Scientific basis for excluding the Burnett/Mary catchments from 'Reef Regulations'.

Executive Summary

The *Environmental Protection (Great Barrier Reef Protection Measures) and Other Legislation Amendment Act 2019*, was designed to apply to Great Barrier Reef river catchments. However, the legislation does not stipulate a geographical, or scientific property of a catchment that defines it as being a "Reef river catchment." Instead, Reef catchments are "prescribed by regulation"[1]. The government in 2019 prescribed the Burnett and Mary Catchments as Reef catchments without presenting any scientific reasoning despite the following objections.

- The Burnett and Mary rivers do not discharge into, or anywhere near, the Great Barrier Reef Marine Park.
- The closest coral reef (in the Capricorn-Bunker sector) is 75 km north of the Burnett mouth, and 120 km from the Mary mouth.
- The East Australia Current (EAC), runs predominately southwards, taking river discharge predominantly away from the Great Barrier Reef.
- The Capricorn Bunker Sector of the Great Barrier Reef, which is nearest to the Burnett/Mary mouths, is flushed by the huge quantities of water in the East Australia Current (EAC) – quantities that completely dwarf the Burnett/Mary flows.
- The water flow of the Burnett River for an entire year is equivalent to just two minutes flow of the EAC. And the EAC direction is largely taking river discharge southwards.
- Sediment: The nearest reefs to the Burnett/Mary are bathed, continuously, in sparkling blue waters of the Pacific Ocean. There is effectively zero sediment on these reefs indicating zero impact from rivers.
- Nutrients: The Capricorn eddy, which is often embedded in the EAC, upwells vast amounts of deep, nutrient-rich, water to the Capricorn Bunker Reefs. This eddy delivers up to ten times as much nutrients as the Burnett River, and very close to the reefs, rather than over 75 km distant for the Burnett. In addition, recycling of nutrients on the sea bed is around 100 times the discharge of the Burnett.
- Pesticides: Pesticides are in unmeasurably small concentrations on the entire main reef matrix of the GBR where 99% of the corals exist.

The worst facet of this issue is that no evidence has ever been advanced for why the Burnett/Mary catchments were defined as reef catchments in 2019. A useful step forward would be to invite the relevant science and management institutions to produce evidence for why the inclusion might be continued. This would provide a useful basis for a genuine scientific debate that would be valuable for the government to consider possible changes to the catchments prescribed, by regulation, as reef catchments.

[1] Section 75(1)

(1) Reef Regulations: The legislation

The Environmental Protection (Great Barrier Reef Protection Measures) and Other Legislation Amendment Act 2019, applies largely to agricultural operations and is environmental Red-Tape on top of other legislation that already applies to every part of Queensland. Among other factors that reduce productivity, these 'Reef Regulations' impose added restrictions on fertilizer and pesticide use, and require a lengthy and costly bureaucratic procedure to change land use (for example changing crop types and developing new commercial cropping areas). In addition, the legislation is written in such a way that a future government can easily escalate the restrictions on agriculture by changing the regulations associated with the legislation. Because they can be escalated so easily by a future government, Reef Regulations are thus a Sword-of-Damocles hanging over the future agricultural sector.

Reef Regulations were designed to apply to Great Barrier Reef (GBR) river catchments. However, the legislation does not stipulate a geographical, or scientific property of a catchment that defines it as being a Reef catchment. Instead, a *"Great Barrier Reef catchment is the area shown on a map prescribed by regulation as the Great Barrier Reef catchment."* [2] In other words, the government draws a map with catchments that it defines as the GBR catchments – as shown in Figure 1.

It is notable that the Burnett and Mary River mouths are well south of the Great Barrier Reef Marine Park (GBRMP) (figure 2). Unlike all other catchments, further north, these rivers do not directly impact the GBRMP. They are thus different from all other GBR catchments, and no reason was given by the previous government why the Burnett/Mary were defined as Reef catchments.

Because the Burnett/Mary does not flow into the GBRMP, the onus of proof should rest with those wishing to include these rivers as 'Reef catchments' to show that there is some impact of the rivers on the GBR.

In the absence of any scientific argument why the Burnett/Mary were defined as reef catchments, the following gives reasons why the effect of these catchments on the GBR is completely negligible.

(2) Proximity of Burnett/Mary catchments to the GBR

The nearest coral reef to the Burnett and Mary River mouths is Lady Elliot Island Reef, which is respectively 75km and 120 km away (Figure 3). In addition, the distance to the GBRMP is respectively about 30km and 80 km from the Burnett and Mary Rivers respectively. Given the large distance of the rivers to even the closest single reef of the GBR, there needs to be very compelling evidence that the rivers affect the GBR. As will be shown

[2] Section 75(1)

below, data on the behaviour of the ocean currents in the region demonstrates that the impact of the rivers must be negligible.

