DEPARTAMENTO DE RECURSOS NATURALES
NATURAL RESOURCES DEPARTMENT

Completion Report

Entitled

TRAP MESH SELECTIVITY OFF THE WEST COAST OF PUERTO RICO

by

Aida Rosario Jiménez

Project Leader

and

Yvonne Sadovy

Director

Fisheries Research Laboratory

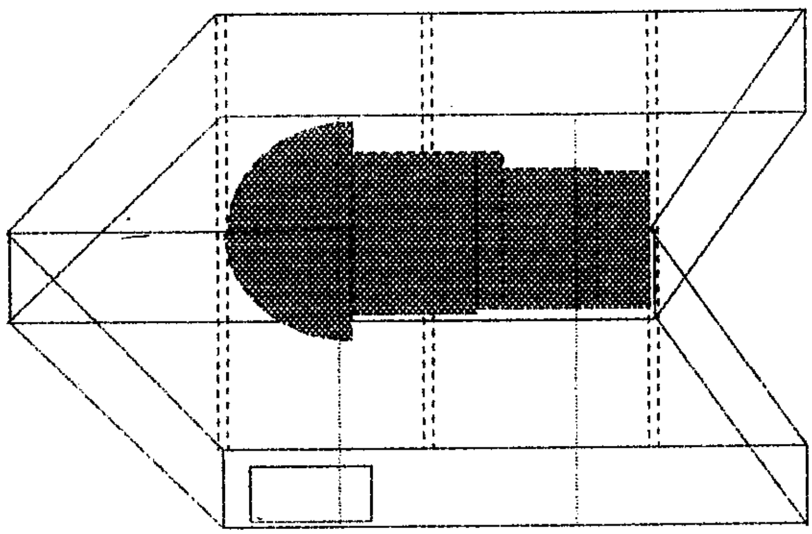
Santos Rohena

Puerto Rico Department of Natural Resources Secretary

DRN

March 1991

TRAP MESH SELECTIVITY OFF THE WEST COAST OF PUERTO RICO
(January 1990 - December 1990)



Aida Rosario
and
Yvonne Sadovy

October 31, 1991

TRAP MESH SELECTIVITY OFF THE WEST COAST OF PUERTO RICO

ABSTRACT

Catch selectivity of wire mesh fish traps was tested for six different mesh sizes ranging from 0.5" x 0.5" (13 x 13 mm) to 3 x 2" (76 x 51 mm). A total of 4,471 fish representing 90 species, 35 families, and 1,096 kg were captured during 1,076 trap hauls off the west coast of Puerto Rico from January 1990 to December 1990. Significant differences were noted in catches by mesh size. On a per haul basis, the 1.5" hexagonal mesh caught the most fish by number, weight, and value. Traps with smaller and larger meshes tended to catch fewer fish and less weight per trap haul. Median fish size increased with mesh size.

Catch species composition was affected by the mesh size used. Smaller mesh sizes accounted for higher species diversity than larger meshes. The percentage of trash fish or bycatch (species with little or no market value) fluctuated from 20 to 35% of total catch by weight. None of the tested mesh sizes seems to be effective in substancially reducing the bycatch, with the possible exception of the 2 x 3" vinyl coated wire.

Median commercial value ranged from a minimum of $0.00/haul for the 2 x 3" galvanized mesh to $2.39/haul for the 1.5 x 1.5" mesh. Median value per haul tended to decrease for meshes larger and smaller than 1.5" mesh. Median value per fish as a function of mesh size also tended to decrease with meshes larger and smaller than 1.5" mesh size. While median size tended to increase with mesh size, median price per fish did not increase primarily because individuals caught with larger mesh sizes tended to consist predominantly of species of little or no commercial importance.

Spawning condition of species of major commercial importance, such as groupers and snappers, showed that most of the individuals caught with different mesh sizes were not sexually mature. Smaller mesh sizes tended to capture relatively greater numbers of juveniles individuals than larger mesh sizes.

On the basis of the biological and economic analyses of this study it was determined that although the 1.5 x 1.5" mesh would likely provide a better economic return to fishermen on a short-term basis, management of the fishery for increased yield on a long-term basis would likely require an increase of the mesh size used on traps to at least 2 x 2", or the total elimination of trap fishing. A full analysis of the long-term effects on productivity under these various scenarios is necessary to enable development of a management plan for optimization of yield.

ACKNOWLEDGMENTS

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

Specials thanks are due to all the members of the Exploratory Fishing Project for their dedication to their work, which in the most adverse conditions and, for a period, lacking one member of the crew, made this survey possible. Special thanks to Mr. Stephen Meyers, of the Caribbean Fisheries Management Council, who assisted in the statistical analysis of the data.

TABLE OF CONTENTS

LIST OF FIGURES

Page

Page

LIST OF TABLES

LIST OF APPENDICES

Page

TRAP MESH SELECTIVITY OFF THE WEST COAST OF PUERTO RICO

INTRODUCTION

As in most parts of the Caribbean, the fishery in Puerto Rico is almost exclusively artesenal in nature. The fish trap or "nasa" has historically been the most important fishing gear in terms of total units of gear fished and in the percentage of total reported landings by weight. In 1976 and the early 1980's traps accounted for 67% of total reported production on the Island. By 1988 it was estimated that 37% of the total fishing units were fish traps accounting for 34% of the total landings of fish and shellfish. Total annual catch per trap reported over the past 12 years has declined steadily from 159 kg in 1976 to 23 kg in 1988 (Weiler and Suarez-Caabro, 1980; García-Moliner and Kimmel, 1986; Matos and Sadovy, 1989).

Great concern arises from the fact that fish traps are an extremely effective, but non-selective, passive fishing gear and that relatively little is known about the way in which traps work. In the Caribbean Munro **et al** (1971) and Munro (1974) identified some of the more important factors affecting fish trap catches. Among these are the baiting effect, soak time, moon phase, conspecific attraction and escapement of traps by fishes considered to be important. A model that describes trap catches against time was developed by Munro (1974) showing that trap catches will approach an asymptotic level with increasing soak time over a number of days. It has also been noted that catch composition changes with soak time (Munro, 1974; Stevenson and Stuart-Sharkey, 1978; Hartsuijker and Nicholson, 1981).

Other factors, such as the distance that traps are set away from reefs, affect the performance of traps in the capture of target species (High and Beardsley, 1970; Hartsüijker 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). In recent years, however, greater attention has been paid to the importance of different mesh sizes utilized to build fish traps. Mesh size can greatly influence catch profile, such as catch composition and fish size, and can lead to overfishing of resources if too small. Of particular concern is growth overfishing in which individuals are removed at too small a size from the fishery to maximize yield. A further concern is that if too many juveniles are removed from the fishery there will result insufficient numbers of reproductive adults to maintain stocks.

In Puerto Rico, Stevenson, (1978) and Stevenson and Stuart-Sharkey (1980) demonstrated that the red hind, **Epinephelus guttatus** (cabrilla) and the white grunt, **Haemulon plumieri** (cachicata blanca), were being overfished by the 1" (25 mm) and the 1.25" (32 mm) trap mesh sizes. They tested the effects on capture of using 3 different mesh sizes and found that increasing mesh size led to a significant reduction in the number of fish caught, especially those of smaller size classes, and also to changes in the species composition of the catch. They also found that squirrelfishes (**Holocentrus** spp) were more effectively harvested by larger meshes. These species are of little or no commercial importance although their removal in high numbers as bycatch (brosa) results in wasteful loss of biomass.

There are four principal areas of concern regarding the effectiveness, and non-selectivity, of fish traps and the resulting impact on fisheries resources.

A) High mortality of juveniles: smaller mesh sizes tend to discriminate more heavily against juveniles and smaller individuals of exploited species (Stevenson and Stuart-Sharkey, 1978; Munro, 1983; Taylor and McMichael, 1983). This can lead to growth overfishing.

B) Non-selective catch retention: fishes of no commercial value are removed which are an integral part of the reef community and its health (Sutherland **et al**, 1987), and they may constitute an important food source for species of commercial importance.

C) Mortality or injury of juvenile and adult fish. This occurs by escape attempts, by embolism through changes in pressure as traps are lifted to the surface, by stress or predators which enter traps (Bohnsack **et al**, 1989; Luckhurst and Ward, 1987), and by "ghost" fishing when traps are lost but remain intact and continue to fish (Munro **et al**., 1971; Munro, 1974; Sutherland and Harper, 1983; Harper and McClellan, 1983; Cofer-Shabica, 1989)

D) Damage to the reef caused by traps.

In Puerto Rico, specifically, there is concern over the marked decline in catch per unit effort (pounds taken per trap haul) over the last decade. There is also concern over the sharp increase in the number of traps being used, because of the detrimental aspects of trap fishing on the fishery. As a result of these concerns, the Fisheries Research Laboratory (FRL) of the Department of Natural Resources (DNR) carried out a one year study to address the biological and economic impacts of a total of six different mesh sizes on the standard fish trap of Puerto Rico.

METHODS

Traps

To determine the effect of trap mesh size on catch composition, value, weight and number of fish caught, five galvanized metal mesh sizes were used: 0.5" x 0.5" (13 x 13 mm) square mesh, 1.25" x 1.25" (32 x 32 mm) hexagonal mesh, 1.5" x 1.5" (38 x 38 mm) square mesh, 2" x 2" (51 x 51 mm) square mesh, 2" x 3" (51 x 76 mm) rectangular mesh. Since a mesh size of 1.25" is that most commonly used by Puerto Rican fishermen, this size was considered the control mesh size, leaving four experimental mesh sizes (Appendix A). After initiation of the study, two other kinds of mesh were incorporated into the study: 2" x 3" (51 x 76 mm) vinyl coated mesh, and 2" x 1" (25 x 51 mm) rectangular mesh size. Mesh size characteristics and measurement conversions are listed in Table 1.

Trap design, in terms of dimensions and form of the entrance funnel ("nasillo"), was the standard used by pot fishermen on the shallow water platform area of Puerto Rico. Traditional Antillean arrowhead traps of 4′ x 4′ x 1.5′(122 x 122 x 30 mm) were constructed of galvanized wire mesh and reinforcing rod (Appendix B). Trap doors incorporated an autodestruct component ("pop-up" type fasteners) to comply with Commonwealth Law and to prevent "ghost" fishing by lost traps. Prior to deployment, trap doors were fastened in such a way as to enable detection of pilfering during the soak period.

Sampling Areas

Sampling areas were selected using data from the results of the 1988-1989 Monitoring Project (Rosario, 1989). The selected areas comprised the ten most productive 2 x 2 mile quadrants sampled during the 1988-1989 Monitoring Project. Sampling thus covered a total of 40 (not necessarily contiguous) square miles on the platform/shelf break area of the insular platform of western Puerto Rico (Appendix B).

Field Procedure

A minimum of 100 hauls was made per combination of mesh size (5) and fishing zone (2) from January to December 1990 except for the 2 x 3" vinyl coated wire (58 hauls). Approximately 100 trap hauls per mesh were estimated to be necessary to complete the study and ensure a sufficient sample size for statistical analysis. Two boats were used for sampling. On each boat, for each sampling trip, two traps of each mesh size were deployed between January to December 1990, except for the 1 x 2" and 2 x 3" vinyl coated mesh, as noted. The 1 x 2" mesh was introduced at the end of July 1990 and 133 hauls made by December 1990. Additional trips were scheduled to compensate for trap losses, as necessary.

To partially control for season and weather conditions, each fishing trip generally deployed at least one of each mesh size. The traps were deployed, each trap a different mesh size, in strings of five to ensure that similar substrate was being sampled on each trip and to aid relocation. A buoy with a timed release marked the location of the buoy string. Traps were set no closer than 150 feet (46 m) apart to prevent possible intertrap interference.

Traps were generally hauled once every 5-8 days on a regular basis on the return leg of a subsequent deployment trip. This soak period reflects that commonly used by local fishermen. Soak time varied considerably due to weather and current conditions but averaged 7 days (range 1 to 52 days). However, only soak periods of 5-8 days were included in the data analysis. Lost, stolen or damaged fish traps were replaced or repaired as needed and different traps units of a given mesh size were rotated into the fishing schedule. Data from traps that were suspected to have been pilfered, or had been damaged, were discarded.

Collection and Analysis of Data

-Collection

The following data were collected on the day that traps were hauled:

1. Date
2. Quadrant No.
3. Soak time period (days)
4. Depth of trap deployment (meters)
5. Mesh size
6. Condition of trap door mechanism; good condition, broken, or pilfered.
7. Total weight of catch for each trap
8. Species composition for each trap (identification, lengths (FL/mm) and weights (g) of all individuals, and sex and stage of sexual maturation where possible)
9. Total number of individuals in each trap
10. Gonads and otoliths of selected species were removed to support Laboratory studies on the general biology of commercially important species.

In addition, the economic value (in US $) of each catch was determined by using data on average price per pound for each species for the west coast of Puerto Rico, available from the Statistics Division of the Laboratory (Matos and Sadovy, 1989). All data were entered into a DBASE III+ program for storage and sorted prior to analysis. Summaries and analysis were made in LOTUS 123 version 2.1, Statistix version 3.1 and SAS software.

-Analysis

Data were tested for normality. They were found to be non-normal. The high incidence of zero haul catches was a major factor in producing non-normal data. Data transformations were performed. Neither transformation by log + 1, nor by square root (x + 0.5), was found to normalize the data. Analysis was carried out using non-parametric methods. Non-parametric analyses used were Wilcoxon Ranked Sum test (WRS), similar to the Mann-Whitney U test (Sokal and Rohlf, 1981) when used to compare two samples only. Also used were the Wilcoxon 2-Sample Test (Normal Approximation with continuity of .5), and the Kruskal-Wallis Test (Chi-Square Approximation). Length frequency distributions were compared using the Kolmogorov-Smirnov two sample test (Sokal and Rohlf, 1981).

