



WESTERN AUSTRALIAN
MARINE SCIENCE
INSTITUTION

Assessment of the impact of the Garden Island Causeway on the marine environment in Cockburn Sound: WAMSI/Westport Workshop report

Workshop date:

Thursday 6 September 2018

Location:

Indian Ocean Marine Research Centre (UWA)

Garden Island Causeway Workshop Summary

Westport: Port and Environs Strategy (Westport) is a comprehensive research, data and feedback-gathering project to deliver the Westport Strategy. This will be an integrated plan to meet the freight and logistics needs for Perth and the South West for the next 50 to 100 years. The Western Australian Marine Science Institution (WAMSI) is currently working with Westport to provide marine science information to support their decision making. More specifically, WAMSI is interested in understanding gaps in marine science information to identify areas for future research focus.

The WAMSI Garden Island Causeway (GIC) Workshop was rapidly convened to assist Westport make an immediate decision on whether to pursue an opportunity to modify the GIC to improve the ecological health of the system. To provide immediate advice to Westport, WAMSI convened a workshop with 24 scientists and managers with expertise working within Cockburn Sound (refer to List of Attendees; Attachment 1) to determine whether or not modification of the GIC should be considered.

To provide structure to the workshop, a series of short background presentations were provided on some of the ecological components including: hydrodynamics, seagrass, fish, and coastal processes (refer to WAMSI Workshop Agenda, Attachment 2). The workshop participants were then divided into four groups that workshopped three major questions:

- Workshop question 1: What's the problem in southern Cockburn Sound?
- Workshop question 2: Does the GIC have a net benefit or net impact to the social and environmental values of the system?
- Workshop question 3: Would an increase in flow from the GIC southern end of Cockburn Sound have a net benefit or net impact to the social and environmental values of the system?

The group findings were presented to the wider workshop and were discussed and distilled into major points (refer to WAMSI Garden Island Causeway Workshop Questions and Notes; Attachment 3).

Note that after the workshop, it was apparent that expertise with water and sediment quality within Cockburn Sound had not been adequately represented by the workshop participants. Water and sediment experts Dr John Keesing and Dr Jim Greenwood from CSIRO, were invited to provide a review and critique of the workshop report (this document). The letter of review is provided in Attachment 4.

Summary

Answers to the workshop questions are summarised below:

Workshop question 1: What's the problem in southern Cockburn Sound?

1. We do not have a complete understanding of the system – there are considerable recent and historical data and literature on Cockburn Sound. However, the tools and information for making Adaptive Environmental Management decisions that take into account the impacts of residential and industrial growth (under climate change) are not available. The group felt there was considerable environmental uncertainty related to the effects of and the value in removal of GIC.
2. Sediment quality is poor - historical impacts associated with industrial discharge and nutrient pollution have contributed to a legacy of benthic issues, including accumulation of sediment contamination and low bottom water oxygen concentration in southern Cockburn Sound. The group agreed that southern Cockburn Sound is not dramatically improving, despite significant reduction in both point source contamination from industry and diffuse contamination from the air, runoff and groundwater.
3. Benthic sediments are a sink for contaminants, which likely impact the ecological health of benthic species (e.g. seagrass shoot density has significantly declined), which has a bottom up effect on trophodynamics (i.e. food chain impacts on invertebrates and fish).
4. Physical water mixing is constrained – the GIC has restricted water flow to the depth of the sill (~5 m). However, the workshop participants were uncertain that water quality issues were related to restricted flow. There was consensus that water quality and sediment quality were directly related and impacted by the legacy of sediment contamination. It was agreed that altering the GIC would not achieve an improvement in water and/or sediment quality.
5. Seagrass health is declining – seagrass is stressed and meadows are thinning. Although, expansion of seagrass is occurring into deeper waters within the sound, perhaps due to better water clarity and less sediment contamination legacy issues. Seagrass species distribution is highly variable and chaotic. The 2018 State of Cockburn Sound Marine Area Report states that there has been a significant decline in seagrass shoot density. There was a shared view that modifying the GIC would likely cause more damage to seagrass through increasing the benthic shear in the vicinity of the GIC.
6. Important fauna is in reasonable to good health - the little penguin population that forages within Cockburn Sound (especially the southern half of the Sound) and the resident community of bottlenose dolphins are in reasonable to good ecological health. There is no evidence of impacts from the GIC on migrations of snapper joining breeding aggregations.
7. Coastal processes are described and managed – there was strong consensus that the GIC provides significant protection from prevailing wind and swell, particularly during storm events. There was a strongly shared view that modification of GIC would likely lead to impacts associated with coastal instability, including erosion of seagrass meadows and erosion/accretion of sand in Cockburn Sound. Significant residential and industrial infrastructure, which has increased significantly since the construction of GIC, would be vulnerable to an increase in wave energy.

