasing heatwaves and more prevalent infectious diseases,[51] noting that climate change is increasing the risk of zoonotic diseases such as H5N1 avian influenza.[52]

Australia would also strongly benefit from a standardised, central monitoring program which tracks the responses of human communities to increasingly widespread ecological perturbations; documents impacts on livelihoods and general wellbeing, and identifies relevant factors that contribute to the effectiveness of responses and the support of local social-ecological resilience. Each major perturbation provides a quasi-experimental opportunity to learn more about how people respond to ecological change and improve our understanding of what kinds of responses are successful, in both the short- and long- term. The absence of climate change readiness planning and the tendency to treat each new ecological shift under climate change as a new and isolated event mean that we currently lack a set of evidence-based, well-coordinated and effective responses. This significantly limits efforts to build adaptive capacity and respond proactively to ongoing ecological change.

Recommendations

16. Accelerate Australia's decarbonisation efforts and become a global leader in climate action. Minimising climate change-related stressors such as ocean warming, marine heatwaves, ocean acidification, and seawater hypoxia is the most important step in preventing harmful algal blooms, not just in South Australia but also along other Australian coastlines.
17. Convene an expert panel to develop a standardised monitoring and data collection approach focusing on human responses to ecological change; provide funding support and a home within a governmental agency for a long-term initiative to collect and house the relevant data.
18. Identify and support long-term adaptation and resilience-building measures for social-ecological sustainability informed by best available evidence (Guided by 16).

Conclusion

Without decisive, coordinated action across all levels of government, these events will increase in frequency, severity and impact around Australia. Urgent investment in scientific research, ecological monitoring, marine habitat restoration, land-based pollution reduction, and climate action is essential to protect biodiversity and secure the social, cultural and economic values of South Australia's marine environments.

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[50] Thiery, W., Lange, S., Rogelj, J., Schleussner, F., Gudmundsson, L., Seneviratne, S. I., Andrijevic, M., Frieler, K., Emanuel, K., Geiger, T., Bresch, D. N., Zhao, F., Willner, S. N., Büchner, M., Volkholz, J., Bauer, N., Chang, J., Ciais, P., Dury, M., . . . Wada, Y. (2021). Intergenerational inequities in exposure to climate extremes. *Science*. **374**(6564), 158-160 https://doi.org/10.1126/science.abi7339

[51] Watts, N., Adger, W. N., Agnolucci, P., Blackstock, J., Byass, P., Cai, W., Chaytor, S., Colbourn, T., Collins, M., Cooper, A., Cox, P. M., Depledge, J., Drummond, P., Ekins, P., Galaz, V., Grace, D., Graham, H., Grubb, M., Haines, A., … Costello, A. (2015). Health and climate change: Policy responses to protect public health. *The Lancet*, **386**(10006), 1861–1914. https://doi.org/10.1016/S0140-6736(15)60854-6

[52] Franklin, S. I. (2023). Can One Health fight H5N1 avian influenza? *The Lancet Planetary Health*, **7**(6), e442–e443. https://doi.org/10.1016/S2542-5196(23)00086-4