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Shallow-water Reef Fish Monitoring
Caribbean/NMFS Cooperative SEAMAP Program

text by

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ABSTRACT

During the project sampling period of April 1992 to March 1993, a total of 45 stations were sampled west of Parallel 67 of Puerto Rico. Fifty eight species representing 25 families yielded over 796 kg of fish. The two most important commercial groups, snappers and groupers, constituted 69% by weight of total catch. Two species of groupers (**Serranidae**) constituted 59% of the hook and line catch in terms of weight.

Red hinds (**Epinephelus guttatus**) and coneys (**E. fulvus**) represented by weight 33 and 26.0%, respectively of the total hook and line catch. Other species that constituted more than one percent of hook and line catches by weight were: the silk snapper (**Lutjanus vivanus**, 2.2%); the black snapper (**Apsilus dentatus**, 4.2%); vermillion snapper (**Rhomboplites aurorubens**, 2.1%); queen triggerfish (**Balistes vetula**, 1.3%); the ocean tally (**Canthidermis sufflamen**, 2.9%); the african pompano (**Alectis ciliaris**, 1.3%) the blackjack(**Caranx lugubris**, 3.1%); sand tilefish (**Malacanthus plumieri**, 9.6%), great barracuda (**Sphyraena barracuda**, 2.5%); and the longjaw squirrelfish (**Holocentrus ascensionis**, 1.5%). The later four species are consider to be bycatch, due to their low or non commercial value.

Trap catches were dominated by the same two species as for hook and line catches. Red hinds constituted 41.3% of total trap catches by weight, while coneys made up 21.1%. Other species that represented part of trap catches by weight were: the queen triggerfish **Balistes vetula**, 9.1%); silk snapper (**Lutjanus vivanus**, 6.7%); yellowtail snapper (**Ocyurus chrysurus**, 1.1%); nassau grouper (**E. striatus**, 1.1%); longjaw squirrelfish (**H. ascensionis** 2.4%); the longspine squirrelfish (**H. rufus**, 1.2%); the white grunt (**Haemulon plumieri**, 1.9%); the porgy (**Calamus pennatula** 1.2%); the whitespotted filefish (**Cantherhines macrocerus**, 2.5%); the scrawled cowfish (**Lactophrys quadricornis**, 1.0%); and the banded butterflyfish (**Chaetodon striatus**, 3.4%).

Species composition by sampled stations varied according to three factors: area, fishing gear and depth. Nevertheless, observed species composition is believed to reflect actual composition of commercial landings in Puerto Rico for the gear used in this study, since data collected by port agents under represents certain fish groups which are discarded by fishermen due to low economic value (**e.g.** buterflyfish). Differences in species composition between those reported in commercial landings and those obtained in this survey may be reflection of differences in soak times of fish traps and in times of the day fished with hooks.

Catch per unit effort (CPUE) by stations varied from 0.17 to 423 g/trap hours; and from 0 to 1,372 g/hook hours. Fishermen experience influenced CPUE, most experienced fishermen had a greater CPUE than those with less experience. Also, most experienced fishermen landed a higher number of fish with less effort than least experienced fishermen.

ABSTRACTO

Durante el período de muestreo de abril de 1992 a marzo de 1993, un total de 45 estaciones fueron muestreadas al oeste del Paralelo 67 de Puerto Rico. Cuarenta y cinco especies

representativas de 25 familias produjeron sobre 796 kg de pescado. Los dos grupos de mayor importancia comercial, meros y pargos, constituyeron el 69% por peso de la captura total. Dos especies de meros (**Serranidae**) constituyeron 59% por peso de la muestra total de anzuelos.

Las cabrillas (**Epinephelus guttatus**) y las mantequillas (**E. fulvus**) representaron por peso 33 y 26.0%, respectivamente de la captura total de anzuelos. Otras especies que constituyeron por lo menos el 1% de la captura en términos de peso fueron: el chillo (**L. vivanus**, 2.2%); el chillo negro (**Apsilus dentatus**, 4.2%); la chilla rubia (**Rhomboplites aurorubens**, 2.1%); el peje puerco (**Balistes vetula**, 1.3%); peje puerco oceánico (**Canthidermis sufflamen**, 2.9%); el corcobado de pluma (**Alectis ciliaris**, 1.3%); el jurel negrón (**Caranx lugubris**, 3.1%); el jolocho (**Malacanthus plumieri**, 9.6%), picúa brava (**Sphyraena barracuda**, 2.5%); y el gallo o candil (**Holocentrus ascensionis**, 1.5%). Las últimas cuatro especies mencionadas no poseen en la actualidad ningún valor comercial y son consideradas como brosa.

Las especies que dominaron la captura de las nasas fueron las mismas dos especies que dominaron la captura de anzuelos. La cabrilla representó 41.3% de la captura total por peso, mientras que la mantequilla constituyó un 21.1%. Otras especies que representaron la captura de nasas fueron: el peje puerco (**Balistes vetula**, 9.1%); el chillo (**L. vivanus**, 6.7%); la colirrubia (**Ocyurus chrysurus**, 1.1%); mero cherna (**E. striatus**, 1.1%); gallo o candil (**H. ascensionis**, 2.4%); el gallo de espina larga (**H. rufus**, 1.2%); cachicata blanca (**Haemulon plumieri**, 1.9%); la pluma (**Calamus pennatula**, 1.2%); la pereza (**Cantherhines macrocerus**, 2.5%); chapín (**Lactophrys quadricornis**, 1.0%); y la mariposa sargento (**Chaetodon striatus**, 3.4%).

La composición de especies por estaciones muestreadas varió de acuerdo a tres factores principales: área, arte de pesca y profundidad. De todas formas, se cree que la composición obtenida refleja la composición actual de los desembarcos comerciales en Puerto Rico para las artes utilizadas en este estudio, debido a que la data recopilada por los agentes pesqueros no representa ciertos grupos de pescados (i.e, mariposas). Las diferencias en composición entre la reportada en los desembarcos comerciales y la obtenida en esta encuesta, pueden ser reflejo de diferencias en el tiempo de remojo de las nasas y en la hora del día pescadas con anzuelo.

La captura por unidad de esfuerzo (CPUE) por estaciones varió de 0.17 a 423 g/nasa horas; y de 0 a 1,372 g/anzuelo horas. Un factor que influye en el CPUE lo es la experiencia de los pescadores envueltos; los pescadores más experimentados reportaron un CPUE más alto que los menos experimentados. De igual manera, los pescadores más experimentados abordaron un mayor número de pescado con un esfuerzo menor a aquellos de menor experiencia.

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INTRODUCTION

Shallow-water Reef Fish Monitoring

There is a paucity of fisheries-dependent data on shallow-water reef fish resources. Artisanal fishermen maintain few records and reporting is poor. Fisheries-dependent data collection systems in Puerto Rico are underfunded and data reliability is questionable. Fishing effort has increased and a shift in species composition has been noted by fishermen and fisheries agencies (Weiler and Suarez-Caabro, 1980; Bohnsack **et al**, 1986; García-Moliner and Kimmel, 1986; Appeldoorn, 1987; Collazo and Calderón, 1988; Matos and Torres, 1989; Sadovy, 1989; Matos, 1990; Matos and Sadovy, 1990; Dennis **et al**, 1991). Several species have declined below the level of economic harvest, among the most notable the Nassau grouper, **Epinephelus striatus**, and the yellowfin grouper, **Mycteroperca venenosa**, which have become fisheries extinct.

A preliminary survey was conducted in 1989 by the Fisheries Research Laboratory of the Puerto Rico Department of Natural Resources (Rosario, 1989) to provide fisheries-independent data on local fisheries and to obtain information that would allow analysis aimed at defining or establishing an appropriate experimental design. The data from this preliminary survey were analyzed and presented in the Final Report, "Statistical Sampling Design Analysis of the Puerto Rico Fishery-Independent Survey", Bannerot **et al** , 1991. The Statement of Work prepared for this study and second survey undertaken in 1991, is based on the results of the Bannerot report. Data collected during the second survey, 1991, was analyzed to assess the sampling protocol used in the Statement of Work and presented a revised sampling protocol for future sampling, (Smith and Ault, 1993).

