Environment Institute

THE UNIVERSITY of ADELAIDE

21 August 2025

Submission by the Environment Institute, University of Adelaide, for the Senate Inquiry on the causes, frequency, scale and duration of recent algal blooms in South Australian marine and coastal environments

Dear Sir/Madam

Thank you for the opportunity to provide a submission to the *Senate Inquiry 'On the causes, frequency, scale and duration of recent algal blooms in South Australian marine and coastal environments*' from members of the Environment Institute at the University of Adelaide.

The Environment Institute was established in 2009. Our purpose is to invest in the environment through world-leading research to halt and reverse environmental decline and create a future that is healthy, diverse and equitable. The current research foci of the institute include restoration of temperate marine ecosystems; biodiversity conservation and climate adaptation; climate and environmental risk; water resource management and policy; greening urban environments and improving human health; combatting wildlife and environmental crime; engaging citizens in science; and pollution reduction.

The Environment Institute has nationally important research expertise in marine, coastal and freshwater ecosystem science, which is critical to understanding, monitoring, developing solutions, restoring and building future resilience to the unfolding algal bloom crisis impacting southern Australian coastal waters. Our researchers are national leaders and champions of change in understanding the drivers of loss and restoration across a range of ecosystems, including fisheries and fish health, seagrass communities, kelp forests, shellfish reefs, mangroves and saltmarshes.

Our multidisciplinary approach brings together the disciplines of marine biology, social sciences, psychology, health, education, economics and legal studies to drive policy development, legislative change, and social and ecological progress. We also have a broader range of expertise working in South Australian freshwater, estuarine and coastal systems such as the Coorong and Lower Lakes, and includes hydrologists, ecologists, biogeochemists, engineers, architects, modellers, economists and social scientists, working in collaboration with the water sector and water users.

We would like to submit the following statement on the causes, frequency, scale and duration of recent algal blooms in South Australian marine and coastal environments as structured in the call for submissions.

The Environment Institute is poised to assist, support, advise and participate in the recovery in light of the recommendations made.

Yours sincerely

Professor Andrew Lowe, Director, Environment Institute

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1 - Contributing environmental, land management or water quality factors

The South Australian algal bloom is the culmination of at least three, long-term, high-impact threats that have been degrading the resilience of the State's coastal ecosystems for decades.

A Marine Heatwave in a Warming Ocean
The algal bloom was preceded and fuelled by a persistent and powerful marine heatwave that began affecting southern Australian waters in September 2024. This event drove sea surface temperatures to approximately 2.5°C above the long-term average. This prolonged period of exceptionally warm water created the perfect thermal conditions for the rapid growth and proliferation of dinoflagellate species, including *Karenia mikimotoi*.

The impact of the heatwave was compounded by associated weather conditions. The period was characterised by unusually calm seas, light winds, and small swells. In a normal year, strong winter winds and rougher seas would help to mix the water column and physically break up and disperse an incipient bloom. The absence of these disruptive forces allowed the bloom to incubate and intensify quickly, causing a regional crisis.

Nutrient Pollution
For decades, the coastal waters of Gulf St Vincent and Spencer Gulf have been receiving excessive loads of nutrients, primarily nitrogen and phosphorus, from the surrounding catchments. This pollution has two distinct components: a chronic, long-term overload and an acute, recent shock.

> Chronic Eutrophication: Decades of Urban and Agricultural Runoff
> Historically, Adelaide's coastal waters have been impacted by high-nutrient discharges from a combination of sources, including wastewater treatment plants (WWTPs), industrial outfalls, and diffuse-source stormwater runoff from both urbanised areas and agricultural land. The state's gulfs are naturally susceptible to the accumulation of pollutants due to their shallow nature and relatively poor water exchange with the open ocean, which limits their flushing capacity. The scale of this issue was explicitly identified and quantified over two decades ago. In 2001, the South Australian Environment Protection Authority (EPA) initiated the Adelaide Coastal Waters Study (ACWS) in response to growing concerns over declining water quality. The study's final report was unequivocal: it directly linked high nutrient loads, particularly nitrogen, to the devastating loss of over 5,000 hectares of vital seagrass habitat along the metropolitan coastline. The report concluded that a 75% reduction in nitrogen inputs and a 50% reduction in suspended solids were necessary to create conditions for seagrass recovery. The study identified the Torrens River catchment as a particularly significant contributor, responsible for 30% of the total nitrogen load entering the gulf. Although there have been significant improvements in wastewater management and treatment in the intervening decades, weather events causing pulses of stormwater discharge to the coast are still a major issue for coastal water quality.
>
> The Acute Shock: The 2022-23 River Murray Flood Pulse
> On top of this chronic nutrient overload came an acute, massive shock. The 2022-2023 La Niña weather pattern resulted in the River Murray flood, the largest since 1956 and the third-highest flood event ever recorded in South Australia. This immense volume of floodwater carried with it an enormous load of nutrients and organic material—accumulated from agricultural and other sources across the vast Murray-Darling Basin—and discharged it directly into the state's coastal waters. This event caused a high level of fertiliser input, saturating the marine environment with the raw materials needed for an explosive algal bloom.

