Fish Population Studies of the Seagrass Beds and Coral Reefs of Cayo Berberia and Cayo Ratones, Ponce, P.R.

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Scientific Research Area
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DEPARTMENT OF NATURAL RESOURCES
SCIENTIFIC RESEARCH AREA
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FISH POPULATION STUDIES OF THE SEAGRASS BEDS AND CORAL REEFS OF CAYO BERBERIA AND CAYO RATONES, PONCE, P.R.

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ABSTRACT

Two coral reefs in the south coast of Puerto Rico (Cayo Berberia and Cayo Ratones) were visually censused between 1983 and 1985 to determine the effects of sedimentation on their sport fish populations.

Species **composition,** species diversity, dominant species and abundance were the parameters compared within and between the zones of the two reefs studied. These parameters were correlated with the degree of sedimentation to measure the effects of this stressor. Similarity indices were calculated within and between the reef zones. Mann-Withney U-test was used to test for significant differences in species abundances between the reefs.

The censusing technique used was a modification of the visual method developed by Brock (See Brock, 1954). The reason for chosing the visual method was because this is a non-destructive technique for assessing fish populations. We compared the reefs over a period of two years by setting permanent transect lines and making visual assessments periodically without disturbing the populations.

Sixty three reef sport fish species were chosen as target species. Nine reefs were evaluated during the first year in order to choose the most convenient, logistically, for detailed study. Cayo Berberia and Cayo Ratones were chosen on that basis.

Correlation analysis showed that there was a significant relationship between sedimentation and the abundance values of four of the species studied. Another seven species showed a correlation marginally close to the 95% confidence limit. A significant correlation was also found between sedimentation and total number of fish/census for Cayo Ratones and between sedimentation and the evenness and diversity values for combined data. Fourteen species showed significant differences in abundance

between the reef slopes of Berberia and Ratones reefs. For the **A.** palmata zones, ten species were significantly different in abundance.

Cayo Berberia showed the highest **overall** abundance, **species diversity and density. The reef slope of Berberia displayed the greater abundance and species diversity. In Ratones, although the slope was more diverse, the A. palmata zone showed the highest abundance. Mean abundance was very much influenced by large nummbers of juvenile parrotfishes, grunts and acanthurids. Acanthurus spp. were represented in all of** the censuses at both reefs.

The maximum number of species in a particular census was 30 for the slope of Berberia while the maximum number of **individuals** was 457 for the A. palmata zone of Ratones. The density (ind/m^2) in the reef slope of Berberia ranged between .23 to .83 with a mean of .52 while in the reef slope of Ratones it ranged between .13 to .43 with a mean of .27. The high density values were very much influenced by schooling species such as surgeonfishes, grunts and parrotfishes. Acanthurids were the dominant species in Berberia as well as in Ratones with 26.20% and 33.67%, respectively, of the total abundance. In Berberia the ten dominant species accounted for 69.43% of the total abundance while in Ratones they **made** up 78.49% of the total.

The A. palmata and slope zones proved to be very different in species composition and abundance. Cayo Berberia and Cayo Ratones slopes showed an average similarity of .59 and .43 based on the Sorenson (S) and the Bray and Curtis (B&C) Indices, respectively. The A. palmata zones of these reefs showed an average similarity of .57 (S) and .37 (B&C). The slope zones were more similar than **the A. palmata zones. The largest similarity between the two zones, within a reef, was** .74 **(S)** and .72 (B&C).

INTRODUCTION

The role of several factors such as structural complexity, **live coral cover, and microhabitat availability on species diversity of coral reef fish populations has been well documented. (See Williams, 1982; Sale, 1977; Randall, 1963; Talbot, Russell and Anderson, 1978; Alevizon and Brooks, 1975). The effects of major storms and other atmospheric disturbances on the coral community and associated fish faunas have** also been studied **(Walsh,** 1983).

Reef fish communities have been increasingly recognized and utilized as valuable economic and recreational resources but, although an important resource, little is known about the impact of different types of pollution and other human activities on the reefs and their associated systems. Literature about the effects of sedimentation on the diversity and abundance of coral reef fishes, specially sport fish, is very scarce.

Some of the few studies include that of Johnston and Wildish (1981) who demonstrated experimentally that the feeding of larval herring was affected by the degree of sedimentation to which they were subjected. They found that in greater concentrations of suspended sediment (> 20mg/L) the visibility of prey and light intensity were significantly decreased and the feeding rate depressed.

Sale and Douglas (1981) found that the number of species seen in several censuses was affected by water transparency but they fail to state if that effect was caused by a reaction of the fishes to the suspended sediments and turbidity or because the observers could not see the fishes even if they were present.

Galzin (1981) outlined the effects of sand dredging on fish fauna from a lagoon habitat on the French West Indian Island of Guadalupe. He found that the resuspension in the water of fine sand particles caused by dredging activities had the following effects:

a) **provoked** the **disappearance** of 20 fish species out of 29 which **had** colonized the principal dredging site during a **dredging** interruption,

b) caused **an almost** total **disappearance,** or a large decrease, in the **ichthyological** fauna in neighboring areas,

c) caused an unbalanced ichthyological population as shown by the great **variability** in the **diversity** indices and low **equitability** values.

Amesbury (1981) **reported** that fish abundance and **diversity** in Truck were **significantly** reduced in areas subjected to intense **deposition of sediments.**

Seelye, Hasselberg and Mac (1982) conducted a series of controlled experiments to examine the potential absorption by fish of contaminants from suspended sediments. They used fish from lake and hatchery origin and found accumulation of PCB's, Fe, As, Cr, and Na within a 10 day study period. These results demonstrate that several common environmental contaminants can be accumulated by fish directly from suspended sediments. They suggested the possibility that contaminants associated with sediment particles that collected on the gills of the fish were taken up directly through these tissues.

Diversity indices have been used by many authors to indicate stress in aquatic systems. Wilhm and Dorris (1968), as cited in Betchel and Copeland (1970), state that values below 1.0 represent highly polluted areas, values between 1.0 and 2.0 indicate stress and values 2.0 and above indicate relatively unstressed ecosystems. But the diversity values are influenced by combined effects of factors such as habitat size, current patterns, availability of recruits, habitat structure and others which cannot be considered as stressors. Furthermore, those values apply to temperate and subtropical fish populations (Martin and Patus, 1973).

There exists a well known latitudinal effect on species diversity (Pianka, 1980). For example, Hobson (1982) counted only

30 species on 33 transect lines over three years in four Californian habitats compared to 133 species on 22 transects over one year in four Hawaiian habitats. Generally, there. is more diversity and less abundance per species in tropical areas. Diversity indices by themselves are meaningless, so we used diversity indices in conjunction with similarity indices to make comparisons within and between reefs.

Many of the effects caused by sedimentation do not affect the fishes directly but the invertebrates which they feed upon. Mollusks, urchins, corals, algae and all sedentary fauna are seriously affected when subjected to high sediment rates (Galzin, 1981).

Many fish species are highly adaptable to stress situations (Hocutt et al. 1982). There are oportunistic species which are tolerant of heat, chemicals, organic load and high turbidity (Martin and Patus, 1973). Thus, it was felt that a turnover in species composition or abundance, or a significant difference in these attributes in two similar reefs could be an indicator of stress in a community and would be useful as a parameter to measure or estimate the effects of certain type of disturbance.

The objective of this study was to determine the density of the principal sport fishes in two reef areas in the South Coast of Puerto Rico and to assess the impact of sedimentation stress on coral reef communities and their fish population by comparing healthy and stressed sites.

MATERIALS AND METHODS

Visual census of coral reef fishes has become a widely used method in the study of coral reef fish ecology because it is the only non-destructive way to sample coral reef fish populations (Brock 1954; Alevizon and Brook 1975; Jones and Chase 1975; Jones and Thompson 1978; Risk 1972; Smith and Tyler 1975; Kimmel 1985; Sanderson and Solonsky, 1980; Bohnsack and Bannerot, 1985). Many researchers **have statistically** proved the **validity** of the method and have pointed out the possible biases and ways to correct them (See Jones and Thompson, 1978; Sale and Sharp, 1983; Sale and Douglas, 1981). Kimmel (1985) tested three methods for visual counts of fishes **and** has used the technique in Puerto Rico.

The technique **employed** for this research is a modification of the **Brock visual** method (See Brock,1954). Two **observers equiped** with **SCUBA,** a watch, **and** a slate with a **data** collecting format made **quantitative** visual censusing of reef fish fauna along 100 meters transect lines. The counting path for each diver was 2.5 meters wide. Each diver counted only the fishes at his side of the transect. The two counts were summed together to arrive at a total count.

At the preliminary phase of the study a test was made to determine the optimum size of the sample area. Several 100 meters transects divided into 10 meters intervals were laid along the different zones of the reefs and all the individuals of the target species were identified and counted. The 10 meter intervals were later analyzed as independent transects and the cumulative number of species in the first 10, the first 20, the first 30 meters, etc. were compared with the qualitative lists previously made for each zone. When cumulative number of species was plotted against the transect length the curve reached an asymptotic level at 80 meters (Figure 1). The results shows that a length of 80 meters is adequate to sample more than 90% of the assemblage. We conservatively chose 100 meters to provide for a greater margin for variation. Also it was felt that a 100 x 5 area was capable of accomodating all the available species and thus any difference between transects is independent of the size of the area chosen.

Due to the uneven distribution of fish throughout the coral reefs we stratified them into four zones according to depth and coral structure (see Ferrer, 1985 for study site description). Through this process we grouped elements which shared some characteristic so that a better estimate of density could be obtained. When the total population is divided into several

subpopulations the efficiency of the sampling is increased (Caughley, 1978)

During the preliminary survey the four zones were sampled in each reef. Nevertheless fish faunas present in the mixed and A . **palmata zones** were not significantly different (t-Test, **p** < .05), and thus the mixed zone censuses were not performed **subsequently. The** reef crest **or breaker** zone was almost **always** so **rough** that it was impossible to make enough counts for comparisons with the **other** areas.

In this **method** time is not a limiting factor. The time taken to complete a transect is primarily a function of the density of the fish at a given time of the day. The 100 meters transects were completed in an average time of 27 minutes. The observers were allowed to search in caves, crevices, under ledges and had enough time to make a careful identification of the species. Nevertheless, the standard deviation between the time spent for running the transects was only 7.5 minutes. Observers were previously trained for quick identification of the species by the use of slides and also by practical tests underwater previous to the start of the study.

Maximum depth was 35 feet so bottom time was not a limiting factor and decompression dives were not necessary. A record of the counts was kept on two 7 x 11 Mylar sheets stapled together and preprinted with the target species scientific names arranged in **alphabetical** order. The form had rows for the 63 species and was ruled vertically into twelve columns. The first for the specific name, the next 10 corresponding to the 10 meter intervals and the last column for the totals (Figure 2). Our study was restricted to 63 reef sport fish species which were chosen based on the literature review and the previous experience of the researchers on the reefs of the Island. The 10 meter intervals allowed the researcher to obtain data about the distribution of species and to identify the microniches along the 100 meters transect.

On the **top** side of the form, space is provided for recording the area and station name, **visibility,** depth, time and date. A lead pencil was used for taking notes and extra pencils were **always** kept in the vest pocket. **A** safety diver **accompained** the **observers** swimming **about** three meters **above** the bottom **and** five meters **behind** them. Although not taking notes, he was alert to the species and their movements along the strip. Later, the species seen **by him and not by** the observers were **added** to the counts.

If a fish school entered the transect they were **counted-or** estimated to the nearest 5 to 10 **individuals.** At the end of the transect, the observers swam back and counted those fishes not previously seen.

For setting the transects, the reefs were divided into zones, as explained before, and a transect was laid along each of them. Each zone was more or less homogeneous if compared with the total area. Transect lines were not necessarily laid straight but following the contours of the different zones. The lines were made of a non-floating braided nylon rope. Ten small numbered buoys were attached with 1 meter cords to mark the 10 meters intervals. It took no more than fifteen minutes to lay down the transect line. They were set permanently in position.

Of the visually censusable fishes there were several groups that presented special problems. Individuals of the genera Kyphosus, Calamus and juvenile Scaridae often could not be accurately identified underwater at the species level. Thus, these groups are reported collectivelly but treated as species in the analyses. The only exception was Sparisoma viride (Scaridae) whose juvenile is distinguishable from the other species of the Family. Species such as Lutjanus analis and Calamus sp. were rapidly search for because this species tend to flee as soon as divers approach them. The main shortcoming of visual censusing in this study was the accurate counts of wandering schooling species such as the Acanthurus so the three species of Acanthurus were counted as a single species when they ocurred in mixed schools.

In the ***Thalassia* beds** fishes were collected with experimental gillnets whose stretched mesh ranged from 1 to 5 inches. **Collection periods spanned from 3 to 4 hours. Day and night collections were made.**

We had certain limitations for sampling in *Thalassia* beds. Gill net samples were not taken as often as necessary because the equipment used has to **be managed** from a larger **vessel which was available only twice. From the samples taken is not possible to provide abundance data. Visual qualitative and quantitative censuses were made but the latter proved** to be ineffective due to the low fish density and the large size of the *Thalassia* meadows at both reefs. Individuals observed were visually categorized as juveniles or adults.

To calculate fish density the total number of individuals of all species per transect were summed and divided by the total area covered by the transect ($500m^2$).

Within and between community comparisons were made using the Shannon and Weaver(1948) diversity function (log base 10) and the evenness values of Pielou (1978).

To examine the similarity in community structure within and between reefs we used the Sorenson (1948) and Bray and Curtis (1957) Indices of Similarity. Sorenson Index considers only the presence or absence of species while Bray and Curtis considers also the abundance values by taking into account the relationship of each species to its counterpart in another community (Jones and Thompson, 1978).

A program for the Apple computer was developed for calculating diversity and similarity indices using VisiCalc based da to f i l e s . The statistical analyses were made with the Stat-Pro and Key-Stat packages for the Apple.

