Structural Changes and Vulnerability of a Coral Reef (Cayo Enrique) in La Parguera, Puerto Rico

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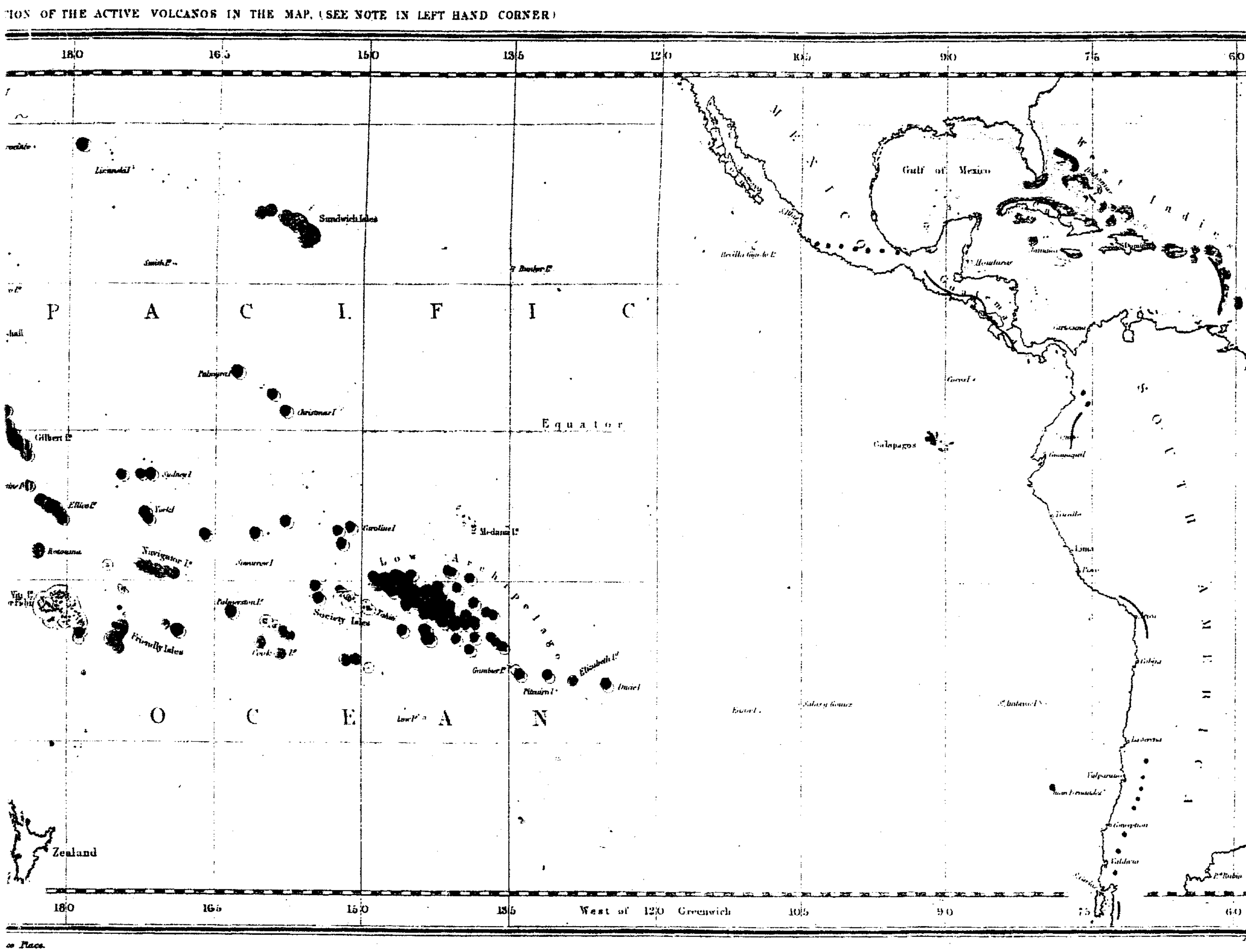
Global Aspects of CoralReefs

Health, Hazards, and History

June 10 and 11, 1993

Case Histories



UNIVERSITY OF MIAMI

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Case Histories for the Colloquium and Forum on

