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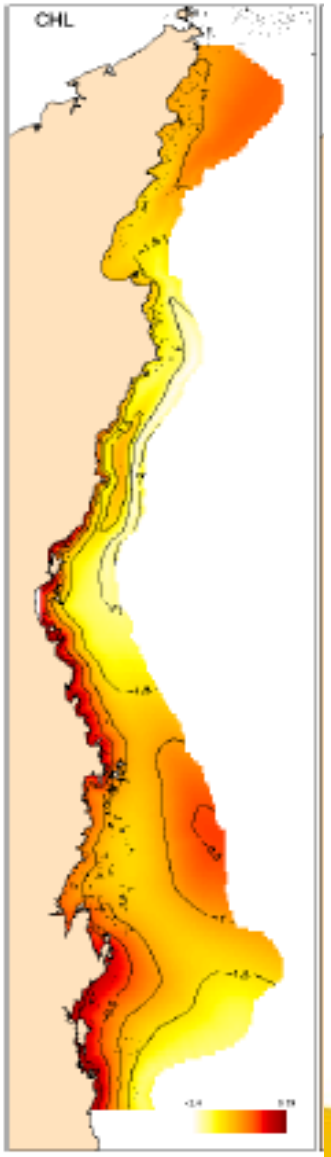
Project 5.2: Experimental and field investigations of combined water quality and climate effects on corals and other reef organisms

Sven Uthicke, Katharina Fabricius, Andrew Negri
Sam Noonan, Florita Flores, Frances Patel, Michelle Liddy, Niko Vogel, Melissa Rocker, Yan Xiang Ow, Martina de Freitas-Prazeres, Adriana Humanes Schumann

Australian Government | Australian Institute of Marine Science

RELEVANCE OF WORK



Stressors for coastal environments

- Overfishing
- Runoff
- Habitat destruction
- Pollution
- Temperature
- Ocean Acidification

De'ath and Fabricius 2008. GBRPMA Res Pub 89

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Stressors for coastal environments

Local

- Runoff
- Habitat destruction
- Pollution
- Overfishing

Global

- Temperature
- Ocean Acidification

Total Pressure

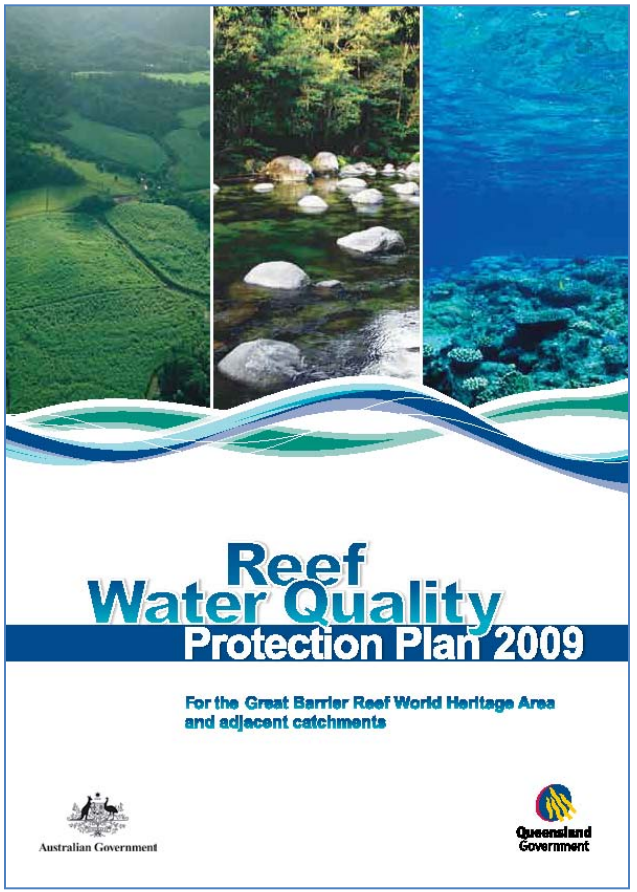
- Nutrients
- Light/Turbidity
- Pollution
- Temperature
- Ocean Acidification

- Temperature
- Ocean Acidification

Does management of land runoff 'buy time' for coral reefs to adapt/acclimatise to Climate change or OA?