RESULTS

CORAL REEF FISHES

General Description and Species Distribution

The **data for all** the transects within a reef was **combined** and **analyzed to examine** the **overall** status of the fish communities of **Berberia and Ratones reefs .**

Table 1 is a checklist of the species present per zone and **per** reef **and** shows **a** cumulative total of 47 species **observed in Berberia** and 48 species in Ratones. Ten species considered in this study were never observed in any of the quantitative or qualitative censuses of the reefs studied. Epinephelus striatus, although observed during the qualitative censuses in Cayo Ratones; was never found in the transect area. The most surprising and unexpected finding was that Epinephelus fulvus, a common reef fish, was not present in any of the qualitative or quantitative censuses of Berberia.

Two species, Epinephelus striatus and Scarus coelestinus were recorded in Berberia but not in Ratones and three species, Epinephelus fulvus, Haemulon bonariense and Lutjanus synagris were represented in Ratones but absent in Berberia. Caranx Tuber, Kyphosus spp. and the juveniles of Scarus although present in Ratones were not as abundant as in Berberia. The opposite was true for Haemulon chrysargyreum, Holocentrus ascencionis and Sparisoma rubripinne. Forty five species were common to both reefs. This does not means that species not shared in common would not eventually appear if additional censuses were made because some species seen during the qualitative censuses were never seen during the counts. Three species, Acanthurus spp., Sparisoma aurofrenatum and S. viride were represented in 100% of the censuses of Berberia while in Ratones only Acanthurus spp. was counted in all the censuses (Figures 3 and 4). It is also evident from these figures that in general the fish species in Berberia reef were more associated with the reef than the species at

Ratones reef. In Berberia seven species were found in more than 90% of the censuses and the least frequent species were found in 18% of the censuses. In Ratones reef only three species were found **in more than 90% of the censuses and 16 species appeared in 18% or less of the countings.**

Species Richness

The total number of species in the reef slope of Berberia was 44 whereas in the slope of Ratones it was 41. Eigth species, Balistes vetula, Caranx hippos, **Epinephelus** striatus, Haemulon macrostomum, Kyphosus spp. Lutjanus jocu, Hycteroperca tigris and Scarus coelestinus, five of them of high food and sport value, were recorded for the reef slope of Berberia but not in the same area of Ratones making a great difference in the quality of the species present in each area. Five species, including Lutjanus analis and L. synagris were present in the reef slope of Ratones but absent for that area in Berberia. Nevertheless L. analis was fairly common in the A. palmata zone of Berberia. There were 36 species in common between the reef slopes of Berberia and Ratones. Eight and three species were recorded in 100% of the censuses of the slope of Berberia and Ratones respectively.

The A. palmata zone of Ratones showed a cumulative total of 43 species compared to 40 species in Berberia. Two important food fishes, Lachnolaimus maximus and Lutjanus griseus were represented in the A. **palmata** zone of Berberia but not in Ratones and seven species that were recorded from the A. palmata zone of Ratones were absent from the A. palmata zone of Berberia. There were 37 species in common in the A. palmata zone of both reefs. Five species were counted in 100% of the censuses of Berberia and also five species were represented in 100% of the censuses of Ratones. The reef crest or breaker zone of Ratones showed a total of 28 species.

Comparing the different zones within a reef we found that the reef slope of Berberia had seven species that were not found in the A. palmata zone. Conversely three species in the A. palmata were not represented in the reef slope. Five and seven species were represented in 100% of the censuses of the A. palmata and reef **slope of Berberia respectively. Five** species were represented in 100% of the censuses of the A. palmata zone of Ratones and three species in 100% of the slope's censuses of this reef. For Ratones reef there were seven species in the A. palmata zone not **represented** in **the** reef **slope and** four species in the reef **slope** that were absent from the A. **palmata** zone.

Table 2 **shows** the **diversity** characteristics for **Berberia and** Ratones reefs. The **average** number of species seen per census was significantly different (t-Test, $p < .01$) for the two reef slopes but not for the A. **palmata** zones. Mean number of species/census for the reef slope of Berberia was 26.57 and for Ratones it was 20.25. The A. palmata zone of Berberia showed 17.87 species/census which was not significantly different from the 21.89 species/census in the corresponding zone of Ratones. The mean for all zones combined for Berberia was 23.41 which was not significantly different from that of Ratones with 19.70 (t-Test, $p > .05$). However, there exists a difference in the mean number of species/census between the zones of Berberia. The mean number of species/census for the reef slope (26.57) was significantly different from the 17.87 species/census counted in the A. palmata zone (t-Test, $p < .02$). Mean values for the reef slope and A . palmata zones of Ratones were very similar; 20.25 and 21.84 respectively.

Number of Individuals

When one considers total numbers of individuals it is evident that the reef slope is richer than the A. palmata zone in Berberia, while the opposite is true for Ratones. The reef slope zone supported the largest number of fish/census in Berberia with an average of 258 while in Ratones the A. palmata zone had the highest value with 305.89 fish/census. The latter was caused mainly by large concentrations of schooling species such as Acanthurus spp., Anisotremus surinamensis and haemulon chrysargyreum. The reef slope of Ratones showed a mean of 134.89 fish/census which was significantly different from the 258 fish/census of Berberia's slope. The mean number of fish/census for the combined data of Berberia (244.95) was not significantly different from the mean of Ratones (215.37) (t-Test, $p > .05$). The A. palmata zones of these reefs did not show a significant difference (t-Test, $p > .05$). A significant difference (t-Test, $p < .05$) was found by comparing the mean number of fish/census within Ratones reef but not for Berberia.

Density

We compared overall fish densities for the two reefs. Density values for corresponding zones were also compared. Berberia had a mean density of .49 fish/m^2 based on combined data which was not significantly different from the .43 fish/m^2 calculated for Ratones (Mann-Whitney U-Test, $p > .05$). The reef slope of Berberia with .52 fish/m^2 was significantly different from the slope of Ratones with .27 fish/m^2 (Mann-Whitney U-test, $p < .05$). However the A. palmata zone of Ratones with .61 fish/m^2 did not show a significant difference with the A. palmata zone of Berberia with .44 fish/m^2 (Mann-Withney U-Test, $p > .05$). The zones of Ratones were significantly different (t-Test, $p < .05$) in terms of density but not Berberia's zones. The mean density for the reef crest of Ratones was higher than that of the reef slope. The highest density in a particular census was .91 fish/n^2 for the A . palmata zone of Ratones.

Species Diversity

We calculated the Shannon - Weaver Index and found the lowest diversity ocurring at the A. palmata zones with values ranging from .55 to 1.08 (mean = .82) in Berberia and .55 to 1.07 (mean = .88) in Ratones. For the slope the values ranged from 1.00 to 1.30 (mean = 1.17) in Berberia and .90 to 1.21 (mean = 1.01) in Ratones. Overall, Berberia showed the highest diversity with 1.05 compared to .91 in Ratones. The reef slope of Ratones was less diverse than the reef slope of Berberia while the reverse was true for the A. palmata zones of these reefs. The evenness component of diversity influenced very much the values for the slope of Berberia. In this zone the individuals were more evenly

distributed within the species present. Mean evenness in this zone was the highest with .83. The mean overall evenness value was higher for Berberia (.77) than for Ratones (.71).

Similarity

The Bray and Curtis Index (B&C) of similarity and the Sorenson Index (S) were computed for zones between and within reefs and placed in a matrix of similarity coefficients.(Table 3).

Qualitative similarities (Sorenson) between the slopes of Berberia and Ratones ranged from .43 to .69 (mean = .59) whereas **quantitative** similarities **(Bray and** Curtis) ranged from .30 to .54 (mean = .43). **Qualitative** similarities between the A. palmata zone of Ratones and Berberia ranged from .51 to .67 (mean = .57) and quantitative similarities ranged from .17 to .57 (mean = .37). The similarity coefficients between the fish faunas of Berberia's zones ranged from .44 to .76 (mean = .56) and quantitative similarities from .25 to .60 (mean = .41). For the zones of Ratones the qualitative similarities coefficients ranged from .46 to .82 (mean = .48) and the quantitative similarities from .18 to .72 (mean = .41).

The greatest degree of qualitative similarity (Sorenson Index) between Ratones and Berberia reefs was .69 for the slopes and .67 for the A. palmata zones.

Abundance

The abundance numbers of the species recorded in more than 50Z of the censuses for each zone were compared with the Mann-Whitney U-test to test for significant differences between reefs.

From Table 4 we see that there was a significant difference in abundance between the slope zones of the reefs for 14 species. Ten species were significantly different for the A. palmata zones (Hann-Whitney U-test; $p < .05$). For the reef slope only Epinephelus fulvus and Haemulon chrysargyreum were more abundant in Ratones, the other 12 were more abundant in Berberia. For the

A. palmata zone only Lutjanus griseus and Scarus guacamaia were more **abundant** in Berberia. Epinephelus fulvus and Haemulon **chrysargyreum** were more abundant in both zones of Ratones while Scarus guacamaia dominated in both zones of Berberia. Lutjanus apodus was more abundant in the reef slope of Berberia than in the reef slope of Ratones but less abundant in the A. palmata zone of **Berberia** than in the **A. palmata** zone of Ratones.

Anisotremus surinamensis represented 7.41% of the total abundance for the reef slope of Berberia while for the reef slope of Ratones it accounted only for .19%. This difference may be **attributable to the** lack of a **suitable** habitat in the reef slope of Ratones for this species. In Berberia reef it was always present in caves formed by large Montastrea colonies. Such caves were not available in the reef slope of Ratones. Although Epinephelus _ fulvus was not very abundant in the reef slope of Ratones, it was completely absent from Berberia This situation requires further studies because there is no apparent reason for their absence in Berberia. Factors such as competition, fishing pressure, food availability and habitat availability should be considered.

Some species showed marked differences in abundance between the two zones of each of the reefs studied, as for example, Kyphosus spp. and Anisotremus surinamensis were always recorded at the same spot in Berberia's reef slope and not in the A. palmata zone although the transect lines for these zones were fairly close. Most of the species ocurred in both zones but had preference for one of them. The difference between the zones within a reef were not tested statistically.

Dominant Species

The 10 dominant fish species per zone and for each reef are shown in Table 5. These represented 78.89% of the total abundance for Ratones and 69.43% for Berberia. Seven of the dominant species were common to both reefs although their abundance varied greatly between them. Three of the ten dominant species of Ratones were not represented in the ten dominant species of Berberia. Similarly three of the ten dominant species of Berberia were not represented in the ten dominant species of Ratones. The reef slope of Ratones **and Berberia shared six** of the ten dominant species for that zone while five species were shared in the A. palmata zone. The slope and A. **palmata** zones of Ratones shared eight of the dominant species and the **slope and A. palmata** zones of **Berberia** shared **six** species.

Acanthurus spp. ranked first in abundance in **all zones** of both reefs. **Numbers** of Acanthurus **spp. represented 33.67% and** 26.2% of the abundance for Berberia and Ratones respectively being the most **abundant** species. Within the Acanthurus most of the individuals observed were A. bahianus. Ocassionally they ocurred in monospecific schools of more than 100 individuals. A. chirurgus was the rarest of the acanthurid group. Haemulon chrysargyreum, . which ranked second in Ratones (11.79%), was not represented in the ten dominant species of Berberia. The species which ranked second in berberia, Sparisoma aurofrenatum, was the nineth in Ratones with 3.36% of the total abundance.

The greatest difference in abundance for the reef slope was shown by Haemulon macrostomum and Lutjanus jocu which were very common in Berberia but not in Ratones. In the A. palmata zone the greatest difference was shown by Haemulon chrysargyreum which was very common in Ratones but few individuals were recorded for Berberia. In another common reef fish species there was more divergence than expected. The usually very common Haemulon flavolineatum ranked third in Ratones while it was the seventh in abundance in Berberia.

FISHES OF THE THALASSIA BEDS AND 1-IANGROVES

General Description

A total of 23 species of fishes were recorded for Ratones and 22 species for Berberia (Table 6). Seven species that were recorded for Ratones were absent in Berberia and six of the berberia's species were absent in Ratones. Sixteen species were common to both areas.

Visual observations in the Thalassia beds of both areas indicated a large number of juvenile fish species. Large numbers of juvenile grunts, parrotfishes, and yellowtails were commonly observed. One of the few exceptions were adult Sphyraena barracuda which were common at both areas. Also, adult individuals of Caranx ruber were **observed** in the mangrove area of Ratones.

Juveniles of Balistes vetula, Acanthurus spp. and Holocentrus spp. were frequently-found living in the empty shells of queen conchs. Almost every object or structure in the grass flats of both areas was occupied by one or several species of fishes.

Schools of more than 100 individuals of juvenile Haemulon flavolineatum and Mulloidichthys martinicus were commonly seen in the mangrove area of Ratones. Pseudupeneus maculatus was also fairly common. Medium size Lut janus griseus, L. apodus and H . sciurus were common in the mangrove and Thalassia beds of Berberia.

Qualitative similarities between the fish assemblages of the two areas studied yielded a value of .71 for the three year study period.

DISCUSSION *CORAL* REEF FISHES

Berberia and Ratones reefs were expected to differ in fish species composition and/or abundance since they are subjected to different rates of sedimentation. Sedimentation rate in Berberia's slope ranged from 2.34 $mg/cm^2/day$ to 47.55 $mg/cm^2/day$ while for the same area of Ratones it ranged from 8.09 $mg/cm^2/day$ to 53.07 $mg/cm^2/day$. For the A. palmata zones Berberia's values ranged from 3.96 $mg/cm^2/day$ to 16.61 $mg/cm^2/day$ and from 27.83 $mg/cm^2/day$ to 116.83 $mg/cm^2/day$ in Ratones. (see Ferrer, 1986). These values proved to be significantly different, (t-Test, $p < .05$).

Fourteen species out of 49 showed significant differences in abundance between the two reef slopes and 10 species out of 46 showed **significant** differences between the **A. *palmata*** zones (Table 4). The fish **faunas of these two reefs are slightly over 50% similar. Mean qualitative similarity between the reef slopes was only .59 and the mean quantitative similarity was only .43. The A. *palmata*** zones **showed** a mean **qualitative** similarity of .57 and a **mean quantitative similarity of .37. Considering values down to** .80 as indicating identity in faunal composition (Sale and Douglas, 1981), we have that the values obtained represent a significant difference in the composition of the fish faunas of the reefs studied.

