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

Herbicide-climate interactive effects on calcifying and symbiont bearing marine species

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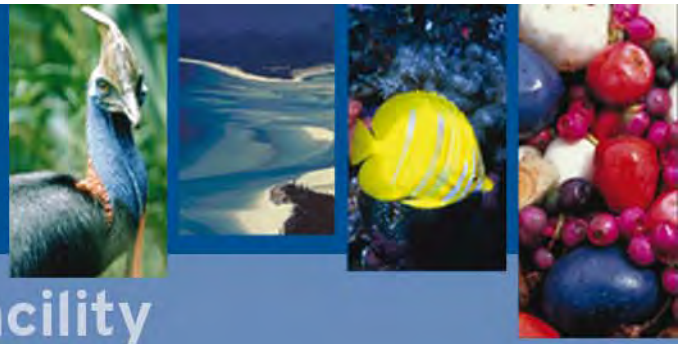
Recent monitoring data showed that inshore waters of the Great Barrier Reef (GBR) have low, but consistently measurable concentrations of agricultural herbicides, with generally higher values during the summer wet season. Previous research into the effects of herbicides on coral reef organisms has primarily focused on single dose-response relationships and on a single group of target organisms (a few species of reef building corals). There is a large knowledge gap about herbicide effects in other autotrophic reef organisms. Furthermore, studies to date have not addressed the fact that field herbicide exposures are likely to occur in combination with other environmental stressors such as high irradiance intensities, high water temperatures, low salinity or elevated nutrient concentrations. This MSTRF research focuses on the effects of herbicide exposure on a group of autotrophic coral reef organisms, symbiont-bearing foraminifera, which have been suggested as model organisms for experimental work on pollution and climate change. We aimed to contribute to the development of threshold values for exposure to herbicides and also to test potential climate and herbicide interactions. Our results showed that symbiotic foraminifera [13 species tested, hosting all major groups of endosymbionts known in these organisms (diatoms, dinoflagellates, red and green algae)] are sensitive to low level herbicide contamination. Experiments simulating chronic exposures (manipulating both temperature and herbicide concentration) revealed that photosystem II (PSII) herbicides can amplify the adverse effects of thermal stress on foraminifera. Our results provide information on threshold herbicide concentrations for various foraminifera and demonstrate that low herbicide concentrations can negatively affect these key reef species in addition to thermal stress at projected climate change scenarios.



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Herbicide-climate interactive effects on calcifying and symbiont bearing marine species

Photophysiological response of symbiotic foraminifera to high temperature and PSII herbicides

JW van Dam[1,2], S Uthicke[1], AP Negri[1] and JF Mueller[2]

[1] Australian Institute of Marine Science

[2] The University of Queensland, National Research Centre for Environmental Toxicology

An extension of MTSRF project 3.7.1. **May 2010**

Mass bleaching attributed to elevated SSTs (Baker 2008, GBRMPA 2009)

Many key reef organisms live close to thermal tolerance thresholds (Lesser 2007)

Mass bleaching attributed to elevated SSTs (Baker 2008, GBRMPA 2009)

PSII herbicides ubiquitous contaminants GBR (Lewis 2009, Shaw 2010, AMMP)

