U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL MARINE FISHERIES SERVICE
DUVAL BUILDING
9450 KOGER BOULEVARD
ST. Petersburg, Florida 3370:

REPORT FOR:

[ ] COMMERCIAL FISHERIES RESEARCH AND DEVELOPMENT ACT (PL 88-309)

[ ] ANADROMOUS FISH ACT (PL 89-304)

[**X**] STATE/FEDERAL [ ] COUNCIL LIAISON

STATE__________ TYPE OF REPORT: [ ] Quarterly (Coordination projects only)

[ ] Annual Progress or Segment

[**X**] Completion

PROJECT NO. **NA077FS0084** SEGMENT NO. 01-03

PROJECT TITLE **Shallow-water Reef Fish Monitoring SEAMAP-Caribbean Fisheries Independent Monitoring**

PERIOD COVERED April 1, 2000 to March 31, 2004

PREPARED BY Aida Rosario Jiménez DATE __________

APPROVED BY Luis. E. Rodríguez Rivera DATE __________

ABSTRACT

67 of Puerto Rico. Hook and line yielded thirty-eight species representing 19 families weighing over 288 kg of finfish. The groupers, constituted 47.1% of total catch, of which two species of represented 45.7% of the hook and line catch in terms of number. During this sampling period efforts were made to mark and release these two species of groupers. In this report were considering only those individuals that were landed, not those released.

Red hinds (*Epinephelus guttatus*) and coneys (*Cephalopholis fulva*) represented by weight 19.8% and 25.8%, respectively of the total hook and line catch. The graysby (*C. cruentata*) was the third species of grouper that made up the bulk of this group category for both sampling periods. Snappers, which are considered the most valuable commercial species group, were scarcely represented.

Fish traps yielded seventeen species representing nine families weighing over 36 kg of finfish. Catches by number were dominated by the same species as for hook and line catches. Red hinds constituted 14.6% of total trap catches by number, while coneys made up 18.2%.

Species composition by sampled stations varied according to three factors: area, fishing gear and depth. Nevertheless, observed species composition is believed to reflect the actual composition of commercial landings in Puerto Rico for the gears used in this study. Fisheries dependent landings data collected by port agents under represents certain fish groups that are discarded by fishers due to low economic value (***e.g.*** butterflyfish).

Catch per unit effort (CPUE) by stations ranged from 26.48 to 88.83 g/trap hours; and from 47.00 to 1,433.56 g/hook hours, disregarding cero catches. Fishers experience influenced CPUE; in general terms most experience fishers had a greater CPUE than those with less experience. The two most experience fishers accounted for over 50% of total landed fish by number and weight, respectively.

A fishery independent survey of the queen conch resource was conducted off the west coast of Puerto Rico. A simple random sampling design was used. Paired (and pooled) transects were conducted at each station, with data collected by divers using visual census. Data were collected on conch abundance, length and age, and on habitat type and distribution. Mean density overall was 14.42 conch/ha. The estimated population size of the stratum was 1,284,000 conchs. The majority of conchs were juveniles. Density was highest in seagrass habitats (15-36 conch/ha). Comparison to past surveys indicates a large, but still statistically non-significant increase in density and population size. Nevertheless, even if the increase is real, total density and abundance are still quite low in comparison to other areas and in consideration with known aspects of conch biology and reproduction.

A fishery independent survey of the spiny lobster was conducted during the sampling period of April 1, 2002 to March 31, 2004 off the west coast of Puerto Rico. This survey involve to different objectives: 1. monitoring of post-larvae settlement and 2. juveniles settlement. Postlarvae recruitment was conducted off the West Coast of Puerto Rico using Whitman collectors. Sampled areas included different types of habitat substrate, in order to assess preferences in habitat by puerulus. A total of 188 post larvae were collected, 22% occurred in one sampling events, suggesting that recruitment is somewhat by pulses. The relative abundance of post larvae was approximately 1.1 post larvae/collector/sample. Data collected were not enough to determine recruitment seasonality pattern.

Juveniles recruitment was performed on two sites with ten stations at each one comprised the areas to be sampled with the casitas. All stations where visited once a month to collect data on juvenile lobster recruits. Recruits quantity and size information was collected. The sizes are from the cephalothorax, measuring from the spines to the end of the thorax. Juvenile lobster recruits were reported in only eight of the twenty artificial shelters. These were all from the first set, in the shallow water. No juvenile recruits were found on stations set at deeper water. Strong currents and, perhaps fishing activities, destroyed the square of several shelters. One factor that might be influencing the lack of recruitment is this area is the habitat type, besides the strong current which might prevent settlement of pueruli in the area.

Assuming that the recruits observed on one visit are directly related to the ones observed on the previous visit, the following conclusion could be reached. Estimating from the size of the recruits observed, on stations 3 and 4, we could assume that some of the recruits might have stayed on the shelters for a couple of months. Table 1 show, that 30% of the observed recruits on the first size category passed to the second size category. From those on the second size category 15% passed to the third size category. Predation, fishing and migration are possible causes for not observing more of the recruits developing to bigger sizes for a longer time.

Fisheries Independent Monitoring of Shallow Water Reef Fisheries

Completion Report
to
NOAA/NMFS/SEAMAP PROGRAM

Prepared
by
Aida Rosario
Miguel Figuerola
Nilda M. Jimenéz
Dr. Richard S. Appledoorn

Submitted
by
Honorable Luis E. Rodríguez Rivera
Secretary
DEPARTMENT OF NATURAL AND ENVIRONMENTAL RESOURCES

AUGUST 2004

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AUGUST 2004

Abstract

During the sampling period of April 1, 2000 to March 31, 2001, a total of 12 stations were sampled west of Parallel 67 of Puerto Rico. Hook and line yielded thirty-eight species representing 19 families weighing over 288 kg of finfish. The groupers, constituted 47.1% of total catch, of which two species of represented 45.7% of the hook and line catch in terms of number. During this sampling period efforts were made to mark and release these two species of groupers. In this report were considering only those individuals that were landed, not those released.

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Abstracto

Durante el período de muestreo del 1^ro abril de 2000 31 de marzo del 2001, un muestreo fue hecho en un total de 12 estaciones al oeste del Paralelo 67 de Puerto Rico. Las líneas capturaron treinta y ocho (38) especies representativas de 19 familias con un peso sobre 288 Kg. de pescado. Los meros constituyeron el 47.1%, de los cuales dos especies representaron un 45.7% por número del total de la captura.

Las cabrillas (*Epinephelus guttatus*) y las mantequillas (*Cephalopholis fulva*) representaron 19.8% y 25.8% por peso del total de la muestra. La cabra mora (*C. cruentata*) fue la tercera especie más capturada en la categoría de los meros. Por otra parte, los pargos que constituyen el grupo de mayor valor comercial, tuvieron una representación baja.

Las capturas de las nasas resultaron en 36 Kg. de pescado representando 17 especies pertenecientes a nueve familias. Las capturas en término de número fueron dominadas por las mismas especies que las capturas de las líneas. Las cabrillas constituyeron el 14.6% del total de las capturas por número, mientras que las mantequillas representaron el 18.2%.

La composición de especies por estaciones varía de acuerdo a tres factores: área, arte de pesca y profundidad. La profundidad y el área pueden ser un reflejo del hábitat. De todas maneras, la composición de especie obtenida es un reflejo actual de los desembarcos comerciales en Puerto Rico para las artes de pesca usadas en estos muestreos, ya que los desembarcos dependientes de las pesquerías recopilada por los agentes pesqueros no representan todos los grupos de pescado ya que ciertos grupos o especies son descartadas por los pescadores, debido a su bajo valor comercial (Ej. las mariposas).

La captura por unidad de esfuerzo (CPUE) por estaciones varió desde 26.48 a 88.83 g/nasa hora; y desde 47.00 a 1,433.56 g/ anzuelo hora, sin contar las capturas 0. La experiencia de los pescadores influenció el CPUE, en términos generales, los pescadores de mayor experiencia tienen un CPUE mayor que aquellos menos experimentados. Los dos pescadores de mayor experiencia capturaron sobre el 50% del total de la captura desembarcada en términos de número y de peso.

Acknowledgments

I wish to express my sincere gratitude to all who, in one way or another, contributed performed the project and to the completion of the report.

Special thanks are due to all the members of the Exploratory Fishing Project for their dedication to their work, those that are still members of this program and those that no longer are with us. To Ms. Verónica Seda and Ana Rivera which help with the edition of this report. As well to Ms. Nilda Jiménez, Ms. Milagros Cartagena, Mr. Luis A. Rivera, Mr. Hector López, Mr. Miguel Figuerola for his help in the performance of the surveys.

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Introduction

There is a paucity of fisheries dependent data and an increasing decline of shallow water reef fish resources point to the need in fisheries independent data to make wise management decisions. Fisher maintain few and poor records and reporting is therefore biased and data reliability is questionable. Fishing effort increased and a shift in catch species composition has been noted by fisher and management 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. Reef fish resources are the most important fisheries in the Caribbean (Munro, 1983). Due to the lack of reliable fisheries-dependent data, fisheries-independent data are needed to effectively evaluate management plans and measures.

In 1989 a preliminary survey was conducted by the Fisheries Research Laboratory of the Puerto Rico Department of Natural and Environmental 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 survey were analysed 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 analysed 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 fishers. 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 fisher.

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 exploring, identifying new fishing areas and implementing new fishing technique and gears and establishing the viability of introducing them in Puerto Rico. Several researchers conducted different surveys testing several fishing gears, being the two most often used the fish traps and snapper reels. The results of these surveys are published, among those are Juhl, 1969 and 1972, Juhl and Suarez-Caabro, 1973; Cole, 1976; and Boardman and Weiler, 1980.