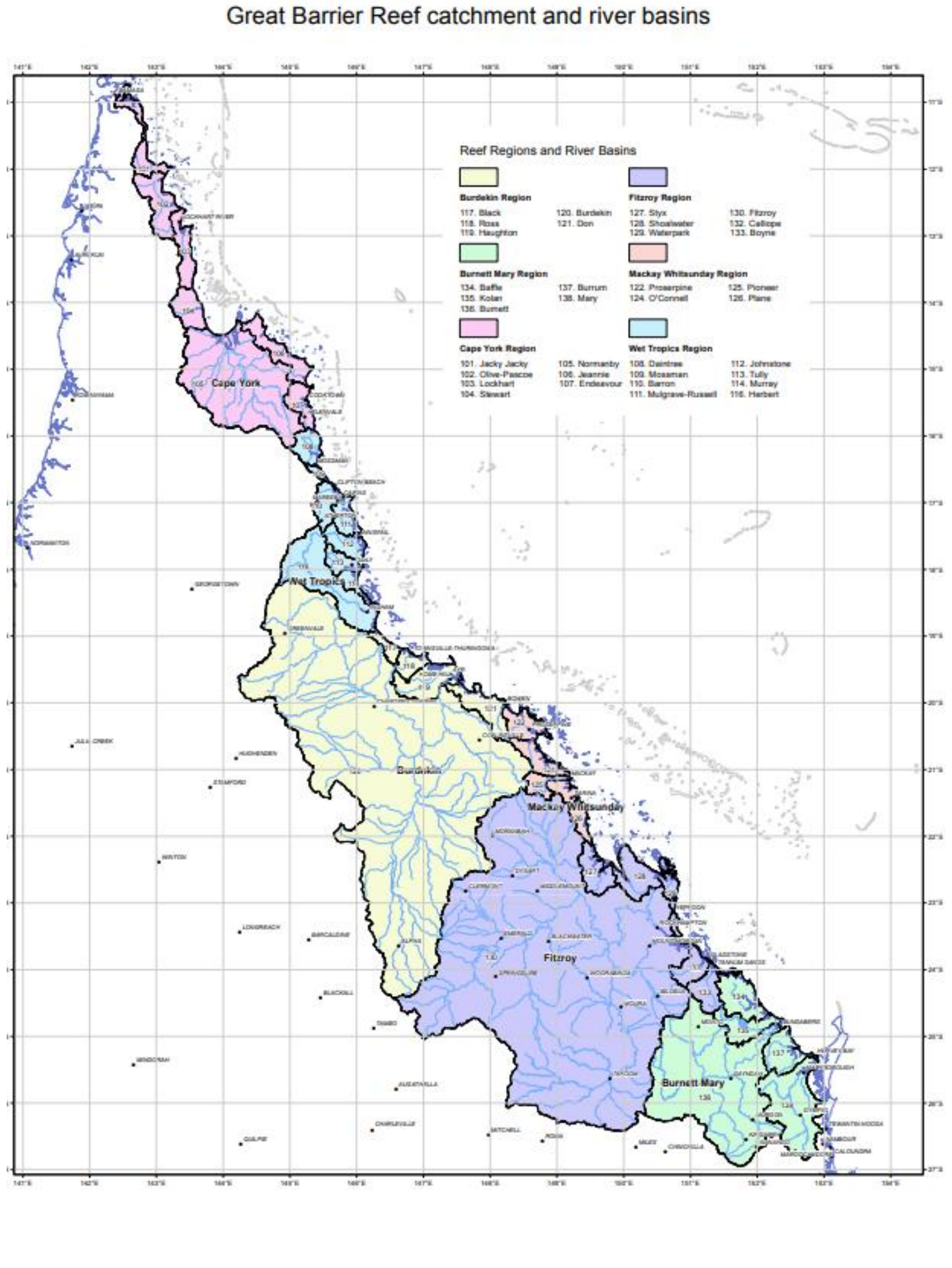

Figure 1: Great Barrier Reef Catchments and River Basins Map which defines the area that fall under Reef Regulations.[3]

[3] https://www.qld.gov.au/__data/assets/pdf_file/0019/105247/gbr-catchment-river-basins-map.pdf

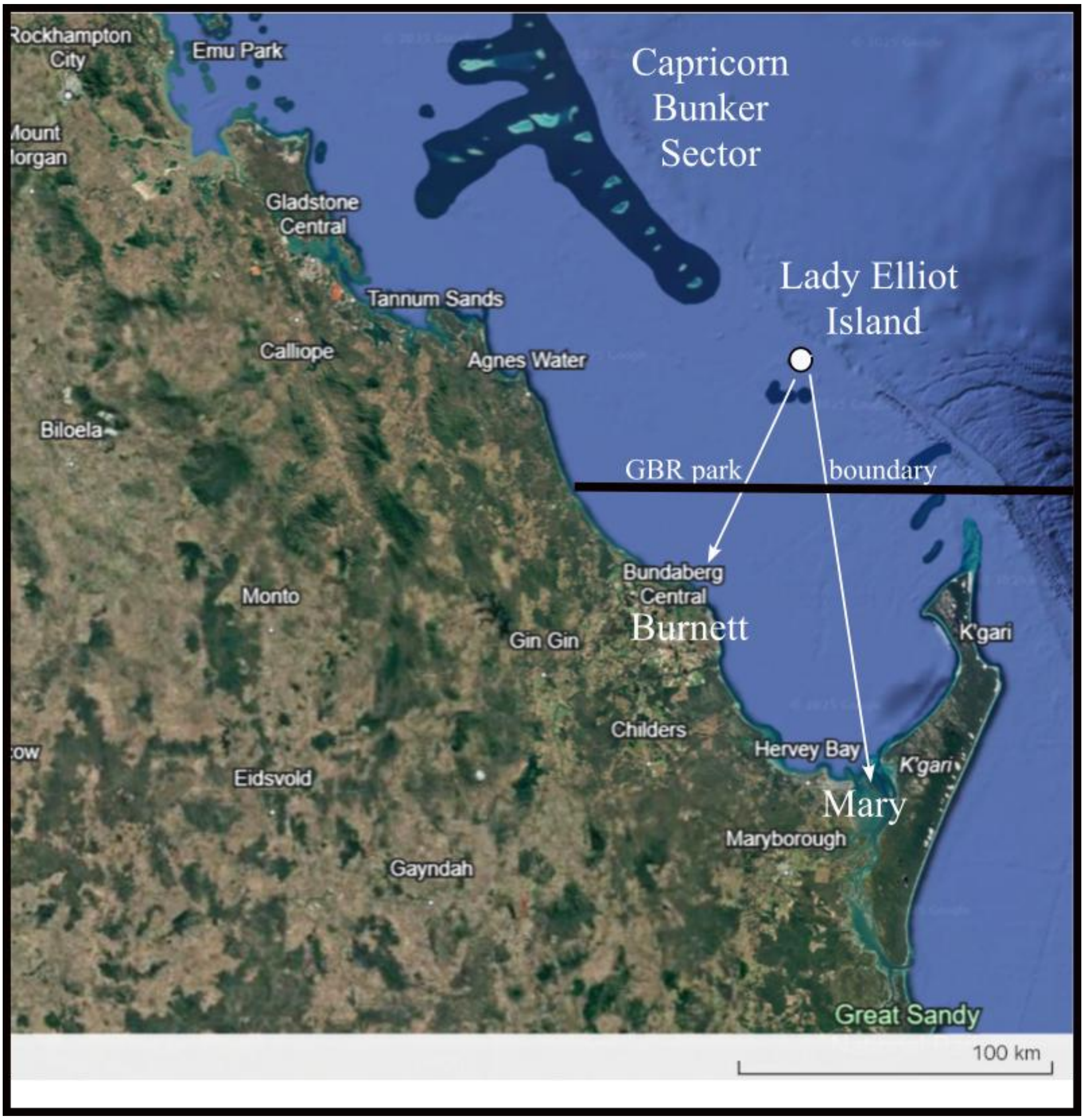

Figure 2: Google Earth image of Burnett River mouth relative to Lady Elliot Island Reef, which is the most southern reef of the GBR. This reef is 75km and 120 km from the Burnett and Mary mouths respectively. The GBR marine park is north of the black line.

