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Regulatory tools a must for watershed management for the Great Barrier Reef.

Jon Brodie, COE Coral Reef Studies, Townsville
C2O Consulting, Australia

Island Arks Symposium V – Fiji 2017

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Outline

The Great Barrier Reef is in dire condition despite decades of management costing hundreds of millions of dollars.

Much of the funding has been spent on managing terrestrial runoff of fine sediment, nutrients and pesticides.

I demonstrate that this effort has resulted in minimal progress in reducing pollutant loads.

Given the quickly increasing threats from climate change what further could we do in managing water quality.

Knowledge from around the tropics (and globally) shows that the only really successful land-sourced pollution management resulting in observable marine ecosystem condition improvement had strong regulation as one component of the policy mix.

A policy mix with regulation as an important component is the only hope left for effective water quality management for the GBR.

Are there lessons for other tropical marine ecosystems outside of Australia?

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Status of the GBR

- Coral cover from about 50% fifty years ago to 28% in 1987 to 22% in 2004 to 14% in 2012 (11% south of Cooktown – 75% decline) and predicted to decline further on mid and outer shelf reefs. Inner-shelf reefs in similar state. Current 2017 state given recent bleaching (2016 and 2017) with extensive mortality and cyclone Debbie (also with substantial coral mortality) not published yet.
- Coral cover on reefs in northern Cape York and Torres Strait (Sweatman et al. 2015a) were still near 50% but coral now bleached severely in 2016 with high mortality (Hughes et al. 2017a)
- Dugong populations reduced greatly in the central and southern GBR (perhaps 2000 animals) (but recent good news). Largest remaining populations south of GBRMP in Hervey Bay (~ 1000) and in far northern GBRMP (~ 6000) and north of GBRMP in Torres Strait (~110,000). Some recent recovery in southern GBR.
- Seagrass in decline associated with both chronic stress (water quality) and extreme events (Petus et al. 2014) – large cyclones and large floods but able to recover when stressors are removed
- Crown of thorns starfish outbreaks from 2009 – the 4th ‘wave’ since about 1962.
- Increasing incidence of coral diseases
- Declining coral calcification
- And now more severe bleaching

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The water quality issue - terrestrial runoff of pollutants from agriculture

- Sediment – between 1 - 5 times increase since 1850 depending on river – sourced mainly from erosion in grazing lands and some cropping lands.

- Total Nitrogen – 1 - 6 times increase since 1850 depending on river – Particulate nitrogen loads mainly from erosion in grazing lands, nitrate from fertiliser use in sugarcane, cotton, horticulture, grains.

- Total Phosphorus – 1 - 9 times increase since 1850 depending on river – Particulate P loads also from grazing lands.

- PSII herbicides (atrazine, diuron, tebuthiuron and others) – 28 tonnes (no natural load) – from sugarcane, grains cropping and weed control in grazing lands. Other pesticides as well, including imidacloprid, found regularly at above guideline concentrations. Concentrations above guidelines in many fresh, estuarine and coastal waters.

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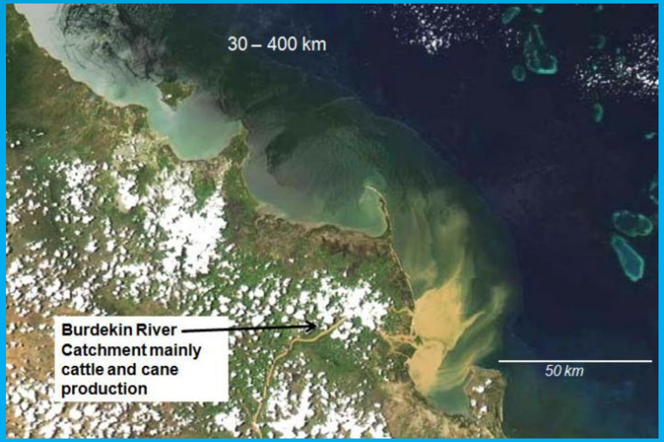
Adverse effects on GBR species and ecosystems