Fisheries-independent data are critically needed to obtain essential information for fisheries management. Data collected by fisheries-independent surveys is not derived with direct reliance on statistical and biological information collected from commercial fishermen. Fisheries-dependent data are significantly influenced by a combination of various factors such as economic conditions, changes in gear designs, discard patterns, changes in fishing strategies and practices that are difficult to measure or account for, and most important of all the inaccuracy of the data provided by the fishermen.

Rational decision making requires long time-series of biological and environmental information to predict fluctuations in resources abundance, which is provided by fisheries-independent data. Fisheries-independent data collection has been carried out by the Fisheries Research Laboratory (FRL) since 1967. During the early years, efforts were concentrated in identifying new fishing areas and implementing new fishing techniques and gears. Most of the effort was concentrated mainly in exploring, developing and teaching new fishing techniques to fishermen. Various and numerous projects were conducted by the Exploratory Fishing Program of the FRL. All kinds of gears and a diversity of new species were studied, trying to establish the viability of introducing them in Puerto Rico. Most of these works were conducted and published by Mr. Rolf Juhl (1969 and 1972), Juhl and Suarez-Caabro

(1973). Others were conducted by Mr. Jon Cole (1976) and in the early 1980's by Mr. Charles Boardman and Ms. Deborah Weiler (1979). All these surveys tested several fishing gears, being the two most often used the fish traps and snapper reels.

Presently, this program is more concerned with the conservation of the resources and gathering data that could help in a better understanding on the status of the resources, undertaking fisheries-independent data collection.

Reef resources are the most important fisheries in the Caribbean (Munro, 1983). Due to the lack of reliable fisheries-dependent data, the fisheries-independent data are needed to effectively evaluate management plans. Information from this effort may be used by the National Marine Fisheries Service, the Commonwealth of Puerto Rico and the Government of the US Virgin Islands.

OBJECTIVE:

The aim of the present survey was to collect, manage, and disseminate fisheries-independent data collection of shallow-water reef fish resources and their environment. These data were used to obtain catch per unit effort estimates, to determine species composition and to evaluate annual trends in the fishery. The data are also available for comparison with fisheries-dependent data collected under other statistics project of Puerto Rico and the US Virgin Islands.

APPROACH:

Assess the survey design and standardize sampling methodologies identified in the Statistical Survey Design Analysis. Establish and conduct fishery-independent surveys to obtain CPUE, (biomass per unit gear), determine species composition, evaluate trends in the fishery, and characterize the fishery habitats. Data obtained from the Pilot Study were also analyzed in order to establish the optimal design for the long term Reef Resources Survey.

METHODS:

1. Sampling was carried out using fish hooks (size #06), using squid as bait, and the standard fish trap using 1-1/4" hexagonal mesh size using sardines as bait (exemption from mesh size restrictions under federal regulation was obtained). Over the western shelf area of Puerto Rico the platform was divided into 2x2 mile sampling units, subsequently referred to as 'quadrats' (Figure 1). Quadrats were further subdivided into 16 quadrats of 0.5x0.5 miles for sampling purposes. Location of subquadrats were established by Global Positioning Systems (GPS). Some details concerning sampling were subject to minor modifications depending on logistics and prevailing conditions of weather and boats.
2. The sampling areas were stratified based on the following depth criteria which generally distinguish shallow water platform areas from shelf edge areas:
    a) 0-10 fathoms;

b) 11-20 fathoms;

c) 21-50 fathoms;

3. Sampling frequency was assigned equally to each depth stratum a) to c) above. Within a given depth stratum, quadrat samples were assigned randomly as was the sampled subquadrat within the selected quadrat. Five different quadrats were randomly selected per depth stratum for sampling. Ten samples were planned for each quadrat over the 12 month period of the study resulting in 50 samples per stratum, and a total of 150 samples (trips) for Puerto Rico. Numbering of subquadrats were as follows: 1= extreme northwest corner; 16=extreme southeast corner; 4= extreme northeast corner; 13=extreme southwest corner.

4. A minimum of 12 standardized fish traps (4' x 4' x 1.5') were set on any one sampling day by a single research vessel in the randomly chosen subquadrat for the selected week. Fish traps were baited with sardine. Mesh size of traps was 1.25" hexagonal. It originally was intended to have two research vessels in operation, but this was not feasible due to mechanical complications. The week of the year to sample any particular sub-unit was also selected at random. Soak time was standardized at approximately five to six hours. Traps were set in strings of three traps per string and inter-trap distance was at least 150 feet to avoid intertrap interference.

5. Three lines each with three hooks (#06) per line were fished for 4-5 hours daily with standardized bait and sinker units (weights) during fish trap soak period.

6. For each trip the following data was recorded:

A. date, time (i.e. time out and time returned to dock).

B. quadrat code and sub-quadrat code (1-16).

C. depth.

D. total number of traps hauled/hooked fished per vessel.

E. trap set and number of the trap in the set.

F. number, weight, length (fork length), and identification of fish per individual trap and hook and line as well as by individual fishermen.

G. substrate type was characterized whenever possible, mostly from whatever got entangled in the fish traps.

H. two principal gonad stages were used for each sex to establish the spawning period of selected species shown in Table 5 and 6. These stages are the following: M3 or Ripe Testes with loose or running milt; F3 or Ripe Ovaries usually transparent and colorless (enlarged gonad with large, well developed eggs); spent gonads, enlarged and flaccid gonads (M4 and F4 for males and females, respectively). Unripe individuals are designated as F1 and M2, meanwhile F2 and M2 corresponds to subripe individuals.

7. Catches by individual fishermen were kept separated for each fishing trip.

The data were entered with an identification code for each fishermen, so that it could be analyzed for each fishing member. These data could provide an estimate of fishermen productivity and also an indication of the variability of individual fisherman performance.

8. Data were entered and stored on microcomputer in standardized format. Quarterly summaries and annual progress reports including data summaries were completed.

9. A statistical analysis of data, including recommendations on sampling design will follow completion of the Pilot Study.

Geographic Location
Puerto Rico, west coast.

RESULTS

Total execution of the objectives of the Pilot Study as originally proposed, were partially hindered due to a series of situations; during the period of December to February, both vessels confronted mechanical problems. The R/V Abreu had problems with the turbo charger, and the R/V Guayanilla I, with the transmission. Therefore, collection efforts were limited to 9 months instead of the originally intended 12 months. Most of the available data were collected by a single vessel.

The sampling protocol was revised when the sampling started. A number of changes were made, such as to establish the best sampling methodology.

1) Hook and Line

Catches

A total of over 687 kg of fish belonging to 40 species, representing 23 families, were sampled. Serranids comprised 75% and 60%, in terms of total number of individuals and weight caught, respectively (Table 1).

Total catch was dominated by a single family, **Serranidae**, representing 61%. Six species of lutjanids represented 9.42% of the catch, in terms of weight. Other species accounted for a total of 30.87% of the catch.

Other families that comprised an important part of the catch in terms of weight, were the jacks (Carangidae), of which eight species made up 7.9%; triggerfishes (Balistidae) with 5.2%. The sand tilefish (**Malacanthus plumieri**) 9.60%; the great barracuda (**Sphyraena barracuda**, 2.5%); and two species of holocentrids 2%. Of these families, the only one that has some commercial importance are the triggerfishes, the others were considered bycatch, of little or no commercial value until 1991, when they started to be reported in landings data. The sale of two species of jacks (**Caranx lugubris** and **Seriola rivoliana**) and the great barracuda is prohibited in Puerto Rico, since they are prone to ciguatoxins.

Catch per unit effort (CPUE) can be described in several ways. Commonly, CPUE is expressed in terms of kg/hook hours. For this sampling period the obtained total CPUE was 0.151 kg/hook hours. In terms of weight per trip 17 kg/trip was obtained. Catches range from zero on parts of the west coast platform to 0.803 kg/hook hours at the Bajo de Cico site.

The results obtained show a trend in which, within a particular fishing day, a single fishermen would dominate the catch. Weather conditions, or moon phase did not affect this particular trend. One thing that particularly affected the catch was the sampling station.