Diuron, Atrazine, Simazine, Hexazinone, Tebuthiuron, Ametryn

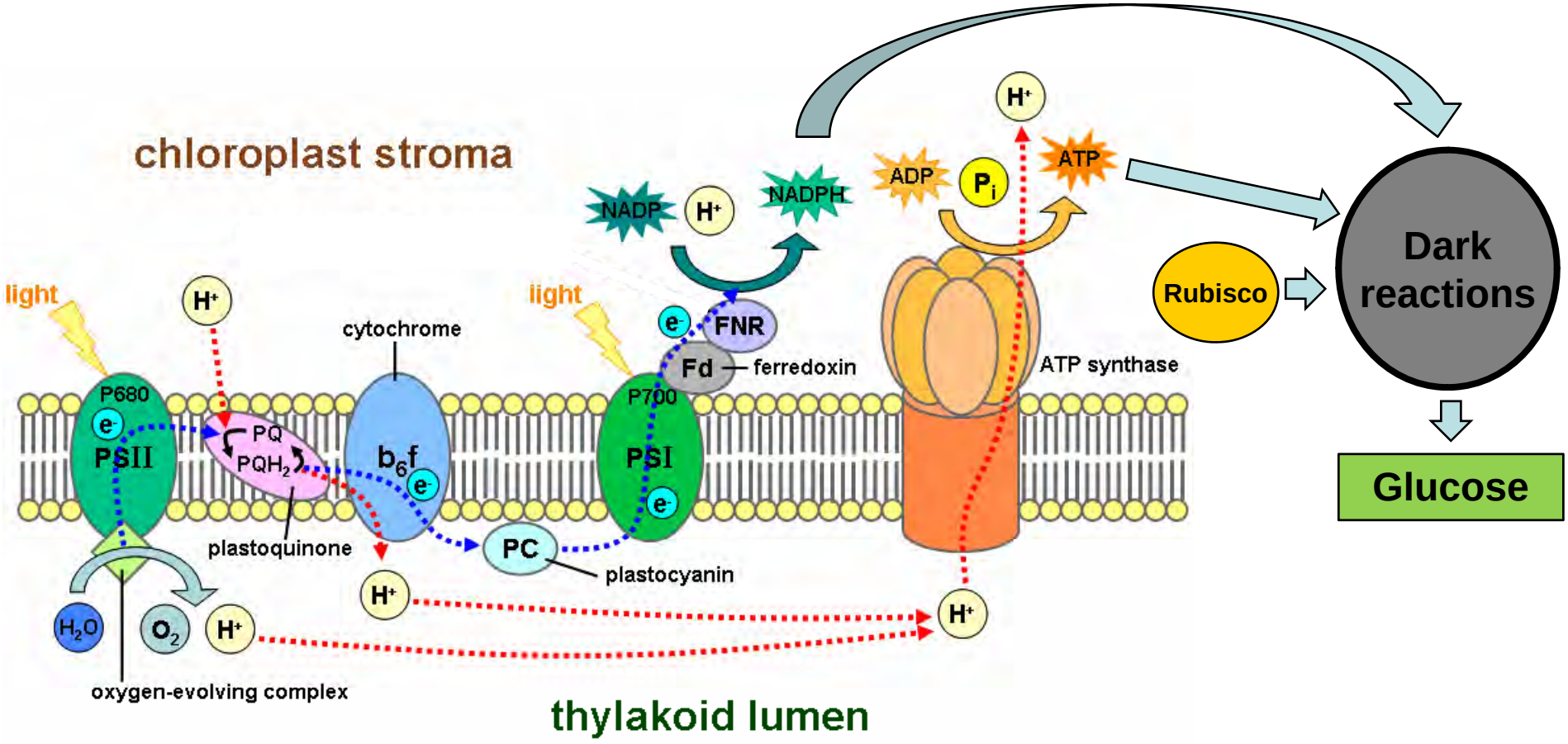
Effects shown at environmentally relevant concentrations (Cantin 2007, Negri 2005, Jones 2003)

Mass bleaching attributed to elevated SSTs (Baker 2008, GBRMPA 2009)

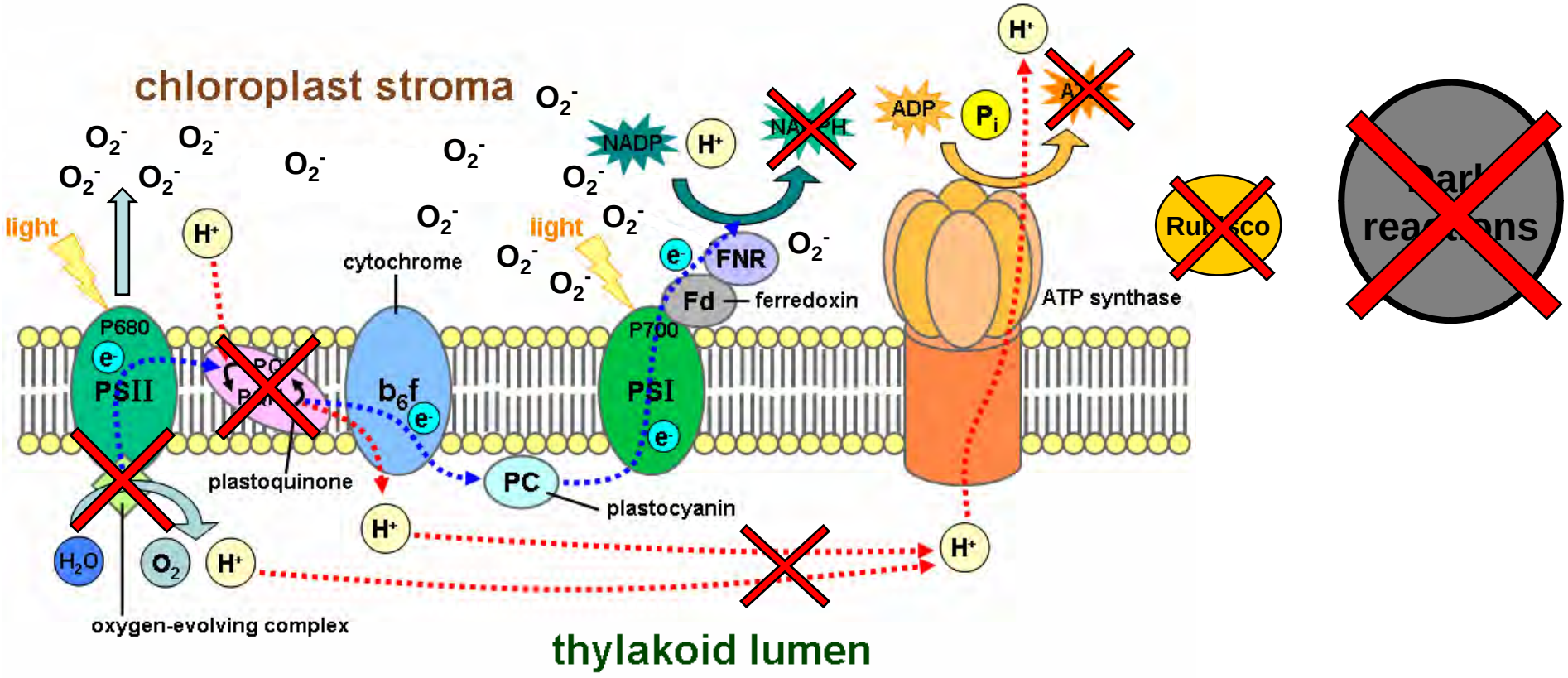
PSII herbicides ubiquitous contaminants GBR (Lewis 2009, Shaw 2010, AMMP)

