Ecological competition between corals and macroalgae in a high carbon dioxide world: Understanding the mechanisms and implications for reef ecosystems

Project team

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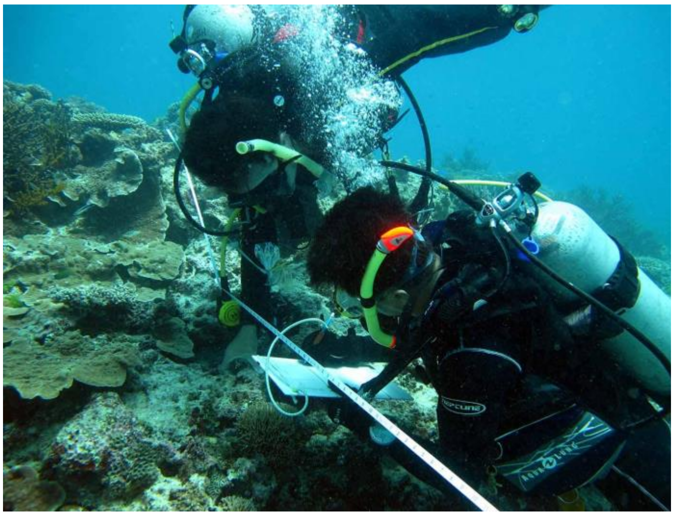

Timeframe

Project is complete, however, ongoing collaborations and publications continue.

Project description

Space competition between reef-building corals and macroalgae (seaweeds) is an important ecological process structuring coral reef communities.

There have been important advances in the knowledge of ecological processes driving coral-algal competition. However, very little was known about the role of global climate change, in particular carbon dioxide (CO2) enrichment and associated ocean acidification (OA) in coral –algal competition.

Ocean acidification is a major problem facing coral reefs, not only because it affects coral calcification and reef growth, but also because it favours the growth of macroalgae. Macroalgae are well known to outcompete and harm corals in tropical reefs. Since macroalgae use CO2 for photosynthesis, CO2 enrichment is hypothesised to enhance algal metabolism and growth. This in turn may intensify competition with reef-building corals, with potential negative consequences for corals, reef growth and stability, and reef conservation.

Outcomes

Our research project provided new knowledge in two key thematic areas:

1) The outcomes and mechanisms of competitive interactions in the context of global climate change; and,

2) The physiological responses of macroalgae to CO2 enrichment.

The outcomes of competitive interactions in the context of OA:
Our experiments demonstrated the critical role of ocean acidification and warming as a driver of space competition between macroalgae and corals. Using sophisticated and innovative laboratory and field techniques developed in collaboration with our international collaborator Prof Mark Hay (USA), world leader in chemical ecology, we demonstrated for the first time that allelopathic interactions (caused by secondary chemical compounds) mediate space competition under ocean acidification. More importantly, we demonstrated that the strength of allelopathic interactions is

intensified when corals and macroalgae are exposed to high CO_2 concentrations, similar to those projected to occur by the end of this century. Since allelopathic compounds are carbon based, it is likely that allelopathic interactions continue to intensify in the future and coral –algal competition continues to strengthen in detriment of the corals.

The physiological responses of macroalgae to CO_2 enrichment:
We discovered that macroalgae exposed to elevated CO_2, considerably enhance the release of dissolved organic carbon (DOC). This result is important because algal DOC has been implicated in the death of corals in coral – algal competition experiments conducted by other research groups (e.g. USA). DOC released by macroalgae is used by bacteria living on the coral surface; as bacteria use DOC, their metabolism increases producing anoxic conditions causing the coral death. Our experiments show that the increase in DOC released may be an important factor contributing to coral mortality under OA conditions. Manipulative CO_2 experiments conducted with international colleagues (A/Prof Carol Thornber & Dr Gordon Ober, USA), demonstrated that the biomass of algal turf communities increased with rising CO_2. This experiment provided direct evidence of the beneficial role of CO_2 on algal growth. Further studies looked at the strategies by which macroalgae utilise CO_2 for photosynthesis. For this purpose, we teamed up with A/Prof Hurd and Dr Cornwall (NZ) and used carbon isotope techniques and showed that red macroalgae may be more responsive to increased CO_2, particularly in deep reef habitats. This study, together with our competition assays, and the DOC experiments, suggest that a variety of macroalgal species will benefit from rising CO_2 and will continue to outcompete corals in the future, compromising coral reef resilience.

Our project also provided the opportunity to investigate the role of ocean warming in coral bleaching. As part of a multi-institutional collaborative effort we documented the footprint and severity of the 2016 and 2017 coral bleaching event in the Great Barrier Reef. Prof Terry Hughes (JCU) lead this research which was published in the prestigious journal Nature. Our ARI team (Dr Emma Kennedy and Dr Alex Ordoñez) play an important role in this research contributing information of the mass coral bleaching from the southern Great Barrier Reef.

One of the most important benefits arising from our project is that we have provided new knowledge about the ramifications of rising atmospheric CO_2 concentrations in coral reefs. Increased CO_2 not only affects reef-building organisms directly, but also alters the ecological relationships between species. We demonstrated that increased CO_2 intensifies space competition of a range of seaweeds over corals. This indicates that if atmospheric CO_2 concentrations continue to rise, reef-building corals will be outcompeted and severely affected by seaweed overgrowth. Seaweed overgrowth is detrimental for coral reefs because corals are the main reef builders and increased mortality of corals will affect the ecosystem services provided by reefs, including habitat provision, coastal protection and food provision for millions.

Funding

ARC Discovery Grant

Partners

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Publications

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