# THE BIOGEOCHEMICAL ECOLOGY OF POROLITHON GARDINERI (FOSLIE)

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## ABSTRACT

Coralline algae are an important world-wide component of shallow water marine communities. They are the deepest dwelling plant life recorded in the ocean. Therefore, biogeochemical cycles in the ocean reservoir should include an understanding of the factors influencing the growth and composition of coralline algae. The effects of kinetic (growth rate) and physico-chemical (seawater temperature and calcite saturation state) factors on the bulk magnesium content of Porolithon gardineri were examined in controlled microcosm environments. Latitudinal variations in the magnesium content of P. gardineri were measured from field collections between 0° N. and 29° N. latitude. In situ growth rates were obtained on the windward reef flats of Enewetak Atoll, Bikini Atoll, Oahu, French Frigate Shoals, and Kure Atoll. Field measurements of coralline algal growth rate and percent cover and reef area obtained from charts were used to estimate carbonate production by P. gardineri and coralline algal crusts on reefs in the Hawaiian Archipelago.

Experimental results from the microcosm studies showed that the magnesium content of P. gardineri was little influenced by growth rate but changed primarily because of physico-chemical factors. The growth rate of P. gardineri decreased at low light levels without a concomitant

decrease in magnesium content. Magnesium content increased linearly with temperature, whereas growth rate as function of temperature varied in a curvelinear manner. Growth reate increased linearly with calcite saturation state, whereas, magnesium content increased in a curvelinear manner with calcite saturation state.

Skeletal magnesium concentrations varied directly with increasing temperature and saturation state of seawater in the microcosm experiments. A physico-chemical control of magnesium content for this alga is further suggested by the overall similarity in equations describing the relationship between magnesium content and temperature determined in this study on two species of coralline algae, and from the literature for other organisms. Temperature and saturation state accounted for 89% of the variability in magnesium content of P. gardineri grown in controlled experimental environments and approximately 73% of the total variation in magnesium content measured in field collections of this species between $0^{o}$ N. to $29^{o}$ N. latitude.

Growth of P. gardineri was influenced primarily by temperature and calcite saturation state, and to a much lesser extent by light intensity. Low temperature and light conditions resulted in only small decreases in growth rate. Temperatures only a few degrees above ambient (29-30 $^{o}$C) led to a dramatic decrease in growth rate. A two-fold increase in growth rate was measured over a range of calcite

saturation states from 100% to 800% calcite saturation. The settlement of coralline crusts was highest at calcite saturation states between ambient (400%-500% calcite saturation) and 772% calcite saturation.

From these experimental results, it was concluded that the growth of P. gardineri would not be reduced at light and seawater temperature regimes characteristic of environmental conditions at the latitudinal extremes of reef growth. Indeed, in situ field growth measurements indicated no systematic changes in growth rate between 21° and 29° N. latitude as has been described for coral growth. Estimated coralline algal production of calcium carbonate by P. gardineri and coralline algal crusts accounted for 60-70% of the total carbonate production estimated for reefs at the northern extremes the Hawaiian Archipelago. The importance of coralline algal and total benthic carbonate production is estimated and discussed in reference to the oceanic budget of carbon.

Past and future physico-chemical changes in surface seawater may influence the growth and composition of coralline algae. The findings of this study suggest that the growth rate of Porolithon gardineri in subtropical seawater may be reduced by approximately 60% if the calcite saturation state decreases from 450% to 250% in association with a decrease in pH from 8.2 to 7.8 and temperature increases from 27°C to 29°C in Hawaii owing to a doubling of

atmospheric $CO_2$. The species diversity and abundance of coralline algae in the fossil record are discussed with respect to the past ocean environment. The appearence of the Corallinaceae during the Pennsylvanian and Permian, their disappearance during the Triassic and radiative explosion at the beginning of the Cenozoic are patternes consistent with recent reports in the literature of oscillating trends in Phanerozoic non-skeletal carbonate mineralogy around an "aragonite threshold".