The data were analyzed to address the following:

1) WEIGHT per catch per MESH SIZE;

2) VALUE per catch per MESH SIZE;

3) NUMBER OF INDIVIDUALS per catch per MESH SIZE.

4) LENGTH-FREQUENCY DISTRIBUTION of key species by MESH SIZE

5) Evaluation of CATCH COMPOSITION (by number and weight) by MESH SIZE.

6) Evaluation of BYCATCH (by weight) by MESH SIZE.

REPORTING--Quarterly reports were submitted 30 days after the end of each quarter, and the final annual report 90 days after termination of the study.

RESULTS

Sample Size

The number of hauls varied from a minimum of 58 for the 2 x 3" vinyl coated wire to a maximum of 207 for the 2 x 2" mesh. The 2 x 3" galvanized wire resulted in the highest number of zero catch hauls with 129, while the 1.25" mesh recorded the lowest with 7.

Catches

A total of 4,471 fish and shellfish belonging to 90 species, representing 35 families, and weighing 1,096 kg were captured during 1,076 trap hauls.

Median number of fish ranged from a low of .75 fish/haul for a 2" x 3" rectangular mesh to a high of 7.07 fish/haul for the 1.5" mesh (Table 2, Fig. 1). The median number of fish per haul tended to decline with mesh sizes larger and smaller than 1.25" square mesh.

The relative percentage contribution of various families to total catch (Table 3) showed that snappers (27.72%), squirrelfishes (15.39%), groupers (12.0%), trunkfishes (8.03%), mullids (4.66%), triggerfishes (4.40%), parrotfishes (4.26%), grunts (3.68%), doctorfishes (2.22%), porgies (1.93%) and jacks (1.66%) dominated the trap catches in terms of weight (Table 4). These data are compared with data on catch composition from previous laboratory studies from 1986 to 1989 (Table 3).

The relative percentage contribution of various families to total catch by number showed that snappers (31.56%), squirrelfishes (19.57%), mullids (9.01%), groupers (8.88%), trunkfishes (7.52%), grunts (4.29%), parrotfishes (3.42%), doctorfishes (2.23%) and porgies (2.17%) dominated the trap catches (Table 5). Median total weight per haul ranged from a minimum of 0 g/haul for the 2" x 3" galvanized mesh to a maximum of 1,216 g/haul with the 1.25" hexagonal mesh. The median weight per haul tended to decline with meshes larger or smaller than 1.25" hexagonal (Table 2; Fig. 1).

Both mean and median weight per fish tended to increase with mesh size (Table 2; Fig. 1, 2). The median weight per fish ranged from a low of 145 g/fish for a 0.5" x 0.5" mesh to a maximum of 405 g/fish for the 2" x 3" galvanized mesh (Table 2).

Median size of fish generally increased with mesh size. The median size ranged from a minimum of 1982 mm for a 0.5" x 0.5" mesh to a maximum of 260 mm for a 2" x 3" galvanized mesh (Table 2).

The total number of species (diversity) caught in larger mesh traps was considerably lower than with smaller meshes (Table 2). The total number of species ranged from 15 caught in the 2" x 3" vinyl coated mesh to 60 species caught in the 1.25" hexagonal mesh.

Catch per unit effort ranged from 50.60 g/trap haul for a 2" x 3" mesh to 249.80 g/trap haul for the 1.25" mesh (Table 2, Fig. 1e).

The Kruskal-Wallis Test gave non-statistically significant (significance of all tests is at the 5% level) differences for total weight caught per haul for the following mesh sizes: 0.5" and 1" x 2"; .05 and 2" x 2"; 1.25" and 1.5"; 1" x 2" and 2" x 2" mesh (Table 6a). All other comparisons exhibited significant differences.

The Kruskal-Wallis Test gave no statistically significant differences for total number of individuals per haul (Table 6b) for the following mesh sizes: 0.5" and 1.25"; 0.5" and 1.5"; 1.25" and 1.5"; 1" x 2" and 2" x 2"; and 2" x 3" g and 2" x 3" vinyl coated wire. All other comparisons exhibited significant differences.

Median length for all fish caught per haul (Table 6c) gave no statistical significant differences for the following mesh sizes: 1.25" and 1.5"; 1.25" and 1" x 2"; 1.5" and 1" x 2"; 1.5" and 2 x 2"; 2" x 2" and the two different wires of 2" x 3"; and finally among the two 2" x 3" wire (both galvanized and vinyl coated). All other comparisons exhibited significant differences.

Economics

The catches were evaluated based on fish dealer categories reported to the F.R.L. Statistics Program (Matos and Sadovy, 1990). First class commercial species had the highest market value (an average of $2.03/lb) and included, in general, groupers (**Serranidae**), snappers (**Lutjanidae**), hogfish (**Lachnolaimus maximus**), and trunkfishes (**Ostraciidae**). Second class species were valued, on average at $0.85/lbs, and include, besides small individuals of first class species, grunts (**Haemulidae**), porgies (**Sparidae**), triggerfishes (**Balistidae**), and goatfishes (**Mullidae**). Third class species had a low market value (an average of $0.54/lbs) and are composed mainly of small second class fishes, and parrotfishes (**Scaridae**). In certain areas "third class" includes large individuals of squirrelfishes (**Holocentridae**), and doctorfishes (**Acanthuridae**). First class fishes were the major component of total value for most meshes although the relative contribution to the total catch, by weight, varied considerably (Table 7, Fig. 3).

The estimated median commercial value ranged from $0.0/haul for the 2 x 3" galvanized mesh to $2.39/haul for the 1.5" mesh size (Table 2). Catch value tended to decline for meshes smaller and larger than the 1.5". The Kruskal-Wallis Test indicated non-statistically significant results for differences in price per haul for the following mesh sizes: 0.5" and 1.25"; 0.5" and 1 x 2"; 1 x 2" and 1.25" and 2 x 3" gal. and 2 x 3" vinyl (Table 6d).

Median price per fish per haul as a function of mesh size gave non statistically significant results for the following mesh sizes: 0.5" and 1.25"; 0.5" and 1 x 2"; 0.5" and 2 x 2"; 1.25" and 1 x 2"; 1.25" and 2 x 2"; 1 x 2" and 2 x 2"; 2 x 2" and 2 x 3" gal; and 2 x 3" gal. and 2 x 3" vinyl coated (Table 6e). All other comparisons exhibited significance differences.

Species composition

The classification by first, second, third and trash fish is the general market value presented by Matos and Sadovy (1990). This classification varies markedly from coast to coast, but in general, reflects the one used by the majority of fishermen. 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 squirrel fishes. For example, on the west coast, this group is considered to have no market value (trash fish). On the south coast however, it is classified as third class fish. Considering that a single species of holocentrid made up 14.8% by weight of the total catch (all mesh sizes combined). This local market classification of this group could considerably influence total catch value depending on its frequency of capture. The general trends discussed in this section have not been analyzed statistically.

The species composition by weight for the smaller mesh sizes was very similar with respect to the major groups of commercial importance captured (Tables 5, 7, 8; Fig. 3). The greatest difference in species composition was observed between the smaller mesh sizes and the 2 x 3" mesh size, both galvanized and vinyl coated (Tables 5, 7; Fig. 3). The catch for these two types of traps consisted mainly of species of little or no commercial importance and included few snapper and no grouper.

The two major groups of commercial importance in Puerto Rico are snappers and groupers, which represent first class fish. The combined percentage of these two groups for the 0.5", 1.25", and 1 x 2" mesh sizes were similar (44%), Figure 3a,b, and d. The 1.5" mesh was the mesh with the highest percentage (52%) of snappers and groupers, combined (Figure 3c). The 2 x 2" mesh (Fig. 3e) yielded 30% of the total catch as snappers and groupers.

The two most abundant species of grouper reported in the catches were the coney (**Epinephelus fulvus**) and the red hind (**E. guttatus**). The percent contribution of each species to total catch by mesh size varied, however. For the 0.5" and 1 x 2" mesh coneys were more abundant in terms of number (Table 5) than red hinds; although in terms of weight red hinds (Table 4) accounted for a higher percentage. For the 1.25", 1.5", and 2 x 2" mesh sizes red hinds were more abundant by both weight and number.

The relative percentage contribution in terms of weight (Table 8), by mesh size of total sampled coneys decreased as mesh size increased. The red hinds presented a similar trend.

Of total sampled snappers the most abundant species was the lane snapper, (**Lutjanus synagris**), in terms of both number (15.2%) and weight (12.4%). The percent contribution of this species to the different mesh sizes was basically the same, being the second most abundant species for all mesh sizes, with the exception of 0.5" mesh. Comparing the relative percent contribution to total sample by mesh size (Table 8), it can be observed that this species decreases by both number and weight for mesh sizes greater than 1.5".

The snappers appeared to be particularly susceptible to the 1.5" mesh size compared to other mesh sizes. Catch by weight with this mesh was comprised of over 42% of snappers similar to the percentage taken with the 0.5", 1.25", and 1 x 2" meshes (44%) of snappers and groupers combined. Vermillion snapper and silk snapper appeared to be most susceptible to the 1.5" mesh, recording 68.0, and 51.1 % by weight, respectively, of each species in the total sample for most species across al mesh sizes (Table 8).

The trend for most mesh sizes was for a higher proportion of the catch by weight to consist of snappers rather than groupers.

Second class fish includes mainly grunts, porgies, triggerfishes and goatfishes. This class of fish varied markedly with the different mesh sizes. The highest recorded percentage was with the 0.5" mesh (Fig. 3a) with 22%, followed by the 1 x 2" mesh (Fig. 3d) with 18% and the 2 x 3" vinyl coated (Fig. 3g) with 16%. The high percentage recorded for the 0.5" mesh was due to a single species, the spotted goatfish (**Pseudupeneus maculatus**). This species was almost exclusively caught with this mesh size, making up 76% (Table 8) of the total sample in terms of weight. The other mesh sizes took a fairly low percentage of second class fish (Fig. 3b,c,e,f).

Of the total sampled triggerfishes the 2 x 2" mesh and the 2 x 3" galvanized wire mesh sizes reported a high percentage of capture in terms of weight, 28.8 and 23.4%; respectively. The lowest percentage was recorded with the 2 x 3" vinyl coated wire, with 6.9% (Table 8).

Third class fish includes parrotfishes, trunkfishes, small grunts and porgies. The recorded percentage of this class of fish presents the reverse situation to that obtained for snappers and groupers. The larger mesh sizes tended to catch greater amounts of this class of fish than the smaller . The highest percentages were reported by both types of wire used of the 2 x 3" mesh (Fig. 3f,g), with 65 and 48%, captured with the vinyl coated and galvanized wire, respectively. This was followed by the 2 x 2" mesh (Fig. 3e) that recorded 28% of third class fish. The other four mesh sizes reported relatively low percentages of this class of fish. The lowest percentage was taken with the 0.5" mesh size (Fig. 3a).

Trunkfishes of the genera **Acanthostracion** and **Lactophrys** constituted 8.0% by weight and 7.5% by number of the total catch of all meshes combined. Of the five species sampled the most abundant in terms of weight were the scrawled cowfish, (**A. quadricornis**

(2.8%), spotted trunkfish, (**L. triqueter**, 1.9%), and the honeycomb cowfish (**A. polygonius**, 1.8%). Three species of parrotfishes belonging to the genus **Sparisoma** constituted 4.3% by weight and 3.4% by number of the total catch. The most abundant species of parrotfishes, both in terms of weight and number, was the redtail parrotfish, **S. chrysopterum**, 2.0 and 1.4%, respectively.

The lowest percentage in terms of weight of sampled trunkfishes was recorded for the 0.5" mesh (5.56%), followed by the 2 x 3" vinyl coated wire (8.7%). The 1.25" mesh reported 16.1%, the 1.5" (12.9%), and the 1 x 2" mesh 12.2%. The highest percentages were recorded with the 2 x 2" mesh (24.8%) and the 2 x 3" galvanized wire mesh size (19.7%).

The percentage of bycatch or trash fish in terms of weight for the smaller mesh sizes fluctuated between 23 to 34% of the total sample (Fig. 3). The bycatch consisted mainly of squirrelfishes, surgeonfishes, butterfly fishes, jacks, morays and scorpion fishes. The percentage of bycatch captured by the two types of 2 x 3" mesh differed markedly. The percentage captured by the 2 x 3" galvanized wire was similar to that caught by smaller mesh. The vinyl coated wire, on the other hand, recorded the lowest percentage of bycatch of any mesh (Figure 3g). The highest percentage of bycatch was taken by the 1.25" mesh.

For the 0.5", 1.25", 1.5", 1 x 2", and 2 x 2" mesh sizes the bulk of the bycatch was composed of a single species, the longjaw squirrelfish, **Holocentrus ascensionis**. This was the most abundant species caught in terms of weight and number for all the above mesh sizes, with the exception of the 0.5" mesh. The 2 x 3" galvanized wire mesh caught a single individual of this species, while the vinyl coated wire captured none. The percent contribution to total sample by mesh for this species was, in terms of weight, as follows 3.1% (0.5"), 3.7% (1.25"), 3.8% (1.5"), 2.2% (1 x 2"), and 2.1% (2 x 2"), respectively.