Workshop question 2: Does the Garden Island Causeway have a net benefit or net impact to the social and environmental values of the system?

1. Benefits of GIC

a. Protection

- i. modified conditions to enable mussel farming and an increase in blue swimmer crab abundance
- ii. provided protected waters from wind and swell, which has increased recreational use (e.g. boating, swimming, water skiing, fishing, beach use)
- iii. provided coastal stability on the Rockingham and Kwinana foreshores
- iv. provided protection for infrastructure (e.g. harbours, boat ramps)

b. Ecological health

- i. seagrass density and the cover of seagrass meadows has increased on Southern Flats
- ii. sediment deposition on Southern Flats has improved seagrass health
- iii. seawall has acted as an artificial reef, increasing biodiversity and biomass of some groups.

c. Important fauna

- i. Little penguin numbers at Garden Island are increasing
- ii. no evidence for negative impacts on snapper stock (at west coast level or within Cockburn Sound)

d. Other

- i. economic benefits – spin-offs from Department of Defence presence
- ii. unknown impacts or protection of indigenous history

2. Impacts of GIC

a. Protection

- i. erosion on One Palm Beach, accretion on west side of Cockburn Sound;
- ii. sediment transport blocking (i.e. lack of sediment by-pass along the Rockingham foreshore) – uncertain about impacts
- iii. poor water circulation around Mangles Bay

b. Ecological health

- i. seagrass health impacts and loss in southern Cockburn Sound – likely associated with anoxia/hypoxia from restricted water exchange, but unable to decipher from sediment contamination due to a lack of information
- ii. impacts on invertebrates and fish (composition/abundance) due to loss of seagrass in southern Cockburn Sound

c. Other

- i. perception that GIC has a negative impact
- ii. uncertainty around impacts (insufficient information to make decisions)
- iii. unknown impacts or protection of indigenous history

3. Impacts vs benefits of GIC

- a. There are more direct benefits than impacts from GIC. While available data are insufficient to draw definitive conclusions, it is considered that removing or modifying the GIC is unlikely to result in a net benefit to social and environmental values of the system.

Workshop question 3: Would an increase in flow from the Garden Island Causeway at the southern end of Cockburn Sound have a net benefit or net impact to the social and environmental values of the system?

1. Possible benefits of increasing flow

- a. Protection
 - i. increase in flushing
 - ii. decreased costs for sediment management (i.e. maintenance of boat ramp sediment accumulation)
- b. Ecological health
 - i. improvement in water quality
 - ii. decrease in sea surface temperature fluctuation
 - iii. increase or decrease in seagrass cover
- c. Important fauna
 - i. may improve fish stocks if more waves result in less access (impacts on fishes are also dependent of individual species relationship with broader west coast stocks)
- d. Other
 - i. may improve visual amenity (removal of built structure)
 - ii. may improve navigation and recreational fishery access

2. Possible impacts of increasing flow

- a. Protection
 - i. increase in wave and wind activity
 - ii. potential disruption to naval activities
 - iii. potential disruption to ports and harbours
 - iv. coastal erosion issues (Kwinana and Rockingham) – increased cost
 - v. more waves, less protection
 - vi. large cost to manage coastal protection
- b. Ecological health
 - i. loss of seagrass
 - ii. ecological impact on other species from loss of seagrass
- c. Important fauna
 - i. sediment resuspension during construction and as a result of more waves may impact the fishery and related species (penguins) (also a social issue)
- d. Other
 - i. large cost and no guarantee of benefits
 - ii. large cost for construction and opportunity lost (i.e. what else could the money be spent on?)
 - iii. construction impacts (also a social issue)

3. Possible impacts vs benefits of increasing flow

- a. While available data are insufficient to draw definitive conclusions, it is considered that the risks to social amenity, ecological stability and highly valued infrastructure are likely to outweigh any ecological gain from potential improved flushing associated with modification of the GIC.

