NOAA Technical Memorandum NMFS-SEFSC-331

Technical Reports of the Caribbean SEAMAP

compiled by

Nancy B. Thompson

August 1993

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
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Preface

The three reports contained herein were submitted directly to the Caribbean SEAMAP. Two of these reports (Smith and Ault; Jimenez) deal with fishery independent data collected in waters of Puerto Rico. The third report (Beets) deals with fishery independent data collected in U.S. Virgin Islands waters. All three reports were completed with Caribben SEAMAP funding, Dr. Scott Nichols, Program Manager, Pascagoula Laboratory, Southeast Fisheries Science Center. These reports were submitted to me for compilation as a Technical Memorandum and the opinions ,views, data and results included are entirely those of the authors and not of the NMFS. I am very pleased to have the opportunity to compile these reports for rapid dissemination of the technical information and data presented by these authors.

Nancy B. Thompson

Southeast Fisheries Science Center

August 1993

Statistical Sampling Design Analysis of the 1991-1992 Puerto Rico Shallow-Water Reef Fish Monitoring Survey

by

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Final Report

February 11, 1993

ACKNOWLEDGEMENTS

The analyses presented in this report were enhanced by a series of discussions, covering topics from specific field-sampling techniques to the reproductive ecology of groupers, with Ms. Aida Rosario of the Puerto Rico Department of Natural Resources and Mr. Stephen Meyers and Dr. Yvonne Sadovy of the Caribbean Fishery Management Council. Their assistance is greatly appreciated. Work was conducted under contract #SEA-92-004 with the Caribbean Fishery Management Council.

Figure 1. Sampled stations during survey carried out during April 1992 to March 1993.

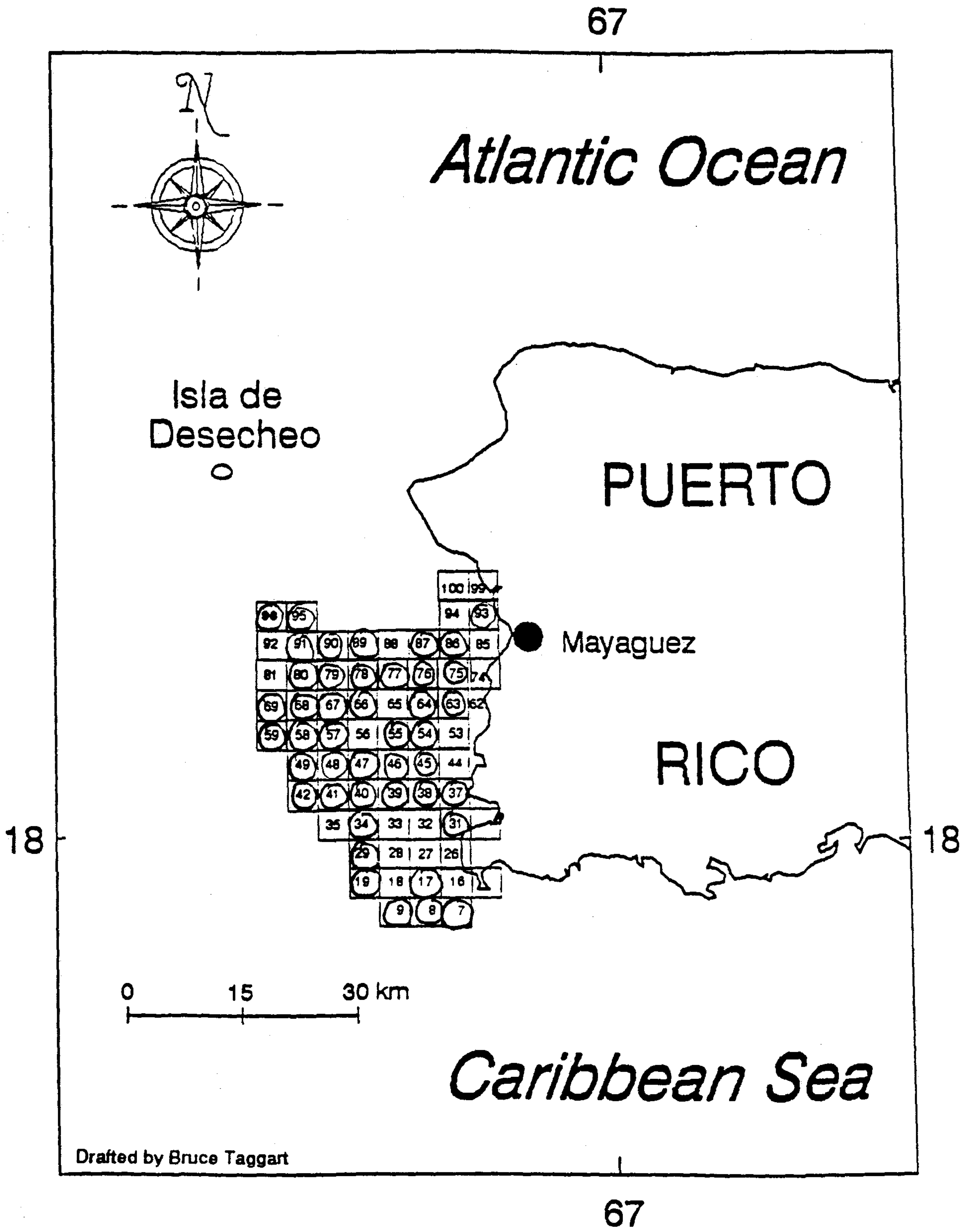


Figure 1. Sampled stations during survey carried out during April 1992 to March 1993.

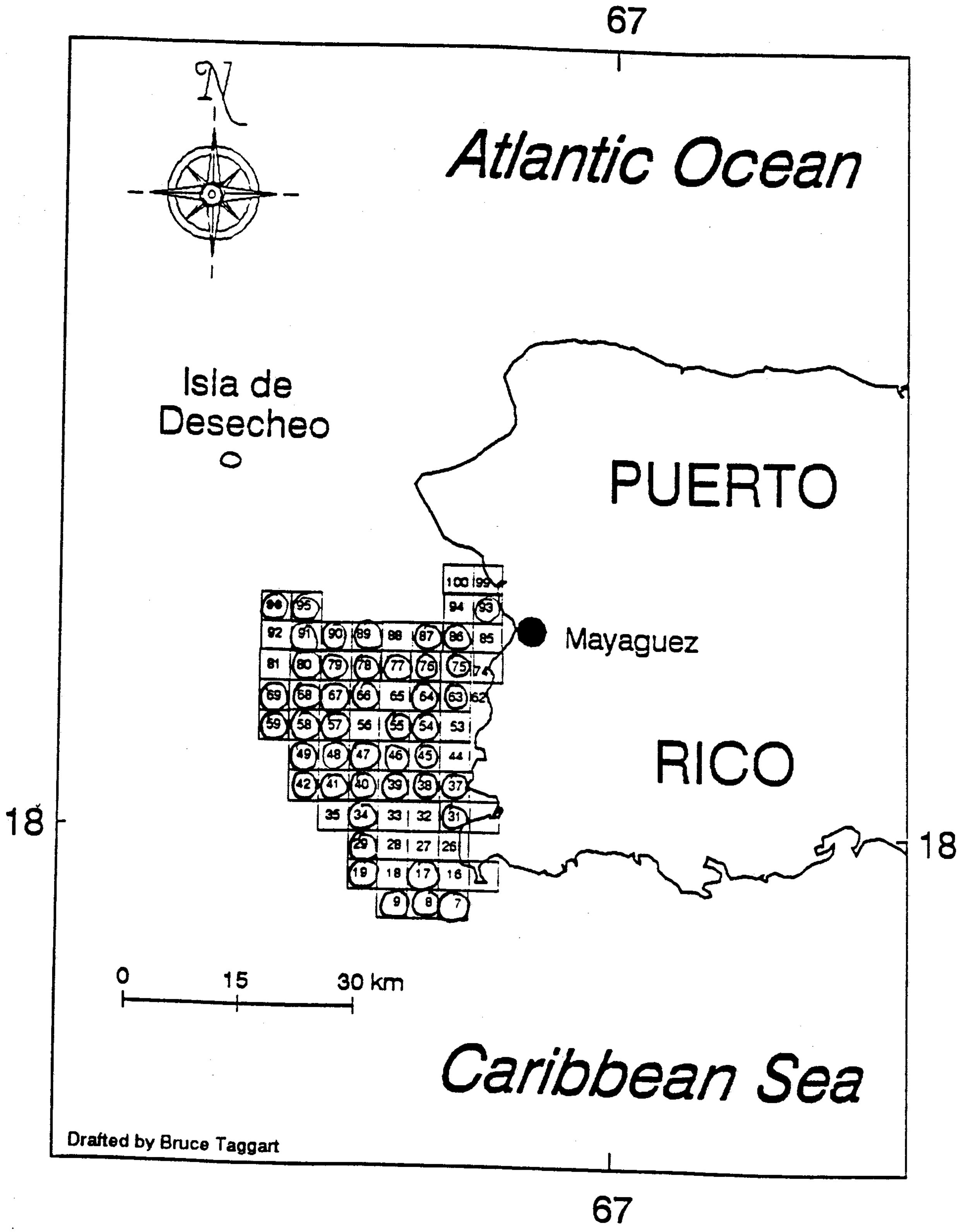


Table 1. Sampling allocations (days, sample sizes) for traps and hook and line by location and month from September to June 1992.

Location #	Depth	Substrate	Month	Traps: Sampling days	Traps: n	Hook-and-Line: Sampling days	Hook-and-Line: n
34	shallow, 0-10 f	some coral	June	1	12	1	3
37	shallow, 0-10 f	rocky/ no coral	June	1	12	1	3
40	shallow, 0-10 f	rocky/ no coral	June	1	12	1	3
66	intermediate, 11-20 f	coral	June	1	12	1	3
80	intermediate, 11-20 f	coral/ sand	April	3	36	3	9
			May	3	36	3	10
90	deep, 21-50 f	coral/ sand	April	2	24	3	9
93	shallow, 0-10 f	mud	June	3	36	3	9
95	deep, 21-50 f	coral	September	5	87	5	15
			October	6	72	6	18
			December	3	36	3	9
			January	–	–	3	9
			February	3	36	6	18
			March	5	60	7	22
			April	5	60	5	15
96	deep, 21-50 f	coral	September	5	85	5	16
			October	4	48	4	12
			November	2	24	2	6
			December	6	72	6	18
			January	–	–	3	10
			February	6	72	6	18
			March	2	24	5	17
			April	3	36	3	9
Total				70	892	85	261

substrate composition for each sampled quadrat was additionally provided (A. Rosario, personal communication).

Geographical locations (quadrats) sampled during the survey are indicated on Figure 1. Table 1 lists depth and substrate characteristics for these locations, as well as the number of sampling days allocated per month for each gear. Locations 95 and 96 were exclusively sampled each month from September 1991 throughMarch 1992, while all nine survey locations were sampled during the April-June 1992 period. The catch was dominated by two grouper species, Epinephelus guttatus and Epinephelus fulvus, for both traps (Table 2a) and hook-and-line (Table 2b). Of the 47 species captured in the survey, 14 (30%) were exclusively captured by traps, 20 (42%) were exclusively captured by hook-and-line, and 13 (28%) were captured by both gears.

1.2 Scope of Analysis and Report Organization

This report focuses on statistically analyzing the effects of season, geographical location, depth, and substrate composition on abundance estimates and future sampling survey designs for grouper and snapper target species. Survey data is also evaluated with respect to supplying information needed for conducting stock assessments.

Following the results shown in Table 1, two sets of analyses were performed. The first analyzed data from similar habitats (i.e. depth and substrate composition) in different months. Data collected in locations 95 and 96 from September 1991 to April 1992, termed the "seasonal" dataset, were the subject of this analysis. The second analyzed data from different habitats in the same season. Data collected in all locations during April-June 1992, termed the "habitat" dataset, were utilized for this task. Both sets of analyses focused on two grouper species, red hind (Epinephelus guttatus) and coney (E. fulvus), captured by the two sampling gears as suggested by the results of Tables 2a and 2b.This report is organized into six sections, including this introduction. Statistical methods are described in section 2.0. Sections 3.0 and 4.0 present analysis results for the seasonal and habitat datasets, respectively. Stock assessment considerations with respect to information obtained from the survey are discussed in section 5.0. Conclusions and recommendations for future sampling surveys are presented in section 6.0.

2.0 STATISTICAL METHODS

Statistical procedures can be grouped into three principal tasks: 1) estimating relative abundance and associated descriptive statistics; 2) determining seasonal and habitat factors influencing relative abundance; and 3) utilizing results of the

Table 2a. Number of each species captures for traps.

Code	Species	Number captured in each location by traps									
		34	37	40	66	80	90	93	95	96	Total
88	Epinephelus guttatus	0	0	1	0	5	0	0	170	269	445
80	Epinephelus fulvus	0	0	1	0	7	2	1	41	71	123
251	Balistes vetula	0	0	0	0	1	0	0	17	33	51
65	Holocentrus ascensionis	0	0	0	0	3	4	0	17	7	31
561	*Chaetodon striatus	0	0	0	0	9	0	5	6	6	26
135	Lutjanus apodus	0	0	0	0	0	0	0	1	18	19
140	Ocyurus chrysurus	0	0	0	0	1	0	0	5	10	16
139	Lutjanus vivanus	0	0	0	0	0	14	0	0	0	14
142	Rhomboplites aurorubens	0	0	0	0	1	5	0	0	0	6
727	*Cantherines macrocerus	0	0	0	0	2	0	0	1	2	5
255	*Cantherines pullus	0	0	0	0	0	0	0	1	2	3
89	*Epinephelus striatus	0	0	0	0	0	0	0	1	1	2
165	Calamus pennatula	0	0	0	1	1	0	0	0	0	2
117	Caranx crysos	0	0	0	0	0	0	0	1	1	2
726	*Aluterus scriptus	0	0	0	0	0	0	0	1	1	2
822	Chilomycterus antillarum	0	0	0	0	1	0	0	0	1	2
91	*Mycteroperca venenosa	0	0	0	0	0	0	0	1	0	1
136	Lutjanus synagris	0	0	0	0	1	0	0	0	0	1
700	*Lactophrys quadricornis	0	0	0	0	1	0	0	0	0	1
625	Holocentrus rufus	0	0	0	0	0	0	0	0	1	1
560	*Chaetodon ocellatus	0	0	0	0	1	0	0	0	0	1
575	*Holacanthus tricolor	0	0	0	0	0	0	0	0	1	1
662	*Halichoeres bivittatus	0	0	0	0	0	0	0	0	1	1
651	*Acanthurus chirurgus	0	0	0	0	0	0	0	0	1	1
652	*Acanthurus coereleus	0	0	0	0	0	0	0	0	1	1
820	*Diodon holacanthus	0	0	0	0	0	0	0	0	1	1
245	Scorpaena plumieri	0	0	0	0	1	0	0	0	0	1
	Total	0	0	2	1	35	25	6	263	428	760

*exclusively captured by traps

Table 2b. Number of each species captured by location for hook and line.

Code	Species	Number captured in each location by hook-and-line									
		34	37	40	66	80	90	93	95	96	Total
88	Epinephelus guttatus	1	0	2	1	11	9	0	1,410	1,382	2,816
80	Epinephelus fulvus	0	0	1	0	80	3	2	314	363	763
103	†Malacanthus plumieri	0	0	0	0	25	2	0	37	50	114
65	Holocentrus ascensionis	0	0	0	0	6	3	0	68	30	107
142	Rhomboplites aurorubens	0	0	0	0	31	1	0	0	0	32
139	Lutjanus vivanus	0	0	0	0	0	27	0	0	0	27
119	†Caranx lugubris	0	0	0	0	0	0	0	14	13	27
111	†Seriola rivoliana	0	0	0	0	0	0	0	12	12	24
53	†Melichthys niger	0	0	0	0	0	0	0	3	20	23
251	Balistes vetula	0	0	0	0	0	0	0	9	10	19
625	Holocentrus rufus	0	0	0	0	0	0	0	9	4	13
252	†Canthidermis sufflamen	0	0	0	0	0	0	0	4	8	12
442	†Gymnothorax moringa	0	0	0	0	0	0	1	5	3	9
136	Lutjanus synagris	0	0	0	1	5	0	0	0	0	6
203	†Sphyraena barracuda	0	0	0	0	0	0	0	2	4	6
245	Scorpaena plumieri	0	0	0	0	1	0	0	0	4	5
82	†Epinephelus cruentatus	0	0	0	0	0	0	1	2	0	3
124	†Elagatis bipinnulatus	0	0	0	0	0	0	0	0	3	3
99	†Priacanthus cruentatus	0	0	0	0	0	0	0	2	0	2
140	Ocyurus chrysurus	0	0	0	0	0	1	0	1	0	2
165	Calamus pennatula	0	0	0	0	2	0	0	0	0	2
750	†Mycteroperca tigris	0	0	0	0	0	0	0	0	1	1
96	†Rypticus saponaceus	0	0	0	0	0	0	0	1	0	1
757	†Serranus phoebe	0	0	0	0	0	0	0	0	1	1
128	†Coryphaena hippurus	0	0	0	0	0	0	0	0	1	1
135	Lutjanus apodus	0	0	0	0	0	0	0	0	1	1
138	†Lutjanus buccanella	0	0	0	0	0	0	0	1	0	1
159	†Haemulon aurolineatum	0	0	0	0	1	0	0	0	0	1
254	†Xanthichtys ringens	0	0	0	0	0	0	0	1	0	1
116	†Caranx bartholomaei	0	0	0	0	0	0	0	1	0	1
117	Caranx crysos	0	0	0	0	0	1	0	0	0	1
118	†Caranx latus	0	0	0	0	0	0	0	0	1	1
257	†Lactophres taebonos	0	0	0	1	0	0	0	0	0	1
	Total	1	0	3	3	162	47	4	1,896	1,911	4,027

†exclusively captured by hook-and-line

first two tasks to construct an efficient statistical sampling design for future surveys. In turn, successful completion of these tasks will yield the most accurate and precise estimate of relative abundance obtainable from the 1991-1992 survey data. All procedures were performed with the SAS statistical software package.

2.1 Descriptive Statistics

The sample unit for traps was defined as an individual trap fished during a single soak period. Relative abundance was measured as catch-per-unit-effort, which was computed for a trap sample as the number of fish captured divided by the trap soak hours. The sample unit for hook-and-line was defined as an individual hook-and-line rig fished by a single fisherman during a single fishing period. Catch-per-unit-effort for a hook-and-line sample was computed as the number of fish captured divided by the number of hours fished. For both gears, mean relative abundance, CPUE, was computed as

$$\mathrm{CPUE} = \sum_i \mathrm{CPUE}_i / n$$

for a particular stratum (e.g. location, month, depth), where CPUE_i is the catch-per-unit-effort of sample i and n is the sample size. Variance and standard error of CPUE were computed following standard procedures.

Sampling patchy fish distributions often results in obtaining data which do not follow the Normal probability distribution, usually due to a high frequency of samples with zero catch. Means and variances are positively correlated in these situations, e.g. strata with high CPUE also have high variance and vice-versa. A measure of relative variability was thus employed, the standard error-to-mean ratio (SEMR),

$$\mathrm{SEMR} = \mathrm{SE}/\mathrm{CPUE} \times 100$$

which is simply the standard error (SE) expressed as a percentage of mean CPUE. An additional statistic, the percentage of zero-catch samples, was computed to provide a measure of favorable and unfavorable habitats.

2.2 Factors Influencing Relative Abundance

Two methods were employed to determine the main factors influencing CPUE estimates. The first was visual inspection of CPUE and standard error bar graphs. The second was standard analysis of variance (ANOVA) procedures for identifying seasonal and habitat variables which produced significant differences in mean CPUE. If significant CPUE differences were detected for a given variable (i.e. treatment), the Scheffe (1953, 1959) multiple comparison procedure was used to test for CPUE differences among treatment levels. Although the main ANOVA assumptions of normality and homogeneity of variance are typically not satisfied for patchy sample data, ANOVA can be a useful guide for identifying candidate variables (e.g. depth) and variable subgroups (e.g. shallow, deep) for constructing sampling survey designs.

2.3 Survey Sampling Design

Principles and procedures described in Cochran (1977) were used to compare simple versus stratified random sampling designs for the seasonal and habitat datasets. The basic idea of stratification is to group survey CPUE data into time periods and/or habitat regions which have similar means and variances. Done properly, stratification can result in fewer samples needed to achieve a specified variance level in a future survey as compared to simple random sampling. However, improper stratification (e.g. incorrect habitat variable) can produce the opposite results (i.e. more samples needed) as well as a biased estimate of CPUE. A certain amount of caution was therefore employed in conducting these analyses.

Data from the 1991-1992 survey were post-stratified by seasonal and habitat variables identified from previous analyses described above. Stratified mean CPUE, $CPUE_{st}$, was estimated from

$$CPUE_{st} = \sum_h w_h CPUE_h$$

and variance of $CPUE_{st}$, $s^2(CPUE_{st})$, was computed from

$$s^2(CPUE_{st}) = \sum_h \frac{W_h^2 s_h^2}{n_h} - \sum_h \frac{W_h s_h^2}{N}$$

where $CPUE_h$, , and n_h are the respective mean CPUE, variance, and sample size of stratum h. The standard error of $CPUE_{st}$ is the square root of equation (4). The variable N is the total possible survey sample size, and W_h is the stratum weighting factor,

$$W_h = \frac{N_h}{N}$$

where N_h is the total possible sample size of stratum h. For the present survey, W_h is equivalent to the proportion of the total survey sampling area occupied by stratum h.

For fixed variance, the sample size required for a future survey, n*, is computed from

$$n^* = \frac{\left(\sum_h W_h s_h\right)^2}{V + \frac{1}{N} \sum_h W_h s_h^2}$$

where V is the desired variance. The quantity V is given by

$$V = \left(\frac{d \cdot CPUE_{st}}{2}\right)^2$$

where d is the "detection" level, or the proportion of the stratified mean CPUE which constitutes the 95% confidence interval. Thus, d = 0.1 is equivalent to a 95% confidence interval which is ±10% of $CPUE_{st}$. The variables SEMR and d are related, since the 95% confidence interval is approximately 2 standard errors. To achieve detection level d = 0.1 would require SEMR = 5%, or a standard error value which is 5% of the mean CPUE.

Sample allocation of n* among strata is based on stratum size, W_h, and standard deviation, s_h, and is computed by

$$n^*_h = n^* \frac{W_h s_h}{\sum_h W_h s_h}$$

This can also be expressed as a percentage,

$$\%n^*_h = \frac{n^*_h}{n^*} \cdot 100$$

Calculations for equations (3)-(9) from the survey data were relatively straightforward except for obtaining values for variables N and W_h. For traps, the total possible sample size N is the number of traps required to cover the entire sampling area shown in Figure 1. A question arises as to the correct intertrap distance such that adjacent traps do not interfere with one another in attracting fish. In the survey, traps were set at least 150 ft apart (Rosario, 1992). Based on discussions with Mr. Stephen Meyers (Caribbean Fishery Management Council), the midpoint intertrap distance was set at 150 ft, ranging from 75 to 225 ft, for calculating N. Values of N ranged from 143,178 to 1,288,602. The effect of different values of N on calculations of $s^2(CPUE_{st})$, equation (4), and n*, equation (6), was less than a 3% change in the quantities calculated. Note that as N becomes larger, the terms involving N in equations (4) and (6) become closer to zero. All values of N were sufficiently large, thus having little effect on the calculations. The value of N assuming a midpoint intertrap distance of 150 ft was therefore used in post-stratification analyses. The minimum interference distance between adjacent hook-and-line rigs was considered to be much shorter than intertrap distance, resulting in much larger hook-and-line N values which had even less influence on sampling design calculations.

The 1991-1992 survey sampled 9 of the 65 quadrats shown in Figure 1; consequently, relative abundance information correlated with seasonal and habitat characteristics is unknown for much of the survey sampling region. Values of N_h are also unknown. Stratum weights W_h, equation (5), were therefore assumed equal for post-stratification analyses. For example, $W_h = 0.5$ for each stratum of a 2-strata design, $W_h = 0.2$ for each stratum of a 5-strata design, etc. Equal W_h eliminates the effects of different strata areas on post-stratification results, and thus focuses the analysis on differences in strata variability.

3.0 ANALYSIS OF SEASONAL DATASET

3.1 Red Hind, Epinephelus guttatus

E. guttatus mean CPUE and standard error values by month and location (quadrat number) for traps and hook-and-line are presented in Table 3 and Figure 2. In locations 95 and 96, CPUE was generally higher in the winter months than in the spring or fall for both traps (Figure 2a) and hook-and-line (Figure 2b). Female CPUE was much higher than male CPUE in all months sampled, and males were primarily captured in late winter and spring (Figures 2c and 2d). Peak monthly CPUE levels (Figure 2) coincided with pre-spawning (November-December) and spawning (January-March) periods (Figure 3; see section 1.1 for a description of reproductive stage codes).

The standard error-to-mean ratio (SEMR) ranged from 16.6 to 30.8% for traps, while SEMR values for hook-and-line were lower, ranging from 9.8 to 20.2% (Table 3). This difference is mainly due to the relatively few hook-and-line samples in which no E. guttatus individuals were captured as compared to traps (Table 3). In general, variability in CPUE as measured by SEMR is higher when sample sizes are lower and percent zero samples are higher.

Appendices A and B list ANOVA results for the E. guttatus seasonal dataset for traps and hook-and-line, respectively. A two-way ANOVA for the variables month and location yielded a significant month-location interaction for both trap (p) and hook-and-line (p) gears. Data were subsequently grouped intospawning (November-March) and nonspawning (September-October, April) seasons. These seasonal groups were suggested by results from a Scheffe multiple comparison test on monthly CPUE means and by the results illustrated in Figures 2 and 3. For traps and hook-and-line, mean CPUE was significantly

Table 3. Epinephelus guttatus mean catch per unit effort (CPUE), standard error (SE), and associated statistics by month and location for traps and hool and line (SEMR= standard error to mean ratio).

Month	Location #	Traps					Hook-and-Line				
		n	CPUE	S.E.	SEMR (%)	% zero samples	n	CPUE	S.E.	SEMR (%)	% zero samples
SEP	95	87	0.0709	0.0142	20.0	72.4	15	3.714	0.399	10.7	0.0
	96	85	0.0737	0.0165	22.4	74.1	16	1.613	0.179	11.1	0.0
OCT	95	72	0.0417	0.0118	28.3	83.3	18	1.722	0.255	14.8	0.0
	96	48	0.1542	0.0378	24.5	54.2	12	3.315	0.381	11.5	0.0
NOV	95	0	–	–	–	–	0	–	–	–	–
	96	24	0.2250	0.0569	25.3	45.8	6	3.333	0.571	17.1	0.0
DEC	95	36	0.1722	0.0407	23.6	55.6	9	5.309	0.650	12.2	0.0
	96	72	0.1167	0.0243	20.8	66.7	18	5.407	0.669	12.4	0.0
JAN	95	0	–	–	–	–	9	5.133	0.535	10.4	0.0
	96	0	–	–	–	–	10	3.300	0.349	10.6	0.0
FEB	95	36	0.1889	0.0436	23.1	50.0	18	3.369	0.462	13.7	0.0
	96	72	0.2500	0.0416	16.6	52.8	18	3.017	0.491	16.3	5.5
MAR	95	60	0.1200	0.0234	19.5	61.7	22	3.001	0.294	9.8	0.0
	96	24	0.2583	0.0518	20.1	25.0	17	1.940	0.283	14.6	5.9
APR	95	60	0.0774	0.0199	25.7	73.3	15	1.425	0.199	14.0	0.0
	96	36	0.0529	0.0163	30.8	75.0	9	1.259	0.254	20.2	0.0

Table 4: Seasonal dataset post-stratification results for E. guttatus: (a) comparison of sampling designs (d=0.1); (b) values of n* at four detection levels; (c) stratum statistics and sample allocations (%n*) for the 2-strata "season" design.

(a)

No. of Strata	Stratification	Traps (n=712)				Hook-and-Line (n=212)			
		$CPUE_{st}$	SE_{st}	SEMR(%)	n*	$CPUE_{st}$	SE_{st}	SEMR(%)	n*
1	Simple Random	0.1230	0.0082	6.66	1261	3.034	0.138	4.55	176
2	Season	0.1277	0.0084	6.55	1089	2.892	0.122	4.23	152
4	Season & Location	0.1265	0.0083	6.53	1067	2.895	0.121	4.18	148

(b)

No. of Strata	Stratification	Traps, d level				Hook-and-Line, d level			
		0.05	0.1	0.2	0.5	0.05	0.1	0.2	0.5
1	Simple Random	4985	1261	316	51	702	176	44	7
2	Season	4328	1088	272	44	607	152	38	6
4	Season & Location	4244	1067	267	43	592	148	37	6

(c)

Stratum	Traps					Hook-and-Line				
	n	CPUE	SE	SEMR(%)	%n*	n	CPUE	SE	SEMR(%)	%n*
Spawning Season	324	0.1796	0.0147	8.18	62.8	127	3.608	0.190	5.27	60.2
Nonspawning Season	388	0.0757	0.0080	10.51	37.2	85	2.176	0.154	7.07	39.8
Total	712	0.1277	0.0084	6.55	100.0	212	2.892	0.122	4.23	100.0

Figure 2: Epinephelus guttatus mean CPUE (with standard error bars) by month and location for (a) traps and (b) hook-and-line. Female and male CPUE by month and location for (c) traps and (d) hook-and-line.

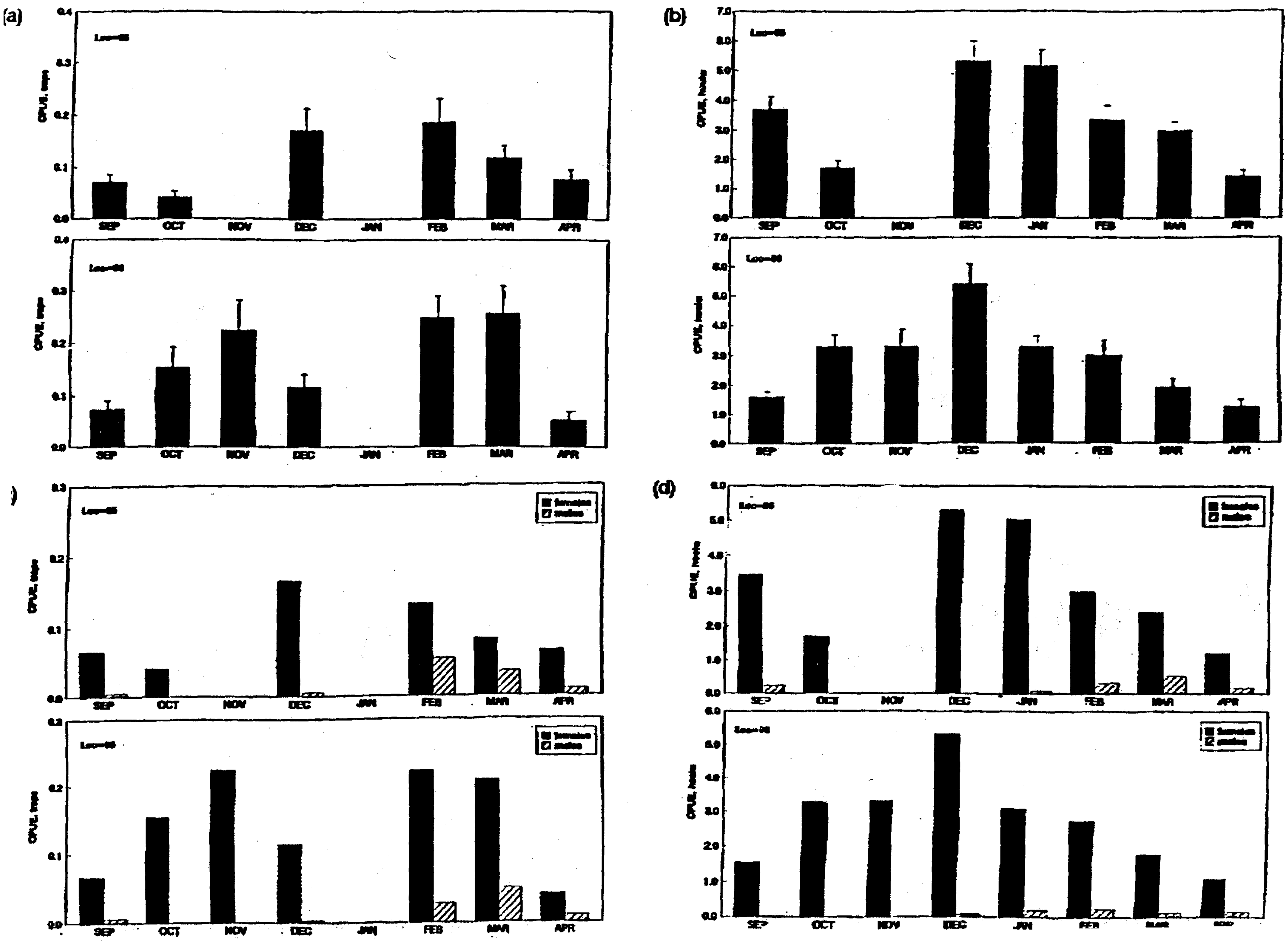
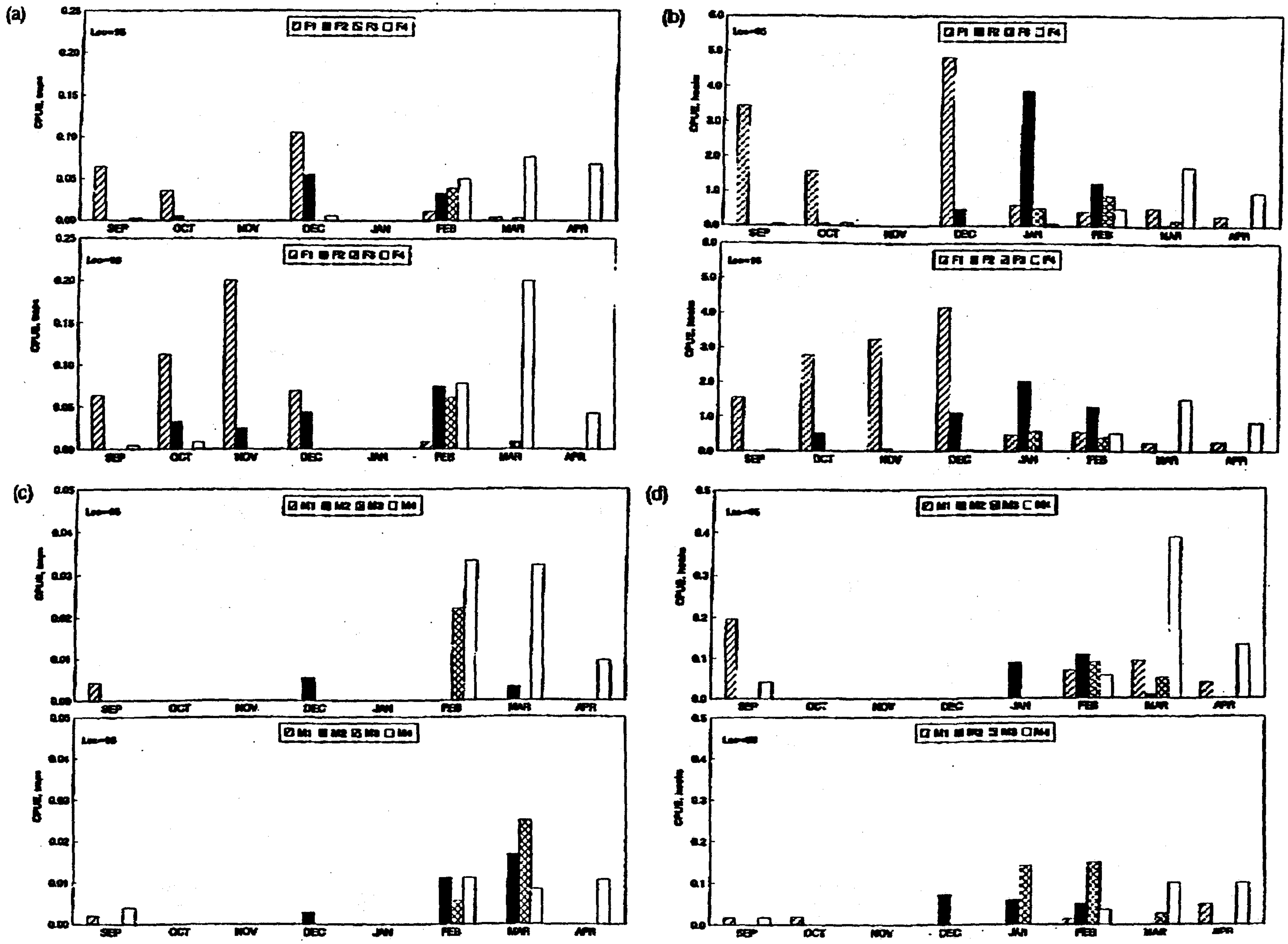


Figure 3: Epinephelus guttatus reproductive stage mean CPUE by month and location for the following sex and gear categories: (a) females, traps; (b) females, hook-and-line; (c) males, traps; (d) males, hook-and-line.



higher during the spawning season, but no differences in mean CPUE were detected between locations 95 and 96 within each season.

The above results suggest that season has the most effect upon CPUE, and thus would be a logical choice for a stratification variable. Two sampling designs were formulated: (1) a 2-strata design based on spawning and nonspawning seasons; and (2) a 4-strata design based on two locations within each season. These sampling designs are compared with simple random sampling in Tables 4a and 4b. For both traps and hook-and-line, stratification results in a slightly reduced SEMR and an approximately 14% reduction in the required sample size for $d=0.1$. There is little difference between the 2- and 4-strata designs, indicating that stratifying by location is probably not warranted.

For the 2-strata design, mean CPUE was 1.5 to 2 times higher during the spawning season than during the nonspawning season for both gears (Table 4c). The associated higher variance of CPUE in the spawning season results in 60-63% of samples being allocated to spawning months and 37-40% allocated to nonspawning months.

3.2 Coney, Epinephelus fulvus

E. fulvus mean CPUE and standard error values by month andlocation are presented in Table 5 and Figure 4. CPUE for traps was higher in winter and lower in fall and spring in location 95, but in location 96 there was no apparent trend in CPUE (Figure 4a). In locations 95 and 96, CPUE for hook-and-line was similar in each month, except for a peak value during September in location 95 (Figure 4b). Female CPUE was higher than male CPUE in all months for both sampling gears except for traps in February (Figures 4c and 4d). In contrast to E. guttatus, E. fulvus males were captured throughout the sampling period. CPUE during the peak spawning months of November-February (Figure 5) was generally similar to CPUE in nonspawning months (Figure 4).

Trap SEMR values ranged from 24.9 to 65.1%, while hook-and-line SEMR values were lower, ranging from 14.2 to 33.0% (Table 5). Greater variability in trap CPUE as compared to hook-and-line CPUE corresponds with a higher percentage of zero samples for traps than for hook-and-line (Table 5).

Appendices C and D list ANOVA results for the E. fulvus seasonal dataset for traps and hook-and-line, respectively. For traps, CPUE was significantly higher (p) in location 96 than in location 95. No monthly differences in CPUE were detected. Hook-and-line CPUE exhibited a significant (p) month- location interaction. Results of a multiple comparison test and inspection of Figure 4b

Table 5. Epinephelus fulvus mean CPUE, standard error, and associated statistics by month and location for traps and hook and line.

Month	Location #	Traps					Hook-and-Line				
		n	CPUE	S.E.	SEMR (%)	% zero samples	n	CPUE	S.E.	SEMR (%)	% zero samples
SEP	95	87	0.0183	0.0072	39.3	92.0	15	1.812	0.332	18.3	0.0
	96	85	0.0297	0.0084	32.2	79.2	16	0.913	0.255	27.9	6.3
OCT	95	72	0.0083	0.0047	56.6	95.8	18	0.264	0.087	33.0	50.0
	96	48	0.0583	0.0188	32.2	79.2	12	1.222	0.174	14.2	0.0
NOV	95	0	–	–	–	–	0	–	–	–	–
	96	24	0.0667	0.0287	43.0	75.0	6	0.481	0.106	22.0	16.7
DEC	95	36	0.0278	0.0181	65.1	91.7	9	0.642	0.183	28.5	22.2
	96	72	0.0306	0.0094	30.7	86.1	18	0.827	0.167	20.2	5.6
JAN	95	0	–	–	–	–	9	0.533	0.120	22.5	22.2
	96	0	–	–	–	–	10	0.780	0.138	17.7	10.0
FEB	95	36	0.0500	0.0167	33.4	77.8	18	0.714	0.130	18.2	0.0
	96	72	0.0417	0.0104	24.9	80.6	18	0.882	0.158	17.9	5.6
MAR	95	60	0.0342	0.0129	37.7	86.7	22	0.718	0.139	19.4	9.1
	96	24	0.0417	0.0240	57.6	87.5	17	0.724	0.132	18.2	11.8
APR	95	60	0.0185	0.0084	45.4	91.7	15	0.469	0.116	24.7	13.3
	96	36	0.0265	0.0111	41.9	86.1	9	0.272	0.072	26.5	22.2

Table 6: Seasonal dataset post-stratification results for <u>E. fulvus</u>: (a) comparison of sampling designs (d=0.1); and (b) values of n* at four detection levels.

(a)

No. of Strata	Stratification	Traps (n=712)				Hook-and-Line (n=212)			
		$CPUE_{st}$	SE_{st}	SEMR(%)	n*	$CPUE_{st}$	SE_{st}	SEMR(%)	n*
1	Simple Random	0.0312	0.0033	10.55	3144	0.772	0.051	6.65	375
2	Location	0.0311	0.0033	10.53	3123	0.772	0.051	6.65	373

(b)

No. of Strata	Stratification	Traps, d level				Hook-and-Line, d level			
		0.05	0.1	0.2	0.5	0.05	0.1	0.2	0.5
1	Simple Random	12218	3144	792	127	1498	375	94	15
2	Location	12310	3123	784	125	1491	373	93	15

Figure 4: *Epinephelus fulvus* mean CPUE (with standard error bars) by month and location for (a) traps and (b) hook-and-line. Female and male CPUE by month and location for (c) traps and (d) hook-and-line.