GLOBAL ASPECTS OF CORAL REEFS: HEALTH, HAZARDS AND HISTORY

Commemorating the Fiftieth Anniversary of

University of Miami's

ROSENSTIEL SCHOOL OF MARINE AND ATMOSPHERIC SCIENCE

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JUNE 10, 11, 1993

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ABSTRACT

Over the last five decades, Cayo Enrique reef has been exposed to local extinctions, warm sea surface temperatures, hurricanes, competitive displacements of hermatypic corals by sponges, and coral bleaching. The overall effects of these disturbances have been a decrease in coral cover and an increase in algal biomass. Filamentous algae, articulated coralline red algae and calcareous green algae are causing the displacement of intrinsic reef front components: corals and sponges. At present, Cayo Enrique may be considered as vulnerable. Coral reefs with low coral cover and/or high bioerosion rates cannot cope with expected sea level rise scenarios. If management measures oriented towards the restoration and enhancement of coral reefs are not implemented promptly, the ecological integrity of many reefs may be lost.

INTRODUCTION

Cayo Enrique forms part of a reef system which began to develop between 6,000 and 9,000 ybp. Eustatic sea level rise, shallow water, high water transparency, and proper substrata allowed the development of extensive coral reefs and seagrass beds within the shelf of La Parguera, Puerto Rico. Like other coral reefs along the southern coast of the island, Cayo Enrique reef is built on a light topographic high, which may represent drowned eolianitic structures (Kaye, 1959) deposited parallel to shore during the Wisconsian glacial period (see Goenaga, 1988). The reef is located 1.6 km from shore and extends 132 km along a northeast southwest axis (Figure 1). At present, Cayo Enrique bounds the southern limit of the inner shelf (Morelock et al., 1977).

Qualitative and quantitative assessments of benthic community structure have been conducted by Dr. Goenaga and myself at Cayo Enrique, since 1970. Several disturbances have significantly modified the structure of this reef at different scales of time, space, and intensity. The response of the reef to these disturbances, and the vulnerability of this reef is discussed.

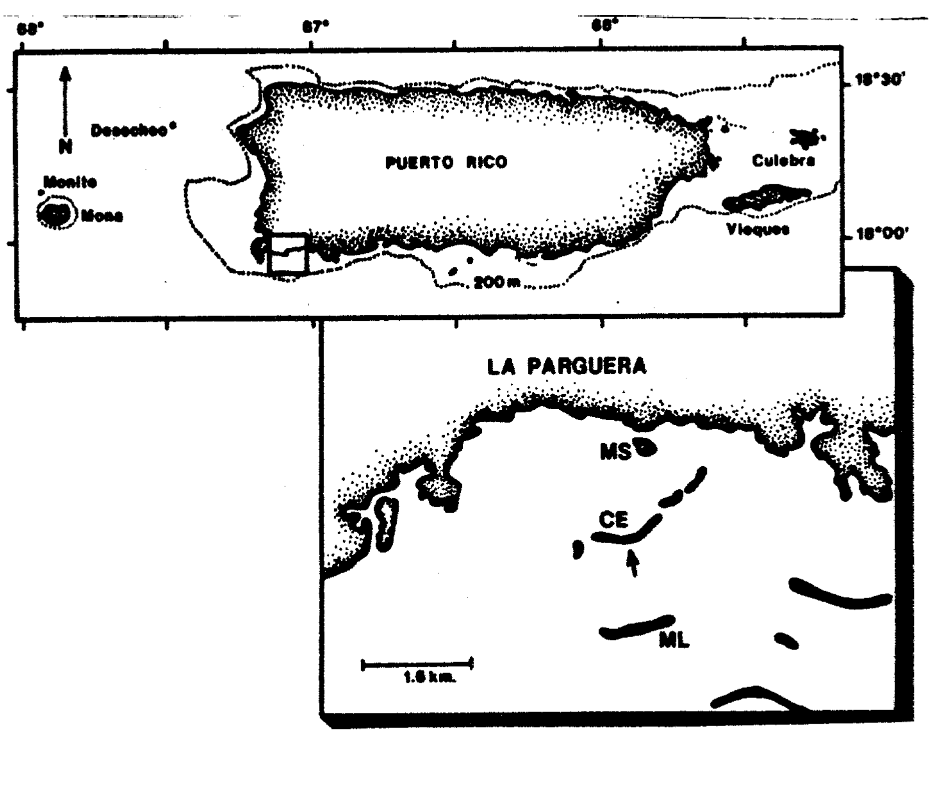


Figure 1 - Location of Cayo Enrique Reef in La Parguera, southwest coast of Puerto Rico.
CE = Cayo Enrique;
ML = Media Luna Reef;
MS = Marine Science Laboratory (Magueyes island).

