Within ARMS’ Reach: An Assessment of Diversity, Abundance, and Size Effects of CO₂ Venting and Associated pH Change on Coral Reef-Dwelling Invertebrate Communities

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Context

Ocean Acidification: As the concentration of carbon dioxide (CO₂) increases in the atmosphere, CO₂ levels also increase in the ocean thus changing the water chemistry, a phenomenon known as Ocean Acidification (OA).

Impacts on Coral Reefs: OA has been shown to negatively impact calcifying organisms such as corals and many invertebrate species (Kroeker et al. 2013) but studies evaluating the impacts of OA on the invertebrate communities associated with coral reefs are scarce (Fabricius et al. 2014).

Invertebrate community patterns on Acidified Reefs: We investigated the effects of low pH on the invertebrate communities associated with naturally acidified coral reefs near Normandy Island, Papua New Guinea. There, portions of the reef featuring CO₂ seeps (Figure 1) exhibit a pH gradient that is comparable to projected pH conditions over the next century and coral communities have adapted to these environmental conditions (Fabricius et al. 2011).

We hypothesize that invertebrate diversity and abundance will show an overall decrease with decreasing pH and that the size of organisms will exhibit mixed responses depending on their biological characteristics.

Methods

Invertebrates were collected from 18 Autonomous Reef Monitoring Structures (ARMS) deployed for two years at two locations (Illi and Dobu) and three pH sites (control: pH 8.2; medium: pH 7.5; and low: pH 7.7).

The organisms (>2mm in size) were all sampled, counted and the cytochrome oxidase subunit I (barcoding gene) was sequenced in order to discriminate species at a 95% threshold and investigate their diversity.

All the specimens with a shell or an exoskeleton were photographed for measurements of their bodies (Figure 2).

Implications

Stronger effects of global ocean acidification?

These reefs represent communities that are adapted to their respective pH conditions but with a replenishing effect from drifting of invertebrate larvae from nearby healthy reef communities. Global ocean acidification could potentially induce more drastic diversity reductions due to the scariness of unaffected “refuge” habitats.

Some organisms may benefit from ocean acidification...

Seagrasses and macro-algae have been shown to exhibit a higher growth rate when exposed to higher CO₂ concentrations (Koch et al. 2013). Therefore, grazers could potentially benefit from the increased food supply, as seen in the sea urchins at the seep sites (Uthicke et al. 2016). The size trend observed in this study for the gastropods could result from a similar dynamic.

Size

• Relative to the control pH, low pH communities have 45.8% fewer species in Illi and 59.7% fewer species in Dobu.

• The diversity of the medium pH is in the same range as that of the control pH in both locations.

• The rarefaction curves for low and medium pH reach a plateau, so our sampling is representative of the true diversity.

• The curve for control pH is still growing, indicating that we are yet to encompass the higher diversity that is present.

Abundance

• In Illi, the abundance was highest at control pH (n=200), followed by medium pH (n=185) and low pH (n=136).

• This trend is seen in all taxa except for the gastropods (Figure 4).

• In Dobu, trends are different. The medium pH exhibits the highest abundance.

Whole communities’ responses to ocean acidification

This study focuses on community-level trends and confirms the findings of species-specific studies. Studying whole communities in their natural habitats enables us to broaden our understanding of the potential consequences of ocean acidification from direct impacts (physiological) and indirect impacts (loss of reef structure, changes in the food chain, and more), thus allowing a clearer picture of coral reef responses in the face of ocean acidification.

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Fabricius KG et al. (2013) Seasonal effects of ocean acidification and habitat complexity on coral-associated invertebrate communities. Biol. Lett. 9:20120242