Two major changes has undergo in the sampling methodology. The first involves stations replicates in order to detect trends and lower variability. The second involves catch and release of the red hinds (*Epinephelus guttatus*) mainly during the spawning season to determine the population of this species. These changes reflect the need of fishery independent data to manage the fisheries and to assess the effect of management measures of certain species. The case of red hind spawning aggregations closures off the west coast of Puerto Rico has proved to be highly effective. Presently, this program is more concerned with the management and conservation of the resources and gathering data that could help in a better understanding on the status of the resources, undertaking fisheries-independent monitoring and data collection.

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 projects of PR and the USVI.

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 analysed in order to establish the optimal design for the long term Reef Resources Survey.

Method

1. Sampling was carried out using fish hooks (size #06), using squid as bait, and the standard fish trap using 1-1/2" square mesh size using sardines as bait. Over the western shelf area of Puerto Rico the platform was divided into 2x2 nmile sampling units, subsequently referred as ‘quadrants’ (Figure 1). Quadrants were further subdivided into 16 quadrants of 0.5x0.5 nmiles for sampling purposes. Global Positioning System (GPS) established location of sub-quadrants. Some details concerning sampling were subject to minor modifications depending on logistics and prevailing conditions of weather and vessels.
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; (0-18 m)
    b) 11-20 fathoms; (19-36 m)
    c) 21-50 fathoms; (37-90 m)
3. Sampling frequency was assigned equally to each depth stratum a) to c) above. Within a given depth stratum, quadrant samples were assigned randomly as was the sampled sub quadrant within the selected quadrant. Five different quadrants were randomly selected per depth stratum for sampling. Ten samples were planned for each quadrant over the 12 months period of the study resulting in 50 samples per stratum, and a total of 150 samples (trips) for Puerto Rico. Numbering of sub quadrant was 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' 1.5') were set on any one sampling day by a single research vessel in the randomly chosen sub quadrant for the selected week. Fish traps were baited with sardine. Mesh size of traps was 1.5" square vinyl coated. The week of the year to sample any particular sub-unit was 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-traps distance was at least 150 feet to avoid inter-trap interference. It originally was intended to have two research vessels in operation, but this was not feasible due to mechanical complications.
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; time of soak; and time fishing with hooks).
    B. Quadrant code and sub quadrant code (1-16); GPS bearings (latitude and longitude).

C. Depth (fm).
D. Total number of traps hauled/hooked fished per vessel.
E. Trap set and number of the trap in the set. Record the condition of the traps (i.e. broken wire, door open, escape panel condition).
F. Number, weight, length (fork length), and identification of fish per individual trap, as well as by individual fisherman.
G. Substrate type was characterized whenever possible, mostly from whatever got entangled in the fish traps.
H. All fish captured was sexed as follows:
   1. Unripe individuals are designated as F1 and M1.
   2. Sub-ripe individuals are classified as F2 and M2.
   3. Ripe individuals are designated F3. (females with ovaries usually transparent and colorless; enlarge gonad with large, well developed eggs); and M3 (males with testes with loose or running milt).
   4. Spent gonads F4 and M4; individuals with enlarged and flaccid gonads.

Two principal gonad stages were used for each sex to establish the spawning period of selected species: ripe and spent gonads.

7. Catches by individual fisherman were kept separated for each fishing trip. The data were entered with an identification code for each fisher so that it could be analysed for each fishing member. These data could provide an estimate of fisherman productivity and also an indication of the variability of individual fisherman performance. In the same manner, data collected from individual traps are kept separated and identified by set and trap.
8. Data were entered, edited, and stored on microcomputer on DBASE IIIPlus standardized format. Semi-annual summaries performance and annual reports including data summaries were completed using Quatro Pro 4.0 and Word Perfect 5.1. Data was also entered and stored on SEAMAP software 3.0 and sent to the SEAMAP Database Manager in Pascagoula, MS.
9. A statistical analysis of data, including recommendations on sampling design will follow completion of the study.
10. 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. Some modifications have arisen to this classification, as certain species that formerly did not have commercial values are now being reported in landings, with commercial value (Matos, 1993). This classification varies markedly from coast to coast, but in general, reflects the classification used by the majority of fishermen in 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.
11. Species with a minimum sample size of one hundred individuals for the entire year were taken into consideration for the analysis of length-frequency data. A 10 mm size class interval was considered most appropriate for collected groupers, sand tilefish and squirrelfishes. For the butterflyfishes the most seemly class interval corresponds to 5 mm, while for snappers and parrotfishes a 20 mm class interval was selected. Some of the species taken into consideration for this analysis had a minimum sample size of fifty or less individuals, but were considered to be important part of the catch during the first year of this survey as well as during the present survey.

Geographic Location

Sampling was on the west coast of Puerto Rico from Rincón to Cabo Rojo (Figure 1).

Hook and Line Catches

General Catch

Hook and line yielded a total of 1,049 finfishes weighing over 288 kg, belonging to thirty-eight (38) species representative of 19 families. A single family, Serranidae, dominated the catch comprising 53.6s and 47.1.0% of total catch in terms of number and weight, respectively (Table1). This family represents the second most important one of commercial importance in Puerto Rico. In general terms, twelve (12) species comprised 93.43% of total catch by weight. On the other hand in terms of number the catch was dominated by eight (9) species, representing 94.75% of the catch.

Two species of groupers were the dominant species. The red hind, *Epinephelus guttatus*, made up 19.8% and 24.1% by number and weight, respectively. Meanwhile the coney, *Cephalopholis fulva*, represented 25.8% and 18.2%, by number and weight.

Total hook and line effort for this sampling period amounted to 560.8 hook hours and 136 line days. A total of 39 trips were performed, covering 12 stations off the west coast of Puerto Rico. The obtained total CPUE was 514.87 g/hook hours and 2,123.06-g/line day (Table 2). Average CPUE by trip in terms of g/hook hours was 512.2 ± 331.3 (Table 2). In terms of weight per trip 7,403.49 g/trip ± 4,794.9 was obtained. Catches range from zero on areas off the west coast platform to a maximum of 1,433.6 g/hook hours at station 96 in March 2001. Meanwhile, in terms of g/line day varied from zero on areas of the platform to a maximum of 5,871.33 at station 95 during October 2000 (Table 2).

Catch per unit effort by fisher

Table 3 summarizes total CPUE by fisherman for the sampling period. Of those fishers listed in Table 3, the first five (1 to 21) are regular members of the Monitoring Program. During the sampling period drastic changes in the crewmembers of the program occur.

Of those fishers listed in Table 3, the first five (1 to 21) are regular members of the Monitoring Program. As can be observed in Table 3, three fishers dominated the catches, fishers #2, #20, and #6. These three fishers accounted for over 71% and 67% of total captured finfish, both in terms of number and weight, respectively. The highest catch was accounted by fisher #20, with over half of the catch in terms of weight (50.7%). The lowest CPUE among these fishers, and the lowest, amounted to 1.34g/hook hour by fisher #1, which turns out to be the fisher with less fishing experience. Accounting for the number of trips in which fishers (regular crew members) recorded zero catches, the greater percentage was reported by fisher #1, with 15.38%.

Figure 2a plots fisher's catches in terms number of fish caught and weight of fish caught by their years of experience. The resulting trends show that catches tend to increase with the number of years of experience, although there is variability in their catches. It's appropriate to point out that the higher catches were recorded by the fisher with more years of experience (fisher 6). Deleting data points from fishers that are not regular crewmembers yield a clearer trend of the results.

Table 4 summarizes fisher catches by number and weight per station, asterisks represents stations that were not sampled by any given fisher. Stations 59, 69 and 95 were stations in which fishers catches were consistently high.

Catch Per Unit Effort by Station

Table 5 summarizes CPUE by stations for sampling period of April 2000 to March 2001. Stations closer that lie 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. Consistently four stations yielded high catches, stations 49, 59, 80 and 95 (Table 5). Catches for these stations represented over 63% of total catch by number and weight, respectively (Table 5). Some of the trends that can be observed may be useful in the allocation of sampling strategies, at least for the grouper species. Snapper sample sizes were so low that it precluded any conclusion regarding their distribution.

A total of 39 stations were sampled, of which 19 stations were sampled in more than one occasion. Sampling frequency per station ranged from a minimum of one up to a maximum of eight (8). Three stations were sampled at least three times, (stations 59, 69 and 95) Table 5a. CPUE per trip for these particular stations varied from a minimum of 241.2 g/hook hours to 297.1g/hook hours (Table 5). The minimum corresponded to station 69; meanwhile, the maximum corresponded to station 59. Station 95 represented a midpoint between these other two stations.

CPUE per trip by station fluctuated from a minimum of 16.0-g/hk hrs for station 48, (disregarding zero catches) to a maximum of 1,112.9-g/hk hrs for station 89. On the other hand, mean CPUE in terms of g/line trip fluctuated from a minimum of 60.00 for station 48 to a maximum of 6,396.9 for station 49. Other stations at which catches were fairly high were: station 59, station 69, and station 95.

Catch Per Unit Effort by Species

Red hind catches are displayed in Tables 6a by station for each sampling years. Most red hinds (56.7% of total number) were sampled at stations 59 (Table 6a) during 2000-01. Higher CPUE were reported for stations 95 and 49 that also reported high numbers of red hinds. All these stations are located at the edge of the west coast platform. Hard bottoms predominate at these stations. In all other stations, catches were considerably low. Of the 12 sampled stations 3 (25.0% of total sampled stations) yielded zero catches of red hind. CPUE ranged from a minimum of 3.75 g/hook hours to a maximum of 264.72, disregarding zero catches (Table 6a). CPUE in terms of g/line day fluctuated from a minimum of 52.80 to a maximum of 2,382.50.