(3) Ocean Currents

The ocean currents in the region offshore from the Burnett/Mary means that almost all the river discharge will we be moved south away from the GBR, and whatever remains will be massively diluted to the point of complete negligibility. The East Australia Current (EAC) (Figure 3a and 3b) starts around the central GBR and flows south past the Bundaberg region. For much of the time the EAC recirculates in the Capricorn eddy as shown in figure 3a. Figure 3b shows the typical flow when the eddy is absent.

Vast quantities of water recirculate past the Capricorn Bunker Sector[4] of the GBR, which is the group of reefs closest to the Burnett/Mary (see figure 2, 3a and 3b). The quantities of water flowing in these ocean flows is prodigious. For example, the EAC mean flow of 22 million cubic meters per second is 275000 times the mean flow of the Burnett, and over 400000 times that of the Mary. Table 1 shows some of the statistics of the river and ocean current flows. An entire year's flow of the Burnett is equivalent to around 2 minutes flow of the EAC. In order to place the huge numbers of the EAC flow rate into some perspective, the time for each to fill Sydney Harbour is given. The EAC could fill Sydney Harbour in just 20 seconds, compared to 50 days for the Burnett River.

It is this clear that the main factor that determines the water-quality of the Capricorn Bunker Reefs is the enormous 'river' of ocean water (EAC), which flows close by and around the reefs. The trivial quantities of water that come from the Burnett/Mary rivers, which are also very far from the reefs, are essentially irrelevant to the GBR.

The effect of the EAC is two-fold. First, pollutants that reach any significant distance out to sea will be caught in the huge ocean flows which largely runs south. Second, any material that does move north, will be diluted in the colossal volumes of ocean water circulating into, and out of, the Capricorn -Bunkers region. Concentrations of any man-made material such as fertilizer and pesticides, which may be in low concentrations in the river flow, will be diluted to completely negligible quantities by this mixing.

Flushing of the GBR water by ocean currents is an important, but often ignored, feature of the entire GBR. For the regions offshore from the Burnett/Mary, it is particularly enormous due to the location and behaviour of the EAC. For this region alone, the Burnett/Mary catchments should be considered in a different category to all the other catchments that are defined as GBR catchments in the Reef Regulations legislation.

[4] Note: Lady Elliot Island is the southern most reef in this group

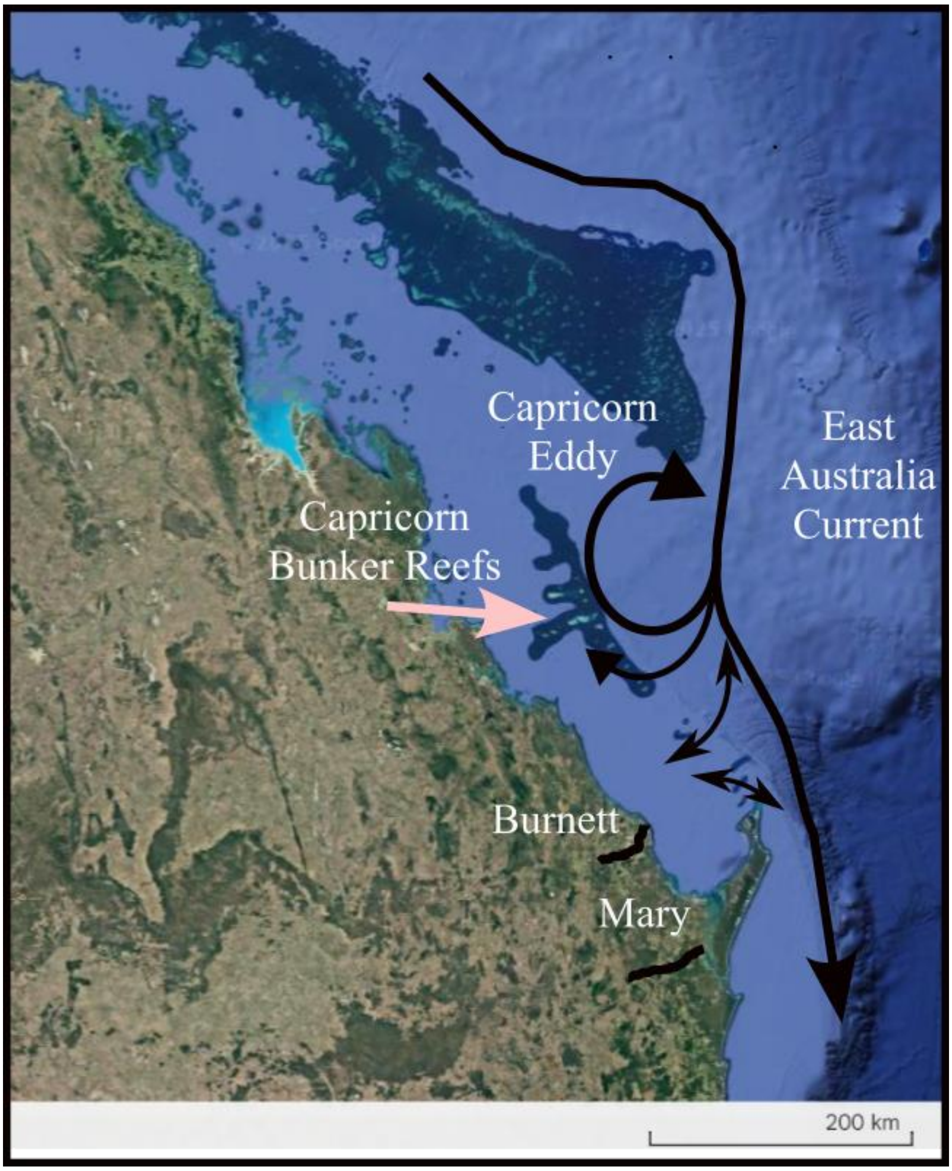

Figure 3a: The East Australia Current (EAC) and associated Capricorn Eddy recirculating flows offshore from the Burnett/Mary rivers. Any material emanating from the rivers reaching the offshore areas will be quickly moved south by the EAC or massively diluted by the vast quantities of water circulating on to the continental shelf.