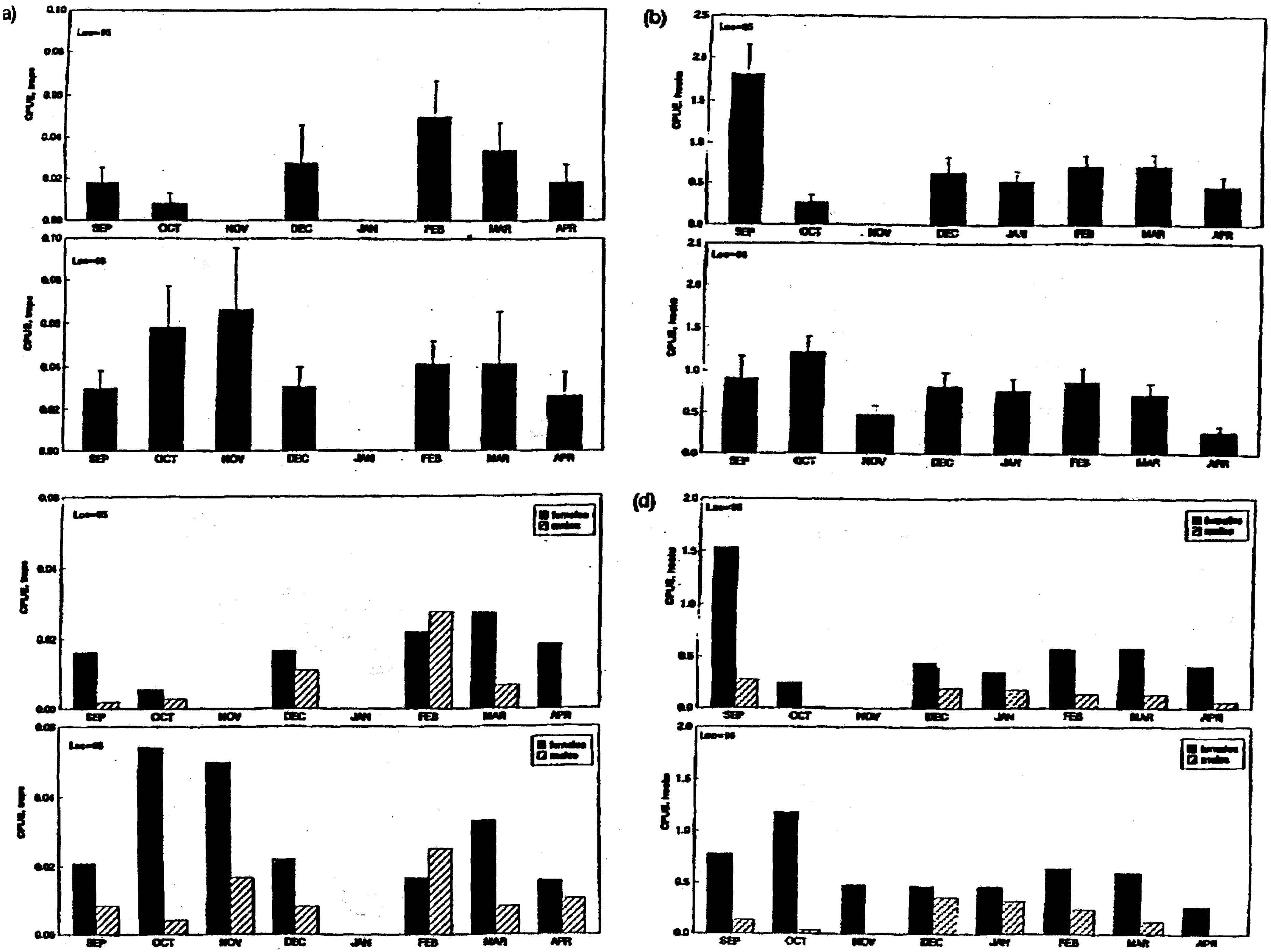
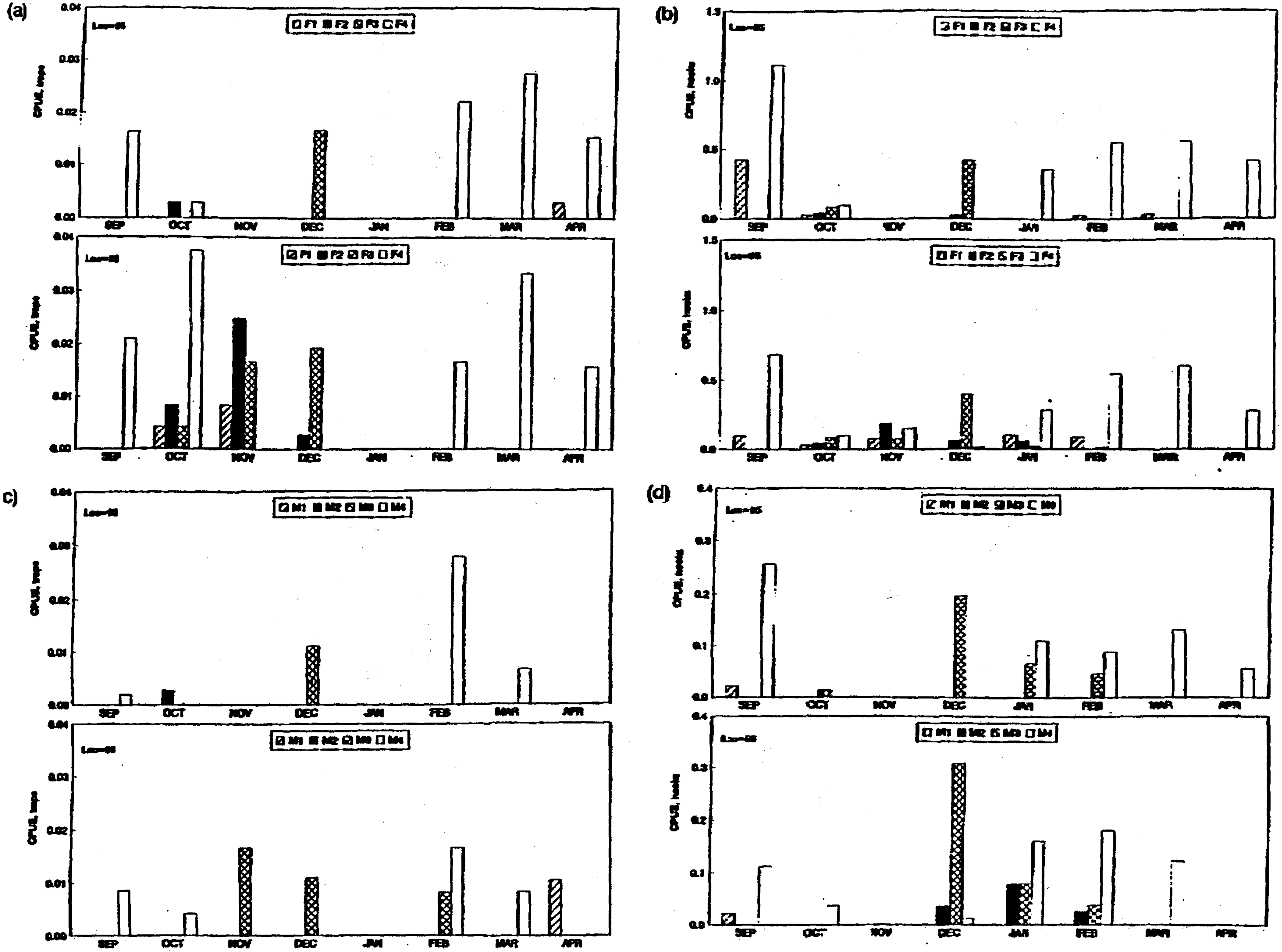


Figure 5: Epinephelus fulvus reproductive stage mean CPUE by month and location for the following sex and gear categories: (a) females, traps; (b) females, hook-and-line; (c) males, traps; (d) males, hook-and-line.



suggest that differences in September and October CPUE levels between locations 95 and 96 are primarily responsible for this interaction. Mean hook-and-line CPUE is similar for the two locations during November-April. The above results suggest that location rather than season may be an appropriate stratification variable. A 2-strata sampling design for locations 95 and 96 is compared to simple random sampling in Table 6. Stratification yielded no improvement over a simple random design.

3.3 Snappers and Other Groupers

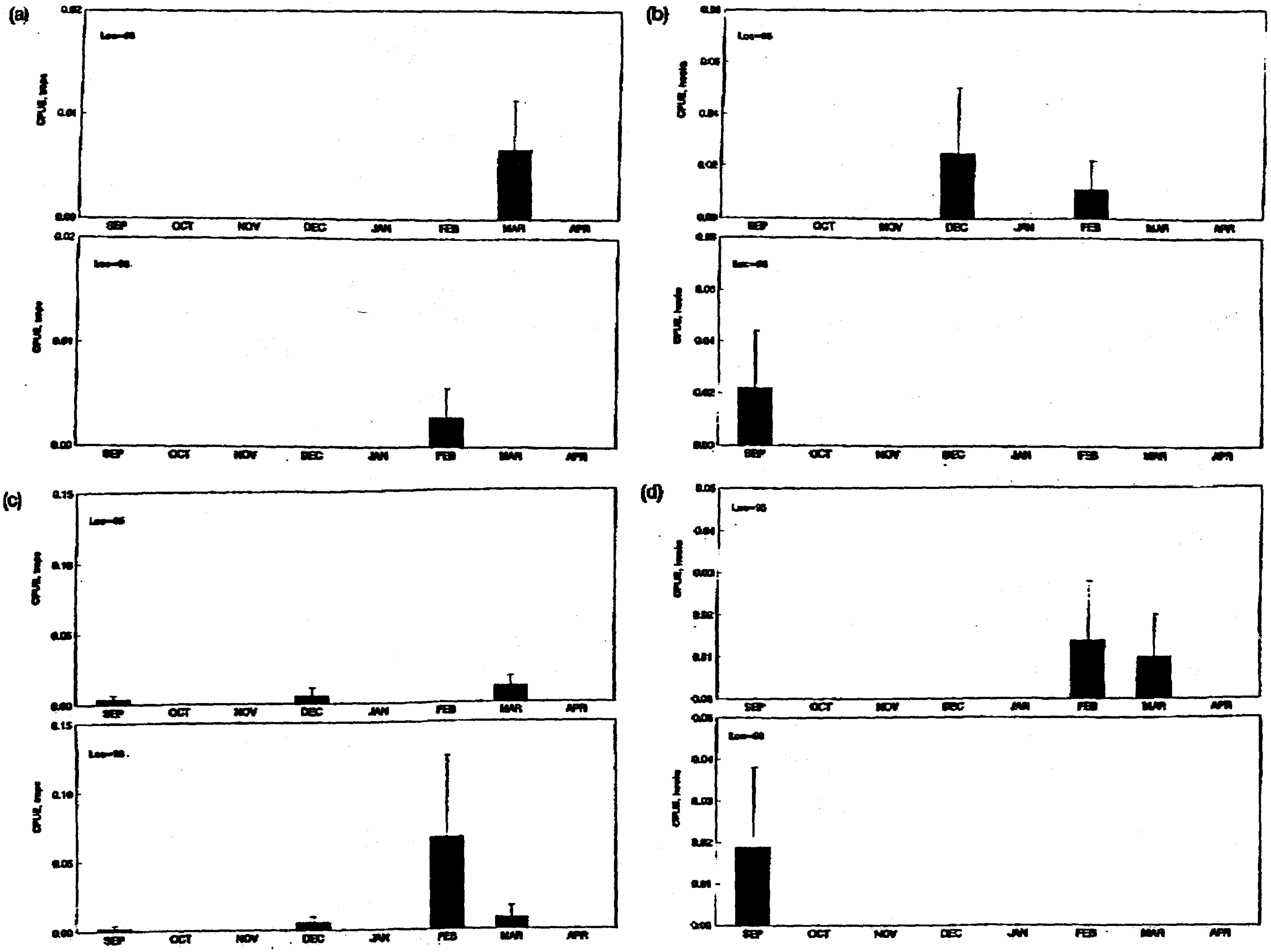
Numbers of snappers (Lutjanus spp., Ocyurus chrysurus, and Rhomboplites aurorubens) and other groupers (E. striatus, E. cruentatus, and Mycteroperca spp.) captured during the survey were quite low (Table 2). Monthly snapper CPUE and standard error values are shown in Figure 6a for traps and Figure 6b for hook-and-line. Monthly CPUE and standard error values for other groupers are shown in Figure 6c for traps and Figure 6d for hook-and-line. The low CPUE and relatively high standard errors illustrated in Figure 6 reflect the sporadic occurrence of these fishes in trap and hook-and-line samples. Further inspection of the dataset revealed that in most cases individuals of each particular species were captured exclusively on a single day in a single month.

3.4 Discussion

In locations 95 and 96, E. guttatus exhibits seasonal variation in relative abundance with higher CPUE during the spawning period. In contrast, CPUE of E. fulvus does not vary seasonally. These results are not surprising, since E. guttatus is known to form large spawning aggregations while this behavior isnot evident for E. fulvus. It is likely that E. guttatus individuals migrate to aggregation sites from other areas of the sampling region during the spawning period. While relative abundance may be the same for the entire sampling region, seasonal changes in spatial distribution patterns must be accounted for in the sampling design. It may be advantageous to sample during spawning months when fish are concentrated in a smaller geographical area than during non-spawning months when fish are dispersed throughout a comparatively larger area. Sampling during a restricted period would not adversely affect abundance estimates of E. fulvus which does not exhibit seasonal changes in its spatial distribution. At present, the infrequent occurrence of snappers and other groupers in capture data precludes incorporating these species into the sampling design.

For both E. guttatus and E. fulvus, approximately 7-8 trap samples per one hook-and-line sample are required to achieve the same detection level (Tables 4 and 6). A "typical" sampling day of the 1991-1992 survey consisted of 12 trap

Figure 6: Mean CPUE (with SE bars) by month and location for snappers captured by (a) traps and (b) hook-and-line, and for other groupers captured by (c) traps and (d) hook-and-line.



samples and 3 hook-and-line samples (fishermen), or 4 traps per hook-and-line sample.

4.0 ANALYSIS OF HABITAT DATASET

4.1 Red Hind, Epinephelus guttatus

E. guttatus mean CPUE and standard error values by location, depth, and substrate are presented in Table 7 and Figure 7. Results were similar for trap and hook-and-line sampling gears. Locations 95 and 96 exhibited high CPUE values relative to other locations (Figures 7a-b). Differences in CPUE by depth (Figures 7c-d) and substrate (Figures 7e-f) can also be attributed to locations 95 and 96, which are comprised of deep coral habitat. Differences in CPUE are apparent for locations with the same depth or substrate characteristics; likewise, CPUE values are similar for locations with different depths or substrates (Table 7). Thus, E. guttatus CPUE does not appear to correspond exclusively to either depth or substrate.

Most locations exhibit highly variable CPUE, as evidenced by high SEMR values (Table 7). Low sample sizes and a high frequency of zero samples contribute to high SEMR for traps and hook-and-line (Table 7).

Appendices E and F list the respective trap and hook-and-line ANOVA results for the E. guttatus habitat dataset. Significant differences (p) in mean CPUE for variables location, depth, and substrate were detected by one-way ANOVA for both traps and hook-and-line. Multiple comparison tests for the three variables did not yield many significantly different groups, however, mainly due to the high variability of CPUE values and the correspondinglylow degrees of freedom (i.e. low sample size).

Three sampling designs were formulated: (1) a 3-strata design based on depth; (2) a 5-strata design based on substrate composition; and (3) a 3-strata design based on depth-substrate categories. Strata definitions for designs (1) and (2) followed the depth and substrate categories listed in Table 7 and Figures 7c-f. For design (3), the three strata were defined as (i) deep coral (locations 95 and 96), (ii) shallow mud (location 93), and (iii) all other locations. These sampling designs are compared with simple random sampling in Tables 8a and 8b. For both traps and hook-and-line, stratifying by either depth or substrate yielded lower estimates of $CPUE_{st}$ than the simple random and depth-substrate designs. The 3-strata depth-substrate design yielded the lowest values of SEMR of all designs tested, and resulted in 47% and 78% reductions in required sample sizes

Table 7. Epinephelus guttatus mean CPUE, standard error, and associated statistics by location, depth, and substrate for traps and hook and line.

Location #	Depth	Substrate	Traps					Hook-and-Line				
			n	CPUE	S.E.	SEMR (%)	% zero samples	n	CPUE	S.E.	SEMR (%)	% zero samples
34	shallow, 0-10 f	some coral	12	0.0000	0.0000	–	100.0	3	0.095	0.095	100.0	66.7
37	shallow, 0-10 f	rocky/ no coral	12	0.0000	0.0000	–	100.0	3	0.000	0.000	–	100.0
40	shallow, 0-10 f	rocky/ no coral	12	0.0167	0.0167	100.0	91.7	3	0.190	0.190	100.0	66.7
66	intermediate, 11-20 f	coral	12	0.0000	0.0000	–	100.0	3	0.095	0.095	100.0	66.7
80	intermediate, 11-20 f	coral/ sand	72	0.0139	0.0072	51.8	94.4	19	0.165	0.050	30.3	52.6
90	deep, 21-50 f	coral/ sand	24	0.0000	0.0000	–	100.0	9	0.222	0.117	52.7	44.4
93	shallow, 0-10 f	mud	36	0.0000	0.0000	–	100.0	9	0.000	0.000	–	100.0
95	deep, 21-50 f	coral	60	0.0774	0.0199	25.7	73.3	15	1.425	0.199	14.0	0.0
96	deep, 21-50 f	coral	36	0.0529	0.0163	30.8	75.0	9	1.259	0.254	20.2	0.0

Table 8: Habitat dataset post-stratification results for *E. guttatus*: (a) comparison of sampling designs (d=0.1); (b) values of n* at four detection levels; (c) stratum statistics and sample allocations (%n*) for the 3-strata "depth-substrate" design.

(a)

No. of Strata	Stratification	Traps (n=276)				Hook-and-Line (n=73)			
		$CPUE_{st}$	SE_{st}	SEMR(%)	n*	$CPUE_{st}$	SE_{st}	SEMR(%)	n*
1	Simple Random	0.0281	0.0055	19.58	4183	0.534	0.087	16.37	782
3	Depth	0.0231	0.0044	19.08	3441	0.418	0.052	12.51	365
5	Substrate	0.0159	0.0032	20.08	3111	0.319	0.043	13.37	345
3	Depth-Substrate	0.0255	0.0048	18.77	2236	0.507	0.053	10.46	173

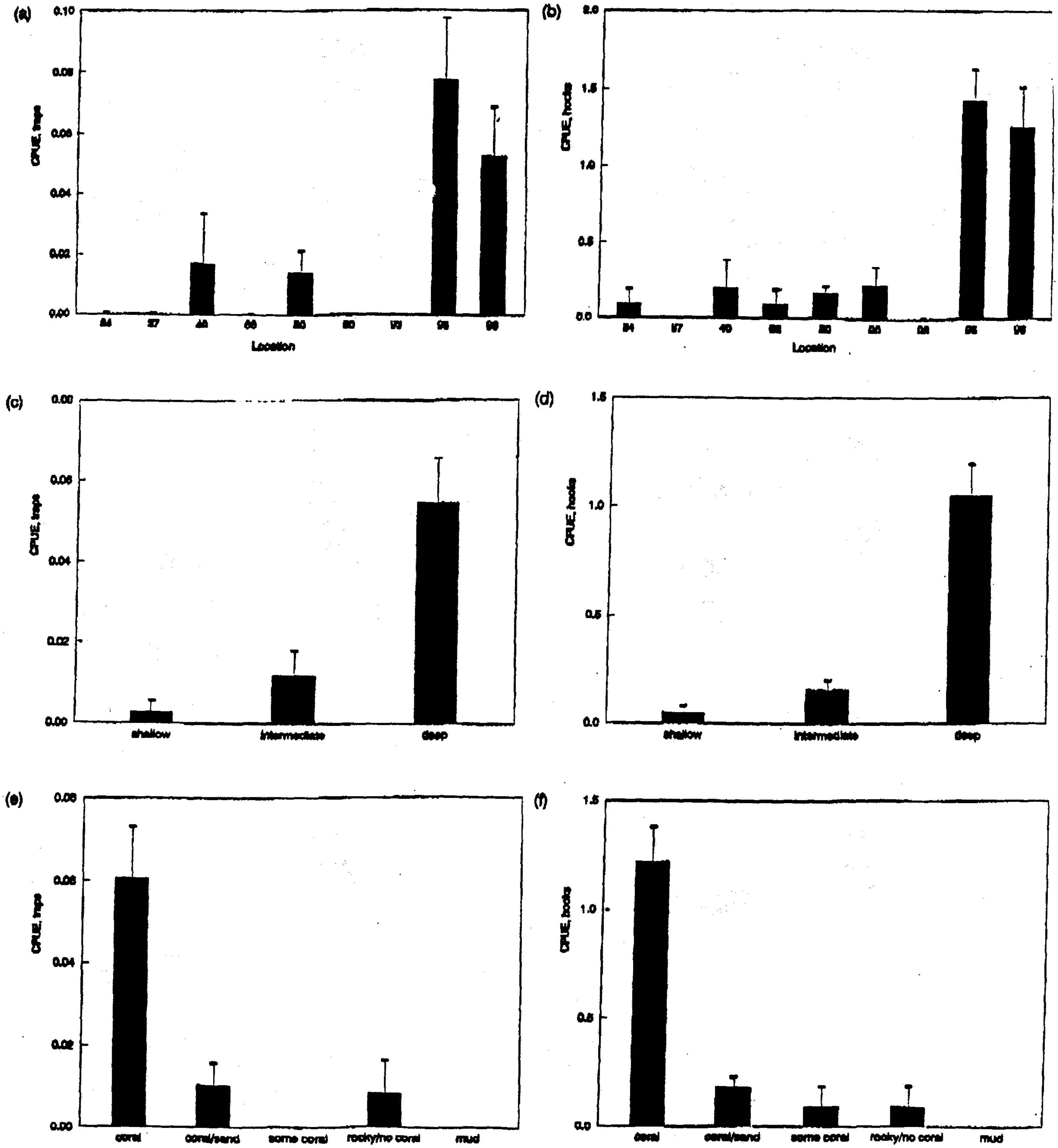
(b)

No. of Strata	Stratification	Traps, d level				Hook-and-Line, d level			
		0.05	0.1	0.2	0.5	0.05	0.1	0.2	0.5
1	Simple Random	16105	4183	1056	169	3129	782	196	31
3	Depth	13183	3441	870	140	1460	365	91	15
5	Substrate	11720	3111	790	127	1378	345	86	14
3	Depth-Substrate	8612	2236	565	91	692	173	43	7

(c)

Stratum	Traps					Hook-and-Line				
	n	CPUE	SE	SEMR(%)	%n*	n	CPUE	SE	SEMR(%)	%n*
Deep Coral	96	0.0682	0.0138	20.3	74.4	24	1.363	0.154	11.3	75.6
Shallow Mud	36	0.0000	0.0000	–	0.0	9	0.000	0.000	–	0.0
Other	144	0.0083	0.0039	46.6	25.6	40	0.157	0.039	24.6	24.4
Total	276	0.0255	0.0048	18.77	100.0	73	0.507	0.053	10.46	100.0

Figure 7: <u>Epinephelus</u> <u>guttatus</u> mean CPUE (with SE bars) for habitat dataset variables: (a) location, traps; (b) location, hook-and-line; (c) depth, traps; (d) depth, hook-and-line; (e) substrate, traps; (f) substrate, hook-and-line.



to achieve d = 0.1 for traps and hook-and-line, respectively, as compared to simple random sampling.

For the 3-strata depth-substrate design, mean CPUE was much higher in deep coral than in other habitats for both gears (Table 8c). The deep coral habitat is allocated 75% of future samples, no samples are allocated to the shallow mud habitat, and 25% are allocated to all other habitats combined.

4.2 Coney, Epinephelus fulvus

E. fulvus mean CPUE and standard error values by location, depth, and substrate are presented in Table 9 and Figure 8. For traps, CPUE was similar in locations where E. fulvus was captured(Figure 8a). CPUE values were relatively higher at intermediate and deep depths (Figure 8c) and in coral and coral/sand substrates (Figure 8e); however, standard errors were quite large in all locations. Hook-and-line CPUE values were highest in location 80, at intermediate levels in locations 95 and 96, and low in other locations (Figure 8b). Differences in CPUE by depth (Figure 8d) and substrate (Figure 8f) can also be attributed to location 80, comprised of intermediate depth coral/sand habitat, and locations 95 and 96, comprised of deep coral habitat. As demonstrated for E. guttatus, both trap and hook-and-line CPUE values exhibited differences in similar depths or substrates and similarities in different depths or substrates (Table 9). Both SEMR and percent zero samples were high for traps and hook-and-line (Table 9).

Appendices G and H list the respective trap and hook-and-line ANOVA results for the E. fulvus habitat dataset. For traps, no significant differences in mean CPUE for variables location, depth, and substrate were detected by one-way ANOVA. This is in direct contrast to hook-and-line samples in which all three variables exhibited significantly different CPUE values.

Three sampling designs were formulated: (1) a 3-strata design based on depth; (2) a 5-strata design based on substrate composition; and (3) a 3-strata design based on depth-substrate categories. Strata definitions for designs (1) and (2) followed the depth and substrate categories listed in Table 9 and Figures 8c-f. For design (3), the three strata were defined as (i) intermediate coral/sand (location 80), (ii) deep coral (locations 95 and 96), and (iii) all other locations. These sampling designs are compared with simple random sampling in Tables 10a and 10b. For traps, stratifying by either depth or substrate was less efficient than simple random sampling. The 3-strata depth-substrate design yielded $CPUE_{st}$ and SEMR values similar to simple random sampling, but resulted in a 10% reduction in n*. Stratification was more effective for hook-and-line

Table 9. Epinephelus fulvus mean CPUE, standard error, and associated statistics by location, depth, and substrate for traps and hook and line.

Location #	Depth	Substrate	Traps					Hook-and-Line				
			n	CPUE	S.E.	SEMR (%)	% zero samples	n	CPUE	S.E.	SEMR (%)	% zero samples
34	shallow, 0-10 f	some coral	12	0.0000	0.0000	–	100.0	3	0.000	0.000	–	100.0
37	shallow, 0-10 f	rocky/ no coral	12	0.0000	0.0000	–	100.0	3	0.000	0.000	–	100.0
40	shallow, 0-10 f	rocky/ no coral	12	0.0167	0.0167	100.0	91.7	3	0.095	0.095	100.0	66.7
66	intermediate, 11-20 f	coral	12	0.0000	0.0000	–	100.0	3	0.000	0.000	–	100.0
80	intermediate, 11-20 f	coral/ sand	72	0.0194	0.0070	36.1	90.3	19	1.203	0.210	17.5	10.5
90	deep, 21-50 f	coral/ sand	24	0.0167	0.0115	68.9	91.7	9	0.074	0.037	50.0	66.7
93	shallow, 0-10 f	mud	36	0.0056	0.0056	100.0	97.2	9	0.063	0.042	66.7	77.8
95	deep, 21-50 f	coral	60	0.0185	0.0084	45.4	91.7	15	0.469	0.116	24.7	13.3
96	deep, 21-50 f	coral	36	0.0265	0.0111	41.9	86.1	9	0.272	0.072	26.5	22.2

Table 10: Habitat dataset post-stratification results for <u>E. fulvus</u>: (a) comparison of sampling designs (d=0.1); (b) values of n* at four detection levels; (c) stratum statistics and sample allocations (%n*) for the 3-strata "depth-substrate" design.

(a)

No. of Strata	Stratification	Traps (n=276)				Hook-and-Line (n=73)			
		$CPUE_{st}$	SE_{st}	SEMR(%)	n*	$CPUE_{st}$	SE_{st}	SEMR(%)	n*
1	Simple Random	0.0154	0.0033	21.37	4968	0.464	0.081	17.46	890
3	Depth	0.0142	0.0031	21.67	5001	0.465	0.071	15.30	415
5	Substrate	0.0103	0.0026	25.33	5550	0.260	0.040	15.34	566
3	Depth-Substrate	0.0161	0.0035	21.45	4495	0.549	0.075	13.67	291

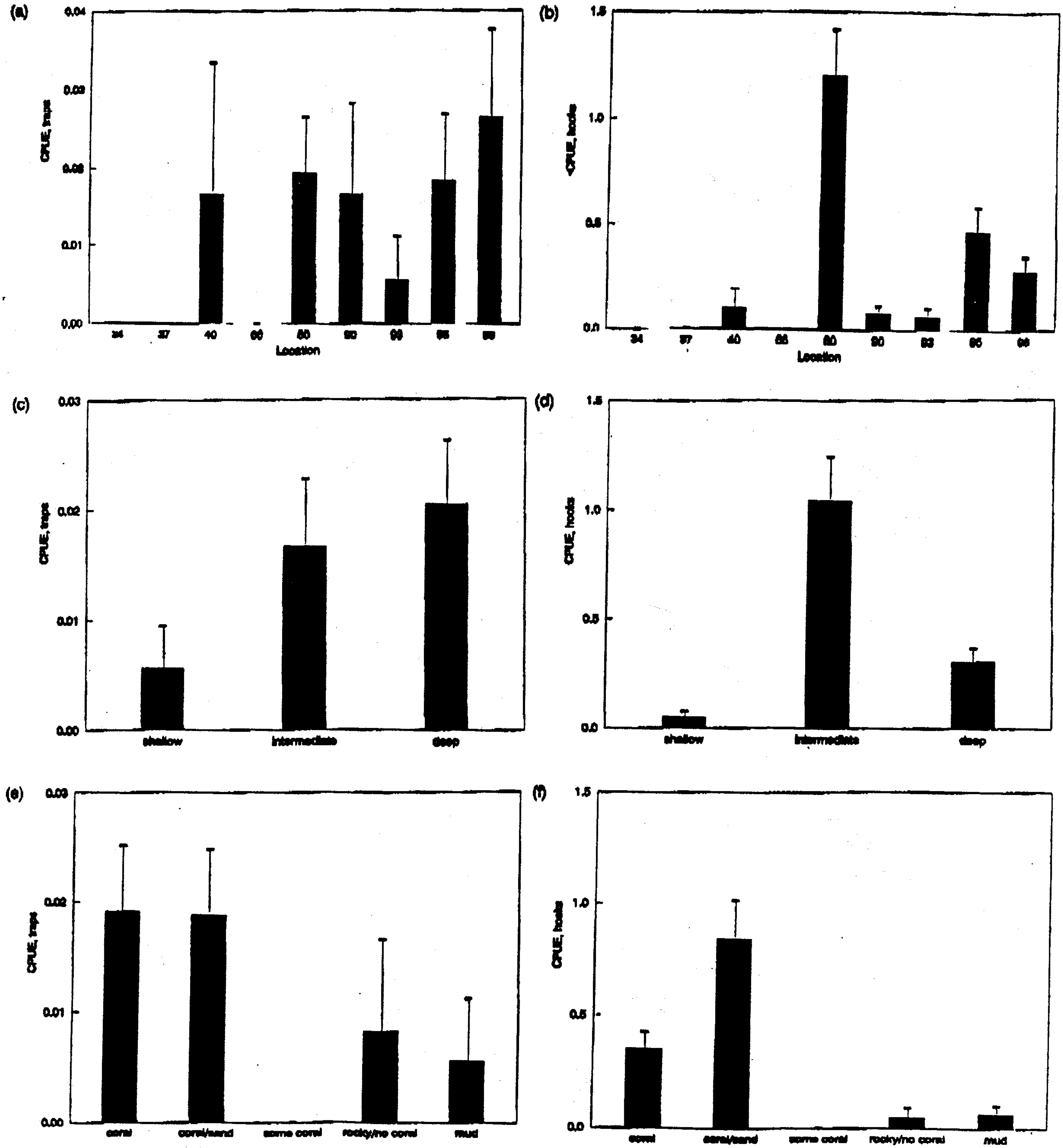
(b)

No. of Strata	Stratification	Traps, d level				Hook-and-Line, d level			
		0.05	0.1	0.2	0.5	0.05	0.1	0.2	0.5
1	Simple Random	18994	4968	1257	202	3559	890	223	36
3	Depth	19059	5001	1266	203	1658	415	104	17
5	Substrate	20777	5550	1412	227	2265	556	142	23
3	Depth-Substrate	17224	4495	1136	182	1164	291	73	12

(c)

Stratum	Traps					Hook-and-Line				
	n	CPUE	SE	SEMR(%)	%n*	n	CPUE	SE	SEMR(%)	%n*
Intermediate Coral\Sand	72	0.0194	0.0070	36.2	36.6	19	1.203	0.210	17.5	65.2
Deep Coral	96	0.0215	0.0067	31.2	40.2	24	0.395	0.079	19.9	27.4
Other	108	0.0074	0.0037	49.3	23.3	30	0.051	0.019	37.5	7.4
Total	276	0.0161	0.0035	21.45	100.0	73	0.549	0.075	13.67	100.0

Figure 8: *Epinephelus fulvus* mean CPUE (with SE bars) for habitat dataset variables: (a) location, traps; (b) location, hook-and-line; (c) depth, traps; (d) depth, hook-and-line; (e) substrate, traps; (f) substrate, hook-and-line.



samples than for trap samples. The 3-strata depth-substrate design yielded lower SEMR and resulted in a 67% reduction in n* as compared to simple random sampling.

For the 3-strata depth-substrate design, mean CPUE was relatively high in intermediate coral/sand and deep coral habitats as compared to other habitats for traps; however, for hook-and-line samples mean CPUE in intermediate coral/sand habitats was much higher than in deep coral habitats (Table 10c). Sample allocations for the two gears reflect these differences in relative abundance estimates. For traps, approximately 80% of samples are divided equally between intermediate coral/sand and deep coral habitats, with 20-25% of samples allocated to all other habitats combined. For hook-and-line, the majority of samples, 65%, are allocated to intermediate coral/sand, with 27% allocated to deep coral and 7% allocated to all other habitats.

4.3 Discussion

Stratifying by a combination of depth and substrate composition was the most efficient sampling design for both speciesand both gears. Of the geographical locations sampled in 1991-1992, both E. guttatus and E. fulvus were abundant in areas comprised of deep coral habitat. E. fulvus was also abundant in intermediate depth coral/sand habitat while E. guttatus was not, indicating that habitat preferences and thus spatial distributions may be somewhat different for the two species. Certain habitats had very low or zero CPUE estimates for both species. However, it is difficult to make definitive conclusions regarding favorable and unfavorable habitats for E. guttatus and E. fulvus since only one day of sampling occurred in 4 of the 9 quadrats. It is also quite probable that depth-substrate combinations different from those analyzed above occur in quadrats that were not sampled in 1991-1992.

The two sampling gears provide similar CPUE information for E. guttatus with respect to geographical location, depth, and substrate composition (Figure 7). For E. fulvus, however, trap and hook-and-line CPUE estimates were different with respect to depth and substrate preferences. Trap CPUE estimates were highest in both deep and intermediate depths and in both coral and coral/sand substrates, while hook-and-line CPUE estimates were 2-3 times higher in intermediate depth coral/sand habitats compared to deep coral habitats (Figure 8). The variance properties of CPUE for traps and hook-and-line were similar for the two species, however. For both E. guttatus and E. fulvus, approximately 13-15 traps per hook-and-line sample are required to achieve the same detection level (Tables 8 and 10). This represents a nearly four-fold increase over the 4 traps per hook-and-line sample ratio employed in the 1991-1992 survey.

For both the seasonal and habitat datasets and both grouper species, SEMR and the percentage of zero samples are always much lower for hook-and-line than for traps. A possible explanation for this phenomena is that hook-and-line rigs simply attract fish better than traps, maybe due to the more frequent replenishment of fresh bait and/or better retention properties of hooks. Another possibility is that the two gears sample slightly different environments, with traps placed directly upon the sea floor and hooks fished just off the bottom. It may be more critical for traps as to exactly where they are placed, with zero samples indicating "unfavorable" habitats for the target species. The percentage of zero trap samples may thus provide an indication of substrate heterogeneity within a particular quadrat, e.g. locations comprised of "coral" substrate may also contain substantial areas without coral, such as sand, rock, or mud.

5.0 STOCK ASSESSMENT CONSIDERATIONS

Analyses of 1991-1992 survey data presented thus far have been concerned with estimating relative abundance. Performing stock assessments requires additional information concerning population size-specific abundance, growth, mortality, and reproduction.

The 1991-1992 survey employed gears similar to those used in the commercial fishery; consequently, size classes of E. guttatus and E. fulvus captured in the survey generally correspond with those captured in the commercial fishery (Yvonne Sadovy, personal communication). Minimum sizes captured of both species are close to the size at which reproductive maturity occurs (Rosario, 1992). Assuming an efficient sampling design was followed, the survey in its present form could obtain robust estimates of relative abundance for the exploitable spawning stocks of E. guttatus and E. fulvus. However, no information is collected for smaller, pre-exploitable juvenile fishes. Relative abundance estimates of these smaller size groups will yield an index of recruitment.

Two important properties of the trap and hook-and-line sampling gears are unknown: 1) size-specific selectivity and 2) effective fishing area. Size-specific gear selectivity is required for correcting relative abundance-at-size estimates for sampling bias and also for estimating size-specific fishing mortality, a critical variable in cohort-structured stock assessment models. Understanding the effective fishing area of the sampling gears is necessary for estimating the important sampling design parameters N, N_h, and W_h. As discussed in section 2.3, gear effective fishing area relates to the minimum interference distance between adjacent traps or hook-and-line vessels. Knowledge of gear effective fishing area is also necessary for eventually relating estimates of relative abundance to absolute abundance. Comparing absolute abundance estimates from a fishery-independent survey with estimates of the commercial catch is a very useful validation method for sampling surveys. Absolute abundance-at-size estimates can also provide harvest projections for upcoming fishing seasons.

Three variables required for developing growth curves are length, weight, and age. Weight-length data are currently obtained by the survey, but no routine collection of otoliths for subsequent ageing is carried out. Length-age data is essential for estimating growth parameters, e.g. von Bertalanffy, and also for converting relative abundance from numbers-at-size to numbers-at-age. In turn, estimation of population instantaneous mortality rates requires numbers-at-age data. Growth and mortality information, including size-specific gear selectivity, would also be incomplete without samples from smaller, pre-exploitable size classes.

Concerning reproduction, the present survey collects excellent information on sex ratios and spawning seasons of E. guttatus and E. fulvus. One drawback of the current procedure for reproductive staging is that reproductively mature and immature individuals are not distinguished within the stage 1 category for unripe gonads. Also, fecundity estimates are not routinely performed on ovaries in spawning condition (Yvonne Sadovy, personal communication).

6.0 CONCLUSIONS AND RECOMMENDATIONS

It is evident from the analyses presented in this report that the 1991-1992 pilot study achieved what it set out to achieve: (i) an improved understanding of the main factors influencing spatial and temporal distributions of reef fish off the west coast of Puerto Rico; and (ii) a solid foundation for developing a long-term fishery-independent monitoring program in this region. However, like any good research program, answering certain basic questions in a present study always leads to asking more refined questions in a future study. This section presents recommendations for refining the statistical sampling design of the monitoring program and enhancing the content of stock assessment information obtained from the survey.

6.1 Survey Sampling Design

The results of sections 3.0 and 4.0 clearly suggest that E. guttatus and E. fulvus populations off the west coast of Puerto Rico distribute spatially according to certain preferred "habitats." The two primary characteristics of "habitat" are depth and substrate composition. However, habitat and CPUE data have only been collected for a small portion of the sampling region. Moreover, the 1991-1992 data also suggest that while general descriptions of substrate such as "coral" or "rocky/no coral" may qualitatively describe the predominate substrate within a 2x2 mile quadrat, a significant amount of substrate heterogeneity may exist. Since substantial gains in sampling efficiency and CPUE estimation are likely to result from a depth-substrate stratified design, the first recommendation is to

1)construct a habitat map of the sampling region.

This map would replace the geographical quadrats in Figure 1 with areas based on depth and substrate characteristics. A map of this type is essential for designing a future sampling survey since it would enumerate the proportion of the total sampling area occupied by each habitat type and also provide latitude and longitude coordinates for randomly allocating samples among the different habitats.

The extent of increases in sampling efficiency and accuracy and precision of CPUE estimates achieved by a habitat-stratified sampling design will depend upon how accurately the habitat map is constructed. It is likely that depth information exists to a high degree of spatial resolution for the sampling region, and can be obtained at precise latitude-longitude coordinates from navigational charts or databases. The major practical constraint is the characterization of substrate composition at specific spatial coordinates. General qualitative substrate information may be available from previous field studies conducted in the sampling region or from anecdotal records of experienced commercial fishermen. Quantitative substrate information may be available from historical oceanographic surveys. In lieu of obtaining a comprehensive historical substrate dataset, it may be a worthwhile investment of resources to conduct a habitat mapping survey of the sampling region. A variety of techniques and gears could be employed for this task, e.g. hydroacoustics, benthic sediment sampling, etc. A lower-cost approach could be patterned after a pilot mapping survey conducted in the U.S. Virgin Islands utilizing an underwater video camera (Stephen Meyers, personal communication).

Until recommendation 1 is completed, it will not be possible to specify exactly how samples should be allocated in a future survey. However, the results of sections 3.0 and 4.0 provide general guidelines for a future sampling design. Recommendation 2 lists the following sample allocation strategy:

2a)samples should be allocated separately for two seasons, spawning and non-spawning;

2b)within a season, the majority of samples should be allocated proportionally among different habitats according to habitat area; and

2c)additional samples should be allocated to high CPUE habitats.

An example sampling design involving 2 vessels with 3 fishermen per vessel is as follows: A total of 100 annual sampling days are allotted for each vessel, yielding a grand total of 200 sampling days and 600 hook-and-line samples. These 200 sampling days are divided between two 4-month periods, the November-December to February-March spawning season and the June-July to September-October nonspawning season. The spawning season receives 60% of the samples, or 120 sampling days. Of these, 80 days (66.7%) are allocated among depth-substrate habitats in proportion to habitat area, with a minimum of 5 days spent in each habitat. The remaining 40 or so days are added to spawning aggregation areas and other high CPUE habitats. The nonspawning season receives 40% of the total samples, or 80 sampling days. Of these, 60 days (75%) are allocated proportionally among habitats with a minimum of 5 days spent in each habitat. The remaining 20 or so days are added to high CPUE habitats.