Table 2 summarizes CPUE in terms of g/hook hours for each fishermen for the whole sampling period. Total effort (hook hours) and CPUE (g/hook hours) gives a better overview of individual fishermen productivity (Table 2). CPUE varied from a minimum of 121.08 g/hook hours to a maximum of 462.72. The maximum recorded was obtained in a short period of time, by the person that replaced one of the regular fishermen.

The fishermen with the lowest number of trips, fishermen 17, 6 and 21, caught a relatively higher number of grams per trip than the others. Fisherman 18 recorded, with a fair higher number of trips, one of the greatest catch in terms of weight. In terms of number of fish caught by trips, this trend was the same (Table 2).

Appendix 1 summarizes CPUE by date and stations. In general terms, stations closer to the shelf edge registered higher values of CPUE, although some variability could be observed for those stations that were sampled during different months. These results were not statistically tested, but some trends that can be observed are useful in the allocation of sample strategies for at least the grouper species. Unfortunately, snappers sample sizes, were so low that it precludes any conclusion regarding their distribution. A total of 19 stations were sampled in more than one occasion. A total of 10 trips resulted in zero catches, representing 10.28% of the total number of trips.

Mean CPUE per trip (g/hook hours trip) fluctuated from a minimum of 6.07 for station 93, (disregarding zero catches) to a maximum of 1,380.10 for station 42. On the other hand, mean CPUE in terms of g/line trip fluctuated from a minimum of 43.3 for station 87 to a maximum of 14,491.0 for station 42. Both maximum catches corresponded to the same station and date. Catches for that particular sampling date consisted of black snappers (**Apsilus dentatus**).

According to the stratifying depth criteria, minimum recorded CPUE can not be related to a particular depth range (Appendix 1). Meanwhile, the maximum recorded CPUE were recorded at the maximum depth range (21-50 fm), and this is not surprising, since black snapper is a deep water species. Appendix 2, summarizes sampling allocation for both sampled gears by location and dates. Some information on bottom substrate is available for some of the stations. Catches are related more to bottom substrate than to depth. Higher catches were reported for areas were bottom consisted of coral or rocks, than in sandy bottom or algal or grass beds.

Red hinds (**Epinephelus guttatus**) catches are represented in Appendix 3 in both terms of number and weight by station. Most red hinds were sampled at the Bajo de Cico (stations 95 and 96) which is an oceanic bank outside the platform of the island, with a bottom substrate dominated by sponges, soft coral, and in some areas of hard coral. Average depth of this area is 37 fathoms, and the shallowest point is a small area of 11 fm. Stations close to the shelf edge register the highest catches on the island platform (Figure 1). Maximum CPUE for stations 95 and 96 were recorded during September and October (Appendix 4). Stations 29, 79, and 80, were other stations in which CPUE for red hinds were high. In all other stations catches were considerably low.

From Appendix 3 and Figure 1 it can be appreciated that coneys (**E. fulvus**) catches were higher in those stations in which red hinds catches were considerably low. Maximum catches were recorded in stations 49 and 80. From Appendix 5 it can be appreciated that the highest CPUE corresponded to station 49 during August and the highest one during March, the second highest CPUE was recorded in station 7 during July. All maximum CPUE were recorded for the intermediate depth (11-20 fm). Contrary to red hinds catches in which all maximum CPUE were recorded in deep water (21-50 fm).

Other species that are of commercial importance and that represented an important part of the catch are the snappers, of which the vermillion snapper (**Rhomboplites aurorubens**) was the one that was most represented in the catch (Table 1, Appendix 3, Fig. 1). Two stations recorded the bulk of the vermillion snapper catch, stations 80 and 87. These stations are in the shelf edge of the platform, with the shallowest depth of station 80 being 11 fm, and at the northwest reaching 30 fm and over. Station 87 consisted of depths from 24 fm in the shallowest part and up to 102 fm in the deepest part. Another snapper that was caught in fairly good numbers was the silk snapper (**Lutjanus vivanus**), which was almost exclusively caught at station 91 (Appendix 3).

Species Composition

Classification of species composition by first, second, third and trash fish is the general market value presented by Matos and Sadovy (1990) for P.R. This classification varies markedly from coast to coast, but in general, reflects the classification used by the majority of fishermen of P.R. The two categories that tend to vary most in terms of how species are classified according to their market value are third and "trash" ("brosa") fish. The major difference concerns the classification of squirrelfishes. In certain areas, such as the west coast, this group is considered to have no market value (trash fish); meanwhile, in others such as the south coast, it is classified as third class. Although a single species of holocentrid made up only 3% by number of total catch;

this could influence total catch value if frequency of capture were higher.

A total of 58 species were sampled with both gears; of which 25 (43.1%) of the total were exclusively sampled with hook and line, while 17 (29.3%) were exclusively caught with traps and 16 (25.6%) with both gears.

The major groups of fish of commercial importance in Puerto Rico are snappers and groupers, which represent first class fish. The combined percentage of these two groups were 69% by weight and 83% by number of total catch. The species composition was dominated by two species of groupers (Table 1, Figure 2). The coney (**Epinephelus fulvus**), was the most abundant sampled species, in terms of number (44%); in terms of weight represented the second most abundant species (26%). The red hind, (**E. guttatus**), was the second most abundant sampled species, in terms of number (29%); and in terms of weight it was the most abundant species (33%).

Three species of snappers comprised the bulk of the snapper catches in terms of weight; the silk snapper (**Lutjanus vivanus**), constituted 2.2%; the vermillion snapper (**Rhomboplites aurorubens**) 2.1%; and the black snapper (**Apsilus dentatus**) 4.2%.

Second class fish include mainly grunts, porgies, and triggerfishes. This class of fish was scarcely represented in the species composition. The triggerfishes constituted the major representation of this class, with three species, the queen triggerfish (**Balistes vetula**), the ocean tally (**Canthidermis sufflamen**), and the black durgon (**Melichthys niger**). These three species represented 5.2% of the weight of the total catch.

Third class fish were not represented in the species composition, with the exception of the holocentrids, being classified in some places as such. For the purpose of this report this species is classified as bycatch (trash fish), since this is it's predominant classification on the west coast of Puerto Rico.

The percentage of bycatch or trash fish in terms of weight and number was high (Figure 2), compared to second and third class fish. Trash fish constituted 14% and 17% by number and weight, respectively, of total catch. Three families represented the bulk of the bycatch, the holocentrids, tilefishes and the carangids. Some of the carangids are represented as toxic species, as well the great barracuda.

The longjaw squirrelfish, **Holocentrus ascensionis**, was the most abundant sampled species of holocentrids. This species represented 2.1% and 1.5% by number and weight, of total catch. Of the tilefishes, the sand tilefish (**Malacanthus plumieri**) represented the third most abundant species of total catch. In terms of number and weight, it represented 8.51 and 9.6%, respectively of sampled species.

The carangids in terms of number did not represent an important contribution to the catch, but in terms of weight made up 7.90%. A single species constituted the bulk of the carangid contribution, the black jack (**Caranx lugubris**) with 3%. Another species that did not constitute an important contribution in terms of number, but did in terms of weight, was the great barracuda (**Sphyraena barracuda**) with 2.5%.

Length Frequency

Only species with a minimum of one hundred individuals were taken into consideration for the analysis of length-frequency data, with the exception of the vermillion snapper (85). A 10 mm size class interval was chosen as most appropriate for the data collected.

Four species were compared in terms of length-frequency distributions taken with hook and line during this survey. The species were the coney (**E. fulvus**), red hind (**E. guttatus**), vermillion snapper (**Rhomboplites aurorubens**) and the sand tilefish (**Malacanthus plumieri**)

Epinephelus fulvus-coney

Figure 3a shows the length-frequency distribution of sampled coneys. Modal class of the sample was 240 mm, and a mean size of 219 mm $\pm$ 25, with a mean weight of 176 g $\pm$ 65. Table 3 gives the mean length and standard deviations by moon phase. Table 4 gives a summary by of the selected sampled species taken into account for length frequency analysis. Figures 3b-e show the size frequency distribution of sampled coneys by moon phase.