Both factors potentially interfere with photosynthetic pathways in symbiotic algae

Light reactions photosynthesis



Heat and herbicide stress



Past research focused on single stressor and limited species

No clear knowledge on interactions between environmental and chemical stressors

van Dam JW, Negri AP, Uthicke S, Mueller JM. Chemical pollution on coral reefs: exposure and ecological effects. In: Sanchez-Bayo F, van den Brink PJ, Mann RM (Editors). Ecological impact of toxic chemicals. Bentham Science Publishers Ltd. (*in press*).

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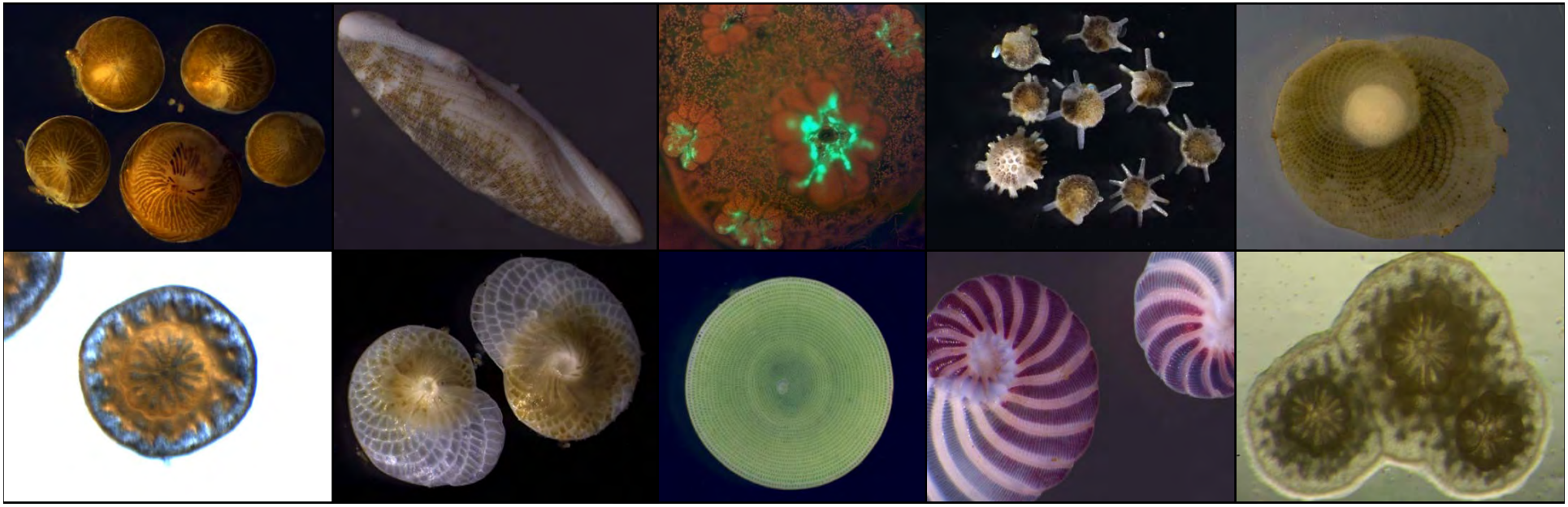
No clear knowledge on interactions between environmental and chemical stressors