Maximum catches of coney in terms of number were recorded in stations 59 and 96 (Table 6b). Two stations yielded zero coneys; both of those were the same that for red hinds. The maximum CPUE's were recorded by station 9 with 142.07 g/hook hours and in terms of g/line day with 710.33. Disregarding zero catches, the minimum CPUE were 3.61 g/hook hours at station 59 and 191.33 g/line day at station 89.

Sand tilefish were caught essentially in a one station (79.62%) where the bottom substrates were dominated by sand patches and/or algal plains (Tables 6c). However, they were sampled in 50.0% of the total sampled stations (6 out of 12 stations, Table 6c). Highest CPUE was reported in station 80 with 83.00 g/hook hours and in terms of 425.55-g/line day at station 59, respectively. Minimums mean CPUE was reported at station 59 with 5.14 g/hook hours and at station 69 in terms of g/line day with 67.50 (Table 6c).

Black dungon were collected in basically two stations 59 (60.7%) and station 96 (34.5%). Besides this two stations there were collected in two other stations. Highest CPUE for the species was 28.70 g/hook hour at station 96 and 341.33 g/line day at station 59 (Table 6d), respectively.

The longjaw squirrelfish was sampled in greater numbers in stations 59 (54.7%) and in station 80 (28.1%). Maximum CPUE was recorded in station 80 with 207.0 g/hook hour and 1,035 g/line day (Table 6e). Longspine squirrelfish were caught in high numbers in station 59 (68.3%) and station 9 (14.6%). Maximum CPUE was recorded in station 9 in both terms of g/hook hour and g/line day (Table 6f).

Catch Per Unit Effort by Depth Ranges

According to the stratifying depth criteria, minimum recorded CPUE corresponded to the intermediate depth range of 19-36 m 18.47 in terms of g-hook hours; in terms of g-line day corresponded to the shallower depth with 2,062.38 (Table 7a). Maximum CPUE corresponded to the shallowest depth range in terms of g per hook hours with 548.27 and to the deepest depth range (37-90 m) 2,338.30 g/line day, respectively (Table 7a).

CPUE of red hinds by depth ranges varied from a minimum of 1.45 g/hook hours to a maximum of 8.45 g/hook hours (Table 7b). The minimum corresponded to intermediate depths of 19-36 m and the maximum to the deepest depth range of 37-90 m. In terms of g/line day, maximum corresponded to the deepest range 3,243.62 and the minimum corresponded to the shallowest depth range with 819.40. Coneys CPUE presented reported minimum CPUE at the intermediate depth range in terms of g per hook and hours with 0.57 (Table 7c). Maximum CPUE of coneys belonged to the depth range of 0-18 m. In terms of g/line day the obtained results reflect those obtained in terms of g per hook hours.

Sand tilefish yielded the maximum CPUE at the shallowest depth range with 0.35 g/hook hours and 80.72-g/line day (Table 7d). The deepest depth ranges yielded the lowest CPUE in terms of g/hook hours, 0.05; as well as, in terms of g/line yielded 19.94-g/line day.

The black dungon was almost exclusively sampled at intermediates depth ranges (Table 7e). Maximum CPUE was recorded for shallow water depth range in terms of g/hook hour and at intermediate depth ranges in terms of g/line day.

None of the sampled squirrelfish were collected at the shallow depth ranges (Tables 7f and g). Both species yielded the maximum CPUE at intermediate depth ranges in terms of g/hook hour and g/line day. Very few squirrelfishes were sampled at the depth range of more than 36 fathom. Curiously the same number of individuals was caught for both species at this depth range.

Catch Per Unit Effort by Month

Total catch summary by month is displayed in Table 8. During the quarter corresponding to July to September sampling was not carried out. The months in which the lowest number of individuals was caught corresponded to May. The highest number of individual was caught during February. October 2000, recorded the highest CPUE in terms of g/hook hours with 761.18. As well, highest CPUE in terms of g/line day was reported during October 2000, with 3,805.89.

Red hinds were captured at all sampled months with maximum CPUE recorded during October (Table 9a). The month with the lowest CPUE was December 2000, (0.28 g/hook hours and 29.29 g/line day), as well in terms of number. October yielded the highest number of sampled red hinds (Table 9a).

Coneys were caught in all sampled months. The maximum CPUE was recorded during October 3.90 g/hook hours and during November with 688.45 g/line day (Table 9b). The minimum corresponded to February 2001 in terms of g per hook hour with 0.34. In terms of g/line day the highest CPUE was recorded in May 162.10. February 2000 represented the month in which the highest number of coneys was collected meanwhile; May was the month in which the lowest number of coneys was recorded.

Sand tilefish were collected in all sampled months, and the greater number was landed on November (Table 9d). Highest CPUE was recorded during November 2000, with 4.28 g/hook hours and 154.03 g/line day, respectively (Table 9d). Lowest CPUE was recorded in May 2000, with 0.16 g/hook hours and 4.32 g/line day.

Not a single black dungon was sampled during May, while during February and March were caught in almost the same amount (Table 9e). Highest CPUE was recorded during November in terms of g/hook hours and during March in terms of f/line day.

Longjaw squirrelfish were not collected during December, meanwhile longspines were not sampled during June. Highest CPUE of longjaw squirrelfish was recorded in November in both terms of g/hook hour and g/line day (Table 9e). On the other hand longspine squirrelfish yielded highest CPUE during December with 1.68 g/hook hours and during January with 179.77 g/line day (Table 9f).

Species Composition

The major groups of commercial importance in Puerto Rico are snappers and groupers, which represent first class fish. First class fish represented 48.3% and 41.7% by number and weight, respectively of total catch (Figure 3). The species composition was dominated by two species of groupers (Table 1). The red hind, (*E. guttatus*), was the most abundant sampled species, in terms of weight (24.2%) and the second most abundant in terms of number (19.8%). The coney (*C. fulva*), was the most abundant sampled species, in terms of number (25.83%) and the second most abundant in terms of weight (13.6%). Snappers made a negligible contribution to first class fish in both terms of number and weight. They were represented by two genera making up less than 1.0% by number and by weight of total catch.

Second class fish include mainly grunts, porgies, and triggerfishes, as well as smaller groupers and snappers. The triggerfishes constituted the major representation of this class, with three species, the porgy (*Calamus pennatula*), the queen triggerfish (*Balistes vetula*), and the black durgon (*Melichthys niger*). Second class fish in general constituted 15.71% and 29.30% by number and weight, respectively.

Third class fish made up 23.24%, in terms of weight and 35.17% in terms of number (Figure 3c and d). Presently, this class is composed almost exclusively of holocentrids, sand tilefishes and jacks. The sand tilefish made the major contribution to this class, with 20.0% in terms of number and 14.25 in terms of weight (Table 1). Sand tilefish (*Malacanthus plumieri*) represented the third most abundant species of total catch. Jacks were not an important part of this fish class as in previous sampling periods.

Two species of squirrelfish were the other mayor contribution to third class. *Holocentrus rufus,* longspine squirrelfish, was the most abundant squirrelfish in the catch. The longjaw squirrelfish, *Holocentrus ascensionis*, was the second most abundant sampled species of holocentrids. The longspine squirrelfish represented 7.82% and 3.04% by number and weight, of total catch. Longjaw squirrelfish represented 6.10% and 3.61% by number and weight. Another species within this fish class whose sale is banned for being ciguatoxic is the great barracuda (*Sphyraena barracuda***,** 2.0%), which is also included as a third, class fish in landings data.

The percentage of bycatch was low (Figure 3c and d), when compared to second and third class fish. Trash fish constituted 0.82% and 5.76% by number and weight, respectively, of total catch. Bycatch is composed of lizard fishes, puffers, scorpionfishes, soapfishes and morays (Table 1). Bycatch changed as species that were not considered commercially important are presently sold as third class fish (mainly, holocentrids, sand tilefish and jacks).

Length Frequency

Six species were compared in terms of length-frequency distributions taken with hook and line during this survey. The species were: the red hind (*E. guttatus*), the coney (*C. fulva*), the sand tilefish (*Malacanthus plumieri*), the black durgon (*Melychthis* niger), the longjaw squirrelfish (*Holocentrus ascensionis*), and the longspine squirrelfish (*H. rufus*). Descriptive statistics for each species is display on Table 10.

Red Hind – Epinephelus guttatus

Figure 4 shows the length-frequency distribution of red hinds sampled in the first sampling period. Modal class of the sample was 260 mm, with a mean size of 275.48 mm ± 49.8 and a mean weight of 336.01 g ± 190.9 (Table 10a). Figure 5 shows the calculated length-weight regression line of sampled red hinds with hooks. The r-value for this sample was 0.99.

Coney – Cephalopholis fulva

Figure 6 shows the length-frequency distribution of sampled coneys during April 2000 to March 2001. Modal classes of the sample were 220 mm and 230 mm, and a mean size of 211.4 mm ± 29.2, with a mean weight of 159.7 g ± 62.5. Table 10b gives descriptive statistics for sampled coneys. Figure 7 shows the calculated length/weight regression line for coneys sampled with hooks. The r-value was 0.97.

Sand tilefish – Malacanthus plumieri

The length-frequency distribution of sampled sand tilefish during the first sampling period is shown in Figure 8. The modal class was 300 mm, with a mean size and weight of 298.46 mm ± 45.5, and 195.0 g ± 84.0, respectively. Descriptive statistics are shown in Table 10c. Figure 9 shows the calculated regression line of sampled sand tilefish. For this line the r-value corresponded to 0.93.