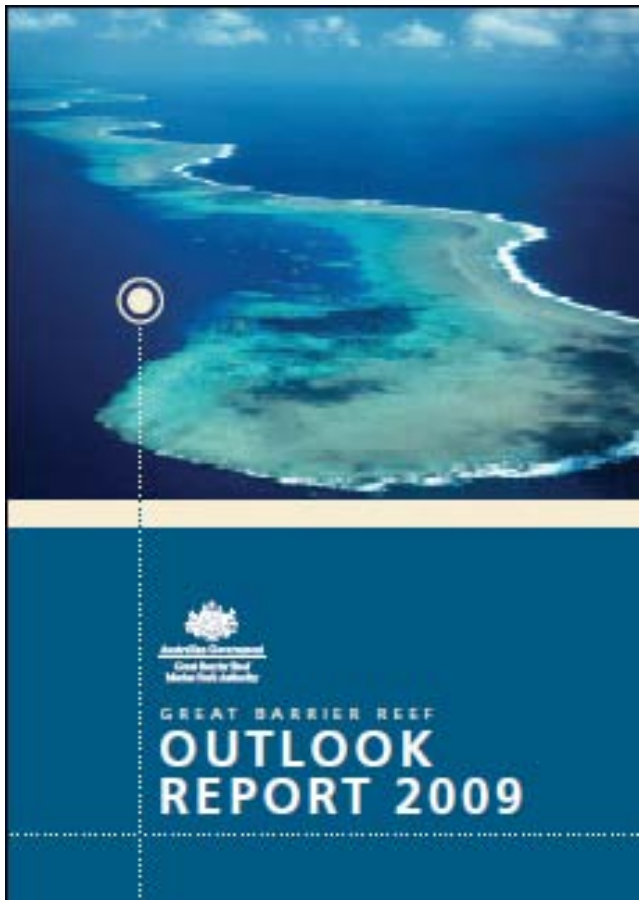
RELEVANCE OF WORK

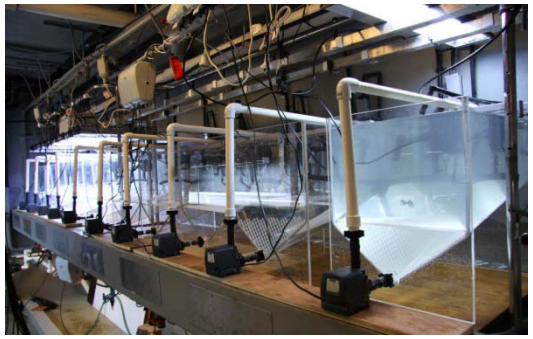
"By improving water quality, governments along with rural industry groups and landholders can help the Reef become more resilient and better able to withstand the impacts of climate change."