Statistically significant correlations were found between sedimentation and some of the diversity parameters in Berberia and Ratones reefs. The number of   was positively correlated (r'l = .438, $p < .05$) with sedimentation in the Ratones reef (Table 7). Nevertheless total diversity and evenness were negatively correlated indicating a possible shift in species composition and abundance. Galzin (1981) found evidence which suggests that highly turbid water caused by dredging directly influences benthic flora and fauna, resulting in the elimination of certain species and permitting the proliferation of others. Apparently, while some species tend to disappear from the area others, which are tolerant to high sedimentation increase in numbers, thus decreasing the diversity and evenness values. How long can a particular species live in a highly sedimented area is not known. That would require laboratory manipulation for testing.

Three species, *Balistes vetula*, *Sparisona rubripinne* and S. *viride* showed significant positive correlation with sedimentation (Table 8). The relationship of **B. *vetula* is** difficult to **explain.** We expected this species to show a negative correlation since it is frequently seen in clear waters. We believe that the abundance of this species was too low to make a valid inference. Nevertheless S. *viride* and S. *rubripinne* were expected to show a positive correlation as they did. These species are common in fairly sedimented areas where algae, their principal foods, are **abundant.** Other three species, Acanthurus spp., Holocentrus ascencionis and Haemulon chrysargyreum showed a positive correlation marginally close to the 95% confidence limit. A high positive correlation was expected for the former two but not for the latter. **Acanthurus** form large schools and are common in areas with **heavy growth of algae** and Holocentrus ascencionis is also **common in areas of high turbidity but Haemulon chrysargyreum is** more common on clear water reefs and in mangrove areas as juveniles. Lutjanus mahogoni showed a negative correlation with sedimentation as was expected for this species and Epinephelus cruentatus and Haemulon flavolineatum showed negative correlation with sedimentation very close to the 95% confidence limit. All are common in reefs of clear waters.

Changes in abundance and species composition were often observed associated with an increase in suspended sediments and poor visibility. Species like Caranx bartholomaei and Sphyraena barracuda were only seen when visibility was poor. These changes in visibility appear to be often correlated with periods of heavy rainfall and moderate to strong wind.

Physical factors such as wind velocity, wave exposure and water depth strongly influences the resuspension of sediments (Marshall and Orr, 1931). Average sedimentation in the shallower A. palmata zones was higher than in the slope zones of both reefs although stations were fairly close (Ferrer, et al. 1985). As a possible consequence of this the distribution of species may be affected as is suggested by the data we obtained. It was found that the mean **quantitative** similarity between the fish communities of the zones of Ratones as well as for the zones of Berberia was only .41. For **Berberia** values as low as .18 were obtained.

It was frequently observed, as Brock (1954) point out, that several species had a definite pattern of distribution associated with bottom topography. Many species were observed consistently in the same places of the reefs. This behavior of restricting their habitat to certain characteristics of the bottom must have a major

effect upon their abundance if their habitat is subjected to any kind of stress and the availability of similar places are limited. The scarcity of suitable areas for these species would become a major obstacle for their abundance since the densities of the species are **related** to the **habitat available and** reef fish **production is strongly habitat dependent (Smith and Tyler, 1972; Sale, 1975; Ogden and Ehrlich,** 1977). **The problem may be exacerbated during the recruitment phase when the fishes may not be able to compete for space and could be more vulnerable to predation. Nevertheless, since fishes are mobile organisms they have the option of avoiding** environmental disturbances and danger (Hocutt, 1982). So management plans for reef fishes should consider the design of artificial structures as refugia in unstressed sites where the physical relief of the bottom does not provide shelter for the fishes to live if the natural areas are subjected to irreversible damages.

FISHES OF THE THALASSIA AND MANGROVES AREAS

A total of 29 (46%) species, almost all of them juveniles, out of 63 target species, were recorded in the Thalassia and mangrove areas of both sites although no exhaustive sampling was done. Martin and Cooper (1981) sampling with ichthyocides in the Thalassia beds in the southwestern coast of Puerto Rico collected only 12 (19%) of our target species. Weinstein and Heck (1979) reported 24 (38%) of our target species for the seagrass meadows along the Caribbean Coast of Panama. If we take into cosideration that many of the target species are exclusively reef fishes we could assume that the assemblage of this areas was fairly well qualitatively described.

The data collected by us, as can be seen from Table 6, shows that the Thalassia beds of both areas proved to be of inestimable value as nursery areas for many juvenile fish species by providing cover for them and for the organisms on which they feed (Randall, 19676; Medina, et al, 1986). Many of this species are an important component of the sport and commercial fishery or are of considerable value as bait or forage.

Other researchers have found similar relationships between the fish communities and the seagrasss meadows. Ogden and Ehrlich (1977) found that many fish species, as well as certain invertebrates, spend all or part of their juvenile life in seagrass beds and Randall (1967), Ogden and Ehrlich, 1977; Smith and Tyler, 1972 have documented the daily migrations of many reef fish species to the beds to feed. Thorhaug (1981) say that the seagrass meadows provide a habitat for hundredes of species of fish, crustacean and mollusks which have juvenile forms needing protection and shelter in the early life stages. Weinstein and Heck (1979) found that juveniles of reef-associated predators are common in the seagrass meadows. In summary, the role of this habitat as a nursery area for many fish species is a well known fact.

Apparently the presence of seagrass beds had an effect on the composition of the reef fish fauna in the areas studied as indicated by the numbers of grunts and snappers. Haemulon flavolineatum, H. chrysargyreum and Lutjanus apodus were very common in both reefs. These fishes depend very much on the Tiialassia beds for feeding and shelter (Randall, 1967; Stoner, 1981).

Although we are unable to produce quantitative data for comparing the seagrass beds of this reefs it is evident from the similarity index (Sorenson Index = .71) that there are differences in their fish communities.

CONCLUSIONS

Many factors are probably involved in the structuring of coral reef fish communities and sedimentation is one of them as suggested by the data. Sedimentation is likely to cause a significant change in the composition and abundance of coral reef fish populations. The relative importance of each factor depends on their magnitude and may differ between different species of fishes. Their influences have implications on the management of this and its associated communities and therefore on the general environment and the well being of a country's fisheries.

The correlation between sedimentation and diversity of coral reef fish communities indicates that their structure may be influenced by the sedimentation stress to which they are subjected. We found significant differences in fish species richness and density in two reefs with different rates of sedimentation. Although Ratones reef was structurally more complex than **Berberia** (Ferrer, 1986), which provides for a higher **diversity and** density of fishes (Risk, 1972; Alevizon and **Brooks,** 1975; Gladfelter and Gladfelter, 1978;), the latter showed the highest diversity and density. Being Ratones reef more affected by sedimentation, it is evident that sedimentation plays a major role in the structuring of these fish communities.

The development of coastal tourism and the sport and commercial fisheries, which depend on a healthy marine environment, could be affected by sedimentation processes. The source of the sediments may be of biological origin but the most dangerous, due to their toxicity, are those that come from industrial, agricultural and domestic wastes.

Sediment loads could seriously affect the fish population of the reefs if not adequately managed, by shifting the composition of species from first category species to less desirable species as is suggested by the data obtained. In general, the species present at Berberia, the least stressed reef, are of higher sport and commercial quality than the species at Ratones reef. Important food and game fish such as groupers, snappers and grunts all prefered clear waters. It appears that these groups of fishes would be detrimentally affected by sedimentation. On the other hand the same process of sedimentation may be a factor contributing to the abundance of other species which prefer turbid weaters but it is well known that the most sought after species are those that prefer clear waters.

Theories regarding the structuring of coral reef fish communities are frequently found on literature. Many authors have suggested the role of stochastic processes to account for it. But there also exists much evidence that many factors, not only chance, are responsible for the patterns of community structure. This investigation presents some evidence that sedimentation could be one of those factors.

This **investigation** provides baseline data on the general ecology of both reefs and general aspects about the structures of their fish communities. These may serve as a frame of reference to evaluate a natural system and to detect changes caused by sedimentation or other disturbances and should be used to formulate management guidelines for the marine environment. No previous data about the -fishes of the reefs studied is available.

RECOMMENDATIONS

1. Extraction of bottom materials, dredging, filling, dumping and other activities which could increase the sedimentation in the coral reefs should be prohibited or highly regulated.
2. The quality and quantity of our fishery resources that depend on the coral reefs should be determined in order to have baseline data for future reference.
3. Coral reef areas with touristic potential should be identified and protected by means of the existing regulations or by the creation of natural reserves.
4. General oceanographic studies to collect baseline data about the normal levels of sedimentation, turbidity, water transparency, and circulation patterns of the currents should be conducted around the Island's reefs. These would serve as a guide to establish water quality standards for those parameters.
5. Statistics on fishing pressure and the recreational use of the reefs is necessary.

6. The use of artificial reefs and fish attractor devices as a method for increasing the fishery resources should be studied.
7. Creel census data should be collected around the Island.
8. **Ocean outfall** sites for disposal of **domestic and** industrial wastes should consider the presence of coral **reef communities and its associated systems and the general oceanographic conditions.**
10. **Sites for future** developments should be chosen taking into consideration the delicate balance of the marine environment and the possible adverse effects of these **activities.**
11. New surveys in other reefs would be useful in establishing the relationships observed between fish population and the condition of the habitat.
12. It was felt that if the reefs were different in fish species composition and abundance, the differences could be documented with the method used. We feel that the method is accurate but could be improved if an underwater tape recorder is used because many species are missed when you are looking at the slate, whereas with a recorder the observer eyes do not leave the transect. Also, the utilization of a video camera would provide a permanent record of each transect.
13. We focused on sport fishes for this investigation but the hypothesis that fish populations could be seriously affected by sedimentation would be better approached by assessing other species that could be better indicators of sedimentation like the chaetodontids which are suspected to have coevolved with corals and thus would be the first species to dissappear if the corals are affected by sedimentation. Additional research is needed considering all the reef fish species and the relationships between them.

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Figure 1. Cumulative curve of number of species vs. transect length for the different reef zones