A sampling design such as the example described above should provide an improved understanding of temporal and spatial distributions of most of the bottom-dwelling fish species inhabiting the west coast shelf region off Puerto Rico. The results of sections 3.0 and 4.0 indicate that the above design should also yield CPUE estimates of E. guttatus and E. fulvus within detection levels $d = 0.1$ and 0.2 for hook-and-line sampling gear. The precision of CPUE estimates for traps would be improved by following recommendation 3,

3)increase the number of traps fished per day.

At present, 12 traps per vessel per day are being fished. Increasing the number to 18 or 21 traps per day (or as many as are feasible) would improve standard error estimates of trap CPUE.

Conducting a habitat-stratified sampling survey requires both habitat and CPUE data to be stored according to precise geographical locations. Recommendation 4 is to

4)record specific latitude and longitude coordinates for each sample.

This will entail acquisition of a reasonably accurate Global Positioning System (GPS). Spatial data for depth, substrate, and CPUE can subsequently be analyzed within the framework of a Geographical Information System (GIS) or other mapping computer programs. These software packages provide powerful tools for visualizing spatial survey data, correlating CPUE with habitat information, and performing randomized sampling allocation procedures.

6.2 Stock Assessment Information

This section presents recommendations for collecting more comprehensive stock assessment information from the sampling program. Recommendation 5 is to

5)modify the survey to capture smaller, juvenile size classes.

This will undoubtedly involve modifying the sampling gears to target smaller fishes, or perhaps utilizing another type of capture gear altogether. It is also probable that juveniles occupy different habitats from adults, e.g. shallow coral environments as opposed to deep coral environments. Following the habitat-stratified sampling design described above and utilizing juvenile sampling gears will provide (i) abundance-at-size data for all size classes, including an index of recruitment, (ii) information on temporal and spatial distributions of smaller fishes, and (iii) information concerning both the timing of recruitment to the capturable stock and the size of recruits.

To carry out recommendation 5, it will be necessary to

6)conduct gear performance field experiments.

These studies should focus on identifying appropriate capture gears for smaller fishes. As a result of these experiments, important information on size-selectivity of the present capture gears will also be obtained. A second set of experiments should be directed towards determining the effective fishing areas of the sampling gears, discussed in sections 2.3 and 5.0. It is possible that gear effective fishing area varies according to habitat. Therefore, gear performance experiments should be conducted in as many different habitats as possible. An improved understanding of gear effective fishing area for different habitats will lead to more accurate estimation of the stratum weighting factor W_h and also enable relating estimates of relative abundance to absolute abundance.

The final recommendation is to

7)collect age and reproduction information from a subsample of the catch.

This will entail obtaining otoliths for ageing and gonads for determination of sexual maturity and fecundity. These biological samples should be collected for a representative number of individuals by size class (e.g. 10 mm intervals) and sex for each species captured. This information is vital for (i) estimating population dynamics parameters of growth, mortality, and reproduction and (ii) performing subsequent stock assessments.

7.0 REFERENCES

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Appendices: SAS Listings of ANOVA Results

Appendix A: ANOVA results for E. guttatus traps seasonal dataset.

RH TRAPS ANOVA, LOC 95 & 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
MONTH	7	APR DEC FEB MAR NOV OCT SEP
LOC	2	95 96

Number of observations in data set = 712

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	6	2.18993784	0.36498964	8.32	0.0001
LOC	1	0.22574721	0.22574721	5.14	0.0236
MONTH*LOC	5	0.69285104	0.13857021	3.16	0.0079
Error	699	30.68244831	0.04389478		

Means with the same letter are not significantly different.

Scheffe Grouping		Mean	N	MONTH
	A	0.2296	108	FEB
	A			
	A	0.2250	24	NOV
	A			
B	A	0.1595	84	MAR
B	A			
B	A	0.1352	108	DEC
B				
B		0.0867	120	OCT
B				
B		0.0723	172	SEP
B				
B		0.0682	96	APR

Appendix A: (cont.)

RH TRAPS ANOVA, LOC 95 & 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
SEASON	2	NSPWN SPAWN

Number of observations in data set = 712

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SEASON	1	1.90610161	1.90610161	42.11	0.0001
Error	710	32.14104784	0.04526908		

------------------------------- SEASON=NSPWN -------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
LOC	2	95 96

Number of observations in by group = 388

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LOC	1	0.08064063	0.08064063	3.30	0.0702
Error	386	9.43985166	0.02445557		

Appendix A: (cont.)

--------------------------------- SEASON=SPAWN ---------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
LOC	2	95 96

Number of observations in by group = 324

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LOC	1	0.15760101	0.15760101	2.26	0.1338
Error	322	22.46295455	0.06976073		

Appendix B: ANOVA results for E. guttatus hook-and-line seasonal dataset.

RH HOOKS ANOVA, LOC 95 & 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
MONTH	8	APR DEC FEB JAN MAR NOV OCT SEP
LOC	2	95 96

Number of observations in data set = 212

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	7	246.3380697	35.1911528	13.79	0.0001
LOC	1	14.0595132	14.0595132	5.51	0.0199
MONTH*LOC	6	65.6833333	10.9472222	4.29	0.0004
Error	197	502.7797029	2.5521812		

Means with the same letter are not significantly different.

Scheffe Grouping		Mean	N	MONTH
	A	5.374	27	DEC
	A			
B	A	4.168	19	JAN
B				
B		3.333	6	NOV
B				
B	C	3.193	36	FEB
B	C			
B	C	2.630	31	SEP
B	C			
B	C	2.538	39	MAR
B	C			
B	C	2.359	30	OCT
	C			
	C	1.363	24	APR

Appendix B: (cont.)

RH HOOKS ANOVA, LOC 95 & 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
SEASON	2	NSPWN SPAWN

Number of observations in data set = 212

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SEASON	1	104.4017366	104.4017366	29.31	0.0001
Error	210	748.0093688	3.5619494		

-------------------------------- SEASON=NSPWN --------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
LOC	2	95 96

Number of observations in by group = 85

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LOC	1	0.62191680	0.62191680	0.31	0.5812
Error	83	168.34327218	2.02823219		

------------------------------- SEASON=SPAWN --------------------------------

General Linear Models Procedure
Class Level Information

Class	Levels	Values
LOC	2	95 96

Number of observations in by group = 127

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LOC	1	4.10182943	4.10182943	0.89	0.3468
Error	125	574.94235044	4.59953880		

Appendix C: ANOVA results for *E. fulvus* traps seasonal dataset.

CY TRAPS ANOVA, LOC 95 & 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
MONTH	7	APR DEC FEB MAR NOV OCT SEP
LOC	2	95 96

Number of observations in data set = 712

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	6	0.05937754	0.00989626	1.29	0.2574
LOC	1	0.02084137	0.02084137	2.73	0.0992
MONTH*LOC	5	0.05404759	0.01080952	1.41	0.2171
Error	699	5.34509483	0.00764677		

CY TRAPS ANOVA, LOC 95 & 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
LOC	2	95 96

Number of observations in data set = 712

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LOC	1	0.04428220	0.04428220	5.77	0.0166
Error	710	5.45347805	0.00768095		

Appendix D: ANOVA results for *E. fulvus* hook-and-line seasonal dataset.

CY HOOKS ANOVA, LOC 95 & 96

General Linear Models Procedure
Class Level Information

Class	Levels	Values
MONTH	8	APR DEC FEB JAN MAR NOV OCT SEP
LOC	2	95 96

Number of observations in data set = 212

Source	DF	Type III SS	Mean Square	F Value	Pr > F
MONTH	7	15.51431599	2.21633086	4.91	0.0001
LOC	1	0.21099195	0.21099195	0.47	0.4949
MONTH*LOC	6	13.69189891	2.28198315	5.06	0.0001
Error	197	88.91092411	0.45132449		

Means with the same letter are not significantly different.

Scheffe Grouping		Mean	N	MONTH
	A	1.348	31	SEP
	A			
B	A	0.798	36	FEB
B	A			
B	A	0.765	27	DEC
B	A			
B	A	0.721	39	MAR
B	A			
B	A	0.663	19	JAN
B	A			
B	A	0.647	30	OCT
B				
B		0.481	6	NOV
B				
B		0.395	24	APR

Appendix E: ANOVA results for <u>E. guttatus</u> traps habitat dataset.

RH TRAPS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
LOC	9	34 37 40 66 80 90 93 95 96

Number of observations in data set = 276

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LOC	8	0.25991602	0.03248950	4.26	0.0001
Error	267	2.03682771	0.00762857		

Means with the same letter are not significantly different.

Scheffe Grouping	Mean	N	LOC
A	0.0774	60	95
A			
A	0.0529	36	96
A			
A	0.0167	12	40
A			
A	0.0139	72	80
A			
A	0.0000	12	37
A			
A	0.0000	24	90
A			
A	0.0000	36	93
A			
A	0.0000	12	66
A			
A	0.0000	12	34

Appendix E: (cont.)

RH TRAPS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
DEPTH	3	D M S

Number of observations in data set = 276

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DEPTH	2	0.15230604	0.07615302	9.69	0.0001
Error	273	2.14443769	0.00785508		

Means with the same letter are not significantly different.

Scheffe Grouping	Mean	N	DEPTH
A	0.0546	120	D
B	0.0119	84	M
B			
B	0.0028	72	S

Appendix E: (cont.)

RH TRAPS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BOTTOM	5	SUB1 SUB2 SUB3 SUB4 SUB5

Number of observations in data set = 276

Source	DF	Type III SS	Mean Square	F Value	Pr > F
BOTTOM	4	0.19164046	0.04791012	6.17	0.0001
Error	271	2.10510327	0.00776791		

Means with the same letter are not significantly different.

Scheffe Grouping	Mean	N	BOTTOM
A	0.0606	108	SUB1
A			
A	0.0104	96	SUB2
A			
A	0.0083	24	SUB4
A			
A	0.0000	12	SUB3
A			
A	0.0000	36	SUB5

Appendix F: ANOVA results for *E. guttatus* hook-and-line habitat dataset.

RH HOOKS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
LOC	9	34 37 40 66 80 90 93 95 96

Number of observations in data set = 73

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LOC	8	25.01831514	3.12728939	13.20	0.0001
Error	64	15.15835851	0.23684935		

Means with the same letter are not significantly different.

Scheffe Grouping			Mean	N	LOC
	A		1.425	15	95
	A				
B	A		1.259	9	96
B	A				
B	A	C	0.222	9	90
B	A	C			
B	A	C	0.190	3	40
B		C			
B		C	0.165	19	80
B		C			
B		C	0.095	3	66
B		C			
B		C	0.095	3	34
		C			
		C	0.000	3	37
		C			
		C	0.000	9	93

Appendix F: (cont.)

RH HOOKS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
DEPTH	3	D M S

Number of observations in data set = 73

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DEPTH	2	16.24460004	8.12230002	23.76	0.0001
Error	70	23.93207362	0.34188677		

Means with the same letter are not significantly different.

Scheffe Grouping	Mean	N	DEPTH
A	1.052	33	D
B	0.156	22	M
B			
B	0.048	18	S

RH HOOKS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BOTTOM	5	SUB1 SUB2 SUB3 SUB4 SUB5

Number of observations in data set = 73

Source	DF	Type III SS	Mean Square	F Value	Pr > F
BOTTOM	4	20.50728119	5.12682030	17.72	0.0001
Error	68	19.66939246	0.28925577		

Means with the same letter are not significantly different.

Scheffe Grouping	Mean	N	BOTTOM
A	1.222	27	SUB1
B	0.184	28	SUB2
B			
B	0.095	3	SUB3
B			
B	0.095	6	SUB4
B			
B	0.000	9	SUB5

Appendix G: ANOVA results for *E. fulvus* traps habitat dataset.

CY TRAPS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
LOC	9	34 37 40 66 80 90 93 95 96

Number of observations in data set = 276

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LOC	8	0.01823236	0.00227904	0.75	0.6451
Error	267	0.80878088	0.00302914		

CY TRAPS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
DEPTH	3	D M S

Number of observations in data set = 276

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DEPTH	2	0.01024830	0.00512415	1.71	0.1823
Error	273	0.81676493	0.00299181		

CY TRAPS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BOTTOM	5	SUB1 SUB2 SUB3 SUB4 SUB5

Number of observations in data set = 276

Source	DF	Type III SS	Mean Square	F Value	Pr > F
BOTTOM	4	0.01007892	0.00251973	0.84	0.5034
Error	271	0.81693432	0.00301452		

Appendix H: ANOVA results for E. fulvus hook-and-line habitat dataset.

CY HOOKS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
LOC	9	34 37 40 66 80 90 93 95 96

Number of observations in data set = 73

Source	DF	Type III SS	Mean Square	F Value	Pr > F
LOC	8	15.86764683	1.98345585	6.83	0.0001
Error	64	18.59768228	0.29058879		

Means with the same letter are not significantly different.

Scheffe Grouping	Mean	N	LOC
A	1.203	19	80
A			
A	0.469	15	95
A			
A	0.272	9	96
A			
A	0.095	3	40
A			
A	0.074	9	90
A			
A	0.063	9	93
A			
A	0.000	3	37
A			
A	0.000	3	66
A			
A	0.000	3	34

CY HOOKS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
DEPTH	3	D M S

Number of observations in data set = 73

Source	DF	Type III SS	Mean Square	F Value	Pr > F
DEPTH	2	11.20335576	5.60167788	16.86	0.0001
Error	70	23.26197334	0.33231390		

Means with the same letter are not significantly different.

Scheffe Grouping	Mean	N	DEPTH
A	1.039	22	M
B	0.307	33	D
B			
B	0.048	18	S

CY HOOKS ANOVA, APRIL-JUNE

General Linear Models Procedure
Class Level Information

Class	Levels	Values
BOTTOM	5	SUB1 SUB2 SUB3 SUB4 SUB5

Number of observations in data set = 73

Source	DF	Type III SS	Mean Square	F Value	Pr > I
BOTTOM	4	7.43625254	1.85906313	4.68	0.0021
Error	68	27.02907657	0.39748642		

Means with the same letter are not significantly different.

Scheffe Grouping	Mean	N	BOTTOM
A	0.840	28	SUB2
A			
A	0.351	27	SUB1
A			
A	0.063	9	SUB5
A			
A	0.048	6	SUB4
A			
A	0.000	3	SUB3

DEPARTMENT OF NATURAL RESOURCES

Annual Report

to

National Marine Fisheries Service

NOAA

Shallow-water Reef Fish Monitoring

Caribbean/NMFS Cooperative SEAMAP Program

by

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and

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Secretary of PR Department of Natural Resources

June 1993

ABSTRACT

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

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

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

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

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

ABSTRACTO

Durante el perlodo de muestreo de abril de 1992 a marzo de 1993, un total de 45 estaciones fueron muestreadas al oeste del Paralelo 67 de Puerto Rico. Cincuenta y ocho especies representativas de 25 familias produjeron sobre 796 kg de pescado. Los dos grupos de mayor importancia comercial, meros y pargos, constituyeron el 69% por peso de la captura total. Dos especies de meros (**Serranidae**) constituyeron 59% por peso de la muestra total de anzuelos.

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

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

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

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

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INTRODUCTION

Shallow-water Reef Fish Monitoring

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

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

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

Rational decision making requires long time-series of biological and environmental information to predict fluctuations in resources abundance, which is provided by fisheries-independent data. Fisheries-independent data collection has been carried out by the Fisheries Research Laboratory (FRL) since 1967. During the early years, efforts were concentrated in identifying new fishing areas and implementing new fishing techniques and gears. Most of the effort was concentrated mainly in exploring, developing and teaching new fishing techniques to fishermen. Various and numerous projects were conducted by the Exploratory Fishing Program of the FRL. All kinds of gears and a diversity of new species were studied, trying to establish the viability of introducing them in Puerto Rico. Most of these works were conducted and published by Mr. Rolf Juhl (1969 and 1972), Juhl and Suarez-Caabro (1973). Others were conducted by Mr. Jon Cole (1976) and in the early 1980's by Mr. Charles Boardman and Ms. Deborah Weiler (1979). All these surveys tested several fishing gears, being the two most often used the fish traps and snapper reels.

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

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

OBJECTIVE

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

APPROACH

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

METHODS

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

2. The sampling areas were stratified based on the following depth criteria which generally distinguish shallow water platform areas from shelf edge areas:

a) 0-10 fathoms;

b) 11-20 fathoms;

c) 21-50 fathoms;

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

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

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

6. For each trip the following data was recorded:

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

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

C. depth.

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

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

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

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

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

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

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

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

Geographic Location

Puerto Rico, west coast.

RESULTS

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

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

1) Hook and Line

Catches

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

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

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

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

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

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

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

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

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

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

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

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

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

Species Composition

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

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

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

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

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

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

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

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

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

Length Frequency

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

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

Epinephelus fulvus-coney

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

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

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

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

Epinephelus guttatus-red hind

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

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

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

Rhomboplites aurorubens-vermillion snapper

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

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

Malacanthus plumieri-sand tilefish

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

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

2) Fish Traps

Catches

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

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

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

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

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

Species Composition

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

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

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

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

Length Frequency

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

enough sampled by moon phase to compare the distributions.

Epinephelus fulvus-coney

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

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

Epinephelus guttatus-red hind

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

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

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

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

Reproductive State

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

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

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

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

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

Differences in size distribution between total sample and females ($d = 0.075$ $D_{.05} = 0.062$) were statistically significant, as well as between total sample and males ($d = 0.143$ $D_{.05} = 0.138$).

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

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

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

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

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

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

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

Malacanthus plumieri (sand tilefish N = 196) sample was constituted by 83% males and 17% females. Males with ripe testes composed 8%, while males with spent gonads made up 9%. Sex ratio of females to males was 0.21:4.76 (F:M). Females with ripe ova constituted 24% of total sample females, while females with spent gonads were not sampled.

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

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

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

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

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

DISCUSSION

Catches

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

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

Since 1988 a shift in the types of gear used by Puerto Rican fishermen has been registered. Traditionally, traps constituted over 50% of total landings (Suarez-Caabro, 1970; Weiler and Suarez-Caabro, 1980; Garc1a-Moliner and Kimmel, 1986; Collazo and Calder;n, 1988), but since 1988 an increase in the use of handlines has been registered (Matos and Torres, 1989; Matos and Sadovy, 1990, Matos, 1992). Also the percentage of landings with handlines has increased. Therefore this gear is becoming more important in Puerto Rico fisheries.

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

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

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

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

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

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

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

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

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

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

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

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

Species Composition

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

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

1979 (Bohnsack **et al**, 1986; Garcla-Moliner and Kimmel, 1986; Appeldoorn, 1987; Collazo and Calder;n, 1988; Matos and Torres, 1989; Sadovy, 1989; Matos, 1990; Matos and Sadovy, 1990; Matos, 1991 and 1992; Dennis **et al**, 1991).

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

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

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

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

Length Frequency

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

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

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

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

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

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

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

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

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

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

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

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

Reproductive State

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

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

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

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

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

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

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

Although data regarding spawning season and sexual maturation of silk snappers obtained from this study are very scarce, the available data tends to confirm what is a major concern for this species. Over 100% of sampled silk snapper in this survey were sexually immature. Grimes (1987) demonstrated that species associated with islands and deep habitats mature at relatively large sizes when compared to those associated with continents and shallower habitats. Boardman and Weiler (1980) reported that female silk snappers mature at 500 mm FL and males at 380 mm. More recently Figuerola (1991) reported that the 50% size of sexual maturity for females snapper was 410 mm of FL and 265 mm FL for males. Spawning season of silk snapper in Puerto Rico and Jamaica has been reported as year round (Erdman, 1977; Boardman and Weiler, 1980; Munro, **et al**, 1973).

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

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

CONCLUSIONS AND RECOMMENDATIONS

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

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

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

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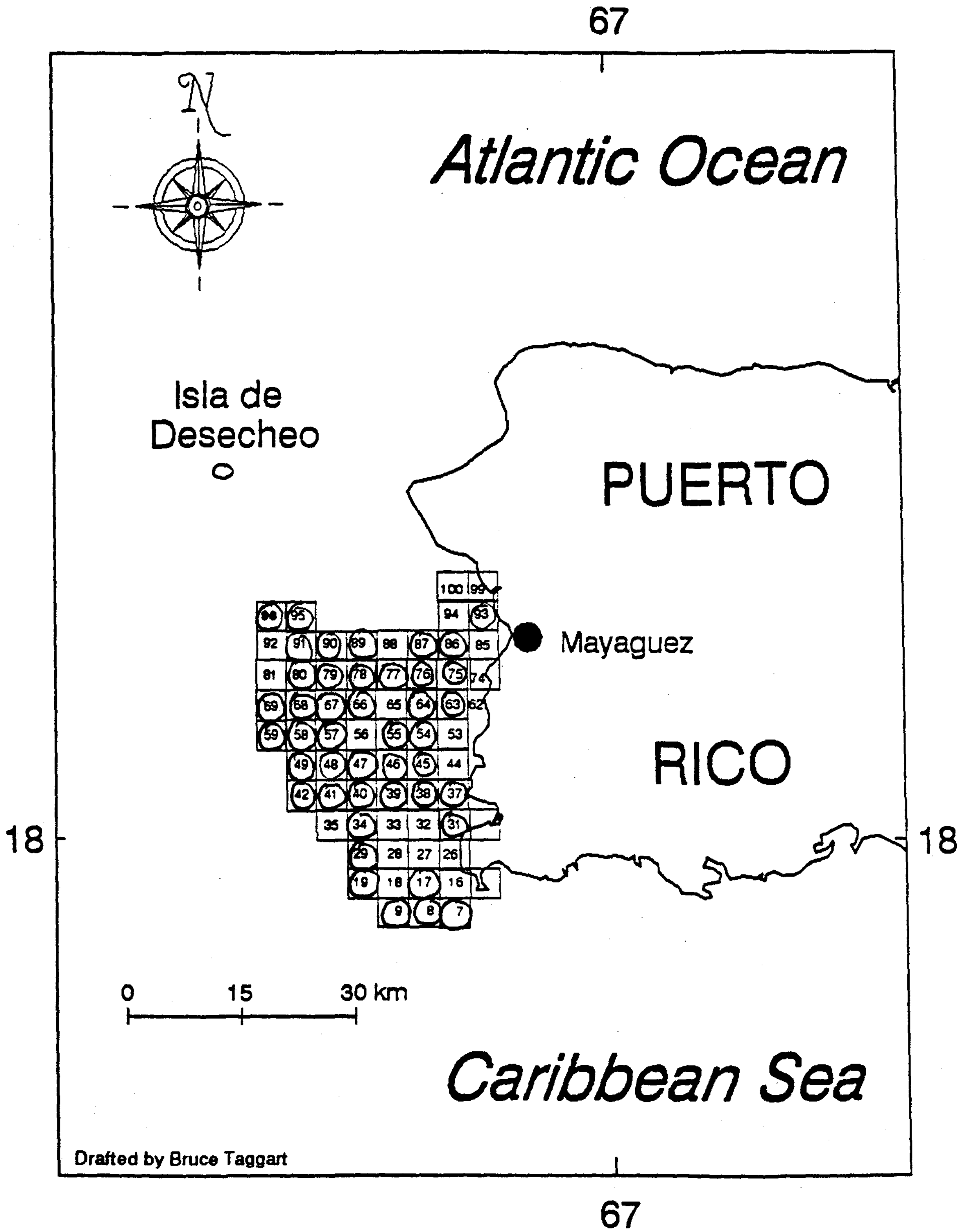
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distribution of sampled coneys by moon phase.

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

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

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

Epinephelus guttatus-red hind

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

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

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

Rhomboplites aurorubens-vermillion snapper

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

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

Table 1. Sampled species during sampling period of April 1992 to March 1993.									
		Hook and Line				Fish Traps			
Code	Species	#	%	W	%	#	%	W	%
82	Epinephelus cruentatus	45	1.95	7,422	1.08	4	1.07	713	0.65
80	Epinephelus fulvus	1,016	44.10	179,058	26.06	91	24.33	23,104	21.05
88	Epinephelus guttatus	671	29.12	226,133	32.91	90	24.06	45,305	41.28
89	Epinephelus striatus	0	0.00	0	0.00	1	0.27	1,134	1.03
138	Lutjanus buccanella	7	0.30	3,010	0.44	1	0.27	175	0.16
136	Lutjanus synagris	13	0.56	2,451	0.36	8	2.14	451	0.41
139	Lutjanus vivanus	44	1.91	15,132	2.20	24	6.42	7,313	6.66
140	Ocyurus chrysurus	5	0.22	1,260	0.18	4	1.07	1,245	1.13
141	Apsilus dentatus	18	0.78	28,598	4.16	0	0.00	0	0.00
142	Rhomboplites aurorubens	85	3.69	14,281	2.08	6	1.60	958	0.87
159	Haemulon aurolineatum	4	0.17	272	0.04	0	0.00	0	0.00
155	Haemulon plumieri	5	0.22	1,725	0.25	7	1.87	2,110	1.92
165	Calamus pennatula	15	0.65	5,885	0.86	5	1.34	1,315	1.20
729	Balistes capriscus	0	0.00	0	0.00	1	0.27	104	0.09
251	Balistes vetula	7	0.30	8,849	1.29	20	5.35	10,035	9.14
252	Canthidermis sufflamen	15	0.65	20,200	2.94	0	0.00	0	0.00
253	Melichthys niger	12	0.52	6,605	0.96	0	0.00	0	0.00
726	Aluterus scriptus	0	0.00	0	0.00	1	0.27	290	0.26
727	Cantherines macrocerus	2	0.09	1,915	0.28	6	1.60	2,755	2.51
675	Sparisoma chrysopterum	1	0.04	480	0.07	0	0.00	0	0.00
700	Lactophrys quadricornis	0	0.00	0	0.00	5	1.34	1,146	1.04
257	Lactophrys trigonus	2	0.09	1,085	0.16	0	0.00	0	0.00
703	Lactophrys triqueter	0	0.00	0	0.00	1	0.27	135	0.12
218	Acanthurus bahianus	0	0.00	0	0.00	2	0.53	580	0.53
651	Acanthurus chirurgus	0	0.00	0	0.00	1	0.27	135	0.12
652	Acanthurus coereleus	0	0.00	0	0.00	1	0.27	130	0.12
116	Caranx bartholomaei	3	0.13	2,225	0.32	0	0.00	0	0.00
117	Caranx crysos	13	0.56	5,985	0.87	0	0.00	0	0.00
122	Alectis ciliaris	5	0.22	9,198	1.34	0	0.00	0	0.00
124	Elagatis bipinnulatus	3	0.13	5,389	0.78	0	0.00	0	0.00
65	Holocentrus ascensionis	49	2.13	10,244	1.49	13	3.48	2,625	2.39
625	Holocentrus rufus	27	1.17	3,059	0.45	12	3.21	1,203	1.10

cont. Table 1.		Hook and Line				Fish Traps			
Code	Species	#	%	W	%	#	%	W	%
103	Malacanthus plumieri	196	8.51	65.938	9.60	0	0.00	0	0.00
104	Caulolatilus cyanops	2	0.09	1.455	0.21	0	0.00	0	0.00
46	Synodus intermedius	1	0.04	215	0.03	0	0.00	0	0.00
98	Priacanthus cruentatus	2	0.09	790	0.11	0	0.00	0	0.00
728	Monacanthus setifer	0	0.00	0	0.00	1	0.27	128	0.12
183	Chaetodon capistratus	0	0.00	0	0.00	2	0.53	128	0.12
560	Chaetodon ocellatus	0	0.00	0	0.00	2	0.53	170	0.15
574	Chaetodon sedentarius	0	0.00	0	0.00	1	0.27	30	0.03
561	Chaetodon striatus	0	0.00	0	0.00	54	14.44	3.756	3.42
660	Halichoeres garnoti	0	0.00	0	0.00	1	0.27	265	0.24
191	Halichoeres radiatus	1	0.04	930	0.14	0	0.00	0	0.00
822	Chilomycterus antillarum	0	0.00	0	0.00	2	0.53	565	0.51
261	Sphoeroides spengleris	1	0.04	305	0.04	1	0.27	720	0.66
757	Serranus phoebe	1	0.04	110	0.02	0	0.00	0	0.00
545	Scorpaenodes caribbaeus	1	0.04	310	0.05	0	0.00	0	0.00
245	Scorpaena plumieri	6	0.26	1.890	0.28	1	0.27	290	0.026
403	Carcharhinus limbatus	1	0.04	2.494	0.36	0	0.00	0	0.00
19	Dasyatis americana	1	0.04	2.381	0.35	0	0.00	0	0.00
442	Gymnothorax moringa	2	0.09	1.760	0.26	0	0.00	0	0.00
601	Caranx hippos	1	0.04	4.557	0.66	0	0.00	0	0.00
118	Caranx latus	1	0.04	1.350	0.20	0	0.00	0	0.00
119	Caranx lugubris	11	0.48	21.611	3.14	0	0.00	0	0.00
111	Seriola rivoliana	4	0.17	3.750	0.55	0	0.00	0	0.00
203	Sphyraena barracuda	5	0.22	16.854	2.45	0	0.00	0	0.00
930	Arenaus cribarius	0	0.00	0	0.00	4	1.07	710	0.65
920	Callapa flammea	0	0.00	0	0.00	1	0.27	130	0.12
	Total	2.304	687.161			374		109.745	

Table 2. Catch summary by fishermen of data collected during sampling period April 1992 to March 1993.

Fishermen ID	# of trips	Effort (hook hours)	Total Weight (g)	Number of Fish	Mean CPUE (g/trips)	CPUE (g/trips)	CPUE (g/hook hrs)
1	55	580.50	70,286	205	1,277.93	121.71	121.08
6	52	606.00	139,562	437	2,683.88	220.42	230.30
13	55	649.50	96,949	366	1,762.71	129.25	129.87
17	46	547.50	94,644	138	2,057.48	174.41	172.87
18	55	670.50	135,730	524	2,467.82	196.34	202.43
21	52	700.50	125,697	427	2,417.25	178.15	179.44
26	5	52.50	24,293	15	4,858.60	462.72	462.72

Table 3. Catch summary by selected species by moon phase for sampling period of April 1992 to March 1993.

(Table 3a). Catch summary by moon phase of sampled coneys with hook and line.

Moon Phase	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.	Min . X	Max . X	Min . W	Max. W
First.	92	14,509	213.3	24.1	585.1	157.7	51.01	2,601	129	261	38	325
Full	317	52,920	217.6	22.8	520.3	166.9	50.27	2,526	160	295	64	390
Last	235	52,920	217,6	26.2	690.1	176.3	70.49	4,968	166	319	74	540
New	372	70,199	220.2	24.7	613.9	188.7	73.00	5,329	112	344	46	795
Total	1,016	179,058	218.7	24.5	603.8	176.2	65.11	4,239	112	344	38	795

(Table 3b). Catch summary by moon phase of sampled red hinds with hook and line.

Moon Phase	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.	Min . X	Max . X	Min . W	Max. W
First.	147	45,051	266.1	49.1	2,406	306.5	198.8	39,519	154	392	52	1,060
Full	23	8,195	286.1	34.9	1,220	356.3	93.7	8,774	180	351	235	585
Last	267	92,158	277.8	56.6	3,203	345.2	263.0	69,170	183	454	54	1,505
New	234	80,729	280.8	47.5	2,257	345.1	223.7	50,049	170	485	82	1,915
Total	671	226,133	279.5	52.8	2,787	336.8	228.6	52,233	154	485	52	1,915

(Table 3c). Catch summary by moon phase of sampled vermillion snapper with hook and line.

Moon Phase	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.	Min . X	Max . X	Min . W	Max. W
First.												
Full	25	4,115	215.0	13.6	185	164.6	31.0	962	180	223	90	225
Last	49	8,470	216.9	15.9	252	172.9	36.1	1,306	188	255	102	270
New	11	1,696	213.5	47.5	727	154.2	50.0	2,497	161	247	60	235
Total	85	14,281	215.9	17.2	295	168.0	37.4	1,400	161	255	60	270

(Table 3d). Catch summary by moon phase of sampled sand tilefish with hook and line.

Moon Phase	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.	Min . X	Max . X	Min . W	Max. W
First.	30	9,130	344.3	37.2	1,383	304.3	99.3	9,864	245	401	90	605
Full	41	15,515	370.0	30.8	946	378.4	61.9	3.828	212	423	230	515
Last	51	16,803	357.5	27.8	773	329.5	67.5	4,558	261	408	118	470
New	74	24,490	357.7	33.2	1,104	331.0	90.8	8,248	275	422	140	550
Total	196	65,938	358.2	33.0	1,087	336.4	84.6	7,161	212	423	90	605

Table 4. Catch summary of selected sampled species by depth ranges (fm) with hook and line, April 1992 to March 1993.

(Table 4a). Catch summary by depth ranges of sampled coneys, April 1992 to March 1993.

Depth Ranges	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.	Min. X	Max. X	Min. W	Max. W
0-10	265	44,872	216.91	20.9	439.26	169.33	44.02	1,937.9	160	291	66	390
11-20	574	102,104	219.53	23.8	570.39	177.88	60.59	3,671.1	129	344	38	400
21-50	177	32,082	218.80	30.8	951.91	181.25	97.07	9,422.2	112	319	60	795
Total	1,016	179,058	218.7	24.5	603.8	176.2	65.11	4,239	112	344	38	795

(Table 4b). Catch summary by depth ranges of sampled red hinds, April 1992 to March 1993.

Depth Ranges	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.	Min. X	Max. X	Min. W	Max. W
0-10	35	10,498	267.2	40.9	1,673	200.66		40,266.	202	425	92	1,270
11-20	141	48,445	276.6	55.9	3,132	231.51		53,596.	154	444	52	1,505
21-50	496	167,330	277.0	50.9	2,598	234.98		55,217	183	485	54	1,915
Total	671	226,133	279.5	52.8	2,787	336.8	228.6	52,233	154	485	52	1,915

(Table 4c). Catch summary by depth ranges (fm) of sampled vermillion snappers, April 1992 to March 1993.

Depth Ranges	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.	Min. X	Max. X	Min. W	Max. W
0-10												
11-20	34	5,676	166.94	33.2	1,106	217.35	15.97	254.99	164	247	72	235
21-50	51	8,605	168.73	39.9	1,595	214.88	17.91	320.61	161	255	60	270
Total	85	14,281	215.9	17.2	295	168.0	37.4	1,400	161	255	60	270

(Table 4d). Catch summary by depth range of sampled sand tilefish, April 1992 to March 1993.

Depth Ranges	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.	Min. X	Max. X	Min. W	Max. W
0-10	33	10,908	350.45	41.3	1,706	330.55	86.99	7,567	212	400	118	455
11-20	106	36,025	363.22	28.7	824	339.86	75.66	5,723	246	423	110	530
21-50	57	19,005	353.21	33.3	1,111	333.42	97.72	9,549	245	422	90	605
Total	196	65,938	358.2	33.0	1,087	336.4	84.6	7,161	212	423	90	605

Table 5. Catch summary of selected sampled species with fish traps, April 1992 to March 1993.

(Table 5a). Catch summary by sex stage of sampled coneys with fish traps.

Sex Stage	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.	Min. X	Max. X	Min. W	Max. W
F1	4	799	227.25	23.78	565.69	199.75	53.20	2,830.19	189	250	114	260
F2	1	145	209.00	0.00	0.00	145.00	0.00	0.00				
F3	1	275	246.00	0.00	0.00	275.00	0.00	0.00				
F4	68	17,790	242.75	30.02	901.01	261.62	102.7	10,546.6	192	315	120	710
M1	3	515	216.33	4.19	17.56	171.67	14.34	205.56	212	222	155	190
M3	3	865	270.33	19.87	394.89	288.33	35.20	1,238.89	244	292	250	335
M4	11	2,715	242.33	27.62	762.74	246.82	84.73	7,178.51	196	283	135	365
Total	91	23,104										

(Table 5b). Catch summary by sex stage of sampled red hinds with fish traps.

Sex Stage	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.	Min. X	Max. X	Min. W	Max. W
F1	15	6,785	299.40	30.90	954.64	452.33	181.24	32,849.56	261	382	305	965
F4	52	22,475	303.48	35.11	1,232.37	432.21	166.67	27,780.21	242	379	150	815
M1	3	2,475	368.33	19.19	368.22	825.00	194.72	37,916.67	345	392	600	1,075
M2	2	515	258.50	7.50	56.25	257.50	32.50	1,056.25	251	266	225	290
M3	1	475	290.00	0.00	0.00	475.00	0.00	0.00				
M4	17	12,580	355.41	45.98	2,114.48	740.00	301.14	90,682.35	286	431	335	1,340
Total	90	45,305	313.62	43.37	1,880.6	503.39	242.2	58,678.79	242	431	150	1,340

Table 6. Summary of sampled species by sex stage with hook and line, April 1992 to March 1993.

(Table 6a). Catch summary of sampled coneys, April 1992 to March 1993.

Stage	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.
F1	28	4,820	221.54	30.70	942.39	172.14	62.81	3,945.62
F2	9	1,293	209.56	25.73	662.25	143.67	42.80	1,831.56
F3	18	2,688	207.83	19.68	387.36	149.33	67.47	4,552.78
F4	854	149,630	218.27	24.18	584.70	175.21	61.39	3,768.94
M1	2	232	195.5	2.50	6.25	116.00	14.00	196.00
M3	9	1,401	208.22	33.61	1,129.73	155.67	68.66	4,714.67
M4	96	18,994	226.25	23.70	561.70	197.85	88.79	7,884.10

(Table 6b). Catch summary of sampled red hinds, April 1992 to March 1993.

Stage	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.
F1	274	68,403	254.74	41.16	1,694.50	249.65	140.50	19,739.38
F2	17	5,566	266.29	47.99	2,303.50	327.41	214.67	46,084.24
F3	5	2,035	281.80	39.24	1,539.76	407.00	206.41	42,606.00
F4	217	68,054	276.92	36.71	1,347.55	313.61	138.21	19,100.91
M1	51	21,520	293.49	62.09	3,854.88	421.96	309.12	95,557.57
M2	15	5,845	288.83	51.80	2,683.58	389.67	231.49	53,588.22
M3	12	5,235	298.83	54.81	3,003.81	436.25	301.29	90,776.52
M4	80	49,475	336.00	58.55	3,427.73	618.44	352.72	124,414.75

(Table 6c). Catch summary of sampled vermillion snappers, April 1992 to March 1993.

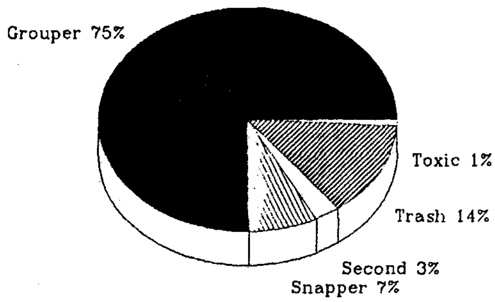
Stage	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.
F1	4	517	193.75	22.94	526.19	129.25	49.46	2,446.69
F2	20	3,795	223.10	13.16	173.29	189.75	31.28	798.69
F3	25	3,974	211.96	13.18	173.64	158.96	31.03	962.68
M2	5	745	03.40	6.25	39.04	149.00	12.00	144.00
M3	28	4,675	219.11	18.85	355.38	166.96	37.40	1,398.89
M4	3	575	220.33	13.82	190.89	191.67	39.65	1,572.22

(Table 6d). Catch summary of sampled sand tilefish, April 1992 to March 1993.

Stage	Tot. #	Tot. W.	Mean X	St. D	Var.	Mean W	St. D	Var.
F1	15	4,455	343.00	42.62	1,816.67	297.00	97.14	9,436.00
F2	11	3,343	338.64	47.77	2,281.87	303.91	13.64	18,670.99
F3	8	1,610	301.13	29.35	861.61	201.25	65.32	4,267.19

Fish Group Percent of Total Number Fish
Sampled With Hook and Line, 1992-1993.

A.



Fish Class Percent of Total Number of
Fish Sampled With Hook and Line 1992-93.

B.

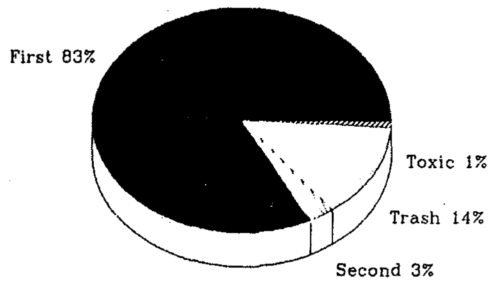
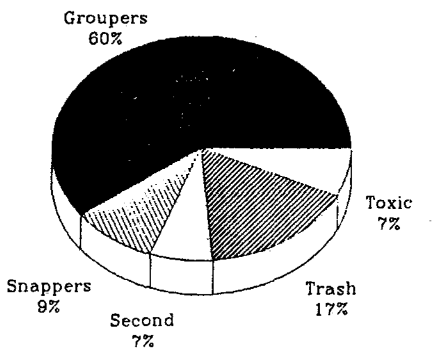


Figure 2. Percent contribution of fish groups and market classification; a) fish groups in terms of number; b) fish class in terms of number; c) fish groups in terms of weight and d). fish class in terms of weight.

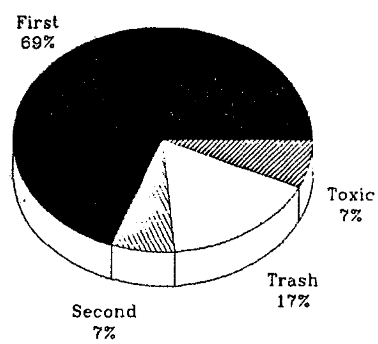
Fish Group Percent of Total Weight (g)
Sampled With Hook and Line, 1992-1993.

C.



Fish Class Percent of Total Weight (g)
Sampled With Hook and Line.

D.



A.