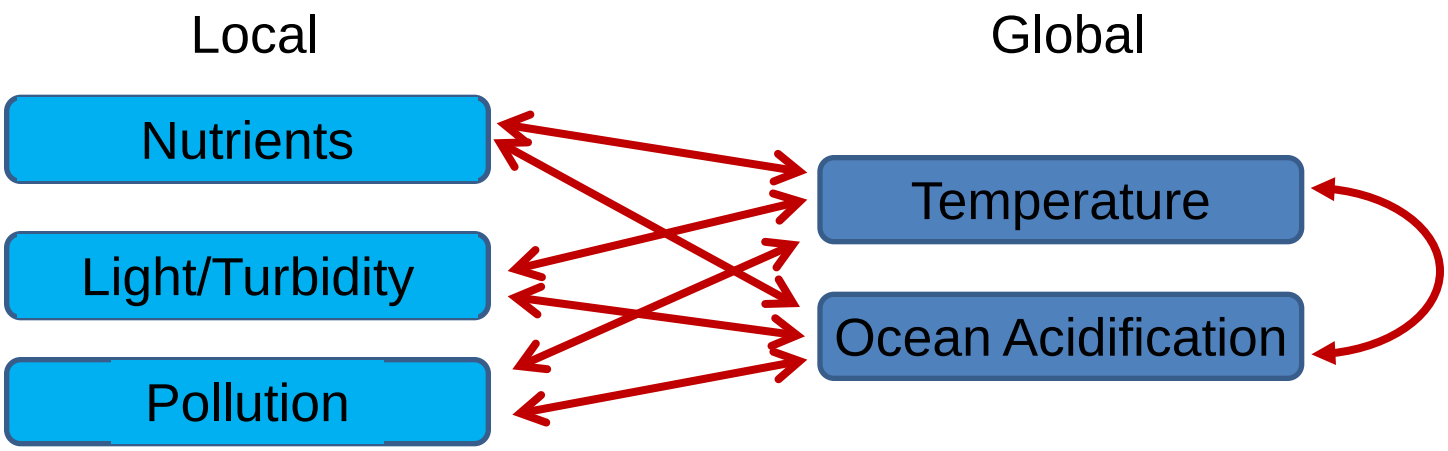
RELEVANCE OF WORK

"Further building the resilience of the Great Barrier Reef by improving water quality, reducing the loss of coastal habitats and increasing knowledge about fishing and its effects, will give it the best chance of adapting to and recovering from the serious threats ahead, especially from climate change."





Stressors for coastal environments



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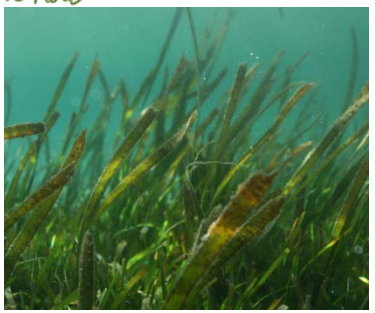
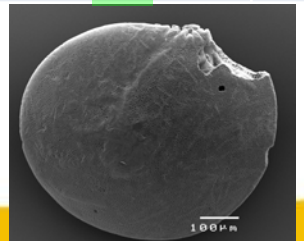
RESULTS



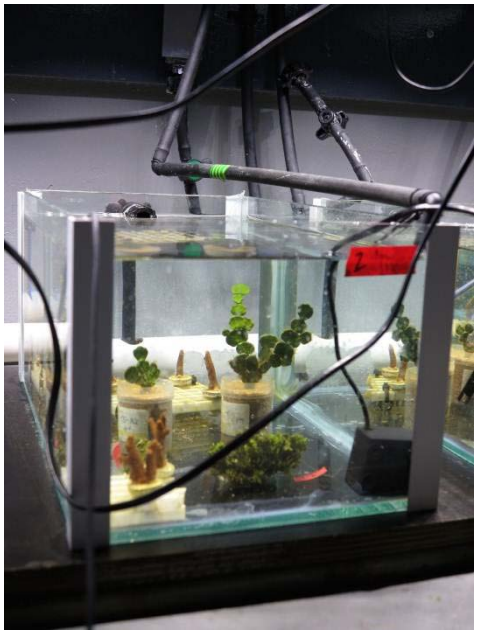
Global	Local
Temp X	Nutrients
	Light/Turbidity
	Pollution
	Salinity
CO_2 X	Nutrients
	Light/Turbidity
	Pollution
	Salinity
CO_2 X Temp	



RESULTS

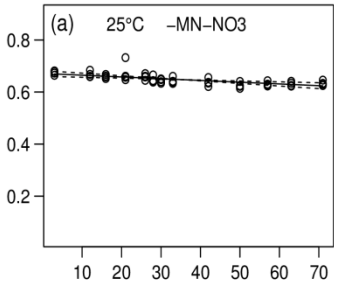
pCO_2 X light: Corals and calcifying algae

Present: increased Runoff – CO_2 slightly increased
Future 1: increased Runoff – CO_2 distinctly increased
Future 2: reduced Runoff – CO_2 distinctly increased
Future 3: reduced Runoff – CO_2 steady

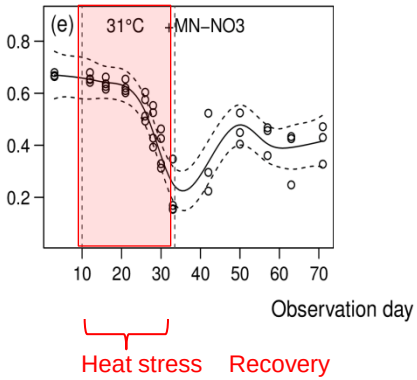


WQ and Thermal Stress Interactions: Corals

No Heat Stress



Heat stress, Organically enriched sediment



Lab experiment exposing *Acropora* corals to nutrient-enriched suspended sediments at environmentally relevant concentrations:

Increased thermal tolerance (**less severe bleaching**, **lower mortality**, **faster recovery**) if local stressor removed

Fabricius, K. E., et al. 2013. Does Trophic Status Enhance or Reduce the Thermal Tolerance of Scleractinian Corals? A Review, Experiment and Conceptual Framework. PLoS ONE **8**:e54399.