Figure 4 shows the calculated length/weight regression line for coneys sampled with hooks. The r value was .92.

Any size distributions by moon phase gave statistically significant results (Kolmogorov-Smirnov, $d < D_{.05}$).

Figure 5 shows the size frequency distribution by depth ranges. Any of the distributions by depth range gave statistically significant results (Kolmogorov-Smirnov, $d < D_{.05}$).

Epinephelus guttatus-red hind

Figure 6a shows the length-frequency distribution of red hinds. Modal class of the sample was 270 mm, with a mean size of 280 mm $\pm$ 53 and a mean weight of 337 g $\pm$ 229. Table 3 gives the mean length and standard deviations by moon phase. Maximum and minimum size and weight are shown in Table 4. Figures 6b-e show the size frequency distribution by moon phase. Figure 7 shows the calculated length-weight regression line of sampled red hinds with hooks. The r value for this sample was .98.

The only size distribution by moon phase that gave statistically significant results (Kolmogorov-Smirnov, $d = 0.366 > D_{.05} = 0.305$), were those among the first quarter and full moon distributions; full moon and last quarter (d = 0.312 > $D_{.05}$ = 0.295); and first quarter and new moon (d = 0.164 > $D_{.05}$ = 0.143).

Depth ranges size distribution are shown in Figure 8. The only distributions that yielded statistically significant results (Kolmogorov-Smirnov, d = 0.235 > $D_{.05}$ = 0.173); d = 0.256 > $D_{.05}$ = 0.189; and d = 0.238 > $D_{.05}$ = 0.175 were among 0-10 and total; 0-10 and 11-20; and 0-10 and 21-50 fm, respectively.

Rhomboplites aurorubens-vermillion snapper

The total catch distribution is shown in Figure 9. The modal class was 220 mm, with a mean size and weight of 216 mm ± 17, and 168 g ± 37 respectively. There were not enough individuals by moon phase, precluding comparison of size distribution for each moon phase. Table 3 gives the number of individuals and mean size and weight of vermillion snapper by moon phase. Maximum and minimum recorded are shown in Table 4. The calculated length/weight regression line is shown in Figure 10. The r value for this regression was 0.96.

Figure 11 shows the obtained size distribution by depth ranges. All the distributions yielded statistically significant results. Between the total sample distribution and the depth range of 11-20 fm, (Kolmogorov-Smirnov, d = 0.598 > $D_{.05}$ = 0.058), among the total and 21-50 fm (d = 0.101 > $D_{.05}$ = 0.043), and among depth ranges 11-20 and 21-50 fm (d = 0.260 > $D_{.05}$ = 0.068).

Malacanthus plumieri-sand tilefish

The length-frequency distribution of the sand tilefish is shown in Figure 12. The modal class was 370 mm, with a mean size and weight of 358 mm ± 33, and 336 g ± 85 respectively. Table 3 shows the number of individuals, as well as the mean size and weight. Table 4 summarizes maximum and minimum size and weight recorded. Figure 13 shows the calculated regression line of sampled sand tilefish, with a r value = .94. Figure 14 displays the size distribution by depth ranges.

All obtained distributions by depth ranges yielded statistically significant results (Kolmogorov-Smirnov d > $D_{.05}$). Total sample vs 0-10 fm (Kolmogorov-Smirnov, d = 0.060 > $D_{.05}$ = 0.049); total vs 11-20(d = 0.063 > $D_{.05}$ = 0.020); total vs 21-50 fm (d = 0.120 > $D_{.05}$ = 0.031); 0-10 vs 11-20 (d = 0.120 > $D_{.05}$ = 0.055); 0-10 vs 21-50 (d = 0.124 > $D_{.05}$ = 0.066); and 11-20 vs 21-50 (d = 0.183 > $D_{.05}$ = 0.037).

2) Fish Traps

Catches

A total of 374 finfish belonging to 33 species, representing 13 families, and weighing over 110 kg were captured during 67 traps hauls. Trap soak time for each trap was recorded, with an average of 5 hrs.

Catch per unit effort ranged from 0 g/trap haul to 0.097 kg/trap haul. The total overall CPUE amounted to 0.019 kg/trap hours. In general, trap catches were very low in any single haul.

The relative percentage of various families in the total catch (Table 1, Fig. 14) showed that serranids (64%), triggerfish (9%), snappers (9%), and the squirrelfishes (3%) dominated the trap catches in terms of weight. In terms of number of individuals captured the relative percentage of these families were serranids (50%), snappers (12%), triggerfish (5%), and the squirrelfishes (7%). The banded butterflyfish, **Chaetodon striatus**, represented an important component of the trap catches in terms of weight and number 3 and 14%, respectively.

Appendix 6 summarizes fish traps catches by date and station. Fish traps recorded a higher percent of zero catches (21.18%), than hook and line. Disregarding zero catches minimum recorded CPUE were of 0.92 g/trap hours, 0.93 g/trap day, and 4.67 g/trap day/trip. This minimum values were recorded in shallow depths, in stations 93 and 39, during June 1992 and October 1992, respectively. Maximum catches were recorded in station 90, during April 1992; in station 49, during August 1992; and in station 90, during September 1992. In general terms, trap catches were much lower than hook and line catches, therefore, CPUE is similarly lower.

Appendix 7a and b, displays obtained results of selected sampled species by station for fish traps catches. Red hinds were mostly sampled at stations 95 and 96, similarly to the hook and line catches, meanwhile, coneys were most dispersed among the sample stations. Station 77 was the only station in which coneys were sampled in fairly high numbers, and that corresponded to the higher values of hook catches. Station 80 recorded the highest values in terms of weight and number of sampled banded butterflyfish (Appendix 7a and b).

Species Composition

Species composition was dominated by serranids, as for the hook and line. The red hind was the principal species caught in terms of weight, with 41%. The other grouper that constituted an important part of the catch was the coney, representing 21% of total catch in terms of weight. Both species contributed the same percentage in terms of number to the catch, 24%. Two other species that represented an important part of the catch were the queen triggerfish, **Balistes vetula**, with 9% and 5%, in terms of weight and number; respectively, and the silk snapper, **Lutjanus vivanus**, with 7 and 6% in terms of weight and number, respectively.

Respectively of total catch, first class fish caught by traps constituted 61% and 73% by weight and by number (Figure 14). Groupers represented 50% by weight, and snappers made up 11% by weight. Contrary to species composition of hook and line, snappers made a greater contribution to trap species composition. Four species of snappers were collected of which the silk snapper (**L. vivanus**) made up 7 and 6% by number and weight of total catch. The vermillion snapper (**<u>Rhomboplites</u> <u>aurorubens</u>**) represented 1 and 2% by weight and number, respectively; while the lane snapper (**<u>L</u>**. **<u>synagris</u>**) made up 2 and 0.4% by number and weight.

Second class fish was composed almost singly by the queen triggerfish, **<u>B</u>**. **<u>vetula</u>** (Table 1, Fig. 14). This species was sampled in greater quantities with fish traps than with hook and line; although, some second class fish were represented in greater amounts in trap catches such as the white grunt (**<u>Haemulon</u> <u>plumieri</u>**), that made up 2% of the catch in both terms, weight and number. The other species that is considered as second class fish that composed the second class fish was the porgy (**<u>Calamus</u> <u>pennatula</u>**) 1% in terms of number and weight.

Trash fish comprised the rest of trap composition (Figure 14). Trap bycatch comprised squirrelfishes, butterflyfishes, doctor fishes, puffers, file fishes, and scorpion fish. The bulk of the catch was constituted by the longjaw squirrelfish, **<u>H</u>**. **<u>ascensionis</u>**, and the banded butterflyfish, **<u>C</u>**. **<u>striatus</u>**.

Length Frequency

Coneys and red hinds were the only two species sampled with traps that were collected in enough numbers to make size distributions. However, there were not enough sampled by moon phase to compare the distributions.