METHODS

Most of the methods utilized in this study have been published in the literature. Methods to evaluate the ecological impacts of sea surface temperature anomalies are given in Vicente (1989a, 1989b). The methodology utilized to evaluate the impacts of interspecific interactions, extinctions, and bleaching events within Cayo Enrique is given in Vicente (1987; 1990a); Vicente and Goenaga 1984; Goenaga et al., 1989; and, Vicente 1990b).

RESULTS

Sea Surface Temperatures

The warmer sea surface temperatures during the 1950's (sec Figure 2) are suspected to have had considerable impact on the benthic community structure of Cayo Enrique Reef. For example, species which are not truly tropical in origin are believed to become locally extinct during warm periods (Vicente, 1989a). This appears to be the case of two commercial sponge genera (Spongia and Hippospongia), which were abundant but became extinct within the Puerto Rican shelf during the 1950's (Vicente, 1989b).

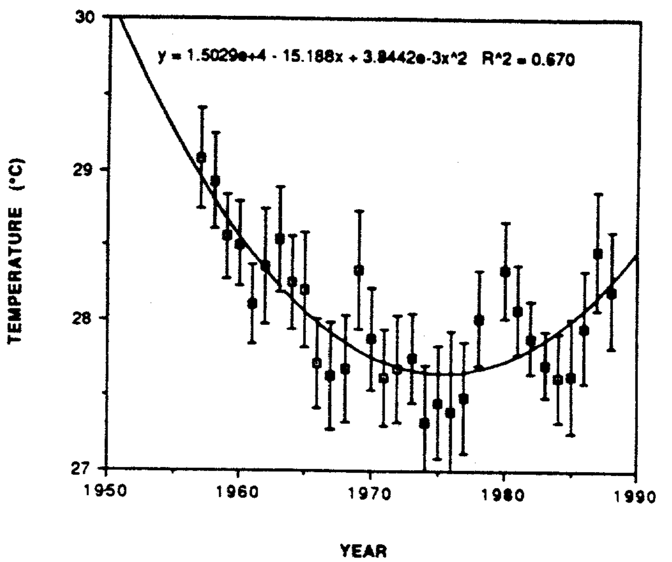


Figure 2. Sea surface temperatures at La Parguera (from Vicente, 1989b). Bars represent the Standard Error (SE). SST readings have been taken by personnel of the Department of Marine Sciences since 1958.

Hurricanes

Hurricane David (in 1979) had devastating effects on the reef front community of Cayo Enrique (and on other reef systems along the south coast of Puerto Rico). Almost all live colonies of elkhorn and staghorn corals (Acropora palmata and A. cervicornis) were broken loose and killed. Cemented elkhorn slabs were torn loose from the reef front and moved onto the reef flat. The populations of other benthic components (e.g. demosponges) within the A. palmata zone were also significantly impacted.

Competitive Displacement

Quantitative data obtained from permanent quadrat observations within the study site since September 1983 demonstrated that all scleractinian corals at the study site were becoming competitively displaced by encrusting taxa (e.g. by the demosponge Chondrilla nucula and by the encrusting alcyonarian Erythropodium caribbaeorum (Figure 3). Overgrowth displacements of corals by sponges were progressive (Figure 4).

All 13 species of hermatypic corals found within the grid became competitively displaced by C. nucula including species with defense mechanisms such as extracoelenteric digestion, sweeper tentacle formation or morphological adaptations. The competitive superiority of C. nucula over scleractinian corals did not change significantly as a function of depth or time (Vicente, 1987; 1990).

Extinction of Diadema antillarum

During January 1984, the sea urchin Diadema antillarum became locally extinct at the study site, and throughout most reefs within the Puerto Rican shelf. This extinction had three major effects on the reef: significant mortalities of competitively dominant species; interference of overgrowth competitive processes; and an increase in filamentous algal biomass. Filamentous and articulated coralline red algae such as Gelidium pucillum, Coelothrix irregularis, and Amphiroa sp., became particularly abundant following the extinction event (Vicente, 1987).

Bleaching Event

An unprecedented Caribbean bleaching event occurred in the summer of 1987 (Williams et at., 1987) which impacted the reef front community of Cayo Enrique. About 22% (n = 326) of the monitored coral colonies became bleached of which 44% showed tissue necrosis (Goenaga et al., 1989). Light exposed bleached coral surfaces died and became colonized by filamentous algae. The overall impact of the bleaching event on Cayo Enrique was a reduction of live coral cover and an increase of filamentous algae.