Ecosystem Degradation: The Loss of Coastal Resilience

Healthy coastal ecosystems possess natural mechanisms to buffer against pollution and maintain stability. The systematic degradation of coastal ecosystems has left the gulfs fragile and unable to withstand the shocks of heatwaves and nutrient pulses. Two critical losses have been:

Shellfish Reef Loss

The functional extinction of the region's native shellfish reefs has had a massive impact. It is estimated that filter-feeding shellfish reefs, dominated by native oysters, once covered 1,500 kilometres of South Australia's coastline. These reefs would have acted as immense natural water treatment plants, filtering billions of litres of water a day and removing suspended particles and algae. Today, these reefs are almost completely degraded.

Seagrass Loss

As documented by the ACWS, more than 5,000 hectares of seagrass meadows have been lost along the metropolitan coast alone, with a far greater loss across the state's entire coastal waters. These losses were primarily due to the light-blocking effects of turbid water caused by high nutrient and sediment loads. Healthy seagrass beds play a crucial role in maintaining water quality by trapping sediment and cycling nutrients, effectively acting as the "kidneys" of the coast. Their loss removed a vital natural filter from the system.

The loss of these foundational habitats represents a slow-moving but catastrophic decline in the coast's natural resilience. It stripped the ecosystem of its capacity to absorb and process nutrient inputs at the same time that nutrient inputs were increasing, making it vulnerable to the kind of shock delivered by the Murray flood.

In summary, the synergistic interaction of climate change, nutrient pollution and coastal ecosystem destruction has created the conditions for disaster. Climate change amplified the nutrient problem by driving an extreme flood, which delivered a massive nutrient pulse into a system that had already been stripped of its natural filters by overfishing, decades of chronic pollution and ecosystem destruction. The marine heatwave then provided the final ingredient—the perfect temperature—for the ecological explosion to occur.

Recommendation

1. **Continue National and State efforts to limit greenhouse gases emissions and increase carbon sequestration. These continued activities will reduce the long-term likelihood of future similar events, but we will also need to plan in the short term for mitigation of similar events.**

2. **Set nutrient and suspended solid reduction targets to reduce the likelihood of negative impacts from discharges due to both normal rainfall and episodic flood events.**

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2 - Ecological, economic, cultural and social impacts of algal blooms with particular reference to:

- **Tourism, commercial and recreational fishing industries**
- **Regional and coastal communities**
- **Marine biodiversity and ecosystem health**

Ecological grief is an increasing concern for the mental health of communities that experience environmental disasters. In some places families have stopped visiting beaches due to the sense of fear, loss and grief associated with the harmful algal bloom. Outreach and education are an important part of a broader public understanding of climate disasters as they help inform communities about what is happening, what people can do about it and what to expect in the future. This work is urgent to combat the misinformation being spread about the initial causes, ongoing drivers, potential solutions and future repercussions of the harmful algal bloom.

It is important that a One Health approach is adopted. The algal bloom has significant negative impacts on human health through of short-term respiratory irritation, and on wellbeing due to the economic and community effects.

