Summary of Presentation:
Decline of Coral Populations in a Coral Reef: Cayo Enrique, La Parguera, Puerto Rico

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DECLINE OF CORAL POPULATIONS IN A CORAL REEF: CAYO ENRIQUE, LA PARGUERA, PUERTO RICO

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ABSTRACT

Underwater photographs and in situ notes were taken within a 160m2 grid **at** Cayo **Enrique** Reef during **1984, 1986, 1988** and **1993** to determine changes in **coral populations.** Of the **293** coral **colonies** found within the reef front grid, 50% (n=146) died during the nine year interval while only 21% (n=61) survived. Only a few colonies (5) increased in cover. Live coral surface decreased in 69 colonies while only 5 colonies showed significant growth. More than 50% mortality was found in 9 of the 14 species found. Mortality was highest in Acropora palmata, Agaricia agaricites and in Eusmilia fastiqiata where all monitored colonies died (100% mortality). As expected, lower (but significant mortality rates were found in Montastrea annularis and in Siderastrea siderea. Mortality was attributed to: damselfish (Stegastes planifrons) behavior (42%); filamentous algal overgrowth (34%); overgrowth of corals by green (Hallimeda opuntia) calcareous algal mat development (16%); and, to overgrowth by sponges (7%). Cayo Enrique Reef, like many other Caribbean reefs are more vulnerable now to any additional external sources of stress, whether natural or anthropogenic in origin. The changes in benthic community structure observed at Cayo Enrique may very well influence the species composition and relative distribution of its fisheries resources.

I. Introduction: History of Cayo Enrique.

Between 6,000 and 9,000 ybp, the southwestern shelf of Puerto Rico became flooded by sea level rise. A slower eustatic sea level rise, shallow water, high water transparency and proper substrate conditions during this mid-Holocene period allowed the development of extensive coral reefs, seagrass beds and of other inner-sublittoral systems within the shelf of La Parguera.

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 Winsconsian glacial period (see Goenaga, **1988).** The reef is located 1.6 km from shore and extends 1.32 km along a northeast southwest axis (Figure 1). At present, Cayo Enrique bounds the southern limit of the inner shelf (Morelock et al., 1977).

Cayo Enrique Reef, as well as most reefs on the southwestern shelf of the island have been able to develop and grow vertically in harmony with mid-Holocene changes in the oceanic (relative sea level) and atmospheric conditions of the time. Under present conditions however, reef development may take a different course.

During the last decades, non-anthropogenic disturbances have had a significant impact on the physical and biological structure of Cayo Enrique reef. These disturbances include massive die-offs of sea urchin herbivores, hurricanes, coral bleaching, changes in sea surface temperature, and competitive displacement of corals by algae and sponges (Vicente, 1993). This study evaluates the status of hermatypic coral populations in the reef front of Cayo Enrique, Puerto Rico.

II. Methods.

A permanent grid (160 m2) was constructed on the reef front of Cayo Enrique in 1983 to monitor sponge and coral populations (for details see Vicente, 1987). Each 1m2 quadrat within the *Acropora palmata* zone, the mixed zone and the base of the reef were photographed during **1984, 1986, 1988** and 1993. Changes in the conditions of the coral heads (visible at a 1m2 spatial scale) were examined through photographic interpretation and with in situ inspections. The status of all the hermatypic corals were evaluated. Four categories were used: those coral heads which survived, those which died, and those which either decreased or increased in cover during the nine year period.

III. Results.

A total of 293 coral colonies were identified within the grid. The species include one hydrocoral (Millepora alcicornis) and 13 scleractinian, hermatypic corals: two poritids (Porites astreoides, P. porites); five faviids (Montastrea annularis, M. cavernosa, Diploria labyrinthiformis, D. clivosa, and Colpophyllia natans); two acroporids (Acropora palmata and A. cervicornis); one siderastreid (Siderastrea siderea); one meandrinid (Dendroqyra cylindricus); one agaricid (Agaricia agaricites); and one caryophyllid (Eusmilia fastigiata) .