Workshop recommendations

1. There are insufficient data to make confident decisions on the consequences of modifying the GIC.
2. The existing data is disparate, owned by individuals, institutions or industries across many different sectors and with levels of accessibility ranging from freely available to confidential. Effort is required to collate existing data into standardised formats so that it can be shared and interrogated for future needs.
3. Updated approaches to monitoring water, sediment and seagrass health are required to identify gaps and assist in prioritising research to enhance decision making, particularly given the renewed development focus and rapidly changing management needs of Cockburn Sound.
4. Real-time physical oceanographic monitoring data is essential to understand the dominant and fine-scale water circulation patterns in Cockburn Sound. Without these data, future modelling efforts will be constrained and only coarse outputs will result.
5. Hydrodynamic model/s for scenario testing of the flushing characteristics of Cockburn Sound should be employed drawing on all available data (see 2 above) and updated as new data is collected (see 4 above). These models will be particularly important for Westport to help understand the influence of changes associated with new infrastructure or dredged channels on the hydrodynamics and the ecology of this seagrass dominated ecosystem for each scenario. These models should also be scalable to scales that influence seagrasses and other benthic organisms through to broader system-wide water movement.
6. There was a consensus that the risk to the social amenity, ecological stability and highly valued infrastructure would far outweigh any ecological gain from potential improved flushing associated with modification of the GIC. A study investigating the ecological and social implications from modifying the GIC, while useful from a scientific point of view and for providing a conclusive answer to the community in general, was considered highly unlikely to result in a recommendation to modify/replace the Causeway.

Attachment 1

List of Attendees (invited):

Ms	Bree	Atkinson	Water Corporation
Mr	Matt	Buckles	Program Delivery Manager, Westport
Dr	Marion	Cambridge	The University of Western Australia
Dr	Belinda	Cannell	The University of Western Australia
<i>Dr</i>	<i>Delphine</i>	<i>Chabanne</i>	<i>Murdoch University (not able to attend)</i>
Dr	Nick	D'Adamo	UNESCO Intergovernmental Oceanographic Commission – Perth Programme Office
Ms	Eloise	Dortch	Functional Leader Environment, Westport
Mr	Matt	Eliot	Damara WA Pty Ltd (Seashore Engineering)
Mr	Ian	Eliot	Consultant
Dr	David	Fairclough	Department of Primary Industries and Regional Development
Dr	Matthew	Fraser	The University of Western Australia
Mr	Hans	Kemps	Functional Leader, Sustainability and the Environment, Westport
Prof	Gary	Kendrick	The University of Western Australia
E/Prof	Kateryna	Longley	Cockburn Sound Management Council
Dr	Des	Lord	DA Lord & Associates Pty Ltd
Mr	Kevin	McAlpine	Department of Water and Environmental Regulation
<i>Dr</i>	<i>Kathryn</i>	<i>McMahon</i>	<i>Edith Cowan University (not able to attend)</i>
Mr	Peter	Millington	Western Australian Marine Science Institution
Prof	Charitha	Pattiaratchi	The University of Western Australia - UWA Oceans Institute
Dr	Tina	Runnion	Cockburn Sound Management Council
Mr	Patrick	Seares	Department of Water and Environmental Regulation
Dr	Jenny	Shaw	Western Australian Marine Science Institution
<i>Dr</i>	<i>Joshua</i>	<i>Smith</i>	<i>Murdoch University (not able to attend)</i>
Dr	Ray	Steedman	WAGOOS
Dr	Alicia	Sutton	Western Australian Marine Science Institution
Dr	Luke	Twomey	Western Australian Marine Science Institution
<i>Dr</i>	<i>Trevor</i>	<i>Ward</i>	<i>University of Technology Sydney / Greenward Consulting Perth (not able to attend)</i>
A/Prof	Peter	Waterman	University of the Sunshine Coast