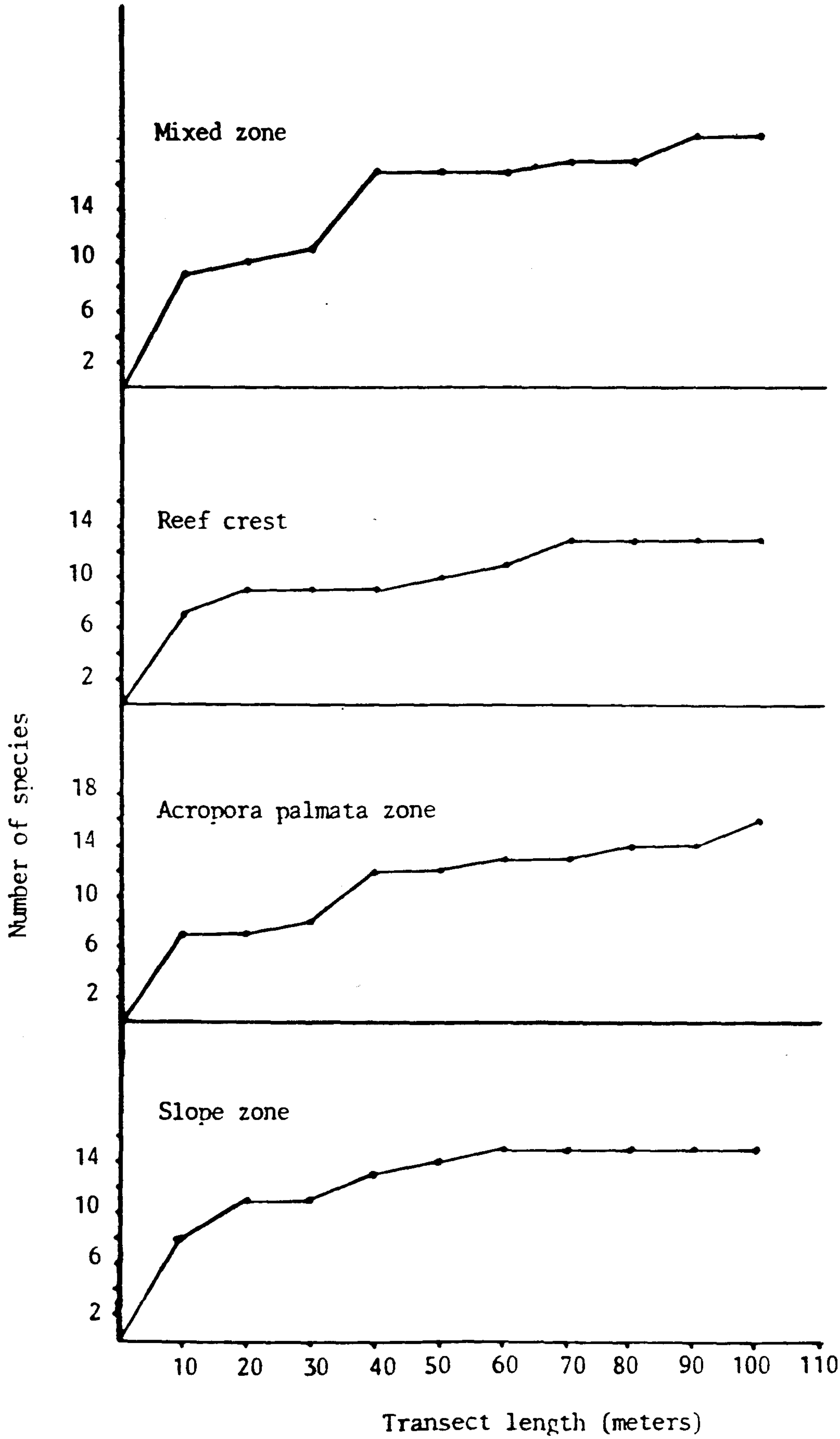


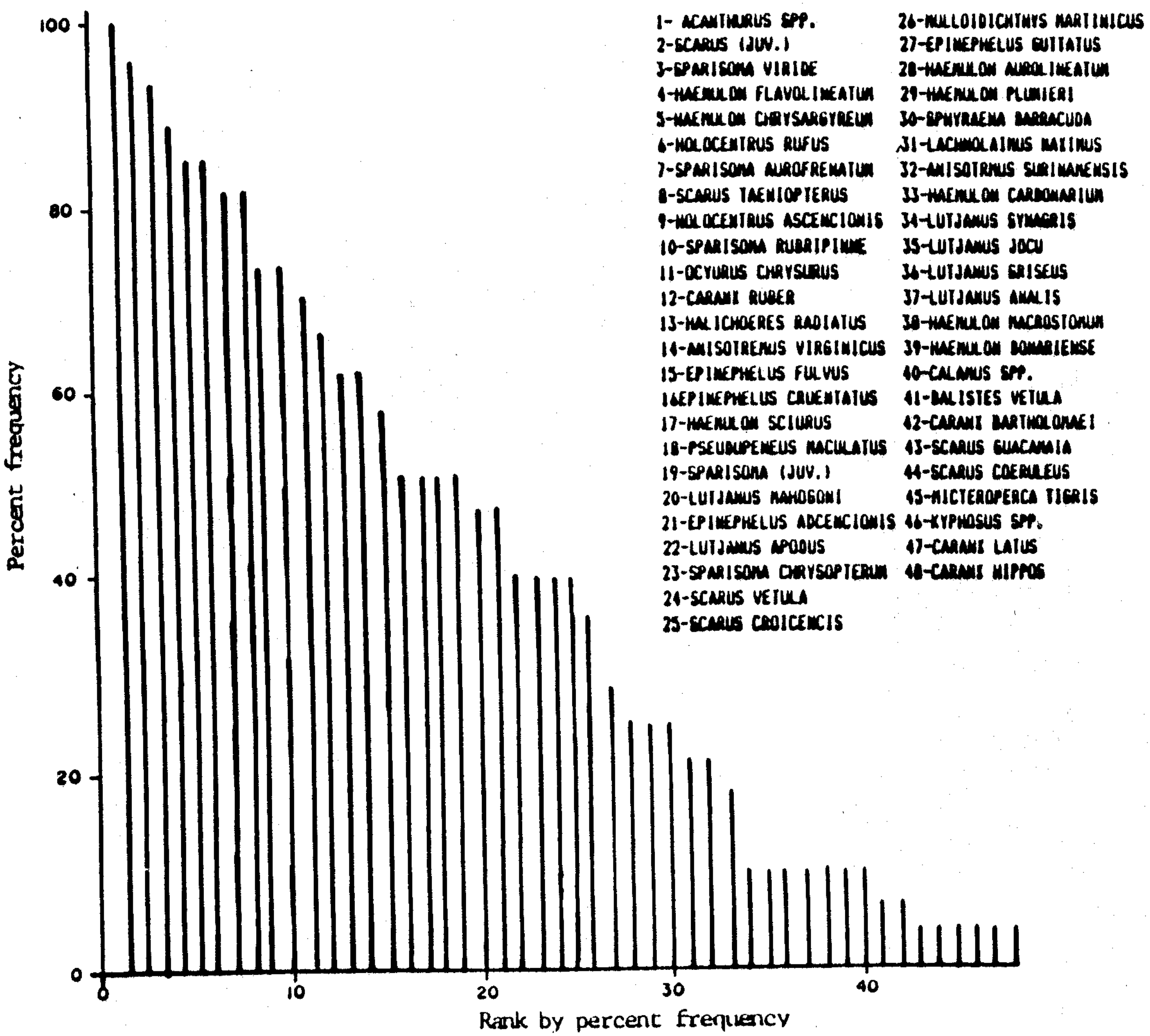
Figure 2. Data collecting format

Lugar ____________ Profundidad ____________ Fecha ____________

Estación ____________ Visibilidad ____________ Hora ____________

Especie	1	2	3	4	5	6	7	8	9	10	Total
Acanthurus bahianus											
chirurgus											
coeruleus											
Anisotremus surinamensis											
virginicus											
Balistes vetula											
Calamus bajonado											
Calamus sp											
Caranx bartholomaei											
crysos											
hippos											
latus											
ruber											
Epinephelus adscensionis											
cruentatus											
fulvus											
guttatus											
itajara											
striatus											
Haemulon album											
aurolineatum											
bonariense											
carbonarium											
chrysargyreum											

Figure - 3. Ranked frequency of ocurrence in Cayo Ratones



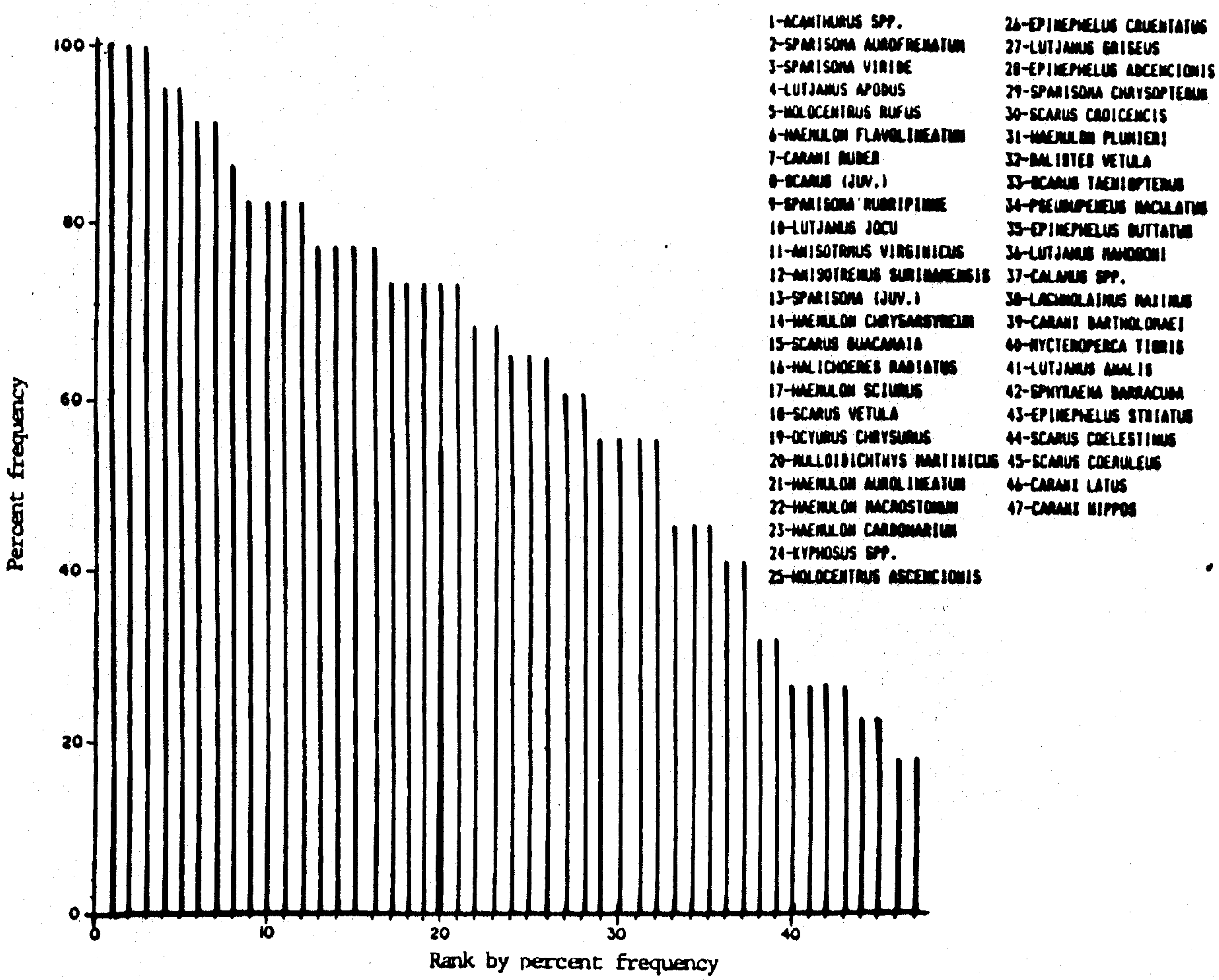


Figure - 4 Ranked frequency of ocurrence in Cayo Berberia

TABLE 1. CHECKLIST OF THE FISHES PRESENT IN BERBERIA AND RATONES

SPECIE	BERBERIA			RATONES			
	SLOPE	PALMATA	OVERALL	SLOPE	PALMATA	CREST	OVERALL
ACANTHURUS (3SP.)	X**	X**	X**	X**	X**	X**	X**
ANISOTREMUS SURINAMENSIS	X	X	X	X	X	X	X
ANISOTREMUS VIRGINICUS	X*	X	X	X*	X	X	X
BALISTES VETULA	X	X	X		X		X
CALAMUS SP.	X	X	X	X	X		X
CARANX BARTHOLOMAEI	X		X	X			X
CARANX HIPPOS	X		X		X		X
CARANX LATUS		X	X		X		X
CARANX RUBER	X**	X	X*	X	X	X	X
EPINEPHELUS ADCENCIONIS	X	X	X	X	X	X	X
EPINEPHELUS CRUENTATUS	X	X	X	X	X	X	X
EPINEPHELUS FULVUS				X	X	X	X
EPINEPHELUS GUTTATUS	X		X	X	X	X	X
EPINEPHELUS STRIATUS	X		X				
HAEMULON AUROLINEATUM	X	X	X	X	X		X
HAEMULON BONARIENSE				X	X		X
HAEMULON CARBONARIUM	X	X	X	X	X		X
HAEMULON CHRYSARGYREUM	X	X	X	X	X	X**	X
HAEMULON FLAVOLINEATUM	X	X	X*	X**	X	X	X
HAEMULON MACROSTOMUM	X	X	X		X		X
HAEMULON PLUMIERI	X		X	X	X		X
HAEMULON SCIURUS	X	X	X	X	X	X	X
HALICHOERES RADIATUS	X	X**	X	X	X	X	X
HOLOCENTRUS ASCENCIONIS	X	X	X	X	X**	X	X
HOLOCENTRUS RUFUS	X**	X	X*	X*	X	X	X
KYPHOSUS (2SP.)	X	X	X		X		X
LACHNOLAIMUS MAXIMUS	X	X	X	X			X
LUTJANUS ANALIS		X	X	X	X		X
LUTJANUS APODUS	X	X**	X*	X	X	X	X
LUTJANUS GRISEUS	X	X	X	X			X
LUTJANUS JOCU	X**	X	X		X	X	X
LUTJANUS MAHOGONI	X	X	X	X	X		X
LUTJANUS SYNAGRIS				X	X		X
MULLOIDICHTHYS MARTINICUS	X	X	X	X	X	X	X
MYCTEROPERCA TIGRIS	X		X		X		X
OCYURUS CHRYSURUS	X	X	X	X*	X		X
PSEUDUPENEUS MACULATUS	X	X	X	X	X	X	X
SCARUS COELESTINUS	X		X				
SCARUS COERULEUS		X	X	X			X
SCARUS CROICENCIS	X	X	X	X	X	X	X
SCARUS GUACAMAIA	X	X	X	X			X
SCARUS (JUV.)	X*	X	X	X**	X**	X**	X*
SCARUS TAENIOPTERUS	X	X	X	X	X	X	X
SCARUS VETULA	X	X	X	X	X	X	X
SPARISOMA AUROFRENATUM	X**	X**	X**	X	X	X	X
SPARISOMA CHRYSOPTERUM	X	X	X	X	X	X	X
SPARISOMA (JUV.)	X	X	X	X	X	X	X
SPARISOMA RUBRIPINNE	X**	X	X	X	X**	X	X
SPARISOMA VIRIDE	X**	X**	X**	X*	X**	X	X*
SPHYRAENA BARRACUDA	X	X	X	X	X	X	X
TOTALS	44	40	47	41	43	28	48

** - REPRESENTED IN 100% OF THE CENSUS
* - REPRESENTED IN 90% OR MORE OF THE CENSUS

Table # 2 . Diversity characteristics of Berberia and Ratones reefs (Figures are the mean values for each parameter)

Parameter	RATONES				BERBERIA		
	Palmata	Slope	Crest	Overall	Palmata	Slope	Overall
No. of fish/ census	305.89	134.67	202.8	215.81	218.37	258	244.95
No. of species/ census	21.89	20.25	15.4	19.70	17.87	26.57	23.41
Diversity	.88	1.01	.79	.91	.82	1.17	1.05
Evenness	.66	.78	.67	.71	.66	.83	.77
Density	.61	.27	.40	.43	.44	.52	.49

Table # 3 . Mean quantitative (Bray & Curtis) and qualitative (Sorensen) similarities between and within Berberia and Ratones reefs.*

Zone	Berberia Slope	Berberia Palmata	Ratones Slope	Ratones Palmata
Berberia Slope		.41	.43	
Berberia Palmata	.56			.37
Ratones Slope	.59			.41
Ratones Palmata		.57	.48	

* Figures above the diagonal are the quantitative values.

