Seasonal Variation in Density, Growth rate and Calcium carbonate Accumulation of *Halimeda macroloba* Decaisne at Tangkhen Bay, Phuket Province, Thailand

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Received in revised form 21st October 2008, accepted 31st October 2008.

ABSTRACT
Seasonal variations in density, growth rate and calcium carbonate accumulation of *Halimeda macroloba* Decaisne, a dominant green alga at Tangkhen Bay on Cape Panwa at Phuket province, Southern Thailand, were investigated. There was difference in density of *H. macroloba* between seasons, 18.72 ± 1.68 in the summer and 5.02 ± 0.66 thalli.m⁻² in the rainy seasons. The higher density of *H. macroloba* in summer is likely to be the result of delayed effect of asexual propagation by vegetative fragmentation. Growth rate of *H. macroloba* at Tangkhen bay, Phuket in summer season was slightly higher than in rainy season. Light availability and photoperiod were higher in the summer season that might increase growth rate by increasing photosynthesis rate in *Halimeda* plants. There was difference in percentage of calcium carbonate accumulation in *H. macroloba* between rainy and summer seasons (*P* < 0.05). This might be a result of high light availability in summer season which might increase photosynthesis and growth rate in *Halimeda* plant. Moreover, high phosphate concentration in rainy season might inhibit calcium carbonate precipitation.

*(Halimeda macroloba*, seasonal variation, Calcium carbonate accumulation, Thailand)*

INTRODUCTION

The genus *Halimeda*, a green alga (Chlorophyta), is widely distributed in the tropical to subtropical marine environment. *Halimeda* consists of articulated, plate-like and calcified segments. These are joined together by small, uncalcified nodes into branching chains to produce a more or less bushy plant. They attach to the substratum by a holdfast. However, *Halimeda* may grow in depths up to 100 - 150 meters, where light levels are calculated to be only 0.05 - 0.08 percent of the surface intensity [1]. They are known as an important contributor of sand to mud-size carbonate sediments [2], primary producers [3], and as a provider of shelter and nursery grounds for a number of invertebrates [1]. *Halimeda* has an ability to deposit CaCO₃ within thalli. All species of *Halimeda* deposit calcium carbonate in form of aragonite. The calcification results in some changes in segment thickness which depends on the species and the segment's location within the thallus. There are many factors that influence calcification process in *Halimeda* such as plant age, growth rate, photosynthesis, respiration, light, concentration of Ca²⁺ and CO₃²⁻ ion and CO₂, phosphate concentration, and herbivory [4, 5, 6, 7, 8, 9, 10, 11, 12].

A study of *H. tuna* in the Florida Keys revealed that densities of *H. tuna* fluctuated because of environmental and seasonal parameters. Moreover, it was found that average growth rate of *H. tuna* at two locations, Shallow Conch (0.012 g plant day⁻¹) and Pinnacle (0.025 g plant day⁻¹), was highest under summer conditions of longer photoperiods and at the highest temperature [13]. *Halimeda* populations were affected by both biotic and abiotic factors, for example, nutrient concentration, light intensity, water motion, herbivore and epiphyte. These environmental factors influence growth, biomass, survivorship, recruitment and segment loss [14, 15, 13]. A study testing the effects of nutrients on growth in *H. tuna* at Conch Reef show that plants respond positively to elevated nutrient concentrations.
photoinhibition as at the shallow Conch site. Moreover, they found the highest growth rate of *H. tuna* under summer conditions of longest photoperiods and highest temperature. Growth rate of *H. macroloba* at Tangkhen bay, Phuket in summer was slightly higher than in rainy season. However, there were no significant differences in temperature and nitrate concentration between summer and rainy season and lower phosphate concentration was observed in summer. Thus, temperature and nutrients were not likely to influence *H. macroloba* growth rate at Tangkhen Bay. Light availability and photoperiod, in contrary, were higher in summer. Thus, growth rate of *H. macroloba* in this study might be positively controlled by light as growth rate of *Halimeda* plants were increase by increasing photosynthesis rate [15, 18].

**Calcium carbonate accumulation**

Calcification process in *Halimeda* is influenced by plant age, growth rate, photosynthesis, respiration, light, concentration of Ca$^{2+}$ and CO$_3^{2-}$ ion and CO$_2$, phosphate concentration, and herbivory [4, 5, 6, 7, 8, 9, 10, 11, 12]. This study showed higher calcium carbonate accumulation of *H. macroloba* in summer season than rainy season. This might be a result of high light availability in summer season which might increase photosynthesis and growth rate in *Halimeda* plant [7]. Moreover, high phosphate concentration in rainy season in our study might inhibit calcium carbonate precipitation, resulting in high calcium carbonate accumulation in summer season [4]. Further investigation on calcification on *Halimeda* or other calcified algae would allow us to understand more of the physiological and ecological aspects of calcium carbonate accumulation of those plants, which is yet still limited. Furthermore, *Halimeda* could be used as a carbon sink species, which could help control of the increasing levels of carbon dioxide in the atmosphere.

**ACKNOWLEDGEMENTS**

We are grateful to the Thai Meteorological department and Department of Biology, Faculty of Science. SS thanks the Development and Promotion of Science and Technology talents project of Thailand (DPST), Graduate School, Prince of Songkla University, and TRF/BIO TEC Special Program for Biodiversity Research and Training grant BRT T 150019 for financial support. We would like to thank the Seaweed and Seagrass Research Unit of the Prince of Songkla University for research facilities and field support.

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