Commonwealth Environment Research Facilities
Marine and Tropical Sciences Research Facility

Impacts and Achievements of the MTSRF

Copy of abstract and presentation given at the
2010 Annual Conference of the
Marine and Tropical Sciences Research Facility (MTSRF)
http://www.rrrc.org.au/news/2010_conference.html

Showcasing the Australian Government's investment in the MTSRF for improved sustainability of the North Queensland region, and Australia

18-20 May 2010
Pullman Reef Hotel & Casino
Cairns, North Queensland

Reef & Rainforest RESEARCH CENTRE

Australian Government
Department of the Environment, Water, Heritage and the Arts

Abstract

MTSRF Project 3.7.1 a

Are symbiont-bearing benthic foraminifera good model organisms to test whether exposure to land runoff increases vulnerability to climate change?

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Recent modeling by Wooldridge (2009) suggested that the temperature tolerance of scleractinian corals may be reduced when corals are exposed to increased levels of nutrients from terrestrial runoff. In several *in situ* and aquaria experiments we tested whether the two foraminifera species *M. vertebralis* (with dinoflagellate symbionts) and *A. radiata* (with diatom symbionts) are more vulnerable to increased temperatures at increased levels of inorganic nitrogen. In a series of transplant experiments, both foraminifera showed significantly reduced growth rates on reefs closer to the mainland with higher exposure to land runoff. Aquaria experiments were conducted manipulating both temperature and nutrient availability. At water temperatures >2°C over current average summer levels, both species had reduced photosynthetic yields and reduced chlorophyll concentration, suggesting an expulsion of symbionts similar to that observed in corals ("bleaching"). Increased temperatures significantly reduced growth in both species, and also increased mortality in *M. vertebralis*. In the latter species, oxygen production immediately decreased upon exposure to elevated temperature, while respiration increased, suggesting that this species cannot derive a net organic carbon gain from its symbionts at >30°C. *A. radiata* showed no significant effect of nitrogen addition in any of the parameters measured. In *M. vertebralis*, increased nitrogen concentrations did not affect photosynthetic yields and chlorophyll content. In contrast, significant effects of nitrogen additions occurred for growth and mortality. Mortality rates of *M. vertebralis* increased and growth decreased with increased nitrate concentrations. Thus, foraminiferal species with different types of symbiont responded differently to increased nutrient conditions. However, the species with symbionts similar to corals (*M. vertebralis*) showed additive stress effects of temperature and nutrients for both mortality and growth. This suggests that, at least for this species improved local management of agricultural runoff would ameliorate potential effects of global stressors such as climate change.

Australian Government

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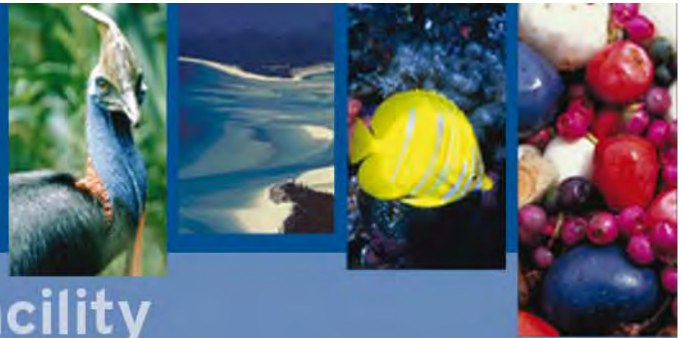


Marine and Tropical Sciences Research Facility

Benthic foraminifera as models to test whether nutrient exposure increases vulnerability to climate change

Sven Uthicke, Craig Humphrey,
Claire Reymond, Christiane Schmidt and
Katharina Fabricius

Australian Government | Australian Institute of Marine Science

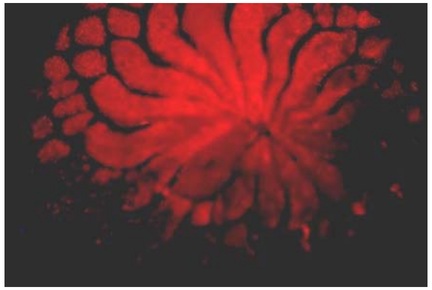
Reef & Rainforest Research Centre

ARC Centre of Excellence Coral Reef Studies

The University of Queensland Australia

Benthic foraminifera:

- Follow-on from WQ Indicator work: Climate context
- Single celled/calcifying animals
- Several tropical foraminifera have symbionts (dinoflagellates, diatoms, chlorophytes, rhodophytes)



- Why work on these?
- Ecologically important (e.g. sediment production)
- Convenient simple model organisms
- Indicators for water quality in Florida and Caribbean
  - Confirmed by our work in 3.7.1

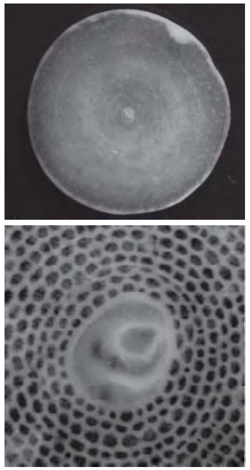
Aims

- Investigate whether foraminifera bearing two different symbiont types are susceptible to temperature increase

  → are these species also bleaching similar to corals?