The number of colonies were found to increase with depth and varied from about 10-20 corals/lOm2 within the Acropora palmata zone to about 30 corals/10m2 at the base of the reef. A significant correlation was found between depth and number of coral colonies where 56% of the variability in the number of colonies can be attributed to some depth-related factor (Figure 1).

Of the 293 coral colonies, 50% (n=146) died during the nine year interval while only 21% (n=61) survived. Only a few colonies (5) increased in cover while. Live coral surface decreased in 69 colonies while only 5 colonies showed significant growth. A significant decrease in survivorship was found with depth (Figure 3).

Mortality by species is presented in Figure 4. More than 50% mortality was found in 9 of the 14 species studied. Mortality was highest in Acropora palmata, Agaricia agaricites and in Eusmilia fastigiata where all monitored colonies died (100% mortality). As expected, lower mortality rates were found in Montastrea annularis and in Siderastrea siderea.

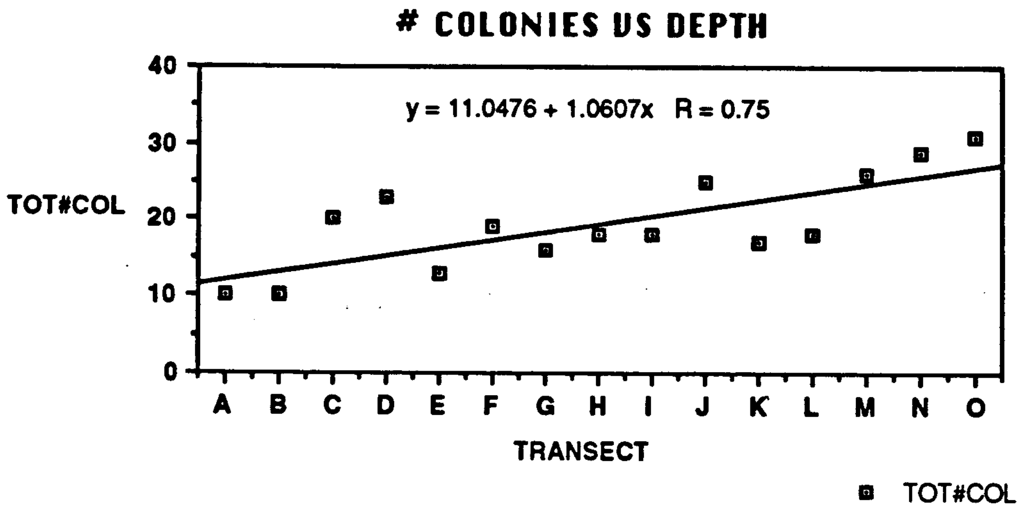
The time photographic series analysis helped to elucidate the mechanisms of coral mortality. Mortality was attributed to: damselfish (Stegastes planifrons) behavior (42%); filamentous algal overgrowth (34%); overgrowth of corals by green (Hallimeda opuntia) calcareous algal mat development (16%); and, to overgrowth by sponges (7%).