Evaluate toxic effects of PSII herbicides on a wider range of symbioses

Understand interactions between elevated SSTs and PSII herbicides

Approach and methodology

Multiple characteristic symbioses – foraminifera and hard corals



Approach and methodology

Multiple characteristic symbioses – foraminifera and hard corals

Exposure studies in a temperature controlled environment

Approach and methodology

Multiple characteristic symbioses – foraminifera and hard corals

Exposure studies in a temperature controlled environment

Acute and chronic exposures

Variables:

- **Species**
- **Temperature**
- **Herbicide concentration**

Approach and methodology

Multiple characteristic symbioses – foraminifera and hard corals

Exposure studies in a temperature controlled environment

Chronic and acute exposures; variables species, temperature and herbicide concentration

Complementary redeployment experiments (field recovery)

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Range of physiological and biochemical endpoints

- **Photosynthetic performance** (PAM fluorometry)
- Primary production (Respirometry)
- Pigment composition (HPLC)
- Growth, mortality and symbiont density

Photophysiological response of symbiotic foraminifera to elevated diuron concentrations

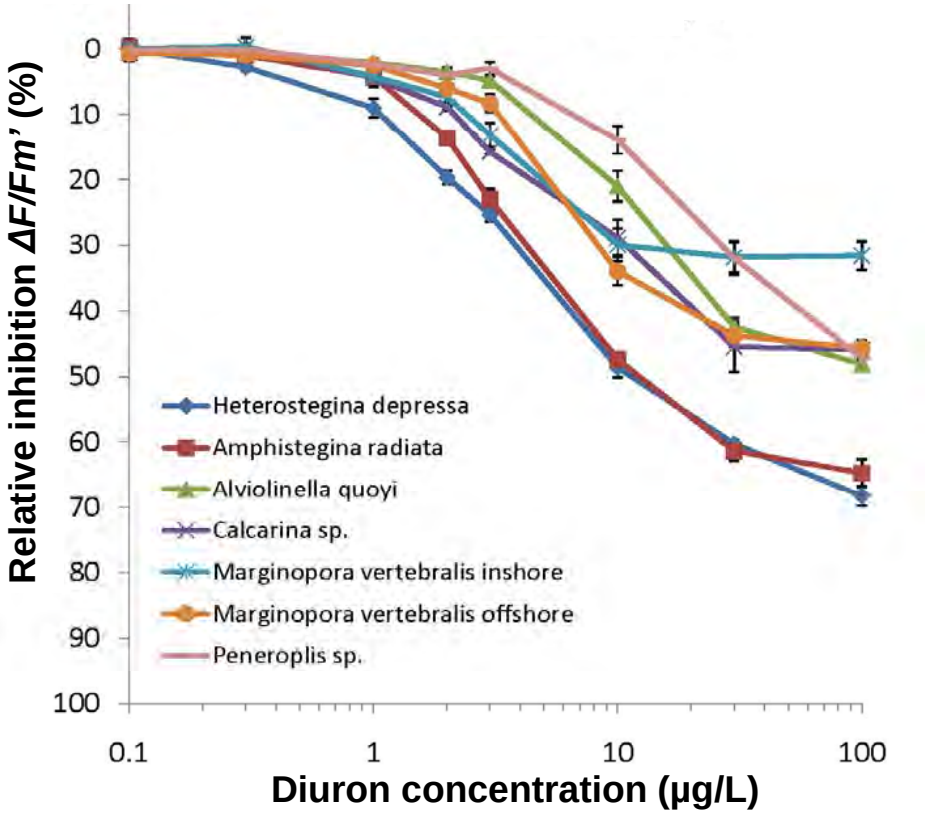
Static exposure experiments

- 7 species tested hosting 3 different symbiont phyla
- 48 hr exposure followed by 48 hr recovery
- 7 diuron concentrations tested against control

Light adapted PSII yield **(*ΔF/Fm'*)** = directly proportional to **energy conversion in PSII**

Dark adapted PSII yield **(*Fv/Fm*)** = indicative of **chronic photoinhibition (damage to PSII)**