Recommendation

3. **Greater resourcing of outreach and education is required to combat the misinformation being spread about the initial causes, ongoing drivers, and future repercussions of the HAB. This outreach needs to be focused on positive, guided community action on the bloom. People want to feel they can do something about it and to help – however, guidance is needed on what they can do and the best way to do that (e.g. more promotion and community training on species identification, water quality and techniques that can be readily applied). One suggestion is to run training for people who want to be involved in documenting the impact through iNaturalist and building a team of expert contributors to ensure data quality.**

4. **A broad piece of work is required to properly document the economic impact and longevity prediction of the harmful algal bloom on fisheries and associated industries. This should include the broader socio-economic benefits and ecosystem services that can be offered by rebuilding marine ecosystems to be more resilient in the future.**

5. **It is also recommended that a One Health approach be used to emphasise the interdependence of environmental, animal, and human health. This means responses should simultaneously consider, (1) ecosystems and marine health (monitoring and mitigating algal blooms), (2) wildlife health (detecting and responding to animal mortalities, and monitoring for future health outbreaks), (3) human health (managing exposure risks and public health advisories), and (4) the economic and community well-being of affected populations.**

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

Under the Australian Government's definition (DCCEEW), heritage encompasses natural and cultural places, landscapes, biodiversity, and living heritage practices. Many coastal and Indigenous communities in South Australia hold deep cultural and spiritual connections to marine ecosystems—connections that are integral to identity, memory, and tradition.

The harmful algal bloom is damaging or threatening to destroy culturally significant species and environments—such as the Giant Australian Cuttlefish of the Upper Spencer Gulf—but the impact is not limited to ecological loss, or loss itself. The anticipation of loss can also be a source of profound distress, contributing to ecological grief, anxiety, solastalgia, and feelings of helplessness. This "anticipatory grief" is not well captured in current environmental response or mental health frameworks, which tend to focus on tangible losses and economic recovery rather than the psychosocial effects of losing place-based heritage.

For Indigenous communities, loss of access to traditional fishing grounds, Sea Country, and sacred marine sites is more than an economic issue—it disrupts cultural continuity and weakens intergenerational knowledge transfer. This disruption has measurable impacts on social cohesion, community identity, and mental health, compounding the ongoing effects of colonisation and dispossession. Cultural continuity is a proven protective factor in community resilience. Recovery services that fail to address the cultural dimensions of environmental change risk leaving communities without the tools they need to adapt in ways that preserve identity and wellbeing.

Recommendation

6. **Include heritage and wellbeing in impact assessments for environmental disasters/natural emergencies, alongside ecological and economic measures, and integrate cultural values into long-term restoration and biodiversity recovery strategies, ensuring that projects align with community priorities.**

7. **Fund transdisciplinary research on the mental health impacts of environmental degradation and heritage change, co-designed with Indigenous knowledge holders and affected communities. In addition, support community-led mapping and documentation of threatened marine heritage—species, sites, and stories—before they are lost. This can aid in alleviating feelings of helplessness.**

4 - Coordination of state and federal government responses, including support, industry engagement and scientific advice

Nutrient pollution and ecosystem degradation have remained as unresolved ecosystem problems for decades.

Revisit the Adelaide Coastal Waters Study (ACWS)
There is a need to revisit the Adelaide Coastal Waters Study (ACWS), completed by the SA Environment Protection Authority (EPA) in the early 2000s. This study explicitly identified that high loads of nutrients (specifically nitrogen) and suspended solids from land-based discharges were the primary cause of the loss of over 5,000 hectares of seagrass. We need to understand how well we addressed these recommendations and whether they are still adequate given the depauperate condition of coastal ecosystems after decades of stress, and their reduced resilience and capacity to recover.

Fragmented Stewardship and Lack of a Unified Catchment-to-Coast Mandate
There is a fragmented governance structure where responsibility for the interconnected land-sea system is divided among multiple agencies and legislative frameworks.

The key actors in South Australia's environmental management landscape include:

- The Environment Protection Authority (EPA): Responsible for regulating water quality under the Environment Protection Act 1993 and the supporting Environment Protection (Water Quality) Policy 2015. Its focus is primarily on the receiving environment and licensing point-source discharges.
- The Department for Environment and Water (DEW): The lead agency for managing the state's natural resources, including water planning and administering the Landscape South Australia Act 2019.
- Regional Landscape Boards: Established under the Landscape SA Act, these boards are responsible for developing regional plans and managing land, water, and pest control within their specific catchments.
- The Department of Primary Industries and Regions (PIRSA) and its research arm, the South Australian Research and Development Institute (SARDI): Responsible for managing and supporting primary industries, including agriculture and fisheries, and conducting relevant research.
- SA Health: Responsible for public health advice and managing the Safe Drinking Water Act 2011.