IV. Discussion.

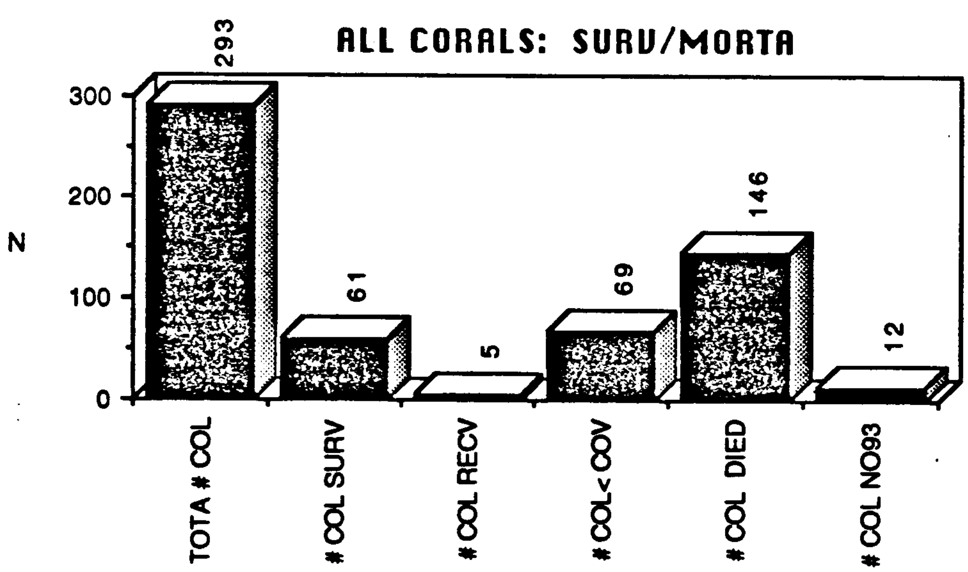
A widespread mortality of hermatypic coral populations has occurred during the last decade at Cayo Enrique. Qualitative assessments of other coral reefs within the Puerto Rican shelf also indicate a significant decline in coral cover and diversity.
Most of the coral mortalities observed at Cayo Enrique are related to increases in biomasss and cover of algae.

Figure 1. Relationship between number of coral colonies with depth on the reef front of Cayo Enrique reef. The number of colonies were found to increase with depth and varied from about 10-20 corals/10m2 within the _Acropora palmata_ zone to about 30 corals/lOm2 at the base of the reef. A significant correlation was found between depth and number of coral colonies where 56% of the variability in the number of colonies can be attributed to some depth-related factor.

Figure 2. Survival and mortality of coral colonies within the reef front grid of Cayo Enrique. Of the 293 coral colonies, 50% (n=146) died during the nine year interval while only 21% (n=61) survived. Only a few colonies (5) increased in cover while. Live coral surface decreased in 69 colonies while only 5 colonies showed significant growth.



# COLONIES VS DEPTH
y = 11.0476 + 1.0607x R = 0.75
TOT#COL
40
30
20
10
0
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
TRANSECT
TOT#COL