APPLICATION OF WORK

- Results will substantiate the concept of managing local stressors to improve resilience of coral reefs to global stressors.

- Improved understanding of climate and WQ interactions will allow to model changes in thresholds and consequences of improved land management.

- Further planned outcomes:
  - Quantification of effects of single stressors or combinations of stressors on larvae and recruits of invertebrates, which are crucial for reef resilience and recovery.

  - Report on carbon chemistry on coral reefs exposed to terrestrial runoff, and possible consequences for photosynthesis and calcification.

FUTURE DIRECTIONS

- Continue experimental work to fill gaps in experiment matrix

Global	Local						
		Coral	Foraminifera	Seagrass	Calc. algae	Echinoderms	Biofilms
Temp X	Nutrients	√	√				√
	Light/Turbidity						√
	Pollution	√	√				
	Salinity						
CO_2 X	Nutrients						
	Light/Turbidity	√		√	√		
	Pollution						
	Salinity	√					
CO_2 X Temp		√	√		√	√	

- Identify remaining knowledge gaps for future work

THANK YOU

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CONTACT

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Australian Government

Australian Institute of Marine Science

PROJECT COMMUNICATION/OUTPUTS

NERP factsheet

Photosubmission to e-atlas

- Fabricius, K. E., S. Cseke, C. Humphrey, and G. De'ath. 2013. Does Trophic Status Enhance or Reduce the Thermal Tolerance of Scleractinian Corals? A Review, Experiment and Conceptual Framework. PLoS ONE **8**:e54399.
- Webster, N. S., S. Uthicke, E. Botte, F. Flores, and A. P. Negri. 2013. Ocean acidification reduces induction of coral settlement by crustose coraline algae. Global Change Biology **19**:303-315
- Reymond CE, Uthicke S, Pandolfi JM (2012) Tropical Foraminifera as indicators of water quality and temperature. Proceedings of the 12th International Coral Reef Symposium, Cairns, Australia, 9-13 July 2012, 21B Enhancing coral reef resilience through management of water quality, D. Yellowlees & T. P. Hughes (eds.), James Cook University, Townsville, Queensland 4811, Australia (result of MTSRF)
- Witt V, Wild C, Uthicke S (2012) Terrestrial runoff controls bacterial community composition of biofilms along a water quality gradient in the Great Barrier Reef. Applied and Environmental Microbiology online first (result of MTSRF)
- Witt, V., C. Wild, and S. Uthicke. 2012. Interactive climate change and runoff effects alter O_2 fluxes and bacterial community composition of coastal biofilms from the Great Barrier Reef. Aquatic Microbial Ecology **66**:117-131.
- Uthicke S, Soars N, Foo S, Byrne M (2012) Effects of elevated *p*CO_2 and the effect of parent acclimation on development in the tropical Pacific sea urchin *Echinometra mathaei*. Marine Biology online first:1-14

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TEAM

Sven Uthicke, Katharina Fabricius, Andrew Negri
Sam Noonan, Florita Flores, Frances Patel/Michelle Liddy

5 PhD students:

1) Niko Vogel (supervision: SU, C. Wild)

Interactive effects of land runoff and climate change on calcifying organisms (Foraminifera, *Halimeda spp.*)

2) Yan Xiang Ow (supervision: SU, C. Collier)

Interactive Effects of land runoff and Ocean Acidification on seagrasses

3) Melissa Rocker (supervision: KF, Line Bay, Bette Willis)

Effects of local and global stressors on the energy budgets and fitness of inshore reef-building corals

4) Martina de Freitas-Prazeres (across 1.3/5.2, supervision: J. Pandolfi and SU)

Foraminifera as tools for analysis of interactions between water quality and climate change effects on the Great Barrier Reef

5) Adriana Humanes Schumann (supervision AN and KF, AIMS-JCU): "*Combined effects of water quality and climate change on the early life history stages of hard corals*".