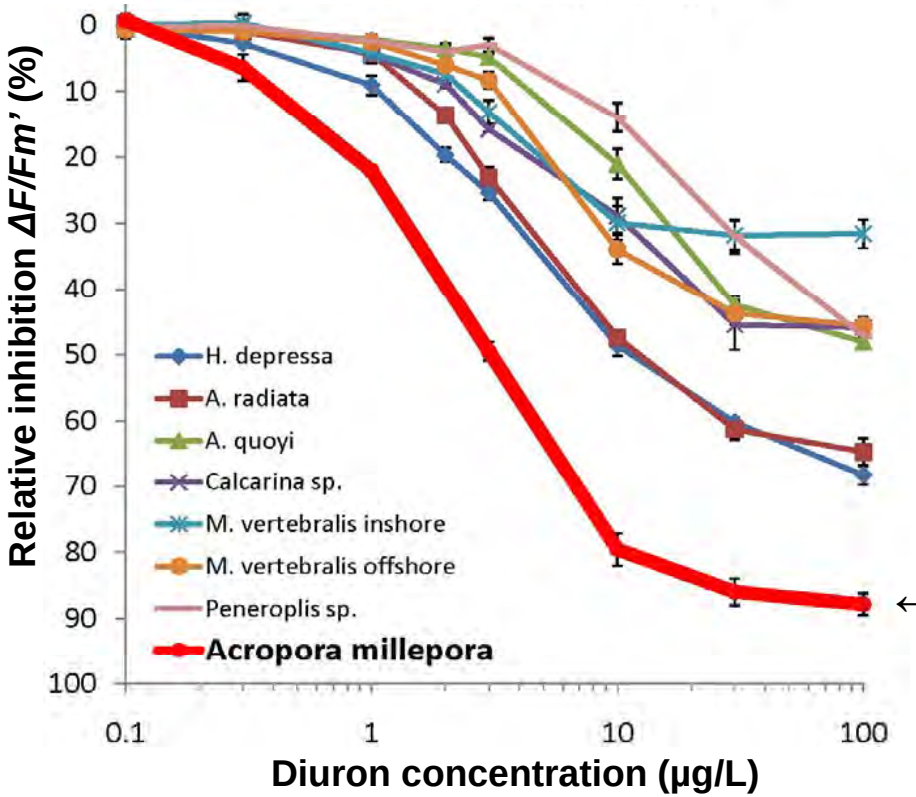
Photophysiological response of symbiotic foraminifera to elevated diuron concentrations



24 hr inhibition *ΔF/Fm'*

- Sensitivity differs between species
- Diatom bearing species most sensitive
- Inshore vs offshore?

Photophysiological response of symbiotic foraminifera to elevated diuron concentrations

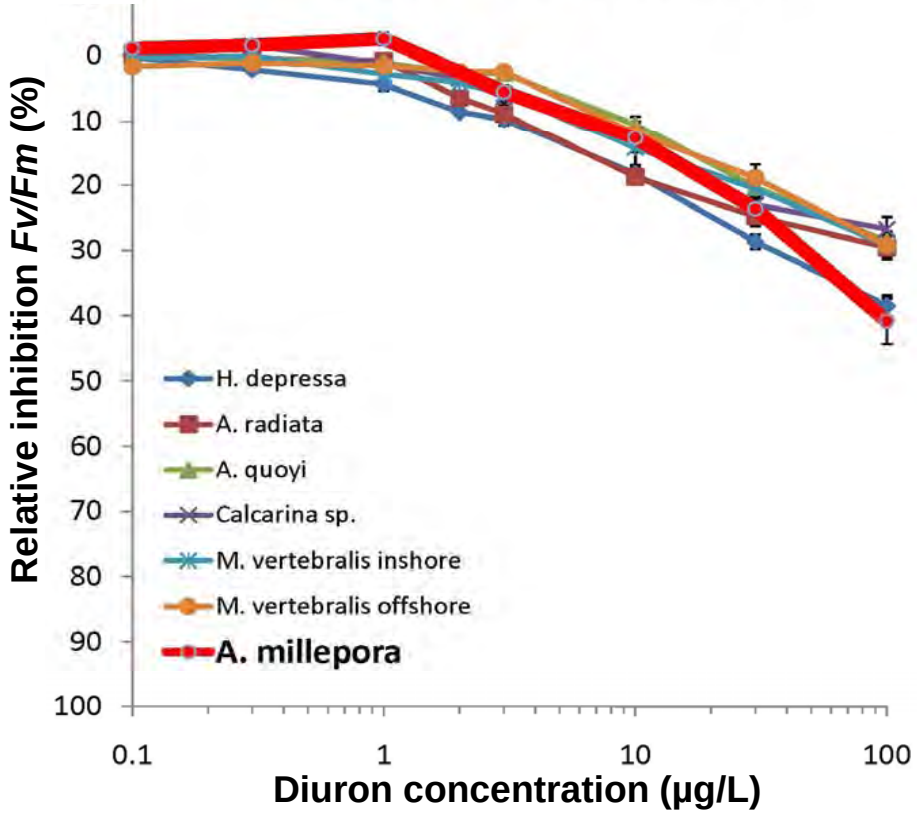


24 hr inhibition *ΔF/Fm'*

- Sensitivity differs between species
- Diatom bearing species most sensitive
- Inshore vs offshore?
- Corals much more sensitive under experimental light intensities