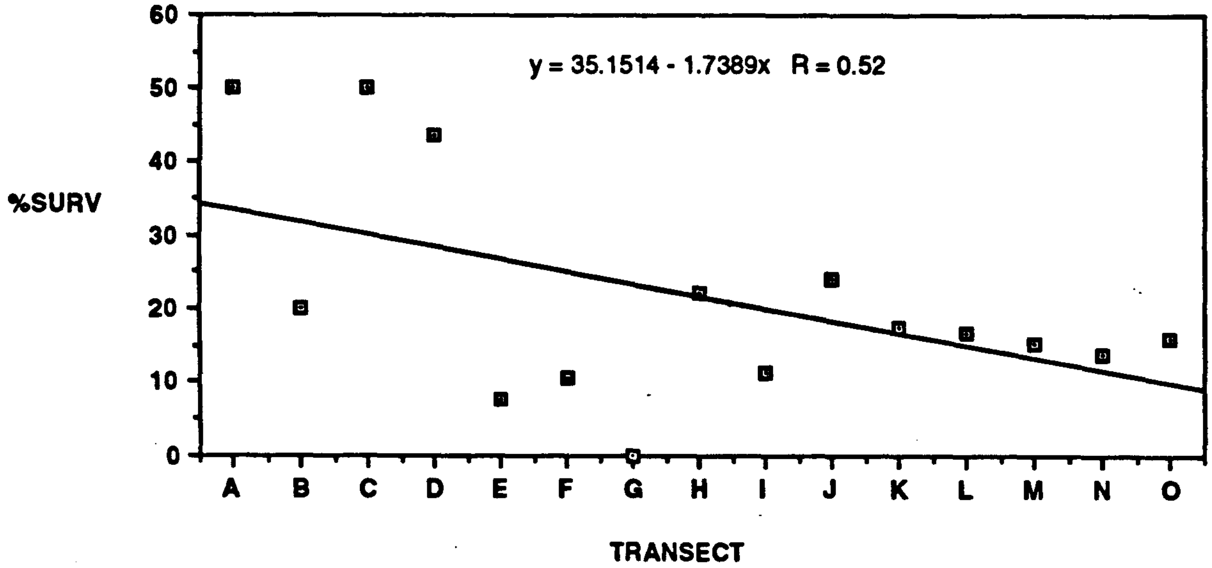


ALL CORALS: SURV/MORTA
N
300
200
100
0
293
61
5
69
146
12
TOTA # COL
COL SURV
COL RECV
COL< COV
COL DIED
COL NO93

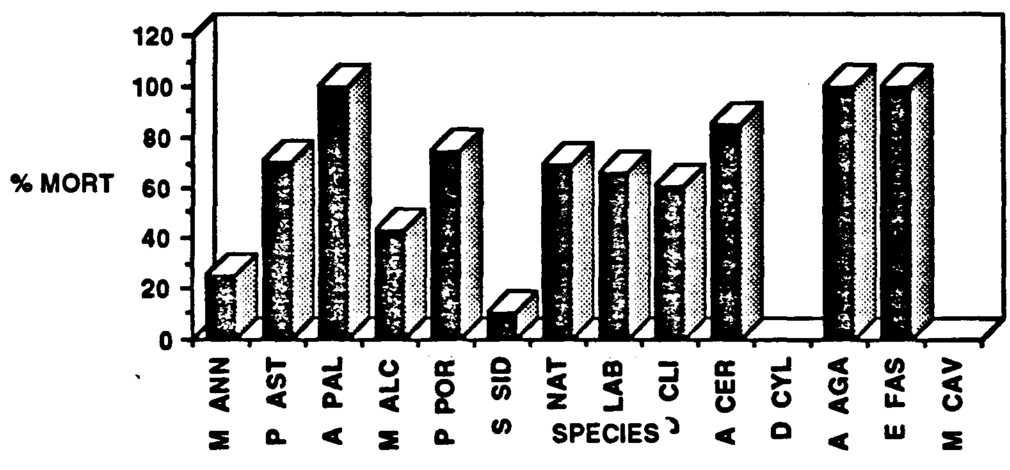
Figure 3. Relationship between depth and percent survivorship of coral colonies within the reef front of Cayo Enrique. A significant decrease in survivorship was found with depth.

Figure 4. Mortality by species (1984-1993). More than 50% mortality was found in 9 of the 14 species studied. Mortality was highest in Acropora palmata, Agaricia agaricites and in Eusmilia fastigiata where all monitored colonies died (100% mortality). As expected, lower mortality rates were found in Montastrea annularis, and in Siderastrea siderea.

PERCENT SURVIVAL: TRA-TRO



PERCENT CORAL MORTALITY: 1984-1993



Both, thin red alga algal mats (e.g. Coelothrix irregularis, Gellidium pusillum) as well as thick mats of green calcareous algae of the order Caulerpales (Hallimeda opuntia) are largely responsible for the population decline of hermatypic coral populations.

The peculiarity of this case study is that the high mortality of coral populations cannot be attributed to direct human (anthropogenic) impact nor to density independent (e.g. stochastic) processes. For example, the reef studied (Cayo Enrique) is located about 1.5 Km from shore, receives very little sediment runoff and rainfall (upland vegetation of La Parguera is primarily xerophytic), there are no significant agricultural practices (therefore the area does not receive loads of nutrients or pesticides), there appears to be no water quality problems in the reef, and the reef has not been severely impacted by hurricanes since 1979 (Hurricane David).