Table #4. Species showing significant differences in abundance between the palmata and slope zones of Berberia and Ratones reefs (Mann-Whitney U-test)

Species	Slope		Palmata	
	Larger U	p	Larger U	p
Anisotremus surinamensis	134	.001		
Epinephelus fulvus	108	.05	60	.002
Haemulon aurolineatum	140	.001		
Haemulon carbonarium	119	.01		
Haemulon chrysargyreum	57	.01	57	.001
Haemulon macrostomum	144	.001		
Holocentrus ascencionis			61.5	.002
Holocentrus rufus			56.5	.02
Kyphosus sp.	120	.005		
Lutjanus apodus	132	.001	54	.05
Lutjanus griseus			52	.05
Lutjanus jocu	144	.001		
Lutjanus synagris			50.5	.05
Mulloidichthys martinicus	133	.001		
Scarus guacamaia	110	.05	52	.05
Scarus (juveniles)	103	.05		
Scarus taeniopterus			53	.05
Scarus vetula	107	.05		
Sparisoma rubripinne			54	.05
Sparisoma viride	132	.001		

Table 5. Ranked dominant species of Ratones and Berberia reefs. (Figures in percentage of total abundance)

Species	Ratones				Berberia		
	Palmata	Slope	Crest	Overall	Palmata	Slope	Overall
Acanthurus (3sp.)	(1) 35.34	(1) 29.46	(1) 45.86	(1) 33.07	(1) 48.65	(1) 15.43	(1) 26.2
Anisotremus surinamensis	(3) 7.45			(7) 3.69	(9) 2.06	(2) 7.41	(4) 5.68
Anisotremus virginicus		(10) 2.97					
Caranx ruber					(5) 3.84	(8) 5.3	(6) 4.82
Haemulon chrysargyreum	(2) 17.62	(7) 3.77	(2) 13.91	(2) 11.79			
Haemulon flavolineatum	(7) 2.65	(2) 12.13	(9) 1.87	(3) 8.37		(7) 5.41	(7) 4.19
Halichoeres radiatus			(10) 1.87				
Holocentrus ascenciones	(6) 3.45	(9) 3.16	(7) 2.17	(10) 2.9			
Holocentrus rufus		(3) 9.84		(5) 3.88		(6) 5.57	(8) 4.01
Kyphosus (2sp.)						(10) 4.64	(10) 3.3
Lutjanus apodus			(5) 2.66		(3) 4.52		
Lutjanus griseus					(7) 3.21		
Mulloidichthys martinicus				(6) 3.69		(9) 4.91	(9) 3.69
Ocyurus chrysurus	(8) 2.14	(5) 6.31					
Scarus guacamaia					(8) 2.46		
Scarus (juv.)	(10) 1.89	(6) 4.7	(6) 2.27		(6) 3.43	(3) 7.08	(3) 5.9
Sparisoma aurofrenatum	(9) 2.0	(4) 7.49	(8) 2.07	(9) 3.38	(2) 6.98	(5) 5.6	(2) 6.05
Sparisoma (juv.)					(10) 1.72		
Sparisoma rubripinne	(5) 3.78		(3) 8.97	(8) 3.64			
Sparisoma viride	(4) 4.79	(8) 3.47	(4) 6.8	(4) 4.48	(4) 3.89	(4) 6.4	(5) 5.59
TOTAL	81.11	83.3	88.45	78.89	80.76	67.75	69.43

TABLE 6. CHECKLIST OF THE SPECIES PRESENT IN THE THALASSIA AND MANGROVE AREAS OF CAYO RATONES AND CAYO BERBERIA.

SPECIES	RATONES	BERBERIA
ACANTHURUS BAHIANUS	j,a	j
ACANTHURUS CHIRURGUS	j,a	
ACANTHURUS COERULEUS	j,a	j
BALISTES VETULA	j	j
CALAMUS SP.		a
CARANX BARTHOLOMAEI	j	
CARANX LATUS	j,a	
CARANX RUBER	a	a
EPINEPHELUS CRUENTATUS	j	
HAEMULON CHRYSARGYREUM	a	
HAEMULON FLAVOLINEATUM	j,a	j,a
HAEMULON PLUMIERI		j,a
HAEMULON SCIURUS	a	a
HAEMULON SP.	j	j
HALICHOERES RADIATUS		j
HOLOCENTRUS ASCENCIONIS	a	a
LUTJANUS ANALIS	j	
LUTJANUS APODUS	j	j
LUTJANUS GRISEUS		j,a
LUTJANUS JOCU		j
LUTJANUS SYNAGRIS	j	
MULLOIDICHTHYS MARTINICUS	j,a	j,a
OCYURUS CHRYSURUS	j	j
PSEUDUPENEUS MACULATUS	j,a	j
SCARUS SP.	j	j
SPARISOMA CHRYSOPTERUM		j
SPARISOMA SP.	j	j
SPARISOMA VIRIDE	j	j
SPHYRAENA BARRACUDA	j,a	a
TOTALS	23	22

j = juvenile
a = adult

TABLE 7. CORRELATION BETWEEN SEDIMENTATION AND THE DIVERSITY CHARACTERISTICS OF CAYO BERBERIA AND CAYO RATONES.

	BERBERIA			RATONES			OVERALL		
PARAMETER	r^2	t	p	r^2	t	p	r^2	t	p
TOTAL # OF FISH/CENSUS	.119	-.636	N.S	.438	2.34	= .05	.143	1.42	N.S
TOTAL # OF SPECIES/CENSUS	.009	.165	N.S	.020	.380	N.S	.099	-1.15	N.S
EVENNESS	.003	-.097	N.S	.116	-.959	N.S	.345	-2.52	= .05
DIVERSITY	.019	-.243	N.S	.198	-1.31	N.S	.361	-2.60	= .05

N.S = $p > .05$

TABLE 8. SPECIES SHOWING SIGNIFICANT CORRELATION WITH SEDIMENTATION

SPECIES	r^2	t	p
ACANTHURUS SPP.	.290	2.12	.10 > P > .05*
ANISOTREMUS VIRGINCUS	.290	1.91	.10 > P > .05*
BALISTES VETULA	.828	6.58	.001 > P > .0005
EPINEPHELUS CRUENTATUS	.319	2.05	.10 > P > .05*
HAEMULON CHRYSARGYREUM	.279	1.85	.10 > P > .05*
HAEMULON FLAVOLINEATUM	.103	2.06	.10 > P > .05*
HOLOCENTRUS ASCENCIONIS	.294	2.14	.10 > P > .05*
LUTJANUS MAHOGONI	.478	2.87	.02 > P > .01
SPARISOMA RUBRIPINNE	.532	3.54	.01 > P > .002
SPARISOMA VIRIDE	.624	4.27	.001 > P > .0005

* - p MARGINALLY CLOSE TO THE 95 % CONFIDENCE LIMIT

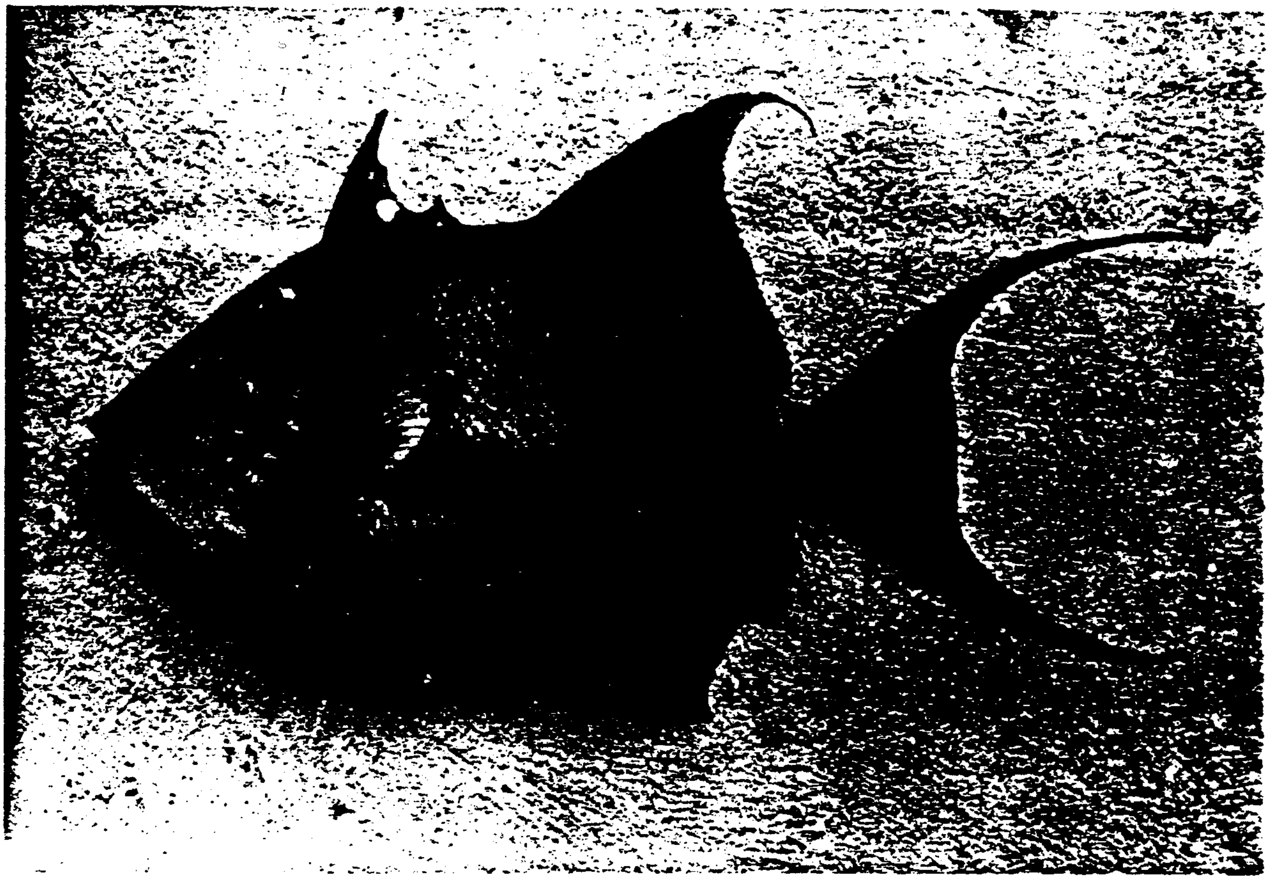


Plate 1. The queen triggerfish (Balistes vetula)

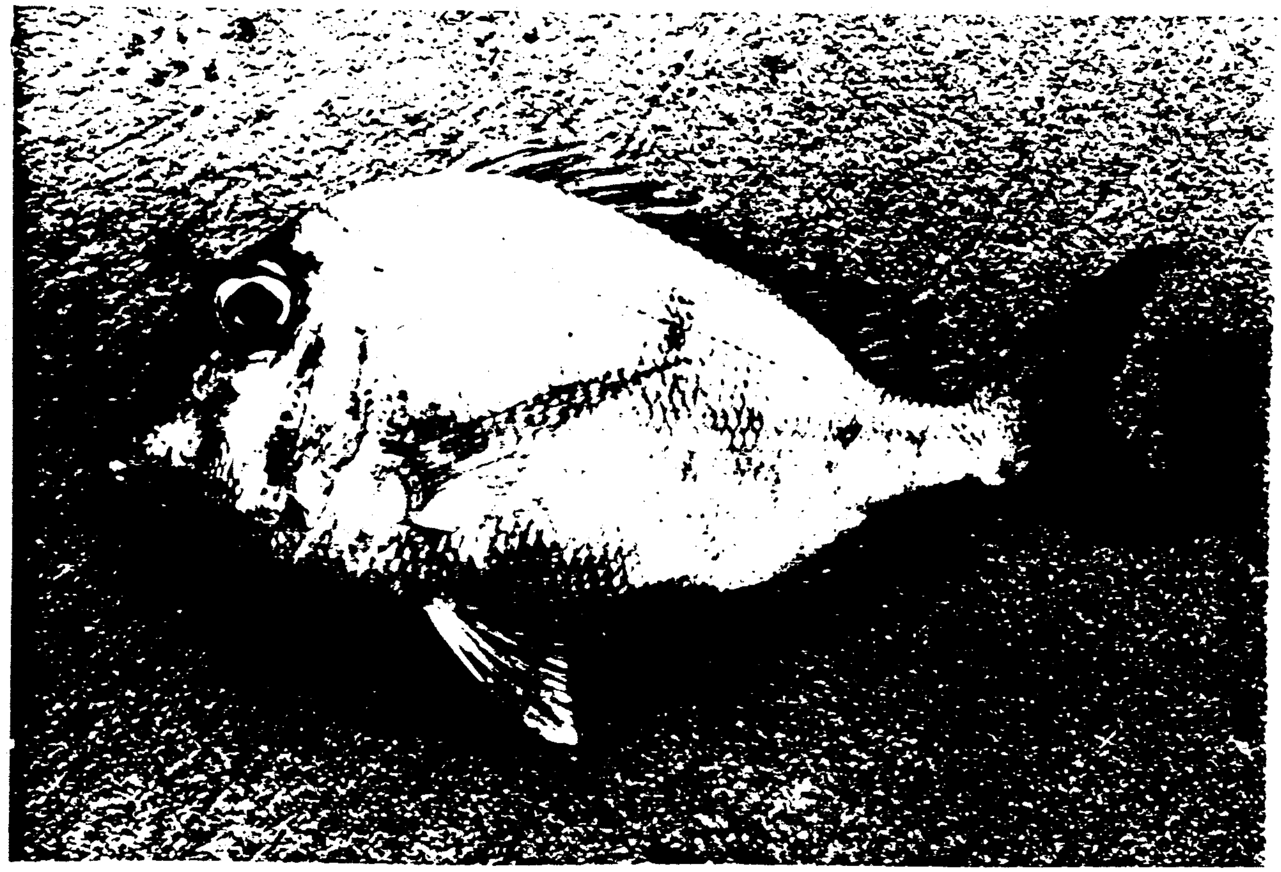


Plate 2. The jolthead porgy (Calamus bajonado)

Plate 3. The bar jack (Caranx ruber)