Fine sediment discharge

1. Increased turbidity associated with fine sediment resuspension on the inner-shelf (e.g. Fabricius et al. 2016)
2. Loss of light associated with the increased turbidity reduces photosynthesis in seagrass and corals. Loss of seagrass (Petus et al. 2014)
3. Sedimentation of organic rich sediment on corals with mortality due to anoxia (Weber et al. 2012; Flores et al. 2012)
4. Fine suspended sediment has adverse effects on juvenile coral reef fish (e.g. Wenger et al. 2011)
5. Terrigenous fine sediment contaminated turf algae affects the feeding behavior of grazing fish (e.g. Gordon et al. 2015)

Gully erosion – Andrew Brooks



Burdekin flood plume

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Adverse effects on GBR species and ecosystems

Nutrient (nitrogen and phosphorus) discharge

1. Increased populations of crown of thorns starfish (e.g. Fabricius et al. 2010; Brodie et al. 2005, 2017)
2. Increased presence of macroalgae (e.g. De'ath and Fabricius 2010)
3. Increased sensitivity of corals to bleaching (e.g. Wiedenmann et al. 2012; Wooldridge et al. 2016)
4. Increased levels of bioerosion (e.g. DeCarlo et al. 2015)
5. Interaction with fine sediment to increase coastal turbidity
6. Interaction with water temperature increases to increase incidence of coral disease (e.g. Lamb et al. 2016)

Crown of thorns starfish AIMS image

Enhanced macroalgal growth on coral reefs K. Fabricius image

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Water quality management

The move to manage water quality

1980 - 2000 – Research, monitoring and research synthesis in GBR water quality

2001 - Water Quality Action Plan (Brodie et al. 2001); 1st Consensus Statement

2003 - Reef Water Quality Protection Plan (Reef Plan). Updated in 2009, 2013 and now in 2017

2007/8 – Reef Plan funded by Federal Government - $200 million + Queensland support; 2nd Consensus satement

2008 – 2013 Stage one of Reef Plan – eventually about $400 million spent on on-farm works; 2013 Consensus Statement

2014 – 2017 Stage two – about $200 million (?) committed (Brodie and Pearson 2016)

2015 Reef 2050 Plan

2016 – Release of 2015 Report Card shows minimal progress

2017 – New basin specific targets (Brodie et al. 2017); 2017 Consensus Statement; and new 2017 Reef Plan

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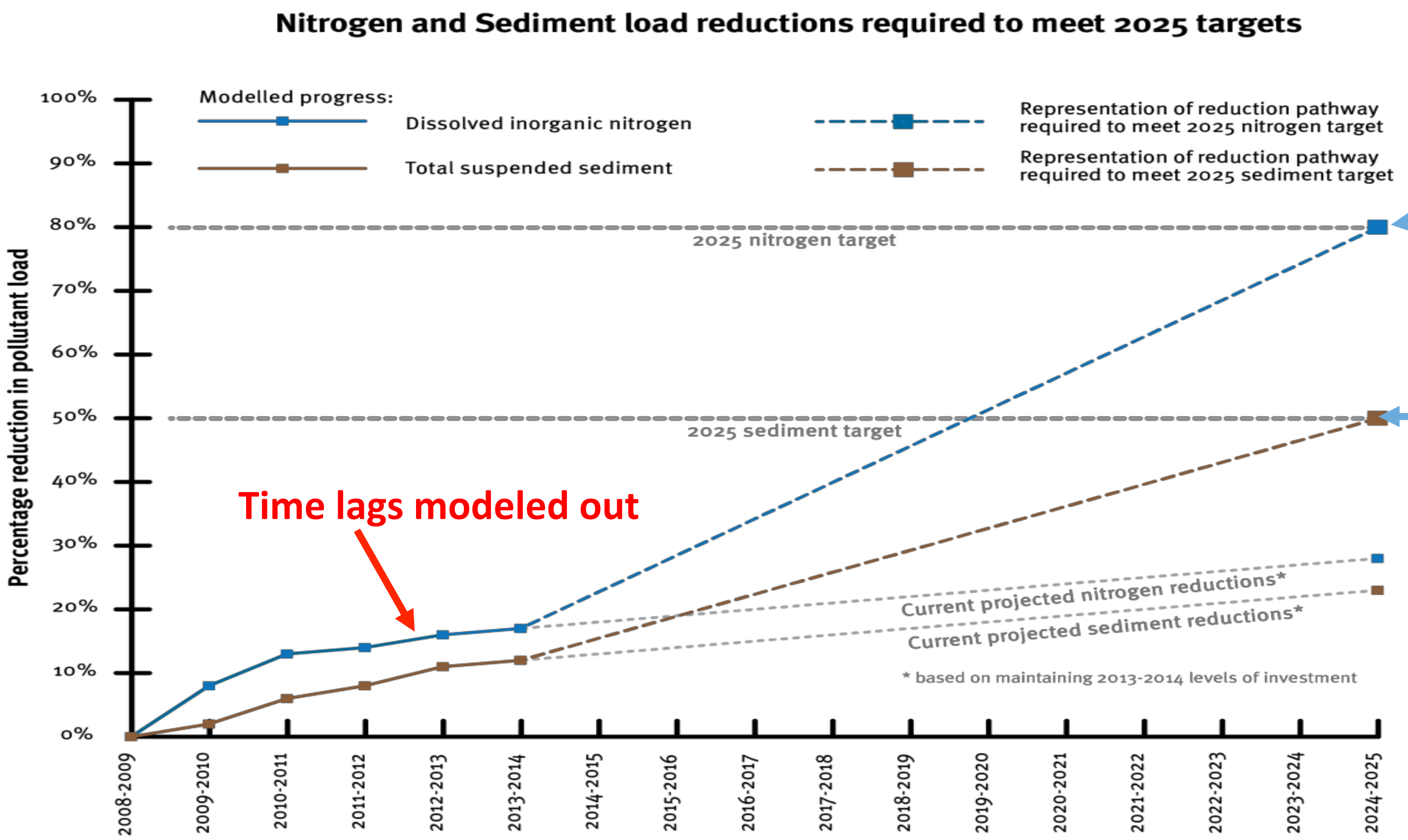
Water quality management