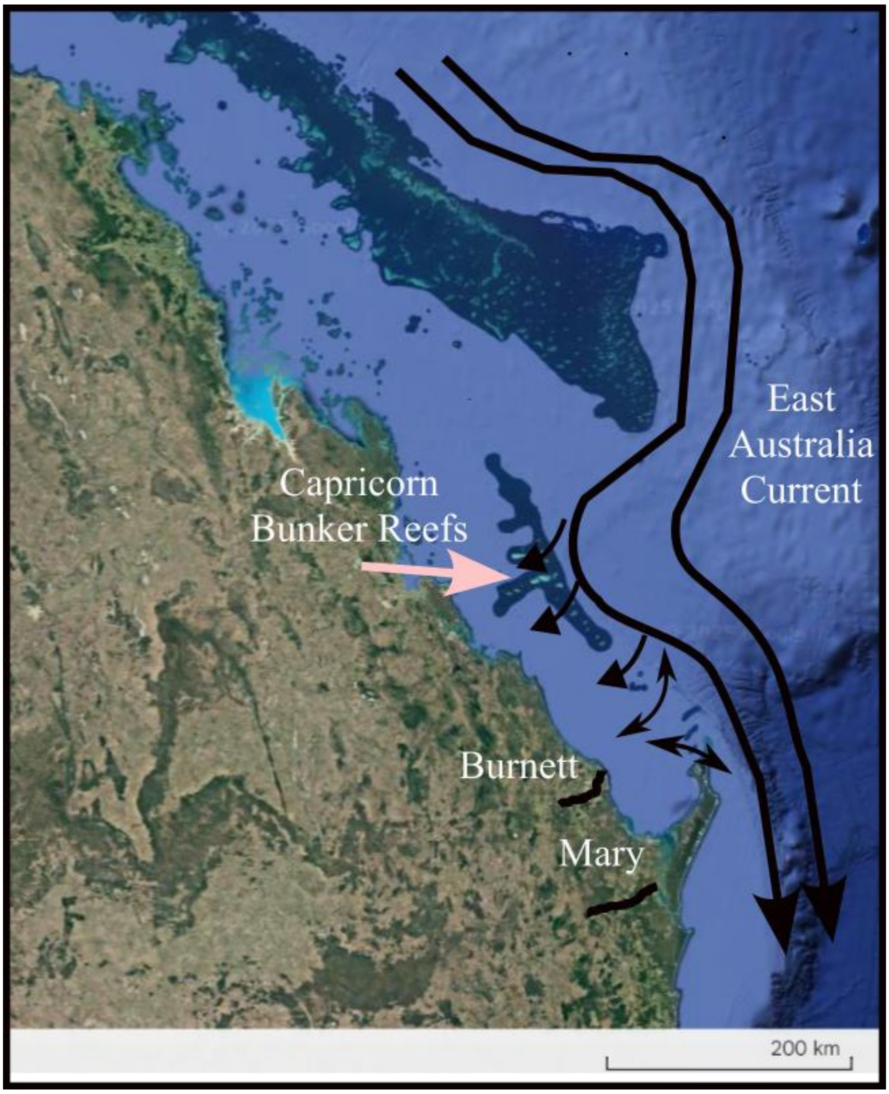

Figure 3(b) The East Australia Current during periods when Capricorn Eddy is absent. [5]

[5] Based on data from https://earth.nullschool.net/ for 15 March 2025

	Width (km)	Depth (m)	Mean Flow m^3/s	Time to fill Sydney Harbour
Burnett	**0.25**	**10 (in flood)**	**80**[6]	**50 days**
Mary	**0.25**	**10 (in flood)**	**55**	**80 days**
East Australia Current	**100**	**500**	**22000000**[7]	**20 seconds**

Table 1: Dimensions and flow rate of the Burnett R., Mary R., and East Australia Current.

(4) Mud:

There is no data available on the quantity of sediment emanating from the Burnett/Mary that reaches any of the reefs of the GBR. Three factors indicate that the quantities must be negligible. First, the distance to the nearest reef from the Burnett River is 75 km. Second, when sediment-laden river water meets the sea, a process of flocculation occurs which binds fine clay particles together causing them to drop out of suspension usually within a few kilometres of the river mouth[8]. Thus, even the fine sediment cannot be transported very far once it enters the ocean. Thirdly, the sediment composition of the Lady Elliot Island Reef, with its sparkling white coral sand (see figure 4), confirms that only very small quantities of land-derived sediment reach the GBR.

[6] https://en.wikipedia.org/wiki/Burnett_River

[7] Sloyan B.M, Cahill M, Roughan M, Ridgway K. (2020). East Australian Current variability. In Richardson A.J, Eriksen R, Moltmann T, Hodgson-Johnston I, Wallis J.R. (Eds). *State and Trends of Australia's Ocean Report*. doi: 10.26198/5e16a23f49e75

[8] Livsey, D. N., Crosswell, J. R., Turner, R. D. R., Steven, A. D. L., & Grace, P. R. (2022). Flocculation of riverine sediment draining to the Great Barrier Reef, implications for monitoring and modeling of sediment dispersal across continental shelves. *Journal of Geophysical Research: Oceans*, **127**(7), e2021JC017988. https://doi.org/10.1029/2021JC017988

Figure 4 Lady Elliot Island. Photo -Wikipedia

(5) Fertilizer 'pollution'.

There is no data available on the quantity of nitrogen and phosphorous nutrients (fertilizer) emanating from the Burnett/Mary that reaches any of the reefs of the GBR. Three factors indicate that the impact is negligible. These are (a) the vast inflow of the EAC will dilute any discharge from the Burnett/Mary, (b) there are far larger amounts of nutrients that naturally cycles across the seabed than come from the Burnett/Mary rivers, and (c) the Capricorn Eddy is responsible for upwelling deep, nutrient rich, offshore water around the Capricorn Bunker reefs – far greater amounts than come from the Burnett/Mary rivers, which are also much further from the reefs than the upwelling zone. The latter two points are expanded below.

