PROCEEDINGS OF THE EIGHTH INTERNATIONAL SEAWEED SYMPOSIUM

BANGOR, NORTH WALES, 18–23 AUGUST 1974

Edited by

G. E. FOGG and W. EIFION JONES

1981

THE MARINE SCIENCE LABORATORIES, MENAI BRIDGE

ALGAL ZONATION ON THE BELIZE BARRIER REEF

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ABSTRACT

Intensive surveys of a 700m transect line across the Belize barrier reef in the Caribbean Sea off Central America have indicated the general patterns of algal zonation as correlated with depth and reef structure. A full spectrum of habitats from the shallow lagoon floor behind the reef to the outermost deep fore-reef slope at a depth of 35m are included in the analysis. These range from shallow patch reefs predominantly covered by algal turf, through a well-developed reef crest and buttress zone with a variety of macro-algae, to deeper reef slopes interspersed with flat, sandy areas with scattered coral and algal development. Algal zonation is shown to reflect community structure much more than species distribution.

INTRODUCTION

The benthic marine algae of temperate shores frequently exhibit marked patterns of zonation correlated with the vertical and horizontal gradients of various environmental factors, and reflecting the narrow distribution bands of many species. On tropical coral reefs, however, there are seldom such distinctive patterns of algal species zonation, and many species range through a considerable diversity of habitats. Nevertheless, there is a distinct series of community types, correlated with certain structural and ecological features, that can be considered the coral reef equivalent of temperate zonation patterns. This can be illustrated by an analysis of the algal associations on the Belize barrier-reef.

The investigations of Marine Shallow-Water Ecosystems (IMSWE) project of the Smithsonian Institution has for several years maintained a field barrier-reef (16°47'N; 88°05'W). Immediately north of the Cay is a permanent 700m long transect line that is

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the focus of an integrated program of biological, geological, and ecological studies. The transect extends from the lagoon bottom to the outer drop-off at a depth of 35m, and has been marked with a nylon line labeled at 10m intervals behind the reef crest and 25m intervals down the fore-reef slope. Data for this study were collected with survey techniques developed earlier,[1] with detailed photographic records made along the transect, and from algal collections now deposited in the National Museum of Natural History (U.S.), as part of a broader study of the significance of algae on the reef.[2,3] One other list of algae from the area has recently been prepared.[4]

RESULTS

The Belize barrier reef in the vicinity of Carrie Bow Cay consists of the following components described seaward from the lagoon: the lagoon itself, sandy with extensive *Thalassia* beds; a region of scattered patch reefs in 1-2m of water, separated by extensive areas of sand and coral rubble which grade into a more stabilized pavement approaching the reef crest; the reef crest itself; a zone of massive buttresses descending to about 8m depth; a gently-sloping region with sandy grooves separated by irregular spurs of more stable bottom with low coral patches and gorgonians; a steep coral-covered slope rising up to an outer ridge about 15m deep; and a steep outer drop-off down which the transect descends to about 35m. Some details on the inner portion of this transect including a quantification of the available substrate surface have been published previously.[2] Analyses of the contribution of the benthic algae to photosynthetic surface area are being published elsewhere.[3]

On the lagoon bottom, the beds of *Thalassia testudinum* themselves provide the principal structural component together with scattered *Syringodium filiforme*, serving as the substratum for an extensive epiphytic algal flora of filamentous red and brown algae and crustose corallines. Dense masses of larger algae such as *Dictyota*, *Acanthophora* and *Liagora* crowd the rare pieces of solid substratum (shells, pieces of coral, or transect rope). This zone ends roughly 80m from the patch reefs, presumably because of grazing reef fishes. The bottom surrounding the patch reefs ranges from sand with only a light "felt" of filamentous algae through increasing percentages of coral rubble to a more solid pavement near the reef crest. The rubble and pavement are heavily encrusted with crustose coralline algae and support a thick algal turf that is visually insignificant but includes a major portion of the reef plant population. Scattered clumps of *Halimeda* are also present. Overlying the rubble in much more of this area is a thick blanket of *Dictyota bartayresii* Lamouroux often reaching a thickness of 10cm or more. The patch reefs themselves can consist of single coral colonies of *Montastrea annularis* or *Acropora cervicornis*, or range up to complex structures 1M high and covering an area of 100m^2. The percentage

of living coral is often low, with the greater part of the surface covered by a short (3-5mm high) algal turf and crustose coralline algae. Larger algae such as *Halimeda, Amphiroa* and *Caulerpa* are only occasionally present.