<u>Epinephelus</u> <u>fulvus</u>-coney

The size distribution of sampled coneys with traps is shown in Figure 16. This distribution modal class was at the 250 mm. The mean size and weight were 246 mm $\pm$ 25 and 245 g $\pm$ 78, respectively. Table 5 shows maximum and minimum size and weight recorded for this species with fish traps. The calculated length/weight regression line is shown in Figure 17. The r value for this regression was .94.

Observed differences among the distributions of sampled coneys with hook and traps (Figure 3a and 16) were statistically significant (Kolmogorov-Smirnov, $d = 0.337 >> D_{.05} = 0.149$).

<u>Epinephelus</u> <u>guttatus</u>-red hind

Figure 18 shows the size distribution of red hinds sampled with traps during this survey. The modal class for this distribution was 350 mm, and the mean size and weight was 313 mm $\pm$ 43 and 503 g $\pm$ 242, respectively. Table 5 shows maximum and minimum size and weight sampled with fish traps.

Figure 19 shows the calculated length/weight regression line. The r value for this line was .95.

Differences in size distribution (Figures 6a and 18) of sampled red hinds with trap and those captured with hook and line were statistically significant (Kolmogorov-Smirnov, d = 0.379 >> $D_{.05}$ = 0.153).

Statistically significant different results of size distribution of coneys and red hinds captured with hook and line and fish traps were obtained (Kolmogorov-Smirnov, d > $D_{.05}$).

Reproductive State

Sex was determined by gross examination of gonads for all fishes collected during the study. For many of the commercial species landed in Puerto Rico, limited information on their spawning cycle is available (e.g. Erdman, 1977; Colin and Clavijo, 1988). For most sampled species, sample size was very low, in other cases most specimens were not sexually mature, therefore, spawning season could not be fully evaluated, although the data provides limited information on the percentage of ripe and spent males and females for certain months for a number of species.

Of the 58 listed species in Table 1 for which reproductive states were assessed, the most complete information is for four species of which three are of commercial importance. These species are the coney (**Epinephelus fulvus**), the red hind (**Epinephelus guttatus**); and the vermillion snapper (**Rhomboplites aurorubens**). The other species is the sand tilefish (**Malacanthus plumieri**).

Epinephelus fulvus (coneys N = 1,016) were constituted by 89% females and 11% males (Table 6). The sex ratio of females to males was 8.5:1 (F:M). Males with ripe testes constituted only 8% of total sampled males, while females with ripe ova made up 2% total sampled females. Individuals with spent gonads constituted the bulk of the catch (94% of total sampled females, and 90% of total sampled males). Figure 20 shows the distribution of total males and females sampled.

Table 6a gives descriptive statistic of sample coneys by sex stage. All ripe females and males were collected during March 1993. Ripe females were sampled in greater numbers in station 79, representing 56% of ripe females; followed by station 80 with 28%, of total ripe females. Other stations at which ripe females coneys were sampled were station 77 (N = 2); and station 90 (N = 1). Correspondingly ripe males coneys were collected in higher numbers in station 79, representing 44% of total sampled ripe males; followed by station 80 and 96 both with 22% each. The other station in which ripe males were collected was station 77 (N = 1).

Table 5a displays descriptive statistics of sampled coneys with fish traps by sex stage. Only one ripe female was sampled at station 77, during March 1993. Ripe males were all collected during March 1993, at stations 77 (N = 1); and at station 87 (N = 2).

Differences in size distribution between total sample and females (d = 0.075 > $D_{.05}$ =

0.062) were statistically significant, as well as between total sample and males ($d = 0.143 > D_{.05} = 0.138$).

Epinephelus **guttatus** (red hinds N = 671) were constituted by 76% females and 24% males. The sex ratio of females to males was 3.25:1 (F:M). Males with ripe testes constituted only 8% of total sampled males, while females with ripe ova made up 1% total sampled females. Individuals with spent gonads constituted the bulk of the catch; 42% of total sampled females, and 51% of total sampled males. Figure 21 shows the distribution of total males and females sampled.

Table 6b display results of descriptive statistics of sampled red hinds with hook and line. Ripe females red hinds were sampled during April 1992 at station 90 (20%), and at stations 80 (20%); and station 95 (60%) during March 1993. Ripe males were collected in March 1993 at the following stations: 79 (17%); 95 (67%) and 96 (17%).

From Table 5b in can be observed that not a single ripe females red hind was sampled with fish traps. The only ripe male collected with fish traps was caught at station 95 in March 1993.

Differences in size distribution between total sample and females ($d = 0.095 > D_{.05} = 0.080$) were statistically significant, as well as between total sample and males; and among females and males ($d = 0.307 > D_{.05} = 0.120$; $d = 0.385 > D_{.05} = 0.124$), respectively.

Rhomboplites **aurorubens** (vermillion snapper N = 85) were made up of 58% females and 42% males. Sex ratio of females to males was 1.39:1 (F:M). Males with ripe testes made up 78% of total sample males, while females with ripe ova constituted 51% of total sample females. Males with spent gonads made up 8% of sampled males, while not a single female with spent gonad was sampled. Figure 22 displays the obtained size distribution of females and males.

Table 6c shows descriptive statistics of sampled vermillion snappers by sex stage. Females with ripe gonads were collected mostly at station 80 during the following months: April 1992 (56%), May 1992 (4%); and March 1993 (4%). The other stations at which ripe females were caught was station 91 (36%), during July 1992. Sampled males with ripe gonads were recorded in the following stations: station 80 (39%) during April 1992, and May 1992 (21%); at station 91 (36%) during July 1992; being these stations the ones with the highest percentages. Station 87 recorded 3.5% of ripe sampled males during September 1992. Meanwhile stations 79 and 87 reported 3.5% during March 1993.

Differences in size distribution between sexes were significantly different $d = 0.090 > D_{.05} = 0.067$).

Malacanthus **plumieri** (sand tilefish N = 196) sample was constituted by 83% males and 17% females. Males with ripe testes composed 8%, while males with spent gonads made up 9%.

Sex ratio of females to males was 0.21:4.76 (F:M). Females with ripe ova constituted 24% of total sample females, while females with spent gonads were not sampled.

Table 6d presents descriptive statistics of sampled sand tilefish by sex stage with hook and line. Females sand tilefish with ripe gonads were captured at the following stations: station 96 (N = 2) during April 1992; at stations 7 and 96 during July 1992 (N = 1, for each station); at station 80 during August (N = 1); at stations 29 and 95 during September 1992 (N = 1); and at station 42 during March 1993 (N = 1). Males with ripe gonads were recorded during 1992 at stations 80 in May; and 95 in September, representing 15% each of total ripe males. All other ripe males were caught during March 1993 at the following stations: 79 and 80, both representing 23% each; and at station 96 embodying 15%.

Figure 23 shows the obtained size distribution of sampled females and males sand tilefish. Differences in size distribution among the sexes were significantly different d = 0.364 > $D_{.05}$ = 0.049).

Chaetodon **striatus** (banded butterflyfish N = 54) although, they were sampled in low numbers they are important, since this is one of the most underrepresented bycatch species of traps landing data. This species has become of great importance since, it is exploited by the aquarium trade fishermen. The obtained sex ratio for this species was 1.25:0.8 (F:M). Of sampled females 70% had ripe ova, meanwhile, females with spent gonads constituted 20% of total sampled females. Males with ripe testes comprised 38% of total sampled males. Males with spent gonads made up 29% of total sampled males.

Ripe females were sampled in all sampled months with the exception of October and November 1992. In April 1992 ripe females were collected at stations 80 and 95, representing 4.8% each of total sampled ripe females. During May ripe females were caught at station 80, making up 9.5%. In June were sampled also, in a single station 93 (9.5%); as well in July (station 7, 9.5%). During August ripe females were recorded at stations 41 and 49 comprising 4.8%, each. In September were collected at station 58 (9.5%). In March 1993, were sampled the greater number of ripe females (42.8%) at the following stations: 80 representing 9.5%; station 79 and 42 comprising 14.3%, each; and station 68 with 4.8%.