Progress towards targets and assigned scores in the 2015 GBR Report Card.

Activity	Target[1]	Progress to target as at 2014-2015[2]	2015 Report Card Score[2]
DIN load	50% reduction by 2018	18%	Poor 'E'
Fine Sediment load	20% reduction by 2020	12%	Moderate 'C'
Sugarcane land – managed to best practice standard	90%	23%	Poor 'D'
Cattle grazing land – managed to best practice standard	90%	36%	Poor 'D'

Notes: 1. Load targets are the reduction in anthropogenic loads based on modelled estimation of anthropogenic loads; 2. 2015 'ABCDE' scoring system.

Water quality management



As noted by UNESCO little (no?) chance of reaching targets by 2025

2025 DIN target (Reef 2050 Plan)

2025 fine sediment target (Reef 2050 Plan)

Nitrogen and sediment load reductions required to meet 2025 targets. Reproduced from GBRWST* (2016).

* Great Barrier Reef Water Science Taskforce

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Water Quality Management status

- More than A$500 million has been spent 2008 – 2015 on terrestrial pollution management – probably about $700 million by 2017 (Brodie and Pearson 2016)
- Only minor progress has been made in that period towards pollution reduction targets (Reef Report Card 2015)
- AUS$10 billion is needed to reach targets over next ten years (Alluvium 2016)
- Only about ~A$600 million is potentially committed over the next 6 years.
- Current Federal government lack of action on GBR management means little hope of adequate water quality management.
- Then there's climate change (Hughes et al. 2017a)

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What will work? – No. 1

Funding – with A$10 billion over ten years (but some time lags) we believe (based on robust modelling) we can largely get water quality up to acceptable standard which does not impact greatly on GBR ecosystems and species by about 2027.

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What will work? – No. 2

Regulation and statutory planning.

Existing Federal and Queensland regulations:

1. Great Barrier Reef Marine Park Act (1975).
2. Environmental Protection and Biodiversity Conservation Act (EPBC) (1989)
3. The Great Barrier Reef Protection Amendment Act 2009 (Queensland)

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Great Barrier Reef Marine Park Act 1975 - Section 66 (2) (e)

- (1) The Governor-General may make regulations, not inconsistent with this Act or with a zoning plan, prescribing all matters required or permitted by this Act to be prescribed or necessary or convenient to be prescribed for carrying out or giving effect to this Act.
- (2) Without limiting the generality of subsection (1), regulations to do any or all of the following may be made:
- (e) regulating or prohibiting acts (whether in the Marine Park or elsewhere) that may pollute water in a manner harmful to animals and plants in the Marine Park;
- This Section relates directly to pollution and, notably, to acts which may occur "in the Marine Park or elsewhere" – thus, actions upstream of the GBR in the GBR catchment are covered.
- Has been used in late 1990s to regulate coastal prawn farms – also outside boundaries of the GBR Marine park

EPBC*

*The *Environment* Protection and Biodiversity Conservation Act 1999 (the *EPBC* Act) is the *Australian* Government's central piece of *environmental* legislation.