← **Thanks Flo!**

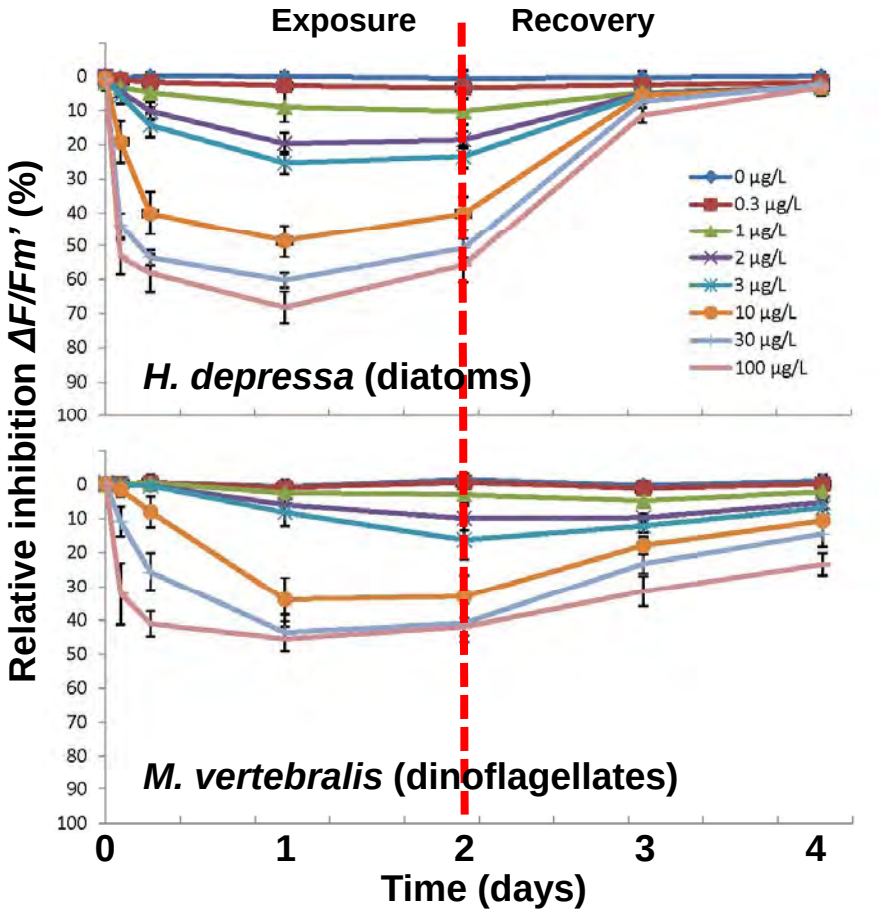
Photophysiological response of symbiotic foraminifera to elevated diuron concentrations



24 hr inhibition *Fv/Fm* (damage)

- Despite low light environment, foraminifera sensitive to photodamage
- Sensitivity reflection of limited photoprotective mechanisms?

Exposure and recovery in symbiotic foraminifera



- Reversible character herbicide binding well visible
- More profound effect, but also more rapid recovery in species bearing diatoms
- Very slow kinetics compared with other photosynthetic species

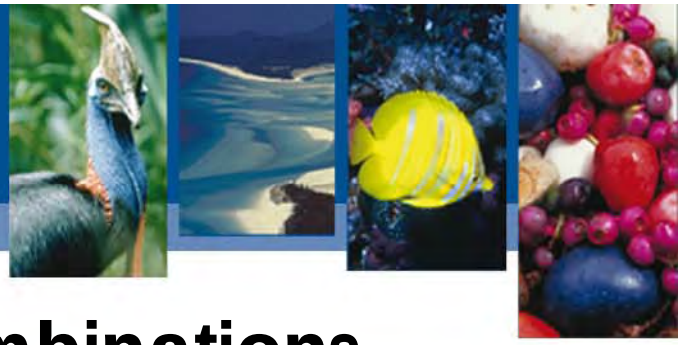
Photophysiological response of foraminifera to temperature-herbicide combinations