Three species of the genus **Acanthurus** constituted 2.2% by weight and number of total catch for all meshes. The most abundant species was the blue tang, **Acanthurus coeruleus**, recording 1.4% and 1.1% by weight and number, respectively. The highest reported percent, in terms of weight, of total sampled surgeonfishes were for the 2 x 2" and the 2 x 3" galvanized wire, with 31.0 and 15.9%, respectively.

Catches by both types of 2 x 3" wire mesh consisted mainly of trunkfishes, triggerfishes, filefishes, and surgeonfishes. Nevertheless, the groups varied with the different types of wire. For both types of wire the trunkfishes were the most abundant species, both in terms of weight and number taken, with 23.9% by weight for the galvanized wire and 27.1% for the vinyl coated. Triggerfishes made up 11.7% by weight for the galvanized wire, for the vinyl coated wire they constituted 12.8%. Filefishes

(2.8%), spotted trunkfish, (**L. triqueter**, 1.9%), and the honeycomb cowfish (**A. polygonius**, 1.8%). Three species of parrotfishes belonging to the genus **Sparisoma** constituted 4.3% by weight and 3.4% by number of the total catch. The most abundant species of parrotfishes, both in terms of weight and number, was the redtail parrotfish, **S. chrysopterum**, 2.0 and 1.4%, respectively.

The lowest percentage in terms of weight of sampled trunkfishes was recorded for the 0.5" mesh (5.56%), followed by the 2 x 3" vinyl coated wire (8.7%). The 1.25" mesh reported 16.1%, the 1.5" (12.9%), and the 1 x 2" mesh 12.2%. The highest percentages were recorded with the 2 x 2" mesh (24.8%) and the 2 x 3" galvanized wire mesh size (19.7%).

The percentage of bycatch or trash fish in terms of weight for the smaller mesh sizes fluctuated between 23 to 34% of the total sample (Fig. 3). The bycatch consisted mainly of squirrelfishes, surgeonfishes, butterfly fishes, jacks, morays and scorpion fishes. The percentage of bycatch captured by the two types of 2 x 3" mesh differed markedly. The percentage captured by the 2 x 3" galvanized wire was similar to that caught by smaller mesh. The vinyl coated wire, on the other hand, recorded the lowest percentage of bycatch of any mesh (Figure 3g). The highest percentage of bycatch was taken by the 1.25" mesh.

For the 0.5", 1.25", 1.5", 1 x 2", and 2 x 2" mesh sizes the bulk of the bycatch was composed of a single species, the longjaw squirrelfish, **Holocentrus ascensionis**. This was the most abundant species caught in terms of weight and number for all the above mesh sizes, with the exception of the 0.5" mesh. The 2 x 3" galvanized wire mesh caught a single individual of this species, while the vinyl coated wire captured none. The percent contribution to total sample by mesh for this species was, in terms of weight, as follows 3.1% (0.5"), 3.7% (1.25"), 3.8% (1.5"), 2.2% (1 x 2"), and 2.1% (2 x 2"), respectively.

Three species of the genus **Acanthurus** constituted 2.2% by weight and number of total catch for all meshes. The most abundant species was the blue tang, **Acanthurus coeruleus**, recording 1.4% and 1.1% by weight and number, respectively. The highest reported percent, in terms of weight, of total sampled surgeonfishes were for the 2 x 2" and the 2 x 3" galvanized wire, with 31.0 and 15.9%, respectively.

Catches by both types of 2 x 3" wire mesh consisted mainly of trunkfishes, triggerfishes, filefishes, and surgeonfishes. Nevertheless, the groups varied with the different types of wire. For both types of wire the trunkfishes were the most abundant species, both in terms of weight and number taken, with 23.9% by weight for the galvanized wire and 27.1% for the vinyl coated. Triggerfishes made up 11.7% by weight for the galvanized wire, for the vinyl coated wire they constituted 12.8%. Filefishes

August to December (Table 9). The percentage of males with ripe gonads peaked from April to July. Males with spent gonads were recorded in April, June, and from September to December (Table 10).

Fifty percent size of sexual maturation was 220-230 mm for males and females.

Vermillion snappers (N = 196) were captured from March to December 1990; 53.1 % were males and 39.8% females, 7.1% were of unknown sex. Ripe males accounted for 74.0% of total sampled males, while females with ripe ovaries constituted 69.2% of total females. The sex ratio of females to males was 0.8:1 (F:M). Figure 5 shows the size distribution of sampled males and females, and ripe males and females. Differences in length frequency distribution between all males and females, ripe females and males, and among ripe females and ripe males were statistically significant (Kolmogorov-Smirnov, d >> $D_{.05}$).

Based on available data the highest percentage of females with ripe ovaries was collected in March, April and September (Table 9). Males with a high percentage of ripe testes were sampled from March and April (Table 10). However, sample sizes were small for both sexes in the fall and winter. Individuals with spent gonads were sampled during October (one of each sex, Tables 9 and 10).

Fifty percent size of first sexual maturation for females was 220-230 mm, while for males was 210-220 mm.

Of sampled spotted goatfish (N = 393) 41.5% were females, of which 64.4% had ripe ovaries. Males made up 57.8%, of which 59.0% had ripe testes. The sex ratio for the sample was 0.7:1 (F:M). Figure 6 represents the percentage of total sampled males and females and the total ripe males and females. Differences in size frequency distributions among all females and males, females and ripe males, ripe females and males, ripe females and ripe males, and males and ripe males were statistically significant (Kolmogorov-Smirnov, d >> $D_{.05}$).

Based on available data the highest percentage of ripe females was sampled from March-May, and from October-December (Table 9). The highest percentage of males with ripe testes was collected from March-June, and from November-December (Table 10). Spent gonads for both sexes were sampled from September-October (Tables 9 and 10).

Fifty percent of first sexual maturation was 180 mm and 200 mm for females and males, respectively.

Females constituted 44.0% of total (N = 814) sampled longjaw squirrelfish, of which 45.0% had ripe gonads. Males made up 47.9%, and 72.8% had ripe testes. Sex ratio of females to males was 1:1 (F:M). Figure 7 represents the percentage of total sampled males found to be sexually immature.

Length Frequency

Only those species with a minimum of seventy individuals were taken into consideration for the analysis of length frequency by mesh size. A 10 mm size class interval was chosen as most appropriate for the data collected.

Eight species were compared in terms of the length-frequency distributions taken by five of the seven different mesh sizes used during this survey. The species are the coney (**Epinephelus fulvus**), red hind (**E**. **guttatus**), blackfin snapper (**L**. **buccanella**), lane snapper (**L**. **synagris**), silk snapper (**L**. **vivanus**), vermillion snapper (**Rhomboplites aurorubens**), spotted goatfish (**P**. **maculatus**), and the longjaw squirrelfish (**H**. **ascensionis**).

Additional species were taken almost exclusively by only one of the mesh sizes. Therefore, any comparison between meshes was precluded. This was the case for the scrawled cowfish, the honeycomb cowfish, and the smooth trunkfish. All lengths are expressed as fork length in mm.

Epinephelus fulvus-coney

Figure 8a shows the length-frequency distribution of total sampled coneys using 0.5", 1.25", 1.5", 1 x 2", and 2 x 2" mesh sizes combined. Modal class of the complete sample was 250 mm, and a median size of 240.5 mm, with a median weight of 185 g. Maximum size and weight for the whole sample were 306 mm and 550 g, respectively, with a minimum size of 168 mm and a minimum weight of 72 g. Figures 8b-8e show the size frequency distributions for mesh sizes 0.5, 1.25, 1.5, and 1 x 2", respectively. Table 11 gives the median length for each mesh size and 25^{th} and 75^{th} quartiles, and maximum and minimum sizes recorded.

Coneys sampled with the 2 x 2" mesh did not exhibit a definite modal class (Fig. 8f), due to small sample size. From Table 11 it can be observed that the median size and weight for this mesh were higher than for the 1.5" mesh.

Differences between the median length taken by the 1.5" and 2 x 2" mesh were statistically significant (Kruskal-Wallis, $P<.05$). A Kolmogorov-Smirnov two sample test gave statistically significant differences for the following size distributions: 0.5" and 2 x 2", and 1.5" and 2 x 2" mesh sizes. All others comparisons yielded non-statistically significant results.

Epinephelus guttatus-red hind

Figure 9a shows the length-frequency distribution of red hinds sampled with 0.5", 1.25", 1.5", 1 x 2", and 2 x 2" mesh sizes

__Lutjanus vivanus__-silk snapper

In Figure 12a are displayed the size distributions obtained for the total sample and by mesh size of the silk snapper. For the total sample the modal class was 210 mm, Figure 12a. The median size and weight were 213 mm, and 155 g, respectively. The maximum size and weight were 382 mm and 530 g, while, the minimum size and weight were 76 mm and 8 g, respectively. Figures 12b-12f show the size frequency distribution for mesh sizes 0.5", 1.25", 1.5", 1 x 2", and 2 x 2", respectively. Table 11 gives the median length and 25^{th} and 75^{th} quartiles.

The differences among medians of silk snappers captured with 1.5" and 2 x 2" mesh size are statistically significant (Kruskal-Wallis, $P<.05$).

A Kolmogorov-Smirnov two sample test yielded statistically significant results for the size distributions of 0.5" and 1.25"; 0.5" and 1.5"; 0.5" and 2 x 2" mesh; 1.25" and 2 x 2"; 1.5" and 1 x 2"; 1.5" and 2 x 2"; and 1 x 2" and 2 x 2" mesh sizes.

__Rhomboplites aurorubens__-vermillion snapper

Figure 13a displays the distribution of the total sample of captured vermillion snappers. The modal class for the whole sample was 220 mm, with a median size and weight of 210 mm, and 150 g, respectively. Maximum and minimum size and weight reported were the following: 260 and 45 mm and 290 and 2 g respectively. Figures 13b-13f show the size frequency distribution for mesh sizes 0.5", 1.25", 1.5", 1 x 2", and 2 x 2", respectively. Table 11 gives the median length and 25^{th} and 75^{th} quartiles.

Not a single vermillion snapper was sampled with the 2 x 2" or 2 x 3" meshes. Indeed meshes greater than 1.5" mesh did not catch any vermillion snappers. A Kruskal-Wallis test gave a statistically significant difference between the results obtained for this mesh and the 1.5" mesh ($P<0.05$).

Differences among the size distributions of the 0.5" mesh compared with that of the 1.25", 1.5", and 1 x 2" mesh were statistically significant, (Kolmogorov-Smirnov two sample test $d >> D_{.05}$).

__Pseudupeneus maculatus__-spotted goatfish

The length frequency distribution of sampled spotted goatfish is shown in Figure 14. Over 83% of this species were captured with the 0.5" mesh size. The 1.25", 1.5", 1 x 2" and 2 x 2" mesh size samples in term of numbers are all very small. The distributions were graphed for the sake of comparison. For the combined total sample the distribution shows a bimodality at 180 and 200 mm size classes (Figure 14a). The median size and weight were 185 mm and

Acanthostracion polygonius-honeycomb cowfish

Figure 16b shows the distribution of sampled honeycomb cowfish. Modal class was 220 mm, with a median size and weight of 232 mm and 250 g respectively. Maximum recorded size for this species was equal to that reported for the scrawled cowfish 375 mm (Table 11), but the maximum weight was slightly lower 650 g. Minimum size and weight for the honeycomb were 157 mm and 58 g respectively.

Lactophrys triqueter-spotted trunkfish

The modal class for the spotted trunkfish was 180 mm (Figure 16c), with a median size and weight of 178 and 190 g respectively. Maximum recorded size and weight were substantially lower than for the two previous species 247 mm and 475 g respectively. The minimum recorded size and weight were 127 mm and 74 g respectively.

DISCUSSION

The efficiency of traps in catching fish depends on many variables, among which the most important are the availability of fish in a determined area. Other factors such as the design of the trap, and the width, length and form of the trap entrance or funnel have been identified as important factors affecting trap catches (Luckhursts and Ward, 1987). One factor which was not tested in this survey, that has been identified by Luckhurst and Ward (1987) to bias the fish attraction to a trap, is its visual silhouette. This was standarized in the study by Bohnsack **et al**, (1989) but not in the present study which constructed traps following local tradition.

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

In general, size of captured fish was related directly to mesh size, larger median fish size was associated with larger meshes, as was observed by Olsen **et al**. (1978), Stevenson and Stuart-Sharkey (1980), Munro (1983), and Bohnsack **et al**. (1989).

Catches

Smaller mesh sizes (0.5", 1.25" and 1.5") had the highest catch rates in numbers of fish caught per haul. The high numbers result from the large numbers of small elongate-shaped fishes such as the spotted goatfish, **Pseudupeneus maculatus**, that are able to escape through larger mesh sizes. Stevenson (1978) reported a marked effect of mesh size on the length of sampled spotted goatfish due to the elongated form of its body. Catch rates were are captured in fewer numbers by the largest mesh sizes. This is partially due to the apparent general lower availability of larger animals, which is supported by skewed size frequency distributions toward smaller size classes for these species.

None of the mesh sizes tested, with the exception of 2 x 3" vinyl coated wire, is likely to achieve one of the main goals in increasing mesh size. That is to decrease the number of bycatch or "trash" fish taken. This remained high and fluctuated from 20 to 35% of total catch for all mesh sizes. This result would, however, vary depending on the classification of what constituted bycatch. This classification can vary depending on species availability and market forces.