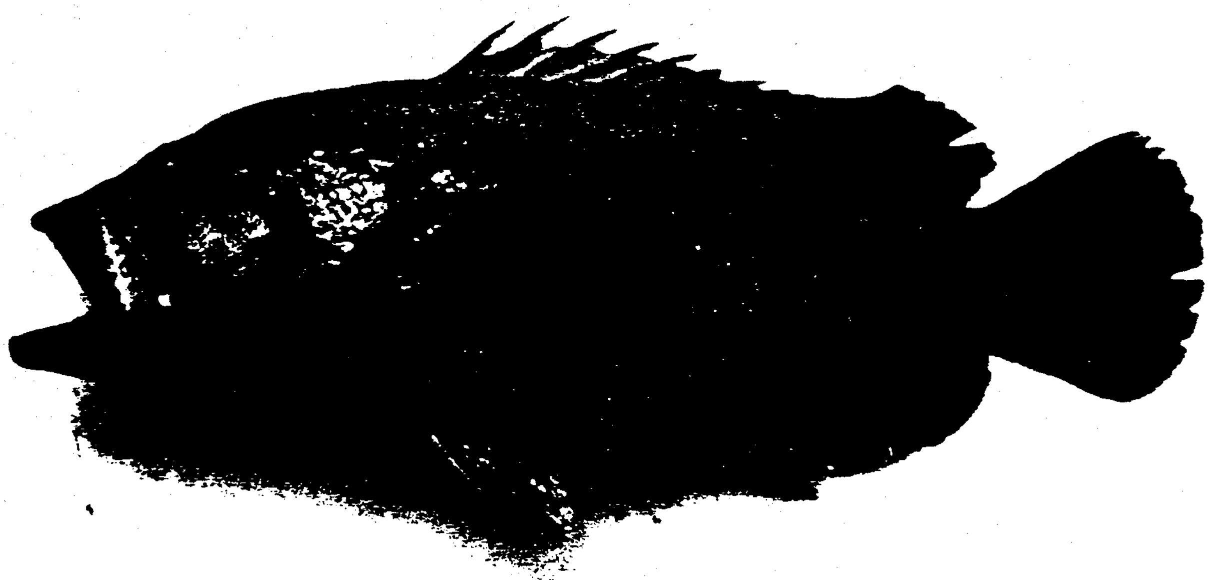


Plate 4. The graysby (Epinephelus cruentatus)

Plate 5. The red hind (*Epinephelus guttatus*)

Plate 6. School of caesar grunts (*Haemulon carbonarium*)

Plate 7. School of french grunts (Haemulon flavolineatum)

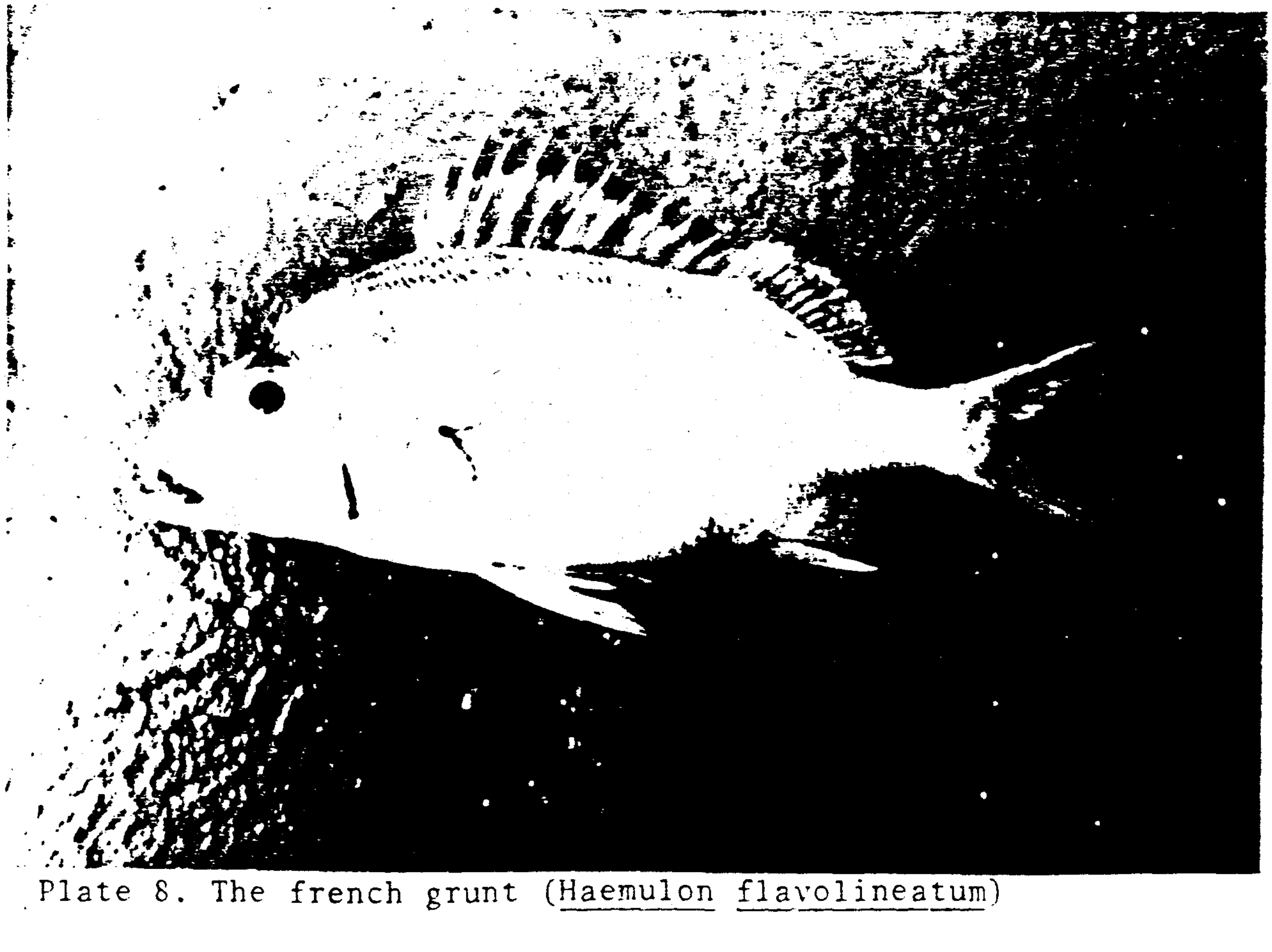


Plate 8. The french grunt (Haemulon flavolineatum)

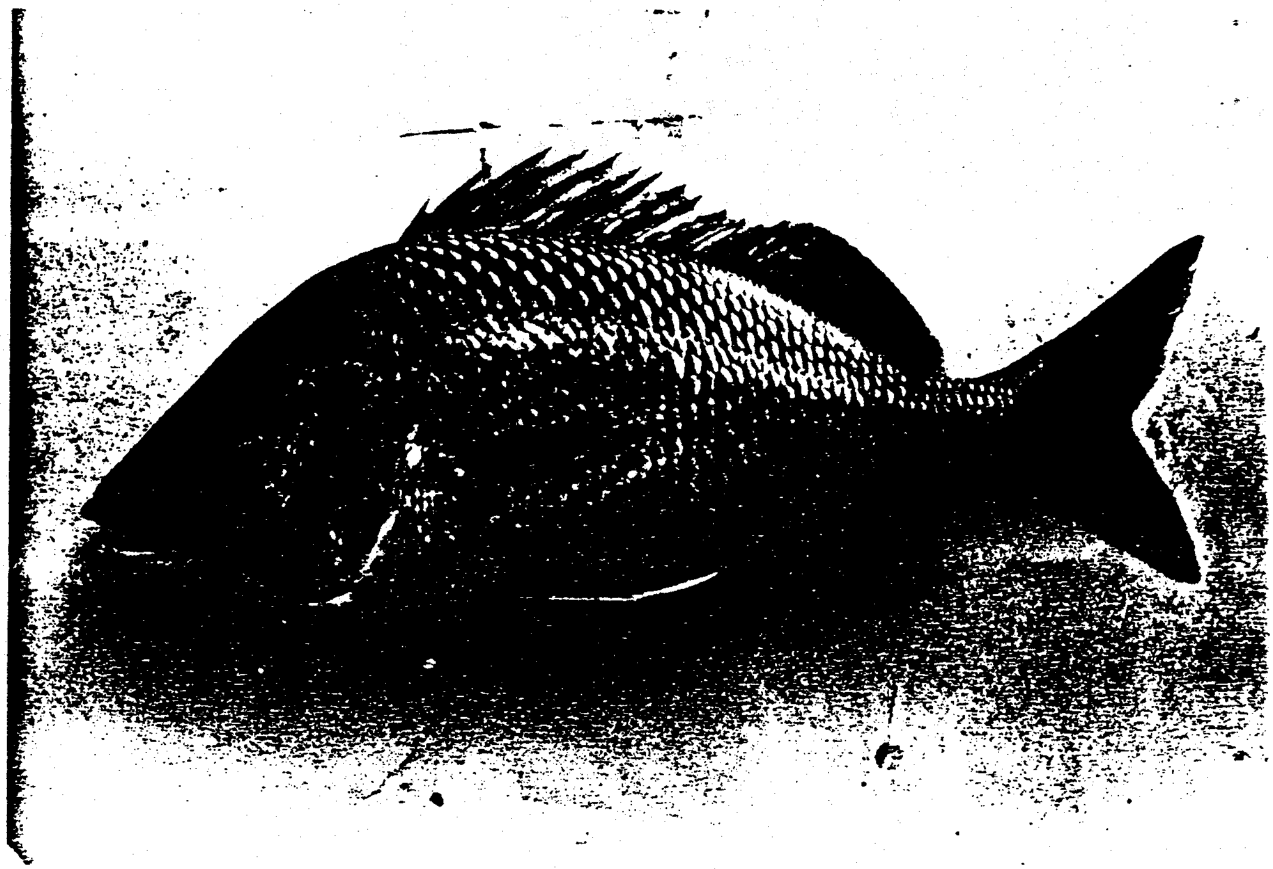


Plate 9. The white grunt (*Haemulon plumieri*)

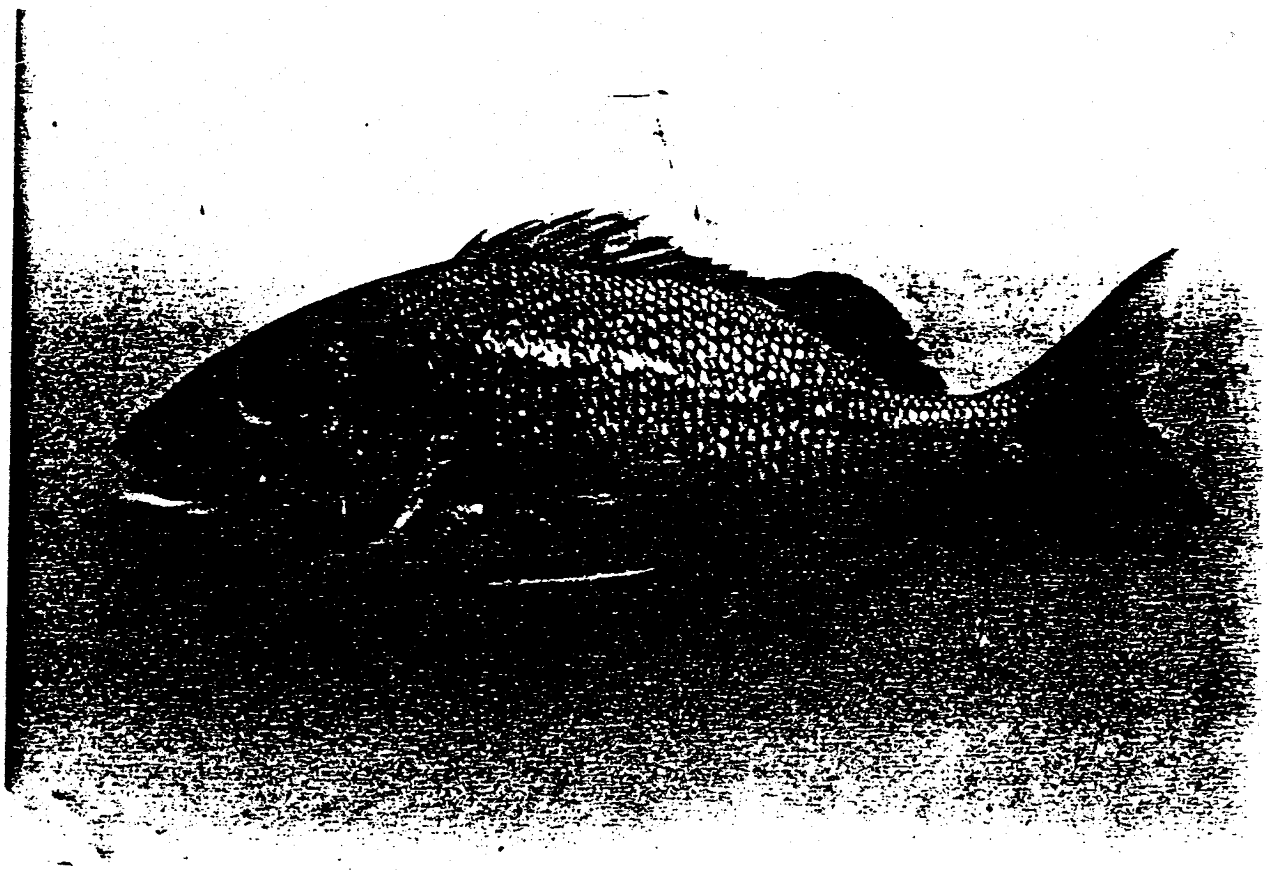


Plate 10. The bluestriped grunt (*Haemulon sciurus*)