On the other hand, interspecific, clonal, invertebrate interactions (Vicente, 1987, 1990), massive die-offs of sea urchin populations (Vicente and Goenaga, 1984), algal overgrowth (Vicente, 1993), coral bleaching (Goenaga et al., **1989)** and even slight natural fluctuations in sea surface temperature (Vicente **1989)** have all been implied in the decline of corals (species diversity, live coral cover, and population densities) and in the decline of other integral components of the reef. Therefore, coactive patterns (sensu Hutchinson) can significantly influence the distribution of coral populations. These changes in community structure can have a serious impact on the fisheries resources associated with this reef.

To my opinion, the single most important indirect human impact on this reef may very well be overfishing. For example, although the natural Diadema antillarum die-off may very well explain the increase in algal abundance within the reef (after 1984) the increased fishing pressure on herbivorous fish populations (e.g. parrot fish) and the removal of large predators (e.g. groupers and snappers) from the reef could also contribute to an increase in filamentous and in articulated coralline red and green calcareous algae. Parrot fish (fam. Scaridae) graze on algal mats while large predators (groupers and snappers) prey, at least in part on damselfishes.

V. Conclusions and interpretations.

1. The benthic community structure of Cayo Enrique reef has undergone dramatic changes due to coactive factors.

2. There has been a significant decline in hermatypic coral populations, coral species diversity and in live coral cover.

3. A considerable increase in algal biomass and cover has been noticeable since 1984.

4. The increase in algal biomass is probably related to an increase in the fishing pressure on herbivorous fish populations.

5. The increase in algal cover may also be the result of the massive die-off of *Diadema antillarum.*

6. The increased population of damselfish within the reef front have caused significant mortality of hermatypic corals.

7. The present high population density of damselfish *(Stegastes planifrons)* may be due to heavy fishing pressure of large predators (groupers and snappers).

8. Under present conditions, Cayo Enrique, as well as many other reefs within the Caribbean (see Ginsburg et al., 1993) are more vulnerable to changes in the environment.

VI. General comments on Caribbean coral reefs.
(from Vicente, 1993).

1. The Tropical Surface Water of the Caribbean Sea is not necessarily the ideal water mass for coral reef development (Vicente, 1992). This water mass receives immense amounts of nutrients (which enhance primary production) since it receives over 20% of the fresh water. discharged annually by the world's rivers. For example, the dispersal of the Amazon's discharge alone, affects surface salinity, phytoplankton concentration and phytoplankton species composition throughout the western tropical Atlantic (Muuler-Karger et al., 1988). These factors do not favor maximum reef development since coral reefs grow best in oligotrophic waters with low primary productivities.

2. Coral reefs within the West Indian Region are also frequently (and intensely) weakened by hurricanes since a large portion of the Caribbean reef tract lies within the hurricane belt. At times however, density independent events (such as storms and hurricanes) may enhance local reef diversity when they disturb the system at an intermediate level (Connell, 1978).

3. Caribbean reefs are also more prone to bioerosion than reefs elsewhere (Highsmith, 1980) and biological diversity is lower than in the IndoPacific (there are about 80% more genera and species of 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 decreased coral cover within many Caribbean reefs. Furthermore, 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). Based on the above, we may state that the ecological integrity of reefs, particularly those within the Caribbean, is at present threatened.

VII. Climate change and Caribbean coral reefs: personal opinion.

There has been widespread national and international concern over the state of coral reefs worldwide because of the increasing awareness of the intrinsic functional values of coral reefs (e.g. shoreline protection, fisheries production, ecotourism). One of the concern 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 many Caribbean coral reefs characterized by low coral cover (like Cayo Enrique reef). The fate of a given coral reef in situations where bioerosion rates are greater than accretion rates for extended periods of time is the loss of its ecological integrity, and therefore, of its functional values.

Management measures oriented towards conservation, restoration, and enhancement of Caribbean coral reefs (if implemented promptly) may result in the preservation of their functional values and in the maintenance of 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) will continue to decline. Meanwhile, Caribbean reefs are vulnerable and should be considered as an endangered ecosystem.

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