1. - Static exposures

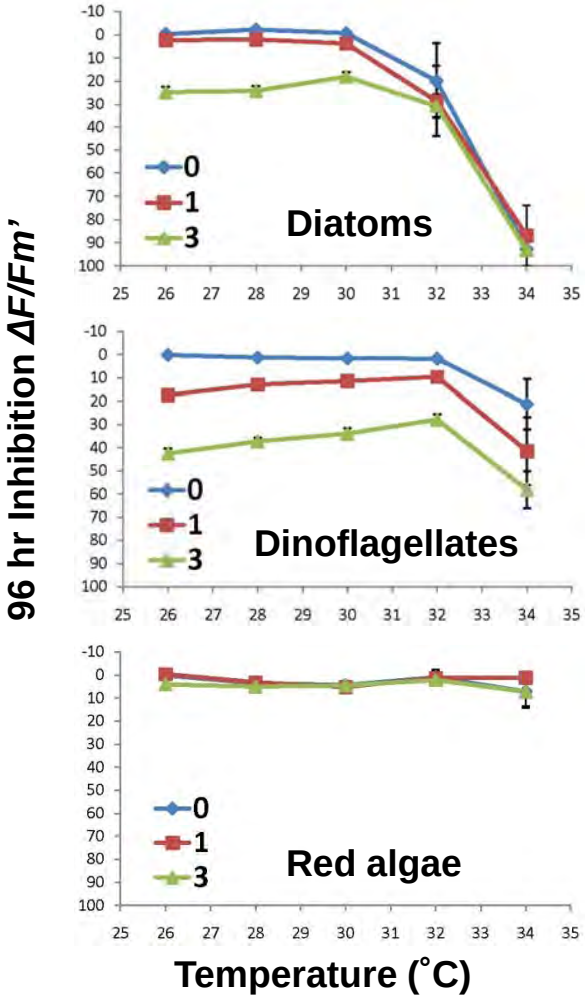
- 4 species tested hosting 3 symbiont phyla
- 4 days exposure
- 5 temperatures
- 1 & 3 µg/L diuron vs control

2. - Flow through exposures

- 2 species tested hosting different symbiont phyla
- 7 days exposure
- 4 temperatures
- 1 & 3 µg/L diuron vs control



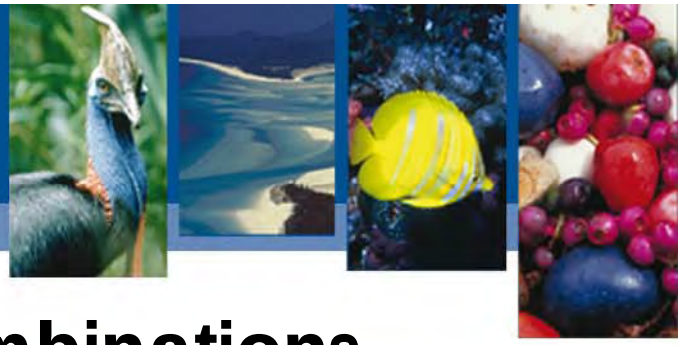
Temperature-herbicide combinations



***ΔF/Fm'* = energy conversion in PSII**

- Differences between symbiont types

- **Diatoms**: major temperature effect > 30˚C (however this is stretched for species living on the reef flat)
- **Dinoflagellates**: more resilient to high temperatures, temperature effect apparent > 32 ˚C
- **Red algae**: resilient to both high temperature and low diuron concentrations



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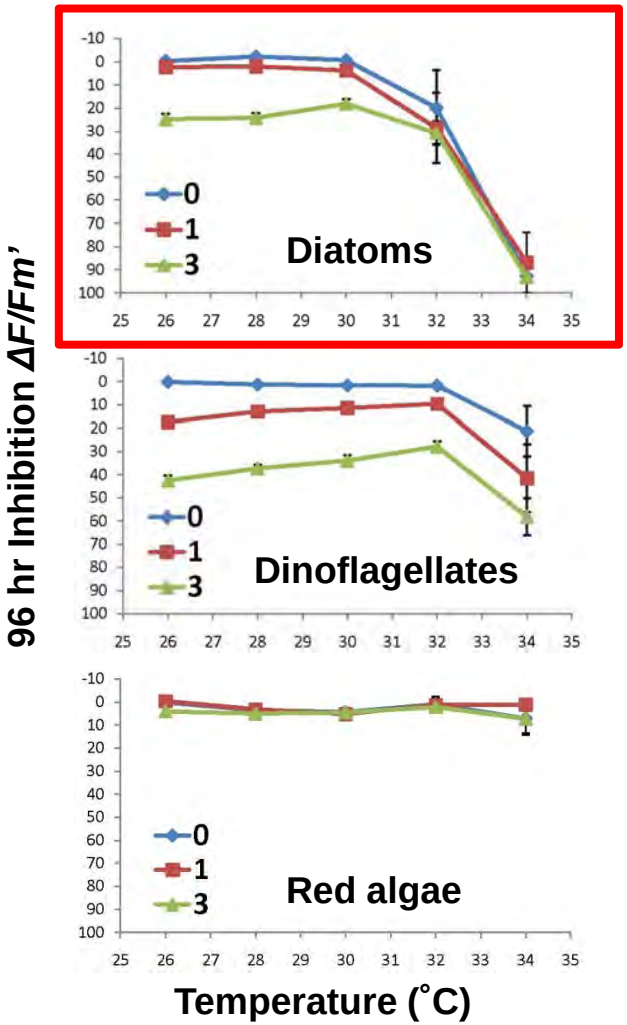