5.1 Nutrient cycling on the Continental shelf

It is often assumed that the only source of nutrients to the GBR is from river discharge. However, there are vast nutrient fluxes operating naturally in the water around the reefs and between the reefs and the land[9]. There is no data available for the nutrient budget of the continental shelf offshore from the Burnett/Mary. However, there is data from other parts of the GBR which indicate that river discharge is only 1% of the biggest nutrient flux which is

[9] See Furnas et al 1995. https://elibrary.gbrmpa.gov.au/jspui/handle/11017/240

continuous cycling of nutrients across the sea-bed as shown in Figure 5. It can be seen that the river discharge is about twice the direct nitrogen input from rain falling on the ocean. Another very large flux of nutrients is water flowing into and out of the GBR lagoon in ocean currents which is about 100 times that of the river discharge.

Data used to construct Figure 5 comes from the Tully region of the GBR where upwelling of deep ocean water is relatively small compared to that of the Burnett/Mary regions (see next section). Nevertheless, upwelling is still of comparable magnitude as the river input – but right next to the reefs, rather than many tens of kilometres distant.

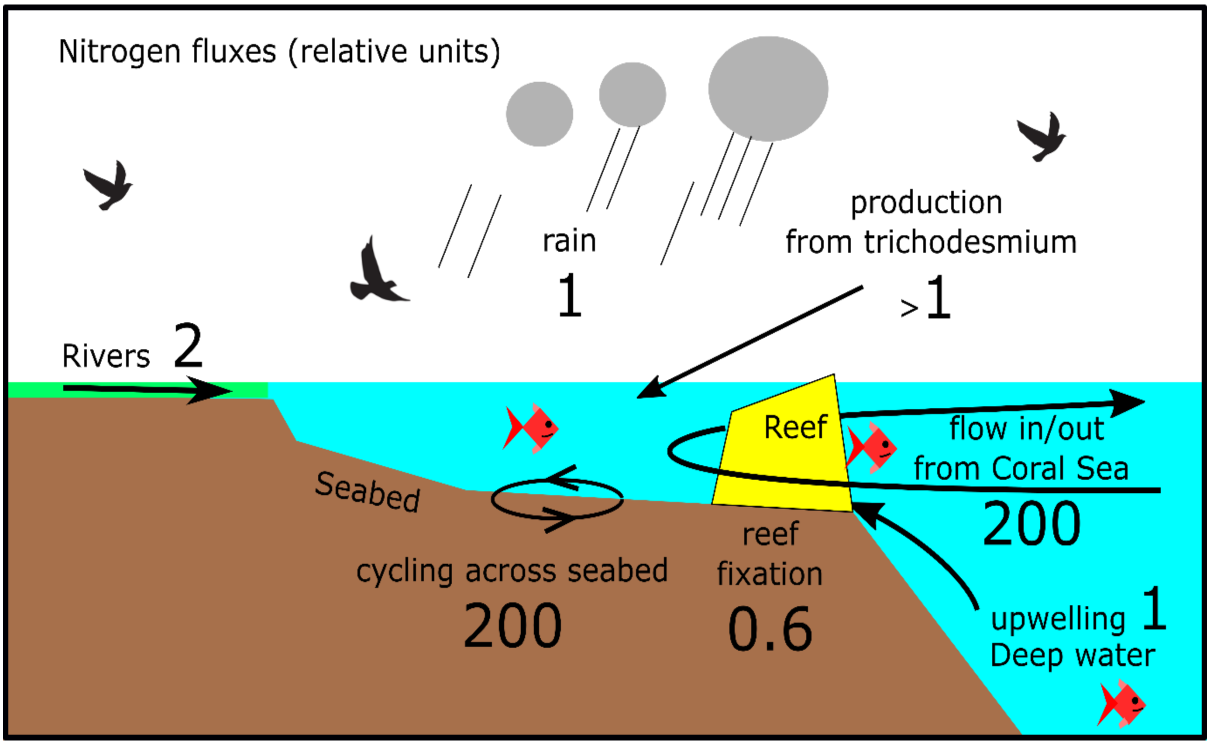

Figure 5: Nitrogen fluxes in the Tully region from Furnas *et al.* (1995)[10]. Figures represent normalised nitrogen fluxes into and out of the ocean with. 1 unit represents the flux into the ocean directly from rainwater. Cycling of sediment across the seabed and inflow from the Coral Sea dominate the nutrient fluxes.

5.2 Nutrient Upwelling from Capricorn Eddy.

When the Burnett/Mary rivers were gazetted as 'Reef Catchments' in 2019, no data was presented on any of the nutrient fluxes in the region, and certainly nothing for the importation of nitrogen, around the reefs, due to upwelling from the deep ocean offshore from the reefs. The 2022 Reef Scientific Consensus Statement states nitrogen is a limiting nutrient in marine water and further knowledge is required to understand marine nutrient variability due to

[10] https://www.australianenvironment.org/gbr-report-2024. Based on data from Furnas et al 1995. https://elibrary.gbrmpa.gov.au/jspui/handle/11017/240

upwelling and oceanic processes[11]. However, data was available, even in 2019, demonstrating that prodigious quantities of deepwater nitrogen nutrients were being upwelled in the Capricorn Buker region[12].

In most of the ocean, there is a sharp change in temperature below 100m water depth known as the thermocline. This exists because the influence of waves mixes water down to about 100 m. The water above the thermocline is relatively deficient in nutrients because there is enough light for phytoplankton to use almost all available nutrients. However, below the thermocline, the water is cooler and has very high concentrations of nutrients. Most of the reefs of the GBR, even those on the outer edge of the continental shelf are in water less than 100 m deep, and are thus relatively unaffected by this deep water. However, the Capricorn Bunkers are different to the rest of the GBR because of the frequent presence of the Capricorn Eddy. Cyclonic eddies, are like a vortex in a stirred tea-cup, or the centre of a tornado – the water at the centre of the eddy is brought to the surface. Weeks et al (2010)[13] found that the Capricorn eddy was so strong, and brought so much water to the surface that it cooled the water by around 0.5 degrees - more than enough to be visible on satellite surface temperature data (see appendix 1, figure A1).

Using the data in Weeks et al (2010), the quantity of nitrogen upwelled can be calculated (see appendix1). This calculation is rough as the data is limited, but a good argument can be made that the nutrient upwelled quantity is 10 times that of the Burnett discharge. Crucially, the upwelling region surrounds the Capricorn Bunker reefs and thus directly affects these reefs. Conversely, the nitrogen from the Burnett must travel 75 km to the nearest reef (Lady Elliot Island). A large quantity of any nitrogen emanating from the Burnett/Mary will end up being swept south, and that which might make its way north to the reef will be largely consumed by phytoplankton well before it reached Lady Elliot Island.