Section 12 of the EPBC Act specifies that a person must not take an action that will have a significant effect upon the values of a declared World Heritage property. In a similar way to the GBRMP Act, prohibited actions may include those that take place within or outside the boundaries of the World Heritage property.

The Great Barrier Reef Protection Amendment Act 2009 (Queensland)

- Currently in force but not being strongly implemented or enforced.
- In process of being ramped up strongly → (September 2017) – however may depend on Queensland political situation and the upcoming election!
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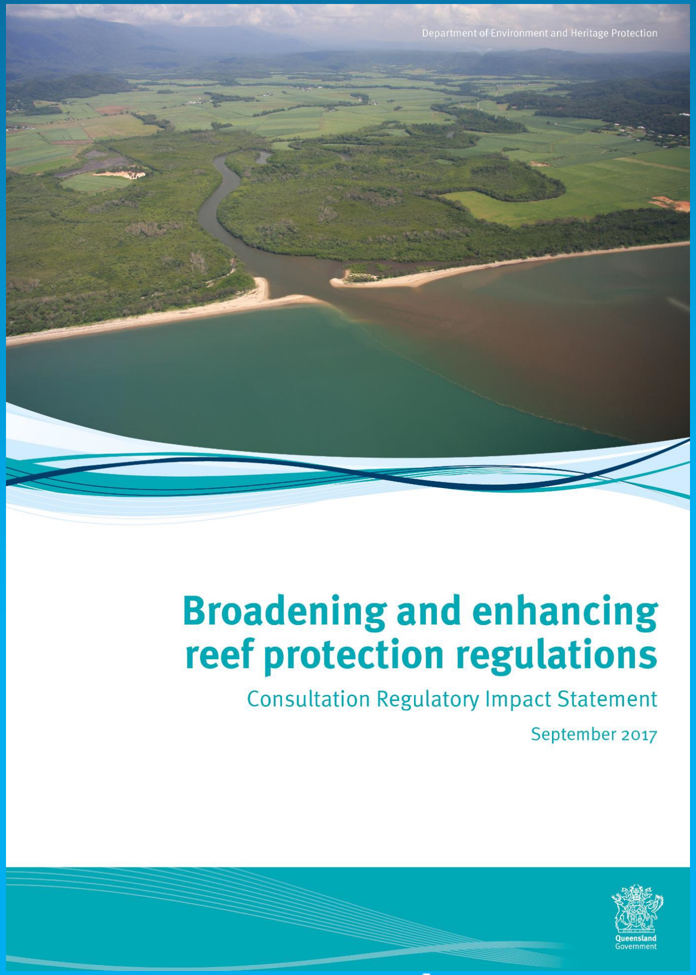

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The need for regulation as part of the policy mix

It has been shown (Kroon et al. 2014) that in the tropics (and largely the temperate zone as well) no purely voluntary watershed management programs have led to receiving waters ecosystem restoration. Successful examples such as Kāne'ohe Bay in Hawaii, where corals have been restored after a sewage discharge was shifted out into deep water outside the Bay, have relied on a mix of approaches including regulatory action (by the USEPA).

