Selected Ecological Processes and Bleaching Induced Alterations in *Acropora formosa* Dominated Shallow Reefs of South West Sri Lanka

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Abstract

The coral reef ecosystem is one of the most valuable coastal ecosystems in terms of ecology and economy having a range of functions. Ecology has often been addressed through the study of the ecological processes that take place within that ecosystem. This study undertook a study of selected ecological processes in *Acropora formosa* dominated shallow reefs of Sri Lanka to document and understand the ecology of Sri Lankan coral reefs. The study also looked at the alterations that took place in the reef environment during and after the coral bleaching event in 1998 while exploring the options for rehabilitation of a degraded habitat.

The current study focused on the reef lagoon at the Hikkaduwa Nature Reserve on the southwest coast. Weligama and Roomassala also on the southwest coast were studied as comparative sites. The overall data collection period extended from January 1997 to March 2001 where a continuous and comprehensive monitoring program of selected ecological processes was carried over 4 years at the reef lagoon of the Hikkaduwa Nature Reserve.

Firstly, the environmental conditions of the study sites were defined by monitoring the basic water quality parameters such as salinity, pH, dissolved oxygen, nitrates, phosphates, water temperature at monthly intervals. In addition, sediment content was determined by measuring suspended particles, settling sediment, turbidity and light intensities using standard methodologies. Settlement of benthic organisms was studied using settlement plates to look at temporal and spatial variations within and between study sites. The settlement of benthic organisms was studied over 4 years documenting one year before bleaching and 3 years after bleaching. Of the benthic organisms studied, the focus was directed to coral settlement.

The ecology of the commonly found calcareous alga, *Halimeda* was also studied. This habitat was sampled monthly using quadrats and the inhabitant fauna were sorted and recorded over an annual cycle. Seasonal variations, effects of patch size and the diurnal cycle in faunal composition and habitation were determined. The *Halimeda* populations were studied by making cover estimates within fixed quadrats. *Halimeda* populations growing on substrates of coral, rubble, rock and sand were studied to identify preferences.

Since the study focused on shallow reefs dominated by *A. formosa*, its growth and feeding of suspended particles were documented. Growth was measured by monitoring the linear extension of coral branches *in-situ*. The effects of two coral associated organisms (*Halimeda* and *Diplosoma virens*) on growth of *A. formosa* was also determined.

With the onset of bleaching during the second year, the effects of bleaching in the reef lagoon at the Hikkaduwa Nature Reserve was determined. Permanent line and belt transects were set up and monitored over 3 years to determine percentage mortality, recovery, changes in substrate and coral composition. After the bleaching event followed by mass coral mortality, transplantation of the dominant coral *A. formosa* carried out at an experimental level using 7 techniques. All techniques used nubbins, fragments or branched fragments of the coral for transplantation. The success of the transplants was determined by monitoring mainly growth and survival.

The major findings of this study are that coral reproduction related settlement occurred throughout the year without a statistically significant difference and settlement was 170.9±38.42 spat.m^{-2}.$month^{-1}$ (mean±s.e.m) at the reef lagoon of the Hikkaduwa nature Reserve. Post bleaching coral settlement was reduced to zero for 4 months. Three years after bleaching coral settlement had recovered to average only

41.0±16.39 spat.m^{-2}.$month^{-1}$. A new non-scleractinian coral (false coral) started to settle after bleaching. The reproduction related settlement of the commonly occurring foraminiferans, serpulid polychaetes, barnacles, oysters and vermetid gastropods settle throughout the year without seasonal variations and averaged 3132.9±580.39, 1295.3±165.19, 184.9±61.18, 79.3±27.59 and 54.9±13.24 m^{-2}.$month^{-1}$, respectively.

Halimeda functioned as a significant component of the reef ecosystem at the study site by functioning as a refuge habitat and a nursery ground throughout the year and throughout a diurnal cycle. This habitat was dominated by crustacea, polychaeta, gastropoda and ophiuroidea contributing to 94% of all sampled fauna. Juvenile stages of anthozoa, cephalopoda, holothuroidea, echinoidea, asteroidean, ophiuroidea and post larval stages of fish were recorded. The study of the *Halimeda* plant populations at the study site suggested a 2-year cycle of increase and decrease with a marked preference for rock and rubble substrata.

A. formosa grew at rate of 111.5±4.760 mm.$year^{-1}$ at the reef lagoon of the Hikkaduwa Nature Reserve and was not statistically different to the growth rate recorded for the same species at Roomassala. Growth of *A. formosa* did not display any seasonality. Survival was of *A. formosa* was reduced by colonization of *D. virens* bringing about 40% mortality by total overgrowth of coral. *A. formosa* displayed ingestion of suspended particles at all concentrations (from 10 to 250mg.l-1) without a statistical difference with a maximum feeding efficiency of 20% from coral colonies from Weligama. Coral colonies from the ref lagoon of the Hikkaduwa Nature Reserve recorded a higher feeding efficiency of 42%.

Following the bleaching event in April 1998, live coral cover was reduced by 81% on average. This mortality of corals led to many changes in the reef ecosystem at the reef lagoon of the Hikkaduwa Nature Reserve. Coral dominance patterns

changed from a branching and plate/tabulate coral dominant to a boulder coral dominated community. The substrate types altered with the wear and tear of the dead reef structures from a live coral dominated system to one that was dominated by dead coral, rock and ruble. These changes brought about suitable surfaces for new organisms to settle such as non-scleractinian coral.

With the degradation of the reef environment the importance coral transplantation was identified and proved to be a success. The most suitable method identified for this study site was to fix branched fragments to concrete blocks which were placed on the sea floor. From these studies it was also identified that the success of the transplant method employed will depend on the environmental conditions of that particular site.

The results of this study highlighted the importance in studying the different processes that are taking place simultaneously in any ecosystem in order to make informed and practicable management decisions. This would also facilitate the identification of suitable tools and methodologies in reef monitoring and management. This thesis will discuss in detail the methodologies used in carrying out this study, the findings of the research, the conclusions and the recommendations that have come out of this study.