Black durgon – Melichtys niger

Total catch distribution of sampled black durgon is shown in Figure 10. The modal classes were 220 mm and 230 mm, with a mean size and weight of 272.0 mm ± 21.4 and 534.5g ± 100.3, respectively (Table 10d). The calculated length/weight regression line is shown in Figure 11. The r-value for this regression was 0.98.

Longspine squirrelfish – Holocentrus rufus

Size distribution of longspine squirrelfish is shown in Figure 12. The modal class was 185 mm and a mean size and weight of 181.70 ± 10.8 and 107.20 ± 19.89 respectively (Table 10e). The calculated length/weight regression line is shown in Figure 13. The r-value for this regression was 0.93.

Longjaw squirrelfish – Holocentrus ascencionis

Size distribution of longjaw squirrelfish is shown in Figure 14. The modal class was 210 mm and a mean size and weight of 201.27 ± 18.0 and 162.92 ± 33.11 respectively (Table 10f). The calculated length/weight regression line is shown in Figure 15. The r-value for this regression was 0.98.

Fish Traps

Catches

A total of 148 finfish belonging to 17 species, representing nine (9) families, and weighing over 36 kg (Table 1) were captured during 86 traps hauls. Trap soak time for each trap was recorded, with an average of 5 hrs. Due to logistical problems traps were set in 6 trips only during the sampling period.

Catch per unit effort (CPUE) in terms of g/trap day ranged from a minimum of 136.57 to a maximum of 591.45 (Table 11); in terms of g/trap hour catches were lower ranging from a minimum of 26.48 to a maximum of 88.83. In general, trap catches were very low in any single haul.

Table 11 displays mean CPUE per station results. Of the twelve sampled stations during this period traps were use in four. In each sampled station with fish traps none yielded zero catches, Table 11. Highest CPUE was recorded at station 69 with 88.83 in terms of g/trap hours. In terms of g/trap day highest CPUE was recorded in station 59 with 591.45. Station 59 yielded the highest numbers of fish caught (Table 11). Station 59 registered the lowest CPUE with 26.48 g/trap hours and station 7 in terms of g/trap day with 136.57, respectively.

Several logistic problems among those the major one, the hydraulic system of the vessel was out of service. Therefore, fish trap sampling was sporadic and only three months were sampled May 2000, October 2000 and February 2001, unlike hook and line sampling that was carried out throughout the intended twelve month of sampling.

From Table 1 it can be observed that the obtained results are negligible for any particular species. Coneys, red hinds, white grunt and doctor fish dominated the catch. The number of individuals caught is so low that is not pertinent to analyze them in terms of CPUE.

CPUE by depth ranges of fish traps yielded the following results maximum CPUE (Table 12) corresponded to the 0-18 m depth range with 30.35 g/trap hours and in terms of g/trap day corresponded to the 37-90 m depth range with 408.54.

Species Composition

Trap catches were constituted by two groups of fish (Table 1, Figure 16a and b) the groupers (35.1%), and the snappers (14.72%) in terms of number of individuals captured. The relative percentages of these families as shown in Figure 16b by weight were similar as those obtained by number with groupers representing (39.3%) and the snappers (15.68%). Species composition was dominated by the same two species of serranids in terms of weight and number, as for the hook and line.

Basically five species constitute the majority of trap catches. The coneys were the principal species caught in terms of number and weight, with 18.2% and 16.64%, respectively. The other species that constituted an important part of the catch was the red hind, representing 14.9% and 20.7% of total catch in terms of number and weight; respectively.

First class fish caught by traps constituted 49.8% and 55.0% by number and by weight, respectively of total catch (Figure 16c and d), of which groupers represented 39.3%, and snappers made up 15.7% by weight. Contrary to species composition of hook and line, snappers made a higher contribution to trap species composition. Snappers were represented by three species of which the dominant one was the blackfin snapper representing over 10% (Table 1) of trap catches in terms of number and weight.

Second class fish was composed of a variety of species among them the grunts, triggerfishes, the filefishes, and parrotfishes (Table 1, Figure 16). Some of these species were sampled in greater quantities with fish traps than with hook and line, as some second-class fish such as the white grunt (*Haemulon plumieri*) that made up 13.5 and 12.1% of the catch in terms of number and weight, respectively. Parrotfishes also are considered second-class fish, although this depends upon their size and the general area in which they are sold. They were represented in our catches almost exclusively by a single species, the princess parrotfish, *Scarus taeniopterus*, as can be observed in Table 1. This species constituted 4.2% and 4.6%, by weight and number, respectively of total catch.

Third class fish (Figure 16a – d) is comprised of squirrelfishes, and doctor fishes. The longjaw squirrelfish made up 7.6% and 5.4%, in terms of weight and number, respectively. Doctor fishes were the other group that constituted the third class fish. Two species of acanthurids made the volume of doctor fishes, although their contribution was not steady. The ocean surgeon (*Acanthurus bahianus*) was more consistent in both terms of number and weight, than the blue tang (*A. coereleus*). Trash fish was not collected during this sampling period as can be observed in Figure 16.

Length Frequency

There were not enough individuals sampled with traps to make size distribution figures of any species. Table 13 displays descriptive statistic of those species that represented the bulk of trap catches. The mean size of sampled red hinds with fish trap was 281.77 mm ± 37.4 and a mean weight of 343.7 g ± 169.1 (Table 13a). For sampled coney the mean size and weight were 236.9 mm ± 21.3 and 225.4 g ± 64.4, respectively. White grunts reported a mean size of 214.2 mm ± 27.2 and a mean weight of 221.3 g ± 84.7. Collected doctorfishes on the other hand recorded a mean size of 203.1 mm ± 45.9, with a mean weight of 224.9 mm ± 127.2.

Reproductive State

Sex was determined by macroscopical examination of gonads for all fishes collected during the study. Gonads were collected from several species. For many of the commercial species landed in Puerto Rico, limited information on their spawning seasons is available (e. g. Erdman, 1976; Colin and Clavijo, 1988). For most sampled species, sample size was very low; therefore, spawning seasons could not be fully evaluated, although the data does provide limited information on the percentage of ripe and spent males and females for certain months for a number of species.

Of the 38 listed species in Table 1 for which reproductive states were assessed, the most complete information is for three species. These species are the red hind (*E. guttatus*); the coney (*Cephalopholis fulva*), and the sand tilefish (*Malacanthus plumieri*). Other species for which some information is available are the black durgon (*M. niger*); for the longjaw squirrelfish (*Holocentrus ascensionis*) and the longspine squirrelfish (*H. rufus*). Table 14 to 15 displays descriptive statistics of selected sampled species with hook and line and fish traps by gonad stage. Data collected for some of the species mentioned above with hook and line and with fish trap were combined to provide a better idea of the spawning cycles.

Epinephelus guttatus

Sampled red hinds during this period (N = 230) were constituted by 78.3% females, and 19.6% males. The sex ratio of females to males was 4.00:1.00 (F:M). Males with ripe testes constituted only 48.9% of total sampled males, while females with ripe ova made up 21.1% total sampled females. Individuals with spent gonads constituted 43.9% of total sampled females, and 17.8% of total sampled males. Table 13a displays results of descriptive statistics of red hinds by sex, while Table 14a displays descriptive statistics by sexual maturation stage of males and females. Figure 17 show the size distribution of total sampled red hinds with both gears. Figure 18 displays the size frequency distribution by sex. Differences in size distribution of red hinds yielded statistically significant results (Kolmogorov-Smirnov) between total sample and males; and among females and males ($d_{\alpha} = 0.306 > D_{.05} = 0.210$; $d_{\alpha} = 0.383 > D_{.05} = 0.226$), respectively.

Red hinds are known to aggregate to spawn throughout its range. In Puerto Rico, effort has been made to monitor two of those aggregations sites since 1989. Starting in December and until March, efforts were made to monitor the spawning aggregation at the Abrir la Sierra (station 59) and Tourmaline reef that lay at the west coast platform. These two places were selected due to the depth at which the aggregation takes place, that enable to tag the individuals and release them. The depth at which they are collected reduces the trauma, increasing the survival rates. The results show here are those of animals that did not survive the process of tag and release therefore does not include all the specimens collected.

Table 15 shows that the highest numbers of ripe (F3) females were recorded during the full moon of February (41.5%), followed by the first quarter moon in February (19.5%). Very few ripe females were recorded during January (12.1%) and none during March. The higher percentage of females with ripening gonads (F2) was sampled during October thru the full moon in January. A few individuals with ripening ova were sampled during February.

Male data, although considerably less than those for females, showed the same trend. February (Table 16a) reported the highest percentage of ripe males (M3) (58.6%). Males with ripening testes followed exactly the same trend as females with ripening gonads (Table 15).

Collection of spent gonads is no conclusive or gives any indication to the spawning event. Individuals collected during that period did not show evidence of spawning therefore there is an absence or very few individuals with spent gonads.

Cephalopholis fulva

Coneys (N = 271) were constituted by 71.8% females and 27.5% males, with a very small proportion of individuals that were not possible to be sexed macroscopically. The sex ratio of females to males was 2.61:1.00 (F:M). Males with ripe testes constituted 42.7% of total sampled males, while females with ripe ova made up 20.6% of total sampled females. Individuals with spent gonads constituted 63.6% of total sampled females, and 43.9% of total sampled males. Table 13b gives descriptive statistic of sampled coneys by sex, and Table 14b displays the same information by sexual maturation stage. Figure 19 shows the distribution of total females and males sampled with both gears. Differences in size distribution between males and females sampled with both gears ($d_{\alpha} = 0.280 > D_{.05} = 0.176$) and between males and total sample ($d_{\alpha} = 0.201 > D_{.05} = 0.169$) were statistically significant.