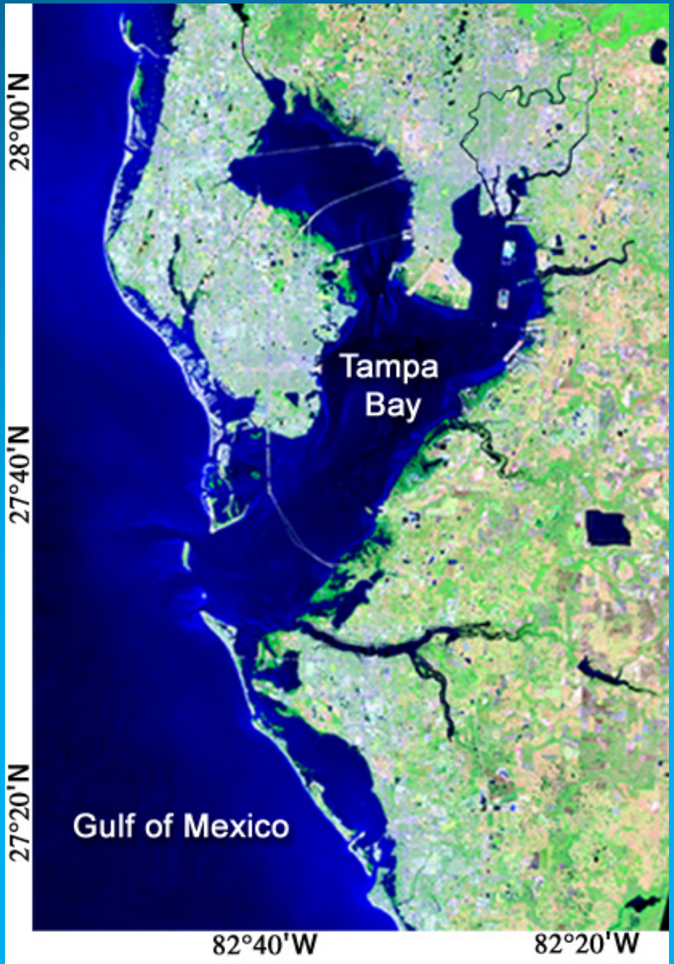
Successful examples in the tropics include (with regulation):

- 1. Kāne'ohe Bay, Hawaii – sewerage discharge diverted to deep offshore waters. Coral recovery
- 2. Pago Pago harbor, American Samoa – tuna cannery wastes diverted to deep offshore waters. Coral recovery
- 3. Tampa Bay, Florida, USA – reduced nitrogen loads from land and seagrass recovery

However these cases all involved point source pollution. NO successful examples of tropical diffuse source management with a successful marine ecosystem endpoint improvement.

Lessons from other tropical marine ecosystem management stories

Tampa Bay, Florida (Greening et al. 2014) where "following citizen demands for action, reduction in wastewater nutrient loading of approximately 90% in the late 1970s lowered external total nitrogen (TN) loading by more than 50% within three years. Continuing nutrient management actions were associated with a steadily declining TN load rate despite an increase of more than 1 M people living within the Tampa Bay metropolitan area. Water clarity increased significantly and seagrass is expanding at a significant rate. Key elements include: 1) active community involvement, including agreement about quantifiable restoration goals; 2) regulatory and voluntary reduction in nutrient loadings from point, atmospheric, and nonpoint sources; 3) long-term water quality and seagrass extent monitoring; and 4) a commitment from public and private sectors to work together to attain restoration goals."



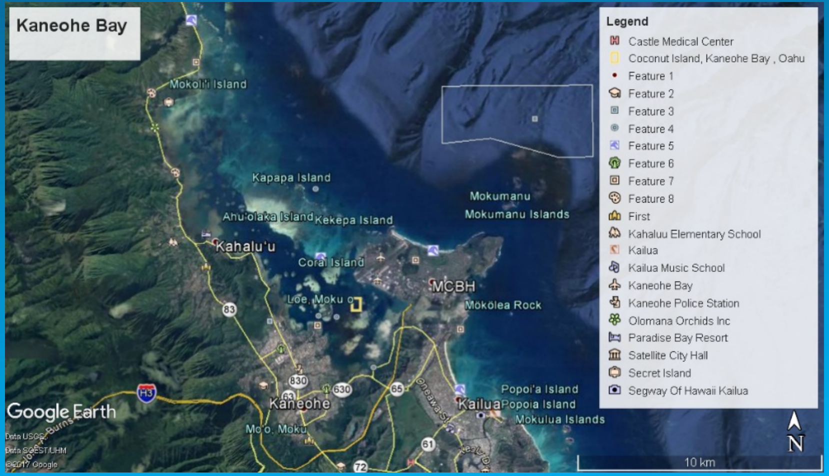
Greening, H., Janicki, A., Sherwood, E.T., Pribble, R. and Johansson, J.O.R., 2014. Ecosystem responses to long-term nutrient management in an urban estuary: Tampa Bay, Florida, USA. Estuarine, Coastal and Shelf Science, 151, pp.A1-A16.

Lessons from other tropical marine ecosystem management stories

Kāne'ohe Bay, Oahu, Hawaii (e.g. Stimson 2015; Bahr et al. 2015).