Spawning and Mean Size of Sexual Maturity

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

Erdman (1977) reported a spawning period for lane snapper in Puerto Rico waters from March to September with a peak in May. Druzhinin (1970) and Rodrigüez-Pino (1962) reported a similar spawning period for lane snappers in Cuban water. Results obtained in this survey are comparable to those reported above.

Fifty percent size of first sexual maturation for this species in the Caribbean has been reported as 85 mm fork length (FL) for both sexes by Rodrigüez-Pino (1962) in Cuban water. Manickchand-Dass (1988) reported 225 mm total length (TL) for females and 230 mm TL for males in Trinidad. Fifty percent size of first sexual maturity for both sexes in this survey was 220-230 mm FL.

Determination of the fifty percent size of sexual maturation of the most highly economically valued species of snapper, the silk and blackfin snappers, showed that 100% of individuals caught were juveniles. Grimes (1987) demonstrated that species associated with islands and deep habitats mature at relatively large sizes when compared to those associated with continents and shallower habitats. Boardman and Weiler (1980) reported that female silk snappers mature at 500 mm FL and males at 380 mm. Blackfin snappers were reported to reach maturity at 200 and 380 mm FL for females and males (Boardman and Weiler, 1980).

Vermillion snappers showed a higher percentage of ripe gonads in March and June. Erdman (1976) reported the spawning period of this species to be from March-May, which is compatible with the results obtained in this survey. Boardman and Weiler (1980) reported a year-round spawning season for this species. Mean size to April, indicating a major spawning period. In contrast, ripe scrawled cowfish were collected in greater numbers between October to December. Munro, **et al** (1973), suggested that **A**. **quadricornis** spawns throughout the year, with a peak in the early spring in the Caribbean. There are no data available for the honeycomb trunkfish from other places in the Caribbean.

There is little information on the reproductive biology and spawning season of the smooth trunkfish, **L**. **triqueter**. Munro, **et al** (1973) suggested that this species in the Caribbean spawns from January to March. Breder and Clark (1947) collected eggs of this species during the summer time in Florida waters. Data collected during this survey suggest a major spawning period from March to April.

Length Frequency

The majority of the species that were taken into consideration for length frequency analysis were caught in greater numbers by the smaller mesh sizes; very few, if any, were collected with the largest mesh sizes 2 x 2", 2 x 3" (galvanized or vinyl coated). In general terms, the distribution of these species is highly skewed towards the smaller sizes. The larger sizes are poorly represented with the mesh sizes utilized, with the distribution mostly centered around 100 to 300 mm. Whether this pattern is due to heavy exploitation or related to some other factors such as depth, soak time, location, changes in fishing power, or simply due to availability of fish is unclear. These latter factors have been identified by several authors in the Caribbean region to be of great importance when considering the effects of mesh size on trap catches (Munro, 1974; Stevenson, 1978; Stevenson and Stuart-Sharkey, 1980; Ward, 1987; Ward and Nisbet, 1987). However, it is likely that, at least for some species such as the silk snapper, gear selectivity and depth are important factors.

This latter factor, gear selectivity, is of great importance as it relates to length of first recruitment into the fishery. The major concern is that small individuals of most key species are being retained by smaller mesh sizes. It is clear that size selection by mesh does occur (Munro, 1974, Stevenson, 1978; Stevenson and Stuart-Sharkey, 1980; Hartsuijker and Nicholson, 1981; Munro, 1983; Ward, 1987; Ward and Nisbet, 1987; Bohnsack, **et al**, 1989). Smaller meshes tend to retain smaller individuals, often juveniles, that either have not yet been able to reproduce or can result in a lower reproductive potential for the stock, and ultimately lower yields.

The following is an example of a positive consequence of increase in mesh size from 1.25" to 2 x 2". A recent analysis of yield per recruit was carried out on the red hind and indicated that this spcies was growth overfished (too many individuals are taken at too small a size to maximize potential yield, Sadovy **et**

LITERATURE CITED

Boardman, C. and D. Weiler. 1979. Aspects of the life history of three deep-water snappers around Puerto Rico. Proc. Gulf Carib. Res. Fish. Inst. 32:158-172.

Böhlke, J.E. and C.C.G. Chaplin. 1968. Fishes of the Bahamas and adjacent tropical waters. Acad. Nat. Sci. Philadelphia, Livingston Publ. Co., Pa. 771 pp.

Bohnsack, J.A., D.L. Sutherland, A. Brown, D.E. Harper, and D.B. McClelland. 1986. An analysis of the Caribbean biostatistical database for 1985. Draft. NOAA/NMFS SEFC, Miami, Fl. 1-47.

Bohnsack, J.A., D.L. Sutherland, D.E. Harper, and D.B. McClelland, Lt M.W. Hulsbeck, and C.M. Holt 1989. The effects of fish trap mesh size on reef fish catch off southeastern Florida. Mar. Fish. Rev. 51(2):36-46.y

Breder, C.M., Jr. and E. Clark. 1947. A contribution to the visceral, development, and relationships of the Plectognathi. Bull. Amer. Mus. Nat. Hist., 88:287-310.

Burnett-Herkes, J. B. Luckhurst, and J. Ward. 1989. Management of antillean trap fisheries-Bermuda experience. Gulf Carib. Fish. Inst. Vol. 39:5-11.

Cofer-Shabica, S.V. 1989. Fish traps in the coral reefs of South Florida. Proc. Coastal and Ocean Mang/ASCE Charleston, SC 6: 3030-3044.

Colin, P.L. and I.E. Clavijo. 1988. Spawning activity of fishes producing pelagic eggs on a shelf edge coral reef, southwestern Puerto Rico. Bull. Mar. Sci. 43(2): 249-279.

Druzhinin, A.D. 1970. The range and biology of the snappers (Family **Lutjanidae**). J. Icthyol. 20:8-14.

Eggers, D.M. N.A. Rickard, D.G. Chapman and R.R. Whitney. 1982. A methodology to estimating area fished for baited hooks and traps along a trap line. Can. J. Fish. Aquat. Sci. 39:448-453.

Erdman, D.S. 1956. Recent fish records from Puerto Rico. Bull. Mar. Sci., 6: 315-340.

______________. 1976. Spawning patterns of fishes from the northeastern Caribbean. Agric. Fish. Contr. Dept. of Agri., Commonwealth of P.R. 8(20): 36 pp.

García-Moliner, G.E. and J.J. Kimmel. 1986. CODREMAR/NMFS Cooperative Statistics Program. Mayagüez, Puerto Rico, Laboratorio Investigaciones Pesqueras.

Grimes, C.B. 1976. Sex ratio and fecundity of vermillion snapper, **Rhomboplites aurorubens**, from North and South Carolina. Jour. Elsha Mitchell Sci. Soc. 42(2):79-80.

Grimes, C.B. 1987. Reproductive biology of the **Lutjanidae**: a review. Part 5. Tropical Snappers and Groupers: Biology and Fisheries Management. J.J. Polovina and S. Ralston eds. Westview Press/Boulder and Colorado 239-294.

Harper, D.E. and J.A. McClelan. 1983. Observations on the behavior and survival of trap-caught reef fish. Miami Lab., SEFC, NMFS, Tech. Rep., CRD-88/89-03: 13 p.

Hartsuijker, L, and W.E.Nicholson. 1981. Results of a potfishing survey on Pedro Bank (Jamaica). The relationship between catch rates, catch composition, the size of the fish and their recruitment to the fishery. Fish. Div. Minist. Agric., Jamaica, Tech. Rep. 4, FAO/TCO/JAM 8902:Potfishing Survey of Pedro Bank, 1-44.

__________. 1982. A re-assessment of the stocks of reef fish on Pedro Bank. Fisheries Division, Ministry of Agriculture, Jamaica. Technical Report No. 4 of the Project. FAO/TCO/JAM 8902:Potfishing survey of Pedro Bank. 1-24.

High, W.L. and A.J. Beardsley. 1970. Fish behavior studies from an undersea habitat. Coom. Fish. Rev: 31-37.

Luckhurst, B. and J. Ward. 1987. Behavioral dynamics of coral reef fishes in Antillian fish traps at Bermuda. Proc. Gulf Carib. Fish. Inst. Vol 38:528-546.

Manickchand-Dass. S. 1987. Reproduction, age and growth of the lane snapper, **Lutjanus synagris** (Linnaeus) in Trinidad, West Indies. Bull. Mar. Sci. 40(1): 22-28.

Matos, D. and Y. Sadovy. 1989. CODREMAR/NMFS Cooperative Statistics Program for 1988-1989. Mayagüez, Puerto Rico. Laboratorio Investigaciones Pesqueras.

Miller, R.J. 1989. Traps as a survey tool for animal density. Proc. Gulf Carib. Fish. Inst. 39:331-339.

__________, and W. Hunte. 1987. Effective area fished by antillean fish traps. Proc. Gulf Carib. Fish. Inst. (in press).

Moran, M. and J. Jenken. 1990. Effects of fish trap mesh size on species and size selectivity in the Australian North West. Fishbyte VIII: 8-13.

----------. 1989. Fisheries-Independent monitoring of commercially exploited reef fish and spiny lobster resources in Puerto Rico. Completion Rep. CODREMAR. Mayagües, Puerto Rico. 1-114.

Sadovy, Y. In Prep. The reproductive biology of two commercially-important trunkfish (Ostraciidae) in Puerto Rico. Unpublished.

Sadovy, Y, M. Figuerola, and A. Román 1989. The status of the red hind fishery in Puerto Rico and St. Thomas, as determined by yield-per-recruit analysis. Gulf and Carib. Fish. Inst. in press.

Sinoda, M and T. Kobayasi. 1969. Studies of the fishery of Zuwai crab in the Japan Sea-VI. Efficency of the toyoma kago (a kind of crab trap) in capturing beni-zuwai crab. Bull. Jap. Soc. Sci. Fish. 35: 948-956.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry. The principles and practice of statistics in biological research. W.H. Freeman and Co., San Francisco, California, second edition, 859 pp.

Stevenson, D.K. and P. Stuart-Sharkey. 1980. Performance of wire fish traps on the western coast of Puerto Rico. Proc. Gulf Carib. Fish. Inst. 32: 173-193.

Stevenson, D.K. 1978. Management of a tropical fish pot fishery for maximum sustainable yield. Proc. Gulf Carib. Fish. Inst. 30: 386-397.

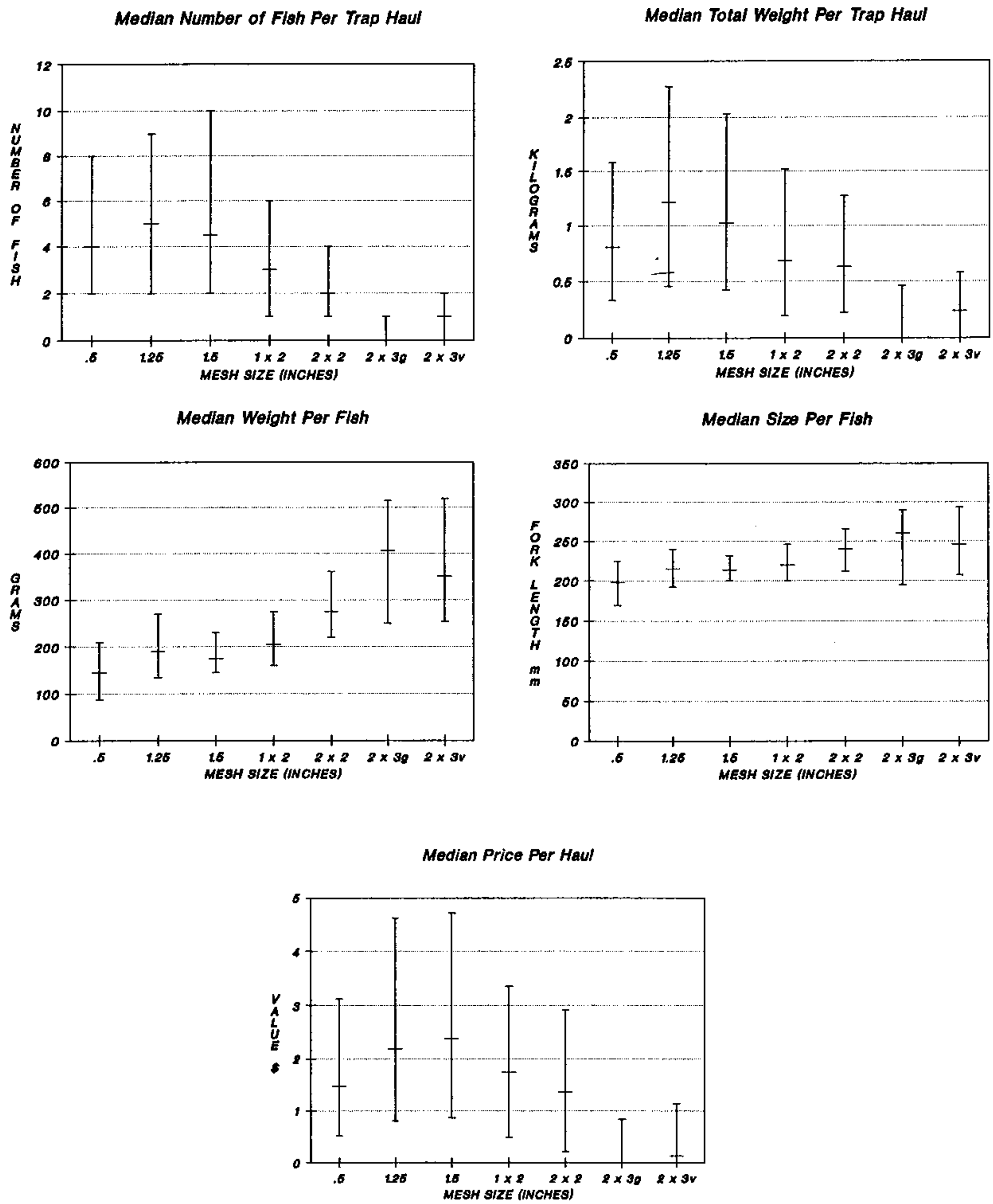
Sutherland, D.L. and D.E. Harper. 1983. The wire fish-trap fishery of Dade and Broward counties, Florida December 1979 - September 1980. Fla., Mar. Res. Pub. No. 40: 1-21.