- If so, how do they respond to combined local (nutrient) and global (temperature) stress

Marginopora vertebralis



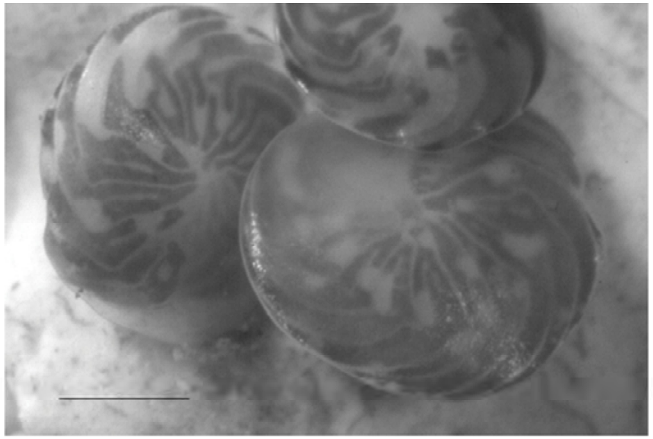
Dinoflagellates
(similar to corals)

Amphistegina radiata

Diatoms

Bleaching – the best-known temperature response in corals

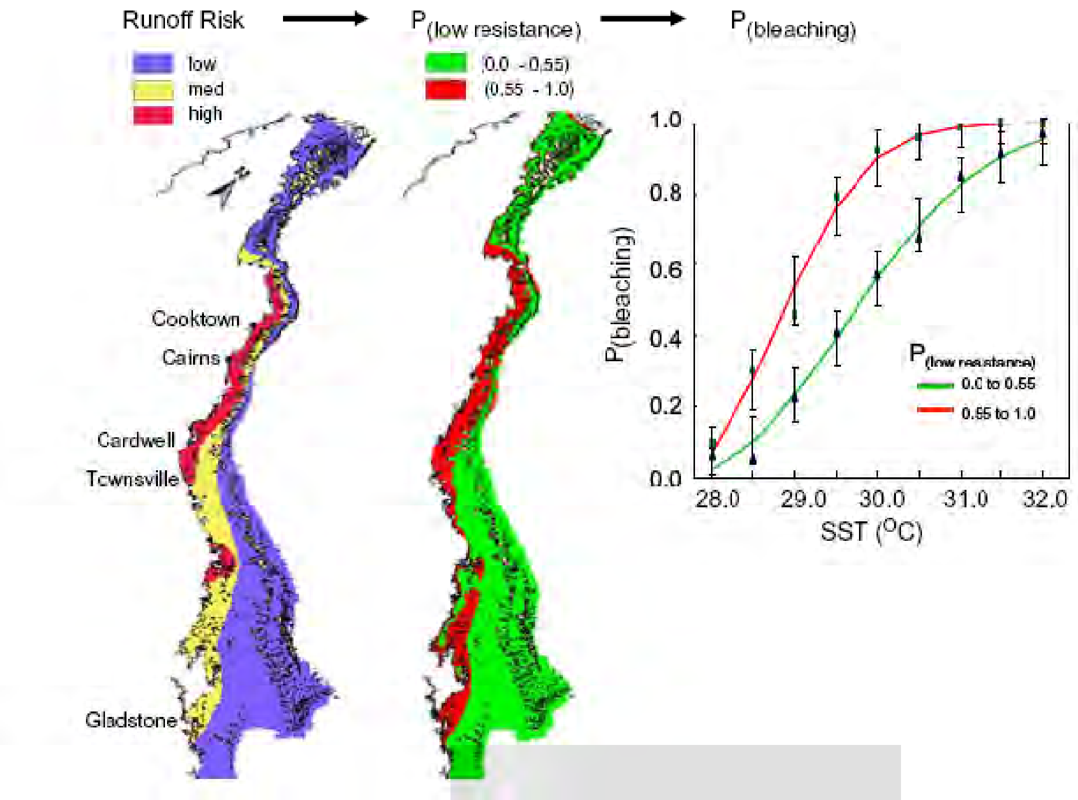
- Several other species groups (e.g. giant clam) have been observed to bleach
- One foram species is known to bleach in response to high temperature



Amphistegina gibbosa

Hallock, P., D. E. Williams, S. K. Toler, E. M. Fisher, and H. K. Talge. 2006. Proceedings, 10th Int Coral Reef Symp. 729-737.
Hallock, P., and D. E. Williams. 2006. Anuário do Instituto de Geociêncieas **29:** 108-128.
Williams, D. E., and P. Hallock. 2004. Marine Biology **145:** 641-649.
Talge, H. K., and P. Hallock. 2003. Journal of Eukaryotic Microbiology **50:** 324-333.

Nutrient supply and coral bleaching



- Mechanisms: Complex interactions, mainly release of symbiont populations from nutrient limitation

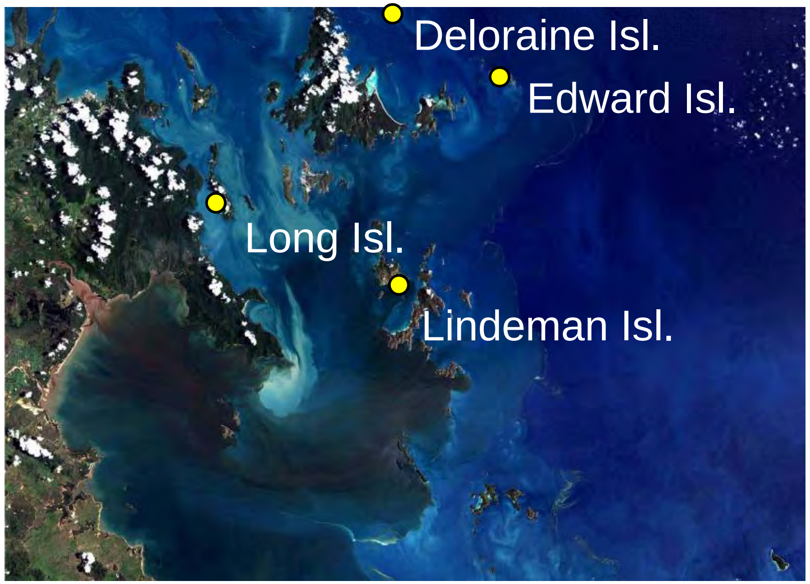
  → unchecked growth, reduced organic matter translocation to host

