CHAPTER ONE

INTRODUCTION

1.0 INTRODUCTION

1.1 Definition of seaweeds

Marine algae may be divided into two biological groups: planktonic algae and benthic algae (Levring, 1969). The former are better known as phytoplankton, which are mainly unicellular organisms found floating freely in the euphotic zone, whilst the latter constitute the sedentary flora of interest in this paper, the seaweeds.

By tradition, the term "seaweeds" has been used mainly to refer to macroscopic, multicellular marine algae (Lobban & Harrison, 1994). However, not all classified seaweeds possess these two defining features, and although some may, there are periods within a life-cycle wherein a seaweed is neither macroscopic nor multicellular. Blue-green algae, for instance, have occasionally been recognised as seaweeds, but amongst these are many microscopic, unicellular species. Furthermore, most seaweeds are unicellular at some point in their life-cycle, as spores or zygotes. In this paper, the term is used in its broader sense, i.e. seaweeds as both macroscopic and microscopic benthic marine algae that are multicellular for the most part of their life cycle.

There are four traditional divisions based on algal pigments, namely, the Cyanophyta (blue-green algae), Chlorophyta (green algae), Rhodophyta (red algae) and the Phaeophyta (brown algae). These thallophyte plants may be found in salt or brackish water on almost any substratum, from rocks, wood, sand, glass, and shell, to more unusual habitats on plant and animal surfaces, such as sponges, seals, and turtles. However, seaweeds are most characteristic of tropical coral reefs and rocky intertidal shores.

1.2 Significance of seaweed diversity & abundance

The term "diversity" is used to refer to the variability of a community within a given ecosystem. This concept is applicable to the three different levels of genetic, organismal, and ecological diversity. Organismal diversity (embracing all taxonomic levels including and below species rank), has been the one most often measured in ecological studies by virtue of it being a characteristic unique to the community level of an ecosystem's organisation.

Organismal diversity itself may be applied to three different relationships. "Alpha diversity" refers to the variability of taxa within a given habitat; "beta diversity" describes the degree of change in taxa from one habitat to another or along an environmental gradient, whilst "gamma diversity" relates to the total regional taxa diversity that results from the number of habitats present, the diversity of taxa within each, and the degree of turnover of taxa between habitats (Cox, 1996). In this paper, attention is confined to organismal alpha and beta diversity. Particular attention is paid to species diversity which, drawing from work done on neotropical forests, is apparently the most relevant level when assessing biodiversity for conservation planning (Prance, 1996).

Species diversity, the most common taxic measure, comprises a combination of two aspects of species composition, namely, species numbers and evenness of their distribution. This distinction is an important one since many diversity surveys have resorted to quoting merely the number of species as a measure of diversity (Kendrick, 1999). However, the distribution of individuals amongst species is just as strong a factor in the measurement of diversity. This has been duly acknowledged in various diversity indices. Moreover, since not all species at a site contribute equally to its biodiversity, the use of the number of species as a quantitative measure would only serve to provide a simplistic view of a complex phenomenon.

Species abundance, on the other hand, is any measure of the amount of an organism, whether it is density, biomass, frequency, cover or even presence/absence.

Species diversity and abundance are regarded by some (Odum, 1975; Dash, 1993) as possible indicators of ecosystem health at the community level, with the rationale being that any change in the quality of an ecosystem would cause a corresponding change in the organisation of its community. In coastal marine ecosystems, seaweeds are often the dominant flora, and as such, their diversity and abundance may be used as indicators of water quality. The general view is that the greater the diversity, the more stable the environment. This isn't true in all cases. Specialisation (and thus, speciation) may be high in regions with stable environments, but it may also be high in unstable environments where perturbations are a periodic and regularly recurring phenomenon (which makes it stable in a sense). These perturbations serve to open up opportunities for inter-species competition, thereby causing a shift towards greater diversity. However, speciation is expected to be low in regions where perturbations are of irregular and unpredictable occurrence (Mueller-Dombois & Ellenberg, 1974), which in this case, result in competitive displacement and reduced diversity.

Seaweed community structure may also be used to infer the evolutionary state of the overall reef ecosystem. In the best developed reefs, algal turfs are almost always the dominant reef community, followed by corals or macroalgae[1] (Berner, 1990).