While these agencies collaborate, particularly in crisis response forums, their core mandates are separate. This structural gap makes it difficult to implement and enforce systemic, watershed-wide nutrient reduction strategies. The result is a system that is effective at managing individual pieces but fails to see or manage the whole system.

Finally, the harmful algal bloom, whilst recognised as a 'serious environmental event,' has still not been recognised as a 'national emergency'. The Commonwealth Government has also cited limitations in defining a 'major disaster' (to unlock Centrelink funding) and an 'eligible natural disaster' (which would provide access to the Disaster Recovery Funding Arrangements).

Recommendation

8. **Establish a South Australian Coastal Catchment Authority. Drawing on the analysis of the governance gap and the success of integrated management bodies elsewhere (e.g. Chesapeake Bay Program, Tampa Bay Estuary Program), a new body is proposed. This should be comprised of the relevant agencies including Department for Environment, Primary Industries and Regions, Landscapes SA, EPA, SA Health, SA Water etc. and have an overarching mandate for the ecological health of the state's gulfs, from the source of the catchments to the coastal waters. Another option is to adopt a broader**

approach to cover all marine waters and activities, not just the catchment and coast, similar to the NSW Marine Estate Department which advocates for a healthy coast and sea - https://www.marine.nsw.gov.au/. At the very least, a full review of legislation to determine the most appropriate governance model is required.

9. **In addition, there is a need to examine how to strengthen and enforce the *Environment Protection (Water Quality) Policy 2015* to include legally binding numeric criteria for water quality and consider how diffuse sources are handled and ensure that the new Biodiversity Act 2025 includes regulations that enable rapid response to conditions evaluated to be a high risk of harmful algal bloom.**

10. **Review the policy and legal frameworks for disasters and nationally significant emergencies, including to support a systems planning approach to assessing future risks and improving long term adaptation and mitigation.**

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5 - Current support and recovery arrangements for impacted industries and communities, including:

- **Financial support for fishing, tourism and other impacted businesses**
- **Community resilience services**
- **Research, monitoring and restoration efforts**

Impact assessments and predictions for key species are required with a focus on economically important, threatened, charismatic and habitat forming species – e.g. fishery species, oysters, seagrass, kelp, leafy sea dragon, cuttlefish. This involves undertaking population surveys, impact and risk assessments and reviewing previous work to understand the drivers of population dynamics and longer-term conservation implications and options for these species.

Anecdotal information suggests that healthy seagrass meadows and oyster reef ecosystems provide a level of resilience to the algal bloom, and that both systems can provide important water filtration and nutrient reduction. However, in some cases these ecosystems have also been impacted. To provide future resilience, a range of ecosystem restoration activities are required, particularly for seagrass meadows and reefs. Further research is required to understand optimal site selection for restoration investment, as well as how to fast track the seeding of seagrass meadows and settlement of reefs. Culminating in an understanding of how to improve the efficiency of recruitment and establishment and long-term survivability. A prioritisation exercise is also required to identify the key regions and locations to repair biodiversity and fisheries productivity.

Recommendation

11. **Rebuild natural defences - The goal must be a massive, state-led effort to restore the thousands of hectares of lost seagrass, a good portion of the 1,500 km of degraded shellfish reefs, and also mangrove habitat. A major "Reefs and Meadows" restoration program should be established for the Gulfs. It would involve large-scale seeding of seagrasses and mangroves, and the construction of new native oyster reef substrates in historically documented locations. Rebuilding terrestrial aquatic ecosystems such as swamps and wetlands will also help. This would not only improve water quality and biodiversity but also support enhanced fish stocks and create new economic opportunities.**

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

The mass beaching of dead marine life reflects only the surface symptoms; the real extent of the damage lies below the waterline and remains poorly documented. Monitoring is essential; not only for early detection but also for identifying vulnerable species and habitats. It forms the foundation for proactive planning and response. A broader understanding of which species are affected, extent of impact, and spatial and temporal spread of impact is required. Integrated monitoring should be undertaken to examine water quality, algal concentration, temperature, pH, oxygen concentration, nutrient load, together with species and ecosystem impact. We need improved identification of algal species and monitoring of their presence and toxicity across space and time (current and historical via sediment analysis and DNA profiling). There needs to be observations in critical water bodies – including the Coorong, Lower Lakes and Murray Mouth region, Spencer Gulf and Gulf of St Vincent - with a focus on key ecosystems and species (e.g. cuttle fish in Spencer Gulf). We also need to identify the origin/inoculum of harmful algal bloom using sediment dating techniques and understand inter-species interactions between HABs and potential algicidal microbes that feed on them and may provide a future control mechanism.