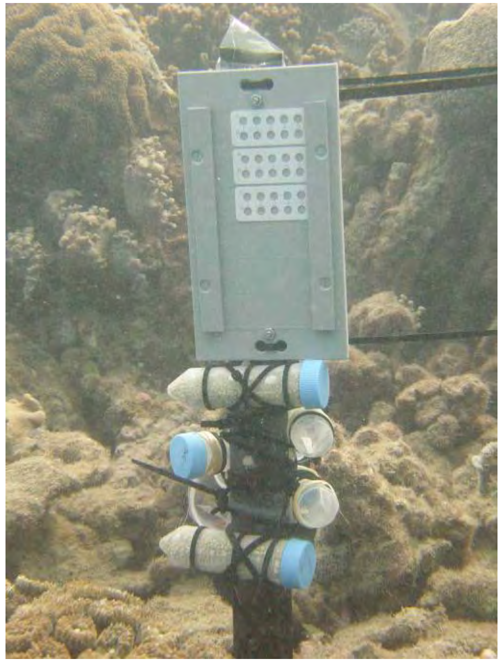
  <u>Consequences:</u>

- This would provide a strong argument for improved local management to increase resilience of the reef

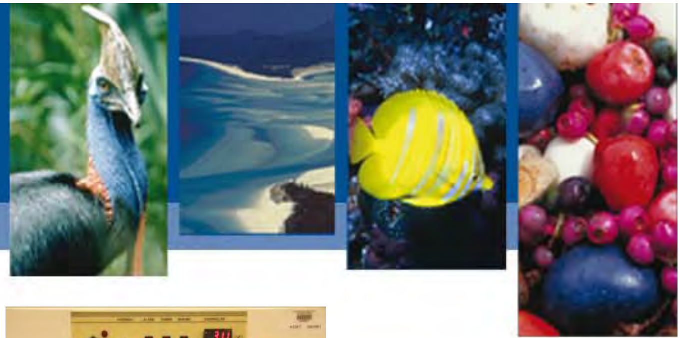
Wooldridge SA (2009) ***Marine Pollution Bulletin*** **58,** ***745-751.***
Wooldridge SA, Done T (2009). ***Ecol Apps 19, 1492-1499.***

Field Experiments: explore responses to nutrients by transplant along gradient





- **7 exposure experiments at 2 inshore vs 2 offshore islands**
- **Both species**
- **Response parameter: growth**



Lab Experiments

1) Temperature effects alone to establish bleaching threshold (no added nutrients)

- Five different temperatures over 6-30 days

2) Testing forams as models for temperature nutrient interactions

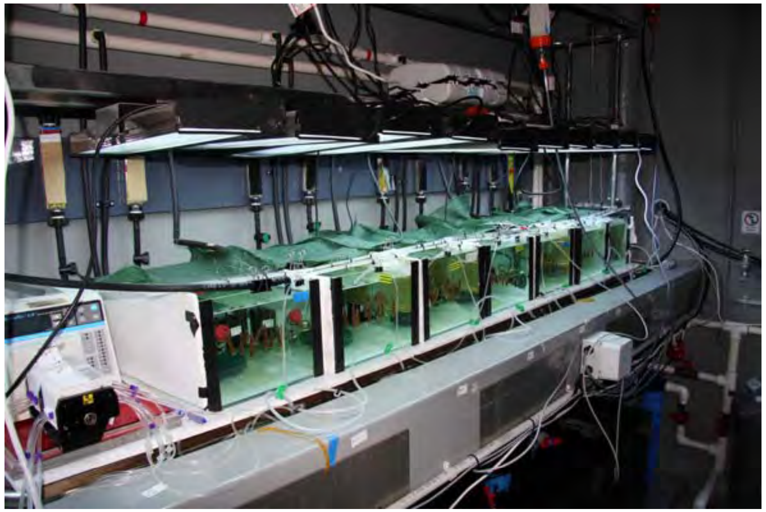
Flow through experiment

- Average nitrate concentrations

0.45, 0.9 and 1.35uM

- Temperature 26, 29, 31°C
- 3 replicate tanks per treatment

→ (27 tanks)



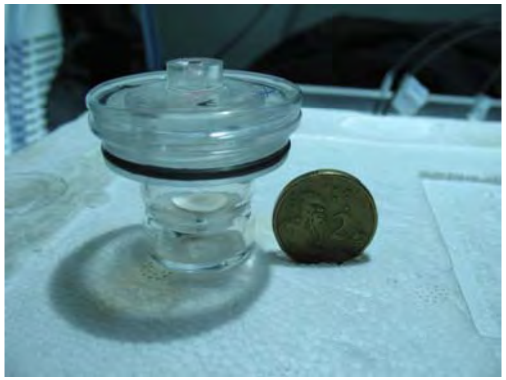
Response parameters:

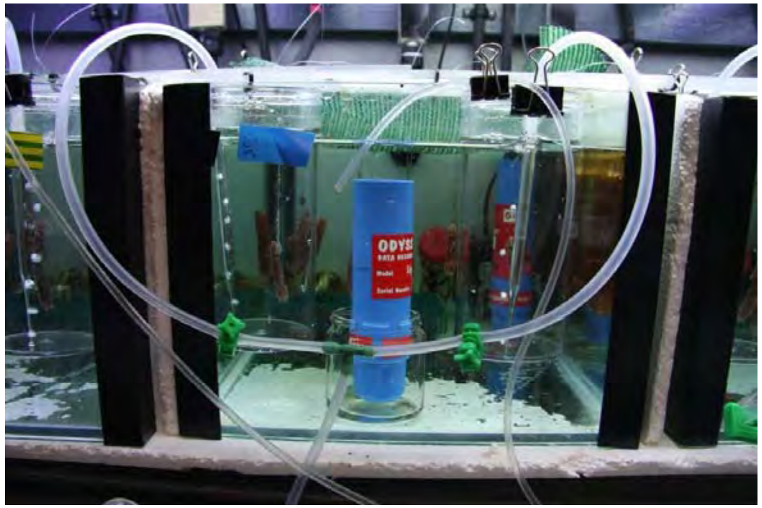
Symbiont-specific

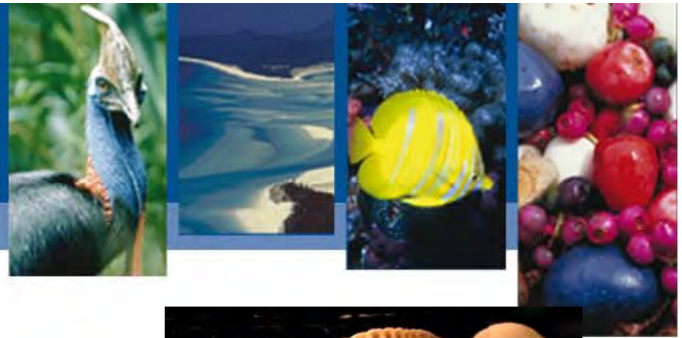
- Chlorophyll a: indicator for symbiont biomass
- PAM: photosynthetic efficiency

Holobiont:

- Productivity (optode based method developed)
- Growth (as increase in surface area)
- Mortality

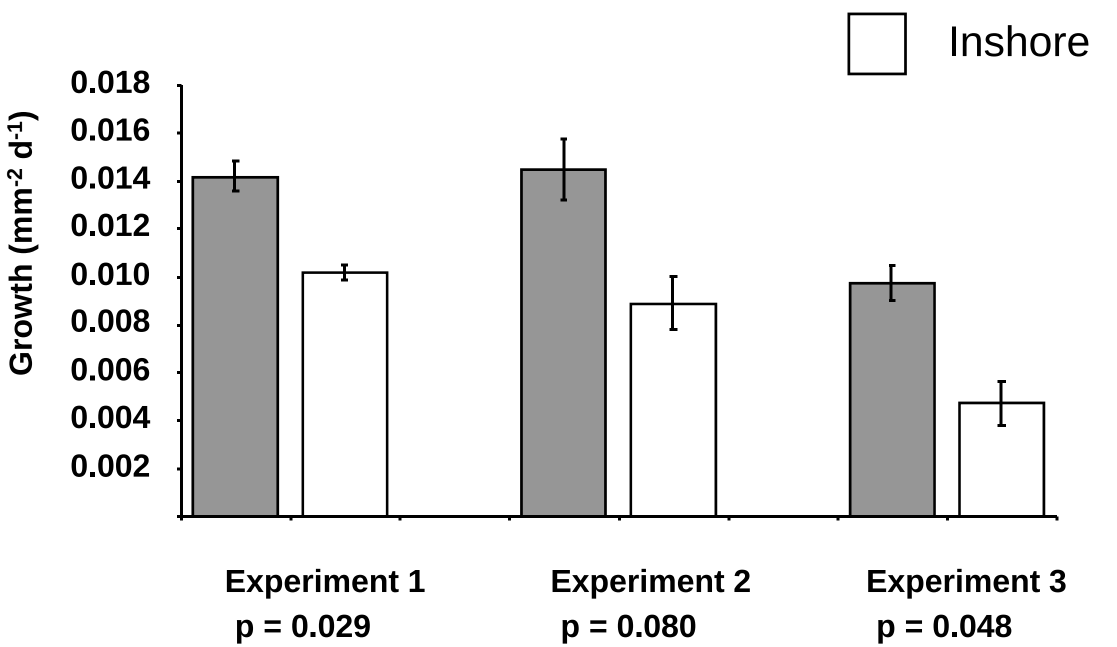






Results: *Amphistegina radiata*

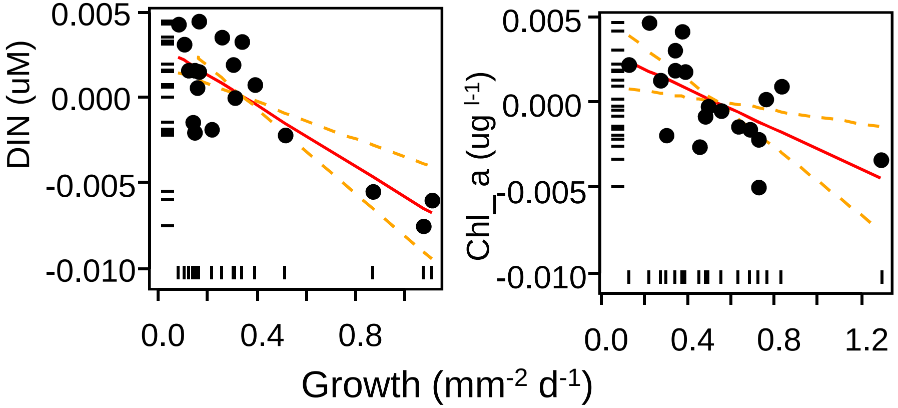
A. radiata growth in situ



- Offshore values consistently higher than inshore values
- Nutrient response?