Attachment 2**WAMSI WORKSHOP**

1.00pm-3.30pm, Thursday 6th September 2018
Indian Ocean Marine Research Centre (IOMRC) Crawley
5th Floor Board Room

AGENDA

#	Item	Presenter	Minutes
1	WAMSI Introduction	Luke Twomey	5
2	Westport Introduction	Hans Kemp	5-10
3	Hydrodynamics in southern Cockburn Sound	Chari Pattiaratchi	5-10
4	Seagrass in southern Cockburn Sound	Gary Kendrick	5-10
5	Fish in southern Cockburn Sound	David Fairclough	5-10
6	Coastal processes in southern Cockburn Sound	Matt Eliot	5-10
7	General discussions / Afternoon Tea		15
8	<u>Workshop question 1</u> : What's the problem in southern Cockburn Sound?		20
9	<u>Workshop question 2</u> : Does the Garden Island Causeway have a net benefit or net impact to the social and environmental values of the system?		20
10	<u>Workshop question 3</u> : Would an increase in flow from the southern end of Cockburn Sound of the Garden Island Causeway have a net benefit or net impact to the social and environmental values of the system?		20
11	<u>Advice to Westport</u> : What should Westport do to include or remove the Garden Island Causeway as an issue for consideration in ongoing strategic planning?		10

WAMSI GARDEN ISLAND CAUSEWAY - WORKSHOP QUESTIONS AND NOTES

	Positive Impacts	Negative Impacts	Discussion Outcomes
<p><u>Question 1</u>: What's the problem in southern Cockburn Sound?</p>			<p>General comments</p> <ul style="list-style-type: none"> • We don't understand the system fully • Benthic issues – pollution/ accumulation • Sediment and legacy from industrial use • Definitely need real-time physical oceanographic monitoring • Competition between recreation and industry • Health issue –water quality vs other stressors (sediments) • Critical to carefully review in detail Causeway studies - seawater circulation-related studies and west coast desalination outfall monitoring data • The Southern Sound is “not improving” • Penguins are doing well – Garden Island (but generally not at Penguin Island). Forage in southern Cockburn Sound during breeding. • Hydrodynamic connection between north and south of the Sound – investigation needs to be re-done in the context of: <ul style="list-style-type: none"> a) New physical structures (port) and related bathymetry of Westport b) Desalination impacts to fisheries. Unknown impacts on (e.g. Snapper eggs, larval survival/juvenile survival/dispersal/crabs etc.) c) Change to south opening flow areas 900 m (600 m +300 m). <p>Water quality issues</p> <ul style="list-style-type: none"> • Poor water quality (i.e. de-oxygenated, relative to rest of Cockburn Sound) • More phytoplankton biomass and blooms? • Water quality is documented in Cockburn Sound Management Council reports • Uncertainty that water quality issues are related to restricted flow? • Lack of consensus on GIC impacts?

			<ul style="list-style-type: none"> • Mangles Bay water quality is generally lowest dissolved oxygen <p>Seagrass issues</p> <ul style="list-style-type: none"> • Seagrass is actually stressed • Thinning of meadows – bottom up impact on fish/invertebrate community • Seagrass is expanding into deeper waters • Variable population of species, chaotic <p>Shoreline maintenance</p> <ul style="list-style-type: none"> • Coastal erosion issues, especially Rockingham • Scouring effects (e.g. Southern Flats)
<p><u>Question 2:</u> Does the Garden Island Causeway have a net benefit or net impact to the social and environmental values of the system?</p>	<ul style="list-style-type: none"> • Little penguin numbers on Garden Island are increasing • Royal Australian Navy presence also helped penguins • Created habitat for blue swimmer crabs, recent years numbers have dropped, likely for a range of reasons • Uncertain whether fish stocks benefited at that small scale • Seagrass coverage increased on Southern Flats <p><u>Social benefits</u></p> <ul style="list-style-type: none"> • Royal Australian Navy (RAN) facility – economic benefits • Mooring and boating • Swimming, beach use • Rockingham foreshore and Kwinana stabilised • Protection from wind for boaters, moorings, skiers • Seagrass on Southern Flats • Established benthic community on Causeway • Reduced flushing helped mussel industry and blue swimmer crabs • Protection of shoreline 	<ul style="list-style-type: none"> • Reduced flushing <ul style="list-style-type: none"> a) Net flushing decreased b) Way it enters/exits • Erosion on One Palm Beach • Accretion on west side of Cockburn Sound <p><u>Negative social</u></p> <ul style="list-style-type: none"> • Loss of Garden Island public use • Perception that Causeway is a negative effect • Lack of sediment by-pass along Rockingham shoreline • Circulation – around Mangles Bay • Seagrass growth • Sediment transport blocking • Localised anoxia in sediments • Seagrass loss, which impacts on fishes/invertebrates (composition/abundance) • Sediment transport impacts (unsure of impact on social/environmental values) • Uncertainty about impacts 	