Sutherland, D.L., J.A. Bohnsack, D.E. Harper, C. M. Holt, M.W. Hulsbeck, and D.B. McClellan. 1987. Preliminary report:Reef fish size and species selectivity by wire fish traps in south Florida waters. A report to the Gulf of Mexico Fishery Management Council, September 1987. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Ser., Southeast Fish. Cent., Miami Lab., Coast. Resour. Div. 86/87-33.

Taylor, R.G. and R.H. McMichael, Jr. 1983. The wire fish-trap fishery in Monroe and Collier Counties, Florida. Fla. Mar. Res. Publ. No. 39: 1-19.

Thompson, R. and J.L. Munro. 1974. The biology, ecology and bionomics of the hinds and groupers, **Serranidae**. Part 7. The biology, ecology, exploitation and management of Caribbean reef fishes. ODA/UWI fisheries ecology research project. Res.

Figure 1. Impact of mesh size on fish trap catches. Horizontal bars show medians and vertical bars show 25 and 75 percentiles. Sample sizes are shown in Table 2.



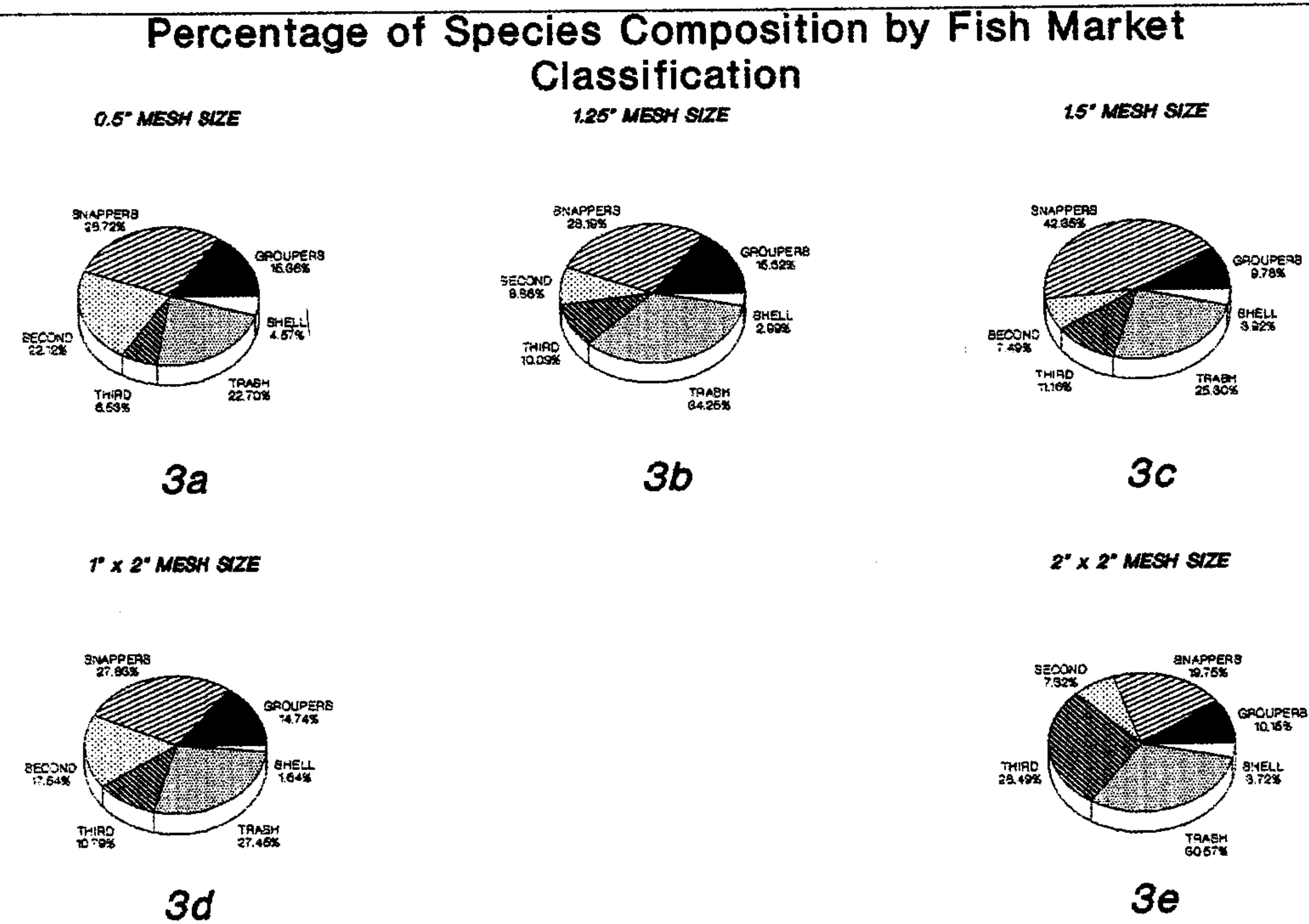


Figure 3. Comparison of percentage of total weight captured with different mesh sizes by market classification: Firstclass (snappers and groupers); second; third; shellfish (shell) and trash fish. For more details on market classification refer to Matos and Sadovy, 1989; and Table 7.

Figure 4. Size distribution by sex and incidence of ripe adult Lutianus synagris with different mesh sizes, 1990

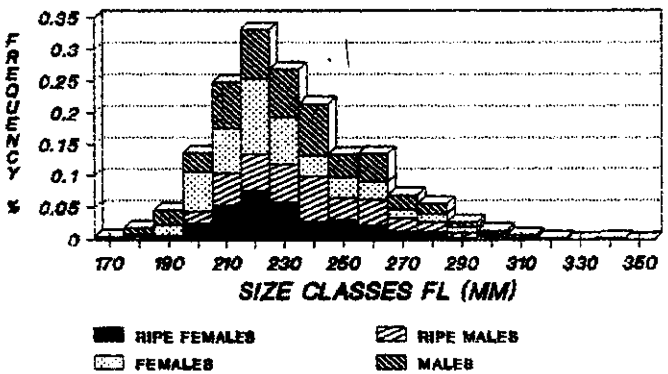


Figure 5. Size distribution by sex and incidence of ripe adult Rhomboplites aurorubens with different mesh sizes.

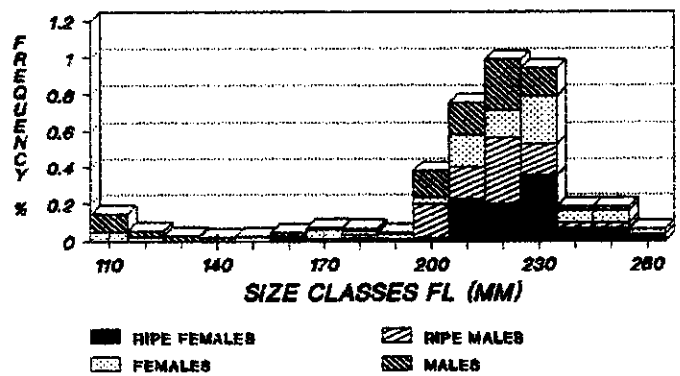


Figure 6. Size distribution by sex and incidence of ripe adult Pseudupeneus maculatus with different mesh sizes 1990

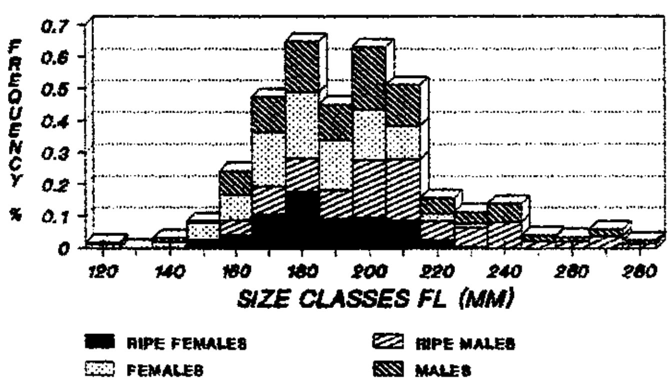


Figure 7. Size distribution by sex and incidence of ripe adult Holocentrus ascensionis with different mesh sizes.

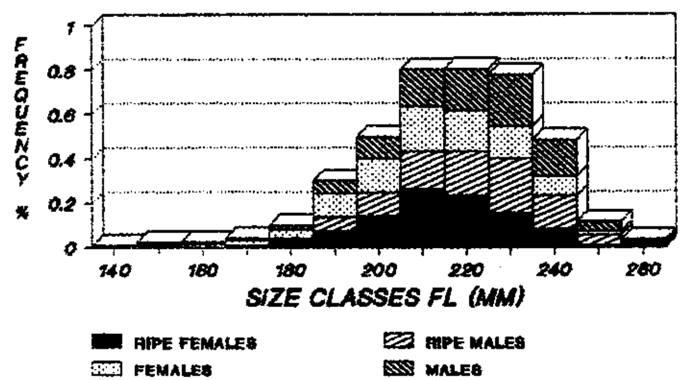


Figure 9. Size distribution of sampled Epinephelus guttatus with different mesh sizes off the west coast of Puerto Rico during sampling period of January to December 1990.

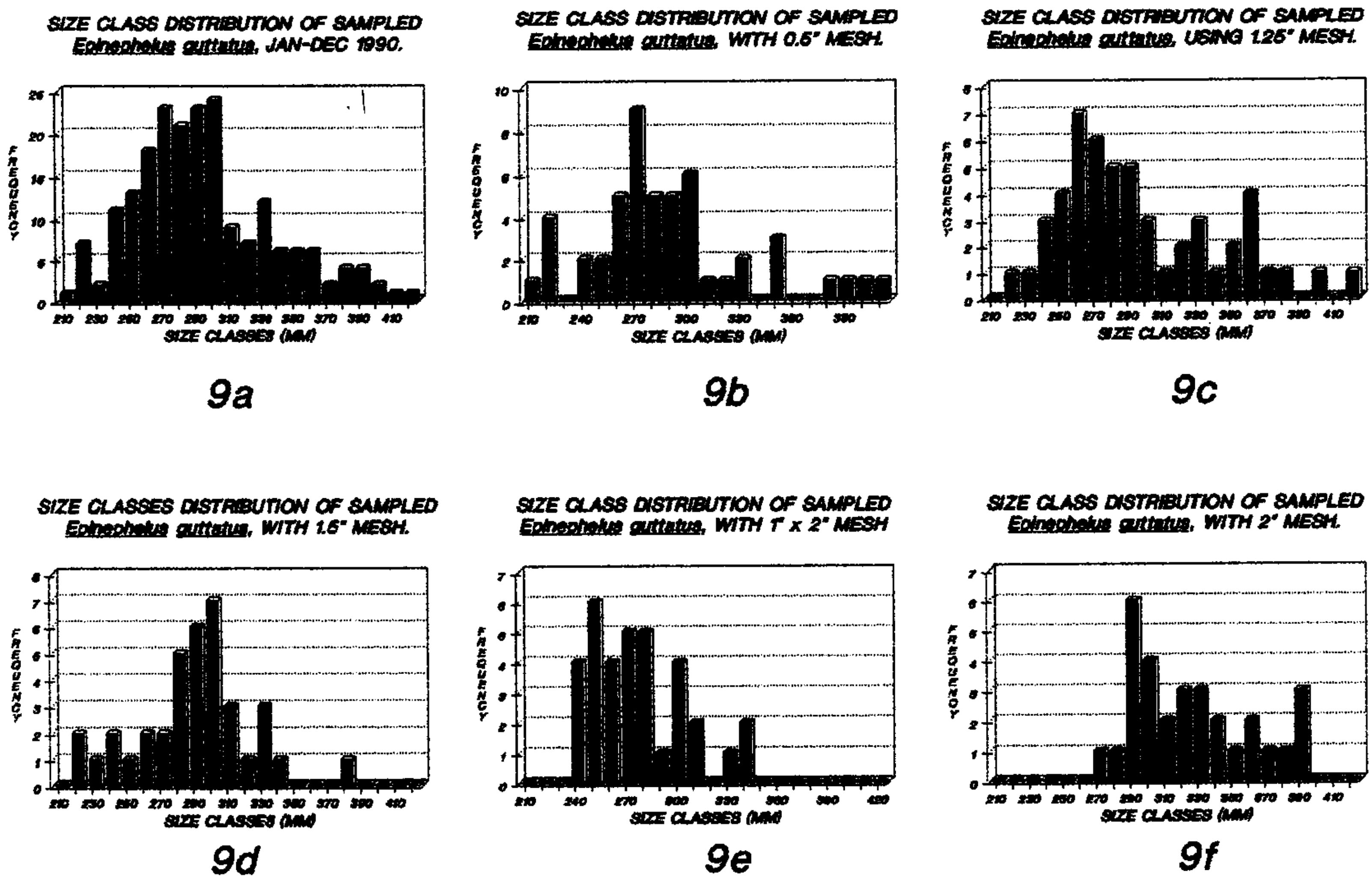


Figure 11. Size distribution of sampled Lutjanus synagris with different mesh sizes off the west coast of Puerto Rico during sampling period of January to December 1990.