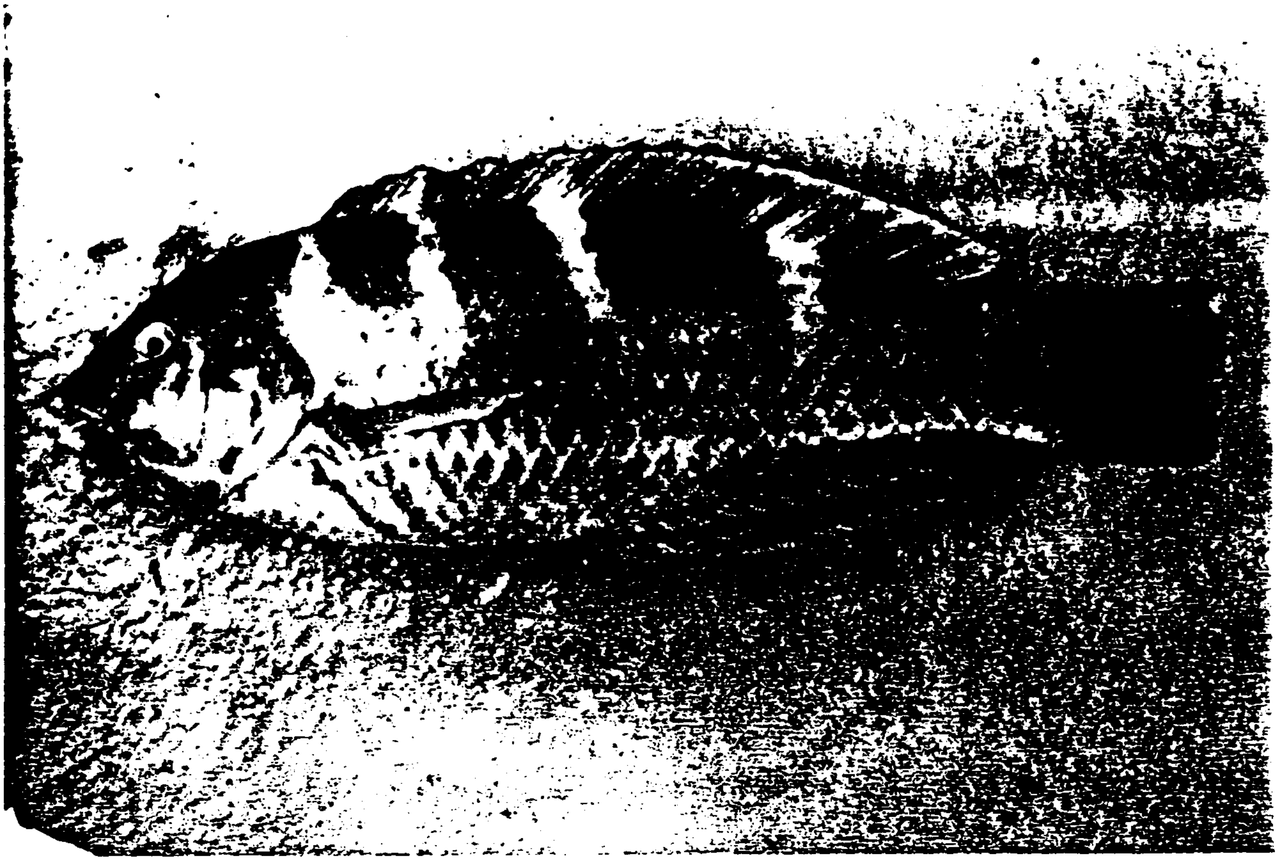


Plate 11. The pudding wife (*Halichoeres radiatus*)

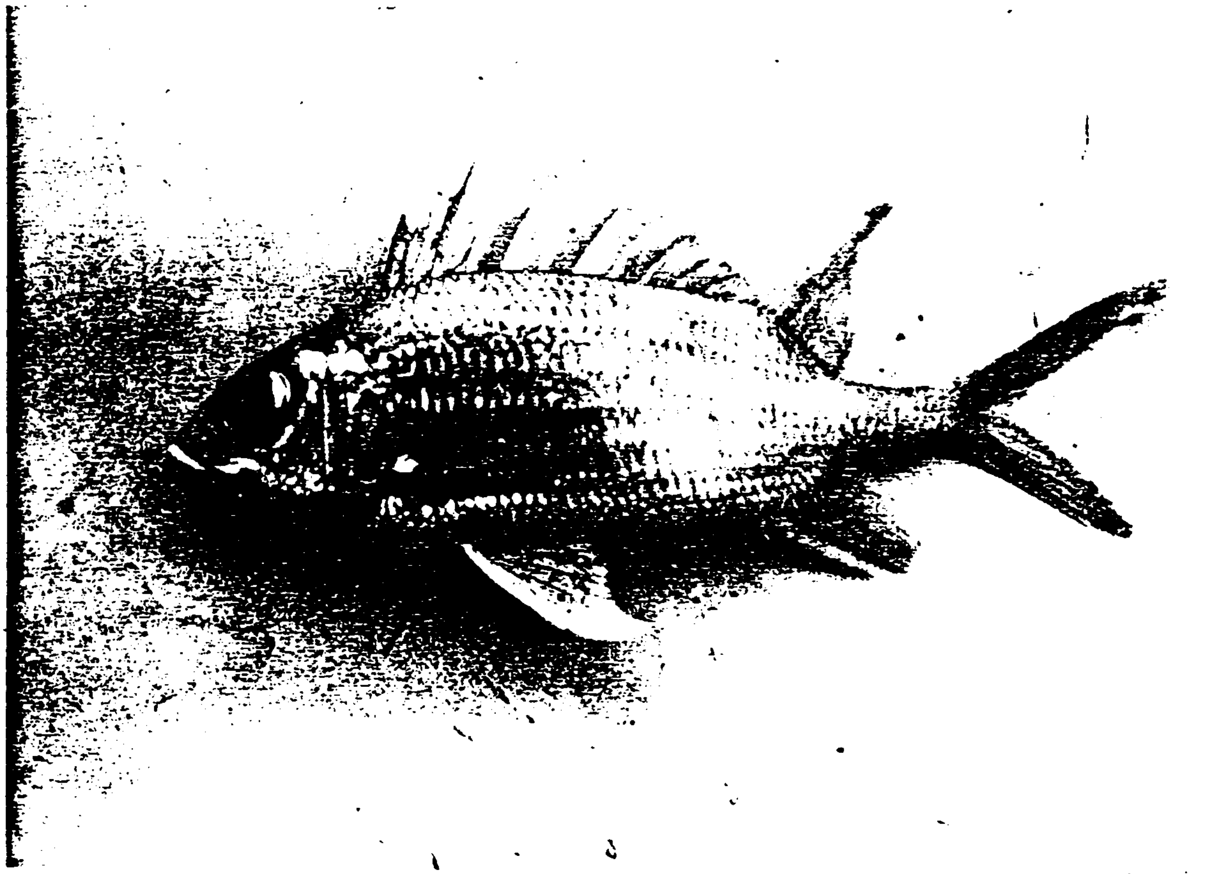


Plate 12. The longjaw squirrel fish (*Holocentrus ascensionis*)

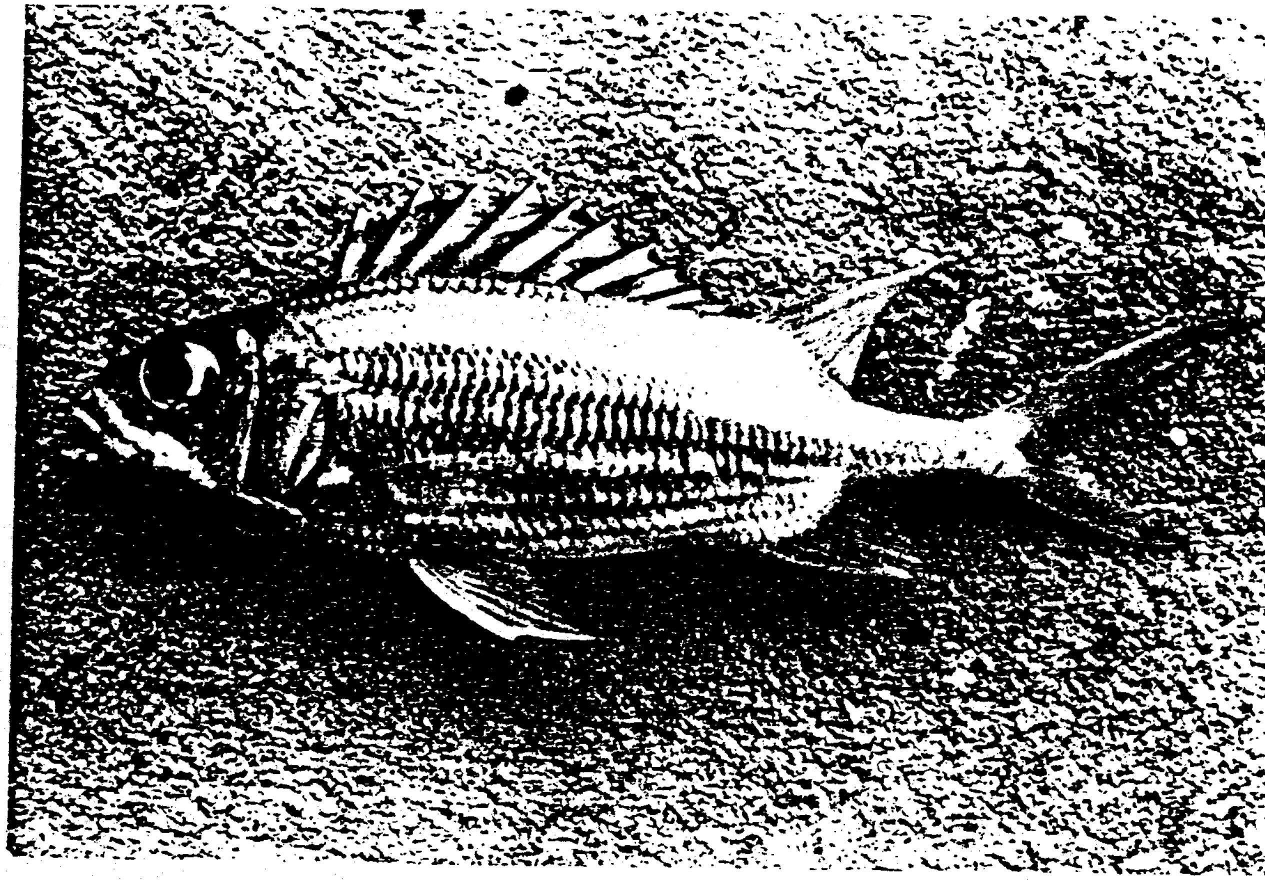


Plate 13. The squirrelfish (Holocentrus rufus)

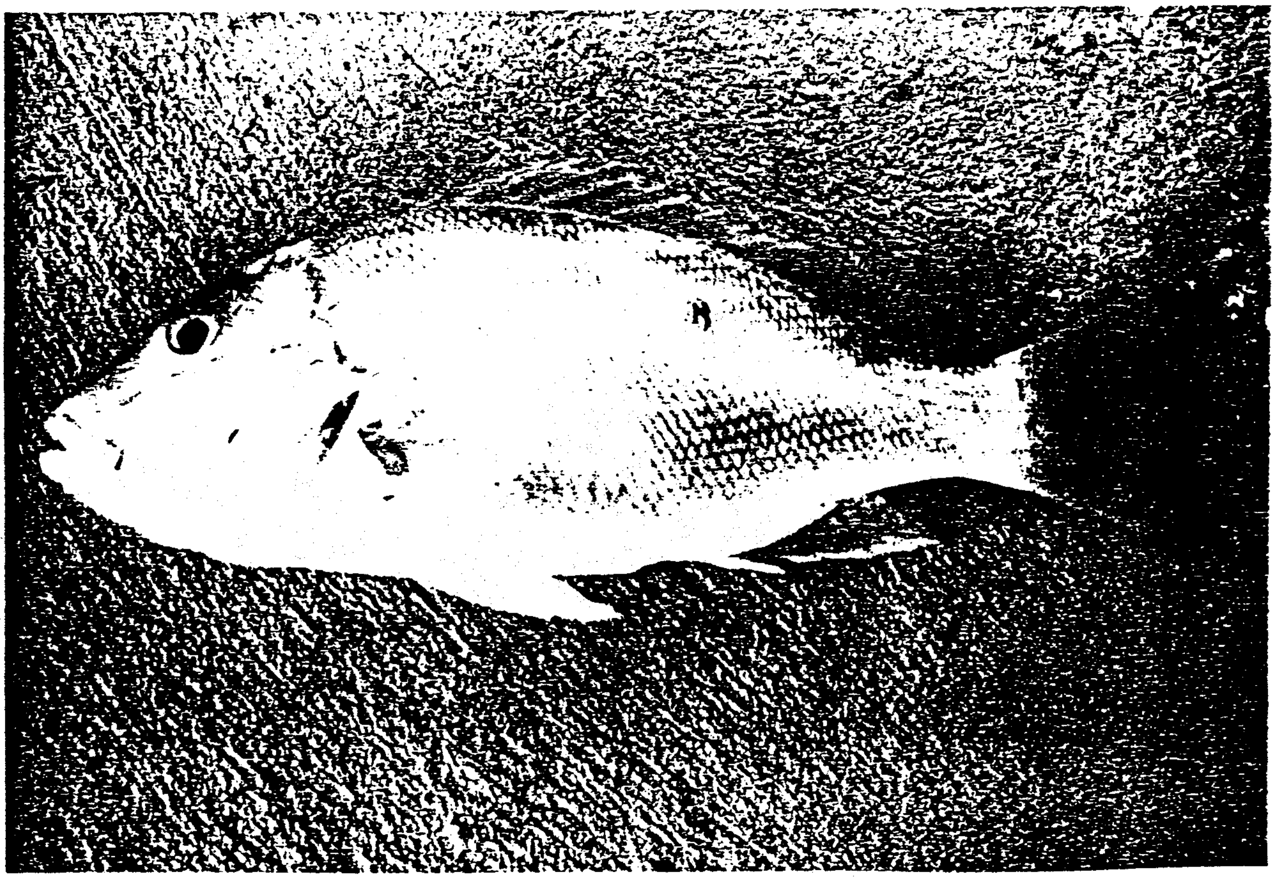


Plate 14. The mutton snapper (Lutjanus analis)

Plate 15. The schoolmaster (*Lutjanus apodus*)