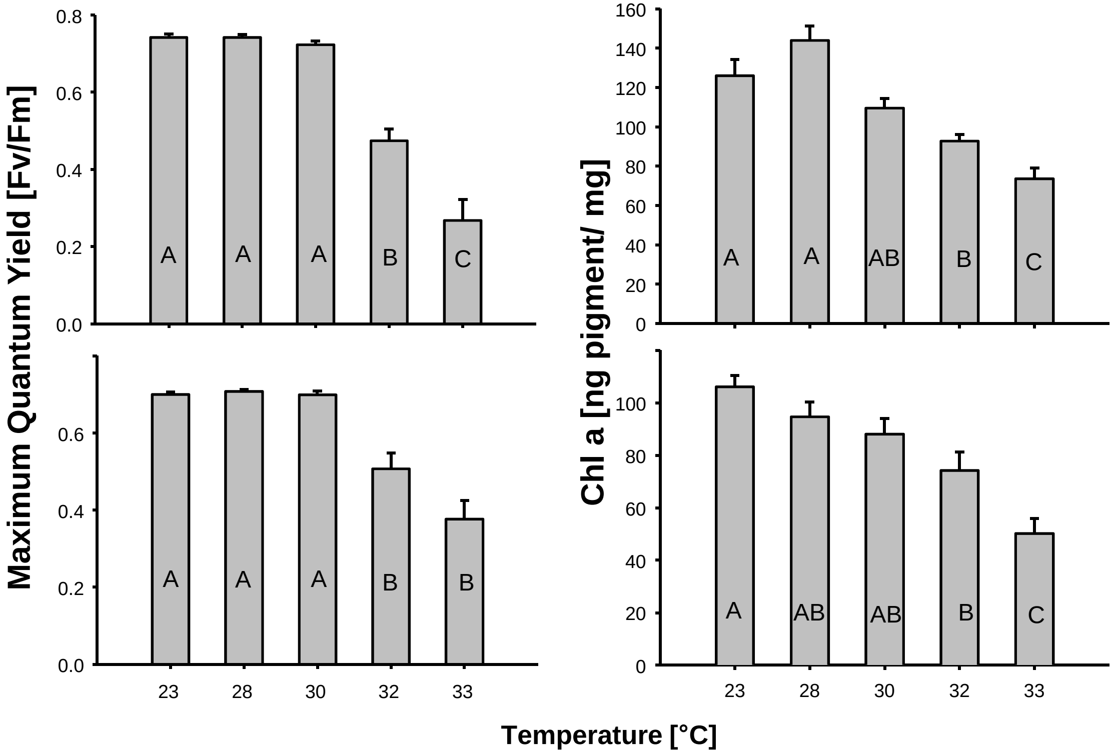
Growth *A. radiata:* Multiple Regression analysis

- 10 environmental parameters (WQ and temperature)
- 69% of growth variation in *A. radiata* can be explained



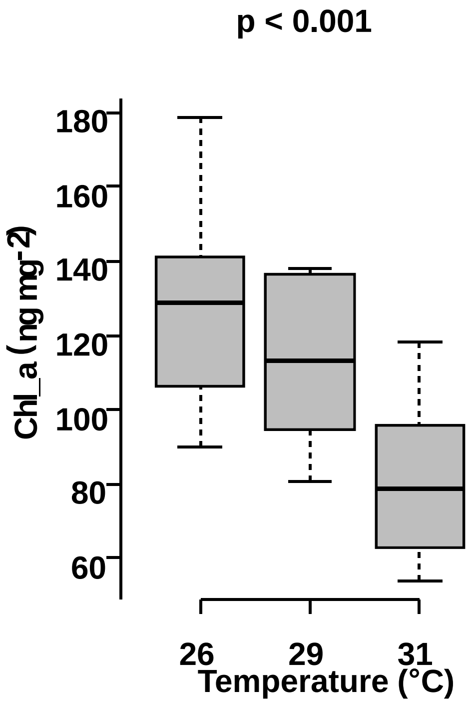
- Only 2 WQ parameters contribute: DIN, chlorophyll a
- No clear temperature effect

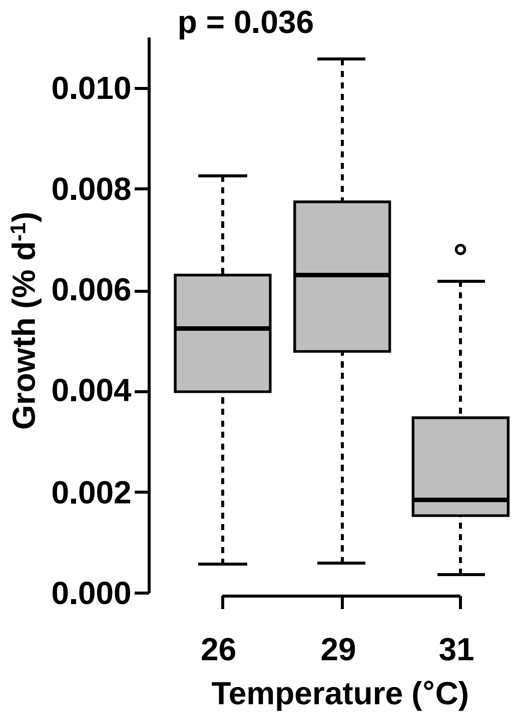
A. radiata: effects of temperature



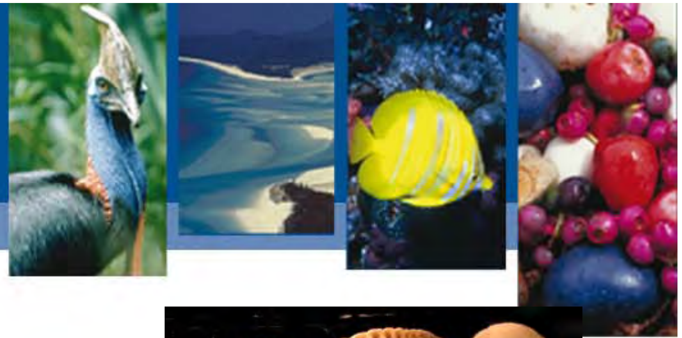
- Several experiments 6-8d exposures
- Distinct reduction in Photosynthetic yield and Chlorophyll with temperature
- → Bleaching