Recent Observations

Between 1987 and 1990, qualitative observations at Cayo Enrique indicated that algal overgrowth has increased and coral cover has decreased. Furthermore, a calcareous green algae Halimeda opuntia (Chlorophyta: Caulerpales) have expanded its range from the reef flat onto the reef front causing extensive mortality of sessile coral reef invertebrates including hermatypic corals.

Cayo Enrique is being revisited in 1993. Permanent quadrats placed in 1983 are being photographed again and new in site information is being obtained. A preliminary, qualitative analysis of photographs taken within the study site during March 1993 indicate the following: there has been no successful recruitment of D. antillarum since its local extinction in January 1984; although Echinometra viridis have increased in abundance, the vacant niche of D. antillarum has not been filled; filamentous algae continue to be the dominant benthic component throughout the reef front community; coral cover is at its lowest level; and new damselfish territories (Stegastes albifrons) have been established over remaining live coral colonies (e.g. Colpophyllia natans).

DISCUSSION

There has been widespread national and international concern over the state of coral reefs worldwide with the increasing awareness of the intrinsic functional values of socioeconomic importance of coral reefs (e.g. shoreline protection, fisheries production, ecotourism). One of the concerns is whether modern reefs will be able to cope with predicted climate change (e.g. an eustatic sea level rise of 6mm/yr over the next century). Buddemeier and Smith (1988) and Smith and Buddemeier (1992) state that this climatic scenario is well within the range of reef accretion rates (a rate of 10mm/yr is the consensus value for maximum sustained reef vertical accretion rates). This cannot hold true for Caribbean coral reefs with low coral cover (e.g. Cayo Enrique). Furthermore Caribbean reefs may be more prone to bioerosion than reefs elsewhere (Highsmith, 1980).

Cayo Enrique is a reef system under constant change. Over the last few decades natural stress factors have caused significant changes in community structure. Many coral colonies have died, coral diversity is low, live coral cover has been reduced, and filamentous algae have overgrown many corals and sponges. These factors have made Cayo Enrique reef vulnerable to any further sources of disturbance whether they be climatic or anthropogenic in origin.

Because the relative impact of the disturbances mentioned vary from reef to reef, the vulnerable state of Cayo Enrique reef may at least be representative of some other reef situations in the Caribbean. Regional characteristics of the Caribbean Sea which may be of direct relevance to the assessment of coral reefs within the West Indian Region are listed in Appendix I.

CONCLUSIONS

During the last few decades, Cayo Enrique reef has been exposed to local extinctions, warm sea surface temperatures, hurricanes, competitive displacements of hermatypic corals by sponges, and coral bleaching. The effects of these disturbances on the reef have been a decrease in coral cover and an increase in algal biomass. Many reefs within the

Caribbean Region have been exposed (but some perhaps have reacted differently) to the same disturbances that have impacted Cayo Enrique. Therefore, the vulnerability of Cayo Enrique reef may be representative of, at least, some other reefs within the Region.

Management measures oriented towards conservation, restoration, and enhancement of Caribbean coral reefs may become necessary to preserve their functional values as well as their ecological integrity. Otherwise, the resistance of coral reefs to natural or enhanced climatic changes, or to any additional external sources of stress (whether natural or anthropogenic) may continue to decline. Meanwhile, some Caribbean reefs such as Cayo Enrique may be classified as vulnerable.