The combined effect of the upwelling being perhaps ten times the river discharge, and the distance of the rivers from the reefs could easily mean that the rivers are barely 1% the effect of the upwelling. This is in addition to the role of cycling of nitrogen across the sediment boundary also being about 100 times greater than the river discharge.

As a final comment, nitrogen and phosphorous, in their various forms are not poisonous. They are nutrients, completely essential for life and in very low concentrations around coral reefs. There is no evidence of direct negative impacts of nutrients on seagrass ecosystems and

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[11] 2022 Reef Scientific Consensus Statement. Spatial and temporal distribution of dissolved nutrients https://reefwqconsensus.com.au/question/4-1/

[12] Weeks, S.J., Bakun, A., Steinberg, C.R. *et al.* The Capricorn Eddy: a prominent driver of the ecology and future of the southern Great Barrier Reef. *Coral Reefs* **29**, 975–985 (2010). https://doi.org/10.1007/s00338-010-0644-z

[13] Weeks, S.J., Bakun, A., Steinberg, C.R. *et al.* The Capricorn Eddy: a prominent driver of the ecology and future of the southern Great Barrier Reef. *Coral Reefs* **29**, 975–985 (2010). https://doi.org/10.1007/s00338-010-0644-z

GBR wetlands, nor any direct links in causing Crown of Thorns starfish outbreaks or coral disease[14].

(6) Pesticide Pollution

Across the entire GBR, pesticide presence offshore has never been measured in anything but negligible, or undetectable, concentrations. There is no data available on the quantity of pesticides emanating from the Burnett/Mary that reaches any of the reefs of the GBR. Thus, in the following, it will be necessary to use data from rivers that discharge directly into the GBR marine park (unlike the Burnett/Mary).

The best source of data is Gallen et al. (2014)[15] which contains results of extensive measurements of a very wide range of the most heavily used herbicides such as diuron. This report, of 100 pages, is notable for what it did not find – pesticides in high concentrations. The researchers basically found very low levels everywhere on the inshore reefs (see figure 6) and generally did not bother to look at the GBR because it was obvious from previous work that the concentrations on the GBR, far offshore, would have been too low to detect.

The work of Gallen et al. (2014) was followed more recently by Gallen et al. (2019)[16] who found no exceedance of 'water quality guideline values' which are set very conservatively. The closest that measurements came to exceeding guidelines was for a short period at a tiny fringing reef around Round Top Island a few kilometres offshore from the mouth of the Pioneer River. The catchment of the Pioneer is one of the biggest areas of cultivation on the Queensland coast. The fact that this site, which is probably the most exposed site in the GBR marine park to pesticides, did not record a guideline exceedance indicates that Lady Elliot Island, which is 75 km from the Burnett River cannot receive a significant amount of pesticide pollution.

[14] 2022 Reef Scientific Consensus Statement. Measured impacts of nutrients on GBR ecosystems. https://reefwqconsensus.com.au/question/4-2/

[15] Gallen, C., Devlin, M., Thompson, K., Paxman, C. and Muller, J. (2014). *Pesticide monitoring in inshore waters of the Great Barrier Reef using both time-integrated and event monitoring techniques (2013-2014)*. Cooper Plains: The University of Queensland, The National Research Centre for Environmental Toxicology (Entox).

[16] Gallen, C., Thai, P., Paxman, C., Prasad, P., Elisei, G., Reeks, T., Eagleham, G., Yeh, R., Tracey, D., Grant, S. and Mueller, J. (2019). *Marine Monitoring Program: Annual Report for inshore pesticide monitoring 2017–18. Report for the Great Barrier Reef Marine Park Authority,* Townsville: Great Barrier Reef Marine Park Authority.

Sample Description	Date collected	Concentration PSII herbicides (ng/L)													% Species Affected
		Ametryn	Atrazine	Diuron	Hexazinone	Tebuthiuron	Bromacil	Fluometuron	Metribuzin	Prometryn	Propazine	Simazine	Terbuthylazine	Terbutryn	
Dunk Island north (repl)	15-Jun-17	n.d.	6.1	1.5	0.85	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	<1.1	1.00
Dunk Island north	21-Oct-17	n.d.	8.7	7.2	2.5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.72	n.d.	4.9	0.60
Dunk Island north	13-Jan-18	n.d.	0.79	1.0	0.33	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	5.3	0.00
Dunk Island north	21-Jan-18	12	1.7	4.2	1.8	0.07	n.d.	n.d.	0.85	11	n.d.	n.d.	n.d.	9.7	0.30
Dunk Island north	28-Jan-18	n.d.	0.30	0.43	0.15	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00
Dunk Island north (repl)	28-Jan-18	n.d.	0.27	0.38	0.16	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00
Dunk Island north	10-Feb-18	n.d.	5.3	7.0	2.6	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	5.7	0.00
Dunk Island north	12-Mar-18	n.d.	7.3	22	6.3	0.43	0.24	n.d.	n.d.	n.d.	n.d.	1.7	n.d.	n.d.	0.60
Dunk Island north	14-Mar-18	n.d.	7.0	24	5.8	0.50	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.50
Dunk Island north	20-Mar-18	n.d.	3.1	4.5	1.6	0.55	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.30
Bedarra Island	15-Jun-17	n.d.	5.8	2.6	1.3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	<0.63	0.70
Bedarra Island (repl)	15-Jun-17	n.d.	5.7	2.6	1.4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.70
Bedarra Island	21-Oct-17	n.d.	33	26	10	n.d.	n.d.	n.d.	4.8	n.d.	0.34	2.28	n.d.	n.d.	1.80
Bedarra Island	13-Jan-18	n.d.	2.09	0.80	0.47	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	5.2	0.00
Bedarra Island	21-Jan-18	n.d.	7.2	30	12	n.d.	n.d.	n.d.	6.9	n.d.	n.d.	n.d.	n.d.	n.d.	0.90
Bedarra Island	28-Jan-18	n.d.	n.d.	<0.12	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.00
Bedarra Island	10-Feb-18	n.d.	50	78	35	n.d.	n.d.	n.d.	n.d.	n.d.	0.33	n.d.	n.d.	4.5	1.80
Bedarra Island	12-Mar-18	n.d.	13	61	19	0.72	0.50	n.d.	1.8	n.d.	n.d.	3.0	n.d.	n.d.	1.60
Bedarra Island	14-Mar-18	n.d.	8.2	31	9.3	0.72	n.d.	n.d.	n.d.	n.d.	n.d.	0.82	n.d.	n.d.	0.80
Bedarra Island	20-Mar-18	n.d.	3.9	6.3	2.4	0.63	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.30