A. radiata: Temperature x Nutrient experiment



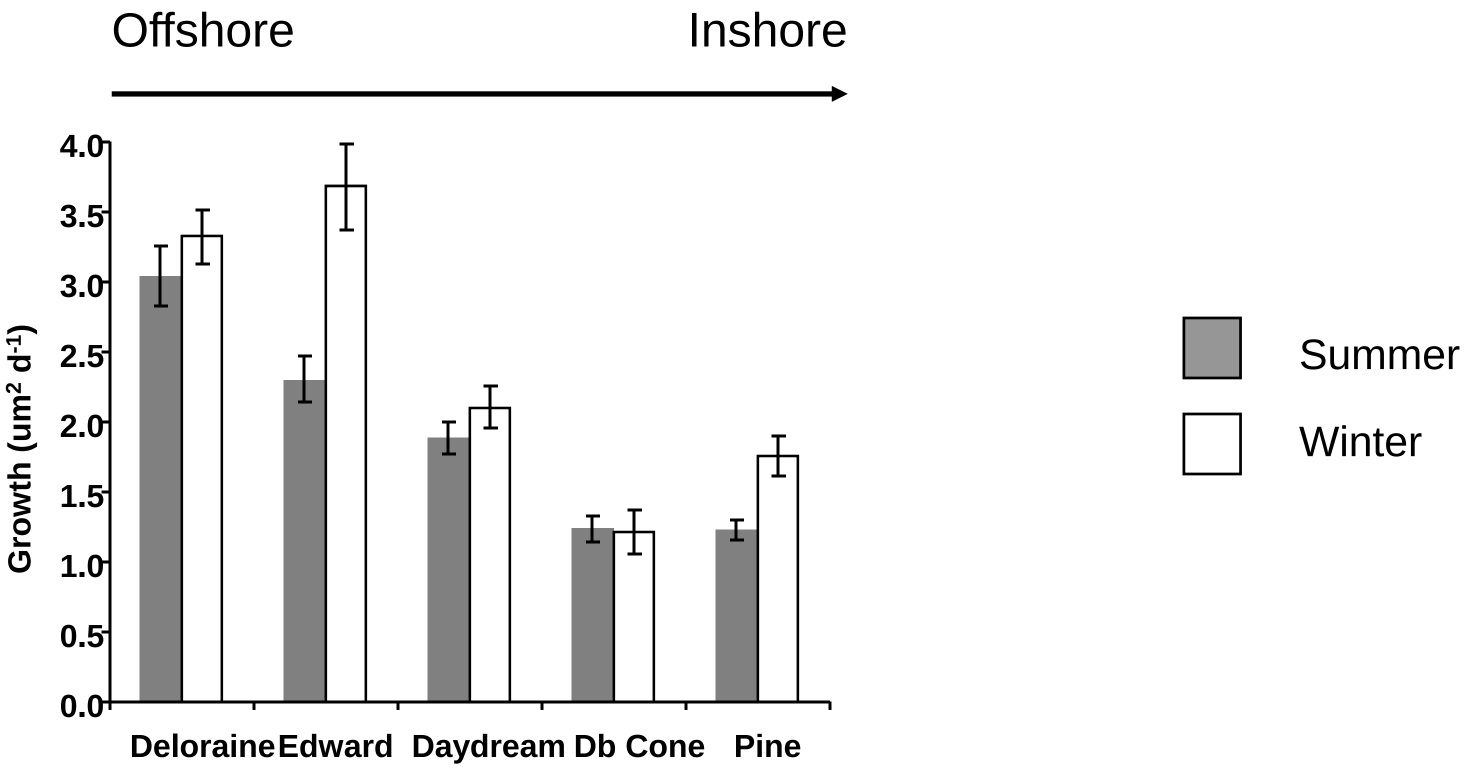


- Decrease in chlorophyll with higher temperature
- Decreased Growth at 31°C
- No nutrient effect