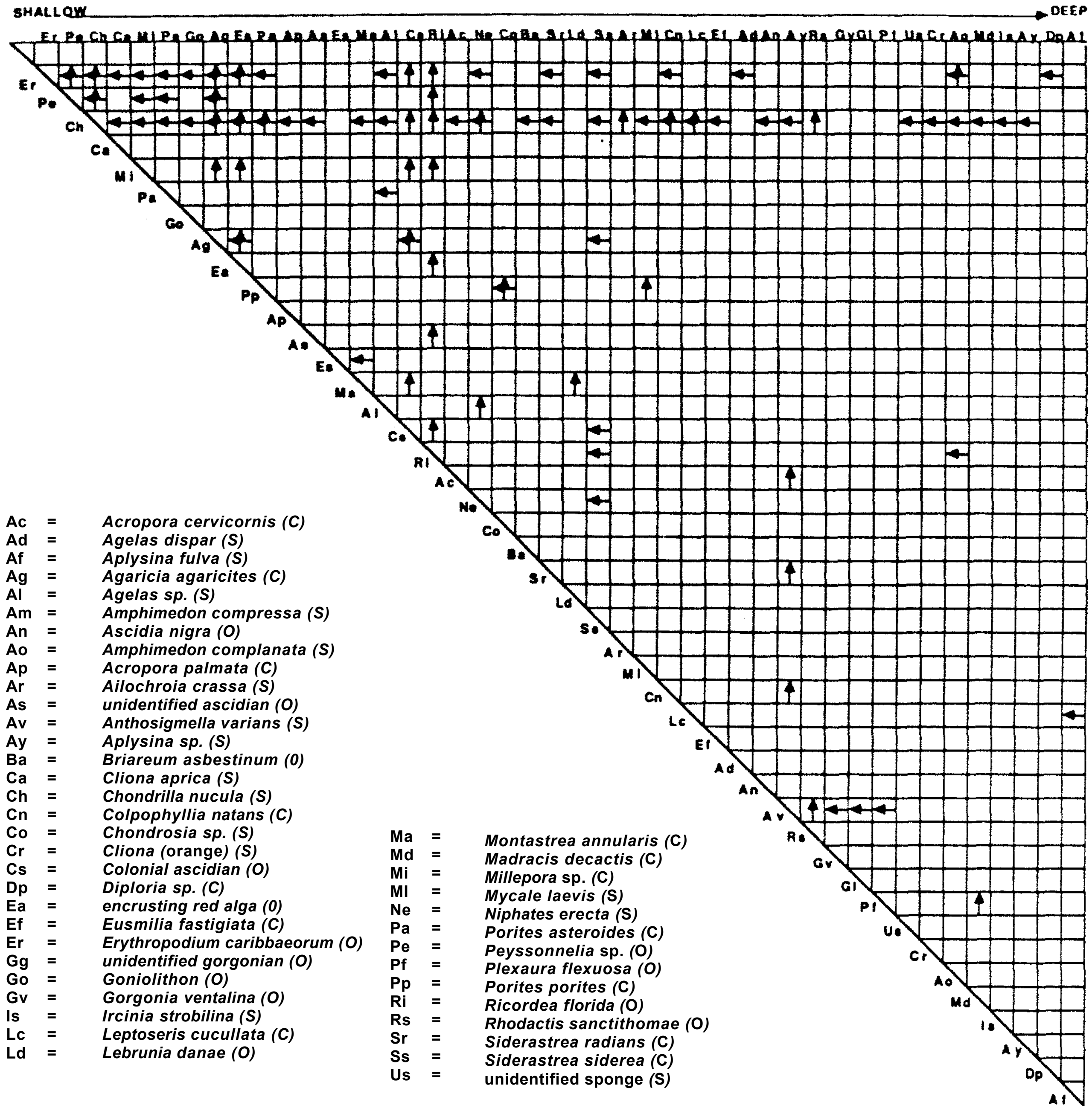
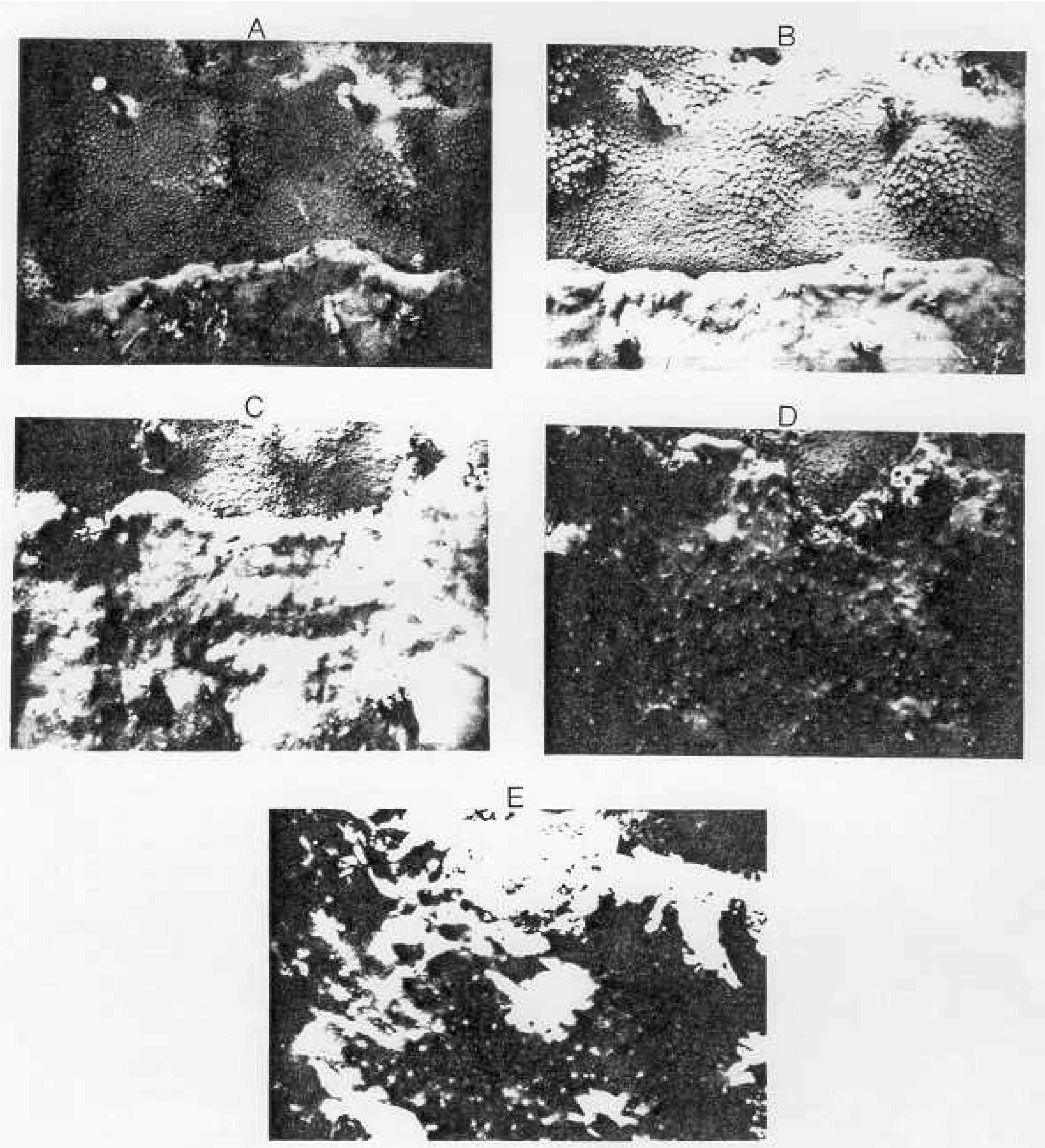