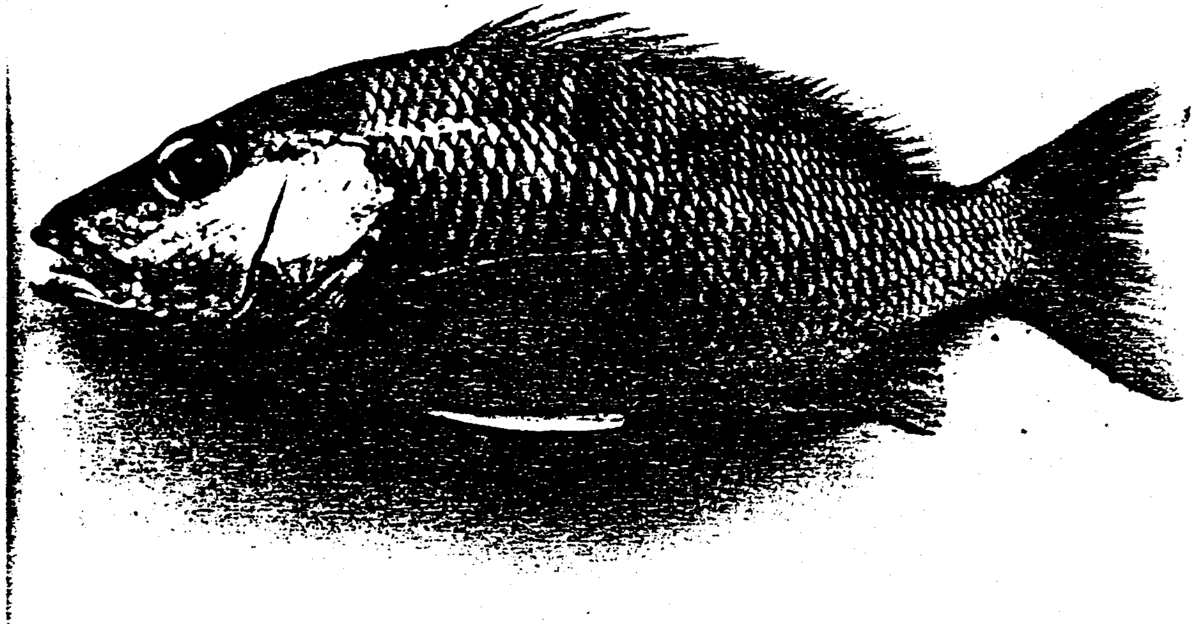


Plate 16. The dog snapper (*Lutjanus jocu*)

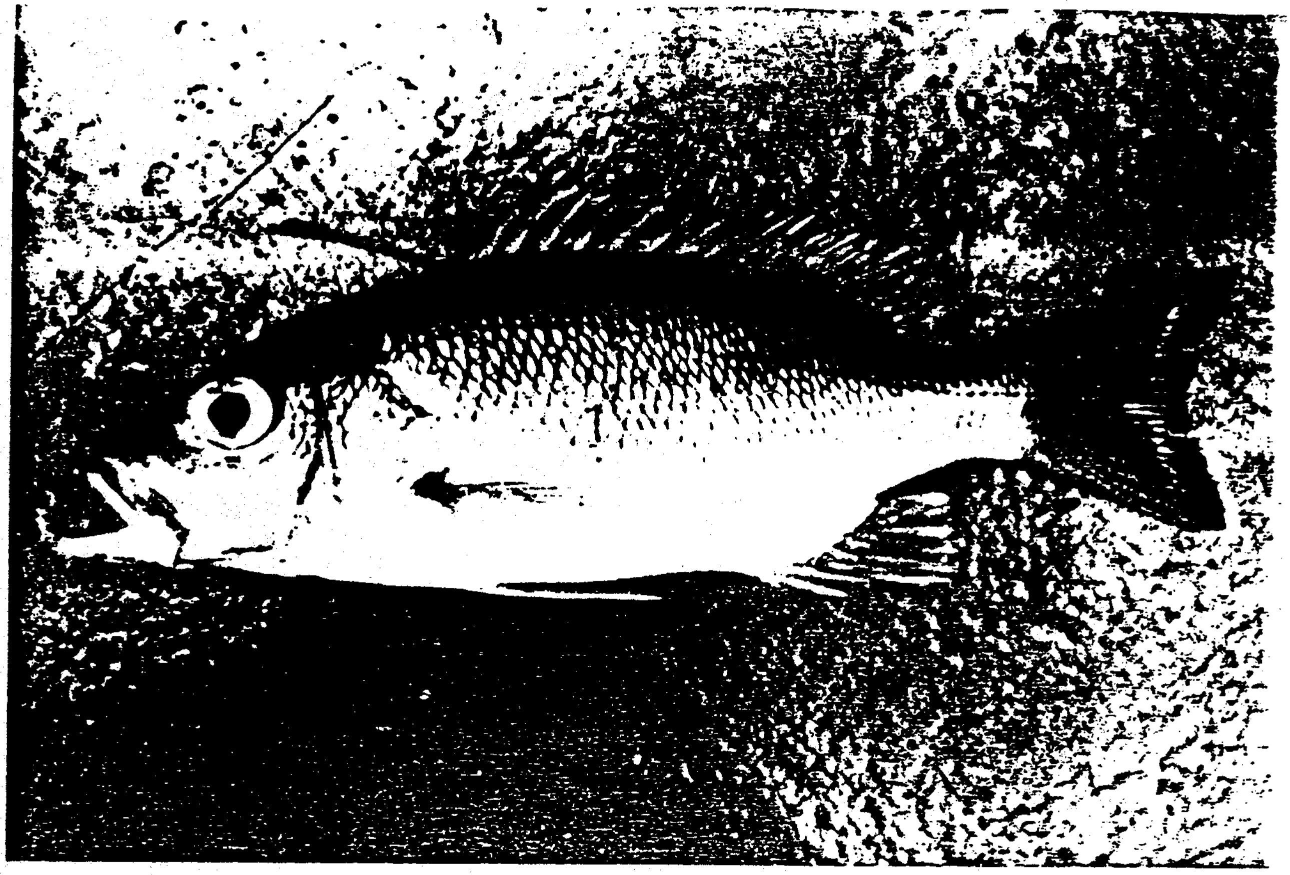


Plate 17. The mahogany snapper (Lutjanus mahogoni)

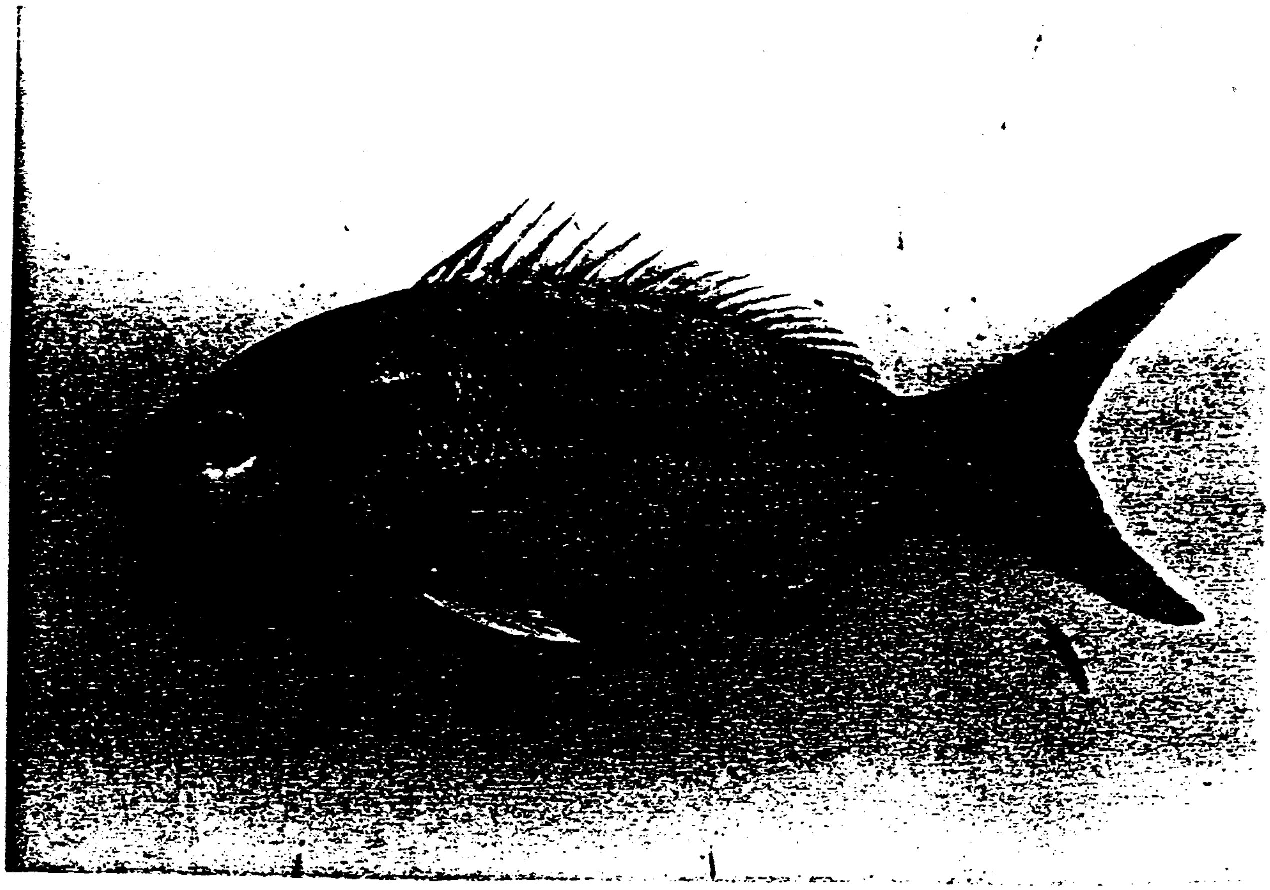


Plate 18. The yellowtail snapper (Ocyurus chrysurus)

Appendix 1. Scientific, English and Spanish Names of the Fishes Included in the Censuses

Scientific Name	English Name	Spanish Name
Acanthurus **bahianus**	Ocean surgeon	Medico
Acanthurus chirurgus	Doctorfish	Medico
Acanthurus coeruleus	**Blue tang**	Medico
Anisotremus surinamensis	Black margate	Vieja
Anisotremus virginicus	Porkfish	Sargento
Balistes vetula	Queen triggerfish	Peje puerco
Calamus spp.	Porgy	Pluma
Caranx bartholomaei	Yellow jack	Guavmen amarillo
Caranx crysos	Blue runner	Cojinua
Caranx hippos	Crevalle jack	Jurel
Caranx latus	Horse eye jack	Jurel ojon
Caranx ruber	Bar jack	Cojinua
Epinephelus adscensionis	Rock hind	Cabra mora
Epinephelus cruentatus	Graysby	Cabrilla
Epinephelus fulvus	Coney	Mantequilla
Epinephelus guttatus	Red hind	Cabrilla
Epinephelus itajara	Jewfish	Judio
Epinephelus striatus	Nassau grouper	Cherna
Haemulon aurolineatum	. Tomtate	Mulita
Haemulon album	Margate	Ronco blanco

Appendix 1. (Cont.)

Scientific Name	English Name	Spanish Name
Haemulon bonariense	Black grunt	Ronco prieto
Haemulon carbonarium	Caesar grunt	Cachicata
Haemulon chrysargyreum	Smallmouth grunt	Ronco
Haemulon flavolineatum	French grunt	Condenado
Haemulon macrostomum	Spanish grunt	Colombiano
Haemulon melanurum	Cottonwick	Ronco
Haemulon parrai	Sailor's choice	Ronco arrayado
Haemulon plumieri	White grunt	Cachicata
Haemulon sciurus	Bluestriped grunt	Boquicolorao
Haemulon striatum	Striped grunt	Ronco arrayado
Halichoeres radiatus	Pudding wife	Capitan de piedra
Holocentrus ascensionis	Squirrelfish	Gallo
Holocentrus rufus	Squirrelfish	Gallo
Kyphosus (spp.)	Chub	Chopa
Lachnolaimus maximus	Hogfish	Capitan
Lutjanus analis	Mutton snapper	Sama
Lutjanus apodus	Schoolmaster	Pargo amarillo
Lutjanus cyanopterus	Cubera snapper	Cubera
Lutjanus griseus	Gray snapper	Pargo Prieto
Lutjanus jocu	Dog snapper	Pargo perro
Lutjanus mahogoni	Mahogany snapper	Pargo ojon
Lutjanus synagris	Lane snapper	Arrayao

Appendix 1. (Cont.)

Scientific Name	**English** Name	Spanish Name
Melichthys niger	Black durgon	Japonesa
Mulloidichthys martinicus	**Yellow goatfish**	Salmonete
Mycteroperca tigris	Tiger grouper	Mery tigre
Myoteroperca venenosa	Yellowfin grouper	Guajil
Ocyurus chrysurus	Yellowtail snapper	Colirrubia
Pseudupeneus maculatus	Spotted goatfish	Salmonete
Scarus coelestinus	Midnight parrotfish	Cotorro
Scarus coeruleus	Blue parrotfish	Cotorro
Scarus croicencis	Striped parrotfish	Loro
Scarus guacamaia	Rainbow parrotfish	Guacamayo
Scares (juv.)	Parrotfish	Loros
Scarus taeniopterus	Princess parrotfish.	Loro princesa
Scarus vetula	Queen parrotfish	Loro
Sparisoma aurofrenatum	Redband parrotfish	Cotorro
Sparisoma chrysopterum	Redtail parrotfish	Loro de cola roja
Sparisoma (juv.)	Parrotfish	Loros
Sparisoma rubripinne	Yellowtail parrotfis1	Cotorro de cola amarilla
Sparisoma viride	Stoplight parrotfish	Loro verde
Sphyraena barracuda	Great barracuda	Picua

Commonwealth of Puerto Rico
Department of Natural Resources
Scientific Research Area
Marine Resources Division

ASSESSMENT OF CORAL REEFS AT CAYO BERBERIA AND CAYO RATONES

HOWARD FERRER HANSEN MIGUEL CANALS MORA

FISH POPULATION STUDIES OF THE SEAGRASS BEDS AND CORAL REEFS OF CAYO BERBERIA AND CAYO RATONES, PONCE, P.R.

JOSE M. BERRIOS DIAZ.
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THALASSIA TESTUDINUM BEDS ASSESSMENT IN CAYO BERBERIA AND CAYO RATONES

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Gerardo Ortiz Miller

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DEPARTMENT OF NATURAL RESOURCES

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This document constitutes the Final Report of the Project F-W-5-2. It contain three parts; Coral Assessment, Fish Population Studies and Seagrass Beds Studies of Cayo Berberia and Cayo Ratones reefs. Each of the parts is written as a separate document with it own conclusion and recommendations but reference exits among them.

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