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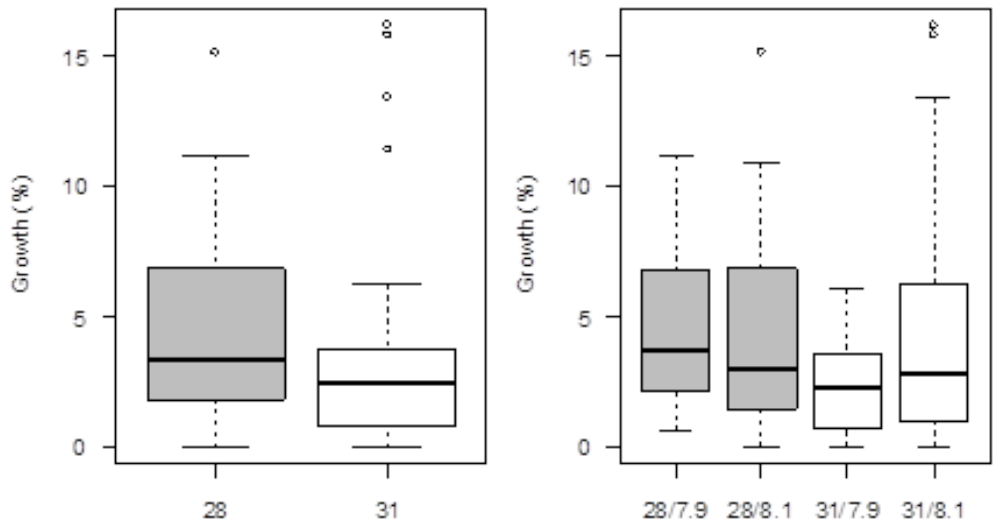
Objective 2: Caring for the next generation

by investigating individual and combined effects of water quality and global change on reproduction, larval development and settlement of key coral reef invertebrates (Uthicke, Negri, Webster, Flores, et al.)

Experiment 1: Exposure of Echinometra sea urchins two temperature and two pH treatments.

Interactive effects on growth and metabolism (growth, respiration ammonium excretion)



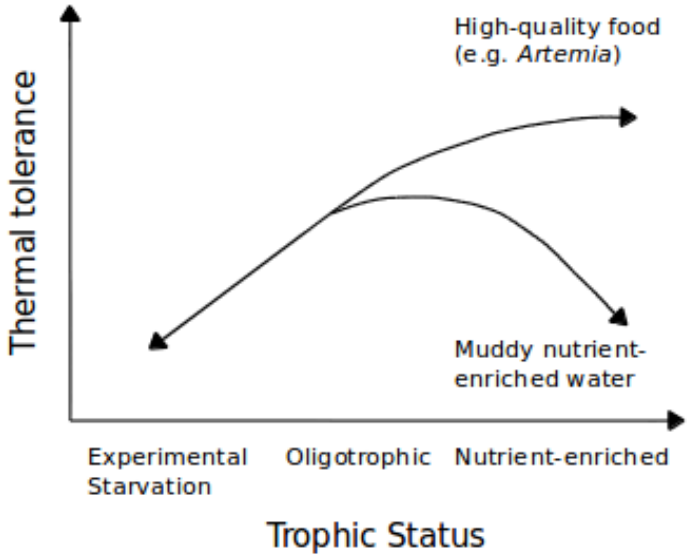
WQ and Thermal Stress Interactions: Conceptual model

Literature review reveals apparently contradictory results:

Four other studies have proposed synergistic effects between WQ and thermal stress, six other studies found the opposite (->corals had greater thermal tolerance at high levels of heterotrophy compared with starved corals).

Conceptual model:

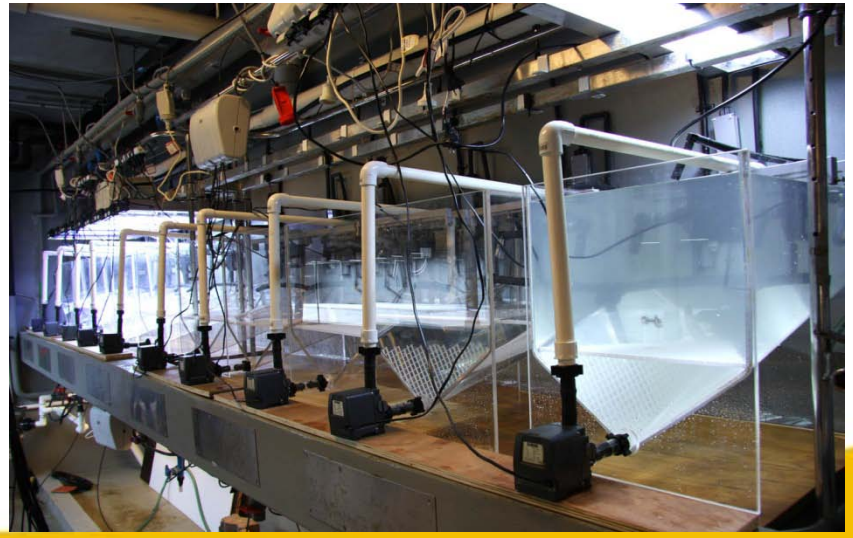
Apparent contradiction due to modal response of corals to food availability (both experimental starvation and exposure to organic enrichment are additional stressors that reduce the thermal tolerance in corals).



Combined effects of water quality and climate change on the early life history stages of Corals

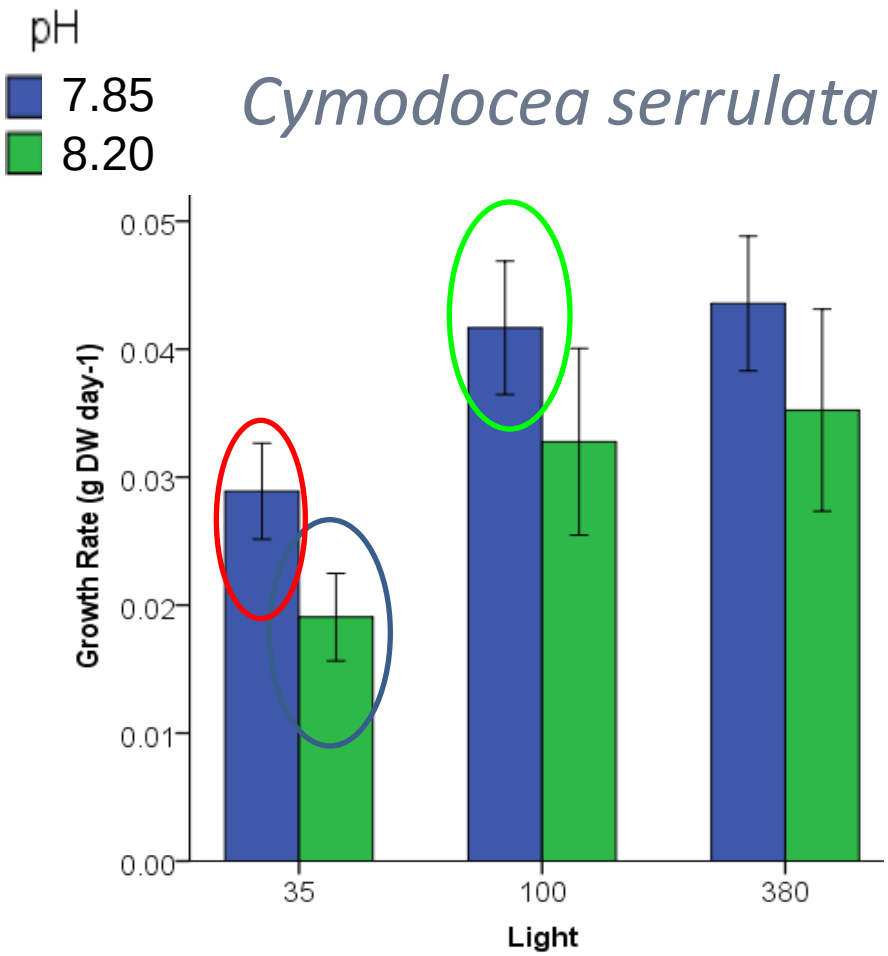
Initial coral spawning experiments completed in December 2012: investigating the effects of turbidity and organic enrichment on fertilisation and embryo development.