	<ul style="list-style-type: none"> • Infrastructure/harbours • Recreational/calm waters • Sediment deposition assists seagrass • Recreational fishing • Protection for beach use • Economic benefits (Department of Defence) • Act as an artificial reef • Enabled mussel farming • No evidence for negative impacts on snapper stocks (at west coast stock level or CS). • Unknown impacts for indigenous history 	<ul style="list-style-type: none"> • Water quality questions? • Unknown impacts for indigenous history 	
<p><u>Question 3:</u> Would an increase in flow and waves from the southern end of Cockburn Sound of the Garden Island Causeway have a net benefit or net impact to the social and environmental values of the system?</p>	<p>If there were any modifications to the Causeway the benefits could be:</p> <ul style="list-style-type: none"> • An increase in flushing (which could also be seasonal). • Potential decrease in cost for digging out the boat ramp near the Causeway (i.e. better sediment management) <p><u>Positive environmental</u></p> <ul style="list-style-type: none"> • Potential improvement in water quality • Potential decrease in sea surface temperature fluctuation • Ultimately we don't know what the positives and negatives will be • If the Causeway was modified to a trestle bridge, this was predicted to have a net environmental benefit • Potential increase in seagrass cover • Potential positive impact on water quality <p><u>Positive social</u></p> <ul style="list-style-type: none"> • Potentially more fish for recreational fishery if more waves results in less 	<p>If there were any modifications to the Causeway the impacts could be</p> <ul style="list-style-type: none"> • Potential reduced seagrass cover • Increased wave activity (depending on modification) • Potential disruption to industrial/RAN activities in Cockburn Sound • Including in size of sediment sink in flats • Potential large costs with modifications when there may be no guaranteed benefits. <p><u>Negative environmental</u></p> <ul style="list-style-type: none"> • Potential negative impact on fish stocks then potential impact on seagrass • Create bigger instability issues in Rockingham/Kwinana foreshore – increased risk to coastal infrastructure • Increased sediments would potentially lead to decreased seagrass which would lead to decreased fish. <p><u>Negative social</u></p> <ul style="list-style-type: none"> • If there are more waves then potential decrease in recreational fishing 	<ul style="list-style-type: none"> • Ultimately we don't know what the positives and negatives will be • Possible improvement/degradation around

	<p>fishing (see first dot point Negative Social). Impacts on fishes are also dependent on individual species relationships with broader west coast stocks; and status of crab stocks in Cockburn Sound</p> <ul style="list-style-type: none"> • Increased visual amenity if the Causeway is modified (removal of built structure and improved natural outlook) • Modify Causeway in a way that allows navigation and better recreational fishery access 	<ul style="list-style-type: none"> • If we are spending more money on the Causeway then what are we foregoing? (i.e. where else could we better spend that money?) • Potentially more waves • May require more coastal protection/management (due to waves) • It could therefore be a worse place for berthing ships as a port or future harbour • Construction impact • If Causeway modified, then potential coastal impacts on modification/removal (negative impacts on seagrass during construction phase) • Re-suspension of sediment – potential fishery impacts (penguins) • Could these be reduced/negated through engineering? • Potential interactions with sea level rise? • Potential impact on water quality and other environmental impacts. • Cost of protecting southern Cockburn Sound 	<p>Mangles Bay – but we don't know</p> <ul style="list-style-type: none"> • There may be more circulation – would this be a positive or a negative outcome? • Do we really know with any certainty what impacts will be?
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Advice to Westport: What should Westport do to include or remove the Garden Island Causeway as an issue for consideration in ongoing strategic planning?