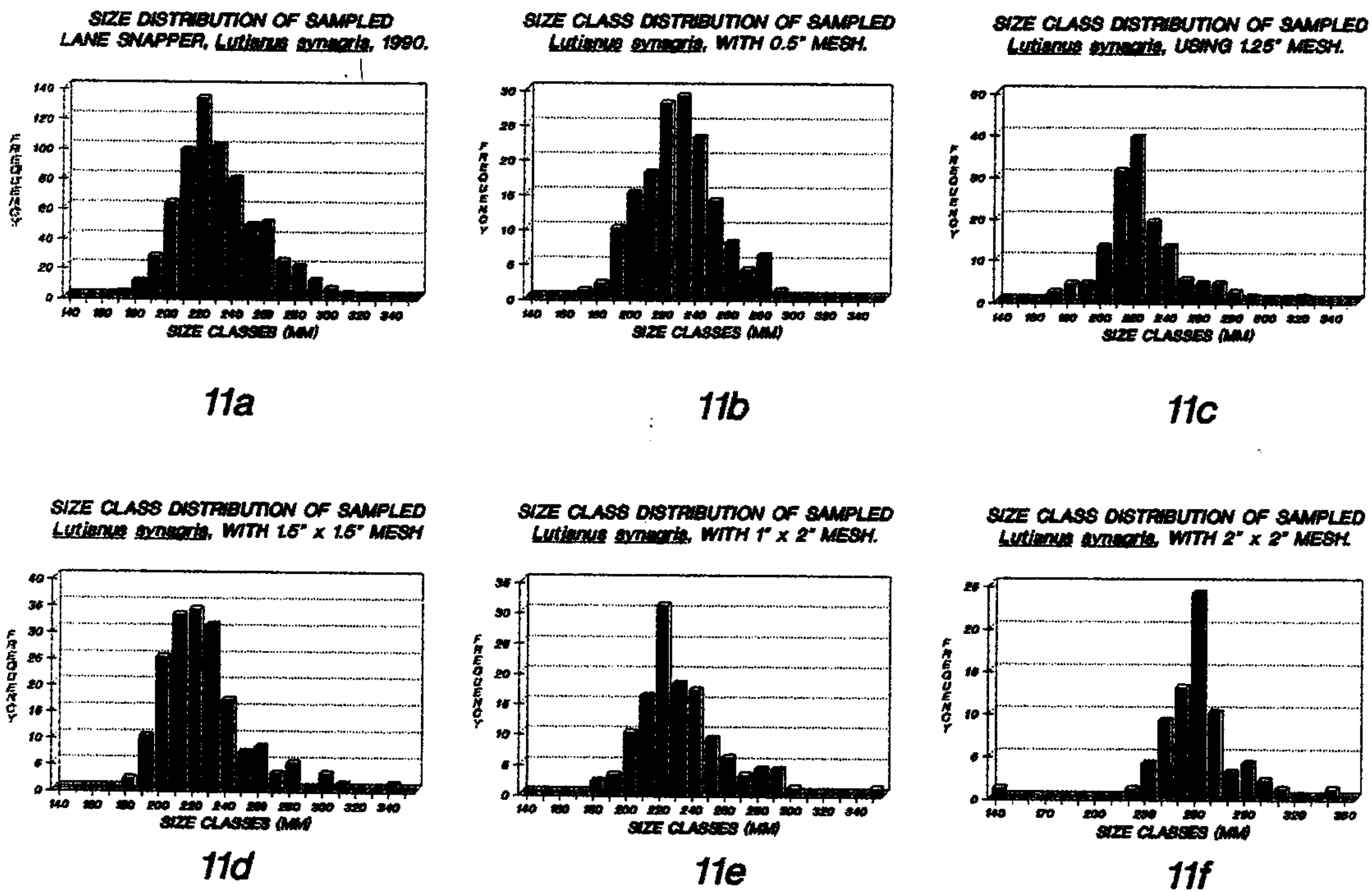


Figure 13. Size distribution of sampled <u>Rhomboplites</u> <u>aurorubens</u> with different mesh sizes off the west coast of Puerto Rico during samplingperiod of January to December 1990.

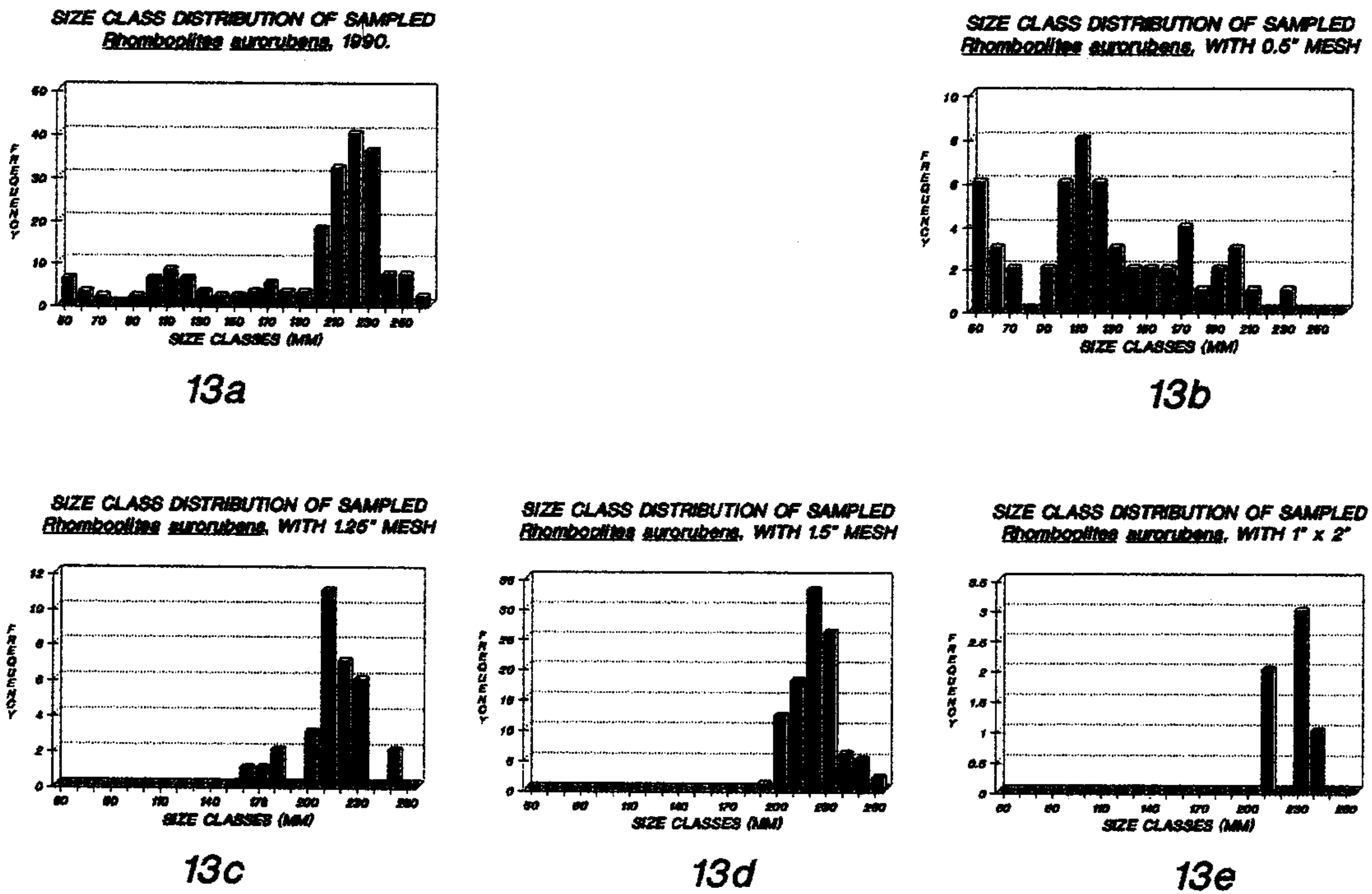


Figure 15. Size distribution of sampled Holocentrus ascensionis with different mesh sizes off the west coast of Puerto Rico during sampling period of January to December 1990.

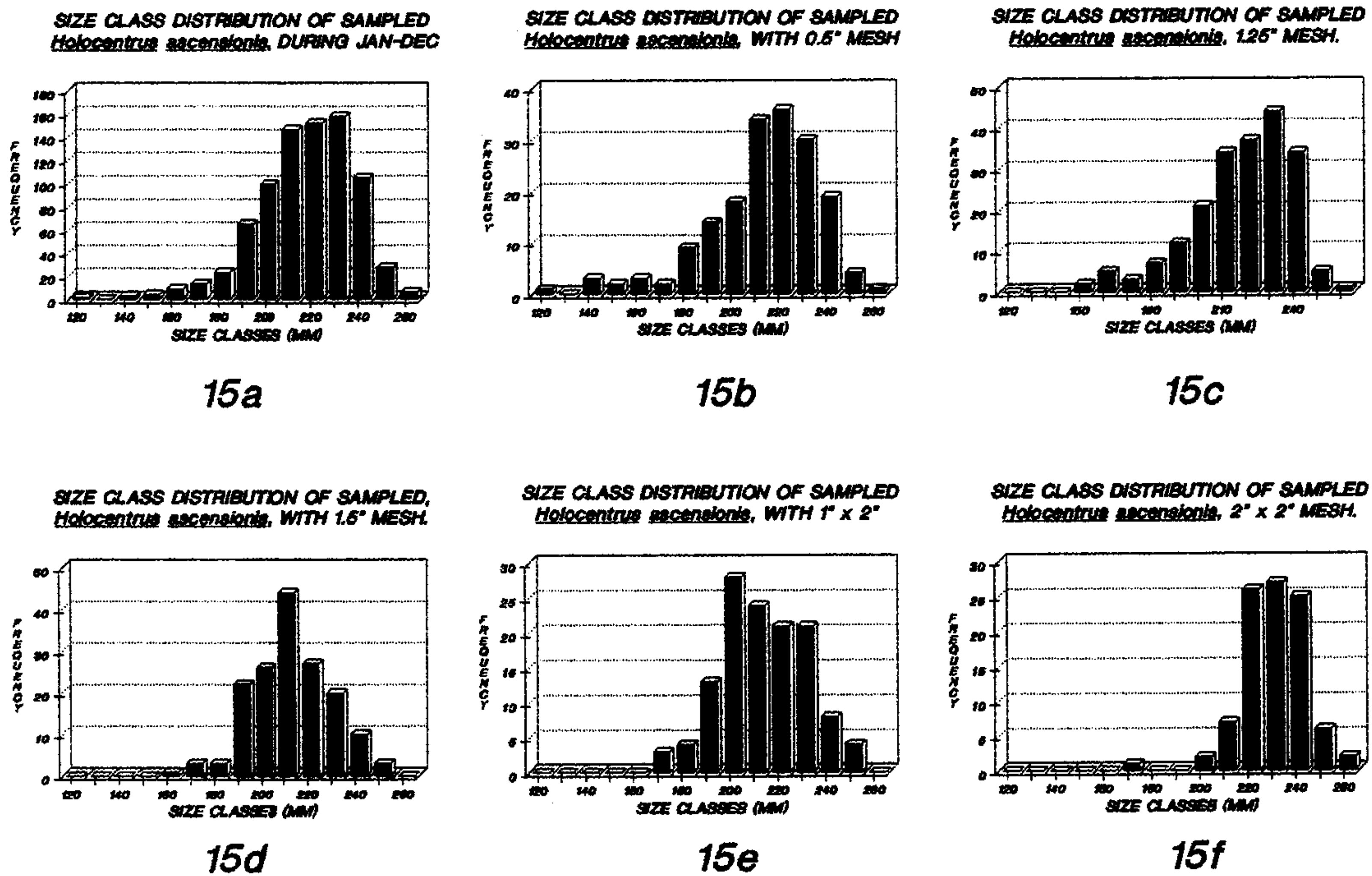


Table 1. Dimensions of trap meshes used in survey.

Mesh Shape	Width (inches)	Length (inches)	Area (inches)^2	Diagonal (inches)	Width (mm)	Length (mm)	Area (cm)^2	Diagonal (mm)
Square	0.5	0.5	0.25	0.71	12.7	12.7	1.6	18.0
Rectangular	1	2	2.00	2.25	25.4	50.8	12.9	57.2
Hexagonal	1.25	1.25	1.56	1.5	21.8	21.8	4.8	38.1
Square	1.5	1.5	2.25	2	38.1	38.1	14.5	50.8
Square	2	2	4.00	2.88	50.8	50.8	25.8	73.2
Rectangular	2	3	6.00	3.75	50.8	76.2	38.7	95.3
Rectangular*	2	3	6.00	3.75	50.8	76.2	38.7	95.3

* vinyl coated mesh

Table 2. Summary of fish trap catch and effort data by mesh size.