Table 16 shows information by sexual stage and moon phase of sampled coneys. Ripening female's coneys started to be collected consistently by the full moon in October 2000 thru December 2000. During January not a single ripening gonad was collected, and a few were sampled in February. Ripe females on the other hand started to be collected from December 2000 thru February 2001. The highest percentage of ripe females was collected in February 2001, 54.5% of total ripe females, followed by January 2001 with 38.6%. Ripe males showed a similar trend to that obtained for females. February reported the highest percentage of ripe males with 71.4%; followed by January with 28.6%. For both sexes the number of ripe individuals started to increase in December, while the number of ripening individuals starts to decline.

Malacanthus plumieri

Sand tilefish (N = 211) sample was constituted by 67.8% males and 32.2% females. Males with ripe testes composed 36.3%, while males with spent gonads made up 2.8% of total sampled males. Sex ratio of females to males was 1.00:2.10 (F:M). Females with ripe ova constituted 64.7% of total sampled females, meanwhile females with spent gonads represented 5.9%. Descriptive statistics by sex of sampled sand tilefish are displayed in Table 13c and by sexual maturation on Table 14c. In Figure 20 displayed the obtained size frequency distribution by sex. Differences in size distribution among the sexes were significantly different ($d_\alpha = 0.629 > D_{.05} = 0.200$). Observed differences between total sample and females, as well as between total sample and males yielded statistically significant results ($d_\alpha = 0.426 > D_{.05} = 0.189$; and $d_\alpha = 0.203 > D_{.05} = 0.147$).

On Table 17a are shown the results by month and sexual stage. Females with ripe ovaries (F3) were collected during June, November and January. On the other hand, females with spent gonads were collected during, June, November and January thru March. Males with ripe testes were sampled in April, June, November and January thru March. Meanwhile males with spent gonads were sampled in the same months than those with ripe gonads with the exception of April.

Melichthys niger

Black durgon (N = 85) females accounted 25.0% and males 75.0% of total sample. Sex ratio of females to males was 1.00:3.00 (F:M). Females with ripe ova constituted 38.1% of total sampled females black durgon. Meanwhile, males with ripe testes constituted 51.5% of total sampled males. Individuals with spent gonads of sampled females made up 38.1% and 7.9% of sampled males. Descriptive statistics by sex of sampled black durgon is shown in Table 13d. Figure 21 displays the obtained size distribution by sex and Table 14d gives descriptive statistics by sexual stage of sampled black durgon.

All the obtained distributions yielded statistically significant results; between total sample and females ($d_\alpha = 0.336 > D_{.05} = 0.331$); and among females and males ($d_\alpha = 0.444 > D_{.05} = 0.342$).

Females with ripe ova were recorded during April, November and March, while the males with ripe testes were collected in April, June, October-November, and January-March (Table 17b). Ripe females were very few (F3), therefore very little can be said regarding the spawning period of this species, although the presence of ripe males almost every sampled month indicates and extended spawning period.

Holocentrus rufus

Sampled longspine squirrelfish (N= 83) were comprised of 41.0% females and 59.0% males. Sex ratio of the sample was of 1:1.4 (F:M). Females with ripe ova represented 20.1% and those with spent gonads 64.7%. Males with ripe testes comprised 39.8%, meanwhile those with spent gonads made up 13.3% of the sampled males. All sampled individuals have active gonad for this species. Descriptive statistics by sex is shown in Table 13e, and by sexual maturation stage on Table 14e. Figure 22 shows the size distribution by sex of the sampled. Observed differences among the size frequency by sex yielded statistically significant results ($d_{\alpha} = 0.413 > D_{.05} = 0.303$).

Ripe females and males were collected during November thru February for females and October thru March for males (Table 17c). Of all sampled the only month in which females with spent gonads were not captured corresponded to June. On the other hand males with spent gonads were collected in October and from January thru March. These results suggested that this species might reproduce year round.

Holocentrus ascensionis

Sampled longjaw squirrelfish (N= 74) were comprised of 43.2% females and 56.8% males. Sex ratio of the sample was of 1:1.3 (F:M). Females with ripe ova represented 40.6% and those with spent gonads 46.8%. Males with ripe testes comprised 57.1%, meanwhile those with spent gonads made up 19.0% of the sampled males. Figure 23 shows the size distribution by sex of the sampled. Observed differences among the size frequency by sex yielded non-statistically significant results ($d_{\alpha} = 0.107 < D_{.05} = 0.319$). Table 13f show descriptive statistics by sex and Table 14f shows the same information by sexual maturation stage.

All sampled longjaw squirrelfish had active gonads, similar to the longspine squirrelfish sample. Ripe females were collected during November and from January thru March (Table 17d). Males with ripe testes were sampled in those same months plus during April. Individuals with spent gonads were collected during April, June, Oct-Nov and Jan thru March for females. Males on the other hand were recorded with spent gonads in May, Oct, and Jan-March. These results suggest a year round spawning season for this species.

Discussion

Hook and Line Catches

Hook and line catches are influenced by a series of factor among which an important factor is the availability of fish in a determined area. Other important factors include the bottom type or habitat, and depth. In any survey is very important to reduce the variability in sampling methodology, in order to be able to detect which variables influenced the obtained results. Although is important to cover a wide number of stations (area) to extrapolate the results to the rest of the population, the number of replicates for those sampled areas is also very important. During the sampling year of the reef fish survey a number of stations were sampled periodically through out the whole cycle.

Several fisheries-independent surveys undertaken at the Fishery Research Laboratory have yielded the same results regarding the family and genera dominating the catches (Rosario, 1989, 1992a and b, 1993, 1995 and 2002). Serranids has comprised over the 50% of total catch in all those surveys. For the present survey the percentage was lower than 50%, but we have to have in mind that we are only presenting the results of animals that did not survive the tag and release process. Still nonetheless they comprise over 40% of reported catch. Among the serranids the two most important components of the catch have been the red hinds, and the coneys. Which of these two species dominate the catches depends almost strictly if the red hinds spawning aggregation is sampled or not.

Another factor that is usually not measured in fisheries-independent surveys is individual fisher's efficiency, a reflection of individual experience and ability. Fishers experience and ability has been a factor affecting the hook and line catches. Experienced fishers' efficiency is almost two folds than less experienced fisher under identical circumstances (Kawaguchi, 1974; and Munro, 1983; Rosario, 1993, 1996). The obtained results for the crewmembers of our vessels that are part time commercial fishers tend to confirm this finding. Since the starting sampling period in 1992, the fishers with more years of experience dominated the catches. On the other hand, the lowest catch per fisher shifted from one sampling period to the other. One factor affecting the results of this study was the retirement of all most experienced fishers, and the addition of none experienced crewmembers.

The area covered during this sampling period basically comprised the broadest part of the west coast platform of P.R., from the Mayagüez Bay to the southwest corner of P.R. The only stations that do not lie on the platform are those at the Bajo de Cico area. Stations closer to the shelf edge registered the highest values of CPUE. Variability in catches at different months suggests some seasonality at these areas. There is a distinctive species composition for the sampled stations, which could be related to two parameters, 1) depth; and 2) bottom or habitat type. The utmost factor seems to be the habitat type. Unfortunately, data regarding bottom type of most of the sampled stations tend to be scarce and patchy. On the other hand, depth influence in catches is quite evident for some of the species caught.

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. Results for the present sampling period confirm these findings. Bannerot et al, 1991, stated that for an optimum stratification of the area covered in the present survey, the number of replicates within sampled stations should be increased. The stratification of data collected during the 1988-89 studies in some cases reduced the system variance by 45%. 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. There is no data available in Puerto Rico regarding depth effects of soak time effects on trap catch rates for coneys prior to that reported by Smith and Ault (1993). These authors reported that red hind CPUE does not appear to correspond exclusively to either depth or substrate.

Of the sampled stations those that encompassed the Bajo de Cico areas, have consistently registered high values of CPUE per trip, not only during the present survey, but also during previous ones. The bottom type of this area consists mainly of sponges, soft coral, and hard coral. A trend to have higher catches in areas with hard bottom (composed mainly of sponges and coral crops) has been observed during the sampling periods. Algal plains and grass beds are more productive than sandy or muddy ones. Of the stations on the west coast platform stations 49, 59, 69, and 80 have been were consistent in high CPUE values throughout the sampled years. Station 59 and 80 are two red hind aggregations sites that definitely have some habitat similar to those of the Bajo de Cico which have been identify as an important feature for this species reproduction.

For the present survey station 59 represented the area where effort was concentrated to tag and release red hinds. The site was selected mainly for two reason the depth at which red hinds were caught, shallower than those of the Bajo de Cico reducing the mortality of the individuals. The second reason was the amount of animals that can be caught. Although higher numbers of red hinds can be fished out at Bajo de Cico the depths at which they were caught reduced the survival rate, due to baurotrauma.

Total catches in terms of number and weight by months showed two peaks, the first one in October-November, and the second from January to March. The second peak is definitely related to the red hind spawning aggregation, while for the first there is no clear indication of what might have caused.

Hook and line catches for the present sampling period is compatible with those obtained during the first three-year sampling cycle (Rosario, 1995). Serranids have dominated the catches of both sampling periods, in hook and line and fish traps. Within the serranids the most important for both sampling periods were the following species: the red hinds, coneys, and graysby, which comprised the bulk. Red hinds and coneys have been the dominant species during the two sampling survey, although their relative percentage of total catch varied slightly from one sampling period to the other.