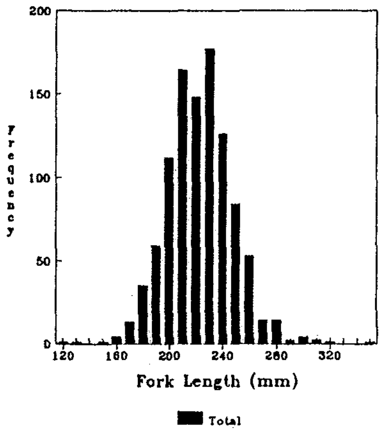
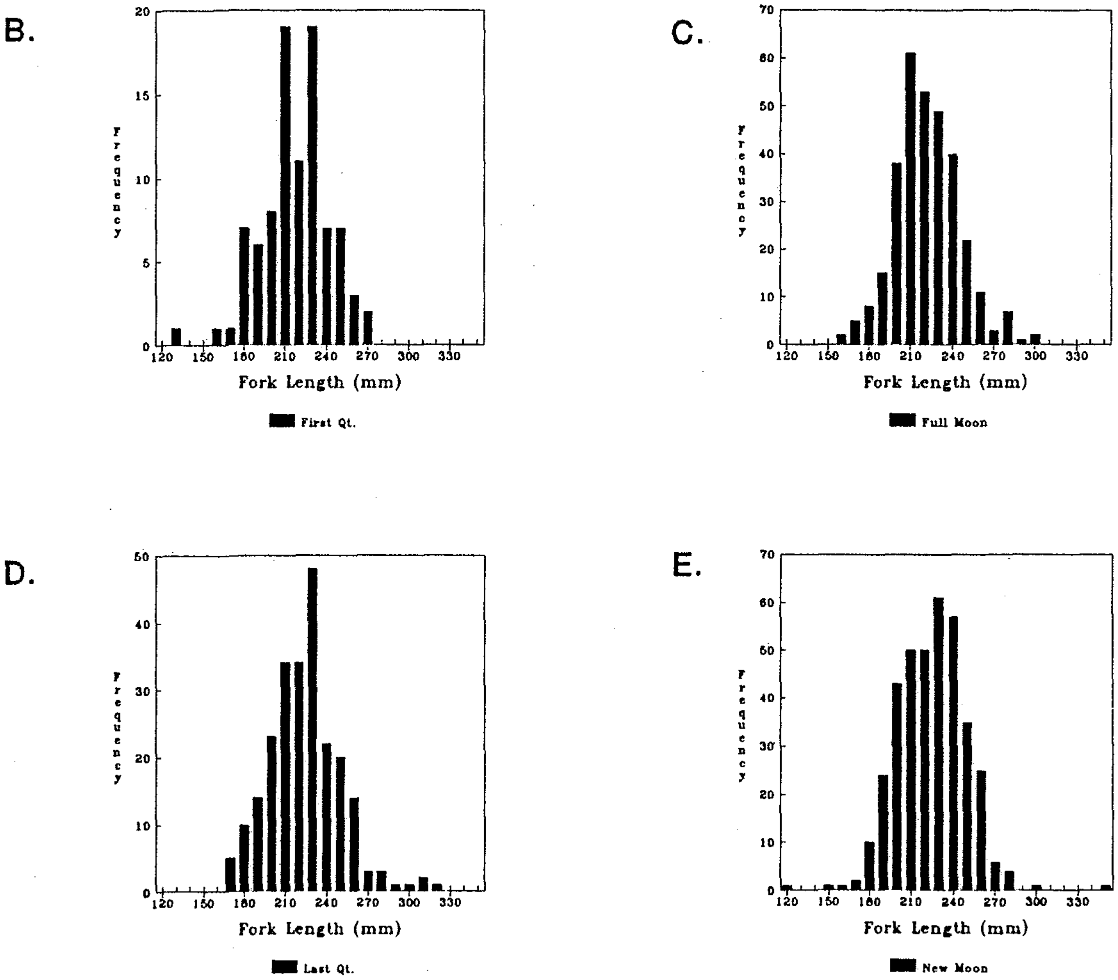


Figure 3. Size frequency distribution of sampled coneys with hook and line by moon phase; a) total sample; b) first quarter; c) full moon; d) last quarter; and e) new moon.



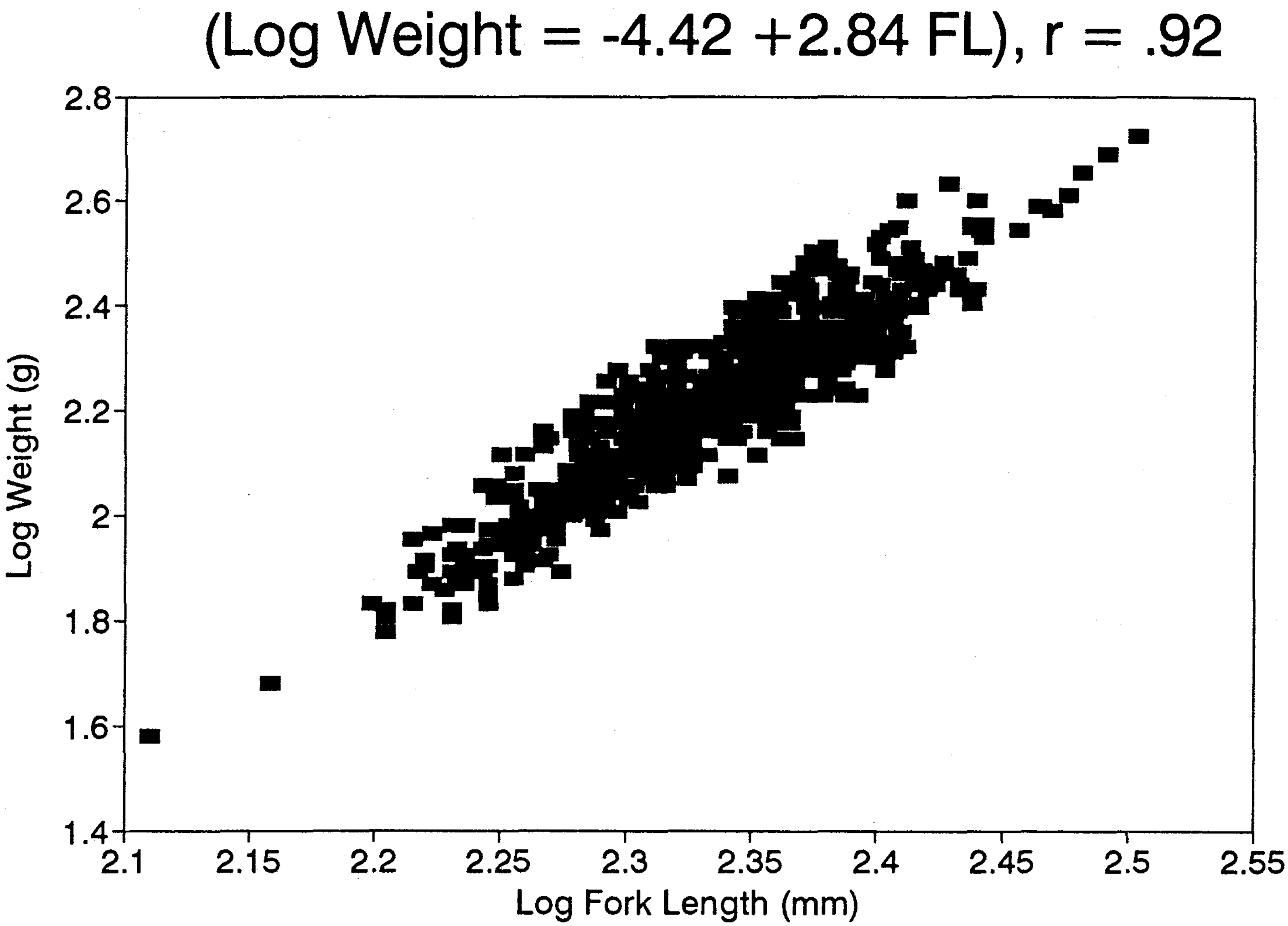


Figure 4. Length-weight analysis of sampled coneys with hook and line, 1992-93.

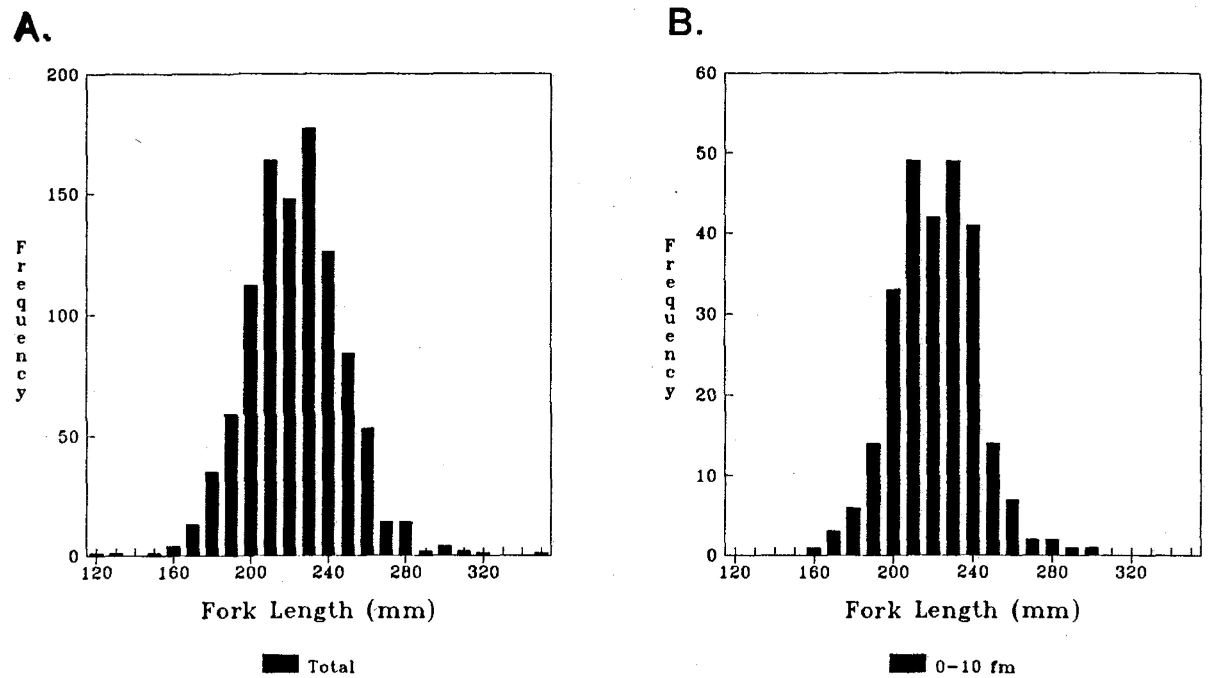
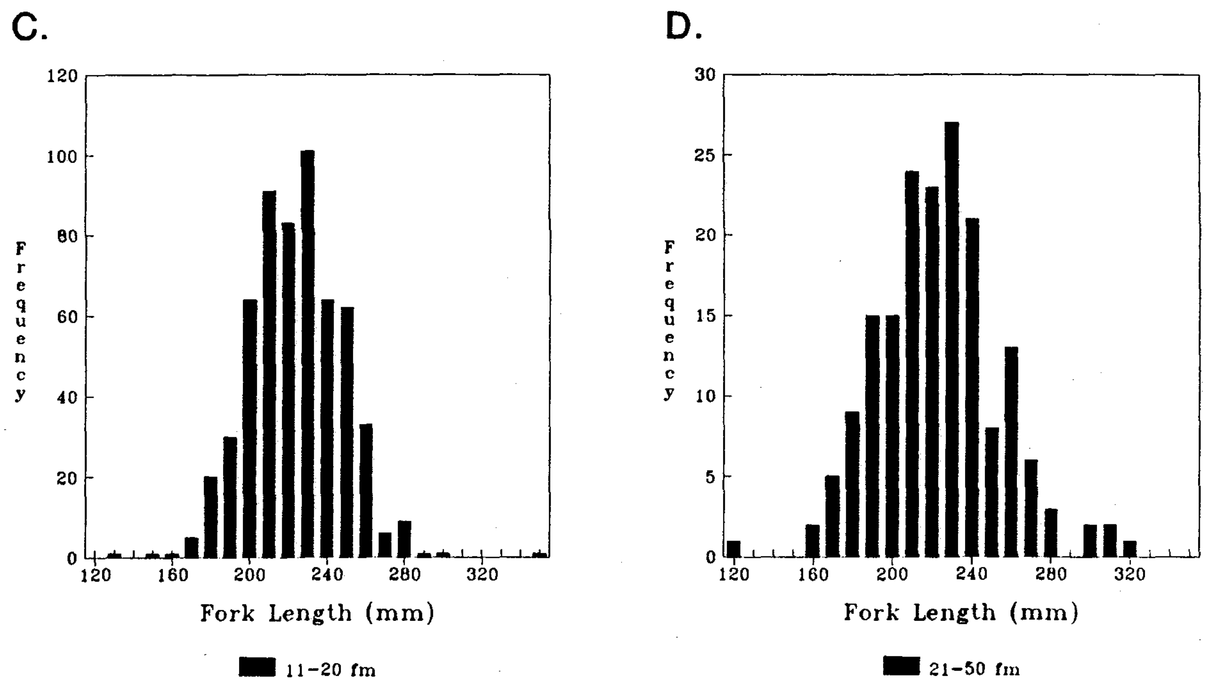


Figure 5. Size frequency distribution by depth ranges of sampled coneys with hooks; a) total sample; b) 0-10 fm; c) 11-20 fm; and d) 21-50 fm.



A.

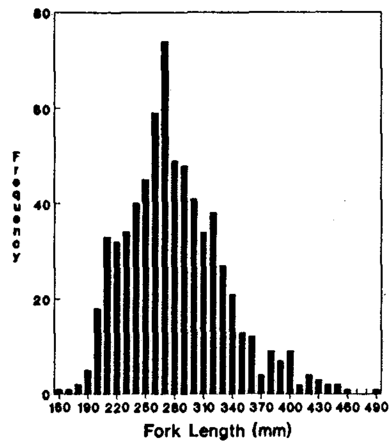
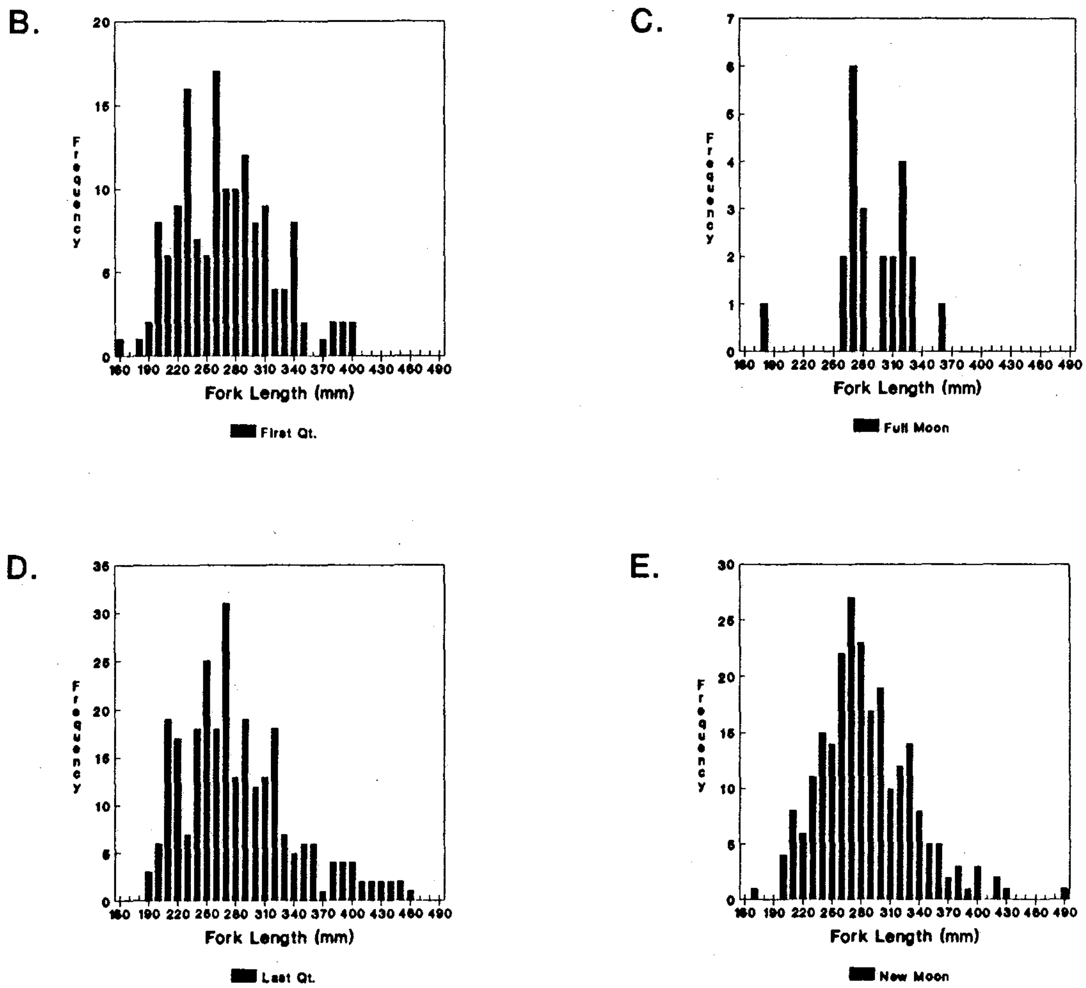


Figure 6. Size frequency distribution of sampled red hinds with hook and line by moon phase; a) total sample; b) first quartr; c) fullmoon; d) last quarter; and e) new moon.



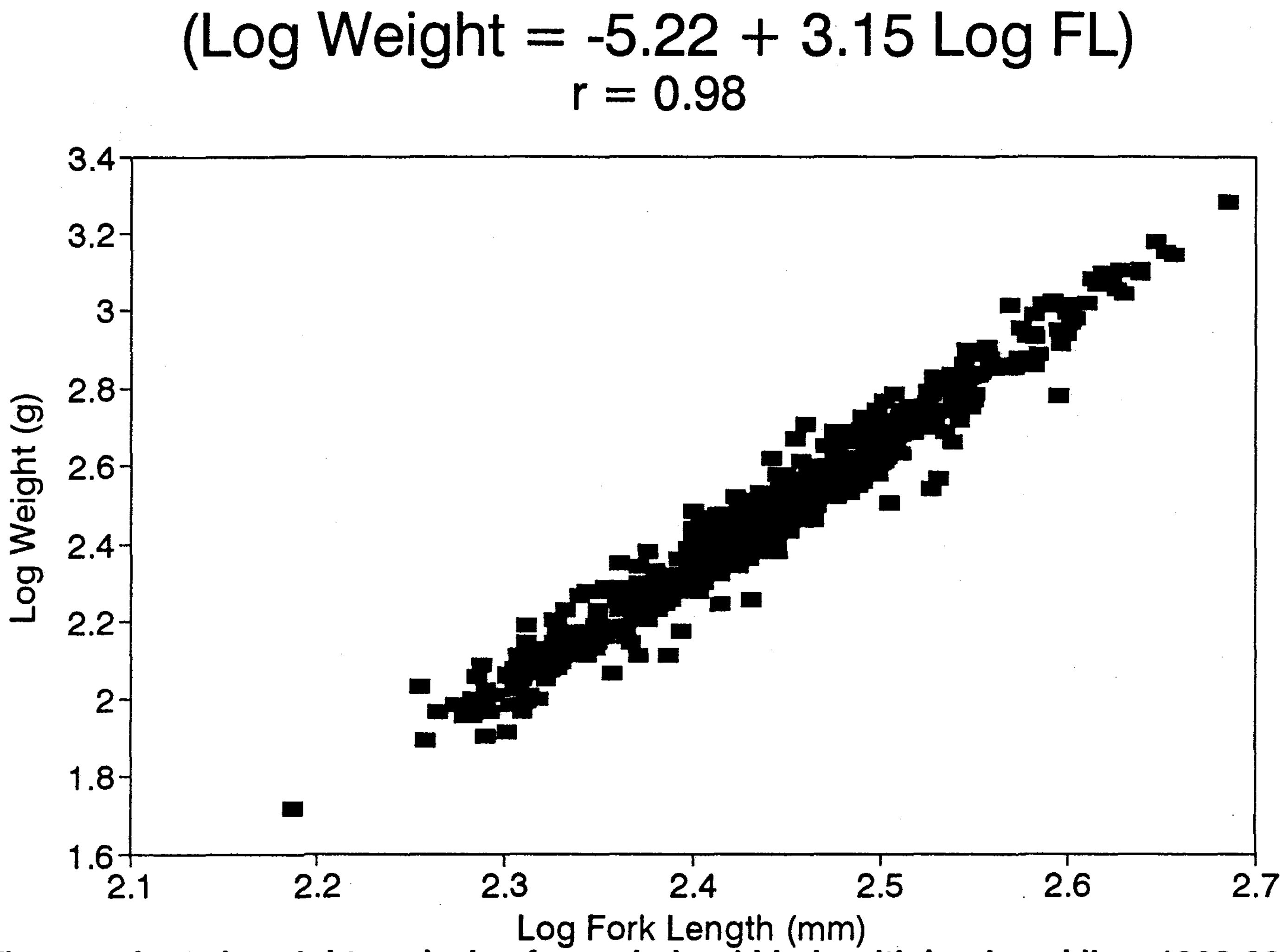


Figure 7. Length-weight analysis of sampled red hinds with hook and line, 1992-93.

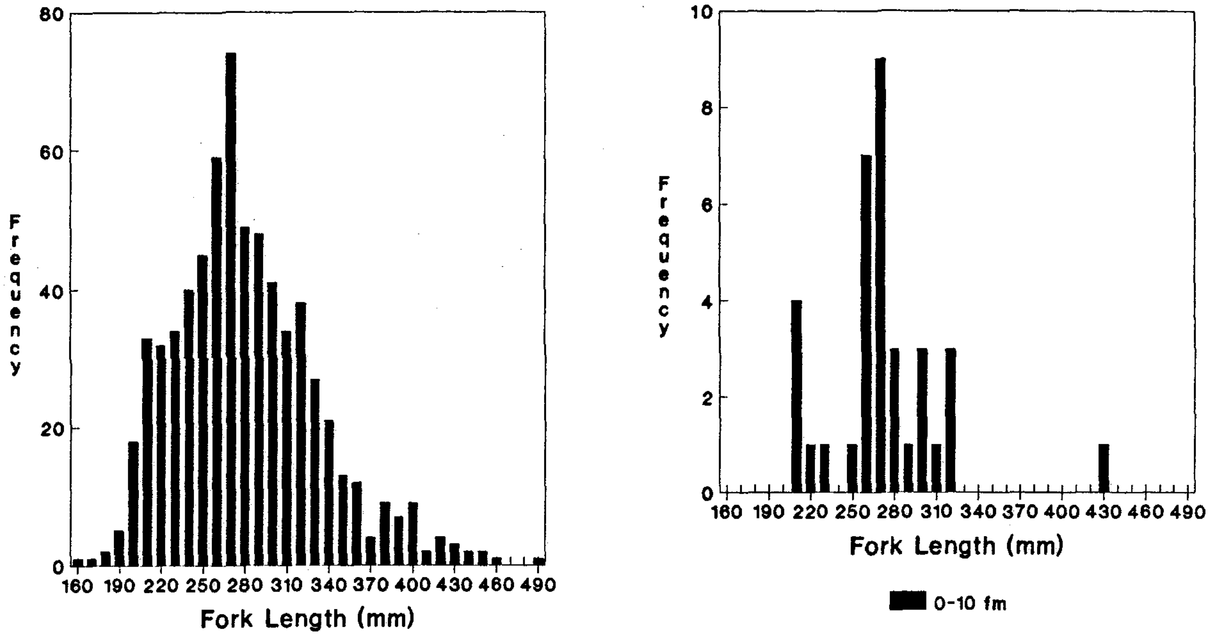


Figure 8. Size distribution by depth ranges of sampled red hinds with hooks; a) total sample; b) 0-10 fm; c) 11-20 fm; d) 21-50 fm.

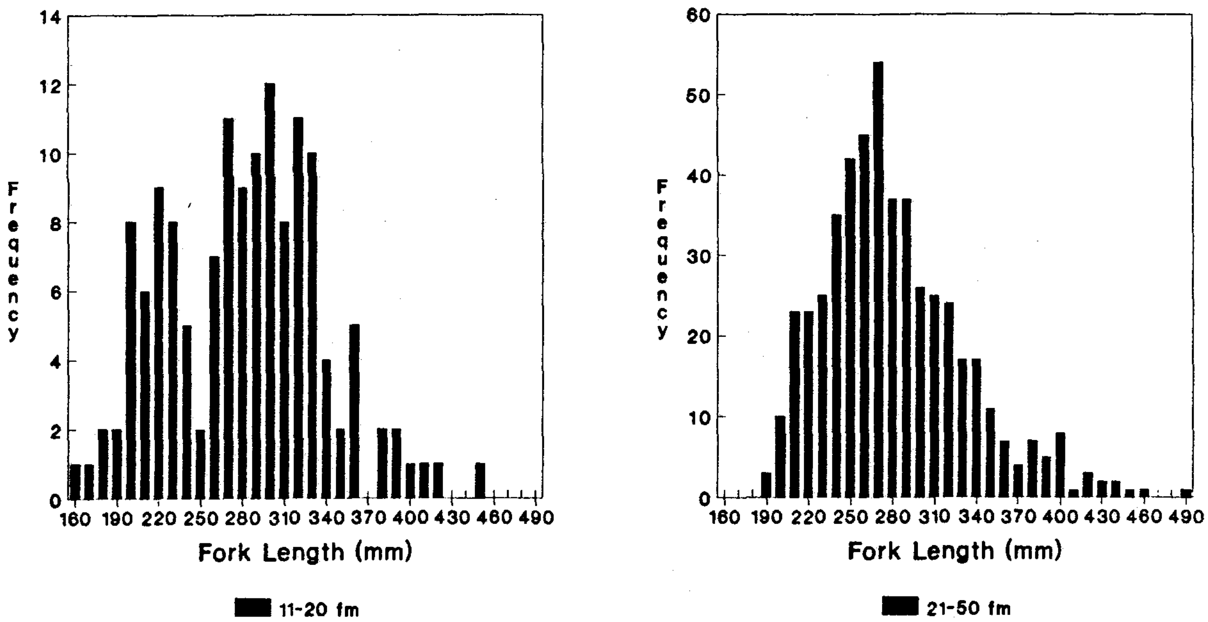
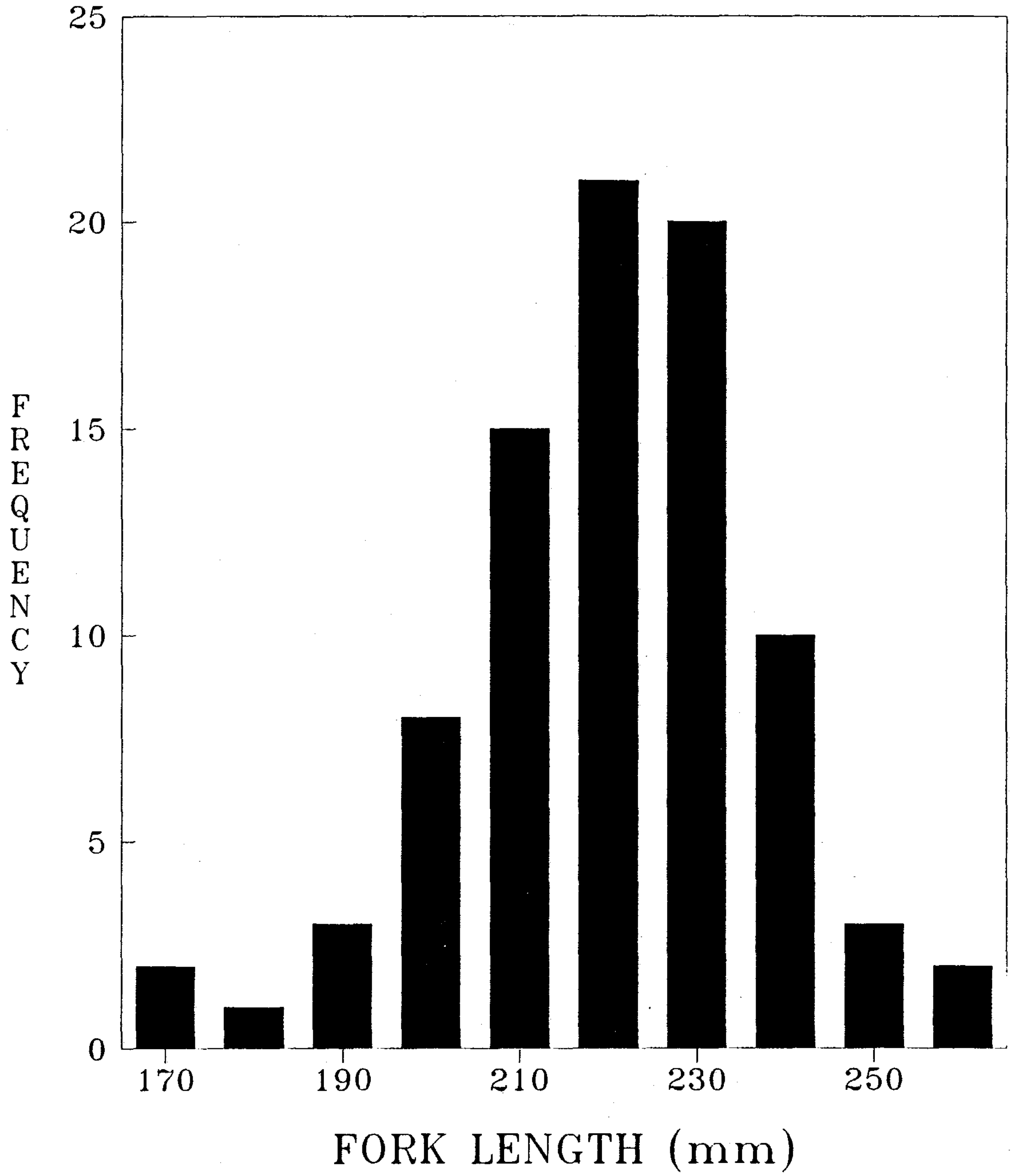


Figure 9. Size frequency distribution of sampled vermillion snapper with hook and line, April 1992 to March 1993.



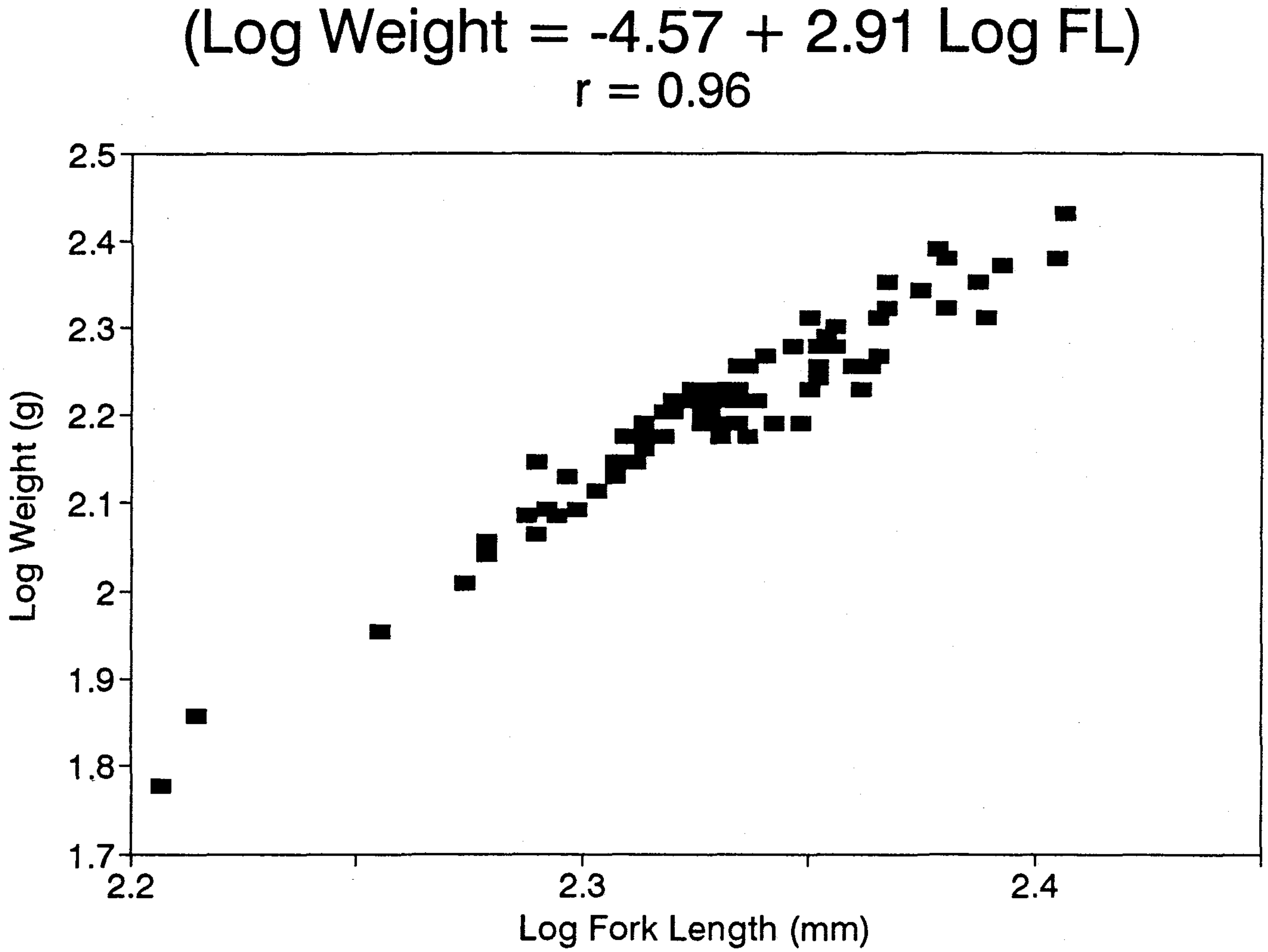
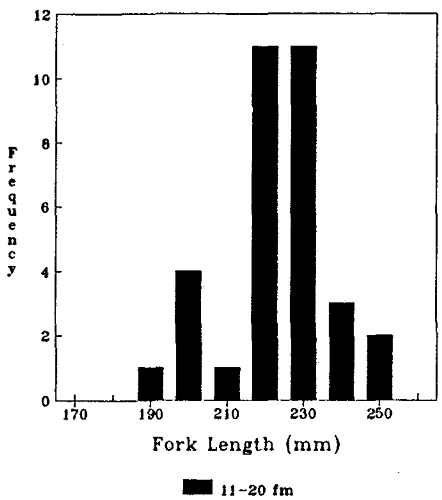


Figure 10. Length-weight analysis of sampled vermillion snappers with hook and line, 1992-93.

A.



B.

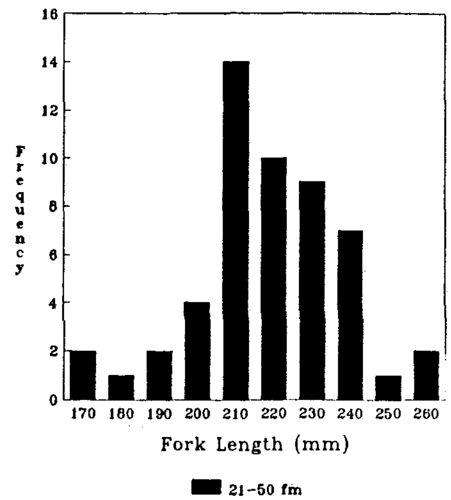


Figure 11. Size distribution by depth ranges of sampled vermillion snapper with hook and line. A) depth range 11-20 fm; b) 21-50 fm and c) total sample.

C.

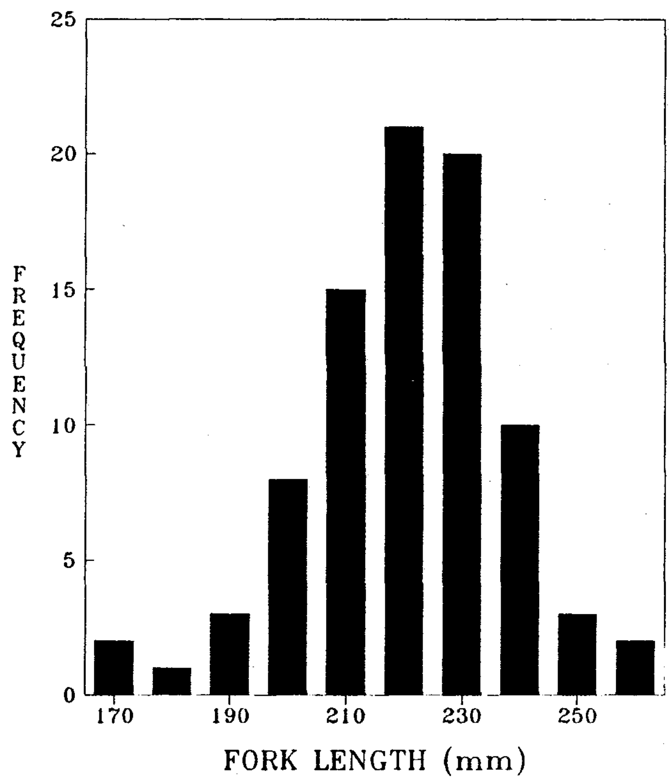
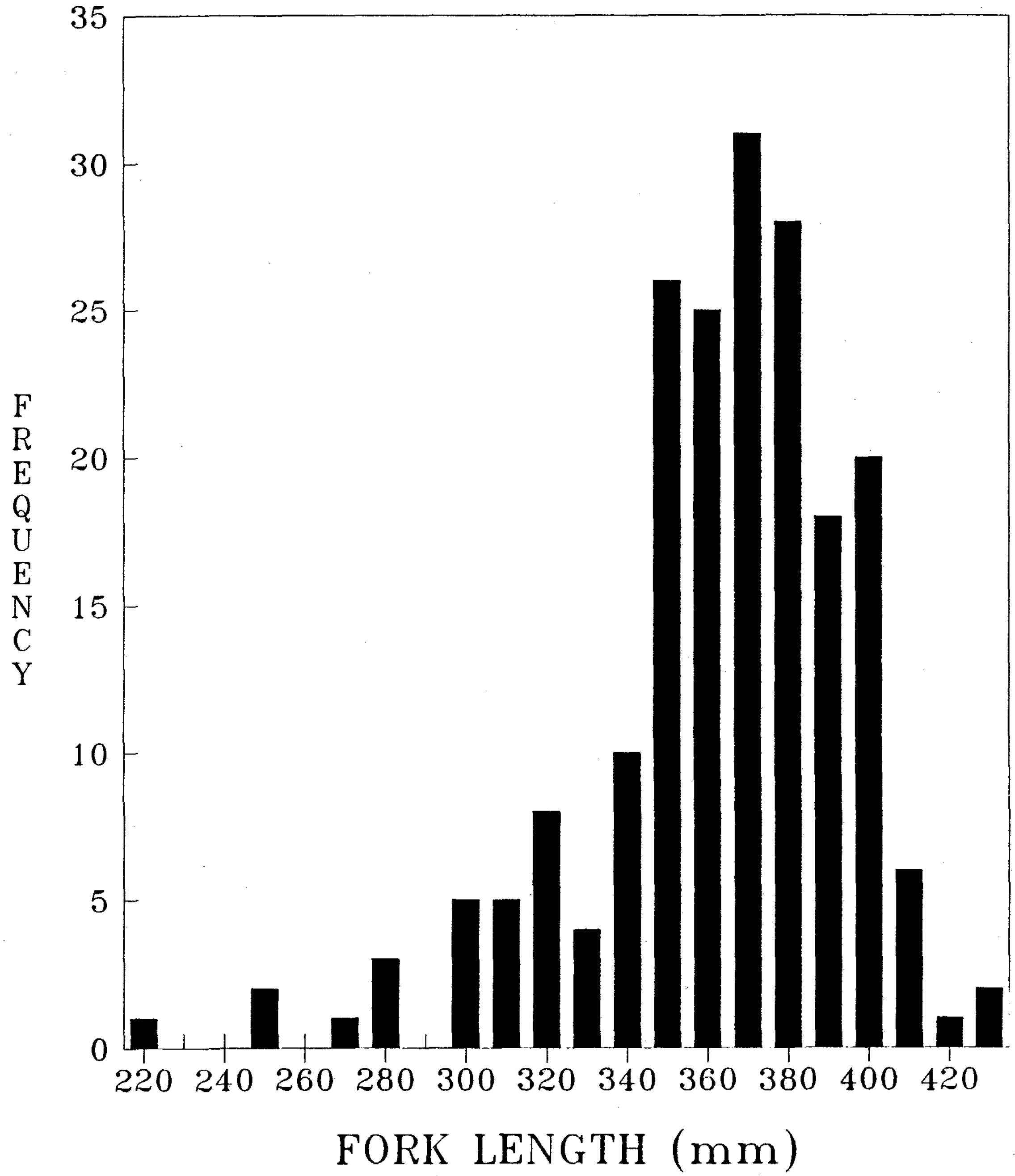


Figure 12. Size frequency distribution of sampled sand tilefish with hook and line, April 1992 to March 1993.