We need to use this monitoring and environmental data in ecological models to determine what is driving the spread and persistence of the harmful algal bloom. This will deliver critical understanding of the mechanisms and drivers of the event, enabling a predictive framework for long-term mitigation to avoid future events. In addition, we need to understand the physiological limits and resilience of key-stone species that enable a broader ecosystem resilience. For example, the sensitivity of species like seagrass, reef-building species and functionally important fish to algal levels, heat and nutrient loads determines the capacity of these species and the ecosystems they support to survive and adapt in the future. Being able to conduct experiments in large tank systems, as well as controlled field tests, is the only way to ascertain this information, and is critical to underpin efforts to model and predict future species and ecosystem responses and management options

Recommendation

12. **A comprehensive ecological baseline assessment: An urgent scientific program is required to map the full extent of the ecological damage. This must go beyond cataloguing fish kills to include detailed subtidal surveys of benthic habitats (seagrass, macroalgal, reef, and soft-sediment communities) to establish a new, post-bloom baseline. This data is critical for quantifying the loss and setting realistic targets for future restoration efforts.**

13. **Establish an integrated monitoring and modelling program: from nutrient level, water quality and physical characteristics of water bodies, to biodiversity and fish stock monitoring, along with the level of algal populations. This monitoring is required to inform on the progress on nutrient reduction, tracking future algal bloom outbreaks and impact, and providing baseline and tracking data to improve future predictive capacity. Timely detection of localised algal blooms is critical to any future strategy aimed at containment or mitigation. Where possible utilise existing platforms (e.g. CoastRI) and consider citizen science opportunities.**

14. **Expand predictive modelling through supporting and expanding the existing teams conducting oceanographic and ecological modelling. This will be crucial to predict the movement of the current bloom and, more importantly, to forecast the risk of future blooms under various climate and nutrient scenarios. This will improve early warning capabilities.**

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7 – Any related matters

Research Funding

Recommendation

15. **In addition to research investment coming from Australian and State Government Departments, the research that is recommended in this submission could be funded (with additional support) through a range of existing instruments that have historically supported similar works. These include the National Environmental Science Program (NESP) and special research funding calls administered by the Australian Research Council (ARC), National Health and Medical Research Council (NHMRC) and Medical Research Future Fund (MRFF).**

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At the Environment Institute, University of Adelaide, we have the multidisciplinary expertise critical to understanding, monitoring, developing solutions, restoring and building future resilience to the harmful algal bloom crisis impacting southern Australian coastal waters. This is detailed in our ***Harmful Algal Bloom (HAB) capability statement****, accessible at:*
https://www.adelaide.edu.au/environment/ua/media/3195/environment-institute-hab-capability-statement.pdf

Coauthors of this submission:

Professor Andrew Lowe – Director, Environment Institute – research on biodiversity and sustainability challenges through the application of technology innovations he is an expert on the management of genetic, biological and ecosystem resources.

Professor Michael Beard – Head of the Viral Pathogenesis Research Laboratory (VPRL) and One Health Lead, School of Biological Sciences – research on the development of model disease systems to study complex cellular interactions with the ultimate aim to develop novel therapeutic strategies and understand disease causation.

Professor Justin Brookes – Professor Justin Brookes, School of Biological Sciences - research on quality of water and river and lake ecology. Also leading expertise in treatment and reuse of water and understanding the threats of climate change and a drying climate.

Professor Sean Connell – School of Biological Sciences, Co-lead Southern Seas Ecology Laboratories – research on conservation and restoration of coastal ecosystems, including the Southern Hemisphere's largest oyster reef restorations, now adopted nationwide; improving coastal water quality through advanced engineering infrastructure; and recovery of seagrass meadows, kelp forests, and oyster reefs.