Sewage discharges into Kāne'ohe Bay , Hawaii increased from 1946-1978 due to increasing population up to 20 ML/day in 1977.

- **This chronic discharge into the lagoon introduced high levels of DIN and DIP, and the southern lagoon became increasingly rich in phytoplankton.**
- **Reefs closest to the outfall become overgrown by filter-feeding organisms, such as sponges, tube-worms and barnacles. Reefs in the centre of the Bay further from the outfalls were overgrown by the indigenous green algae *Dictyosphaeria cavernosa*.**
- **After diversion of the outfalls into the ocean in 1978 following a USEPA directive, in-water nutrient levels reduced, phyto- and zooplankton populations declined and *D. cavernosa* abundance declined to 25% of previous levels.**
- **Later increases in the abundance and distribution of coral species were reported, and the reefs slowly recovered.**
- **A drastic decline in previously dominant *D. cavernosa* occurred in 2006 attributed to a gradual return to a coral-dominated state after the elimination of the sewage nutrient inputs that drove the initial phase shift to macroalgae in the 1970s.**



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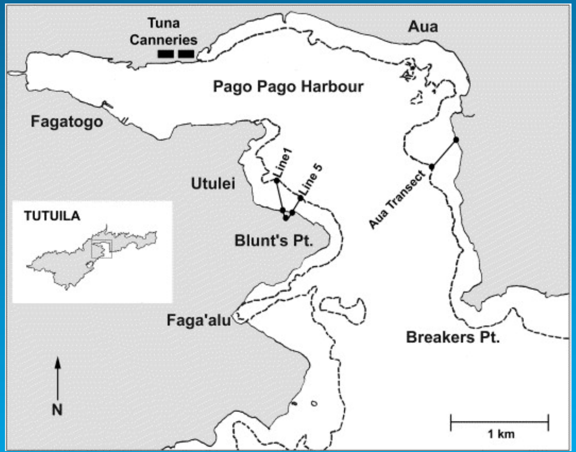
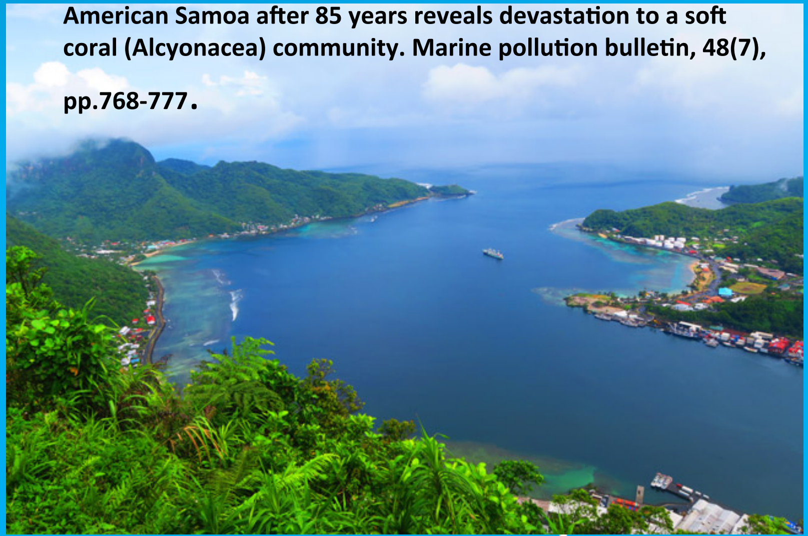
Lessons from other tropical marine ecosystem management stories



Pago Pago, American Samoa

In 1917, diverse coral communities occurred on the reef flat at Aua village in Pago Pago Harbour, American Samoa. Between the 1950s and 1980s, this area was seriously degraded by chronic pollution from two tuna canneries, fuel spills in the inner harbour and coastal development. By the 1970s, coral communities had declined substantially within the harbour (Dahl and Lamberts 1977). In 1992, a pipe was installed (USEPA) to export wastewater from the tuna canneries to the harbour mouth into deeper waters with better flushing. In addition, management of coastal development and fuel spills had improved by the early 1990s. Recent studies (Birkeland et al. 2013) have found that since the 1990s, there has been significant recovery of coral communities on the reef crest and outer reef flat where there is consolidated reef substratum (up to 30 metres behind the reef crest). In contrast, it was found that recovery has been substantially slower or absent behind the reef crest, where the substratum is primarily loose rubble.