In the area between the transect and Carrie Bow Cay, the more shallow sand and rubble bottom (30-100cm deep) supports a more extensive macro-algal flora, including *Turbinaria turbinata* (L.) Kuntze, *Sargassum hystrix* J. Agardh, *Dictyota bartayresii* Lamouroux, *Padina gymnospora* (Kützing) Vickers, *Caulerpa cupressoides* (West) C. Agardh, *Penicillus capitatus* Lamarck, *Udotea flabellum* (Ellis and Solander) Lamouroux, *Gelidiella acerosa* (Forsskal) Feldmann and Hamel, and scattered *Thalassia testudinum* among the more common forms. While the reef crest has only about 1m of relief,[2] the highly convoluted surface built up primarily by *Acropora palmata, Agaricia agaricitis, Porites furcata, Millepora*, provides space for a complex macro-algal assemblage including *Halimeda, Dictyota, Caulerpa, Amphiroa* and *Jania* filling crevices, draped over dead coral, and inter-grading with a thick filamentous algal turf in the twisting channels through the crest.

Beyond the reef crest the coral structure grades into massive buttresses up to 5m in diameter perpendicular to the crest, and separated by channels with a rubble and pavement bottom grading into sand. The algal population of the buttresses resembles that of the reef crest, except that it tends to be more confined to holes and crevices; coverage in the channels is similar to that on the bottom inside the reef crest. A further analysis of this area is presented elsewhere.[3]

The buttress zone ends at a depth of about 9m in a gently sloping shelf about 175m wide with sandy grooves separating more consolidated spurs composed of a heterogeneous mixture of small coral heads, rubble, gorgonians, a thick algal turf, and numerous macro-algae. This is the only zone with an extensive "free-standing" flora, including such species as: *Sargassum hystrix* var. *buxifolium* (Chauvin) J. Agardh, *Stypopodium zonale* (Lamouroux) Papenfuss, *Lobophora variegata* (Lamouroux) Womersley, *Dictyota bartayresii* Lamouroux, *Halimeda opuntia* (L.) Lamouroux, *Halimeda discoidea* Decaisne, *Halimeda goreauii* forma *compacta* Taylor, *Rhipocephalus phoenix* (Ellis and Solander) Kützing, *Dictyosphaeria cavernosa* (Forsskal) Børgesen, *Anadyomene stellata* (Wulfen) C. Agardh, *Amphiroa tribulus* (Ellis and Solander) Lamouroux, *Galaxaura squalida* Kjellman, and *Liagora valida* Harvey. The smaller turf algae have not yet been analyzed.

The spur and groove zone ends at a steep sided trough 22m deep, with slopes covered primarily with a thicket of *Acropora cervicornis* and a sandy bottom bare except for scattered plants of *Halimeda, Rhipocephalus* and *Dictyota*. The *Acropora* shelters among its lower branches a dense growth of *Lobophora variegata* with scattered *Halimeda, Dictyota, Sargassum* and *Amphiroa* clumps where the substratum is more exposed.

From the ridge created by the outer wall of the trough, a nearly-vertical outer fore-reef slope plunges to considerable depths. On the upper portion of this slope accessible to SCUBA diving examination (35m depth) the common solid and shelf-like corals are interspersed with both common reef algae such as *Lobophora, Halimeda, Dictyota, Amphiroa* and *Sargassum*, and with several small foliose red algae not observed elsewhere on the reef.

CONCLUSIONS

It is apparent from even this brief summary that the dominant macro-algae on the Belize barrier reef tend to have wide vertical ranges; few species are restricted to single zones. Yet the overall form and appearance of the algal communities changes, largely through variations in species proportions and density, in response to the reef structure and ecology. Predation, substrate morphology and stability, competition for space, and, in certain zones, water motion appear to be the predominant controlling factors. What occurs as a close-cropped turf over much of the exposed reef surface[1] develops a looser, more spreading form on substrate configurations providing protection from grazing. Major macro-algal populations develop where the reef topography permits or where herbivores are reduced by lack of adequate cover. Plants such as *Dictyota bartayresii* or *Lobophora variegata* occur in most zones, but become extremely abundant where their morphological strategy is most appropriate: *Dictyota* behind the reef crest and *Lobophora* in the deep *Acropora* thickets. The algal zonation on the Belize barrier reef is therefore not the species zonation so common on temperate shores, but a zonation in the community structure of the common reef plants.

ACKNOWLEDGEMENTS

The cooperation and assistance of participants in the IMSWE program of the Smithsonian Institution, of Educational Expeditions International, and of Georges Bockstael in the sorting and identification of collections, is gratefully acknowledged.

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