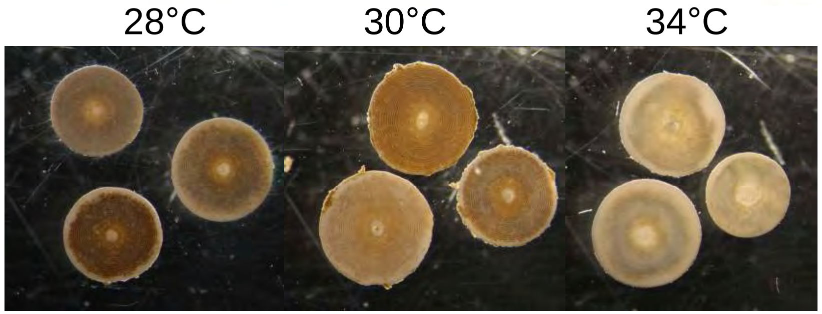
Results: *Marginopora vertebralis*

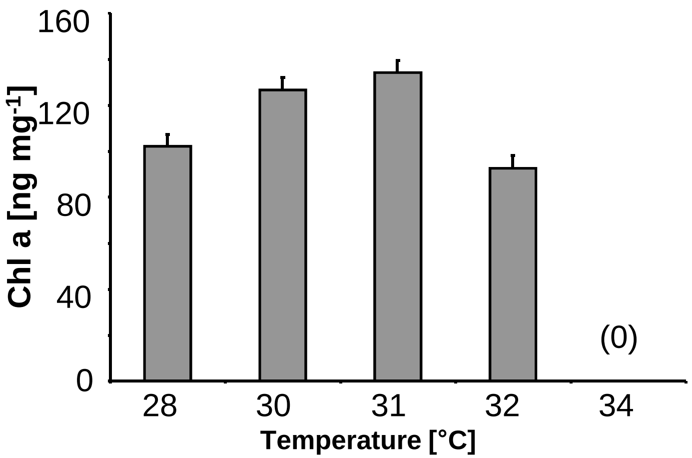
M. vertebralis: Field Growth



- Winter values consistently higher
- Clearly higher growth offshore

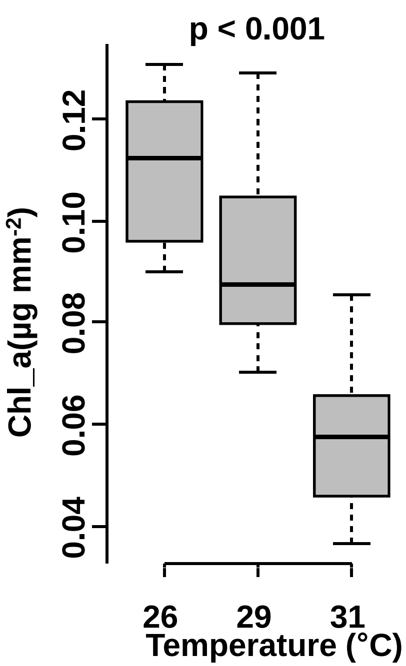
M. vertebralis: effects of temperature

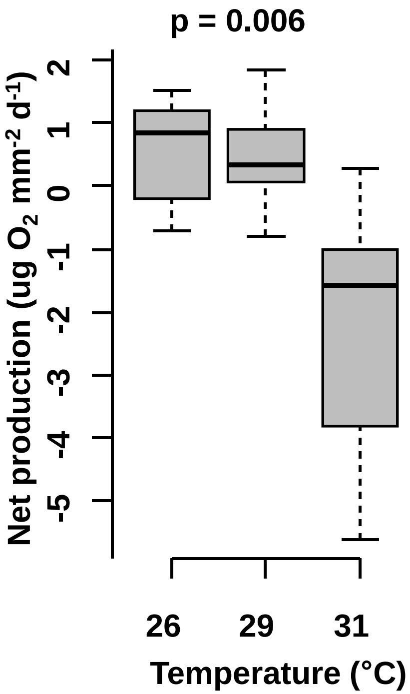


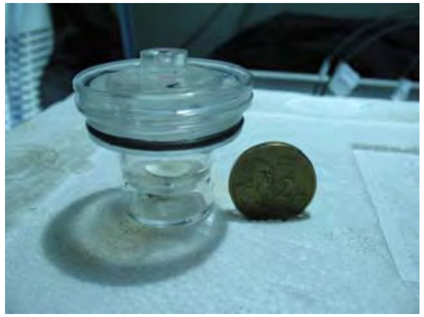


- 30 d exposure to 5 temperatures
- Reduction Chlorophyll with temperature
- Mortality distinctly enhanced > 31**°C**

M. vertebralis: Temperature x Nutrient experiment
a) Chlorophyll and production

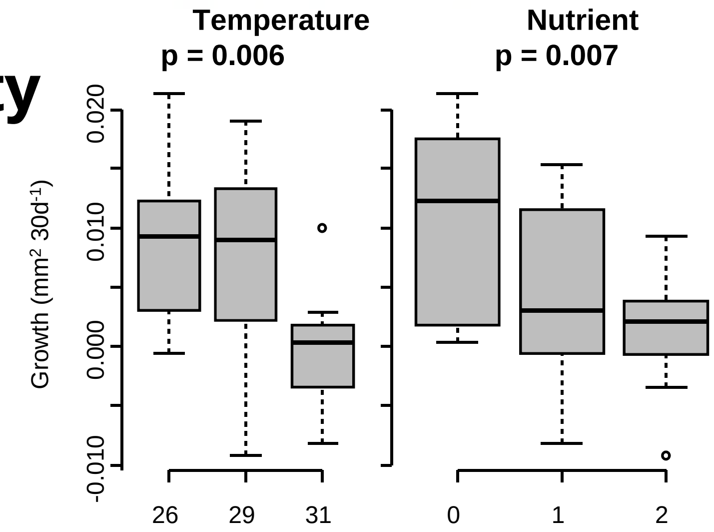






- Decreased chlorophyll a content and productivity at 31°C
- No nutrient effect

M. vertebralis: Temperature x Nutrient experiment
b) Growth and Mortality



- Decrease in growth at higher temperatures and higher nitrate concentrations

--> Additive effect

- Same finding for mortality

Temperature (°C) Nitrate (µmol l-1)

Summary: Temperature and Nutrient Effects

	A. radiata (symbiont: Diatoms		*M. vertebralis* (symbiont: Dinoflagellates	
	Temperature	Nutrient	Temperature	Nutrient
Field				
Growth	No	Yes	Y(?)	Y(?)
Laboratory				
PAM	Yes	No	Yes	No
Chlorophyll	Yes	No	Yes	No
Productivity	--	--	Yes	No
Growth	Yes	No	Yes	Yes
Mortality	Yes	No	Yes	Yes