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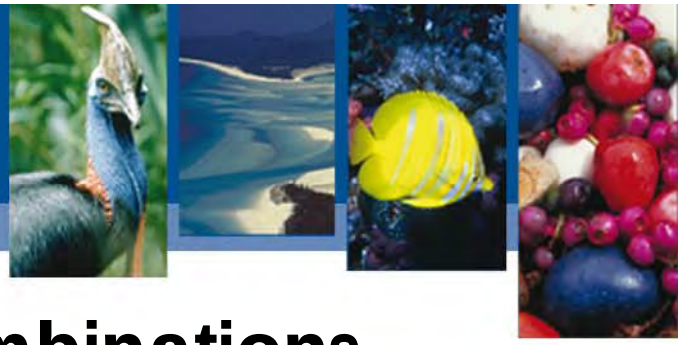
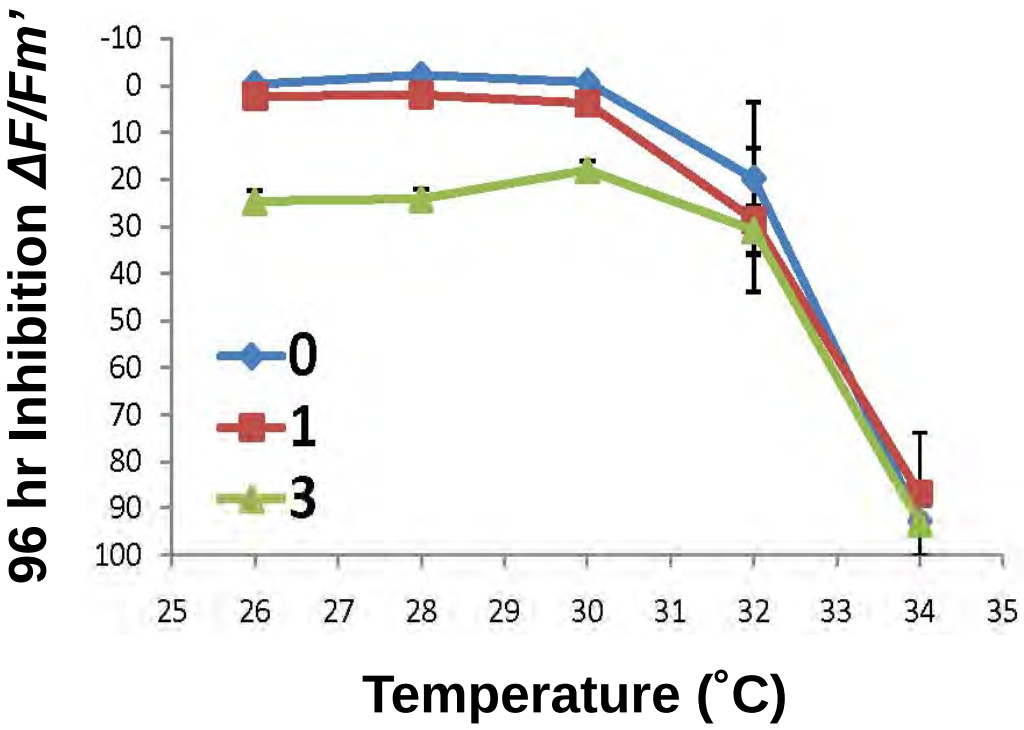


Temperature-herbicide combinations

A. quoyi – bearing diatoms



- **No apparent effect** temperature **< 30˚C**
- **Sub-additivity at 28-32˚C →** probable temperature influences diuron toxicity:
  - Conformational changes D1
  - ↑ Changeover D1
  - Change binding kinetics
  - ↓ Bioavailability
- **Lethal effect temperature > 32˚C**

Summary to date

Determined herbicide effects on a wide range of symbiotic partnerships

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Evaluated effects of combinations of temperature and diuron on the photosystem of selected symbiotic foraminifera

Overall 'additive' toxicity with slight decrease of total effect with increasing temperatures up to 30-32˚C; temperatures over 32˚C lethal to most species

Future work

Broaden to include more species and more endpoints

Expand current experimentation to mimic flood plume style exposures: herbicide & climate interactions with low salinity, high turbidity, nutrients and acidification

Develop standardized protocols to test for these interactions

Ensure relevance to management applications


Thank you
for your
attention