Ripe males were only collected during 1992 from May to September. Station 80 recorded 11.1% of males with ripe testes during May. The higher numbers of males with ripe gonads were collected at station 93 during June, comprising 33.3% of total ripe males. Other stations in which ripe males were sampled were the following: station 7 (11.1%) during July; station 49 in August with 11.1% of total; and in September at stations 58 (22.2%) and 96 (11.1%).

DISCUSSION

Catches

Catches depend on many factors, among which an important factor is the availability of fish in a determined area. Another factor that usually is not measured in fisheries-independent surveys is individual fishermen efficiency, a reflection of individual experience and ability. Kawaguchi (1974) and Munro (1983) reported that experienced line-fishermen tend to catch an average of 50% more than less experienced fishermen under identical circumstances.

The results obtained indicate not surprisingly, that the highest CPUE were recorded by the two most experienced fishermen, with the lowest effort. Although, this result was not tested statistically, it indicates that when fisheries-independent data are evaluated, crew experience clearly affects the results in terms of the CPUE by as much as two folds. Thus, this is another variable that should be taken into account at the time of data analysis and evaluation (Table 2).

Since 1988 a shift in the types of gear used by Puerto Rican fishermen has been registered. Traditionally, traps constituted over 50% of total landings (Suarez-Caabro, 1970; Weiler and Suarez-Caabro, 1980; García-Moliner and Kimmel, 1986; Collazo and Calderón, 1988), but since 1988 an increase in the use of handlines has been registered (Matos and Torres, 1989; Matos and Sadovy, 1990, Matos, 1992). Also the percentage of landings with handlines has increased. Therefore this gear is becoming more important in Puerto Rico fisheries.

Contrary to the surveys undertaken in 1988-89 (Rosario, 1989) and 1991-92, (Rosario, 1992b) from which the methodology for the present study originated, coneys tend to dominate the catch for both tested gears, at least in terms of number, over red hinds. In terms of weight, being a smaller species than the red hind, it represented a lower percent of the catch. Also, two factors contributed to these results; sample locations or stations, and that, unfortunately, the 1993 red hinds spawning aggregation was not monitored since both of vessels used for the study were out of service during the aggregation period. Efforts to monitor red hind spawning aggregations have been made from 1987 to 1992.

Other factors affecting CPUE are related to depth and apparently to moon phase at least with respect to groupers species. Red hinds are caught in deeper waters than coneys, and appear to be more abundant as depth increases. With respect to moon phase, both coneys and red hinds were more prone to be caught during the new moon. Another point of interest is that red hinds are caught in places near the platform edge. Munro (1974a) reported that catches improved as the edge of the Pedro Bank was approached, although he was not able to establish whether this was related to the presence of actively growing corals or simply an "edge effect" which occurs irrespectively of the degree of development of the sill reef. Smith and Ault (1993) found that stratification by a combination of depth and substrate composition was the most efficient sampling design for both red hinds and coneys, for a data set collected using the same methodology of the present study, from September 1991 to June 1992.

Coneys, on the other hand, tend to be caught in shallower waters. However no particular trend has been observed with regards to catch ability related to moon phase. One factor that might have affected the coney catches is the sampled area. During this study, a greater number of stations close to shore were sampled compared with the 1991-92 survey. Data gathered nearer to the coast, reflected that coneys appear to be more abundant in those areas, contrary to catches at the site of El Bajo de Cico, which is an oceanic bank separated from the platform 3/4 of a nautical miles in the nearest point. Whether this pattern might suggest some shift in the species composition for these areas, is not clear at this point. Thompson and Munro, (1974c) reported that at least in some areas in Jamaica where fishing effort was high, red hinds were displaced by the graysby. It has never been cited in the revised literature that higher levels of coneys might indicate overfishing, as in the graysby case, but some thought may be given to it, since, at least on the west coast of P.R., coney seems to have replaced red hinds in some of the shallower parts of the red hind habitats.

Smith and Ault (1993), determined that both coneys and red hinds were abundant in deep coral areas, and that coneys were also abundant in intermediate depth coral/sand habitat while red hinds were not. This indicates that habitat preferences and thus spatial distributions may be different for the two species. They also found that season, defined as spawning and non spawning, has the most pronounce effect upon CPUE of red hinds. They found that mean CPUE was as high as two folds during spawning season than during non-spawning season for hook and line and fish traps catches. Meanwhile, they found that location rather than season affects coneys mean CPUE by gear.

Trap catches are highly influenced by a series of variables of which the most important is fish availability. This factor tends to be influenced markedly when using traps for short soaking periods (Munro **et al**, 1971; Munro, 1974c; Stevenson and Stuart-Sharkey, 1980; Beets, 1993). Other factors such as baiting effect, moon phase, presence of conspecifics, escapement of traps by fishes, the design of the trap, and the width, length and form of the trap entrance or the funnel have been identified as important factors affecting trap catches (Munro **et al**, 1971; Munro, 1974b; Luckhurst and Ward, 1987, Beets, 1993). Nevertheless, trap catches are comparatively similar to those obtained with hook and line.

Beets (1993) demonstrated that there are differences in traps catches among shelf areas. He found differences in species abundance and composition between three sampled areas of the U.S. Virgin Islands. He proposed that although, much of the differences can be accounted by habitat differences, at least for one of the sampled areas, fishing effort is the probable cause of the observed differences.

Retention of fish in a trap is not only affected by the mesh size but also by the shape of the mesh and the flexibility or "gauge" of the wire used. Fish size and shape are also important factors in fish ability to escape through certain mesh sizes and shapes (Sutherland **et al**, 1987).

Miller and Hunte (1987) state that the principal limitation of traps as a survey tool is that they provide only an index of fish abundance, assuming that the fishing area of a trap is about the same for different times and places. This is a major concern when trying to extrapolate from diverse places and habitats. Miller (1989) stated that numerous factors other than density affect catch rates, besides effort must be calibrated to convert catch rates to indices of absolute animal density.

Bannerot **et al**, 1991 stated that for an optimum stratification, the number of replicates within sampled stations should be increased. The stratification of data collected during the 1988-89 study in some cases reduced the system variance by 45%. A stratification by geographic area was less efficient for traps, and more efficient for hooks. Stratifying by depth, was more effective for hooks in the snapper-grouper complex. Smith and Ault, 1993 found that for the red hinds, the best stratification was by season (spawning and non-spawning) and by depth.

Data sampled with hook and line for the study undertaken in 1991-92 (Rosario, 1992a; Smith and Ault, 1993) tends to confirm that, stratification by depth is effective for the snapper-grouper complex caught with hooks. In this study, data pertaining to snappers is very scarce, due to the fact that sampling is restricted to depth lower than 50 fm and to daytime. Snappers caught during 1988-89, were mainly deep water snappers, silk snapper, blackfin snapper, and vermillion snapper, that were caught in the shallower parts of their habitats, between 50 and 100 fm. Of these species, the vermillion snapper and the blackfin snapper are quite common in the depth range of the 50 to 100 fm, while silk snappers are more prone to be caught in deeper waters. Also, the vermillion snapper tends to be quite common in depth ranges of 30 to 50 fm, (at least juveniles). Furthermore, Smith and Ault (1993) demonstrated for the data collected during 1991-92, that one of the best stratification for the groupers was by depth, for both the coneys and red hinds. It was also demonstrated that for red hind, another stratification could be done by spawning season and non-spawning season. Unfortunately, for this survey, the red hind spawning aggregation could not be sampled.

For the same data set 1988-89 (Rosario, 1989) it was found that red hinds caught at deeper waters, over 35 to 50 fm, tend to have a greater mean size than those caught in shallower waters (less than 20 fm). Another finding was that red hinds were caught in greater numbers in waters of depth greater than 30 fm. On the other hand, coney were more prone to be caught in shallower waters.

All these trends were followed and confirmed with data gathered in this study. The question that is unavoidable, is whether the optimum sample size was reached, during this survey. The most probable answer is no, although a great deal of improvement has been achieved. One of the major problems with the data set collected in 1988-89, was that for any single sampling date, data were lumped all together. This fact precludes to identify variance sources. In the present study, data was kept separated for each component, therefore it is easier to identify variance sources, allowing for improved sample design in the future, if necessary.