Professor Bronwyn Gillanders – Head of School of Biological Sciences and co-lead Southern Seas Ecology Laboratories - research on aquatic waters (freshwater, estuarine and marine) with a strong focus on fish and cephalopods, and environmental issues.

Professor Ivan Nagelkerken – School of Biological Sciences – research on temperate and tropical coastal ecosystems, with a focus on fish. Key issues include - ecosystem connectivity, functioning and resilience of coastal ecosystems including coral reefs, seagrasses, and mangroves. Work on climate change contributes directly to management and conservation.

Professor Melissa Nursey-Bray – School of Social Sciences - research on how to engage communities to be part of environmental decision making, particularly in the context of climate change and biodiversity protection. She has worked with Indigenous, ports, local government and fishing communities on a range of projects.

Professor Michelle Waycott – School of Biological Sciences, and Chief Botanist and Head of Science and Conservation, Botanic Gardens and State Herbarium - research on sea grass and coastal ecosystems, including blue carbon, from a species and population, conservation and restoration perspective.

Associate Professor Georgina Drew – School of Social Sciences - research on cultural politics, the emotion-ecology nexus, and inclusive approaches to water management and policy that impact contemporary stakeholders and community water rights.

Associate Professor Damien Fordham – School of Biological Sciences – research on ecology and biodiversity conservation that use computational methods and frameworks that examine responses of biodiversity to global environmental change. Research integrating demographic and biotic

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processes into ecological models has transformed the way that species responses to climate change are forecast and used to inform conservation management and policy.

Associate Professor John Tibby – School of Social Sciences - research on monitoring algae and diatoms to assess marine and aquatic health to improve environmental and human health outcomes.

Dr Peter Atkinson – School of Animal and Veterinary Sciences - research on veterinary epidemiology researching disease occurrence in populations, how to improve productivity, welfare and economics for animal producers.

Dr Marina Delpin – Institute Manager, Environment Institute - focus on strategic research planning and management including partnerships, and research funding, translation and impact.

Dr Alice Jones – Senior Lecturer in Resilience Ecology, School of Biological Sciences - research on understanding and reducing the impacts of climate change by looking to nature for solutions, such as carbon storage (blue carbon) and the other benefits that coastal ecosystems provide for people and nature.

Dr Christopher Keneally – School of Biological Sciences - research on microbial ecology and influence on human, animal, and ecosystem health and role in the environment.

Dr Anna M. Kotarba – Future Making Fellow, Environment Institute and School of Humanities – research on protection, management, and documentation (by means of 'community archaeology') of cultural heritage vulnerable to damage and destruction due to climate change and extreme weather events.

Dr Dominic McAfee – Future Making Fellow, Environment Institute and School of Biological Sciences - research on developing solutions to enable coastal marine ecosystem restorations to be both a social and ecological success. We examine the ecological and socio-ecological interactions that influence ecosystem health and human well-being, so that we can provide an evidence base to inform the sustainable management of coastlines.

Dr Phillipa McCormack – Future Making Fellow, Environment Institute and Adelaide Law School - research on climate change adaptation in Australia, including the effects of climate change on biodiversity and the role of law and policy in facilitating climate adaptation. She has published widely on the challenges and opportunities for legal and policy reform in Australia with the goal of improving nature conservation in a rapidly changing world.

Dr Adriana Milazzo – Senior Lecturer in the School of Public Health – research on infectious disease epidemiology, including the relationship between heatwaves and incidence of disease,
indigenous health, communicable disease control, and national sentinel surveillance system for influenza like-illness.

Dr Jasmin Packer – Research Fellow, Environment Institute and School of Biological Sciences – transdisciplinary research on understanding how ecosystems respond to differing disturbance and other global changes - and what we can do to enhance their capacity to cope with the negative impacts.

Dr Patrick Reis Santos – School of Biological Sciences - research on fish ecology, conservation and management. Use of chemical signatures and other natural tags stored in fish tissues to track migrations, to reconstruct life histories, and assess the impacts of pollution and environmental changes on movement, growth, and recruitment, and to supporting the conservation of critical habitats and advancing fisheries management.

Dr Nina Wootton – School of Biological Sciences - research on environmental issues in the marine space, including science communication and education.

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