Mesh size (inches)	Trap hauls (#)	Total catch (#)	Median # fish per haul	Total Weight (g)	Median wt per haul (g)	Median wt per fish (g)	Median size per fish (FL) (mm)	Median Value per haul ($)	Total species (N)	CPUE— Total g/trap haul
0.5" x 0.5"	206	1,227	5.96	224,715	807.50	145	198.0	1.47	55	159.60
1.25" hex	138	912	6.61	236,812	1,216.00	190	215.0	2.19	60	249.80
1" x 2"	133	555	4.17	135,134	685.00	205	220.0	1.75	49	146.25
1.5" x 1.5"	144	1,018	7.07	216,708	1,025.00	175	214.0	2.39	52	219.34
2" x 2"	190	539	2.84	184,623	627.50	275	240.0	2.06	42	140.72
2" x 3" galv.	207	155	0.75	72,099	0.00	405	260.0	0.00	33	50.60
2" x 3" v	58	65	1.12	25,940	240.00	350	246.0	0.13	15	65.34
Totals	1,076	4,471		1,096,031					95	

CPUE = g/trap haul: a single trap haul consists of a soak period of 5 to 8 days, inclusive.

Table 3. Percent catch composition by family by weight or by number between 1986-90. Families are listed according to decreasing percentage of weights for 1986-87. Data from 1986-1987 are from a Fishery Independent sampling program of the commercial trap fishery of P.R. (Rosario, 1988), using 1.25 x 1.25" mesh traps only. Data for the 1988-89 are from the Fisheries Independent Survey off the west coast of P.R. (Rosario, 1989), using 1.25 x 1.25" hexagonal mesh traps only. Data for 1990 are from the west coast of P.R. Mesh Selectivity project. Sample size:2,248 kg (8,173 fish) in 1986-87; 704 kg (2,879 fish) in 1988-89 and 1,096 kg (4,471 fish) 1990.

Family	Weight			Numbers		
	1986-87 %	1988-89 %	1990 % (this study)	1986-87 %	1988-89 %	1990 % (this study)
Serranidae (groupers)	53.4	35.1	12.0	53.8	30.6	8.9
Lutjanidae (snappers)	19.4	34.8	27.7	18.6	36.2	31.6
Carangidae (jacks)	8.1	1.2	1.7	1.6	0.2	0.8
Balistidae (leatherjackets)	5.8	11.6	4.4	3.5	3.9	1.3
Pomadasyidae (grunts)	3.7	0.5	3.7	9.9	1.9	4.3
Ostraciidae (boxfishes)	2.0	0.2	8.0	3.8	0.2	7.5
Sparidae (porgies)	1.4	0.4	2.7	2.6	0.5	2.2
Scaridae (parrotfishes)	0.9	2.8	4.3	1.9	4.5	3.4
Mullidae (goatfishes)	0.6	3.0	4.7	1.9	4.0	9.0
Holocentridae (squirrelfishes)	0.5	2.4	15.4	0.8	4.7	19.6
Labridae (hogfishes)	0.2	0.0	0.2	0.3	0.0	0.1

Species	Weight of sampled species (g) by mesh size (inches)							
	0.5" x 0.5	1.25"	1.5"	1" x 2"	2" x 2"	2" x 3"	2" x 3"*	TOTAL Wt.
50 Haemulon striatum	76							76
51 Halichoeres bivittatus		225						225
52 Xyrichthys martinensis	74							74
53 Monachantidae		0						0
54 Cantherhines macrocerus	2,636	190	730	645	2,280		3,695	10,176
55 Cantherhines pullus	455		184					639
56 Alutera schoepfii							1,660	1,660
57 Alutera scripta						430		430
58 Myripristis jacobus	840	192		148				1,180
59 Chaetodon capistratus	136	784	188	38				1,146
60 Chaetodon sedentarius	196	374	32					602
61 Chaetodon striatus	146	380	366		320			1,212
62 Chaetodon ocellatus	60							60
63 Equetus lanceolatus	906	872	524	322	86			2,710
64 Holacanthus ciliaris		1,775	865	510	530	920		4,600
65 Holacanthus tricolor	877	286	118	483				1,764
66 Caranx hippos		975						975
67 Seriola dumerilii			500	200				700
68 Scorpaena plumieri	261	585	1,120		880		410	3,256
69 Scorpaenodes caribbaeus	530		430			290		1,250
70 Chylomycterus antennatum		590		370	314			1,274
71 Chylomycterus antillarum		925	170	195	645	940	270	3,145
72 Diodon holocanthus		5,335	1,270	850	3,450	485		11,390
73 Diodon hystrix	1,735	745			1,515	1,330		5,325
74 Canthigaster rostrata	62							62
75 Gymnothorax funebris		12,247			9,752			21,999
76 Gymnothorax moringa	1,050		910					1,960
77 Gymnothorax vicinus	660							660
78 Bothus lunatus				352		250		602
79 Paralichthys tropicus			82	48				130
80 Dactylopterus volitans		1,220	890	975	6,005	1,145		10,235
81 Dasyatis americana		1,170						1,170
82 Panulirus argus	5,830	1,725	4,190	535	1,360	3,970	3,450	20,960
83 Scyllarides nodifer			160					160
84 Carpilius corallinus	4,380	5,345	4,150	1,530	4,565	4,865		24,835
85 Mithrax spinossissimus					950	400		1,350
86 Arenaus cribarius	50			70				120
87 Stenocionops furcata		150						150
88 Calappa flamea		180						180
89 Fasciolaria tulipa				85				85
90 Octopus vulgaris	1,150							1,150
TOTALS	224,715	236,812	216,708	135,134	184,623	72,099	25,940	1,096,031
Number of Samples	206	138	144	133	190	207	58	1,076

* 2" x 3" VINYL COATED WIRE

Table 5. Continued

	Species	Number of fish trapped by mesh size (inches)							
		0.5	1.25	1.5	1x2	2x2	2x3	2x3*	Total
50	Haemulon striatum	1							1
51	Halichoeres bivittatus		1						1
52	Xyrichthys martinencis	1							1
53	Monacanthidae		1						1
54	Cantherhines macrocerus	5	1	2	1	5		7	21
55	Cantherhines pullus	1		2					3
56	Alutera schoepfii							3	3
57	Alutera scripta						1		1
58	Myripristis jacobus	11	2		2				15
59	Chaetodon capistratus	4	20	7	1				32
60	Chaetodon sedentarius	7	14	1					22
61	Chaetodon striatus	3	6	6		5			20
62	Chaetodon ocellatus	1							1
63	Equetus lanceolatus	14	11	5	3	1			34
64	Holacanthus ciliaris		3	1	1	1	2		8
65	Holacanthus tricolor	10	4	1	3				18
66	Caranx hippos		1						1
67	Seriola dumerilii			1	1				2
68	Scorpaena plumieri	2	2	3		3		1	11
69	Scorpaenodes caribbaeus	2		1			1		4
70	Chylomycterus antennatum		2		1	2			5
71	Chylomycterus antillarum		3	1	1	2	3	1	11
72	Diodon holocanthus		16	5	3	14	2		40
73	Diodon hystrix	4	3			7	2		16
74	Canthigaster rostrata	7							7
75	Gymnothorax funebris		2			1			3
76	Gymnothorax moringa	2		1					3
77	Gymnothorax vicinus	1							1
78	Bothus lunatus				2		1		3
79	Paralichthis tropicus			1	1				2
80	Dactylopterus volitans		2	2	2	14	2		22
81	Dasyatis americana		1						1
82	Panulirus argus	6	3	4	1	2	7	5	28
83	Scyllarides nodifer			1					1
84	Carpilius corallinus	8	10	7	4	10	9		48
85	Mithras spinossissimus					2	1		3
86	Arenaus cribarius	2			1				3
87	Stenocionops furcata		1						1
88	Calappa flammea		1						1
89	Fasciolaria tulipa				1				1
90	Octopus vulgaris	1							1
	Totals	1,227	912	1,018	555	539	155	65	4,471
	Number of Samples	206	138	144	133	190	207	58	1,076

* 2" x 3" vinyl coated wire.

Table 6. Continued.

Table 6d. Kruskal-Wallis Test for differences in price per haul by mesh size.

Mesh Size (inches)	Mesh Size (inches)						
	0.5 x 0.5	1.25 x 1.25	1.5 x 1.5	1 x 2	2 x 2	2 x 3 g	2 x 3 v
0.5 x 0.5							
1.25 x 1/25	n						
1.5 x 1.5	*	*					
1 x 2	n	n	*				
2 x 2	*	*	*	*			
2 x 3 g	*	*	*	*	*		
2 x 3 v	*	*	*	*	*	n	

Table 6e. Kruskal-Wallis Test for differences in price per fish per haul as a function of mesh size.

Mesh Size (inches)	Mesh Size (inches)						
	0.5 x 0.5	1.25 x 1.25	1.5 x 1.5	1 x 2	2 x 2	2 x 3 g	2 x 3 v
0.5 x 0.5							
1.25 x 1/25	n						
1.5 x 1.5	*	*					
1 x 2	n	n	*				
2 x 2	n	n	*	n			
2 x 3 g	*	*	*	*	*		
2 x 3 v	*	*	*	*	n	n	

* = significant difference ($p < 0.05$ Prob > Chi Sq)

Species			Value ($) by mesh size							
			0.5" x 0.5"	1.25"	1.5"	1" x 2"	2" x 2"	2" x 3"	2" x 3"*	TOTAL $
50	*Serranus tabacarius*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
51	*Rypticus saponaceus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
52	Priacanthidae	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
53	*Priacanthus arenatus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
54	*Priacanthus cruentatus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55	*Xanthichthys ringens*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
56	*Haemulon striatum*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
57	*Halichoeres bivittatus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
58	*Xyrichthys martinencis*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59	Monacanthidae	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60	*Cantherhines macrocerus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
61	*Cantherhines pullus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
62	*Alutera schoefii*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
63	*Alutera scripta*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
64	*Myripristis jacobus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
65	*Chaetodon capistratus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66	*Chaetodon sedentarius*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67	*Chaetodon striatus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
68	*Chaetodon ocellatus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
69	*Equetus lanceolatus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
70	*Holacanthus ciliaris*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
71	*Holacanthus tricolor*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
72	*Caranx hippos*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73	*Seriola dumerilii*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
74	*Scorpaena plumieri*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
75	*Scorpaenodes caribbaeus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
76	*Chylomycterus antennatum*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
77	*Chylomycterus antillarum*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
78	*Diodon holocanthus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
79	*Diodon hystrix*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	*Canthigaster rostrata*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
81	*Gymnothorax funebris*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
82	*Gymnothorax moringa*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
83	*Gymnothorax vicinus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
84	*Bothus lunatus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
85	*Paralichthys tropicus*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
86	*Dactylopterus volitans*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
87	*Dasyatis americana*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
88	*Stenoclonops furcata*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
89	*Calappa flammea*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
90	*Fasciolaria tulipa*	TR	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	TOTALS $		538.13	517.18	607.58	306.68	400.51	181.39	74.14	2,625.62
	Number of Samples		206	138	144	133	190	207	58	1,076

* 2" x 3" VINYL COATED WIRE

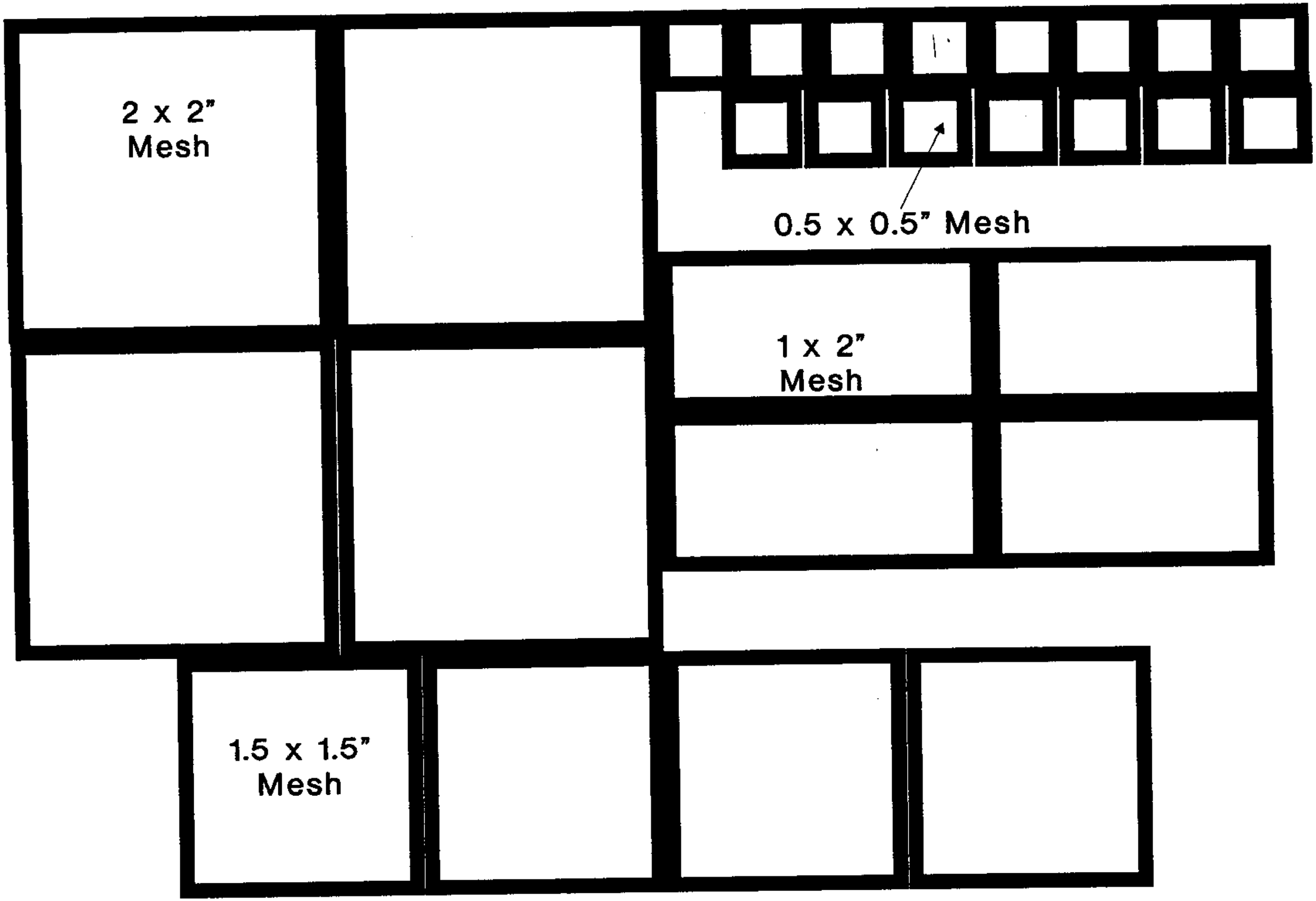
Commercial classification:P = primary; S = secondary; T = third; TR = trash.

