The Effect of Ocean Acidification on Intertidal Benthic Communities

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Abstract

Increased partial pressure carbon dioxide (pCO_2) levels in seawater cause ocean acidification (OA), which has been reported to inhibit calcification in marine organisms. One of the major calcifying groups comprises mollusks, the calcified shells of which provide habitats for other organisms in intertidal rocky shores; therefore, OA is predicted to cause signification reductions in their abundance and body size. In turn, this reduction could indirectly affect associated marine organisms. However, little is known about the process and/or mechanism of these effects of habitat provision. The aim of this study was to: 1) confirm the effects of OA on molluscan (bivalve and gastropod) community structures; 2) assess the potential function of bivalve shells for associated organism communities; 3) examine the impact of reduced gastropod shell availability on Paguroidea (hermit crab) community structures; and 4) investigate the effect of reduced shell size on the size and growth rate of hermit crabs.

Molluscan community structures were compared between three ambient pCO_2 control sites and two high-pCO_2 acidified sites using volcanic CO_2 seeps at Shikine Island (Japan). The volcanic CO_2 seeps provide a natural analogue of future OA conditions. Bivalves were not present at the acidified sites and gastropod numbers decreased, suggesting significant reductions of molluscan abundance and diversity due to OA (chapter 1). To clarify the potential impact of the loss of bivalve shells in acidified environments, the shell utilization patterns in associated organisms were examined at the ambient sites. Dead oyster shells were found to be the most utilized habitat, and a further predation experiment revealed that an abundance of shells significantly reduced the predation rates of smaller organisms. Therefore, the disappearance of oysters due to OA could potentially change rocky shore communities through the modification of predation pressure (chapter 2). To investigate the impact of decreased gastropods, hermit

crab community structures and available shell abundance were examined at the ambient and acidified sites. The results suggest that decreases in hermit crab abundance was associated with a decrease in the number of gastropod shells. A hermit crab rearing experiment showed a high mortality rate in one particular species (*Clibanarius virescens*) but a low mortality rate in another (*Pagurus filholi*), suggesting a direct link to species-specific mortality rates due to limited gastropod shell availability (chapter 3). Size restriction in hermit crabs via a decrease in gastropod shell size was also examined, by comparing the size distribution of hermit crabs and available shells between the ambient and acidified sites, and by conducting growth experiment which examines the effects of both shell availability and acidified seawater on hermit crab size. The size of both the hermit crabs and the available shells was lower at the acidified sites; both smaller shell size and acidified seawater reduced the growth rate of hermit crabs. As such, size restriction is suggested to be both directly and indirectly affected by OA due to its effect on the decreased size of available shells (chapter 4).

In conclusion, this study demonstrated indirect effects of OA on intertidal rocky shore communities through a decreasing abundance of habitat-producing mollusks. The disappearance of bivalve shells as a result of OA could potentially have a considerable impact on associated communities owing to a decline in refuge sites. Although gastropod shells were affected to a relatively lesser extent by OA, the indirect effects of their decline would decrease both the abundance and size of limited associated species such as hermit crabs. Previous studies have focused on the influence of OA on the change in community structures due to the interactions of living organisms; however, the results of this study reveal that the importance of remnant biogenic structures on organisms persists even after death.