Odum & Odum (1955) for example, demonstrated for an Eniwetok reef that algae dominated the reef flat by as much as 85% on a biomass basis: 73% of this constituted algal turfs and corallines whilst macroalgae made up 6%. However, these reefs undergo a phase shift from coral/algal turf-dominated communities to a fleshy macroalgae-dominated state (>1 kg m^{-2}) when plagued by eutrophication or overfishing (Adey, 1998). In this latter state, framework construction by corals is greatly reduced and eventually, constant carbonate erosion causes the reef to degenerate from one of a heterogeneous surface to a flat pavement with relatively low diversity and productivity.

1.3 Past studies at Cape Rachado

Beginning in 1987, the seaweed community on the fringing reef flats at Cape Rachado has become the subject of study by the Algae Laboratory at the University of Malaya. Its published findings documented the species distribution and biomass estimates of the marine algae, and discussed the effects of silt content in the water, exposure period, wave action and temperature and seasonal growth patterns on the algal distribution and abundance (Phang, 1988; Phang, 1995). See Appendix 1 for these two papers.

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[1] Turf-forming algae are those that extend up to a height of not more than 1 to 2 cm above the substrate, comprising both taxa that are inherently of smaller structure and large macroalgae that are actively grazed by herbivores (Borowitzka, 1981, in Berner, 1990). Macroalgae are those at heights above 5 cm, often also called fleshy macroalgae (Lewis, 1977, in Berner, 1990).

The first seaweed diversity survey was conducted from May 1987 to March 1988, with all sites sampled simultaneously in May, August and November of 1987 and March 1988 during the lowest spring tide of the particular month. Line transects perpendicular to the shoreline were laid at intervals of 40 m at Site A (seven) and Site B (four), and at intervals of 60 m at Site C (four). Destructive algal sampling was the chosen method, using 0.09 m^2 (0.3 x 0.3 m) quadrats at 10 m intervals along each transect.

Sixty-nine species were recorded. Of these the Rhodophyta constituted 31 species, the Chlorophyta and Phaeophyta 18 species each, and the Cyanophyta 2 species. In terms of species numbers, the largest was recorded at site A (51 species) followed by site B (50 species) and then site C (45 species). On a dry-weight biomass basis, the greatest was found at site B and the smallest at site A. Site B had the highest diversity indices, the maximum being 1.29, followed by 1.12 at site A and 1.05 at site C. Site A, the most silted area had the lowest biomass and diversity whereas Site B, the area most exposed to human interference, had the highest.

These diversity and biomass results were attributed to sediment load. Where the total suspended solids (TSS) level exceeded 100 mg L^{-1} (site A), biomass and diversity were the lowest. The seaweeds apparently grow best in waters with TSS of up to approximately 100 mg L^{-1}, as found in site B, suggesting a high tolerance to siltation. It was suggested that their proliferation here may have also been encouraged by the frequent trampling of the substrate, which served to increase the distribution and hence, availability of nutrients to the community. Species such as *Sargassum oligocystum* and *Ceratodictyon spongiosum* dominated heavily sedimented areas. Further out where the water was cleaner, species such as *Sargassum siliquosum* and *S. baccularia* proliferated.

Both species diversity and biomass increased away from the shore and towards the reef edge. Phang (1995) attributed this zonation pattern to silt load and exposure periods. Simple indicators were the occurrences of the silt tolerant *Gracilaria salicornia* found mainly at the start of the transect where silt loads were the highest. As exposure periods were longer at quadrats nearer shore, only species tolerant to desiccation were capable of growing here. This may also be a reason for the greater abundance of *Gracilaria salicornia* near the baseline.

1.4 Scope and Objectives

The primary objective of the present study is to determine the diversity and abundance of the seaweed community of the fringing reef flats at Cape Rachado in relation to selected environmental parameters.

The ensuing sub-objectives are:

- to compare current community diversity and abundance to that of the first survey in 1987/1988;
- to identify the possible causes of such changes, if any;
- to make recommendations for the management of the coral reef ecosystem with emphasis on the seaweed community.