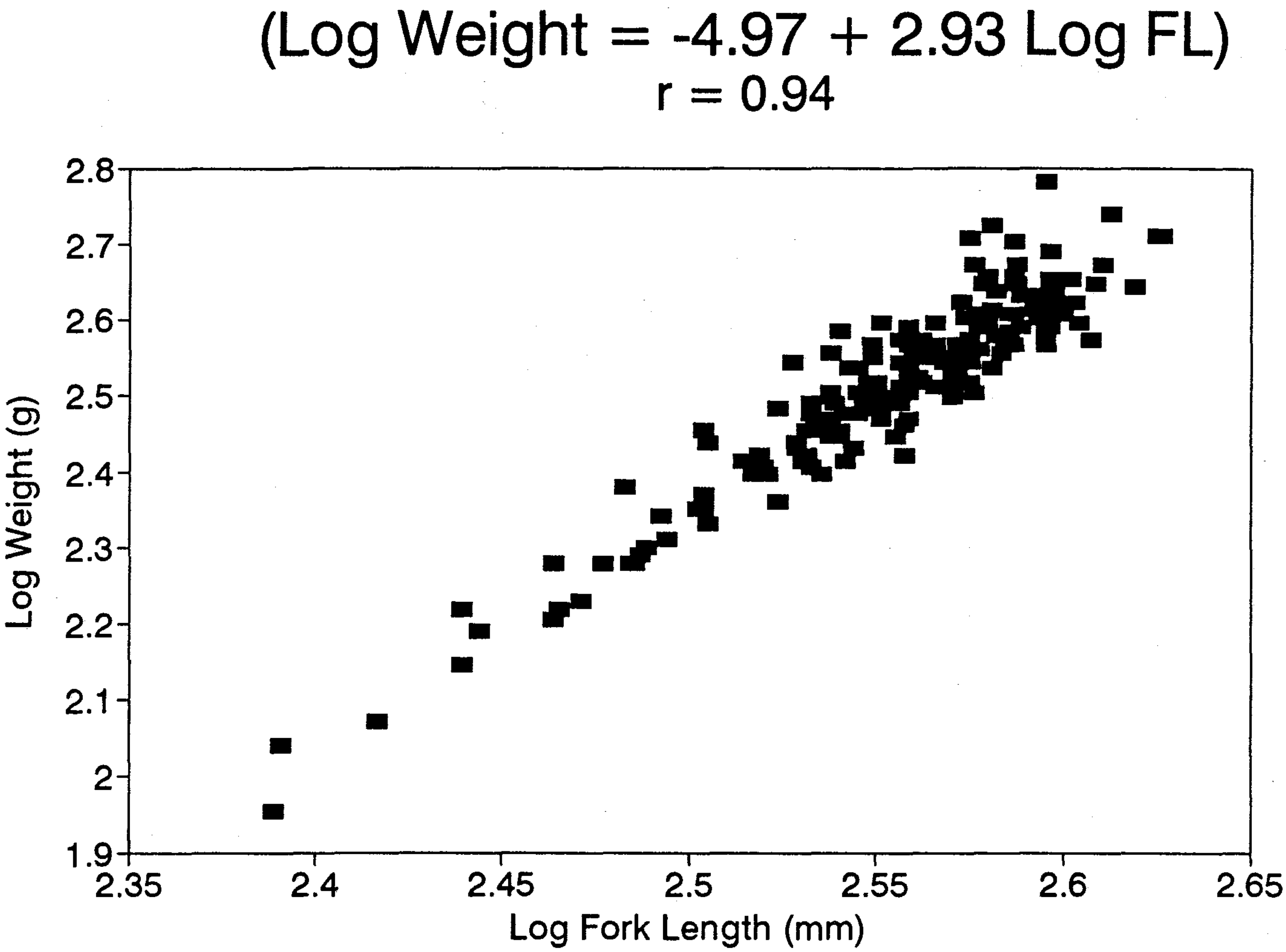


Figure 13. Length-weight analysis of sampled sand tilefish with hooks, 1992-93.

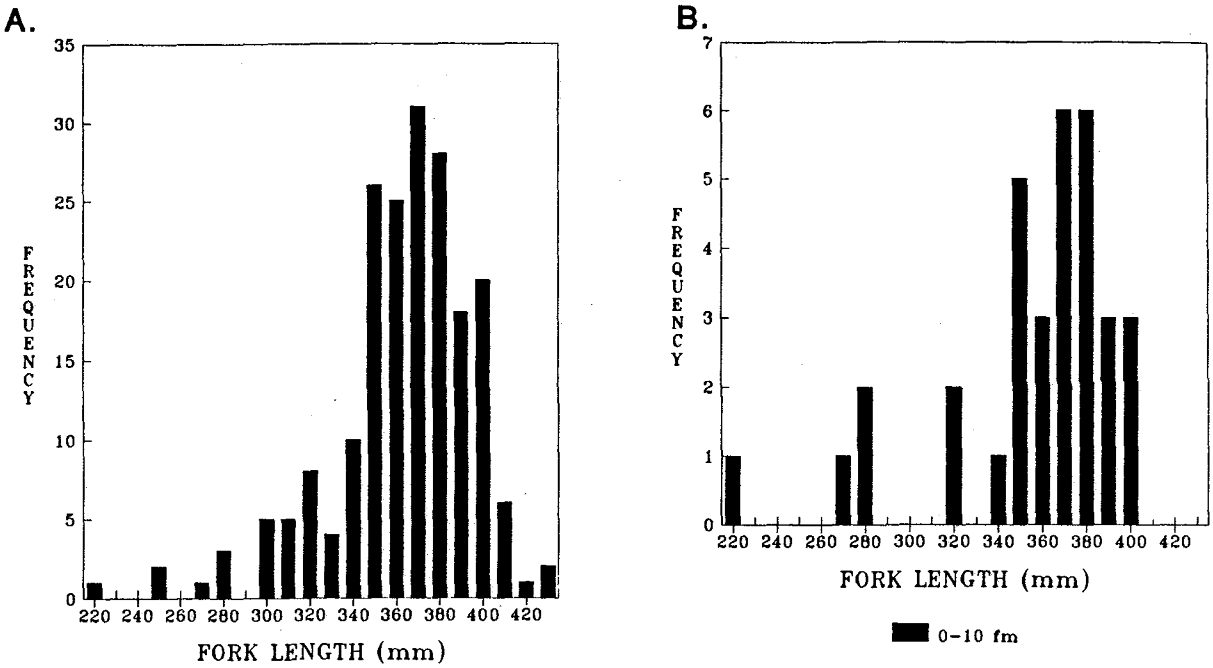
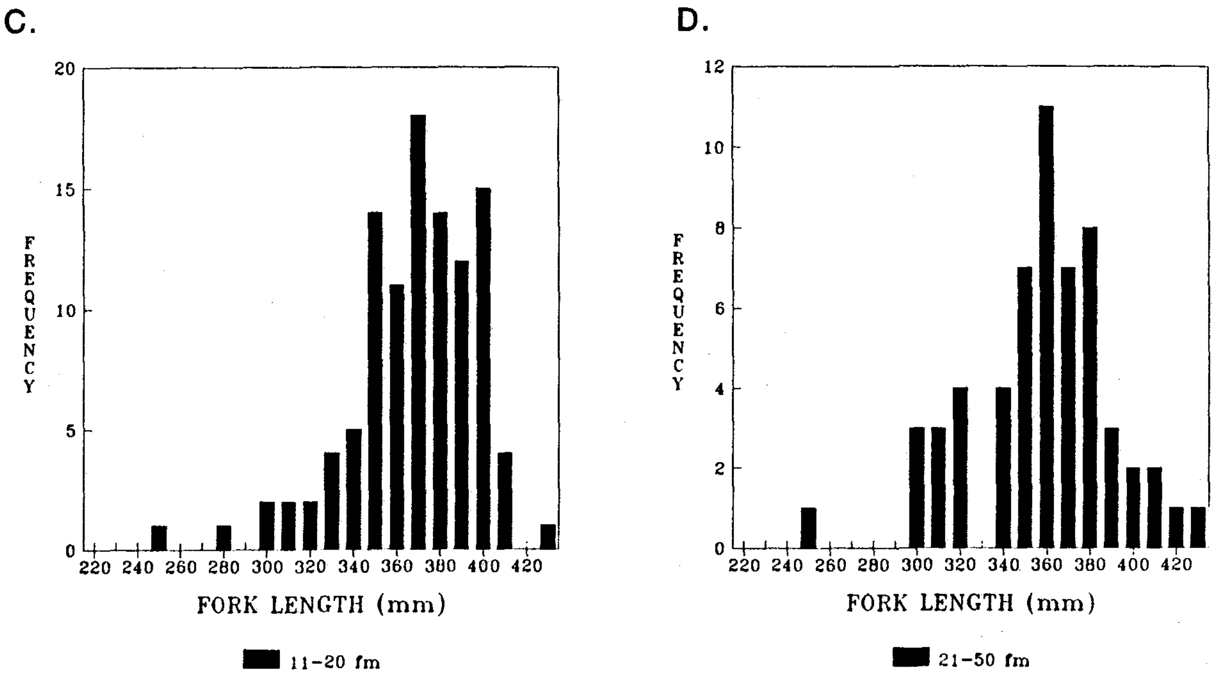
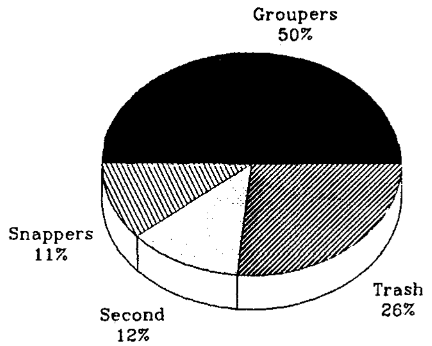


Figure 14. Size frequency distribution by depth ranges of sampled sand tilefish with hook and line; a) total sample; b) 0-10 fm; c) 11-20 fm; d) 21-50 fm.



Fish Group Percent of Total Number Fish
Caught With Fish Traps, 92–March 93.

A.



Fish Class Percent of Total Number Fish
Caught With Fish Traps, 1992–1993.

B.

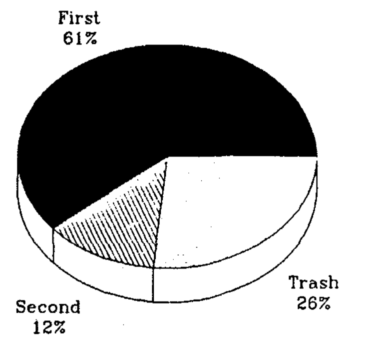
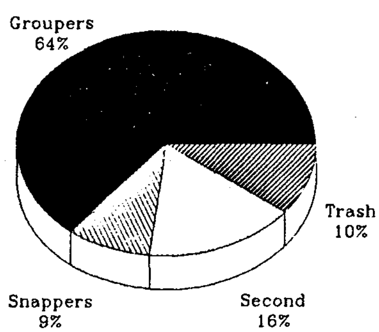


Figure 15. Percent contribution of fish groups and market classification; sampled with fish traps; a) fish groups in in terms of number; b) fish class in terms of number; c) fish group in terms of weight and d) fish class in terms of weight.

Fish Group Percent of Total Weight (g)
Caught With Fish Traps, 1992–1993.

C.



Fish Class Percent of Total Weight (g)
Caught With Fish Traps, 1992–1993.

D.

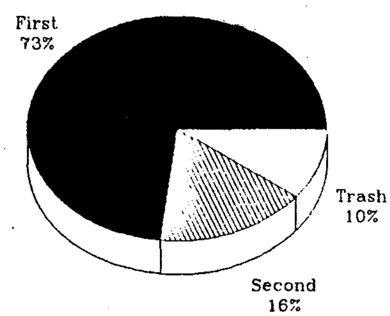
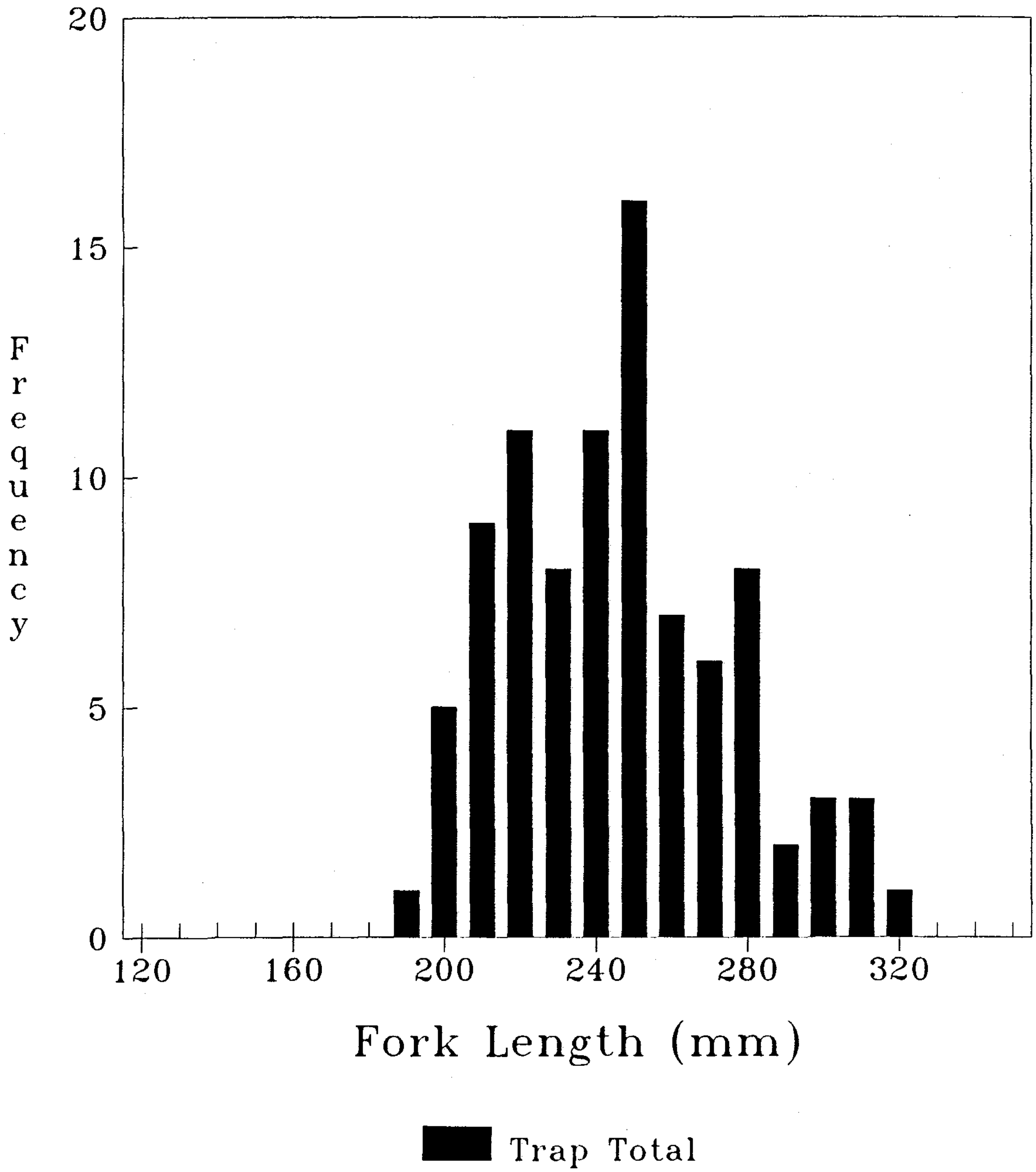


Figure 16. Size frequency distribution of sampled coneys with fish traps, April 1992 to March 1993.



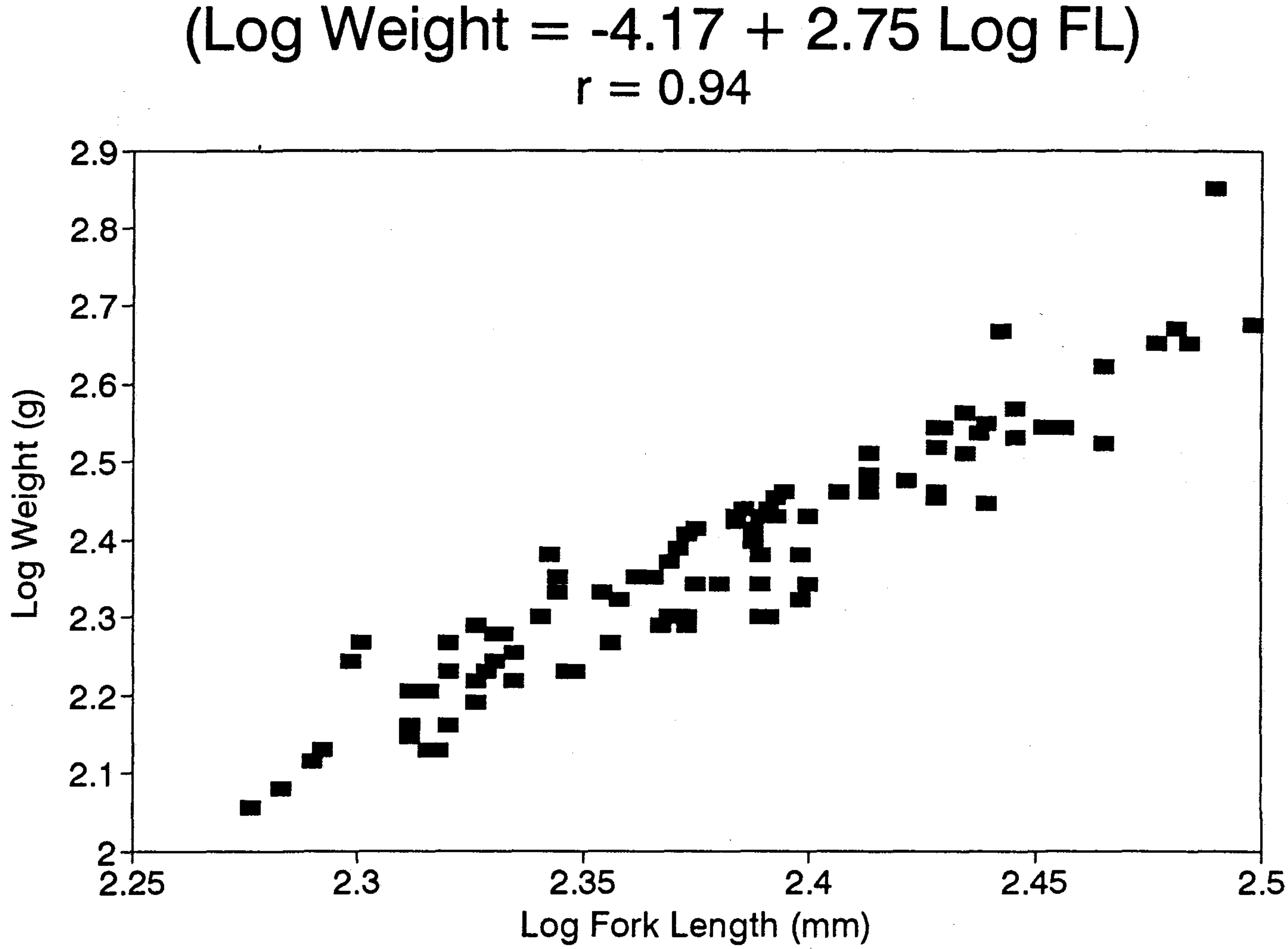
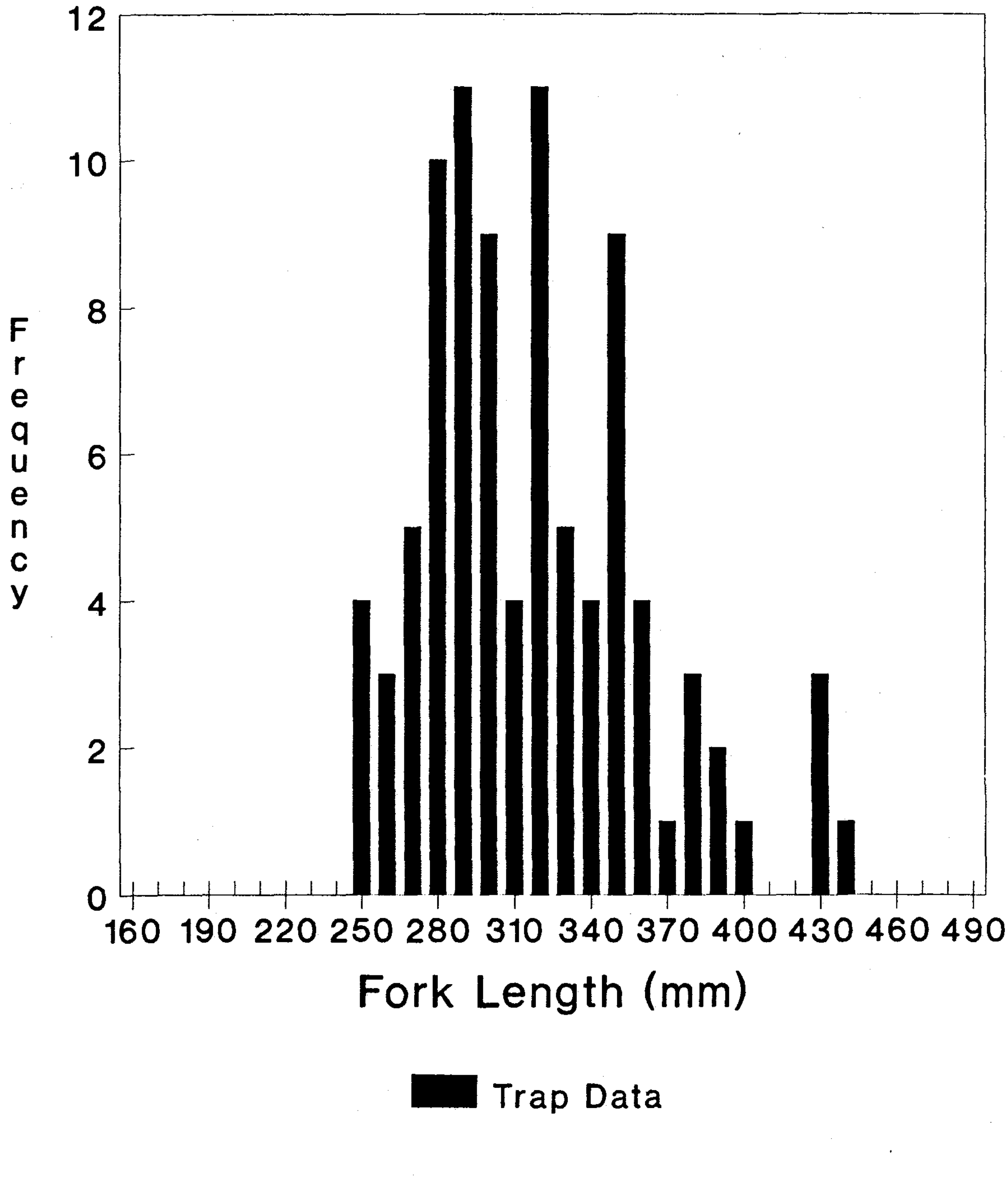


Figure 17. Length-weight analysis of sampled coneys with fish traps, 1992-93.

Figure 18. Size frequency distribution of sampled red hinds with fish traps, April 1992 to March 1993.



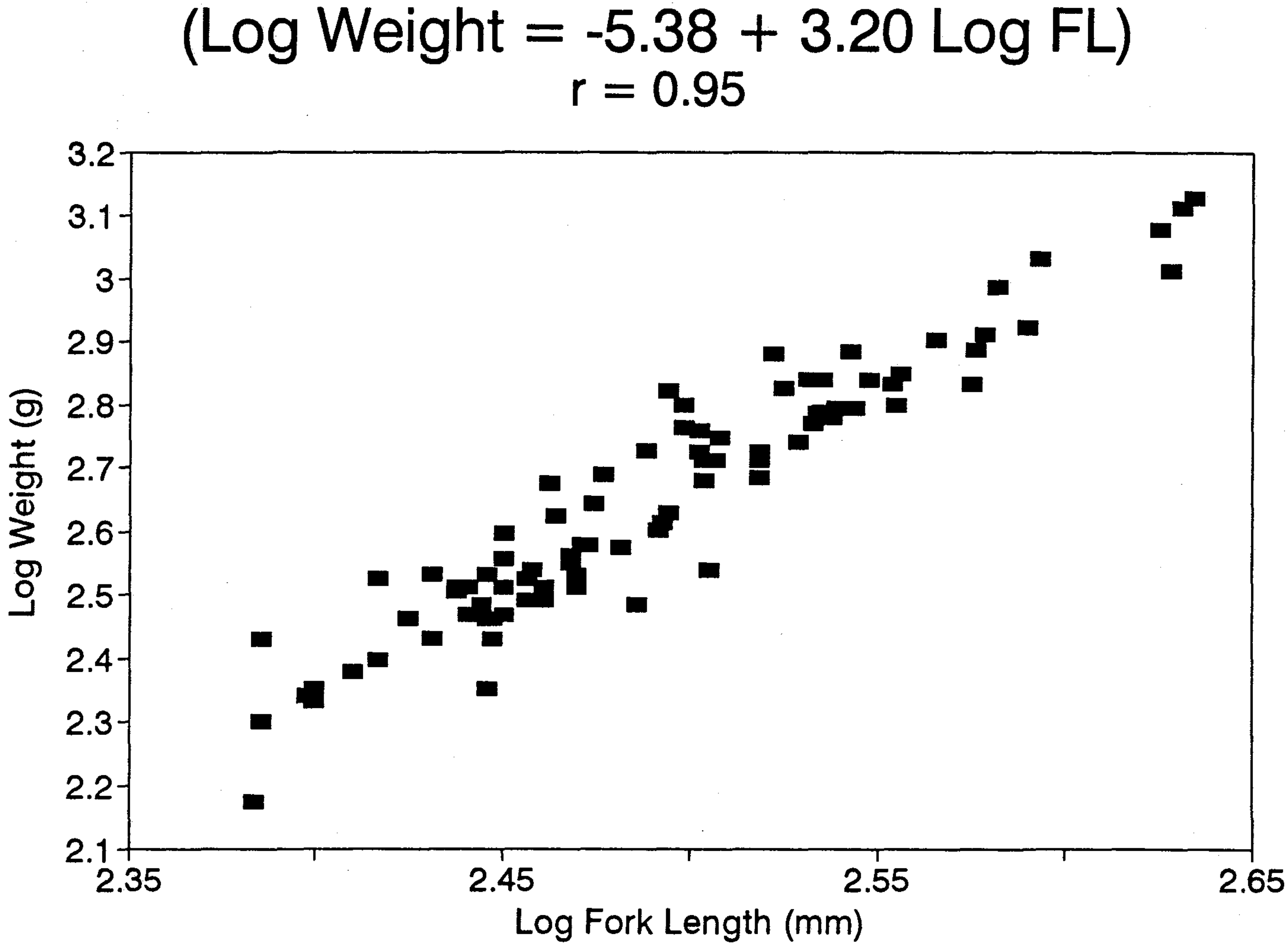


Figure 19. Length-weight analysis of sampled red hinds with fish traps ,1992-93.

A.

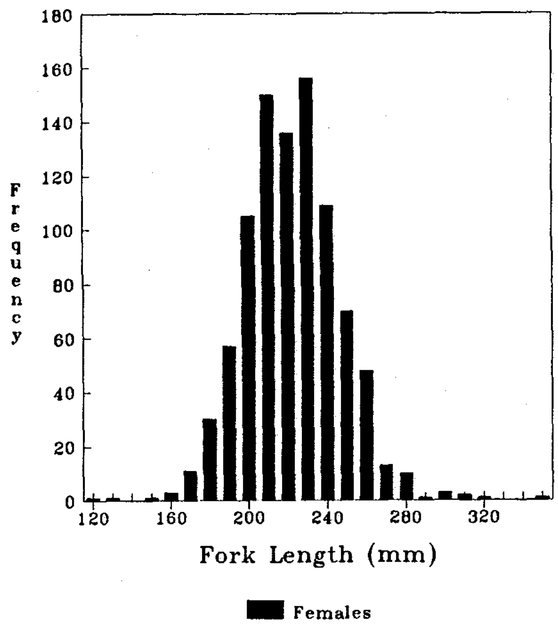
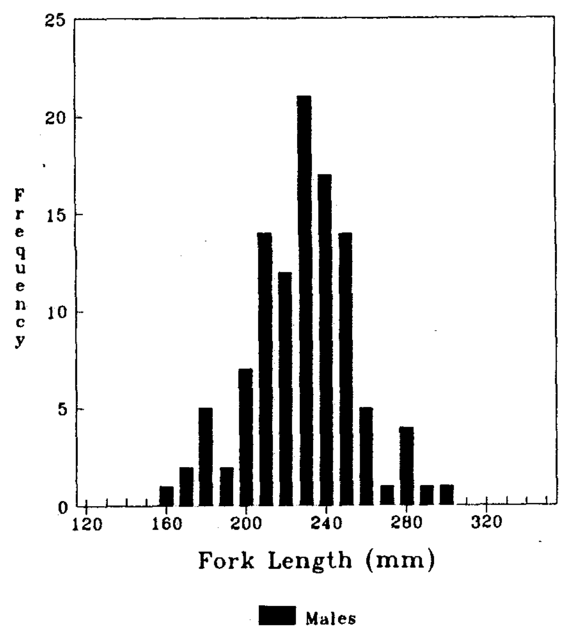


Figure 20. Size frequency distribution by sex of sampled coneys with hook and line; a) females; and b) males.

B.



A.

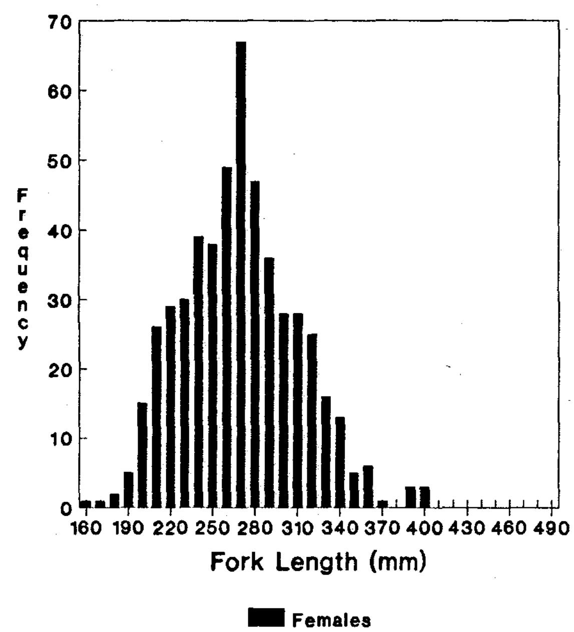
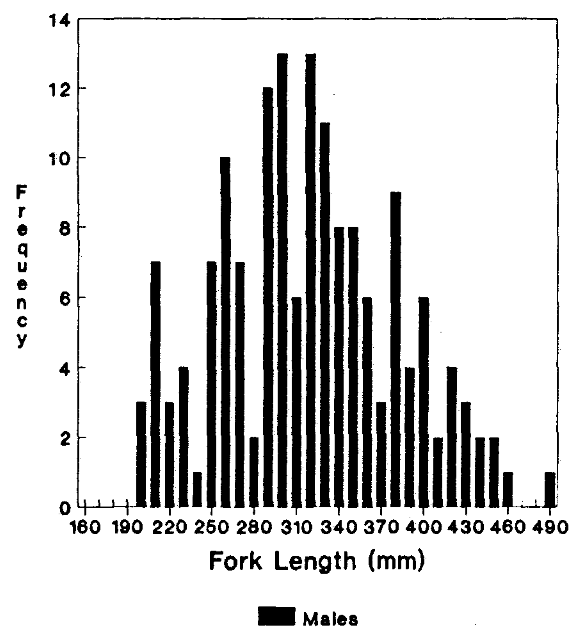


Figure 21. Size frequency distribution by sex of sampled red hinds with hook and line; a) females; and b) males.

B.



A.

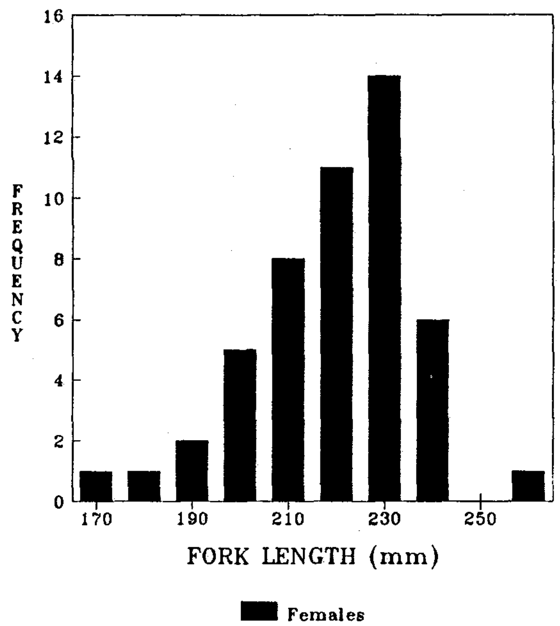
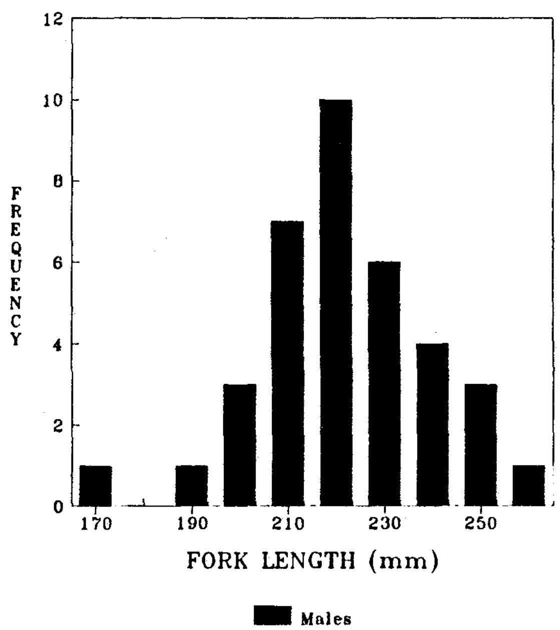


Figure 22. Size frequency distribution by sex of sampled vermillion snapper with hook and line; a) females; and b) males.

B.



A.

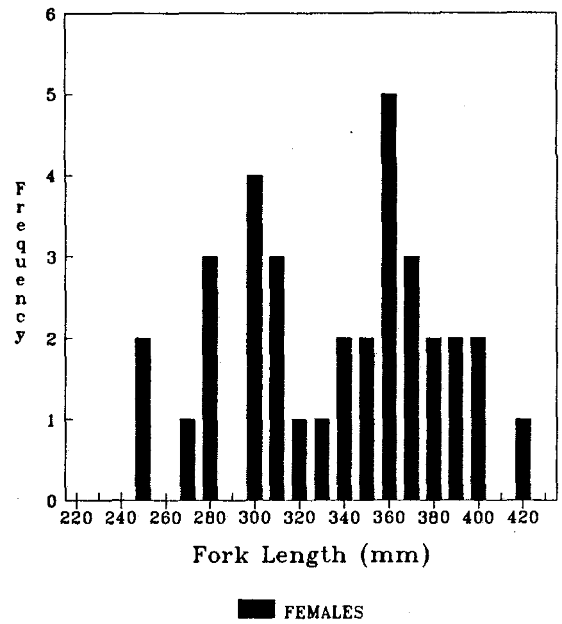
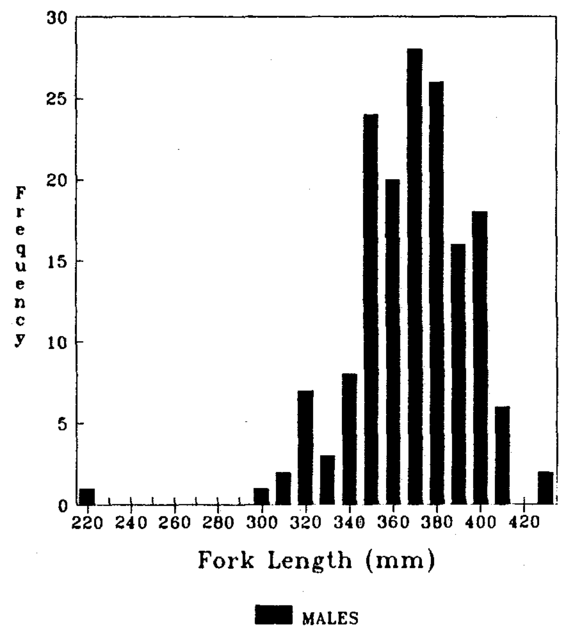


Figure 23. Size frequency distribution by sex of sampled sand tilefish with hook and line; a) females; and b) males.

B.



Appendix 1. Catch summary by date and station sampled with hook and line, April 1992 to March 1993.

Station	Date	# Trips	# Inds.	TotW (g)	# HOOK	HOURS	DEPTH (fm)	EFFORT hook hours	Mean CPUE/Trip g/hook hrs trip	MEAN CPUE g/hook hrs/day	EFFORT Lines/trip	Mean CPUE/Trip g/line trip
80	Apr-92	3	94	19,037	27	10.50	16.0	283.50	67.15	201.45	9	2,115.22
90	Apr-92	3	47	19,511	21	13.50	35.0	283.50	68.82	257.06	9	2,167.89
95	Apr-92	5	138	40,655	45	21.00	33.6	945.00	43.02	201.21	15	2,710.33
96	Apr-92	3	82	27,581	27	13.50	30.0	364.50	75.67	227.00	9	3,064.56
80	May-92	3	68	15,137	27	10.50	19.0	283.50	53.39	160.18	9	1,681.89
34	Jun-92	1	1	260	9	3.50	9.0	31.50	8.25	8.25	3	86.67
37	Jun-92	1	0	0	9	3.50	8.0	31.50	0.00	0.00	3	0.00
40	Jun-92	1	3	722	9	3.50	8.0	31.50	22.92	22.92	3	240.67
66	Jun-92	1	3	1,155	9	3.50	12.0	31.50	36.67	36.67	3	385.00
93	Jun-92	3	4	1,722	27	10.50	6.0	283.50	6.07	18.22	9	191.33
7	Jul-92	1	69	16,489	9	3.50	11.0	31.50	523.46	523.46	3	5,496.33
11	Jul-92	1	0	0	9	3.50	23.0	31.50	0.00	0.00	3	0.00
45	Jul-92	1	0	0	9	3.50	12.0	31.50	0.00	0.00	3	0.00
46	Jul-92	1	4	372	9	4.00	13.0	36.00	10.33	10.33	3	124.00
48	Jul-92	1	4	1,350	9	4.00	13.0	36.00	37.50	37.50	3	450.00
57	Jul-92	1	17	8,800	9	4.00	13.0	36.00	244.44	244.44	3	2,933.33
64	Jul-92	1	1	220	9	4.50	11.0	40.50	5.43	5.43	3	73.33
67	Jul-92	1	2	450	9	3.50	13.0	31.50	14.29	14.29	3	150.00
75	Jul-92	1	0	0	9	3.50	3.0	31.50	0.00	0.00	3	0.00
79	Jul-92	1	6	1,476	9	3.50	12.0	31.50	46.86	46.86	3	492.00
86	Jul-92	1	19	3,848	9	3.50	31.0	31.50	122.16	122.16	3	1,282.67
91	Jul-92	1	46	9,293	9	3.50	38.0	31.50	295.02	295.02	3	3,097.67
93	Jul-92	1	5	454	9	3.50	4.0	31.50	14.41	14.41	3	151.33
96	Jul-92	1	27	10,746	9	4.50	30.0	40.50	265.33	265.33	3	3,582.00
8	Aug-92	1	21	5,028	9	4.50	15.0	40.50	124.15	124.15	3	1,676.00
19	Aug-92	1	20	9,345	9	3.50	24.0	31.50	296.67	296.67	3	3,115.00
41	Aug-92	2	38	9,210	18	9.00	12.0	162.00	56.85	227.41	6	1,535.00
45	Aug-92	1	2	3,014	9	4.50	12.0	40.50	74.42	74.42	3	1,004.67
47	Aug-92	1	5	1,413	9	3.50	15.0	31.50	44.86	44.86	3	471.00
49	Aug-92	1	84	14,919	9	3.50	15.0	31.50	473.62	473.62	3	4,973.00
63	Aug-92	1	0	0	9	4.50	10.0	40.50	0.00	0.00	3	0.00
76	Aug-92	1	8	1,415	9	3.50	4.0	31.50	44.92	44.92	3	471.67
77	Aug-92	1	0	0	9	3.50	4.0	31.50	0.00	0.00	3	0.00
80	Aug-92	1	23	8,895	9	3.50	12.0	31.50	282.38	282.38	3	2,965.00
87	Aug-92	1	1	130	9	4.50	28.0	40.50	3.21	3.21	3	43.33
8	Sep-92	1	11	2,355	9	3.50	8.0	31.50	74.76	74.76	3	785.00
9	Sep-92	1	3	2,215	9	3.50	8.0	31.50	70.32	70.32	3	738.33
17	Sep-92	2	11	2,729	18	9.00	9.5	162.00	16.85	33.69	6	454.83
19	Sep-92	1	48	10,323	9	4.50	11.0	40.50	254.89	254.89	3	3,441.00
29	Sep-92	1	5	1,500	9	4.50	8.0	40.50	37.04	37.04	3	500.00
37	Sep-92	1	0	0	9	4.50	8.0	40.50	0.00	0.00	3	0.00
49	Sep-92	1	82	16,010	9	4.50	11.0	40.50	395.31	395.31	3	5,336.67
54	Sep-92	1	0	0	9	4.50	11.0	40.50	0.00	0.00	3	0.00
55	Sep-92	1	1	390	9	3.50	14.0	31.50	12.38	12.38	3	130.00
58	Sep-92	1	46	10,215	9	3.50	10.0	31.50	324.29	324.29	3	3,405.00
59	Sep-92	1	18	3,213	9	3.50	7.0	31.50	102.00	102.00	3	1,071.00
69	Sep-92	1	27	7,394	9	4.50	25.0	40.50	182.57	182.57	3	2,464.67
76	Sep-92	1	13	6,937	9	3.50	5.0	31.50	220.22	220.22	3	2,312.33
77	Sep-92	1	8	1,743	9	3.50	5.0	31.50	55.33	55.33	3	581.00
78	Sep-92	1	6	792	9	3.50	5.0	31.50	25.14	25.14	3	264.00
87	Sep-92	3	71	20,851	27	13.50	20.7	364.50	57.20	171.61	9	2,316.78

Appendix 1. Catch summary by date and station sampled with hook and line, April 1992 to March 1993.