Species Composition

Species composition is influenced by depth, the amount of effort put into the fisheries (Regier, 1973), and in a broader sense, by the general habitat that is sampled.

One of the main goals of fisheries-independent data collection effort is to reflect as closely as possible the real catch composition by gear type used. It has been widely recognized that fisheries-dependent data does not reflect actual species composition. This has been addressed several times in Puerto Rico because of under and misreporting of catches as well as elimination of bycatch prior to reaching dockside (Bohnsack **et at**, 1986; Matos and Sadovy, 1990; Rosario, 1989). The catch results obtained in the present study are estimated to be a more accurate representation of the catch for the west coast using fish trap and hook and line gears. Variation in species composition between this survey and those that are fisheries-dependent and reported by port agents from the Statistic Project of the Fisheries Research Laboratory may be due to targeted species and fishing time as well as geographic fishing areas. Importantly, the fisheries-independent data collection effort takes into account bycatch, which were usually underrepresented in landings data, such as squirrelfishes, sand tilefishes, and more importantly ciguatoxic species such as the jacks and barracudas. Although, these species were considered bycatch until early 1990's, now are sold as third class fish in most fishing centers around Puerto Rico (Matos, 1991; 1992 in preparation). This fact is a highly distressing one, since is a reflection of the actual status of Puerto Rico fisheries, which have shown a declining trend since 1979 (Bohnsack **et al**, 1986; García-Moliner and Kimmel, 1986; Appeldoorn, 1987; Collazo and Calderón, 1988; Matos and Torres, 1989; Sadovy, 1989; Matos, 1990; Matos and Sadovy, 1990; Matos, 1991 and 1992; Dennis **et al**, 1991).

Data gathered by the Fisheries Research Laboratory (FRL) shows that the bycatch is consistently high, although, the individual contribution of certain species varies through time. From historic data collected since 1986 the bulk of the bycatch has been comprised of squirrelfishes, sand tilefishes, and jacks. Their relative contribution to the catch varies from one year to another.

The results obtained in this study are similar to those obtained from studies of other years, for the same area and with the same gears. The catch was dominated by the same two species of groupers, the red hind and the coney. Previous surveys yielded similar results for the area (Rosario, 1988; Rosario, 1989; Rosario, 1992a, 1992b). From these earlier studies, the results obtained were the following: April 1986-March 1987, red hinds constituted 20% by number and coneys 23%; April 1987-March 1988, red hinds made up 31% by weight and coneys represented 29%; April 1988-June 1989, red hinds represented 39% by weight and coneys 13%; September 1991-June 1992, red hinds 69% and coneys 9%.

Fish traps species composition is influenced by mesh size. From a mesh size study undertaken by the Fisheries Research Laboratory in 1990, (Rosario and Sadovy, 1991; Rosario and Sadovy, in press), it was demonstrated that the mesh size of 1.25" x 1.25" hex (used in the current study), caught the greatest diversity of species. Stevenson, (1978) Stevenson and Stuart-Sharkey (1980) demonstrated that the red hind, **E**. **guttatus** (cabrilla) and the white grunt,

Haemulon plumieri (cachicata blanca), were being overfished by the 1.25" mesh size on the west coast of Puerto Rico.

It has also been noted that catch composition changes with soak time (Munro, 1974b; Stevenson and Stuart-Sharkey, 1980; Hartsuijker and Nicholson, 1981; Beets, 1993). Another factor that affects the performance of traps in the capture of targeted species is the distance that traps are set away from reefs (High and Beardsley, 1970; Hartsuijker and Nicholson, 1981; Luckhurst and Ward, 1987), as does the distance between traps, or the effective area fished by traps (Sinoda, and Kobayasi, 1969; Eggers **et al**, 1982; Miller and Hunte, 1987).

Length Frequency

Although, length-frequency analysis were performed separately for species caught with the two different gears, it is more appropriate to discuss both gears at the same time. The main reason is related to the results obtained during this study, which are different from those obtained in previous years.

Comparing the size frequency distribution of coneys sampled with hook and line and with fish traps, it can be observed that coneys sampled with traps were significantly larger than with hooks. These results are similar to those obtained from data gathered in the survey undertaken from September 1991 to June 1992 (Rosario, 1992). This represented the first time in which the distributions reflected gear selectivity. In the revised literature from the Caribbean area, gear selectivity has never been reported for sampled coneys. Thompson and Munro (1974), reported no gear selectivity for sampled coneys with traps and hook and line. Also there is no data available in Puerto Rico regarding depth effects or soak time effects on trap catch rates for coneys.

Similar results were obtained for the red hind, i.e. sizes of individuals caught with traps were larger on average than those captured with hook and line. The observed differences in size distribution were statistically significant (Kolmogorov-Smirnov, $d >> D_{.05}$). This is a reflection of gear selectivity, being this the second consecutive year in which this trend is recorded, at least, for surveys carried out at the Fisheries Research Laboratory of Puerto Rico. Thompson and Munro (1974b), did not find gear selectivity in the size distributions of red hind sampled with these two gears in Jamaica, although, those captured with traps (1.25" hexagonal mesh) were of slightly higher average size, similar to the results of this survey. Matos (1991), on the other hand, reported that size frequency distribution of red hinds captured with hook and line were significantly larger than those taken with fish traps, for red hinds sampled during 1988-89 and 1990.

Stevenson and Stuart-Sharkey (1980) demonstrated an independent depth effect for red hinds captured with traps. Red hind catches (mean number and weight) were not significantly different for two tested depths (30 and 50 m). They also demonstrated a soak time effect with higher overall catches at intermediate soak times (5 days). The latter could explain the low red hind catches by traps during this study, which were soaked only for 5 to 6 hrs daily. Thompson and Munro (1974b) stated that catch rates by hook and line showed greater variability than those of traps, mostly related to wind and current and not necessarily related to the abundance of groupers at the sampling stations.

Another, point of interest in comparing these two distributions, is that trap distribution clearly shows no catches of small animals and a loss of the larger animals, while hook distribution shows clearly that recruitment occurred during the sampling period, although the loss of larger animals is quite evident. This result differs from what has been the trend over the past six years (1987-1992) (Rosario, 1988; Rosario, 1989; Appeldoorn **et al**, 1992). Data gathered from spawning aggregations from 1987 to 1992, reflects an apparent lack of recruitment of juveniles to the fisheries (Sadovy, **et al**, in press). Although, spawning aggregation data is not available for 1993, at least the obtained size frequency has started to show some evidence of recruitment, during the sampling period.

Sadovy and Figuerola (1992) identified that red hinds in Puerto Rico are growth overfished. One of the major concerns at the present time in Puerto Rico is to find an effective measure of managing this resource. Among proposed management measures in Federal and State Waters, there is a measure to prohibit fishing at the red hind aggregation sites during the spawning season from December to February. This, in conjunction with an increase in the legal mesh size used for fish traps, are considered to be the two most effective management measures.

Regarding trap catches, it is not clear which factors might be affecting these. A mesh size selectivity survey conducted during 1990 (Rosario and Sadovy, 1991 in press) showed that red hinds and coneys were more susceptible to be caught by smaller mesh size, in particular by the mesh size used for this survey (1.25" hexagonal mesh). These results were statistically significant. These latter factors have been identified by several authors in the Caribbean region to be of great importance, not only in considering the effect of mesh size on trap catches, but in trap catches in general (Munro, 1974b and c; Stevenson, 1978; Stevenson and Stuart-Sharkey, 1980; Hartsuijker and Nicholson, 1981; Munro 1983; Ward, 1987; Ward and Nisbet, 1987). Therefore, when considering a management measure such as an increase in legal mesh size, all these factors should be addressed.

Gear selectivity is of great importance as it relates to length of first recruitment into the fishery. It is clear that size selection by mesh occurs (Munro, 1974; Stevenson, 1978; Stevenson and Stuart-Sharkey, 1980; Hartsuijker and Nicholson, 1981; Munro 1983; Ward, 1987; Ward and Nisbet, 1987; Bohnsack, **et al**, 1989; Rosario and Sadovy, 1991, Smith and Ault, 1993).