Table 10. Monthly incidence of ripe and spent testes of selected species sampled during the survey for the sampling period of January 1990 to December 1990. Total # is total males caught in month. Data collected with different mesh sizes was combined. R. T. = ripe testes; S. G. = spent gonads (males); 0 = no samples on either spent or ripe testes; although un ripe individuals were taken; X = no available data (did not catch that particular species during the month).

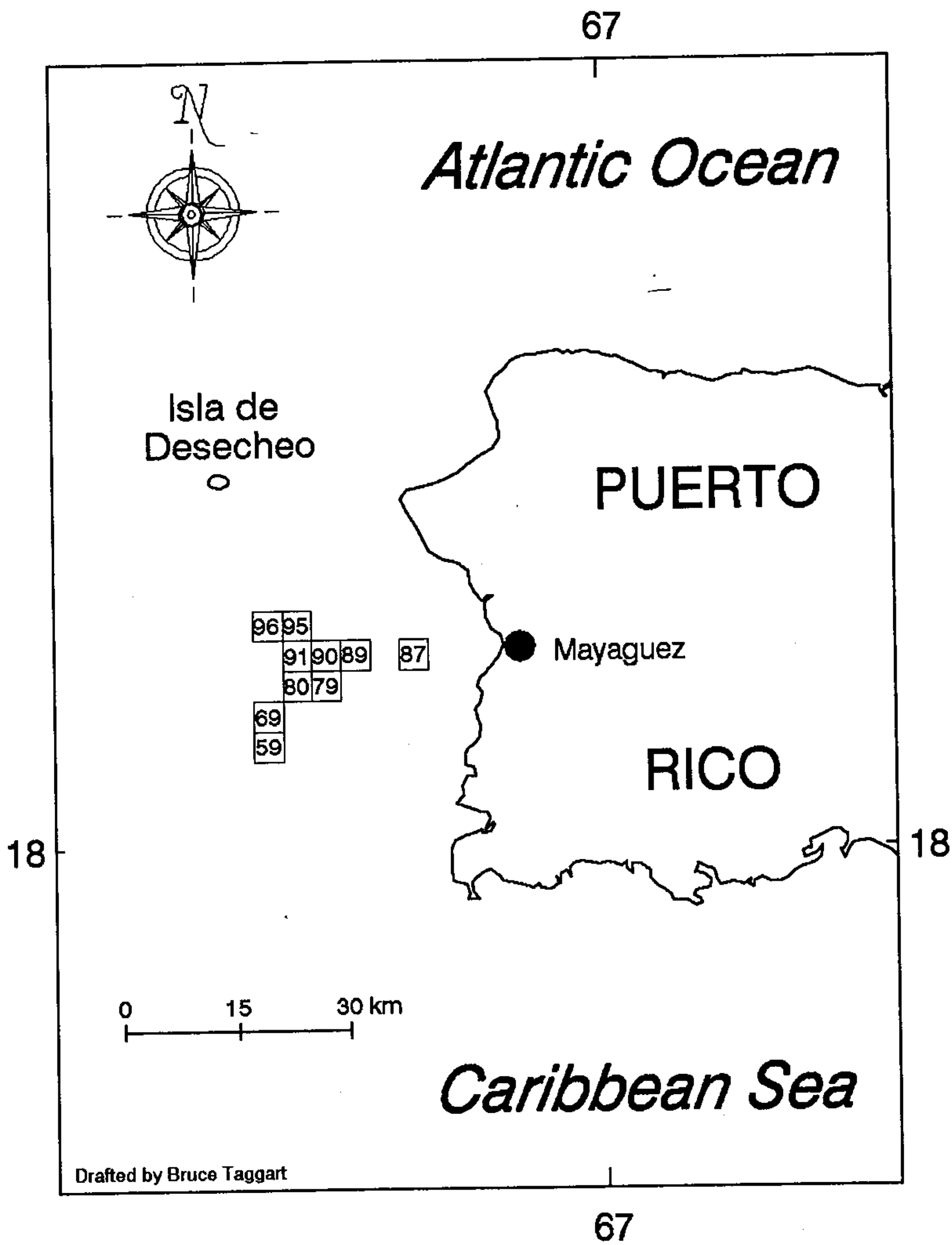
Species		January Tot #	January #R/S	February Tot #	February #R/S	March Tot #	March #R/S	April Tot #	April #R/S	May Tot #	May #R/S	June Tot #	June #R/S
1 Epinephelus fulvus	R. T./S. G.	1	1/0	X	0	1	0	5	1	10	0/10	6	0/6
2 Epinephelus guttatus	R. T./S. G.	0	0	X	0	3	0	6	0	18	0/18	6	0/6
3 Lutjanus analis	R. T./S. G.	X	0	X	0	0	0	0	0	X	0	3	0
4 Lutjanus buccanella	R. T./S. G.	X	0	X	0	15	0	1	0	6	0	8	0
5 Lutjanus synagris	R. T./S. G.	X	0	X	0	17	11	23	20	10	10	48	45
6 Lutjanus vivanus	R. T./S. G.	X	0	X	0	20	0	43	0	20	0	34	0
7 Ocyurus chrysurus	R. T./S. G.	X	0	X	0	X	0	0	0	0	0	X	0
8 Rhomboplites aurorubens	R. T./S. G.	X	0	X	0	59	53	3	0	2	0	35	17
9 Haemulon album	R. T./S. G.	X	0	X	0	0	0	4	0	5	0	3	0
10 Haemulon aurolineatum	R. T./S. G.	X	0	X	0	0	0	10	10	4	0	17	13
11 Haemulon plumieri	R. T./S. G.	X	0	1	0	3	0	1	0	4	0	0	0
12 Calamus pennatula	R. T./S. G.	X	0	X	0	2	0	2	0	6	0	8	0
13 Pseudupeneus maculatus	R. T./S. G.	X	0	1	0	16	12	18	15	5	0	2	0
14 Sparisoma aurofrenatum	R. T./S. G.	X	0	X	0	0	0	1	0	5	0	X	0
15 Sparisoma chrysopterum	R. T./S. G.	X	0	X	0	1	0	5	0	X	0	X	0
16 Sparisoma viride	R. T./S. G.	X	0	X	0	1	0	3	0	X	0	X	0
17 Balistes vetula	R. T./S. G.	X	0	X	0	2	0	5	0	3	0	3	0
18 Cantherhines macrocerus	R. T./S. G.	1	0	X	0	X	0	2	0	X	0	1	0
19 Diodon holocanthus	R. T./S. G.	X	0	X	0	1	0	15	15	X	0	4	0
20 Lactophrys bicaudalis	R. T./S. G.	X	0	0	0	X	0	2	0	2	0	0	0
21 Acanthostracion quadricornis	R. T./S. G.	X	0	X	0	0	0	8	0	7	0	3	0
22 Acanthostracion polygonius	R. T./S. G.	X	0	2	0	7	0	8	0	0	0	1	0
23 Lactophrys triqueter	R. T./S. G.	0	0	X	0	2	0	20	20	19	17	29	29
24 Caranx crysos	R. T./S. G.	X	0	X	0	X	0	2	0	X	0	X	0
25 Holocentrus ascensionis	R. T./S. G.	2	0	2	2	95	60	45	23/12	30	12	33	15/16
26 Holocentrus rufus	R. T./S. G.	8	0	X	0	X	0	2	0	3	0	X	0
27 Chaetodon capistratus	R. T./S. G.	4	0	X	0	14	10	X	0	3	0	X	0
28 Chaetodon sedentarius	R. T./S. G.	1	0	X	0	2	0	X	0	1	0	5	0
29 Chaetodon striatus	R. T./S. G.	2	0	X	0	6	0	1	0	1	0	X	0
30 Acanthurus bahianus	R. T./S. G.	X	0	X	0	0	0	13	0	4	0	2	0
31 Acanthurus coeruleus	R. T./S. G.	1	0	X	0	6	0	3	0	2	0	X	0
32 Dactylopterus volitans	R. T./S. G.	X	0	X	0	2	0	0	0	X	0	X	0
33 Equetus lanceolatus	R. T./S. G.	X	0	X	0	2	0	4	0	2	0	4	0

Species		July Tot #	July #R/S	August Tot #	August #R/S	September Tot #	September #R/S	October Tot #	October #R/S	November Tot #	November #R/S	December Tot #	December #R/S
1 Epinephelus fulvus	R. T./S. G.	1	0/1	6	0/6	3	0	2	0	2	1/1	3	3
2 Epinephelus guttatus	R. T./S. G.	4	0/4	9	0	4	0	4	0	12	0	3	0
3 Lutjanus analis	R. T./S. G.	1	1/0	1	0	X	0	2	0	3	0	3	0
4 Lutjanus buccanella	R. T./S. G.	X	0	1	0	3	0	5	0	5	0	3	0
5 Lutjanus synagris	R. T./S. G.	6	0	43	38	41	34	64	34	64	52	32	19
6 Lutjanus vivanus	R. T./S. G.	X	0	6	0	7	0	2	0	6	0	11	0
7 Ocyurus chrysurus	R. T./S. G.	X	0	X	0	1	0	6	0	1	0	1	0
8 Rhomboplites aurorubens	R. T./S. G.	X	0	1	0	1	0	2	0	1	0	0	0
9 Haemulon album	R. T./S. G.	X	0	4	0	1	0	1	0	2	0	6	0
10 Haemulon aurolineatum	R. T./S. G.	2	0	4	0	10	10	11	0	2	0	2	0
11 Haemulon plumieri	R. T./S. G.	X	0	1	0	1	0	3	0	X	0	3	0
12 Calamus pennatula	R. T./S. G.	0	0	1	0	2	0	3	0	0	0	0	0
13 Pseudupeneus maculatus	R. T./S. G.	X	0	25	0	20	10	60	12/48	35	29	45	45
14 Sparisoma aurofrenatum	R. T./S. G.	X	0	1	0	7	0	13	0	10	0	0	0
15 Sparisoma chrysopterum	R. T./S. G.	X	0	5	0	4	0	8	0	4	0	10	0
16 Sparisoma viride	R. T./S. G.	X	0	5	0	X	0	2	0	7	0	7	0
17 Balistes vetula	R. T./S. G.	1	0	4	0	1	0	6	0	1	0	2	0
18 Cantherhines macrocerus	R. T./S. G.	X	0	2	0	X	0	X	0	1	0	2	0
19 Diodon holocanthus	R. T./S. G.	X	0	5	0	X	0	1	0	X	0	X	0
20 Lactophrys bicaudalis	R. T./S. G.	X	0	1	0	2	0	3	0	1	0	2	0
21 Acanthostracion quadricornis	R. T./S. G.	X	0	5	0	2	0	11	10	5	0	13	0
22 Acanthostracion polygonius	R. T./S. G.	X	0	1	0	6	0	13	10	1	0	3	0
23 Lactophrys triqueter	R. T./S. G.	X	0	8	0	3	0	0	0	3	0	5	0
24 Caranx crysos	R. T./S. G.	X	0	X	0	X	0	9	0	8	0	0	0
25 Holocentrus ascensionis	R. T./S. G.	1	0	55	20/30	32	22/10	74	63/11	45	42	36	24/12
26 Holocentrus rufus	R. T./S. G.	2	0	3	0	6	0	2	0	6	0	X	0
27 Chaetodon capistratus	R. T./S. G.	X	0	X	0	X	0	X	0	0	0	X	0
28 Chaetodon sedentarius	R. T./S. G.	X	0	X	0	X	0	X	0	2	0	X	0
29 Chaetodon striatus	R. T./S. G.	X	0	X	0	1	0	X	0	0	0	X	0
30 Acanthurus bahianus	R. T./S. G.	X	0	4	0	3	0	0	0	2	0	6	0
31 Acanthurus coeruleus	R. T./S. G.	X	0	0	0	1	0	3	0	3	0	X	0
32 Dactylopterus volitans	R. T./S. G.	X	0	3	0	0	0	3	0	X	0	0	0
33 Equetus lanceolatus	R. T./S. G.	X	0	1	0	4	0	3	0	1	0	3	0

APPENDIX A


2 x 2"
Mesh
0.5 x 0.5" Mesh
1 x 2"
Mesh
1.5 x 1.5"
Mesh

APPENDIX B


67
N
Atlantic Ocean
Isla de
Desecheo
PUERTO
96
95
91
90
89
87
80
79
69
59
Mayaguez
RICO
18
18
0
15
30 km
Caribbean Sea
Drafted by Bruce Taggart
67