Conclusions

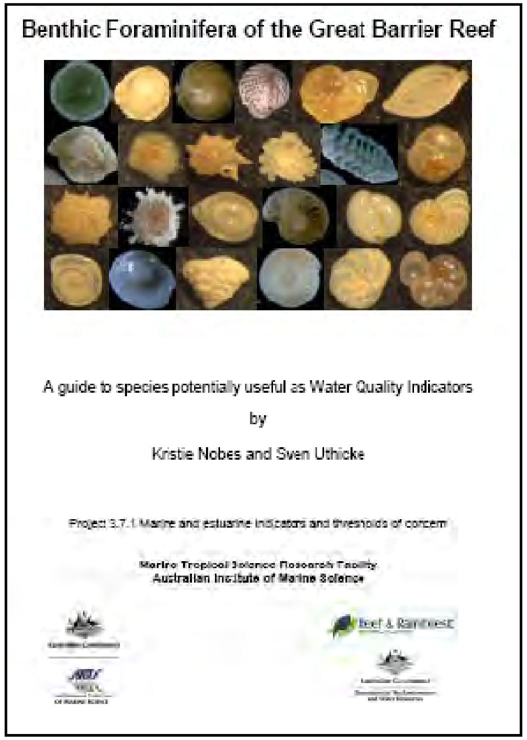
- Foraminifera of both symbiont types are susceptible to bleaching
- Effects were measured at temperatures close to current summer averages
- Negative effects of enhanced nutrient concentrations were detected
- Best response variables are summary parameters for fitness of the holobiont (animal and plant), such as growth and mortality

→Forams are ideal models to investigate climate and nutrient interactions, small size, easy access, high replication possible in relatively small systems

Thank you

Outputs/outcomes from foram research in 3.7.1

Foram Atlas


Benthic Foraminifera of the Great Barrier Reef

A guide to species potentially useful as Water Quality Indicators

by

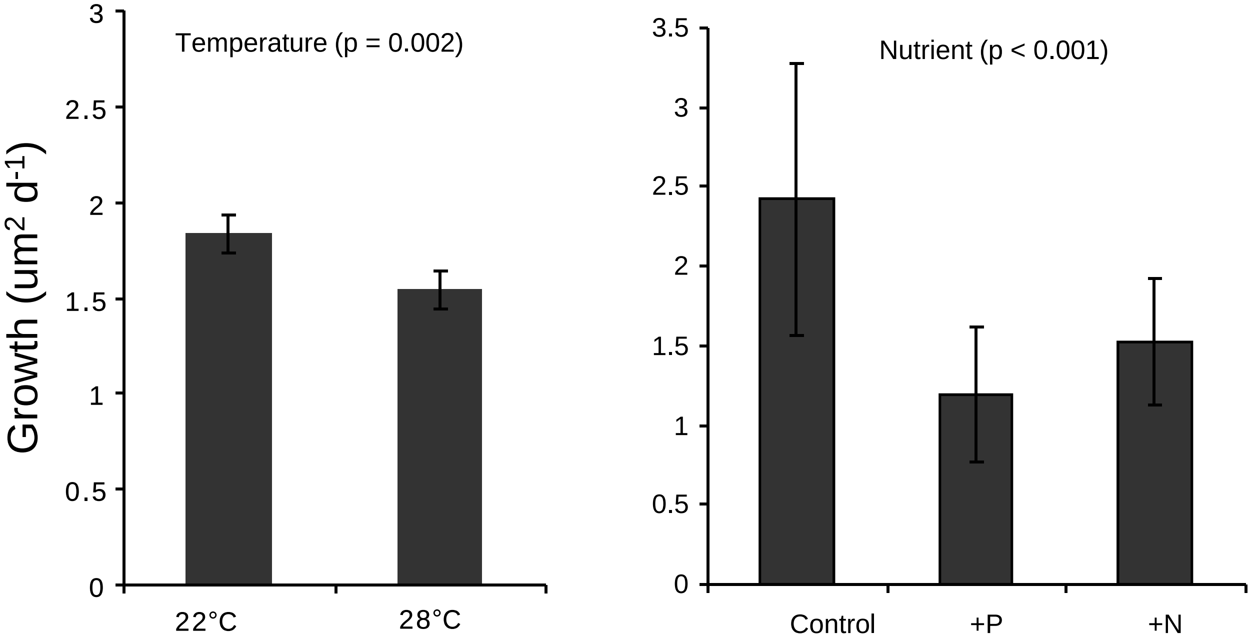
Kristie Nobes and Sven Uthicke

Project 3.7.1 Marine and estuarine indicators and thresholds of concern

Marine Tropical Science Research Facility
Australian Institute of Marine Science

1) Routine application of FORAM Index in Reef Rescue Marine Monitoring Program
2) Fabricius K., Uthicke S., Cooper T., Humphrey C., De'ath G., Mellors J. (2007) MTSRF Research Report Series, Report No. 3.
3) Uthicke, S., Nobes, K. (2008). Est Coast Shelf Sci 78: 763-773
4) Nobes, K., Uthicke, S. Henderson, R (2008). J Exp Mar Biol Ecol 363: 48-54
5) Uthicke, S., A. Thompson, and B. Schaffelke. 2010. Coral Reefs **29:** 209-225.
6) Uthicke, S., and C. Altenrath (in press) Limnol. Oceanogr.
7) 2 PhD theses (ongoing), 4 Honours thesis

Temperature x Nutrients (P, N):
M. vertebralis



- Both Temperature and Nutrient effects significant
- Reduced growth at higher temperatures
- Both higher N and P addition decrease growth
- No interaction → but additive effect