Squirrelfishes have been an important part of the fishery around Puerto Rico, but are greatly underepresented in fisheries dependent samples due to their low economic value. However, Matos and Sadovy (1990) reported that in certain areas "third class" fish include large individuals of squirrelfishes, which points to a possible future exploitation of this species as other economically important species become more scarce. The number of individuals and their contribution to our catches has decline in the last three years, which points to some kind of exploitation, although it is underrepresented in fisheries-dependent data.

Stevenson and Stuart-Sharkey (1980) found that **H**. **ascensionis** sampled with traps off the western coast of Puerto Rico showed a significant depth effect (larger fishes were caught at greater depths) for the number and weight of sampled individuals. Longjaw squirrelfishes were more frequently sampled in deeper water and with soak times of 6 days, than parrotfishes and groupers. These authors also found that during the spring, species composition for the sampled area changed dramatically in shallow waters, being composed of grunts (**Haemulon** **plumieri**), parrotfishes and small squirrelfishes (**H**. **rufus**). Species composition at other times of the year was comprised of groupers, snappers, goatfish, jacks, queen triggerfish and scarids, among others.

Sand tilefish (**M**. **plumieri**) was not represented in Puerto Rico landings data, although the species is traditionally sold in Aguadilla. Matos (1993, in preparation) reported that this species has become of commercial importance and are actually sold. Dooley (1978) compiled information (systematic and biological) of the sand tilefish for specimens collected off the west coast of Puerto Rico. Baird and Baird (1992) described the colonial social structure of this species. But for Puerto Rico, there is very few available data on this species. Their colonial social structure, could lead this species to be overfished, since they are sedentary animals that stay close to their home range, and are usually clustered in definite places (Shapiro, 1987; Baird, 1988; Baird and Baird, 1992). For these reasons, they could be easily targeted in some areas.

From previous surveys carried out by the Fisheries Research Laboratory Exploratory Project, sand tilefish have comprised an important part of the catch, both in terms of number and weight of individuals captured. This species constituted the third most captured with hook and line in 1988-89 (Rosario, 1989), 1990 (Rosario, in preparation), and 1991-92 (Rosario, 1992) as was for this survey.

Reproductive State

Data on spawning seasonality of selected species were collected incidentally and are compared with published literature from the region. Not all months were sampled comprehensively for all species and hence only broad patterns may be presented. These are represented predominantly in terms of percentages of ripe individuals on a monthly basis where data are available.

Spawning periods of coney have been recorded from different surveys conducted at the Fisheries Research Laboratory to be quite variable. Erdman (1977) reported the spawning season of this species to be between the months of December to February. Rosario (1989) reported that for various sampling periods this was the most likely, although data is incidental. Thompson and Munro (1974b) reported ripe fishes between November and July, with peak spawning activity in January to March, and a subsidiary peak in June and July, for sampled coney in Jamaica. They also reported that the highest proportion of spent gonads were taken in April.

From this survey data is to scarce in regard to the number of ripe individuals, although those ripe individuals were all caught in April (1992 or 1993). For the period of December 1992 to February 1993, sampling could not be performed and this period of time represents the spawning period of coneys as well, as red hinds.

The spawning period of red hinds in Puerto Rico waters has been reported to occur around the time of the full moon of January or February (Erdman, 1977). Erdman also reported that every several years there is a shift in the spawning pattern of this species. Other authors from the Caribbean region have reported similar results to those of Erdman (1977), which are similar to data collected during the spawning aggregation of the past five years. Thompson and Munro (1974b) reported ripe fishes only from December to March and the greatest number of fishes with ripe gonads were collected in January.

Data gathered by the Fisheries Research Laboratory confirms these findings, since in some years the spawning activity occurred mainly during January, or in other years during February. Data from this survey is practically non useful in this regard, since data for those months was not collected.

Sand tilefish breeding season in Puerto Rico has been reported to be from December to March (Colin, cited in Thresher, 1984). Erdman (1977) reported males with subripe gonads during March for the southwest coast of Puerto Rico. Colin and Clavijo (1988) reported spawning for sand tilefish in the same area from October to March. Baird (1988) reported spawning season from February to August in Belize. No particular trend was observed for sampled sand tilefish during this study. Although, the high numbers of ripe individuals (males and females) during April tends to point a spawning period around this time.

Vermillion snappers showed a higher percentage of ripe gonads in April and May. Erdman (1977) reported the spawning period of this species to be from March-May, which is compatible with the obtained results in this study. Thompson and Munro (1974a) reported a single active male during May and ripe females during November in Jamaica. Boardman and Weiler (1980) reported a year-round spawning season for this species. Fifty percent size of sexual maturity for this species has been reported to be 140 mm and 200 mm FL for males and females (Boardman and Weiler, 1980), respectively, and 320 to 360 mm FL (Grimes, 1976). In this survey, 50% size of sexual maturity was 220-230 mm FL for females and 210-220 mm FL for males.

Although data regarding spawning season and sexual maturation of silk snappers obtained from this study are very scarce, the available data tends to confirm what is a major concern for this species. Over 100% of sampled silk snapper in this survey were sexually immature. Grimes (1987) demonstrated that species associated with islands and deep habitats mature at relatively large sizes when compared to those associated with continents and shallower habitats. Boardman and Weiler (1980) reported that female silk snappers mature at 500 mm FL and males at 380 mm. More recently Figuerola (1991) reported that the 50% size of sexual maturity for females snapper was 410 mm of FL and 265 mm FL for males.

Spawning season of silk snapper in Puerto Rico and Jamaica has been reported as year round (Erdman, 1977; Boardman and Weiler, 1980; Munro, **et al**, 1973).

Munro **et al**. (1973) provides the only previous information on spawning seasons of chaetodontids. These authors reported that the greatest proportion of ripe fishes in Jamaican waters were collected in January-February, but that more than 40% were ripe in all months. The proportion of inactive fishes was greatest in September to December. In this study, sampled females during the months of December, and from March to June were ripe females. While ripe males were collected during March, May and June, fishes with spent gonads were sampled during April and May. These results suggest a breeding season around April. On the other hand, no active fishes were sampled during September to November, which is consistent with the available information from Jamaica.

Bardach (1958) reported that members of the genus **Chaetodon** usually occurred in pairs, and the members of the pairs were identified as male and female. In the Virgin Islands, Sylvester and Dammann (1972) observed that butterflyfishes entered fish traps in pairs. Information gathered at the Pacific (Hobson, 1972; Reese, 1973), reinforced the above observations. These authors reported that butterflyfishes that were paired around midday, often remain paired. Aiken (1975) reported the same reproductive behavior in butterflyfishes at the Port Royal reefs, Jamaica, while diving and from trap catches. Information gathered from this study are consistent to those in the literature. Over 90% of the sampled banded butterflyfishes were in pairs, and the pairs were usually male and female.

CONCLUSIONS AND RECOMMENDATIONS

The major purpose of this study was to establish a data base of fisheries-independent data, which is essential for fisheries managers. Although there are some gaps in the way the data was collected, at least, the sampling protocol was quite defined, and useful data was collected. The major achievement was to identify the best stratifying criteria for future monitoring of the resources. Some of this criteria were implemented for the last quarter of the sampling period, such as increasing the number of traps, to monitor the effects of depth on catches, and try to establish the bottom substrate in sampled stations.

Species composition results obtained from the present study were compared to those obtained in previous fisheries-independent surveys undertaken by the Fisheries Research Laboratory. Serranids dominated the composition, both in terms of weight and number for both gears. The red hind was the most abundant species of the catch, followed by the coney, in terms of weight. These results are similar to those obtained during the survey conducted in 1988-89, which served as a basis for the sampling protocol of the present study.

As the sampling continues during the next few years, (following the sampling protocols established in the present study, and as they become more refined in the number of stations and replicates) a better and more accurate perspective of the conditions of the resources off the west coast of Puerto Rico should be obtained. Although, to better the picture of the resources off the west coast of Puerto Rico, some other concurrent surveys should be taken, as for example, to map bottom substrate at least for the sampled stations and determine an index of recruitment into fisheries.

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