Station	Date	# Trips	# Inds.	TotW (g)	# HOOK	HOURS	DEPTH (fm)	EFFORT hook hours	Mean CPUE/Trip g/hook hrs trip	MEAN CPUE g/hook hrs/day	EFFORT Lines/trip	Mean CPUE/Trip g/line trip
89	Sep-92	1	2	1,950	9	4.50	39.0	40.50	48.15	48.15	3	650.00
90	Sep-92	1	0	0	9	3.50	39.0	31.50	0.00	0.00	3	0.00
95	Sep-92	2	101	36,858	18	8.00	40.0	144.00	255.96	475.05	6	6,143.00
96	Sep-92	2	55	31,252	18	8.00	29.0	144.00	217.03	475.07	6	5,208.67
29	Oct-92	1	65	19,506	9	4.50	11.0	40.50	481.63	481.63	3	6,502.00
31	Oct-92	1	3	3,016	9	4.50	7.0	40.50	74.47	74.47	3	1,005.33
37	Oct-92	1	0	0	9	3.50	8.0	31.50	0.00	0.00	3	0.00
39	Oct-92	1	2	340	9	4.50	11.0	40.50	8.40	8.40	3	113.33
41	Oct-92	1	21	5,412	9	4.50	3.0	40.50	133.63	133.63	3	1,804.00
42	Oct-92	1	45	9,010	9	4.50	10.0	40.50	222.47	222.47	3	3,003.33
93	Oct-92	1	1	90	9	4.50	14.0	40.50	2.22	2.22	3	30.00
96	Oct-92	1	55	21,067	9	4.50	35.0	40.50	520.17	520.17	3	7,022.33
37	Nov-92	2	7	5,543	18	9.00	8.5	162.00	34.22	68.43	6	923.83
38	Nov-92	1	1	305	9	4.50	10.0	40.50	7.53	7.53	3	101.67
42	Nov-92	1	67	14,487	9	4.50	10	40.50	357.70	357.70	3	4,829.00
42	Mar-93	1	52	43,473	9	3.50	30	31.50	1,380.10	1,380.10	3	14,491.00
49	Mar-93	1	147	35,040	9	4.50	11.0	40.50	865.19	865.19	3	11,680.00
68	Mar-93	1	23	4,371	9	3.50	13.0	31.50	138.76	133.05	3	1,457.00
77	Mar-93	1	23	6,373	9	4.50	14.0	40.50	157.36	157.36	3	2,124.33
79	Mar-93	2	76	16,148	18	9.00	10.5	162.00	99.68	199.36	6	2,691.33
80	Mar-93	3	116	26,315	27	13.50	11.3	364.50	72.19	216.58	9	2,923.89
86	Mar-93	1	3	517	9	3.50	25.0	31.50	16.41	16.41	3	172.33
87	Mar-93	1	7	1,390	9	4.50	41.0	40.50	34.32	34.32	3	463.33
90	Mar-93	1	22	18,063	9	4.50	38.0	40.50	446.00	446.00	3	6,021.00
95	Mar-93	4	126	35,117	36	17.00	35.0	612.00	57.38	241.37	12	2,926.42
96	Mar-93	4	93	32,204	36	17.00	28.8	612.00	52.62	210.95	12	2,683.67

Appendix 2. Sampling allocation (days, sample sizes) for traps and hook and line by location and month from April 1992 to March 1993.

Location #	Depth fm	Substrate	Month	Traps Sampling days	Traps Sampling n	Hook and Lin Sampling days	Hook and Lin Sampling n
95	Deep	soft & hard coral	Apr-92	5	60	5	15
96	Deep	sponges	Apr-92	3	36	3	9
80	intermediate	Coral/sponges	Apr-92	3	36	3	9
90	Deep	Coral/	Apr-92	3	36	3	9
80	intermediate	Coral/sponges	May-92	3	36	3	9
93	Shallow	mud	Jun-92	3	36	3	9
34	Shallow	some coral	Jun-92	1	12	1	3
37	Shallow		Jun-92	1	12	1	3
40	Shallow	rocky	Jun-92	1	12	1	3
66	intermediate	Coral	Jun-92	1	12	1	3
7	intermediate	rocky	Jul-92	1	12	1	3
67	intermediate		Jul-92	1	12	1	3
57	intermediate		Jul-92	1	12	1	3
48	intermediate		Jul-92	1	12	1	3
46	intermediate		Jul-92	1	12	1	3
93	Shallow	Mud	Jul-92	1	12	1	3
11	Deep		Jul-92	1	12	1	3
75	Shallow		Jul-92	1	12	1	3
79	intermediate		Jul-92	1	12	1	3
96	Deep	Sponges	Jul-92	1	12	1	3
64	intermediate		Jul-92	1	12	1	3
91	Deep		Jul-92	1	12	1	3
45	intermediate		Jul-92	1	12	1	3
86	Deep		Jul-92	1	12	1	3
63	Shallow		Aug-92	1	12	1	3
45	intermediate		Aug-92	1	12	1	3
49	intermediate		Aug-92	1	12	1	3
47	intermediate		Aug-92	1	12	1	3
80	intermediate	Sand	Aug-92	1	12	1	3
41	intermediate		Aug-92	2	24	2	6
8	intermediate	rocky	Aug-92	1	12	1	3
87	Deep		Aug-92	1	12	1	3
77	Shallow		Aug-92	1	12	1	3
76	Shallow		Aug-92	1	12	1	3
19	Deep	rocky	Aug-92	1	12	1	3
29	Shallow		Sep-92	1	12	1	3
37	Shallow		Sep-92	1	12	1	3
49	intermediate		Sep-92	1	12	1	3
58	Shallow		Sep-92			1	3
54	intermediate		Sep-92	1	12	1	3
55	intermediate		Sep-92			1	3
77	Shallow		Sep-92			1	3
87	Deep		Sep-92	1	12		
78	Shallow		Sep-92	1	12	1	3
89	Deep		Sep-92			1	3
90	Deep	Sand	Sep-92			1	3
17	Shallow		Sep-92	2	24	2	6
8	Shallow		Sep-92	1	12	1	3
87	Shallow		Sep-92			3	9

Appendix 2. Sampling allocation (days, sample sizes) for traps and hook and line by location and month from April 1992 to March 1993.

Location #	Depth fm	Substrate	Month	Traps Sampling days	Traps n	Hook and Lin Sampling days	Hook and Lin n
69	Deep		Sep-92			1	3
76	Shallow		Sep-92	1	12	1	3
59	Shallow		Sep-92	1	12	1	3
95	Deep	Sponges	Sep-92	1	12	2	6
96	Deep		Sep-92	1	12	2	6
9	Shallow	coral	Sep-92	1	12	1	3
19	intermediate		Sep-92			1	3
37	Shallow	rocky/	Oct-92			1	3
39	intermediate		Oct-92	1	12	1	3
31	Shallow		Oct-92			1	3
42	Shallow		Oct-92			1	3
29	intermediate		Oct-92			1	3
93	intermediate		Oct-92			1	3
96	Deep		Oct-92			1	3
41	Shallow		Oct-92			1	3
42	Shallow		Nov-92	1	12	1	3
38	Shallow		Nov-92	1	12	1	3
37	Shallow	no coral	Nov-92			2	6
80	intermediate		Mar-93	3	45	3	9
79	intermediate	rocky	Mar-93	2	30	2	6
42	Deep	sponges, soft cor	Mar-93	1	15	1	3
49	intermediate	rocky	Mar-93	1	15	1	3
68	intermediate		Mar-93	1	15	1	3
77	intermediate		Mar-93	1	15	1	3
86	Deep	sponges	Mar-93	1	15	1	3
87	Deep	sandy	Mar-93	1	15	1	3
90	Deep	sand, algae,	Mar-93	1	15	1	3
95	Deep	Sponges	Mar-93	4	60	4	12
96	Deep	Sponges	Mar-93	4	60	4	12

Appendix 3a. Selected sampled species with hook and line by number and stations, April 1992 to March 1993.

Code Station	82 Epinephelus cruentatus	80 Epinephelus fulvus	88 Epinephelus guttatus	139 Lutjanus vivanus	142 Rhomboplites aurorubens	103 Malacanthus plumieri
7	3	43	10			7
8	1	24	3			1
9			1			
17					1	8
19	11	44	4			5
29	9	31	14			13
34	0		1			
37						
39			2			
40		1	2			
41		35	2			14
42		91	19	9		13
45			1			
46			1			
47		3				
48		1	1			2
49	1	274	9			16
57		8	5			3
58		37	2			3
59		14	3			
64		1				
66			1			
67						2
68		17	2			2
69		16	15			4
76	3	3	3			
77	10	20				
78		4	2			
79		46	20		1	6
80		136	59		32	41
86	3	15	1		1	
87		17	14	7	32	
90		5	13	28	1	7
91		14	7		17	7
93	2	7				
95		52	269			15
96	2	57	185			27
Total	45	1,016	671	44	85	196

Appendix 3b. Selected sampled species with hook and line by weight (g) and stations, April 1992 to March 1993.

Code Station	82 Epinephelus cruentatus	80 Epinephelus fulvus	88 Epinephelus guttatus	139 Lutjanus vivanus	142 Rhomboplites aurorubens	103 Malacanthus plumieri
7	391	7,438	4,680			2,110
8	180	4,640	995			310
9			235			
17					210	2,163
19	1,908	7,833	2,655			1,700
29	1,398	6,135	8,735			4,345
34	0		260			
37						
39			340			
40		102	620			
41		7,530	855			4,710
42		15,395	7,818	5,725		4,440
45			520			
46			160			
47		878				
48		280	685			385
49	190	49,920	2,975			6,890
57		1,665	1,089			830
58		7,050	545			875
59		1,997	1,090			
64		220				
66			430			
67						450
68		2,831	545			540
69		3,180	4,916			1,375
76	630	430	630			
77	2,045	4,081				
78		542	250			
79		7,285	3,899		225	1,970
80		20,530	16,040		5,379	14,630
86	334	2,899	150		72	
87		2,978	4,434	842	5,575	
90		2,625	8,960	8,565	116	3,040
91		2,229	1,770		2,704	2,260
93	148	768				
95		8,572	86,875			5,040
96	198	9,025	62,977			7,875
Total	7,422	179,058	226,133	15,132	14,281	65,938

Appendix 4. Catch summary of sampled red hinds by date and station with hook and line, April 1992 to March 1993.

Station	Date	# Trips	# Inds.	TotW (g)	# HOOK	HOURS	DEPTH (fm)	EFFORT hook hours	Mean CPUE/Trip g/hook hrs trip	MEAN CPUE g/hook hrs/day	EFFORT Lines/trip	Mean CPUE/Tr g/line trip
80	Apr-92	3	6	2,545	27	10.50	16.0	283.50	8.98	26.93	9	282.78
90	Apr-92	3	9	6,625	27	13.50	35.0	364.50	18.18	54.53	9	736.11
95	Apr-92	5	95	30,090	45	21.50	33.6	967.50	31.10	143.57	15	2,006.00
96	Apr-92	3	51	14,062	27	13.50	30.0	364.50	38.58	115.74	9	1,562.44
80	May-92	3	5	1,670	27	10.50	19.0	283.50	5.89	17.67	9	185.56
34	Jun-92	1	1	260	9	3.50	9.0	31.50	8.25	8.25	3	86.67
37	Jun-92	1	0	0	9	3.50	8.0	31.50	0.00	0.00	3	0.00
40	Jun-92	1	2	620	9	3.50	8.0	31.50	19.68	19.68	3	206.67
66	Jun-92	1	1	430	9	3.50	12.0	31.50	13.65	13.65	3	143.33
93	Jun-92	3	0	0	27	10.50	6.0	283.50	0.00	0.00	9	0.00
7	Jul-92	1	10	4,680	9	3.50	11.0	31.50	148.57	148.57	3	1,560.00
11	Jul-92	1	0	0	9	3.50	23.0	31.50	0.00	0.00	3	0.00
45	Jul-92	1	0	0	9	3.50	12.0	31.50	0.00	0.00	3	0.00
46	Jul-92	1	1	160	9	4.00	13.0	36.00	4.44	4.44	3	53.33
48	Jul-92	1	1	685	9	4.00	13.0	36.00	19.03	19.03	3	228.33
57	Jul-92	1	5	1,089	9	4.00	13.0	36.00	30.25	30.25	3	363.00
64	Jul-92	1	0	0	9	4.50	11.0	40.50	0.00	0.00	3	0.00
67	Jul-92	1	0	0	9	3.50	13.0	31.50	0.00	0.00	3	0.00
75	Jul-92	1	0	0	9	3.50	3.0	31.50	0.00	0.00	3	0.00
79	Jul-92	1	0	0	9	3.50	3.0	31.50	0.00	0.00	3	0.00
86	Jul-92	1	0	0	9	3.50	31.0	31.50	0.00	0.00	3	0.00
91	Jul-92	1	7	1,770	9	3.50	38.0	31.50	56.19	56.19	3	590.00
93	Jul-92	1	0	0	9	3.50	4.0	31.50	0.00	0.00	3	0.00
96	Jul-92	1	14	4,974	9	4.50	30.0	40.50	122.81	122.81	3	1,658.00
8	Aug-92	1	1	450	9	4.50	15.0	40.50	11.11	11.11	3	150.00
19	Aug-92	1	2	2,025	9	3.50	24.0	31.50	64.29	64.29	3	675.00
41	Aug-92	2	2	855	18	9.00	12.0	162.00	5.28	10.56	6	142.50
45	Aug-92	1	1	520	9	4.50	12.0	40.50	12.84	12.84	3	173.33
47	Aug-92	1	0	0	9	3.50	15.0	31.50	0.00	0.00	3	0.00
49	Aug-92	1	0	0	9	3.50	15.0	31.50	0.00	0.00	3	0.00
63	Aug-92	1	0	0	9	4.50	10.0	40.50	0.00	0.00	3	0.00
80	Aug-92	1	6	2,175	9	3.50	12.0	31.50	69.05	69.05	3	725.00
76	Aug-92	1	1	145	9	3.50	4.0	31.50	4.60	4.60	3	48.33
77	Aug-92	1	0	0	9	3.50	4.0	31.50	0.00	0.00	3	0.00
87	Aug-92	1	0	0	9	4.50	28.0	40.50	0.00	0.00	3	0.00
8	Sep-92	1	2	545	9	3.50	8.0	31.50	17.30	17.30	3	181.67
9	Sep-92	1	1	235	9	3.50	8.0	31.50	7.46	7.46	3	78.33
17	Sep-92	2	0	0	18	9.00	9.5	162.00	0.00	0.00	6	0.00
19	Sep-92	1	2	630	9	4.50	11.0	40.50	15.56	15.56	3	210.00
29	Sep-92	1	0	0	9	4.50	8.0	40.50	0.00	0.00	3	0.00
37	Sep-92	1	0	0	9	4.50	8.0	40.50	0.00	0.00	3	0.00
49	Sep-92	1	3	1,020	9	3.50	10.0	31.50	32.38	32.38	3	340.00
54	Sep-92	1	0	0	9	4.50	11.0	40.50	0.00	0.00	3	0.00
55	Sep-92	1	0	0	9	3.50	14.0	31.50	0.00	0.00	3	0.00
58	Sep-92	1	2	545	9	4.50	11.0	40.50	13.46	13.46	3	181.67
59	Sep-92	1	3	1,090	9	3.50	7.0	31.50	34.60	34.60	3	363.33
69	Sep-92	1	15	4,916	9	4.50	25.0	40.50	121.38	121.38	3	1,638.67
76	Sep-92	1	2	485	9	3.50	5.0	31.50	15.40	15.40	3	161.67
77	Sep-92	1	0	0	9	4.50	27.0	40.50	0.00	0.00	3	0.00
78	Sep-92	1	2	250	9	3.50	5.0	31.50	7.94	7.94	3	83.33
87	Sep-92	3	14	4,434	27	12.50	13.3	337.50	13.14	37.14	9	492.67

Appendix 4. Catch summary of sampled red hinds by date and station with hook and line, April 1992 to March 1993.

Station	Date	# Trips	# Inds.	TotW (g)	# HOOK	HOURS	DEPTH (fm)	EFFORT hook hours	Mean CPUE/Trip g/hook hrs trip	MEAN CPUE g/hook hrs/day	EFFORT Lines/trip	Mean CPUE/Tr g/line trip
89	Sep-92	1	0	0	9	4.50	39.0	40.50	0.00	0.00	3	0.00
90	Sep-92	1	0	0	9	3.50	41.0	31.50	0.00	0.00	3	0.00
95	Sep-92	2	84	29,675	18	8.00	40.0	144.00	206.08	378.58	6	4,945.83
96	Sep-92	2	28	11,295	18	8.00	29.0	144.00	78.44	161.98	6	1,882.50
29	Oct-92	1	14	8,735	9	4.50	11.0	40.50	215.68	215.68	3	2,911.67
31	Oct-92	1	0	0	9	4.50	7.0	40.50	0.00	0.00	3	0.00
37	Oct-92	1	0	0	9	3.50	8.0	31.50	0.00	0.00	3	0.00
39	Oct-92	1	2	340	9	4.50	11.0	40.50	8.40	8.40	3	113.33
41	Oct-92	1	0	0	9	4.50	3.0	40.50	0.00	0.00	3	0.00
42	Oct-92	1	4	1,925	9	4.50	10.0	40.50	47.53	47.53	3	641.67
93	Oct-92	1	0	0	9	4.50	14.0	40.50	0.00	0.00	3	0.00
96	Oct-92	1	36	12,125	9	4.50	35.0	40.50	299.38	299.38	3	4,041.67
37	Nov-92	2	0	0	18	9.00	8.5	162.00	0.00	0.00	6	0.00
38	Nov-92	1	0	0	9	4.50	10.0	40.50	0.00	0.00	3	0.00
42	Nov-92	1	6	2,020	9	4.50	10	40.50	49.88	49.88	3	673.33
42	Mar-93	1	9	3,873	9	3.50	30	31.50	122.95	122.95	3	1,291.00
49	Mar-93	1	6	1,955	9	4.50	11.0	40.50	48.27	48.27	3	651.67
68	Mar-93	1	2	545	9	3.50	38.0	31.50	17.30	17.30	3	181.67
77	Mar-93	1	0	0	9	4.50	14.0	40.50	0.00	0.00	3	0.00
79	Mar-93	2	20	3,899	18	9.00	10.5	162.00	24.07	48.14	6	649.83
80	Mar-93	3	42	9,650	27	12.50	10.7	337.50	28.59	91.90	9	1,072.22
86	Mar-93	1	1	150	9	3.50	25.0	31.50	4.76	4.76	3	50.00
87	Mar-93	1	0	0	9	4.50	41.0	40.50	0.00	0.00	3	0.00
90	Mar-93	1	4	2,335	9	4.50	13.0	40.50	57.65	57.65	3	778.33
95	Mar-93	4	94	29,445	45	20.50	30.6	922.50	31.92	198.91	12	2,453.75
96	Mar-93	4	56	20,521	36	17.00	28.8	612.00	33.53	129.83	12	1,710.08

Appendix 5. Catch summary of sampled coneys by date and station with hook and line, April 1992 to March 1993.

Station	Date	# Trips	# Inds.	TotW (g)	# HOOK	HOURS	DEPTH (fm)	EFFORT hook hours	Mean CPUE/Trip g/hook hrs trip	MEAN CPUE g/hook hrs/day	EFFORT Lines/trip	Mean CPUE/T g/line tri
80	Apr-92	3	48	7,697	27	11	16.0	283.50	27.15	81.45	9	855.
90	Apr-92	3	3	1,430	27	14	35.0	364.50	3.92	11.77	9	158.
95	Apr-92	5	29	4,772	45	22	33.6	967.50	4.93	25.00	15	318.
96	Apr-92	3	11	1,837	27	14	30.0	364.50	5.04	15.12	9	204.
80	May-92	3	32	4,923	27	11	19.0	283.50	17.37	52.10	9	547.
34	Jun-92	1	0	0	9	3.50	9	31.50	0.00	0.00	3	0.
37	Jun-92	1	0	0	9	3.50	8	31.50	0.00	0.00	3	0.
40	Jun-92	1	1	102	9	3.50	8	31.50	3.24	3.24	3	34.
66	Jun-92	1	0	0	9	3.50	12	31.50	0.00	0.00	3	0.
93	Jun-92	3	2	320	27	10.5	6	283.50	1.13	3.39	9	35.
7	Jul-92	1	43	7,438	9	3.50	11	31.50	236.13	523.46	3	2,479.
11	Jul-92	1	0	0	9	3.50	23	31.50	0.00	0.00	3	0.
45	Jul-92	1	0	0	9	3.50	12	31.50	0.00	0.00	3	0.
46	Jul-92	1	0	0	9	4.00	13	36.00	0.00	0.00	3	0.
48	Jul-92	1	1	280	9	4.00	13	36.00	7.78	7.78	3	93.
57	Jul-92	1	8	1,665	9	4.00	13	36.00	46.25	46.25	3	555.
64	Jul-92	1	1	220	9	4.50	11	40.50	5.43	5.43	3	73.
67	Jul-92	1	0	0	9	3.50	13	31.50	0.00	0.00	3	0.
75	Jul-92	1	0	0	9	3.50	3	31.50	0.00	0.00	3	0.
79	Jul-92	1	4	571	9	3.50	12	31.50	18.13	18.13	3	190.
86	Jul-92	1	15	2,899	9	3.50	31	31.50	92.03	92.03	3	966.
91	Jul-92	1	14	2,229	9	3.50	38	31.50	70.76	70.76	3	743.
93	Jul-92	1	4	358	9	3.50	4	31.50	11.37	11.37	3	119.
96	Jul-92	1	5	707	9	4.50	30	40.50	17.46	17.46	3	235.
8	Aug-92	1	15	2,830	9	4.50	15	40.50	69.88	69.88	3	943.
19	Aug-92	1	12	2,339	9	3.50	24	31.50	74.25	74.25	3	779.
41	Aug-92	2	25	5,195	18	9	12.0	162.00	32.07	64.14	6	865.
45	Aug-92	1	0	0	9	4.50	12	40.50	0.00	0.00	3	0.
47	Aug-92	1	3	878	9	3.50	15	31.50	27.87	27.87	3	292.
49	Aug-92	1	79	13,014	9	3.50	15	31.50	413.14	413.14	3	4,338.
63	Aug-92	1	0	0	9	4.50	10	40.50	0.00	0.00	3	0.
76	Aug-92	1	3	430	9	3.50	4	31.50	13.65	13.65	3	143.
77	Aug-92	1	0	0	9	3.50	4	31.50	0.00	0.00	3	0.
80	Aug-92	1	4	700	9	3.50	12	31.50	22.22	22.22	3	233.
87	Aug-92	1	1	130	9	4.50	28	40.50	3.21	3.21	3	43.
8	Sep-92	1	9	1,810	9	3.50	8	31.50	57.46	57.46	3	603.
9	Sep-92	1	0	0	9	3.50	8	31.50	0.00	0.00	3	0.
17	Sep-92	2	0	0	18	9	9.5	162.00	0.00	0.00	6	0.
19	Sep-92	1	32	5,494	9	4.50	11	40.50	135.65	135.65	3	1,831.
29	Sep-92	1	1	230	9	4.50	8	40.50	5.68	5.68	3	76.
37	Sep-92	1	0	0	9	4.50	8	40.50	0.00	0.00	3	0.
49	Sep-92	1	63	9,585	9	4.50	11	40.50	236.67	236.67	3	3,195
54	Sep-92	1	0	0	9	4.50	11	40.50	0.00	0.00	3	0
55	Sep-92	1	0	0	9	3.50	14	31.50	0.00	0.00	3	0
58	Sep-92	1	37	7,050	9	3.50	10	31.50	223.81	223.81	3	2,350
59	Sep-92	1	14	1,997	9	3.50	7	31.50	63.40	63.40	3	665
69	Sep-92	1	16	3,180	9	4.50	25	40.50	78.52	78.52	3	1,060
76	Sep-92	1	0	0	9	3.50	5	31.50	0.00	0.00	3	0
77	Sep-92	1	6	1,385	9	3.50	5	31.50	43.97	43.97	3	461
78	Sep-92	1	4	542	9	3.50	5	31.50	17.21	17.21	3	180
87	Sep-92	3	14	2,543	27	14	20.7	364.50	6.98	20.93	9	282

Appendix 5. Catch summary of sampled coneys by date and station with hook and line, April 1992 to March 1993.

Station	Date	# Trips	# Inds.	TotW (g)	# HOOK	HOURS	DEPTH (fm)	EFFORT hook hours	Mean CPUE/Trip g/hook hrs trip	MEAN CPUE g/hook hrs/day	EFFORT Lines/trip	Mean CPUE/Tr g/line trip
89	Sep-92	1	0	0	9	4.50	39	40.50	0.00	0.00	3	0.0
90	Sep-92	1	0	0	9	3.50	41	31.50	0.00	0.00	3	0.0
95	Sep-92	2	3	403	18	8	40.0	144.00	2.80	5.43	6	67.1
96	Sep-92	2	12	2,073	18	8	29.0	144.00	14.40	29.81	6	345.5
29	Oct-92	1	30	5,905	9	4.50	11	40.50	145.80	145.80	3	1,968.3
31	Oct-92	1	0	0	9	4.50	7	40.50	0.00	0.00	3	0.0
37	Oct-92	1	0	0	9	3.50	8	31.50	0.00	0.00	3	0.0
39	Oct-92	1	0	0	9	4.50	11	40.50	0.00	0.00	3	0.0
41	Oct-92	1	10	2,335	9	4.50	3	40.50	57.65	57.65	3	778.3
42	Oct-92	1	37	6,135	9	4.50	10	40.50	151.48	151.48	3	2,045.0
93	Oct-92	1	1	90	9	4.50	14	40.50	2.22	2.22	3	30.0
96	Oct-92	1	11	1,678	9	4.50	35	40.50	41.43	41.43	3	559.3
37	Nov-92	2	0	0	18	9	8.5	162.00	0.00	0.00	6	0.0
38	Nov-92	1	0	0	9	4.50	10	40.50	0.00	0.00	3	0.0
42	Nov-92	1	50	8,408	9	4.50	10	40.50	207.60	207.60	3	2,802.6
42	Mar-93	1	4	852	9	3.50	30	31.50	27.05	27.05	3	284.0
49	Mar-93	1	132	27,321	9	4.50	11	40.50	674.59	674.59	3	9,107.0
68	Mar-93	1	2	1,195	9	3.50	13	31.50	37.94	37.94	3	398.3
77	Mar-93	1	14	2,696	9	4.50	14	40.50	66.57	66.57	3	898.6
79	Mar-93	2	42	6,714	18	9	11	162.00	41.44	82.89	6	1,119.0
80	Mar-93	3	52	7,210	27	13	10.7	337.50	21.36	62.25	9	801.1
86	Mar-93	1	0	0	9	3.50	25	31.50	0.00	0.00	3	0.0
87	Mar-93	1	2	305	9	4.50	41	40.50	7.53	7.53	3	101.6
90	Mar-93	1	17	2,831	9	4.50	38	40.50	69.90	69.90	3	943.6
95	Mar-93	4	38	6,478	45	21.5	35.6	967.50	6.70	32.80	12	539.8

Appendix 6. Catch summary by date and sampled station with fish traps, April 1992 to March 1993.

STATION	DATE	# TRIPS	#	WG (g)	HOURS	# Traps	Trap/ day	DEPTH (fm)	EFFORT trap hour	CPUE g/trap hour	CPUE g/trap day	Mean CPUE g/trap hour/trip	Mean CPUE g/trap day/tr
80	Apr-92	3	12	3,916	15.00	36	36	12.0	540.0	7.25	108.78	39.75	205.5
95	Apr-92	5	34	12,333	25.75	60	60	36.6	1,545.0	7.98	205.55	39.75	205.5
96	Apr-92	3	17	6,695	15.75	36	36	30.7	567.0	11.81	185.97	17.12	86.0
90	Apr-92	2	25	6,573	10.00	24	24	34.0	240.0	27.39	273.88	54.78	273.8
80	May-92	3	23	4,565	15.00	36	36	17.0	540.0	8.45	126.81	25.36	126.8
93	Jun-92	3	6	498	15.00	36	36	6.0	540.0	0.92	13.83	2.77	13.8
34	Jun-92	1	0	0	5.00	12	12	9.0	60.0	0.00	0.00	0.00	0.0
37	Jun-92	1	0	0	5.00	12	12	8.0	60.0	0.00	0.00	0.00	0.0
40	Jun-92	1	2	550	5.00	12	12	8.0	60.0	9.17	45.83	9.17	45.8
66	Jun-92	1	1	135	5.00	12	12	12.0	60.0	2.25	11.25	2.25	11.2
7	Jul-92	1	10	3,290	5.00	12	12	11.0	60.0	54.83	274.17	54.83	274.1
11	Jul-92	1	5	848	5.00	12	12	4.0	60.0	14.13	70.67	14.13	70.6
45	Jul-92	1	3	120	5.00	12	12	12.0	60.0	2.00	10.00	2.00	10.0
46	Jul-92	1	0	0	5.00	12	12	13.0	60.0	0.00	0.00	0.00	0.0
48	Jul-92	1	0	0	5.00	12	12	12.0	60.0	0.00	0.00	0.00	0.0
57	Jul-92	1	5	804	5.00	12	12	14.0	60.0	13.40	67.00	13.40	67.0
64	Jul-92	1	0	0	5.00	12	12	14.0	60.0	0.00	0.00	0.00	0.0
67	Jul-92	1	0	0	5.00	12	12	13.0	60.0	0.00	0.00	0.00	0.0
75	Jul-92	1	0	0	5.00	12	12	36.0	60.0	0.00	0.00	0.00	0.0
79	Jul-92	1	2	360	5.00	12	12	11.0	60.0	6.00	30.00	6.00	30.0
86	Jul-92	1	0	0	5.00	12	12	31.0	60.0	0.00	0.00	0.00	0.0
91	Jul-92	1	2	770	5.00	12	12	38.0	60.0	12.83	64.17	12.83	64.1
96	Jul-92	1	3	2,155	5.00	12	12	38.0	60.0	35.92	179.58	35.92	179.5
8	Aug-92	1	3	700	5.00	12	12	9.0	60.0	11.67	58.33	11.67	58.3
19	Aug-92	1	4	554	5.00	12	12	11.0	60.0	9.23	46.17	9.23	46.1
41	Aug-92	2	16	4,327	10	24	24	12.0	240.0	18.03	180.29	36.06	180.2
45	Aug-92	1	0	0	5.00	12	12	12.0	60.0	0.00	0.00	0.00	0.0
49	Aug-92	1	14	4,154	5.00	12	12	9.0	60.0	69.23	346.17	69.23	346.1
47	Aug-92	1	2	325	5.00	12	12	15.0	60.0	5.42	27.08	5.42	27.0
63	Aug-92	1	0	0	5.00	12	12	10.0	60.0	0.00	0.00	0.00	0.0
77	Aug-92	1	3	860	5.00	12	12	5.0	60.0	14.33	71.67	14.33	71.6
76	Aug-92	1	1	120	5.00	12	12	5.0	60.0	2.00	10.00	2.00	10.0
80	Aug-92	1	0	0	5.00	12	12	12.0	60.0	0.00	0.00	0.00	0.0
87	Aug-92	1	2	625	5.00	12	12	33.0	60.0	10.42	52.08	10.42	52.0
8	Sep-92	1	5	900	5.00	12	12	8.0	60.0	15.00	75.00	15.00	75.0
9	Sep-92	1	3	995	5.00	12	12	12.0	60.0	16.58	82.92	16.58	82.9
17	Sep-92	1	5	1,975	5.00	12	12	8.0	60.0	32.92	164.58	32.92	164.5
29	Sep-92	1	6	1,511	5.00	12	12	10.0	60.0	25.18	125.92	25.18	125.9
37	Sep-92	1	1	82	5.00	12	12	8.0	60.0	1.37	6.83	1.37	6.8
49	Sep-92	1	9	1,814	5.00	12	12	10.0	60.0	30.23	151.17	30.23	151.1
54	Sep-92	1	2	275	5.00	12	12	14.0	60.0	4.58	22.92	4.58	22.9
59	Sep-92	1	8	2,425	5.00	12	12	7.0	60.0	40.42	202.08	40.42	202.0
76	Sep-92	1	0	0	5.00	12	12	5.0	60.0	0.00	0.00	0.00	0.0
78	Sep-92	1	5	862	5.00	12	12	5.0	60.0	14.37	71.83	14.37	71.8
87	Sep-92	1	5	1,320	5.00	12	12	37.0	60.0	22.00	110.00	22.00	110.0
90	Sep-92	1	3	1,030	5.00	12	12	36.0	60.0	17.17	85.83	17.17	85.8
95	Sep-92	1	0	0	5.00	12	12	38.0	60.0	0.00	0.00	0.00	0.0
96	Sep-92	1	10	5,712	5.00	12	12	15.0	60.0	95.20	476.00	95.20	476.0
39	Oct-92	1	2	56	5.00	12	12	8.0	60.0	0.93	4.67	0.93	4.6
38	Nov-92	1	3	842	5.00	12	12	10.0	60.0	14.03	70.17	14.03	70.1
42	Nov-92	1	1	420	5.00	12	12	10.0	60.0	7.00	35.00	7.00	35.0
42	Mar-93	1	16	3,733	5.00	15	15	30.0	75.0	49.77	248.87	49.77	248.8
49	Mar-93	1	6	1,841	5.00	15	15	11.0	75.0	24.55	122.73	24.55	122.7
68	Mar-93	1	2	275	5.00	15	15	13.0	75.0	3.67	18.33	3.67	18.3
77	Mar-93	1	16	5,359	5.00	15	15	14.0	75.0	71.45	357.27	71.45	357.2
79	Mar-93	2	9	1,047	10	30	30	10.5	300.0	3.49	34.90	6.72	67.1
80	Mar-93	2	10	2,984	10	30	30	11.0	300.0	9.95	99.47	13.62	78.0

Appendix 6. Catch summary by date and sampled station with fish traps, April 1992 to March 1993.

STATION	DATE	# TRIPS	#	WG (g)	HOURS	# Traps	Trap/ day	DEPTH (fm)	EFFORT trap hour	CPUE g/trap hour	CPUE g/trap day	Mean CPUE g/trap hour/trip	Mean CPUE g/trap day/tric
86	Mar-93	1	2	473	5.00	15	15	23.0	75.0	6.31	31.53	6.31	31.53
87	Mar-93	1	11	3,890	5.00	15	15	45.0	75.0	51.87	259.33	51.87	259.33
90	Mar-93	1	9	4,590	5.00	15	15	38.0	75.0	61.20	306.00	61.20	306.00
95	Mar-93	4	23	6,732	20	60	60	35.0	1,200.0	5.61	112.20	22.44	112.20
96	Mar-93	4	3	1,795	20	60	60	27.0	1,200.0	1.50	29.92	5.98	29.92

Appendix 7a. Selected sampled species by weight (g) and station with fish traps for sampling period of April 1992 to March 1993.

Code	82	80	88	139	142	251	561
Species	Epinephelus cruentatus	Epinephelus fulvus	Epinephelus guttatus	Lutjanus vivanus	Rhomboplites aurorubens	Balistes vetula	Chaetodon striatus
7		260	2,710				208
8	155	235	320			460	140
9		225				555	
11						540	
17		290				1,355	
19		290					134
29		665					56
37							
38							
40		190	360				
41	248	1,140	1,990			390	174
42		185	2,285				660
45							
49		2,415	2,385				176
58		360	1,090				280
59		1,115	1,310				
68			225				50
76		120					
77	310	3,280	665			530	
78		710					72
79		580					366
80		1,805	3,120		190	1,675	776
86				98			
87		615	400	615		2,455	
90		2,825		6,600	768	1,260	
91		770					
93		330					328
95		3,364	14,785				214
96		1,335	13,660			815	122
Total	713	23,104	45,305	7,313	958	10,035	3,756

Appendix 7b. Selected sampled species by number and station with fish traps for sampling period of April 1992 to March 1993.

Code Stations	82 Epinephelus cruentatus	80 Epinephelus fulvus	88 Epinephelus guttatus	139 Lutjanus vivanus	142 Rhomboplites aurorubens	251 Balistes vetula	561 Chaetodon striatus
7		1	5				3
8	1	1	1			1	2
9		1				1	
11						2	
17		1				3	
19		1					2
29		3					1
37							
38							
40		1	1				
41	2	5	3			1	2
42		1	4				8
45							
49		9	4				2
58		2	2				4
59		5	3				
68			1				1
76		1					
77	1	12	2			2	
78		3					1
79		3					6
80		9	7		1	2	12
86				1			
87		2	1	2		5	
90		6		21	5	1	
91		2					
93		2					5
95		14	35				3
96		6	21			2	2
Total	4	91	90	24	6	20	54

Fisheries-independent Trap Sampling in the U.S. Virgin Islands 1988-1992

Prepared for the SEAMAP-CARIBBEAN COMMITTEE

by

Jim Beets

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ABSTRACT

Three sets of fisheries-independent data using fish traps were collected in the U.S. Virgin Islands between 1988 to 1992. These data were collected using standardized fish traps (1.5-inch hexagonal mesh) in three discrete areas: 1) north of St. Thomas (NORTH), 2) south of St. John (SOUTH), and 3) inshore of St. John (INSHORE).

The sampling effort north of St. Thomas represented a replication of a trap study conducted in 1975-1976. Results demonstrated a 28.5% decline in catch per unit effort (CPUE; catch per trap haul) in this area since the initial study with a CPUE of 2.303 kg/trap in 1975-1976 and 1.646 kg/trap in 1989-1990.

Differences in CPUE and relative abundance of fishes in catches were noted among the three sampling areas. The NORTH site had lower average CPUE by number of fish (5.24 fish/trap haul) than the SOUTH site (5.71 fish/trap), but NORTH had a greater CPUE by weight than SOUTH (1.65 & 1.57 kg/trap, respectively). Catches at the NORTH site were dominated by grunts (Haemulidae) and groupers (Serranidae). The SOUTH site catches were dominated by squirrelfishes (Holocentridae) and grunts (Haemulidae). Herbivorous fishes, surgeonfishes (Acanthuridae) and parrotfishes (Scaridae), dominated catches at the INSHORE site where average CPUE was lower than in the other two areas (5.15 fish/trap). The differences observed between the NORTH and SOUTH areas appear to be due to differences in fishing effort by fishermen (trap fishing effort on the northern portion of the shelf off St. Thomas/St. John is estimated at 1/3 the effort of the southern portion) and possibly also due to habitat differences. The difference in species composition at the INSHORE site is due to habitat differences and habitat preferences by different fish species and ontogenetic stages.

Of the 77 species captured among sampling areas, 70 species were captured INSHORE with 61 and 48 species captured NORTH and SOUTH, respectively. Average length of fishes were generally smaller INSHORE with the greatest average length for most species being observed at the NORTH site.

An analysis of CPUE by soak time was conducted for the three data sets. Soak times of 7-8 days yielded the greatest CPUE for number of fish caught per trap for all three areas. Soak time of 7 days yielded significantly greater CPUE for number of fish and weight per trap haul than for soak times of 3 or 4 days.

Fisheries-dependent data collected in the U.S. Virgin Islands since 1976 do not provide reliable information on fisheries resources, especially for effort estimates. Fisheries-independent monitoring is needed to provide data for documenting trends in fishery resources. This type of information yields an independent measure of resources from fisheries-dependent sampling but

also can provide information of natural differences and changes in different areas which may not be observed in fisheries-dependent sampling.

Recommendations for future studies and monitoring activities have been provided.

INTRODUCTION

Fish traps are the most common gear used in the commercial and artisanal fishery in the U.S. Virgin Islands (accounting for 60-80% of landings by weight in recent years, USVI-DFW files). Numerous assessments and evaluations have demonstrated declining fishery resources in the area, but unfortunately little data on catch and effort exists to accurately substantiate declines. Fisheries-dependent monitoring has been conducted in the U.S. Virgin Islands since 1982, but these data have little reliability and large bias with inadequate effort data. Fisheries-independent monitoring using accepted methods and design was recognized as a valuable and critical approach to providing necessary data for reliable analysis and management recommendations.

Fisheries-independent surveys of coral reef fishes in the Virgin Islands were initiated in 1988 to provide a baseline of information on the relative abundance, species composition and catch per unit effort (CPUE). These data were needed to provide a basis for design of a sound monitoring program. Information from these preliminary surveys in different areas were to be used as baseline information in the development of a comprehensive long-term monitoring program in the US Virgin Islands.

The SEAMAP PROGRAM stimulated collaboration the Division of Fish and Wildlife and the Fisheries Laboratory in Puerto Rico to develop a comprehensive fisheries-independent monitoring program in this region of the Caribbean. This program was envisioned to address three components: 1) ichthyoplankton, 2) pelagic resources, and 3) reef resources. The intent was to monitor these resources, assess abundance and trends, and evaluate the relationship among these components in the area. Although one cruise was conducted in 1989 dedicated to the first two objectives, ichthyoplankton and pelagic resources, no additional cruises were scheduled and additional funding has not been available for these components. The SEAMAP-CARIBBEAN COMMITTEE on advisement from the Reef Resources Committee focused effort on reef resources. Since finfish resources were identified to be in the greatest decline and of great importance, monitoring of finfish resources received highest priority.

Fisheries-independent monitoring studies of reef fish resources have been conducted by the Fisheries Research Laboratory of the Department of Natural Resources in Puerto Rico during the past two years in order to determine the best approaches to developing the SEAMAP-CARIBBEAN sampling protocol. Reports and analyses have been completed on these data to determine sampling strata and to establish the best survey approaches, such as sample size by depth, area and quadrat (i.e, 2 x 2 nm quadrats in defined grid). All samples for these analyses were collected on the western end of the Puerto Rican Shelf.

The primary goal of the present analysis was to compare fishery resources among three areas on the shelf around St. Thomas and St. John, U.S. Virgin Islands, where fisheries-independent sampling had been conducted. Fisheries resources are known to differ in terms of species composition, abundance and biomass across the Puerto Rican Shelf, which Puerto Rico shares with the U.S. Virgin Islands (excluding St. Croix) and British Virgin Islands to the east (Bohnsack 1986; fishermen interviews). This is primarily due to differences in fishing effort, as noted by Bohnsack et al. (1986), and suspected habitat differences across the shelf. Indeed, as one reviews catches in the British Virgin Islands on the eastern end of the Puerto Rican Shelf, which has low fishing effort and numerous offshore banks, large fish sizes and large abundances of preferred species in catches are striking. In the three surveys analyzed, fishing effort during each survey was similar in the three areas sampled using fish traps of similar size and mesh. The data from the samples were analyzed for differences in species composition, catch per unit effort and soak time. It was not possible to analyze for optimal sample size within or among areas sampled.

METHODS

Site descriptions

The sites selected for trap sampling were: 1) the shelf area north of St. Thomas (NORTH), 2) the shelf area south of St. John (SOUTH), and 3) a fringing reef between Greater and Lesser Lameshur Bays on the south side of St. John (INSHORE)(Figure 1). St. Thomas and St. John are remnants of volcanic formations which emerge from the insular shelf shared with Puerto Rico and the British Virgin Islands. The shelf extends shore to shelf edge ca. 25 km on the north side and ca. 11 km on the south side. The shelf edge drops precipitously from 20-50 m to abyssal depths along the southern (Caribbean) side and has a more gradual slope along the northern (Atlantic) side to the Puerto Rican trench. The shelf platform is relatively uniform ranging in depth from 20 m to

30 m beyond the 20 m isobath with occasional banks and reefs. The offshore sampling sites (NORTH and SOUTH) were open shelf areas with large offshore banks and small patch reefs. The banks and reefs are usually dominated by sparse coral and/or gorgonian cover. Much of this area is sparse algal plain with patches of gorgonian-dominated pavement. The inshore sampling area (INSHORE) was a well-developed fringing reef with a high percentage of live coral, dominated by Montastrea annularis.