Prof Chari Pattiaratchi advised a continuous forecast model available at: <http://coastalocyanography.org/> (this has been running continuously since 2016).

- Does it make sense to conduct a comprehensive study relating to modifying the Causeway? What evidence do we have that there is, in fact, a problem?
- If such a study were conducted, then the outcomes could be incorporated in Westport's advice to Government.

Assoc. Prof Peter Waterman advised that over the last 40 years or so he has never heard a consensual view of what the benefits or negative impacts of the causeway could be. He noted that in 1969, Dr Joe Gentilli, Reader in Geography UWA, presented a paper at the Australian New Zealand Society for the Advancement of Science recommending that there should be an integrated study of Cockburn Sound *to address the information deficiencies in the light of proposed major maritime works by the Commonwealth and the Fremantle Port Authority*. The suggestion was taken up by the Fremantle Port Authority and this spawned more than a generation of research activities. As well, it led to a joint research initiative between the Authority and the Commonwealth Department of Works (CDW) that between 1970 and 1975 produced baseline reports on the hydrodynamics, coastal geomorphology and components of the marine ecosystem. This work documented pre and early post causeway conditions.

Peter Waterman also reported that a proposal has been prepared and circulated for a Longitudinal Case Study (LCS) to address the question: *what measurable effects has the Garden Island Causeway (GIC) had on the environmental conditions of the southern sector of Cockburn Sound*. He went on to say that: *The CSMC were supportive of the initiative but have no funds to support any activities.*" The LCS proposal suggests: *Holding a symposium or forum to celebrate the success of the infrastructure and its engineering and environmental performance as an extemporary example of team approaches and commitment to integrated approaches to planning, design, delivery and monitoring of the measurable effects of maritime projects. Contributory papers or presentations could be sought from researchers who over the past fifty years have contributed to enhancing knowledge on the environmental conditions and values of Cockburn Sound and environs. Proceedings could be made available publically.* The event could be badged to commemorate the contribution to integrated multi-disciplinary research projects initiated fifty years ago by Dr Joe Gentilli and other senior researchers from UWA such as Ernest Hodgkin from Zoology, GG Smith from Botany, Brian Logan from Geology and Alan Rundell and Tony Sheppard from Geography.

Peter Waterman advised that in the last 50 years he has never heard a consensus of what the benefits or negative impacts would be.

Mr Patrick Seares commented that there seemed to be around 90% consensus of Workshop attendees that "it would not provide the best bang for our buck" to do a study investigating modification of the GIC.

Prof Gary Kendrick recommended ongoing real-time physical oceanographic monitoring was needed. Professor Kendrick strongly suggested that real time data were important to truly understand what was happening in Cockburn Sound. These data are critically important to ensure accurate and verified modelling.

Hydrodynamic models would be useful for testing scenarios related to major physical changes (i.e. shipping channels, physical structures associated with port infrastructure).

It was proposed that the recommendations from this Workshop be written up advising this is what generally was felt by the attendees. *"Please don't reinvent the wheel – there are 50 years' worth of valuable data (sporadic and episodic) that should be reviewed before we start anything further."*

Important to get ALL data in a format that we can interrogate - it is currently in different formats which make it very difficult to compare.

Attachment 4

Letter of review from Drs Keesing and Greenwood (CSIRO Oceans & Atmosphere Research) to Luke Twomey (WAMSI CEO), received 2 July 2019.

Dear Luke

Thank you for the opportunity to review the summary of the WAMSI workshop on the Garden Island Causeway held in September last year.

It is good to see an evaluation being made of the pros and cons of modifying or removing the Garden Island Causeway and, in particular, the impact this may have on environmental values in Cockburn Sound.