If we were to characterize the distribution of these species along the west coast of P.R. based on the obtained results we would obtain the following: Red hinds seem to dominate in areas of hard bottom (coral crops, sponges, etc.). Meanwhile, coneys are abundant at some deep coral areas, although they can be found in sand/coral areas, whereas red hinds are not. This could be a very broad description of their distribution, basic interaction between these three species and their relative abundance at certain areas, and vertical distribution (by depth). How much of the obtained results are a reflection of the population by itself (over fished or not), to the specific habitat (degradation of their habitat), are a question that remains unanswered. A broad habitat map of these areas needs to be drawn to understand how does specific species is related to this habitat, before we have an answer to it.

One factor that affects red hinds catches during the sampling periods between 1999 to 2001 was a change in sampling strategy regarding this species. One question that involves the size of the population of red hinds in certain selected stations required tag and release. Starting in September 1999 through out February 2001 most of the individuals caught were tag and released. Obviously this affected the results obtained for the period of September 1999 to March 2001. Those red hinds are accounted in other papers and were not included in our results (Sabat, 2002). This effort was a continuation of a previous pilot survey of tag and release of red hinds and coneys undertaken from January 1997 to June 1997 (Rosario and Figuerola, 2001). Individuals that did not survive the process of tag and release were landed an accounted in our survey and in the surveys undertaken from April 1999 to March 2000 (Rosario, 2002).

Smith and Ault, 1993 found that for the red hind, the best stratification was by season (spawning and non-spawning) and by depth. The obtained results in the present survey might not confirm this finding. Red hind maximum CPUE corresponded to October previous to the spawning season. CPUE obtained from December to February, were lower than those obtained during October. Once again this result is a reflection of the fact that most red hinds were tag and released and thus not taken into account in this survey results. It has been demonstrated that species that aggregate to spawn are highly susceptible to overfishing, not only in P.R. but also throughout the Caribbean. Comparing the results obtained during this survey to the one performed from July 1992 to June 1993; confirm the suggested stratification by Smith and Ault (1993). They demonstrated that the spawning season yields mean CPUE 1.5 to 2 times higher than non-spawning season. Logistic problems prevented us from sampling the red hind spawning aggregation in 1999, thus the red hinds that were caught during that particular survey corresponded to the non-spawning season and were less than those caught in 1997 to 1998, which turn out to demonstrate that the propose red hind stratification by season (spawning and non-spawning) is effective. The obtained results for red hind clearly exhibit seasonal variation in relative abundance with higher CPUE during the spawning period (Table 9a). This is in accordance with the Smith and Ault (1993) findings. They also reported that coneys do not vary seasonally, and the obtained results of the present studies also confirmed this. One factor that influenced the coney's catches per month was the stations sampled rather than any other factor.

Coneys dominate the catch in terms of number while the red hinds dominated catches, in terms of weight. Coneys tend to be caught in shallower waters. One factor that might have affected the coney catches is the sampled area. Heemstra and Randall (1993) describe coneys as inhabitant of clear waters and prefer coral reefs; and at the Gulf of Mexico they are found at depth of at least 45 m, but are rare at more silty areas. It was demonstrated by Smith and Ault (1993) that both coneys and red hinds were abundant in deep coral areas, and that coneys were also abundant in intermediate depth coral/sand habitats. This indicates that habitat preferences and thus spatial distributions may be different for the two species. They found that location rather than season affects coneys mean CPUE by gear.

A detailed habitat type map was not available for any of the sampled stations, however, the unrefined habitat type references that are accessible, allow assumptions in regard to bottom substrate. Habitat types have been defined as those that are represented in the nautical chart #25671 for the west coast of Puerto Rico. Also, several kinds of habitat can be inferred by incidental catch of traps and hook and line, for example, when parts of sponges, soft coral are entangled either in the traps or in the hooks. Traps for their part, are very good collectors of algae and grass. This is not the best way to describe a given area, since one can not ascertain the percent coverage of the particular habitat, but at least gives an idea of the particular location where one has been sampling on a particular date. These methods were used to describe in the best possible manner, the habitat type of sampled areas, in order to correlate habitat type with catches.

The Bajo de Cico habitat is mostly sponges and soft corals; the shallowest point (18 m) is composed of hard and soft corals and sponges. This particular type of habitat seems to be highly preferred by red hinds. Unfortunately, habitat type for those stations on the platform off the west coast of Puerto Rico is extremely heterogeneous, varying widely from great extensions of algal and grass beds, to a variety of combination of alternated algal plains with sponges and soft corals; or algal plains with sand patches, followed by soft coral, sponges, etc. In those areas a more detailed map of the sampling stations is necessary to be able to determine which parameters are determinant in the catches.

Since 1987 the FRL has monitored a spawning aggregation off the west coast of P. R., the only year in which the aggregation was not monitored was 1993. During those years the data distribution shows discreet recruitment in two of the sampled years (Rosario, unpublished). Sadovy, *et al*, 1994 demonstrated recruitment overfishing of red hinds sampled at the Bajo de Cico area, which is one of the areas monitored during the present survey. These two stations encompass the Bajo de Cico site, which is an oceanic bank northwest of Mayagüez. Bottom substrate is mainly sponges, and soft coral. Another area (Buoy #6) Abrir La Sierra was also monitored, since it has been reported as an area where most of the red hind have been caught during the last three spawning aggregations. Catches at the Abrir La Sierra (station 59) area were fairly high. These three stations comprised 80.3% of total red hind catches for the sampling period of 2000 to 2001. At all other sampled stations, red hinds catches were low in both terms of number and weight, resulting in low CPUE for these areas. During the sampling period of 2000 to 2001 red hinds catches for stations 95 and 96 were much lower due to the fact that survival of individual to be tagged was reduced by embolism when hauled. At this area the shallower depth is 18 m, which is a very small area, and the surrounding areas increase in depth rapidly making difficult the hauling of animals without suffering decompression trauma.

Coney distribution by station, on the other hand, was more constant. The only station in which very high number of coneys was reported is station 59 (Abrir La Sierra). No geographical gradient was observed at the platform regarding this species. Nonetheless, if we consider the two species of grouper that dominated the catch, a trend in their spatial distribution arises. Red hinds and coneys seem to be more or less evenly distributed within the west coast platform.

Prior to 1996 there were many factors that indicate that the population of red hinds and coneys were declining quite rapidly (age and growth; size at first maturity, etc.). Unpublished data from the Fisheries Research Laboratory showed a sharp decline in the mean size of red hinds capture off the west coast of Puerto Rico. Management measures were set in 1996 (CFMC, 1996), which establishes a close season at the spawning aggregation sites of Bajo de Cico (stations 95 and 96), Abrir La Sierra (station 59) and Tourmaline (station 80). It is necessary to monitor the effects that this management measure have over the populations of these species. Sabat (2002) found out that this management measure has been effective protecting the red hind population of these areas.

Catches of sand tilefishes were more prone at places in which the habitat was mostly sand patches. Most of sampled individuals were caught at Abrir La Sierra. These results are consistent with those obtained in previous surveys. Black dungon were caught almost exclusively in station 59 although station 96 reported high number of this species. At least from station 96 most of black dungon seam to be prone to catch at areas where coral reefs are abundant. Since at the Bajo de Cico shallow point the water transparency is so high with can say with certainty that this species is closely related to the coral reef of that area. As well in Station 59 at shallow depths we can see the bottom with clarity, we can see this fish associated to the coral of the area.

The two species of holocentrids have followed the areal distribution displayed in previous survey (Rosario, 1992, 1993 and 1996). Longjaw squirrelfish seems to be abundant to the north stations of station 59 (Figure 1), while the longspine squirrelfish are caught in greater numbers to the south of this station. Very few longjaw squirrelfish were caught of the Abrir la Sierra area, and very longspine were collected north of this area. At Abrir la Sierra both species are caught in fairly high numbers, although this seems to be a midpoint in the aereal distribution of both species.

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 bottom fishing with hook and line gears. Variation in species composition between this survey and those that are fisheries-dependent and reported by port agents from the Statistics 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 under represented 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 the early 1990's, they are now sold as third class fish in most fishing centers on Puerto Rico (Matos, 1991; 1992; 1993, 2000). This fact is a highly distressing one, since it 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; Appeldoorn et al, 1992; Collazo and Calderón, 1988; Matos and Torres, 1989; Sadovy, 1989; Matos, 1990; Matos and Sadovy, 1990; Matos, 1991 and 1992; Dennis et al, 1991). Most important is the effect in catch composition due to regulation discards. There are a few species that might be misrepresent in fisheries dependent data due to this fact.

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; 1993; 1996, 1998 and 2002). One factor that will determine which of these two species, red hind or coney, will dominate the catch is the red hind spawning aggregation. Although this species can be caught during any given month, they are highly susceptible to be caught in great numbers in short period of time during the spawning aggregation. For the present survey as well as for the two previous sampling years the dominance of red hinds or representation of this species in our catch was affected by the tag and release activity.

Persistently, the sand tilefish has been the third most abundant species of hook and line catches for all the fisheries-independent surveys undertaken since 1988. We have seen how this species has become more important in commercial landings since then. In the past, sand tilefish were sold at a single fishing center and was considered to be trash fish in most areas. From 1992 onward they have started to appear in commercial landings and are being classified as third class fish. It is evident that they are subject to suffer increased fishing effort as well as holocentrids, which have been an important catch, both in hook and line and in trap catches. These species have been under represented in commercial landings for a long time, but nonetheless have been part of the catches, and therefore their populations have suffered the same fishing pressure of most important commercial species. If we now add their increasing commercial value, we may have them in a similar situation as most commercially important species.