Sampling methods

Trap sampling in the three areas was conducted using the same trap design. Traps were constructed using the typical antillean (arrow-head) design. Trap dimension was ca. 1.0 x 1.0 x 0.5 m. Traps were constructed of hexagonal wire mesh with mesh size of 38.1 mm (1.5 in) in the smallest dimension. Water depth at the NORTH and SOUTH sites was 20-30 m and 10-18 m at the INSHORE site. Number of individuals by species was recorded per trap. Individuals were measured to the closest mm (FL) and weighed (g). Traps which were opened or were lost during the sampling period were excluded from analysis.

Trap sampling was conducted from February 1988 to June 1989 at the NORTH site (north of St. Thomas) in the area used for a previous study (Olsen and LaPlace 1981). Ten to twelve traps were hauled at soak times of 2 to 14 days.

Sampling at the SOUTH site was conducted south of St. John from August 1989 to June 1990. Six traps were hauled weekly at one randomly selected 2 x 2 nm quadrat (16 total) within a grid. Soak time was scheduled for 7 days but ranged from 4 to 14 days.

An average of six traps were hauled weekly at the INSHORE site from May 1989 through June 1992. Soak time was scheduled for 7 days but ranged from 2 to 14 days. Trap sets targeted the halo zone next to the reef between 10-18 m in water depth in order to standardize sampling and to avoid damage to coral structure. Since samples at the INSHORE site were taken within the Virgin Islands National Park, fishes were released after length measurements were taken, usually without harm. Individual estimated weights were calculated using length-weight relationships in Bohnsack and Harper (1988). At the INSHORE site new traps were constructed and used from 9/91 to 6/92. These traps were of similar dimension to the antillean-style traps previously used at this site but square in shape instead of arrow-head design with square (1.5 in) vinyl clad mesh wire. The data from new traps at the INSHORE site were analyzed separately and not compared to data from the other two sites.

On several dates, captured fishes at the INSHORE site were tagged with dart tags and released. Data were recorded on recaptures in order to calculate proportion of total fish recaptured and to obtain growth rates. Due to small sample size and other assumption restrictions (e.g. open system, movement of fishes, etc.), estimations of assemblage size (or species abundance) within the area were not appropriate.

Since the sampling record at the INSHORE site covered the period before and after the passage of Hurricane Hugo in 1989, it was possible to analyze for changes in the species composition of the catches with the original antillean-style traps.

Data analysis

Data were analyzed using Quattro Pro, Paradox, and Systat on microcomputers. Frequency of occurrence for each species in trap catches was calculated in addition to total abundance and proportion of catch for each species. This yields a comparative view of species which may be caught frequently in trap hauls but not necessary in the greatest abundance.

Non-parametric tests (Kruskal-Wallis and Mann-Whitney U tests) were employed for statistical analyses. Medians were used in all non-parametric analyses, but means are given in tables and figures for comparison.

RESULTS

A total of 77 species were captured from the three sites during the sampling period. At the NORTH site, 61 species and 2697 individuals were captured in 498 trap hauls (Table 1). Overall catch per trap haul (CPUE) in the area averaged 5.24 fish/trap haul and 1.65 kg/trap haul (Table 2A). As in most trap studies, catch per trap was extremely variable (Figure 2). Honeycomb cowfish, Lactophrys polygonia, was the dominant fish in catches in this area comprising 10.4% of total fish caught (Table 3).

The SOUTH site had the fewest species of all areas (48) and number of individuals captured (1140), but also had the lowest effort with only 200 trap hauls (Table 1; Figure 3). Overall CPUE in the area averaged 5.71 fish/trap haul and 1.57 kg/trap haul. The dominant species in catches was the longspine squirrelfish, Holocentrus rufus, comprising 18.6% of total fish caught (Table 3).

At the INSHORE site, 70 species and 4042 individuals were captured from 529 trap hauls (Table 1). The dominant species in trap catches was a surgeonfish, blue tang (Acanthurus coeruleus), comprising 21.5% of the total number of fishes captured in traps. The dominant families in trap catches were herbivorous fishes, with surgeonfishes (Acanthuridae) accounting for 38.9% of total catches and parrotfishes (Scaridae) accounting for 17.0%.

Catch per trap haul between the two periods using different trap designs at the INSHORE site differed significantly (Mann-Whitney U: 2479.5; p 0.001)(Figure 4). Using the original antillean-style trap design from 5/89 to 1/91, the CPUE averaged 6.07 fish/trap haul with 7-day soak time. During the period from 9/91 to 6/92, the square trap design yielded a CPUE of 12.70 fish/trap haul.

Catch per trap haul (CPUE) for number of fish was significantly different among areas using the same trap design and for equivalent soak times (soak time = 7 days, Table 2B; Figure 5). The NORTH and SOUTH sites demonstrated similar CPUE for number of fish per trap haul (7.91 and 7.87, respectively) and fish weight per trap haul (2.320 and 2.294 kg/trap haul, respectively)(Table 2B; Figure 5). The INSHORE site had significantly lower CPUE for number of fish using antillean-style traps and 7-day soak time (6.07 fish/trap haul).

Differences in relative abundance and frequency of occurrence of fishes in catches were noted among the sampling areas (Tables 3 & 4). When viewed at the family level, the NORTH site had a greater proportion of grunts (Haemulidae) and groupers (Serranidae) in catches, whereas, the SOUTH site had a greater proportion of squirrelfishes (Holocentridae) and grunts (Haemulidae) in catches (Table 5). Herbivorous fishes, surgeonfishes (Acanthuridae) and parrotfishes (Scaridae), dominated catches at the INSHORE site (proportion of fish captured: 0.389 and 0.170, respectively) (Table 5). The proportion of groupers (Serranidae) in catches was greater at the NORTH site than at the SOUTH site (0.126 and 0.089, respectively) and much lower at the INSHORE site (0.039) (Table 5). Snappers (Lutjanidae) demonstrated a much greater proportion in catches at the NORTH site than at the SOUTH site (0.091 and 0.017, respectively). Squirrelfishes (Holocentridae), jacks (Carangidae) and surgeonfishes (Acanthuridae) had a greater proportion of catch at the SOUTH site than the NORTH site (Table 5). Triggerfishes (Balistidae) and trunkfishes (Ostraciidae) comprised similar proportions of catches at the NORTH and SOUTH sites and greater proportions than at the INSHORE site.

Average size of fish by species differed among sites (Table 6). For species with adequate sample sizes (15 fish), the average length of fish at the INSHORE site was smaller than at the offshore sites. Fish from the NORTH site were generally larger than those captured at the SOUTH site (examples for 15 families: Figures 6-20). Only two species of the 20 numerically dominant species in catches with sample sizes greater than 15 individuals per area had a larger average length at the SOUTH site than the NORTH site, coney (Epinephelus fulvus) and white grunt (Haemulon plumieri).

An analysis of CPUE by soak time was conducted for the three data sets. For number of fish per trap, soak times of 7-8 days yielded greatest CPUE for a

ll areas (Figure 21). The trend was not clear for the square traps used at the INSHORE site (Figure 21). Soak times of 7-8 days also yielded the greatest CPUE by weight of fish per trap haul at the NORTH and SOUTH sites.

Sample size was large enough for three soak times (3, 4, and 7 days) at the NORTH site for statistical analysis. The 7-day soak time yielded significantly greater CPUE for number of fish and weight per trap haul than for 3-day and 4-day soak times (Table 7).

Since data at the INSHORE site were collected before and after the passage of Hurricane Hugo in 1989, it was possible to analyze for possible storm effects assuming that the proportion of fish was similar between the two mesh types used. The proportion of surgeonfishes of the total number of fishes captured per trap generally declined over the entire study period (Figure 22). At the specific level, blue tang (A. coeruleus) was the dominant species of surgeonfish captured prior to Hurricane Hugo but was replaced by ocean surgeonfish (A. bahianus) in the months following the storm (Figure 23). During the final months of trapping, blue tang appeared to reestablish its previous dominance. Doctorfish (A. chirurgus) diminished in catches following the storm and remained low in trap catches until the end of the study.

The proportion of parrotfishes in total catches increased following the hurricane until November 1991 when their proportion within total catches began to decline to pre-storm levels (Figure 22). The commercially-important groupers (Serranidae), declined in catches following the storm but increased to pre-storm levels during the final months of the study (Figure 24). Conversely, snappers (Lutjanidae) accounted for a small proportion of the total catch until the final months of the study (Figure 24). This same trend was noted for grunts (Haemulidae) and porgies (Sparidae)(Figure 25).

At the INSHORE site, 59 species of the 69 species trapped were tagged with only 29 species being recaptured (Table 8). Of 1839 fishes tagged, 207 individuals (11.3%) were recaptured. In review of the species with larger samples of tagged individuals, species known to have high site fidelity had the greatest proportion of recaptures (e.g. angelfish, groupers, grunts). Interestingly, smooth trunkfish (Lactophrys triqueter) had a high proportion of recaptures.

With few exceptions, recaptured fishes were captured within one month of initial tagging and rarely recaptured more than once, therefore, no calculated growth rates were possible. Commercial and recreational fishing pressure within the area is low so the lack of reported recapture by fishermen was not unexpected.

DISCUSSION

The site north of St. Thomas (NORTH) sampled during 1988-1989 was previously sampled by Olsen and LaPlace (1981) in 1975-1976 using traps similar to those used during this study. From 1,016 trap hauls, Olsen and LaPlace (1981) obtained a catch per unit effort (CPUE) of 2.303 kg/trap. During 1989-1990, a CPUE of 1.646 kg/trap was obtained. For this period, a 28.5% decline in CPUE was observed. Unfortunately, the original data from the Olsen and LaPlace study were not available so more intensive analysis and evaluation of changes in species composition could not been conducted. This emphasizes the importance of data management and archiving. The loss of valuable data confounds subsequent analyses.

Results from this analysis of fisheries-independent data demonstrated differences among shelf areas. Although a significant difference for CPUE by number of fish among the three study sites was observed, the differences were small (range: 5.15 - 5.71 fish per trap). No significant difference for CPUE by weight of fish was observed between the NORTH and SOUTH sites. Generally, fish captured at the INSHORE site had smaller average length and comprised a greater proportion of herbivorous fishes. For many species, juvenile nursery grounds are found inshore and juvenile fishes migrate offshore as they grow. Interestingly, average length of fishes was greater for most species captured during these studies than presented in the recent stock assessment of fisheries-dependent data (Appeldoorn et al. 1992; Table 6).

The difference in species abundance and composition between the NORTH and SOUTH sites may be due to two confounding factors: fishing effort and habitat differences. Data from commercial landings reports in the U.S. Virgin Islands

Division of Fish and Wildlife demonstrate much greater landings and trap fishing effort on the south side versus the north side (ratio 3:1) (DFW Annual Summary Report, 1991-1992; DFW files). This is primarily due to demographics and more protected fishing grounds. As presented in the results, CPUE was similar but the proportions of total fish captured of preferred species, such as groupers (Serranidae) and snappers (Lutjanidae), were much greater at the NORTH site. Additionally, average length of fishes were generally larger at the NORTH site. Although habitat differences could account for much of the difference in species abundances and composition, greater fishing effort on the south side is the probable cause of the differences. Shifts in relative abundance appear to have occurred with no relative difference in CPUE between the NORTH and SOUTH sites. Adequate benthic maps and habitat descriptions would assist evaluation. The most effective tests would come from the establishment of marine reserves or closed areas at different sites on the north and south sides followed by a monitoring program to document subsequent changes, if any.

Interesting differences exist between the results from these surveys and results from the fisheries-independent monitoring program conducted by the Fisheries Research Laboratory in Puerto Rico. Data from the western Puerto Rican shelf presented by Rosario Jimenez (1992) and Smith and Ault (1993) show a much lower CPUE for trap data (0.85 fish/trap haul) compared to results from the USVI surveys (5.15-5.71 fish/trap haul;Table 2). The short soak time used in the Puerto Rican survey (6 hours) explains much of the low CPUE but lower CPUE is also expected due to the greater fishing effort off western Puerto Rico (Bohnsack et al. 1986; Appeldoorn et al. 1992). Interestingly, the species composition of the catches from western Puerto Rico were dominated by groupers (Serranidae) and snappers (Lutjanidae) (Rosario Jimenez 1992) instead of less preferred species which can be indicative of overfishing and species shifts. This may be an artifact of using baited traps with short soak time (6 hours).

Soak time must also be carefully considered in monitoring and study design. As seen in Table 7 and Figure 21, soak time greatly influenced CPUE. Optimal soak time for traps used in these studies was 7-8 days. A significantly greater number of fish per trap haul and fish weight per trap haul was observed for 7-day soak time than for 3-day and 4-day soak times (Table 7). Soak time must be tested as trap design changes or sampling modifications are made. Different soak time can yield differences in CPUE and species composition.

Trap design had a profound effect on catches at the INSHORE site. CPUE was significantly lower using the antillean (arrow-head) design (1.5 in hexagonal mesh) than for traps constructed of vinyl-clad, square mesh (1.5 in) and square design. This emphasizes the importance of mesh and design. Additionally, the original traps had been used for several months and yielded declining catch rates. Fishermen state that traps continue to yield lower catches as they age and that periodic removal and rotation improves catches. The important point to note is that traps should be rotated on an established schedule to control for this potential bias.

Fisheries-independent data can demonstrate changes due to natural phenomena. Hurricane Hugo, which passed through the Virgin Islands in September 1989, yielded marked effects at the INSHORE site. Surgeonfishes (Acanthuridae) and parrotfishes (Scaridae) were the dominant fishes in abundance and frequency of occurrence in trap catches prior to the hurricane. The proportion of surgeonfishes in catches decreased after the storm due to the decline in the surgeonfish, blue tang (Acanthurus coeruleus). Ocean surgeonfish (A. bahianus) replaced blue tang in catches following the storm until the end of the study. Parrotfishes (Scaridae) increased in proportion of catch following the storm until the end of the study.

Additional changes in fisheries resources may be expected in the Virgin Islands and Puerto Rico as habitats damaged by the storm recover and as other stresses occur, such as the great increase in coastal development and resulting siltation. Species abundances are constantly changing in response to habitat changes and other natural and anthropogenic stresses, as well as to natural fluctuations from recruitment variability. Adequate resource management depends on analysis of data from long-term monitoring. Natural changes may not be documented using fisheries-dependent data since fishermen maximize yield and avoid fishing in damaged areas.

In conclusion, it should be emphasized that in order to assess fisheries resources over a large area several factors must be considered and sampling design reviewed and modified as additional information and data are obtained. Goals and purposes of monitoring should be reviewed annually. Evaluation of both fisheries-independent and fisheries-dependent data should be conducted. Periodic analysis should be conducted to evaluate design and to provide assessment of resources. In review of monitoring project design, careful attention must be given to factors such as soak time, area sampled, and habitat type. Analysis should always include assessment of species composition as well as catch per unit effort. The potential effects of natural disturbances and changes should be carefully considered.

RECOMMENDATIONS

1) Data management and archiving of fisheries-independent databases, including historic databases, should be a high-priority goal of SEAMAP-Caribbean.

2) Sampling different areas should be incorporated into the SEAMAP-Caribbean monitoring protocol. As demonstrated in this analysis, area differences in CPUE and species composition can yield varying information on the status of fishery resources across the shelf.

3) Although soak time has been standardized in the existing SEAMAP-Caribbean reef fish monitoring protocol, different soak times can yield valuable information on catch per unit effort. Special studies should be conducted periodically to document these differences.

4) Trap design and mesh type are apparently important factors to control. Results from this analysis demonstrated differences in CPUE with different trap design. Based on anecdotal information from fishermen, trap age is apparently also a critical factor which may yield declining catch rates. These factors should be periodically and carefully reviewed.

5) Encourage the development of marine reserves with established monitoring in order to evaluate success of reserves and to assess the resource differences among shelf areas. More detailed assessment of shelf resources should not only provide useful information on fishery resources but provide a basis for evaluation of marine reserve sites.

6) Integrate the British Virgin Islands into monitoring programs. Data from this eastern area of the Puerto Rican Shelf could provide valuable comparative information for assessment.

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Figure 13. Length-frequency histograms for *Haemulon flavolineatum* among three fisheries-independent sampling areas.

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Table 1. Species trapped during fisheries-independent sampling in three areas on the Puerto Rican shelf in the U.S. Virgin Islands. NORTH is north of St. Thomas-St. John, SOUTH is south of St. John; INSHORE is a reef off the southern coast of St. John. Data include number of fish trapped per area (NUMBER), proportion of total fish observed per area (PROP), frequency of occurrence of all fish captured per area (FREQ), and average length in mm of fish captured per area (AV LEN).

FAMILY	GENUS	SPECIES	COMMON	NORTH NUMBER	PROP	FREQ	AV LEN	SOUTH NUMBER	PROP	FREQ	AV LEN	INSHORE NUMBER	PROP	FREQ	AV LEN
Rhincodontidae	Ginglymostoma	cirratum	nurse shark									12	0.003	0.023	785
Holocentridae	Holocentrus	adscensionis	squirrelfish	106	0.0393	0.098	279.6					12	0.003	0.021	227.9
Holocentridae	Holocentrus	rufus	longspine squirrelfish	174	0.0645	0.159	298.1	212	0.186	0.3	252.3	96	0.0238	0.089	194.2
Serranidae	Epinephelus	adscensionis	rock hind	1	0.0004	0.002	370	1	0.0009	0.005	305	3	0.0007	0.006	413.3
Serranidae	Epinephelus	afer	mutton hamlet									16	0.004	0.017	224.3
Serranidae	Epinephelus	cruentatus	graysby	2	0.0007	0.004	290					12	0.003	0.017	239.9
Serranidae	Epinephelus	fulvus	coney	71	0.0263	0.108	249.5	40	0.0351	0.105	258.1	5	0.0012	0.009	221
Serranidae	Epinephelus	guttatus	red hind	262	0.0971	0.348	290	50	0.0439	0.181	291	63	0.0156	0.092	258.5
Serranidae	Epinephelus	mono	red grouper	2	0.0007	0.004	402.5					2	0.0005	0.004	292.5
Serranidae	Epinephelus	striatus	Nassau grouper	2	0.0007	0.002	495	1	0.0009	0.005	540	22	0.0054	0.038	397.5
Serranidae	Mycteroperca	interstitialis	yellowmouth grouper									10	0.0025	0.013	286.5
Serranidae	Mycteroperca	tigris	tiger grouper					1	0.0009	0.005	397	1	0.0002	0.002	275
Serranidae	Mycteroperca	venenosa	yellowfin grouper	1	0.0004	0.002	318	8	0.007	0.038	375	24	0.0059	0.038	411
Priacanthidae	Priacanthus	arenatus	bigeye	2	0.0007	0.004	250					3	0.0007	0.002	225
Priacanthidae	Priacanthus	cruentatus	glasseye snapper	7	0.0026	0.01	291					1	0.0002	0.002	205
Carangidae	Caranx	bartholomaei	yellow jack	109	0.0404	0.09	235.1	141	0.1237	0.219	231	144	0.0356	0.089	211.5
Carangidae	Caranx	latus	horse-eye jack									1	0.0002	0.002	680
Carangidae	Caranx	ruber	bar jack	7	0.0026	0.006	337.9	1	0.0009	0.005	245	10	0.0025	0.013	306
Lutjanidae	Etelis	oculatus	queen snapper	1	0.0004	0.002	400								
Lutjanidae	Lutjanus	analis	mutton snapper	7	0.0026	0.01	415.7					5	0.0012	0.008	321.6
Lutjanidae	Lutjanus	apodus	schoolmaster snapper	25	0.0093	0.031	270.1	4	0.0035	0.019	287.5	65	0.0161	0.066	244.4
Lutjanidae	Lutjanus	griseus	gray snapper									5	0.0012	0.009	250
Lutjanidae	Lutjanus	joco	dog snapper	1	0.0004	0.002	300	1	0.0009	0.005	320	3	0.0007	0.004	286.7
Lutjanidae	Lutjanus	mahogani	mahogany snapper	2	0.0007	0.004	282.5	1	0.0009	0.005	265	5	0.0012	0.008	240
Lutjanidae	Lutjanus	synagris	lane snapper	182	0.0675	0.092	241.8	8	0.007	0.029	254.4	121	0.0299	0.079	213.5
Lutjanidae	Lutjanus	vivanus	silk snapper	18	0.0067	0.014	212.6	4	0.0035	0.01	250				
Lutjanidae	Ocyurus	chrysurus	yellowtail snapper	8	0.003	0.01	329.4	1	0.0009	0.005	285	76	0.0188	0.062	235.5
Lutjanidae	Rhomboplites	aurorubens	vermilion snapper	2	0.0007	0.002	227.5								
Haemulidae	Anisotremus	virginicus	porkfish	4	0.0015	0.006	257.5								
Haemulidae	Haemulon	album	margate	1	0.0004	0.002	280	1	0.0009	0.005	450	7	0.0017	0.008	284.4
Haemulidae	Haemulon	aurolineatum	tomtate									12	0.003	0.011	192.1
Haemulidae	Haemulon	carbonarium	ceasar grunt	1	0.0004	0.002	293								
Haemulidae	Haemulon	flavolineatum	french grunt	173	0.0641	0.108	205.3	62	0.0544	0.062	199.7	139	0.0344	0.096	176.3
Haemulidae	Haemulon	macrostomum	spanish grunt	2	0.0007	0.002	330					1	0.0002	0.002	205
Haemulidae	Haemulon	melanurum	cottonwick	8	0.003	0.012	254.5	21	0.0184	0.048	216.2	2	0.0005	0.002	188.5
Haemulidae	Haemulon	parrai	sailors choice	1	0.0004	0.002	275	2	0.0018	0.01	290	7	0.0017	0.011	196.7
Haemulidae	Haemulon	plumieri	white grunt	205	0.076	0.279	257.6	67	0.0588	0.152	261.4	193	0.0477	0.174	203.5
Haemulidae	Haemulon	sciurus	bluestriped grunt	125	0.0463	0.147	271.4	48	0.0421	0.105	259.1	85	0.021	0.079	242.4
Sparidae	Calamus	calamus	saucereye porgy									139	0.0344	0.072	217.9
Sparidae	Calamus	pennatula	pluma	85	0.0315	0.02	220.6					2	0.0005	0.004	197.5
Sparidae	Calamus	sp.	unidentified porgy	24	0.0089	0.008	232.3					32	0.0079	0.017	201.1
Sciaenidae	Equetus	acuminatus	highhat									3	0.0007	0.006	196.7
Sciaenidae	Equetus	punctatus	spotted drum									2	0.0005	0.004	215.5
Mullidae	Mulloidichthys	martinicus	yellow goatfish	64	0.0237	0.057	264	34	0.0298	0.062	270.7	26	0.0064	0.038	252.9
Mullidae	Pseudupeneus	maculatus	spotted goatfish	2	0.0007	0.004	237.5	3	0.0026	0.005	236.7	43	0.0106	0.043	216.6
Ephippidae	Chaetodipterus	faber	Atlantic spadefish					3	0.0026	0.005	333.3				
Chaetodontidae	Chaetodon	capistratus	foureye butterflyfish	1	0.0004	0.002	105					11	0.0027	0.013	115.4
Chaetodontidae	Chaetodon	striatus	banded butterflyfish	6	0.0022	0.008	131.2					7	0.0017	0.013	122.9
Pomacanthidae	Holacanthus	ciliaris	queen angelfish	4	0.0015	0.004	283.8	5	0.0044	0.024	266	121	0.0299	0.106	176.1
Pomacanthidae	Holacanthus	tricolor	rock beauty	2	0.0007	0.002	170	2	0.0018	0.01		16	0.004	0.021	138.3
Pomacanthidae	Pomacanthus	arcuatus	grey angelfish	36	0.0133	0.045	234.5	7	0.0061	0.019	221.4	27	0.0067	0.042	192.2
Pomacanthidae	Pomacanthus	paru	french angelfish	22	0.0082		233.3	2	0.0018	0.005	217.5	11	0.0027	0.015	189.3
Pomacentridae	Microspathodon	chrysurus	yellowtail damselfish									1	0.0002	0.002	135
Labridae	Bodianus	rufus	spanish hogfish	1	0.0004	0.002	485					4	0.001	0.006	310
Labridae	Lachnolaimus	maximus	hogfish					3	0.0026	0.014	346.7	9	0.0022	0.011	240.6
Scaridae	Scarus	coeruleus	blue parrotfish	2	0.0007	0.002	321								
Scaridae	Scarus	croicensis	striped parrotfish	1	0.0004	0.002	330	11	0.0096	0.01	219	7	0.0017	0.006	235.7
Scaridae	Scarus	taeniopterus	princess parrotfish	1	0.0004	0.002		7	0.0061	0.03	235	50	0.0124	0.057	238.7
Scaridae	Scarus	vetula	queen parrotfish									22	0.0054	0.026	264.1
Scaridae	Sparisoma	aurofrenatum	redband parrotfish	10	0.0037	0.008	224.7	6	0.0053	0.019	220	385	0.0952	0.14	217
Scaridae	Sparisoma	chrysopterum	redtail parrotfish	149	0.0552	0.139	294.7	9	0.0079	0.033	268.9	108	0.0267	0.083	249.4
Scaridae	Sparisoma	rubripinne	yellowtail parrotfish	5	0.0019	0.006	335	2	0.0018	0.005	315	22	0.0054	0.011	237.2
Scaridae	Sparisoma	viride	stoplight parrotfish	16	0.0059	0.02	317.5	17	0.0149	0.057	281.7	93	0.023	0.109	238.8
Acanthuridae	Acanthurus	bahianus	ocean surgeonfish	29	0.0107	0.031	206.6	69	0.0605	0.09	172.7	590	0.146	0.289	164.8
Acanthuridae	Acanthurus	chirurgus	doctorfish	67	0.0248	0.067	243.4	15	0.0132	0.043	232.7	112	0.0277	0.109	187.9
Acanthuridae	Acanthurus	coeruleus	blue tang	154	0.0571	0.139	210	84	0.0737	0.181	190.1	870	0.2152	0.381	160
Bothidae	Bothus	lunatus	peacock flounder	1	0.0004	0.002	290					1	0.0002	0.002	215
Balistidae	Aluterus	scriptus	scrawled filefish	1	0.0004	0.002	379	15	0.0132	0.057	340	3	0.0007	0.004	168.3
Balistidae	Balistes	vetula	queen triggerfish	207	0.0767	0.212	361.6	55	0.0482	0.171	347.8	4	0.001	0.008	207.8
Balistidae	Cantherhines	macroceros	whitespotted filefish	1	0.0004	0.002	354					1	0.0002	0.002	135
Balistidae	Cantherhinus	pullus	orangespotted filefish	2	0.0007	0.002	185	1	0.0009	0.005	170	12	0.003	0.015	159.67
Ostraciidae	Lactophrys	bicaudalis	spotted trunkfish	7	0.0026	0.012	241.3	5	0.0044	0.024	229	19	0.0047	0.023	216.2
Ostraciidae	Lactophrys	polygonia	honeycomb cowfish	282	0.1045	0.151	251.2	95	0.0833	0.195	230.4	12	0.003	0.015	237.9
Ostraciidae	Lactophrys	quadricornis	scrawled cowfish					1	0.0009	0.005	225	18	0.004	0.026	210.7
Ostraciidae	Lactophrys	triqueter	smooth trunkfish	2	0.0007	0.004	127.5	13	0.0114	0.033	221.5	86	0.0213	0.111	175.6
Diodontidae	Diodon	holocanthus	balloonfish					1	0.0009	0.005		4	0.001	0.004	246.2
Diodontidae	Diodon	hystrix	porcupinefish	1	0.0004	0.002	450					8	0.002	0.008	343.1
			NUMBER OF FISH	2697				1140				4042			
			NUMBER OF SPECIES	61				46				70			
			NUMBER OF TRAP HAUL	498				200				529			

Table 2A. Trapping statistics from three areas in the U.S. Virgin Islands with comparative data from Olsen & LaPlace (1981) conducted in the NORTH area and from Rosario Jimenez (1992) from western Puerto Rico.

	NORTH	SOUTH	INSHORE	INSHORE	Olsen & LaPlace (1981)	Rosario Jimenez (1992)
	Antillean traps	Antillean traps	Antillean traps	Square traps	Antillean traps	Antillean traps
Number of fish trapped	2697	1140	1731	2311	na	760
Weight of fish trapped (kg)	819.49	313.44	*	*	2339.9	334.98
Number of trap hauls	498	200	336	187	1016	892
Average number of fish per trap haul	5.239	5.705	5.152	12.369	na	0.852
Standard deviation	4.122	5.32	6.899	11.574	na	na
Average weight of fish per trap (kg)	1.646	1.567	*	*	2.303	0.376

* Specimens released - weights not recorded
na - not available

Table 2B. Results of nonparametric tests of trap data for the three survey areas.
Data used were for antillean-style traps with hexagonal mesh with soaktime = 7 days.
Underlined means denote no significant difference ($p = 0.05$).

	NORTH	SOUTH	INSHORE	STATISTIC	P
Average number of fish per trap haul	7.91	7.87	6.07	KW = 8.725	0.013
Standard deviation	12.73	7.079	7.37		
Average weight of fish per trap (kg)	2.32	2.294	*	MW U= 1811.0	0.823
Standard deviation	1.327	1.479			
Number of trap hauls	65	67	83		

Table 3. Relative abundance of 15 numically dominant species among the three sampling areas. NUMBER is number of fish trapped per area; PROP is proportion of total fish trapped per area; FREQ is frequency of occurrence of total fish trapped in each area; AV LEN is the average length in mm of fish trapped per area.

NORTH SIDE

GENUS	SPECIES	COMMON	NUMBER	PROP	FREQ	AV LEN
Lactophrys	polygonia	honeycomb cowfish	282	0.1045	0.151	251.2
Epinephelus	guttatus	red hind	262	0.0971	0.348	290
Balistes	vetula	queen triggerfish	207	0.0767	0.212	361.6
Haemulon	plumieri	white grunt	205	0.076	0.279	257.6
Lutjanus	synagris	lane snapper	182	0.0675	0.092	241.8
Holocentrus	rufus	longspine squirrelfish	174	0.0645	0.159	296.1
Haemulon	flavolineatum	french grunt	173	0.0641	0.108	205.3
Acanthurus	coeruleus	blue tang	154	0.0571	0.139	210
Sparisoma	chrysopterum	redtail parrotfish	149	0.0552	0.139	294.7
Haemulon	sciurus	bluestriped grunt	125	0.0463	0.147	271.4
Caranx	bartholomaei	yellow jack	109	0.0404	0.09	235.1
Holocentrus	adscensionis	squirrelfish	106	0.0393	0.098	279.6
Calamus	pennatula	pluma	85	0.0315	0.02	220.6
Epinephelus	fulvus	coney	71	0.0263	0.108	249.5
Acanthurus	chirurgus	doctorfish	67	0.0248	0.067	243.4

SOUTH SIDE

GENUS	SPECIES	COMMON	NUMBER	PROP	FREQ	AV LEN
Holocentrus	rufus	longspine squirrelfish	212	0.186	0.3	252.3
Caranx	bartholomaei	yellow jack	141	0.1237	0.219	231
Lactophrys	polygonia	honeycomb cowfish	95	0.0833	0.195	230.4
Acanthurus	coeruleus	blue tang	84	0.0737	0.181	190.1
Acanthurus	bahianus	ocean surgeonfish	69	0.0605	0.09	172.7
Haemulon	plumieri	white grunt	67	0.0588	0.152	261.4
Haemulon	flavolineatum	french grunt	62	0.0544	0.062	199.7
Balistes	vetula	queen triggerfish	55	0.0482	0.171	347.8
Epinephelus	guttatus	red hind	50	0.0439	0.181	291
Haemulon	sciurus	bluestriped grunt	48	0.0421	0.105	259.1
Epinephelus	fulvus	coney	40	0.0351	0.105	258.1
Mulloidichthys	martinicus	yellow goatfish	34	0.0298	0.062	270.7
Haemulon	melanurum	cottonwick	21	0.0184	0.048	216.2
Sparisoma	viride	stoplight parrotfish	17	0.0149	0.057	281.7
Acanthurus	chirurgus	doctorfish	15	0.0132	0.043	232.7

INSHORE

GENUS	SPECIES	COMMON	NUMBER	PROP	FREQ	AV LEN
Acanthurus	coeruleus	blue tang	870	0.2152	0.381	160
Acanthurus	bahianus	ocean surgeonfish	590	0.146	0.289	164.8
Sparisoma	aurofrenatum	redband parrotfish	385	0.0952	0.14	217
Haemulon	plumieri	white grunt	193	0.0477	0.174	203.5
Caranx	bartholomaei	yellow jack	144	0.0356	0.089	211.5
Calamus	calamus	saucereye porgy	139	0.0344	0.072	217.9
Haemulon	flavolineatum	french grunt	139	0.0344	0.096	176.3
Lutjanus	synagris	lane snapper	121	0.0299	0.079	213.5
Holacanthus	ciliaris	queen angelfish	121	0.0299	0.106	176.1
Acanthurus	chirurgus	doctorfish	112	0.0277	0.109	167.9
Sparisoma	chrysopterum	redtail parrotfish	108	0.0267	0.083	249.4
Holocentrus	rufus	longspine squirrelfish	96	0.0238	0.089	194.2
Sparisoma	viride	stoplight parrotfish	93	0.023	0.109	238.8
Lactophrys	triqueter	smooth trunkfish	86	0.0213	0.111	175.6
Haemulon	sciurus	bluestriped grunt	85	0.021	0.079	242.4

Table 4. Rank by frequency of occurrence of 15 species among three sampling areas.
NUMBER is number of fish trapped per area; PROP is proportion of total fish trapped per area; FREQ is frequency of occurrence of total fish trapped in each area; AV LEN is the average length in mm of fish trapped per area.

NORTH GENUS	SPECIES	COMMON	NUMBER	PROP	FREQ	AV LEN
Epinephelus	guttatus	red hind	262	0.0971	0.348	290
Haemulon	plumieri	white grunt	205	0.076	0.279	257.6
Balistes	vetula	queen triggerfish	207	0.0767	0.212	361.6
Holocentrus	rufus	longspine squirrelfish	174	0.0645	0.159	296.1
Lactophrys	polygonia	honeycomb cowfish	282	0.1045	0.151	251.2
Haemulon	sciurus	bluestriped grunt	125	0.0463	0.147	271.4
Acanthurus	coeruleus	blue tang	154	0.0571	0.139	210
Sparisoma	chrysopterum	redtail parrotfish	149	0.0552	0.139	294.7
Haemulon	flavolineatum	french grunt	173	0.0641	0.108	205.3
Epinephelus	fulvus	coney	71	0.0263	0.108	249.5
Holocentrus	adscensionis	squirrelfish	106	0.0393	0.098	279.6
Lutjanus	synagris	lane snapper	182	0.0675	0.092	241.8
Caranx	bartholomaei	yellow jack	109	0.0404	0.09	235.1
Acanthurus	chirurgus	doctorfish	67	0.0248	0.067	243.4
Mulloidichthys	martinicus	yellow goatfish	64	0.0237	0.057	264

SOUTH GENUS	SPECIES	COMMON	NUMBER	PROP	FREQ	AV LEN
Holocentrus	rufus	longspine squirrelfish	212	0.186	0.3	252.3
Caranx	bartholomaei	yellow jack	141	0.1237	0.219	231
Lactophrys	polygonia	honeycomb cowfish	95	0.0833	0.195	230.4
Acanthurus	coeruleus	blue tang	84	0.0737	0.181	190.1
Epinephelus	guttatus	red hind	50	0.0439	0.181	291
Balistes	vetula	queen triggerfish	55	0.0482	0.171	347.8
Haemulon	plumieri	white grunt	67	0.0588	0.152	261.4
Epinephelus	fulvus	coney	40	0.0351	0.105	258.1
Haemulon	sciurus	bluestriped grunt	48	0.0421	0.105	259.1
Acanthurus	bahianus	ocean surgeonfish	69	0.0605	0.09	172.7
Mulloidichthys	martinicus	yellow goatfish	34	0.0298	0.062	270.7
Haemulon	flavolineatum	french grunt	62	0.0544	0.062	199.7
Aluterus	scriptus	scrawled filefish	15	0.0132	0.057	340
Sparisoma	viride	stoplight parrotfish	17	0.0149	0.057	281.7
Haemulon	melanurum	cottonwick	21	0.0184	0.048	216.2

INSHORE GENUS	SPECIES	COMMON	NUMBER	PROP	FREQ	AV LEN
Acanthurus	coeruleus	blue tang	870	0.2152	0.381	160
Acanthurus	bahianus	ocean surgeonfish	590	0.146	0.289	164.8
Haemulon	plumieri	white grunt	193	0.0477	0.174	203.5
Sparisoma	aurofrenatum	redband parrotfish	385	0.0952	0.14	217
Lactophrys	triqueter	smooth trunkfish	86	0.0213	0.111	175.6
Sparisoma	viride	stoplight parrotfish	93	0.023	0.109	238.8
Acanthurus	chirurgus	doctorfish	112	0.0277	0.109	167.9
Holacanthus	ciliaris	queen angelfish	121	0.0299	0.106	176.1
Haemulon	flavolineatum	french grunt	139	0.0344	0.096	176.3
Epinephelus	guttatus	red hind	63	0.0156	0.092	258.5
Caranx	bartholomaei	yellow jack	144	0.0356	0.089	211.5
Holocentrus	rufus	longspine squirrelfish	96	0.0238	0.089	194.2
Sparisoma	chrysopterum	redtail parrotfish	108	0.0267	0.083	249.4
Haemulon	sciurus	bluestriped grunt	85	0.021	0.079	242.4
Lutjanus	synagris	lane snapper	121	0.0299	0.079	213.5

Table 5. Abundance and proportion of total fish captured (PROP) for the 12 dominant families by study site.

FAMILY	COMMON NAME	NORTH NUMBER	PROP	SOUTH NUMBER	PROP	INSHORE NUMBER	PROP
Holocentridae	squirrelfishes	280	0.1038	212	0.186	108	0.0267
Serranidae	groupers	341	0.1264	101	0.0886	158	0.0391
Carangidae	jacks	116	0.043	142	0.1246	155	0.0383
Lutjanidae	snappers	246	0.0912	19	0.0167	280	0.0693
Haemulidae	grunts	520	0.1928	201	0.1763	446	0.1103
Sparidae	porgies	109	0.0404	0	0	173	0.0428
Mullidae	goatfishes	66	0.0245	37	0.0325	69	0.0171
Pomacanthidae	angelfishes	64	0.0237	16	0.014	176	0.0435
Scaridae	parrotfishes	184	0.0682	52	0.0456	687	0.17
Acanthuridae	surgeonfishes	250	0.0927	168	0.1474	1572	0.3889
Balistidae	filefishes	211	0.0782	71	0.0623	20	0.0049
Ostraciidae	trunkfishes	291	0.1079	114	0.1	133	0.0329

Table 6. Average length in mm (AV LEN) and number of fish captured (N) of 20 dominant fish species captured during fisheries-independent trap surveys among three study areas and from fisheries-dependent data from St. Thomas/St. John, St. Croix, and Puerto Rico for 1985 and 1990 (from Appeldoorn et al. 1992).

A. Average length data and sample size from three sampling areas during present study.

GENUS	SPECIES	COMMON NAME	NORTH AV LEN	N	SOUTH AV LEN	N	INSHORE AV LEN	N
Holocentrus	adscensionis	squirrelfish	279.6	106			227.9	12
Holocentrus	rufus	longspine squirrelfish	296.1	174	252.3	212	194.2	96
Epinephelus	fulvus	coney	249.5	71	258.1	40	221	6
Epinephelus	guttatus	red hind	290	262	291	50	258.5	63
Caranx	bartholomaei	yellow jack	235.1	109	231	141	211.5	144
Lutjanus	synagris	lane snapper	241.8	182	254.4	8	213.5	121
Haemulon	flavolineatum	french grunt	205.3	173	199.7	62	176.3	139
Haemulon	plumieri	white grunt	257.6	205	261.4	67	203.5	193
Haemulon	sciurus	bluestriped grunt	271.4	125	259.1	48	242.4	85
Calamus	calamus	saucereye porgy					217.9	139
Calamus	pennatula	pluma	220.6	85			197.6	2
Holacanthus	ciliaris	queen angelfish	283.6	4	288	5	176.1	121
Sparisoma	aurofrenatum	redband parrotfish	224.7	10	220	8	217	385
Sparisoma	chrysopterum	redtail parrotfish	294.7	149	288.9	9	249.4	108
Sparisoma	viride	stoplight parrotfish	317.5	16	281.7	17	238.8	93
Acanthurus	bahianus	ocean surgeonfish	206.6	29	172.7	69	164.8	590
Acanthurus	chirurgus	doctorfish	243.4	67	232.7	15	167.9	112
Acanthurus	coeruleus	blue tang	210	154	190.1	84	160	870
Balistes	vetula	queen triggerfish	361.6	207	347.8	55	207.8	4
Lactophrys	polygonia	honeycomb cowfish	251.2	282	230.4	95	237.9	12

B. Average length data from fisheries-dependent sampling in St. Thomas/St. John, St. Croix, and Puerto Rico.

GENUS	SPECIES	COMMON NAME	ST. THOMAS/ST. JOHN AV LEN 1985	N	AV LEN 1990	N	ST. CROIX AV LEN 1985	N	AV LEN 1990	N	PUERTO RICO AV LEN 1985	N	AV LEN 1990	N
Holocentrus	adscensionis	squirrelfish	218	99	252.5	2	204.9	187	227	4			217	[illegible]
Holocentrus	rufus	longspine squirrelfish			195	86			225.2	6			219	
Epinephelus	fulvus	coney	243.7	189	218.8	21	230.3	1644	243.7	20	232	592	231.3	22
Epinephelus	guttatus	red hind	334.8	448	262.4	21	307.3	567	339	469	276.3	732	302.9	77
Caranx	bartholomaei	yellow jack	263	5			382.7	10					419.2	10
Lutjanus	synagris	lane snapper	259.8	103	210	8	220.8	4	238.3	8	220.9	429	232.8	217
Haemulon	flavolineatum	french grunt	198.3	12	171.5	27	190.4	232	184.8	14	191.9	208	180.6	46
Haemulon	plumieri	white grunt	289.9	39	209.5	75	217.9	1588	218.7	603	213.4	1098	218	264
Haemulon	sciurus	bluestriped grunt	249.4	23	215.1	55	234.1	138			219.3	105	211.4	18
Calamus	calamus	saucereye porgy												
Calamus	pennatula	pluma												
Holacanthus	ciliaris	queen angelfish	294.3	14	206.4	7	276.1	9	359.5	67				
Sparisoma	aurofrenatum	redband parrotfish	223.2	25	223	15	216.7	217	240.9	16			234.1	5
Sparisoma	chrysopterum	redtail parrotfish	284.1	93	249	51	262.4	1862	253.9	1253			259.4	72
Sparisoma	viride	stoplight parrotfish	315	53	243.5	37	283.3	1693	269.1	1257	180	1	276.8	77
Acanthurus	bahianus	ocean surgeonfish			166.9	189	190	355	188.8	135				
Acanthurus	chirurgus	doctorfish	249	139	188.9	23	233.2	227	218.4	575				
Acanthurus	coeruleus	blue tang	200.1	410	160.3	199	184.8	2063	171.2	1162				
Balistes	vetula	queen triggerfish	316.4	509	288.8	44	282.4	815	265	180	275.4	342	269.4	12
Lactophrys	polygonia	honeycomb cowfish			185	86	246.8	199	241.8	622	230.9	203	222.6	12

Table 7. Results of nonparametric tests of trap data for the NORTH site with soak times of 3, 4, and 7 days. Data used were for antillean-style traps with hexagonal mesh. Underlined means denote no significant difference ($p = 0.05$).