CSIRO have carried out some recent work on water quality in Cockburn Sound and most of our comments here, are based on our understanding of the Cockburn Sound system developed during that work. These reports are listed below.

Although the report makes some good points, we disagree with the overall conclusion that modifying the GIC would not lead to environmental benefits.

The report states: "It was agreed that altering the GIC would not achieve an improvement in water and/or sediment quality". It is difficult to see how the participants came to this conclusion when they were "uncertain that water quality issues were related to restricted flow", didn't "have a complete understanding of the system", and "felt there was considerable environmental uncertainty related to the....removal of the GIC"?

We are of the view that any measure that facilitates greater exchange of water in the Sound with that from the open ocean will improve water quality in Cockburn Sound. While this can be stated categorically, the extent to which modifying the GIC will achieve this cannot be stated without a study to determine it. The potential for disbenefits should not outweigh a thorough consideration of the benefits.

A recent nutrient budgeting exercise conducted for the CSMC (Greenwood et al. 2016) highlights how slow circulation has contributed to the long-term build-up of nutrients within the sediment, that are now slowly breaking down. This is the most likely cause of sulphide accumulation in the sediment, and low oxygen content in bottom waters. The former is thought to be a significant factor in declining seagrass health (Fraser and Kendrick 2017) and the latter has been implicated in fish kills in the Sound. There is good evidence that nutrients are being released from the sediment all the time. Some of the nutrients are lost to the adjacent shelf, some lost to bacterial de-nitrification, and the rest of it is taken up by phytoplankton, and ultimately ends up back in the sediment. There is no doubt that increasing exchange with the shelf would alter the nutrient balance, but by how much, and how quickly, is presently unknown.

While we agree that more work is needed to build on our current levels of understanding of Cockburn Sound, we think that it is a mistake to shroud issues related to environmental quality in a cloak of "it's complicated/not enough data" as this report seems to do. There has been a lot of work done on Cockburn Sound recently and we think we understand the dynamics pretty well. Historically the Sound was badly polluted by nutrients from sewage and fertiliser. Poor circulation caused high residence times and seagrass died from over growth of epiphytes. Over time, remediation works have resulted in very low inputs of nutrients to the Sound at present. Annual inputs are now predominantly from the legacy of contaminated groundwater migrating towards the Sound, and it's likely this has peaked and will gradually reduce over time (especially as the climate continues to dry and groundwater levels fall). However, the legacy effects of an enormous amount of organic loading in the sediments coupled with little exchange of water means that the system is now essentially a recycling system and further meaningful gains in water quality from nutrient mitigation works are unlikely. This is obvious as declines in water column nutrients have not been matched by consistent declines in chlorophyll. We think now, depending on rainfall, that as little as 13% of the annual nitrogen budget depends on groundwater intrusion. Nutrient recycling from sediments fuels the phytoplankton production which now uses >90% of nitrogen used in primary production in Cockburn Sound. As a result, light levels in areas that used to support seagrass remain below 10% of surface irradiance. Couple this with the impacts of sulphide intrusion on seagrass health (Fraser and Kendrick, 2017), the inability of seagrass to recover is understandable.

We also think that some of the putative disbenefits of removing the causeway cited in the workshop report are unconvincing and that given the uncertainties referred to in the report that this comes across as lacking balance in places. The report is quite empathic about the disbenefits of removing the causeway while at the same time saying there is great uncertainty about whether removing it would provide any benefits. For example, It is difficult to see how it is possible to conclude that removing the causeway would create so much extra flow that it will scour existing seagrass beds such that they would be lost and that the increase in waves would cause significant coastal erosion AND simultaneously conclude that removing the causeway would not increase water circulation and exchange with the shelf sufficiently to improve water quality.

It is difficult to see how anything that does not facilitate further exchange of water with the open-ocean and gradual export of nutrients out of the Sound will lead to any improvement. It is also difficult to see how a solution that does not include at least partial replacement of the causeway with a bridge could achieve this. The issue warrants a thorough examination and study.

We would be happy to participate in further analysis of these issues.

Regards

John Keesing and Jim Greenwood

CSIRO Oceans & Atmosphere Research

References:

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