Sample Description	Date collected	Concentration other herbicides/ pesticides (ng/L)												
		DE Atrazine	DI Atrazine	Metolachlor	24 D	2,4 DB	Haloxyfop	MCPA	Fluazifop	Fluroxypyr	Imazapic	Imidacloprid	Metsulfuron-Methyl	Tebuconazole
Dunk Island north (repl)	15-Jun-17	0.57	n.d.	1.1	n.d.	n.d.	n.d.	1.0	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Dunk Island north	21-Oct-17	0.78	n.d.	1.7	2.5	n.d.	n.d.	n.d.	n.d.	n.d.	1.6	3.4	n.d.	n.d.
Dunk Island north	13-Jan-18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Dunk Island north	21-Jan-18	0.28	0.11	n.d.	1.2	n.d.	n.d.	n.d.	n.d.	n.d.	0.68	0.97	n.d.	n.d.
Dunk Island north	28-Jan-18	<0.09	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.27	n.d.	n.d.	n.d.
Dunk Island north (repl)	28-Jan-18	<0.08	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Dunk Island north	10-Feb-18	0.52	n.d.	n.d.	2.4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.67	n.d.	n.d.
Dunk Island north	12-Mar-18	2.1	1.3	0.90	20	50	0.65	n.d.	n.d.	3.8	0.78	10	n.d.	n.d.
Dunk Island north	14-Mar-18	2.1	0.86	0.81	18	n.d.	n.d.	n.d.	n.d.	2.9	0.35	9.6	n.d.	n.d.
Dunk Island north	20-Mar-18	1.1	n.d.	0.29	5.2	n.d.	n.d.	n.d.	n.d.	1.6	n.d.	1.2	n.d.	n.d.
Bedarra Island	15-Jun-17	0.83	n.d.	0.78	0.75	n.d.	n.d.	0.69	n.d.	0.81	n.d.	0.89	n.d.	n.d.
Bedarra Island (repl)	15-Jun-17	0.81	n.d.	1.0	0.70	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.77	0.25	n.d.
Bedarra Island	21-Oct-17	3.6	1.4	11	6.5	n.d.	0.65	n.d.	n.d.	n.d.	18	15	n.d.	n.d.
Bedarra Island	13-Jan-18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Bedarra Island	21-Jan-18	1.6	0.61	0.93	6.3	n.d.	0.83	n.d.	n.d.	n.d.	7.8	9.1	n.d.	n.d.
Bedarra Island	28-Jan-18	<0.06	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.22	n.d.	n.d.	n.d.
Bedarra Island	10-Feb-18	4.7	1.9	0.75	31	n.d.	2.1	n.d.	n.d.	n.d.	3.6	14	n.d.	n.d.
Bedarra Island	12-Mar-18	4.3	1.9	1.9	49	79	1.2	n.d.	n.d.	5.1	3.1	29	n.d.	n.d.
Bedarra Island	14-Mar-18	3.8	1.1	1.2	27	n.d.	0.85	n.d.	n.d.	4.1	1.2	22	n.d.	n.d.
Bedarra Island	20-Mar-18	1.5	n.d.	0.47	6.3	n.d.	n.d.	n.d.	n.d.	2.0	n.d.	2.8	n.d.	n.d.

n.d. - not detected

Figure 6: An example of pesticide measurement close to river mouths taken from Gallen et al 2019). This example is for sites a few kilometres offshore from the Tully River. For most entries, the measured pesticide was not detected.

(7) Non-reef ecosystem links

In many of the major documents claiming that agriculture is damaging the GBR, such as the 2022 GBR Consensus Statement[17], it is often claimed that GBR ecosystems extend, not only to the coastline, but onto the land itself. Thus, in the absence of any measurable impact on the GBR, which is far offshore, it is often claimed damage is occurring on the "freshwater ecosystems" of the GBR. For example, the 2022 consensus statement, in its primary summary, states "Pesticides frequently occur at concentrations that exceed protection guidelines for freshwater ecosystems of the Great Barrier Reef"[18]. The idea that the GBR has freshwater ecosystems is stretching credulity far beyond its limits. The GBR is a marine ecosystem. The GBR marine park was proclaimed not for freshwater swamps, as deserving of protection as they are, but to preserve the coral reef ecosystems of its 3000 individual reefs.

It is also often claimed that these inshore and terrestrial ecosystems are linked to the GBR in some fundamental manner and that any impact on, for example, a freshwater swamp in the headwaters of the Burnett will also impact the GBR. The claim is never elucidated past vague notions that there may be some species of animal that migrates between the GBR. It is of

[17] https://reefwqconsensus.com.au/summary/

[18] https://reefwqconsensus.com.au/summary/ see page 12

course true that all organisms on earth are linked – but the scale of the link is crucial. The links between the organisms in freshwater systems on land and the GBR are almost certainly extremely minor. Certainly, no evidence has ever been presented to show they are important.

Expanding the scope of the GBR way outside the marine park boundaries to include ecosystem on land has become necessary for those wishing to claim that the GBR is damaged by agriculture. This is because actual damage from agriculture to the GBR is so limited, it is effectively impossible to measure. This is not the case for terrestrial ecosystems which have sometimes been changed dramatically since British settlement.

Expanding the scope of the GBR, effectively to the top of Great Dividing Range, has become a very effective ploy to extend government regulations to supposedly protect the GBR.

(8) How to Progress

The above analysis makes a brief case of why the Burnett/Mary should have never been included as reef catchments in 2019. However, the analysis is severely hampered because no data has ever been presented on the magnitude of the impact of these rivers on the GBR. In order to progress the resolution of this issue in a scientific manner, it is imperative that science institutions and government departments which presumably advised the previous government on why the Burnett/Mary should be included, provide their data and also answer the set of question listed below. It is also important that the questions be answered in a quantitative way – numbers and measurements are required, not models, speculation or meaningless adjectives.