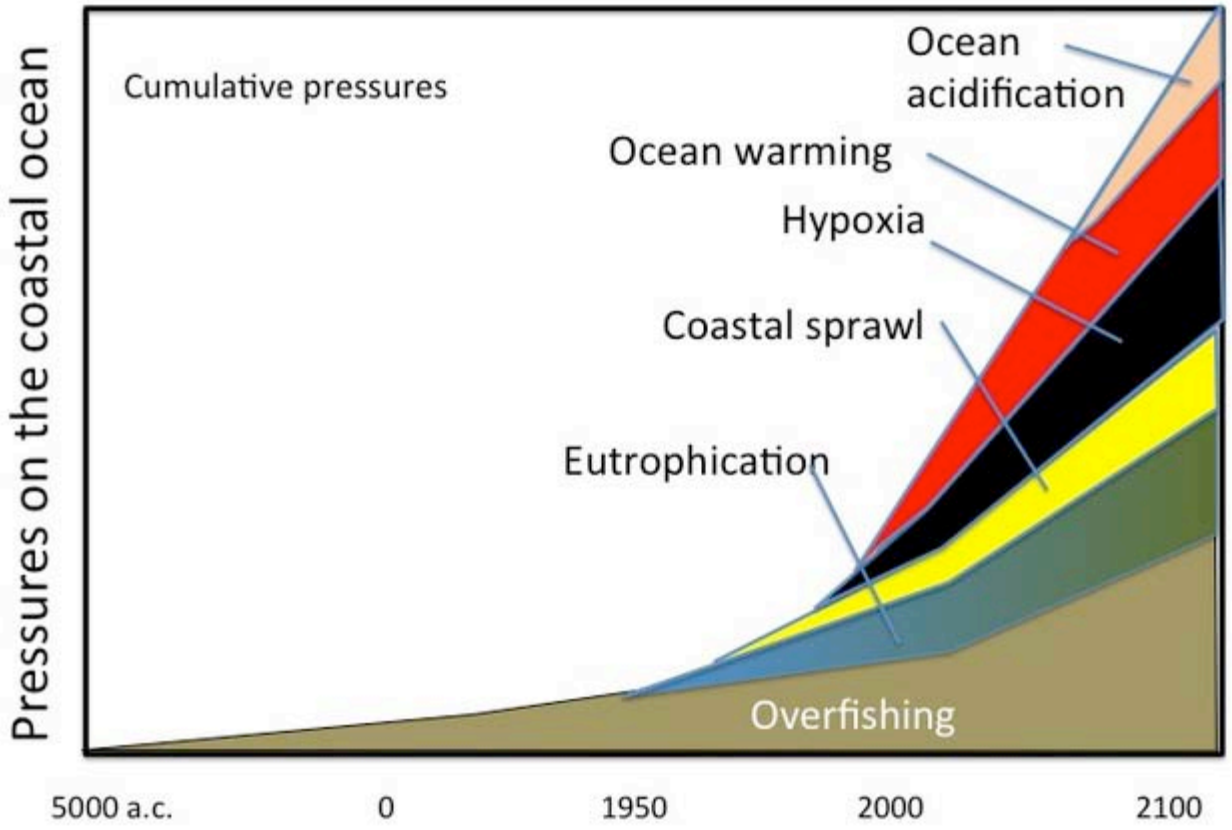
Coral spawning planned in March and Nov 2013 investigating the combined effects of water quality (sediments, organic enrichment) and climate change (thermal stress and acidification).



Present
Future 1
Future 2

Results: Seagrasses





Carlos Duarte http://theconversation.com/auditing-the-seven-plagues-of-coastal-ecosystems-13637

RELEVANCE OF WORK

- Coral reef ecosystem functioning changed through:

- Land runoff (increased nutrients, reduced light, pesticides)
- Climate change (temperature increase → bleaching)
- Ocean Acidification (massive diversity loss, reduced calcification)
- These factors are likely to be additive/synergistic:

Does management of land runoff 'buy time' for coral reefs to adapt/acclimatise to Climate change or OA?

Objective 4: Inshore water chemistry

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5.2 PROJECT OBJECTIVES

1) To experimentally quantify changes in the thresholds for global change stressors due to elevated local stressors

2) Caring for the next generation by investigating individual and synergistic effects of water quality and global change on reproduction, larval development and settlement of key coral reef invertebrates

3) Predicting the future performance of reef organisms, by experimentally testing hypotheses about differences in the vulnerability of coral species to ocean acidification, as derived from our studies of natural CO_2 seeps

4) Using inshore reefs as a model system to investigate the performance of calcifying organisms at low or variable carbonate saturation state