Figure 3. Contact data matrix of specific interactions found in the front reef of Cayo Enrique (from Vicente, 1990a). Arrows in each square point to winning species. Two arrows within a single square signify that either species may win (C. nucula was always the net winner in two arrow situations with corals).

Figure 4. Progressive competitive displacement of the hermatvpic coral *Montastrea annularis* by the encrusting sponge *Chondrilla nucula* (September 1983 - March 1986). Arrow marks a contact area where filamentous algae interferes with the displacement process.



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APPENDIX 1

There are several regional characteristics of the Caribbean Sea and certain episodes which have affected, and some are still affecting, much of the Caribbean Region as whole. These need to be discussed when assessing the status of Caribbean reef! Some of them are listed below.

1. The Tropical Surface Water of the Caribbean Sea may not be the ideal water mass for maximum coral reef developmen (Vicente, 1992), since this water mass receives immense amounts of nutrients and sediments. It is believed that over 20%, of the fresh water discharged annually by the world's rivers enters the Caribbean Sea. The dispersal of the Amazon's discharge alone, affects surface salinity, phytoplankton concentration, and phytoplankton species composition throughout the wester tropical Atlantic (Muller-Karger et al., 1988). These factors do not necessarily promote maximum reef development, since coral reefs grow best in oligotrophic waters with low primary production rates.
2. A large portion of the Caribbean reef tract lies within the hurricane belt. This may weaken the reef structure and may cause extensive mortalities of the Acropora palmata zone and of other reef zones as well. At times however, density independent event (such as storms and hurricanes) may enhance local reef diversity when they disturb the system at an intermediate level (Connell 1978).
3. Caribbean biological diversity is low when compared to the Indo-Pacific (there are about 809; more genera and species o corals in the Pacific than in the Caribbean).
4. The massive demise of D. antillarum which spread throughout the Caribbean from January 1983-84, and the major coral bleaching event of 1987, have probably decreased coral cover within many Caribbean reefs since both events impacted the Region as a whole.
5. Caribbean corals are frequently subjected to various forms of diseases (e.g. Black band and white band disease) and stresses as reviewed by Peters (1984).