Dooley (1978) compiled information regarding sand tilefishes (systematic and biological) for specimens collected off the west coast of Puerto Rico. Baird and Baird (1992) described the colonial 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 over fished, since they are sedentary animals that stay close to their home range, and are usually clustered in definite places (Shapiro, 1987a; Baird, 1988; Baird and Baird, 1992). For these reasons, they could be easily targeted in some areas.

Squirrelfishes have been an important part of the fishery around Puerto Rico, but are greatly under represented 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. Matos (1993) reported an increase on landing data for these species around the coast of Puerto Rico. One possible explanation for their increasing commercial value is that other important species have become scarce. The number and their contribution to past fisheries-independent surveys undertaken by the Fisheries Research Laboratory are very variable.

Black dungon are not reported as a separate species in fisheries dependent data, therefore we can not evaluate how important it is to the commercial fisheries. Information gathered from several fishers tends to point that is not a target species but if caught might be sold as triggerfish, although is mostly discarded by fishers.

Fish Traps Catches

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 effects, 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, 1974a and b; 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.

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 the two study periods, which were soaked only for 5 to 6 hrs daily. On the other hand, Thompson and Munro, (1974) 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 consideration to be taken into account when evaluating catches is that 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 (Rosario and Sadovy, 1991a and b). Fish size and shape are also important factors in fish ability to escape through certain mesh sizes and shapes (Sutherland *et al*, 1987). Luckhurst and Ward, (1987); Ward (1987); Ward and Nisbet (1987); and Bohnsack *et al*, 1989 has also reported on the effect of mesh size selection in Antillean fish traps.

Miller and Hunte (1987) stated 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.

In general, trap catches were very low compared to hook and line catches. One should keep in mind that these traps were soaked for a short period of time, which definitely is a factor that affects trap catches. Nonetheless, the obtained results if compared to landings data are significant. Matos (1993, 2000) has reported a substantial decline both in fish trap catches and the number of fish traps used in Puerto Rico. In fact as the number of fish traps has declined the number of nets has increased since the early 1990 in Puerto Rico's fishery.

Species Composition

Fish trap species composition is influenced by mesh size. From a mesh size study undertaken by the Fisheries Research Laboratory in 1990, (Rosario and Sadovy, 1991a, b), it was demonstrated that the mesh size of 1.25" x 1.25" hexagonal, caught the greatest diversity of species. Stevenson, (1978) Stevenson and Stuart-Sharkey (1980) demonstrated that the red hind, *E. guttatus* and the white grunt, *Haemulon plumieri*, were being over fished by the 1.25" mesh size on the west coast of Puerto Rico.

The mesh size used in our survey is 1.5" x 1.5" square which might account for the lower diversity of species obtained in the two sampled years compare to previous surveys (Rosario, 1993). The 1½" square mesh vinyl coated yielded higher number of fish than the galvanized 1¼" hexagonal mesh. At the moment of changes in wire, half of the fish traps had different wires; therefore it was easy to detect changes in trap catches. A change in species composition was also noted. All these results are consistent with those reported by Rosario and Sadovy, (1991a and b) in which different mesh sizes were compared off the west coast of Puerto Rico.

Species composition changes involved mainly goatfishes, vermillion snappers. The 1½" square mesh vinyl coated wire is more efficient in retaining goatfishes and vermillion snappers. One possible explanation to this apparent contradiction is the wire "gauge" or flexibility of the wire. The galvanized 1¼" hexagonal wire is more flexible having a higher gauge, than the 1½" square mesh vinyl coated, which is very rigid (has a lower gauge). Although the mesh is bigger, the rigidity of the wire prevents escapement of some species of certain shapes or sizes.

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).

Fish trap species composition has been very similar for other projects undertaken by the Fisheries Research Laboratory off the west coast of Puerto Rico. From April 1988-June 1989, red hinds represented 13% by weight and coneys 15%; September 1991-June 1992, red hinds 67% and coneys 13%. From April 1992-March 1993, red hinds represented 41% by weight; meanwhile, coneys accounted for 21% by weight. Factors that contributed to the relative predominance of both species are the general area, depth and spawning seasons. But consistently these are the two dominating species. Comparing these results with those reported by Juhl, (1969); Juhl, (1972); and Juhl and Suarez-Caabro, (1973) we found that these species were not among the five most commercially caught species island wide. Cole (1976), reported coneys as the third or fourth most captured species depending on depth. Juhl and Suarez-Caabro, (1972) reported that for a series of fisheries-independent surveys undertaken from 1968 to 1970, the west coast trap catches were dominated by snappers (24%), followed by groupers (22.38%). Groupers were composed of the following species in order of importance: Nassau grouper (*Epinephelus striatus*); rock hind (*E. adscencionis*); yellowfin grouper (*Mycteroperca venenosa*); red hind (*E. guttatus*); and coneys (*Cephalopholis fulva*). During this survey, a single Nassau grouper was caught and released, since its possession is prohibited in federal waters, as management measure. This species is actually considered to be commercially extinct in Puerto Rico. Results obtained since 1987 for the west coast show that the average number of Nassau grouper, rock hinds and yellowfin groupers caught per survey do not amount to more than one individual, if any; therefore we may consider them commercially extinct.

I would like to compare and underscore the differences reported in groupers composition of the late 1970's and early 1980's fisheries-independent surveys to the one obtained in this survey. Of the three major species were for those years we caught one specimen of Nassau and one yellowfin grouper during the first year. At the present time catches are dominated by the species that were in a fifth position during the late 1970's and early 1980's.

Although one may think that a change in mesh size from a smaller one (1 ¼") to a bigger one (1 ½") will benefit the overall catch, reducing the number of fishes of small size of the total catch, that is not the case in reality. Many factors may confound the results, as to which may be the best mesh size. As mentioned above, the shape, and gauge of the wire to be used are also, extremely important in order to maximize fish trap catches. One reality is that some mesh sizes will benefit some species; meanwhile for other species they could be simply lethal, due to the body shape of the fish. This poses great constrains in fish trap fisheries management, since there may not be a single mesh size that could protect the overall reef fish population from being overexploited.

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. 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 for both sampling years. These results are similar to those obtained from previous surveys (Rosario, 1992b, 1993, 1996, 1998). 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.

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, and is a trend, which has been recorded consistently in our surveys. Thompson and Munro (1974), 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.

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.

Red hinds

Red hinds are known to aggregate to spawn throughout its range. In Puerto Rico, effort has been made to monitor one of the aggregations since 1989. Erdman (1977) reported the spawning period to occur around the full moon of January or February. 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 twelve years. Data collected during the 1992 aggregation indicates that the spawning occurred around the full moon in late February. The results obtained from 1997 suggest several spawning, being the major event in February starting in the full moon and more pronounced in the last quarter moon. In January a small event of spawning was identified during the last quarter moon. Thompson and Munro (1974) reported ripe fishes only from December to March and the greatest number of fishes with ripe gonads were collected in January. Several authors have study the relation of the reproductive seasonality of groupers with environmental factors such as the day length, primary productivity and water temperature (Posada, 1996) and Edgardo Ojeda (personal communication), being the water temperature the factor that better fits and explain the observed variability on the spawning months . Ojeda (unpublished data) found out that red hind spawning was trigger by a mass of relative cold water (around 24□ C) intruding into the platform water column.

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. Sadovy, *et al* (1994a) determined that spawning is circumscribed to a period of 2-3 weeks in January/February each year, spawning through either the full or the new moon period.

One aspect of the red hind spawning aggregation that has been contended and thus far, nobody has clarified is whether red hind travel to spawn to a determined area, every year. Sadovy *et al*, 1992, demonstrated that red hinds does not necessarily moves to the nearest spawning site. On the other hand, there are indications that some spawning aggregation sites heavily utilized for a number of consecutive years, meanwhile adjacent spawning areas become non productive. Shapiro *et al*, 1993a showed that specific sites of fish concentrations within identified areas may vary from year to year and even during the course of an annual aggregation. Whether this situation is an artifact of over exploitation of the aggregation or an intrinsic characteristic of it, is another major concern. Once again, this situation poses a great constraint in management, since one may close a spawning aggregation site thinking that it will help the species and it might be possible that the fish are not aggregating at that area to spawn any longer. Rosario and Figuerola (2001) and Sabat (2002) found out from tag and release studies that red hinds have a homing ability and site fidelity thru the recaptured of tagged individuals during the spawning area within the spawning period. Rosario and Figuerola also reported that as suggested by Sadovy *et al*. (1992) that red hinds does not necessarily migrate to the nearest spawning area. An individual red hind was recorded to travel 24 km from the area of tagging (Rosario and Figuerola, 2001).