List of Questions that must be answered

1. What is the fate of material emanating from the Burnett/Mary, and how is it affected by the prodigious quantities of water that flushes in from the EAC.
2. How much sediment from the Burnett/Mary reaches Lady Elliot Island Reef.
3. What is (a) the nutrient budget for the region between the Burnett/Mary rivers and Lady Elliot Island? (b) the rate of upwelling of nutrients from the Capricorn Eddy? (c) the nutrient recycling across the seabed? (d) the exchange of nutrients with the offshore ocean? (e) the rate of nutrient loss to the southward flowing EAC? and (f) the relative magnitude of these fluxes with the discharge of nutrients from the Burnett/Mary rivers?
4. What concentrations of pesticide are present and detected on Lady Elliot Island Reef.
5. How much coral on Lady Elliot Island has been killed by the advent of farming since British settlement? Is there any evidence that the coral on Lady Elliot Island reef is essentially any different to when Captain Cook sailed past in 1770?
6. If it is to be argued that ecological links between the inshore, estuarine, freshwater and terrestrial ecosystems, and the GBR are important to the GBR, these should be elucidated with data. The following questions need answering. (a) what organisms are involved? (b) how many? (c) by how much have they been affected by agricultural chemicals and sediment? (d) what is the importance of these organisms to the reef? (e)

what function do they play on the reef? (f) are these organisms crucial given that coral reefs exist in many locations very far from land? In answer to these questions, hard facts and not supposition or speculation are required.

Appendix 1. Calculation of upwelled water volume and nutrient flux from the Capricorn Eddy.

Figure 6 of Weeks et al (2019) (figure A1 below) shows an area of cold-water upwelling. They state “it is known that “the Capricorn-Bunker reefs, located on the shelf edge, are flushed by frequent intrusions of oceanic water (Steinberg 2007). The resultant mixing of relatively cooler deeper water (Skirving et al. 2006) is clearly evident even in the long-term mean temperature distribution (Fig. 6), which composites the summer months (December–February) over a number of years. The relatively cooler thermal signal along the shelf edge and immediately surrounding the Capricorn Bunker reefs themselves (Fig. 6) offers a clear indication of tidal mixing/shelf edge upwelling”.

Fig. 6 Long-term summer SST (°C) mean (Dec-Feb 2000-08) for the southern GBR region (20°S-25°S; 149°E-154°E). The 100-m (*thin black*) and 200-m (*thick black*) isobath lines are overlain

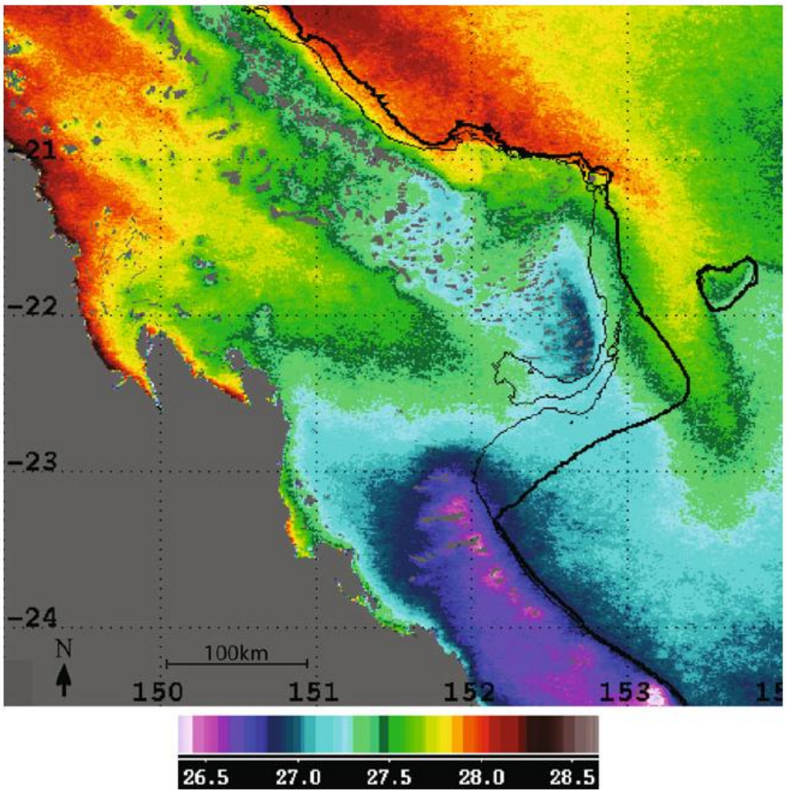

Figure A1: Screenshot of Weeks et al (2010) showing the area of upwelling (purple) around the Capricorn Bunker group of reefs.

An estimate of the quantity of water in the cold-water intrusion can be gauged using the following dimensions. Length 200 km, width 30 km, depth 40 m, giving a volume of 2.4 x10^{11} m^3.

Assume sub-thermocline water is 5°C cooler than the upper mixed layer, and observing it makes the water 0.5 degrees cooler on the shelf leads to a mixing ratio of 10:1. Thus 2.4

$x10^{10}$ m^3 of water came in from upwelling alone to reduce the temperature of the water (not including the surface water, which is roughly 100 times the Burnett yearly discharge).

Given a time scale for residence time of say 10 days (typical of GBR near-shelf edge water), each year, around 86 $x10^{10}$ m^3 of water is upwelled each year which is roughly 90 times the water volume discharged from the Burnett River each year[19].

Assuming the sub-thermocline water has a nitrogen concentration of 5microMol N/l[20], i.e

$5x10^{-6}$x 14grams/litre = $70x10^{-6}$ kg/m^3, volume $86x10^{10}$ in a year. This gives $6x10^7$ kg/year of N in upwelled water. i.e 60000 tonnes per year.

According to Kroon (2012), total nitrogen discharge for entire the GBR is 80,000 tonnes per year and for the Burnett is 5000 tonnes per year. Thus, the nitrogen input from upwelling is in the order of 10 times the discharge from the Burnett, and crucially, enveloping the reefs, rather than 75 km distant.

[19] Based on 1000Gl/a https://reportcard.reefplan.qld.gov.au/home?report=target&year=63feba8962a7eebd85fb06ac&measure=PN&area=BM-Burn

[20] See Furnas et al 1995. https://elibrary.gbrmpa.gov.au/jspui/handle/11017/240 figure 16.