Cornish, A.S. and DiDonato, E.M., 2004. Resurvey of a reef flat in American Samoa after 85 years reveals devastation to a soft coral (Alcyonacea) community. Marine pollution bulletin, 48(7), pp.768-777.



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Lessons from temperate marine ecosystem management stories

Denmark

Even in cases such as in Denmark, where strong regulatory action has led to greatly reduced diffuse loads of nutrients from agriculture, good evidence of a restored estuarine/marine ecosystem is scarce.

Windolf, J., Blicher-Mathiesen, G., Carstensen, J., Kronvang, B., 2012. Changes in nitrogen loads to estuaries following implementation of governmental action plans in Denmark: a paired catchment and estuary approach for analysing regional responses. Environ. Sci. Policy 24, 24–33.

Carstensen, J., Conley, D.J., Andersen, J.H., Aertebjerg, G., 2006. Coastal eutrophication and trend reversal: a Danish case study. Limnol. Oceanogr. 51, 398–408.

Hansen, J., Petersen, D., 2011. Marine områder 2010. NOVANA. Tilstand og udvikling i miljø- og naturkvaliteten. Aarhus Universitet, DCE - Nationalt Center for Miljø og Energi, Aarhus, Denmark, p. 120.

Duarte, C.M., Conley, D.J., Carstensen, J., Sanchez-Camacho, M., 2009. Return to neverland: shifting baselines affect eutrophication restoration targets. Estuaries Coasts 32, 29–36.

Kroon, F.J., Schaffelke, B. and Bartley, R., 2014. Informing policy to protect coastal coral reefs: Insight from a global review of reducing agricultural pollution to coastal ecosystems. Marine Pollution Bulletin, 85(1), 33-41.

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Way forward for GBR WQ management

- Refocus management to the Greater GBR – that is, include management of Torres Strait, Hervey Bay and the GBR Catchment as priorities along with the GBRWHA.
- Investigate methods of cross-boundary management to achieve simultaneous cost-effective terrestrial, freshwater and marine ecosystem protection in the Greater GBR.
- Develop a detailed, comprehensive, costed water quality management plan for the Greater GBR – the current reef 2050 Plan is manifestly inadequate.
- Use the GBRMP Act and the EPBC Act to regulate catchment activities that lead to damage to the Greater GBR, in conjunction with the relevant Queensland legislation.
- Fund catchment and coastal management to the required level to largely solve the pollution issues for the Greater GBR by 2025 ($10 billion), before climate change impacts become overwhelming for the Greater GBR ecosystems.
- Check new and potential agricultural, mining and urban expansion in GBR catchment – may undo any gains made.

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Conclusions

1. Need implementation of radically shifted management regime as described to have some hope of successful management of water quality
2. Critically use of the Federal regulatory powers is needed - using existing Environment Protection and Biodiversity Conservation Act (1989) and Section 66 (2) e of Great Barrier Reef Marine Park Act (1975)
3. Recognise that the aims of managing the GBR are now severely constrained by the rate of current climate change (Hughes et al. 2017a, 2017b)*
4. Water quality aims need to fit into this new realistic management regime for the GBR (Hughes et al. 2017b)*

* Hughes, T.P., Kerry, J.T., Álvarez-Noriega, M., Álvarez-Romero, J.G., Anderson, K.D., Baird, A.H., Babcock, R.C., Beger, M., Bellwood, D.R., Berkelmans, R. and Bridge, T.C., 2017. Global warming and recurrent mass bleaching of corals. Nature, 543(7645), pp.373-377.

Hughes, T.P., Barnes, M.L., Bellwood, D.R., Cinner, J.E., Cumming, G.S., Jackson, J.B., Kleypas, J., van de Leemput, I.A., Lough, J.M., Morrison, T.H. and Palumbi, S.R., 2017b. Coral reefs in the Anthropocene. Nature, 546(7656), pp.82-90.

Lessons for other states

1. Lessons from the GBR are NOT easily transferable to Pacific small island states
2. The GBRMP model is often NOT appropriate elsewhere especially since we now realise it has not been very successful even for the GBR.
3. One lesson is important – we need to take account of all threats in marine protection. (Wenger et al. in review).
4. However I think we still have to look at regulation as part of a policy mix everywhere – this can be traditional rules, state legal system, formally contracted agreements, and some of the other possibilities explored at this conference.