Several reports indicated that the red hinds are suffering overexploitation in Puerto Rico (Appeldoorn *et al*., 1992; Sadovy and Figuerola, 1992; Sadovy, 1993b; CFMC, 1996; Rosario, 1996). Sadovy (1994) also indicate diminish or dissipation of spawning aggregations of red hinds. Red hinds are a protogynious hermaphrodite condition that made more susceptible to be overexploitation than gonocores species (Bannerot *et al.* 1987; Manooch, 1987; Ralston, 1987; Sadovy, 1993a; Huntsman y Schaff, 1994). Between 1993 and 1996 the Department of Natural and Environmental Resources and the Caribbean Fishery Management Council established a seasonal closure (December to February) at three spawning sites off the west coast of Puerto Rico in an effort to protect the reproduction of red hinds at those sites. Seasonal closures in addition to protect vulnerable reproductive individuals in particular and the general fish communities provide the opportunity to perform studies and evaluate the fishing effects and/or the effectiveness of the closure as a management measure (Coleman *et al*., 1996). Beets and Friedlander (1997) evaluate the effect of a seasonal closure on the red hind spawning aggregation in Saint Thomas, USVI. They found out that the mean size as well as the sex ratio during the aggregation showed a significant recuperation comparing data from 1988 and 1997. Figuerola and Torres (2000) made an evaluation of the closure effects on two of the three close areas off the west coast comparing data from 1992-1995 to data from 1997-1999. They did not found significant changes in the compare parameters of mean size and sex ratio. They also stated that their results suggest a probable stabilization of the population, since there was not diminish in any of the parameters. They also point out several possible explanations for the observed trend. First, possibly there was not enough time between the establishment of the closure and the evaluation period and second, the poor enforcement of the measure does not made it effective. On the other hand, Sabat (2002) evaluate the effects of this measure analyzing the size structure of the spawning red hinds during the last consecutive eleven years (1990 to 2001). They did not found significant differences in mean TL among the spawning aggregations, therefore, pooled captures for all the three sites. Mean sizes declined sharply between 1990 and 1996 and a significantly increase in mean sizes between 1997 and 2000, which indicate that seasonal closure of spawning aggregations have been an effective management measure and the stock of red hinds off west coast of Puerto Rico is recovering.

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. Ripe individuals (males and females) were collect at all months, with one or two exceptions. Females with spent gonads were so sparse that it precludes any further comment. No pattern arises from the amount of males with ripe and spent gonads. Data strongly suggests a year round spawning for this species.

Coneys

Coneys, contrary to red hinds, have not been reported to aggregate to spawn. This theme have arise some controversy by several authors. Sadovy *et al*, (1994a, b) points out that coneys do not form aggregations that form rather small groups. She also comments that aggregations are form by groupers of big and median size, and that is not known is smaller species. Rosario (1996) reported data collected during the red hinds spawning aggregation in 1995 showing that coneys spawns at the same sites that red hinds with a difference of one to two weeks. The data on the sexual maturity of coneys was obtained while sampling at the red hind spawning aggregations. Several authors have reported similar results for coneys in Bermuda (Burnett-Herkes, 1975), in Belize (Carter *et al*, 1994), US Virgin Islands (Beets *et al*, 1994). Figuerola and Torres (2000) could not establish if coneys collected from the same areas covered by our survey form spawning aggregation. The results obtained of the absence of sperm competence by these authors is consistent with the direct observations made by Patrick Colin (Sadovy *et al*., 1994a) (e.g. Colin *et al*., 1987; Carter *et al*., 1994; Sadovy *et al*., 1994a and Beets *et al*. 1994) of small groups composed of one male and several females, with spawning occurring in pairs.

Rosario and Figuerola (2001) undertook a tag and release study of red hinds and coneys from January 1999 to June 1999. The aim of the survey was to characterize the movement behavior during the reproductive period of red hinds and coneys at three spawning sites (Tourmaline, Abrir La Sierra and Bajo de Cico). At the present time not a single coney (579 tagged individual) has been recaptured. Efforts were done to mark and release the coney from a single site (Abrir La Sierra) to maximize the probability of recapture. All monitoring efforts, even divers, have not been successful to locate any of this individual. Contrary to the red hinds that was a success the recapture of individuals. The sizes of coney overlapped that of red hinds, suggesting that the survival rate might be similar. Still other factors causing post-tagging mortality are involved. We need to gathered additional information on the coney to determine the probable causes in recapture failure.

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 (1996) reported that for various sampling periods this was the most likely, although data is incidental. In Curaçao Nagelkerken (1979) reported ripe gonads from May to October. In Bermuda spawning activity has been reported form May to August (Bolden, 1994; Smith, 1971). Meanwhile coney reproduction in the Bahamas spawning has been recorded from December to January by Heemstra and Randall, 1993. Thompson and Munro (1974) 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 was taken in April. Figuerola and Torres (2000) found four active males and two females recently spawned in June 1998, suggesting the possibility of some spawning activity in Puerto Rico for June. They also pointed out that the data available from their study could not establish with precision the inter-annual variability of the spawning.

For sampling period of April 1997 to March 1998 ripe individual were recorded from November to March. Data suggested several spawning events in December, January and February around the last quarter moon. Figuerola and Torres (2000) found that the reproductive season based in the presence of active mature gonads was from November to March. Nonetheless, they point out that based on the presence of hydrate ova allows to establish a principal spawning around several days of the last quarter moon in January and February. The pattern reported by them is consistent with that describe by Sadovy, *et al.* (1994a) and Shapiro, *et al.* (1993b) for the red hind in Puerto Rico. Our results are consistent with those reported by Figuerola and Torres (2000).

The sex ratio obtained in our survey varied markedly from one gear to another within the same sampling year and between the two sampling years. It ranges from 4.7:1 for hook data in 1997 to 6.2:1 (F:M) for the hook data in 1999. Trap data yielded lower sex ratios for both periods 1.9:1 for 1997 and 4.7:1 (F:M) for 1999 data. The variability could be reduced combining the data of both gears to calculate the sex ratio. Another factor affecting these results is the error introduced in the macroscopically determination of sex, especially during the non-reproductive season of the species. In Jamaica Thompson and Munro (1974) reported a sex ratio of 2.1:1 (F:M). Figuerola and Torres (2000) reported similar values 1.9:1 (F:M) of operational sex ratio for Puerto Rico, suggesting the stability of the studied population or that there is not significant impact of the fishery over the sex ratio. Their results are based on histological gonad studies, therefore, being more precise classification of sexes. Another factor that confounded the macroscopically classification of the sexes is that the coneys have been reported to be a monandric protaginous hermaphrodite species (Smith, 1959; Shapiro, 1987b; Figuerola and Torres, 2000). Figuerola and Torres (2000) found transitional individuals from 186 to 258 mm FL during all sampled month in their study with the exception of June. Coleman *et al* (1996) mentioned that the sex ratio of male to female can be diminish if the fishing activity is selective toward males or if the fishing pressure destroy the mechanisms that regulate such ratio. When any of these mechanisms operate throughout the year, in and outside the spawning areas, the probability that fishing pressure affect or change the sex ratio increases.

Sexual maturity of 50%of the population for coneys has been reported from several authors in the Caribbean. Thompson and Munro (1974) and Figuerola and Torres (2000) could not calculate a precise size of maturity for the species due to the fact that the smaller size class of their studies has a substantial percentage of ripe females. The size of maturity is lower or at least equal to the minimum size retained by the used gears in both studies mentioned above. In Jamaica the reported size was 160 mm FL and for Puerto Rico tentatively was calculated as 130 mm FL, which occurred at 40% of the maximum size of coneys reported for Puerto Rico. The results obtained by Figuerola and Torres (2000) suggest that basically the gears used do not retain juvenile individuals, as was the case for Jamaica. They concluded that the coney's resource of the west coast of Puerto Rico was stable.

Conclusion and Recommendation

The major purpose of this study was to establish a database of fisheries-independent data, which is essential for fisheries managers. Major achievements included identification of the best stratifying criteria for future monitoring of the resources. The implemented changes of the sampling protocol as suggested by Smith and Ault (1993), 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, yielded results that are important and need to be carefully assessed.

Species composition results obtained from the present study was 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 previous years, which served as a basis for the sampling protocol of the present study. During both sampling years both the red hind and coney were consistently the predominant species caught, although red hinds were the most abundant species in both terms of number and weight.

Spawning aggregations should be continually monitored to detect changes in the spawning stocks. This monitoring should include not only the red hinds, but effort should be directed to assess other species that might be spawning in these areas. As observed, during 1994, the red hind spawning aggregation, and the coney spawning aggregation used the same area to spawn with very little difference in their spawning time. Future surveys should evaluate the effectiveness of the close spawning areas to adjust the management measures if they are not effective. Reproductive information on major components of the catch should be evaluated more closely to provide the much-needed information to manage and evaluate those resources. Another aspect that should be explored is the coney tagging mystery, what factors are affecting the recapture of those individuals.

Management measures involving a change in fish trap mesh size should be very well thought and studied. As demonstrated by Rosario and Sadovy (1991a and b) an increase in mesh size from 1¼" to 1½" does not necessarily help the fisheries. This fact started to show up once we shifted from one mesh size to the other during the present survey. As it turns out, to help the fisheries with a change in mesh size it would probably require a mesh of 2" or greater, to protect the actual fish populations and reduce the bycatch of small non-commercial species, such as the butterflyfishes.

Fishery managers have started to add marine fishery reserves in conjunction to more traditional management measures, such as close areas and season as an alternative to management. Bohnsack (1990) has promoted and discussed the potential of these reserves as a reef fish management tool. The Caribbean Fishery Management Council has included an area off the south coast of St. John as a marine reserve. In Puerto Rico the fishermen of La Parguera, off the southwest coast of Puerto Rico has taken an initiative to close a Key as a marine reserve for a period of time. Effort should be taken to monitor these reserves and evaluated the impact of this particular management measure.

As a more refined sampling protocols become established 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 improve 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 substrates, (at least for the sampled stations), and to determine an index of recruitment into the fisheries. As part of the three year cycle that include these surveys periods a habitat mapping survey was not completed due to the fact that we did not were able to contract the personnel to undertake the project. It is a shame that in three years we were not able to contract the personnel to perform this much needed survey. There is no excuse for such administrative failure to recognize the importance of having the appropriated personnel to carry out the programmatic responsibility contracted with the funding agency. We finally have the personnel to carry out this survey, although not in time to fulfill our responsibility with the SEAMAP program. Nonetheless, the habitat data will benefit our future surveys.

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Figures

Figure 2. Trend of number of fish caught with hooks per number of year of experience fishing.