	3 DAY SOAK	4 DAY SOAK	7 DAY SOAK	STATISTIC	P
Average number of fish per trap haul	4.91	5.09	7.91	KW = 7.492	0.024
Standard deviation	3.09	3.14	12.73		
Average weight of fish per trap (kg)	1.699	1.852	2.683	KW = 11.864	0.003
Standard deviation	0.766	0.807	3.082		
Number of trap hauls	87	124	65		

Table 8. Number of fishes tagged and recaptured and proportion recaptured by species using six fish traps at INSHORE site, 1989 – 1992.

SPECIES		COMMON NAME	NO. FISH TAGGED	NO. FISH RECAPTURED	PROPORTION RECAPTURED
Mycteroperca	interstitialis	yellowmouth grouper	3	3	1
Ginglymostoma	cirratum	nurse shark	4	2	0.5
Lachnolaimus	maximus	hogfish	5	2	0.4
Pomacanthus	arcuatus	grey angelfish	15	6	0.4
Epinephelus	striatus	Nassau grouper	11	4	0.364
Mycteroperca	venenosa	yellowfin grouper	14	5	0.357
Lactophrys	triqueter	smooth trunkfish	48	14	0.292
Haemulon	aurolineatum	tomtate	8	2	0.25
Haemulon	parrai	sailors choice	4	1	0.25
Holocentrus	adscensionis	longjaw squirrelfish	4	1	0.25
Scarus	vetula	queen parrotfish	4	1	0.25
Haemulon	plumieri	white grunt	85	19	0.224
Holacanthus	tricolor	rock beauty	5	1	0.2
Acanthurus	coeruleus	blue tang	377	65	0.172
Holocanthus	ciliaris	queen angelfish	49	7	0.143
Holocentrus	rufus	longspine squirrelfish	42	6	0.143
Lactophrys	quadricornis	scrawled cowfish	7	1	0.143
Lutjanus	apodus	schoolmaster snapper	31	4	0.129
Calamus	sp.	unidentified porgy	8	1	0.125
Acanthurus	chirurgus	doctorfish	68	8	0.118
Epinephelus	guttatus	red hind	35	4	0.114
Lutjanus	synagris	lane snapper	78	7	0.09
Acanthurus	bahianus	ocean surgeonfish	335	27	0.081
Sparisoma	chrysopterum	redtail parrotfish	40	3	0.075
Haemulon	sciurus	bluestriped grunt	29	2	0.069
Sparisoma	aurofrenatum	redband parrotfish	68	4	0.059
Scarus	taeniopterus	princess parrotfish	18	1	0.056
Caranx	bartholomaei	yellow jack	105	4	0.038
Sparisoma	viride	stoplight parrotfish	54	1	0.019
Calamus	calamus	saucereye porgy	64	1	0.016
Aluterus	scriptus	scrawled filefish	3		
Bodianus	rufus	spanish hogfish	2		
Caranx	latus	horse-eye jack	1		
Calamus	pennatula	pluma	2		
Cantherhinus	pullus	orangespotted filefish	2		
Caranx	ruber	bar jack	3		
Chaetodon	capistratus	foureye butterflyfish	1		
Chaetodon	striatus	banded butterflyfish	1		
Diodon	holocanthus	ballonfish	4		
Diodon	hystrix	porcupinefish	7		
Epinephelus	afer	mutton hamlet	11		
Epinephelus	cruentatus	graysby	9		
Epinephelus	fulvus	coney	5		
Equetus	acuminatus	highhat	3		
Haemulon	album	margate	1		
Haemulon	flavolineatum	french grunt	52		
Haemulon	macrostomum	spanish grunt	1		
Lactophrys	bicaudalis	spotted trunkfish	5		
Lactophrys	polygonia	honeycomb cowfish	5		
Lutjanus	analis	mutton snapper	1		
Lutjanus	griseus	gray snapper	5		
Lutjanus	joco	dog snapper	3		
Lutjanus	mahogani	mahogany snapper	5		
Mulloidichthys	martinicus	yellow goatfish	10		
Mycteroperca	tigris	tiger grouper	1		
Ocyurus	chrysurus	yellowtail snapper	42		
Pomacanthus	paru	french angelfish	3		
Priacanthus	arenatus	bigeye	3		
Pseudupeneus	maculatus	spotted goatfish	25		
Sparisoma	rubripinne	yellowtail parrotfish	5		
TOTAL NUMBER OF FISH TAGGED/RECAPTURED			1839	207	
TOTAL NUMBER OF SPECIES TAGGED/RECAPTURED			59	29	

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Figure 18. Length-frequency histograms for *Sparisoma viride* among three fisheries-independent sampling areas.

Figure 19. Length-frequency histograms for *Acanthurus bahianus* among three fisheries-independent sampling areas.

Figure 20. Length-frequency histograms for *Acanthurus coeruleus* among three fisheries-independent sampling areas.

Figure 21. Average number of fish per trap haul by soak time for each sampling area. Data are presented separately for antillean-style traps with 1.5-inch hexagonal mesh (HEXAGONAL) and square traps with 1.5-inch square mesh (SQUARE) for the INSHORE area. Number of trap hauls for each soak time are presented at top of each graph.

Figure 22. Proportion of surgeonfishes (Acanthuridae) and parrotfishes (Scaridae) captured at the INSHORE site before and after Hurricane Hugo.

Figure 23. Proportion of three species of surgeonfishes (Acanthuridae) captured at the INSHORE site before and after Hurricane Hugo.

Figure 24. Proportion of groupers (Serranidae) and snappers (Lutjanidae) captured at the INSHORE site before and after Hurricane Hugo.

Figure 25. Proportion of grunts (Haemulidae) and porgies (Sparidae) captured at the INSHORE site before and after Hurricane Hugo.

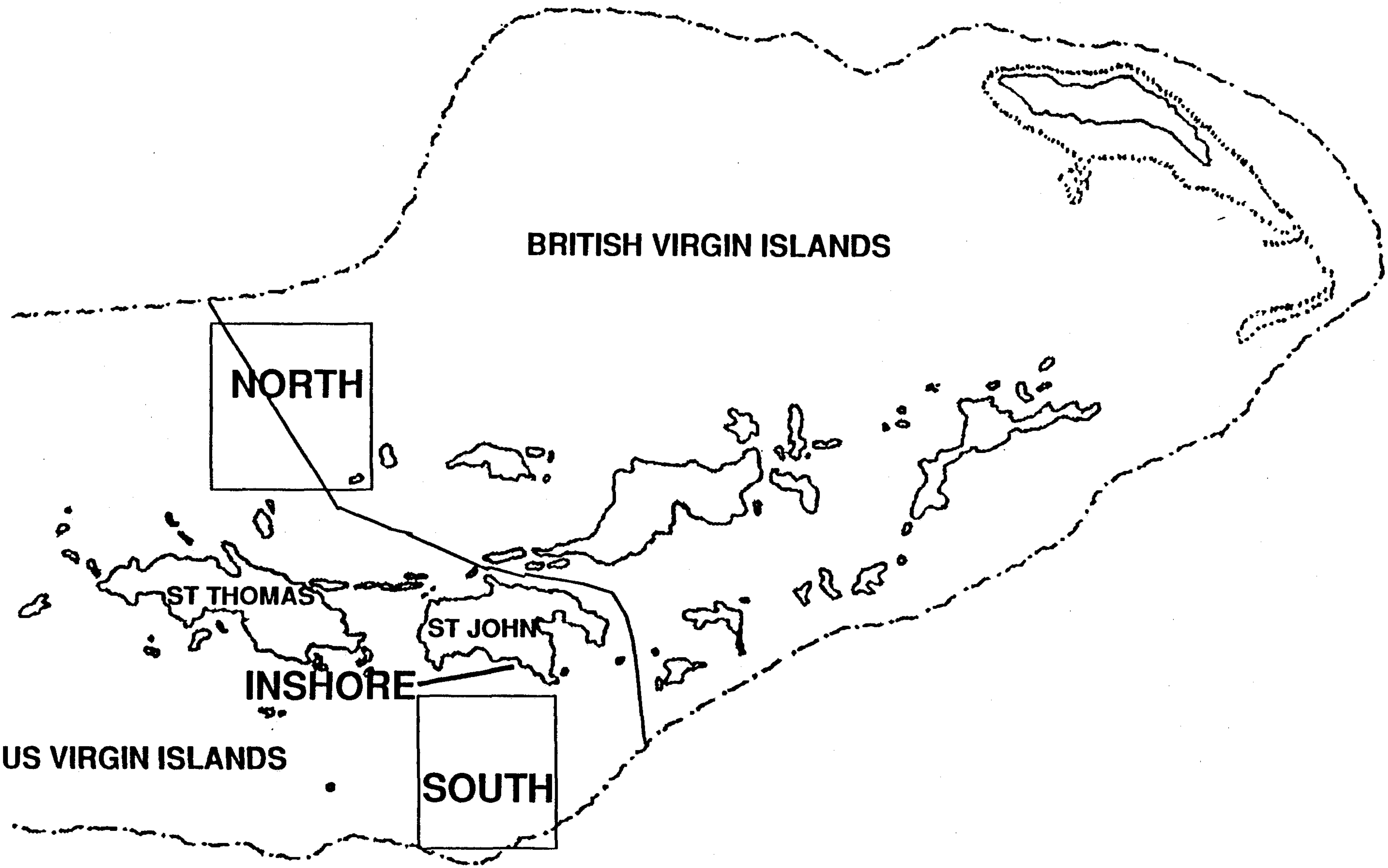


FIGURE 1. LOCATIONS OF THREE SURVEY SITES: NORTH, SOUTH AND INSHORE.

FIGURE 2

NORTH SIDE SAMPLING
CPUE PER SAMPLING PERIOD

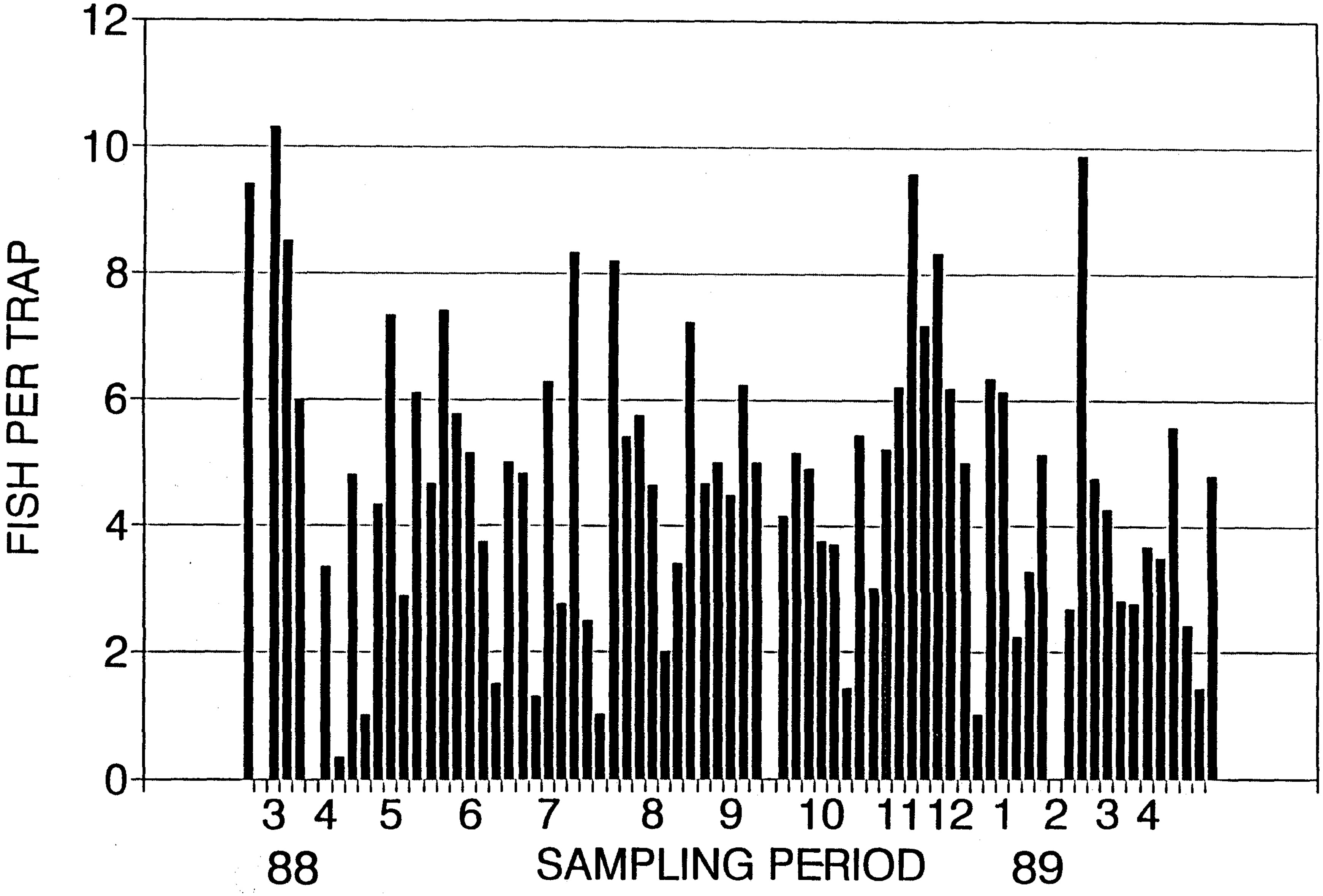


FIGURE 3

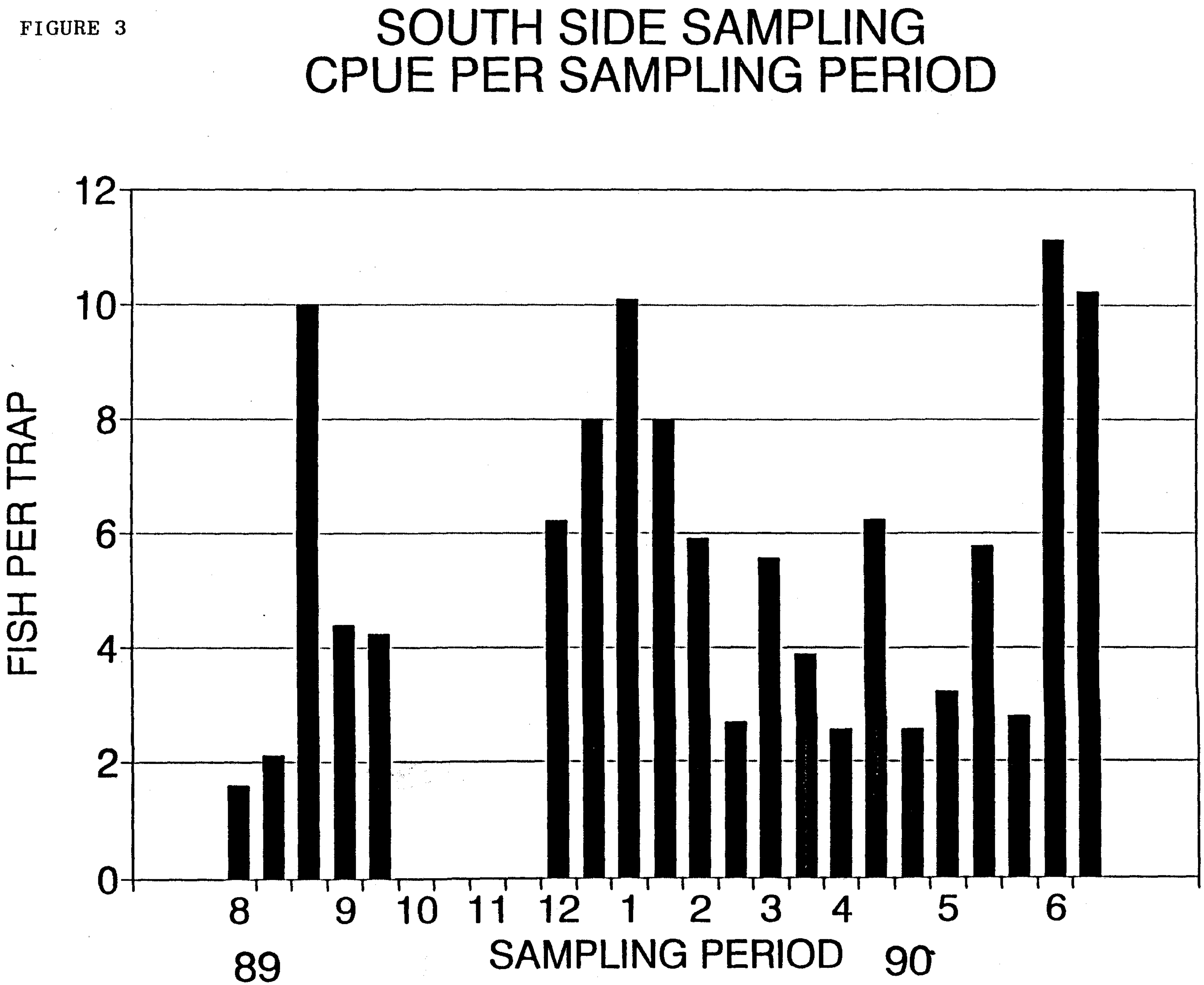

SOUTH SIDE SAMPLING
CPUE PER SAMPLING PERIOD
FISH PER TRAP
0
2
4
6
8
10
12
8
9
10
11
12
1
2
3
4
5
6
SAMPLING PERIOD
89
90

FIGURE 4

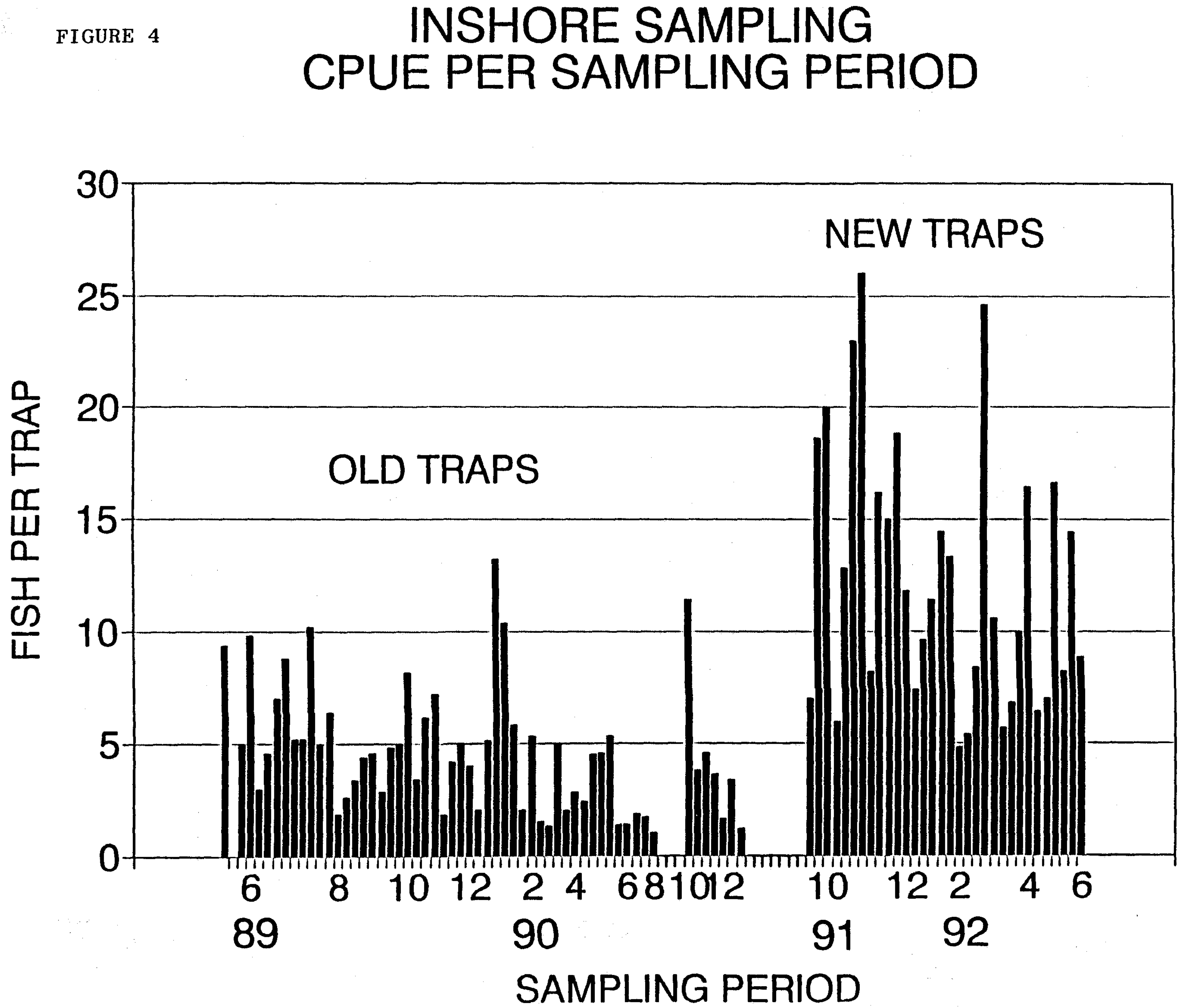
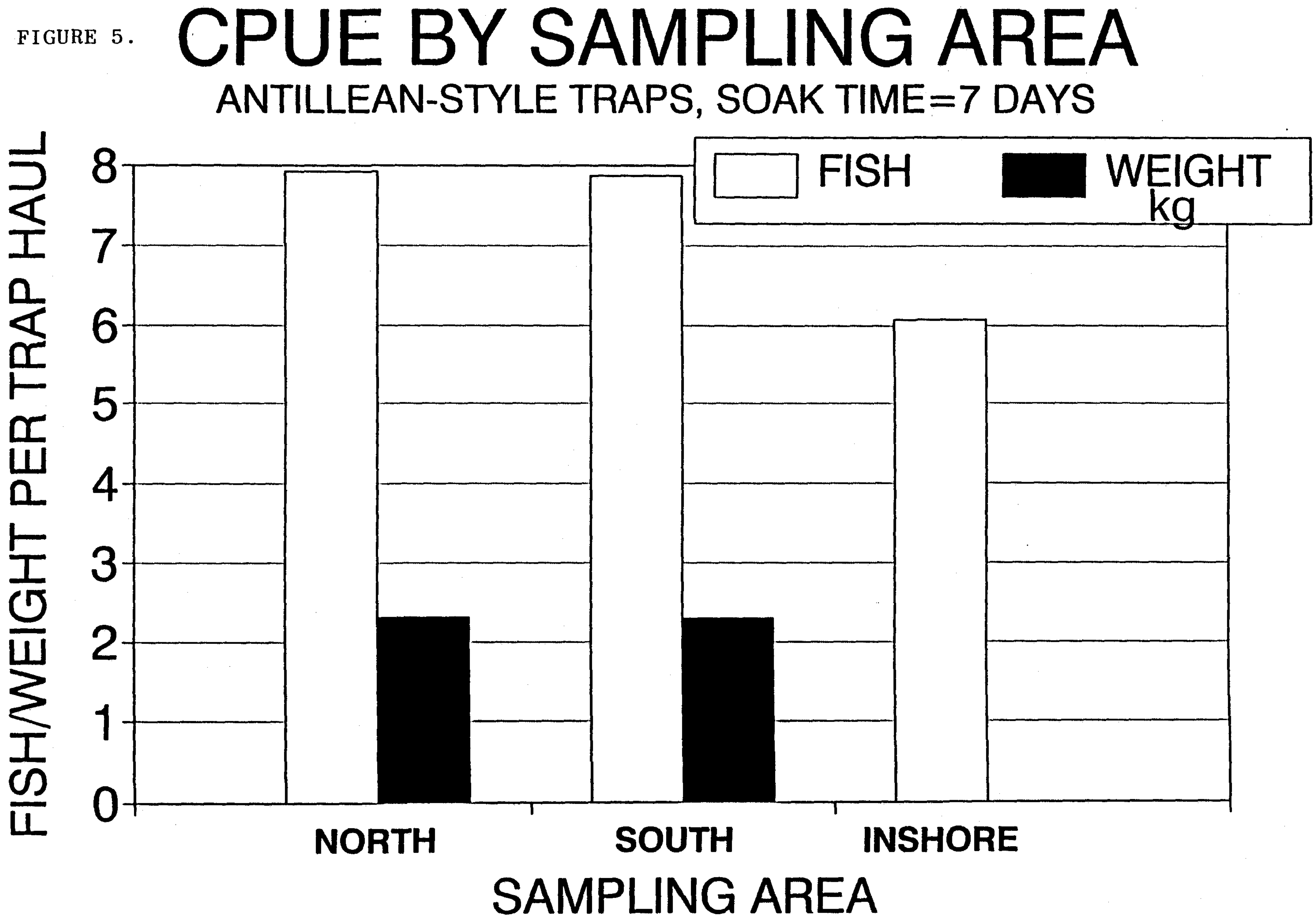

INSHORE SAMPLING
CPUE PER SAMPLING PERIOD
30
25
20
15
10
5
0
FISH PER TRAP
NEW TRAPS
OLD TRAPS
6
8
10
12
2
4
6
8
10
12
10
12
2
4
6
89
90
91
92
SAMPLING PERIOD

FIGURE 5.


CPUE BY SAMPLING AREA
ANTILLEAN-STYLE TRAPS, SOAK TIME=7 DAYS
FISH/WEIGHT PER TRAP HAUL
8
7
6
5
4
3
2
1
0
FISH
WEIGHT kg
NORTH
SOUTH
INSHORE
SAMPLING AREA

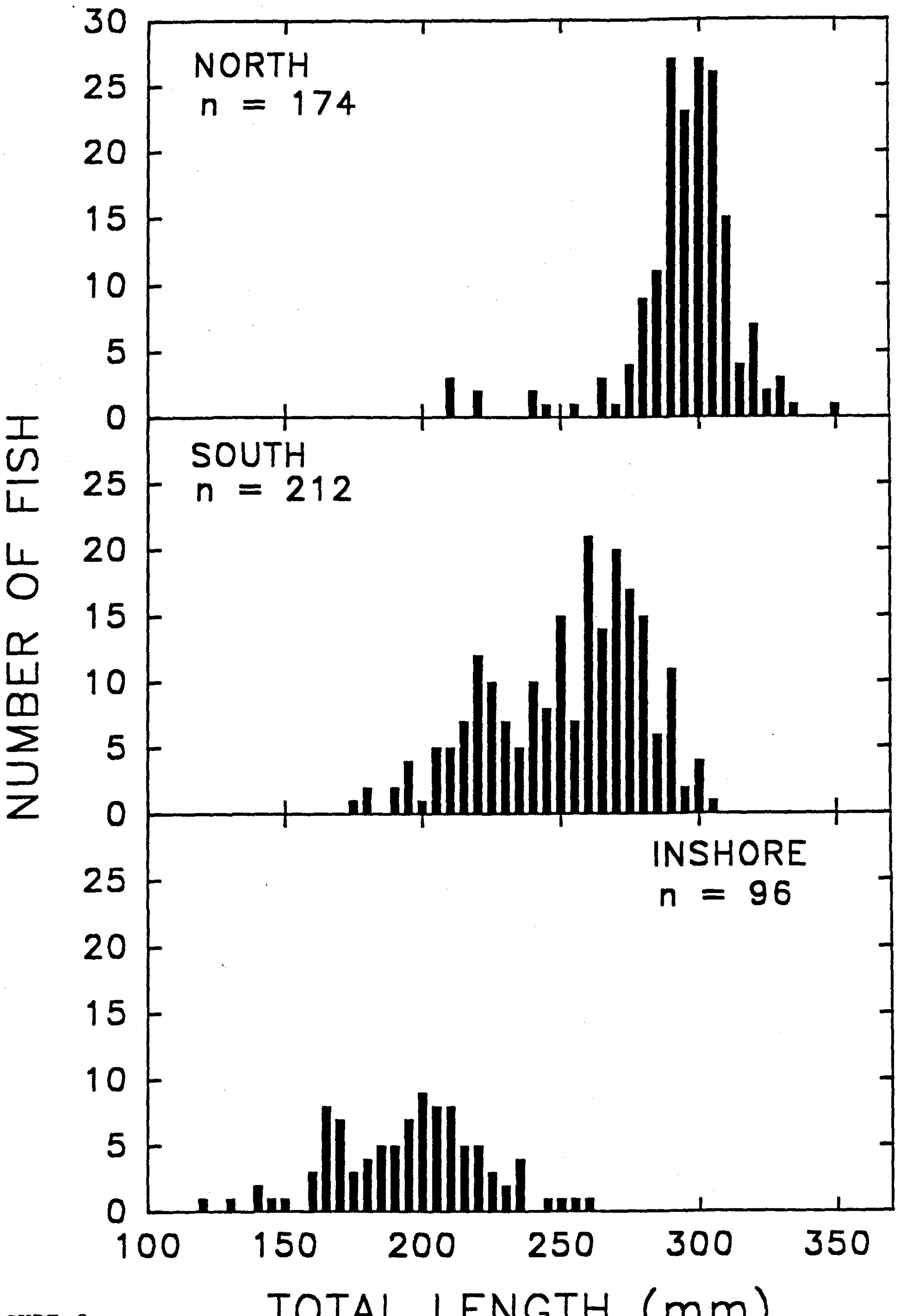


FIGURE 6.
Length-frequency histograms for *Holocentrus rufus*

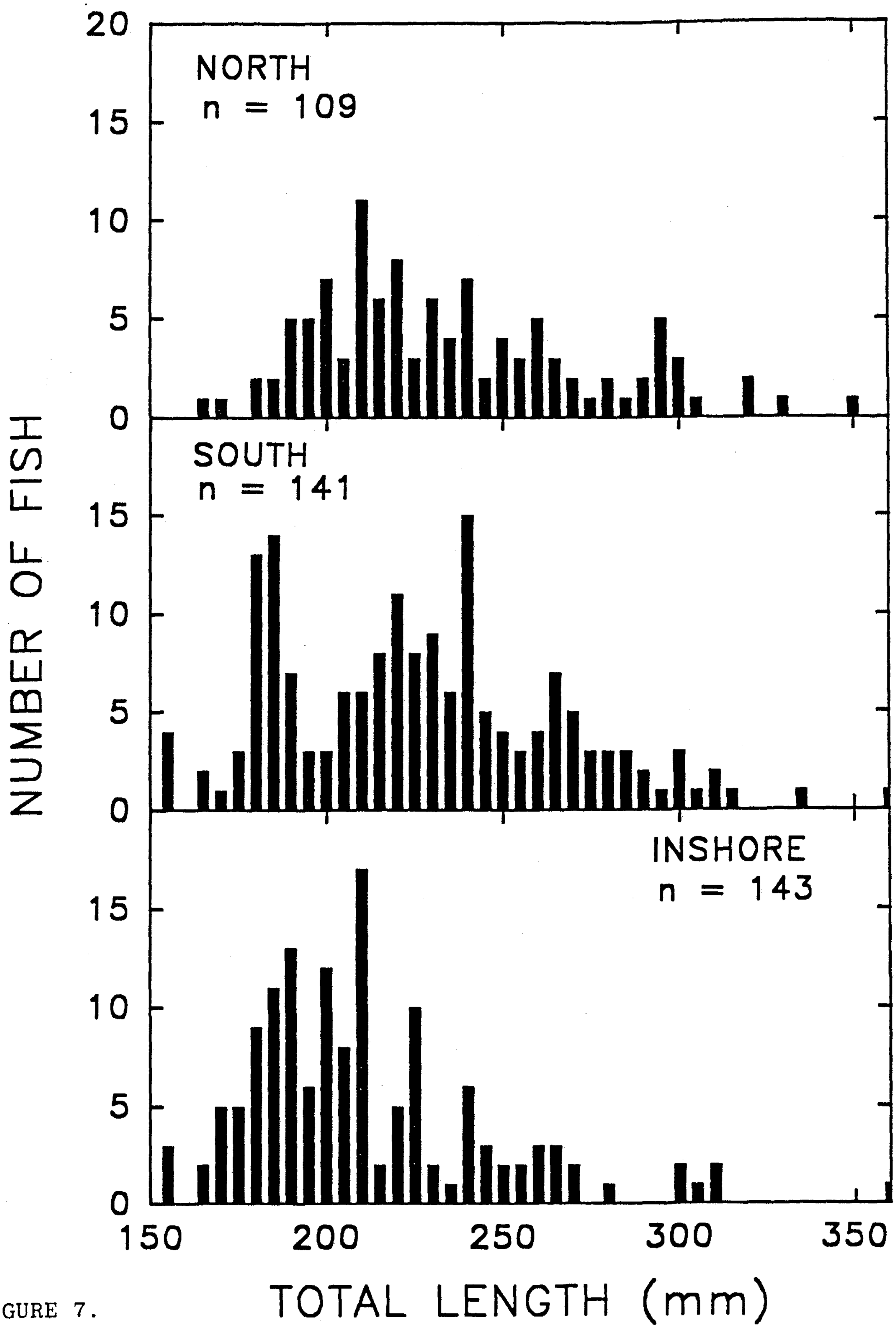


FIGURE 7.

Length–frequency histograms for *Caranx bartholomaei*

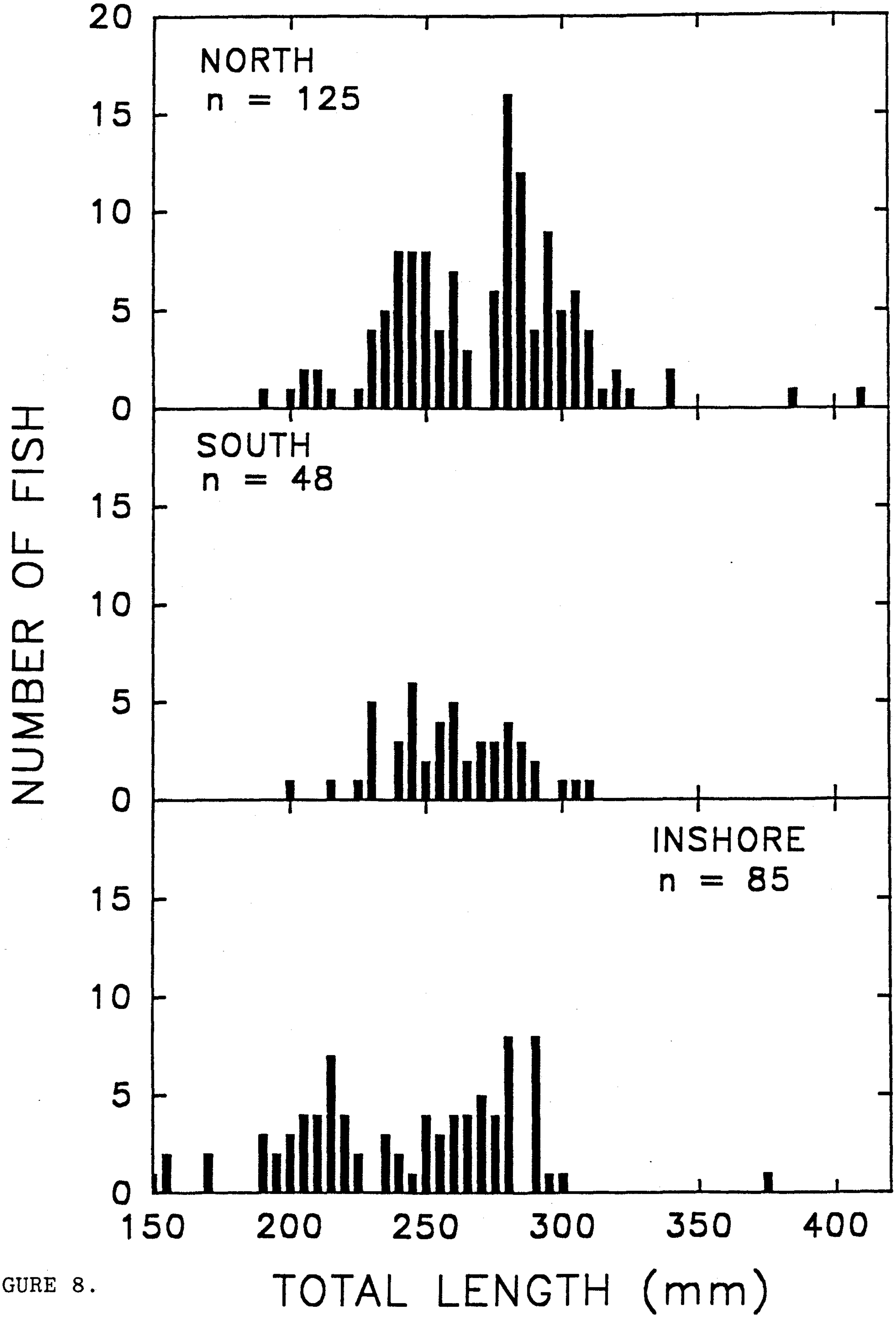


FIGURE 8.

Length-frequency histograms for *Haemulon sciurus*

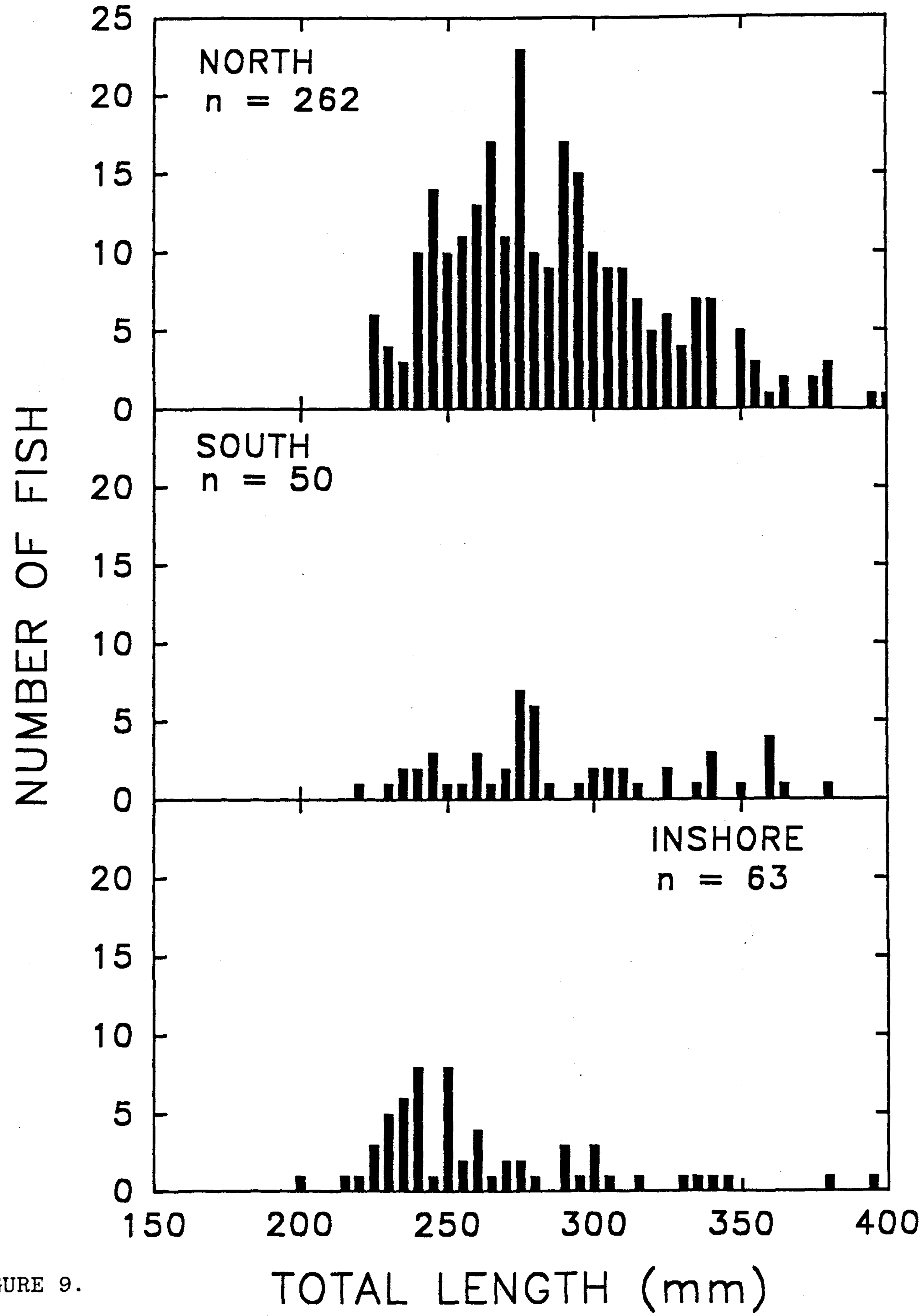


FIGURE 9.
Length–frequency histograms for *Epinephelus guttatus*

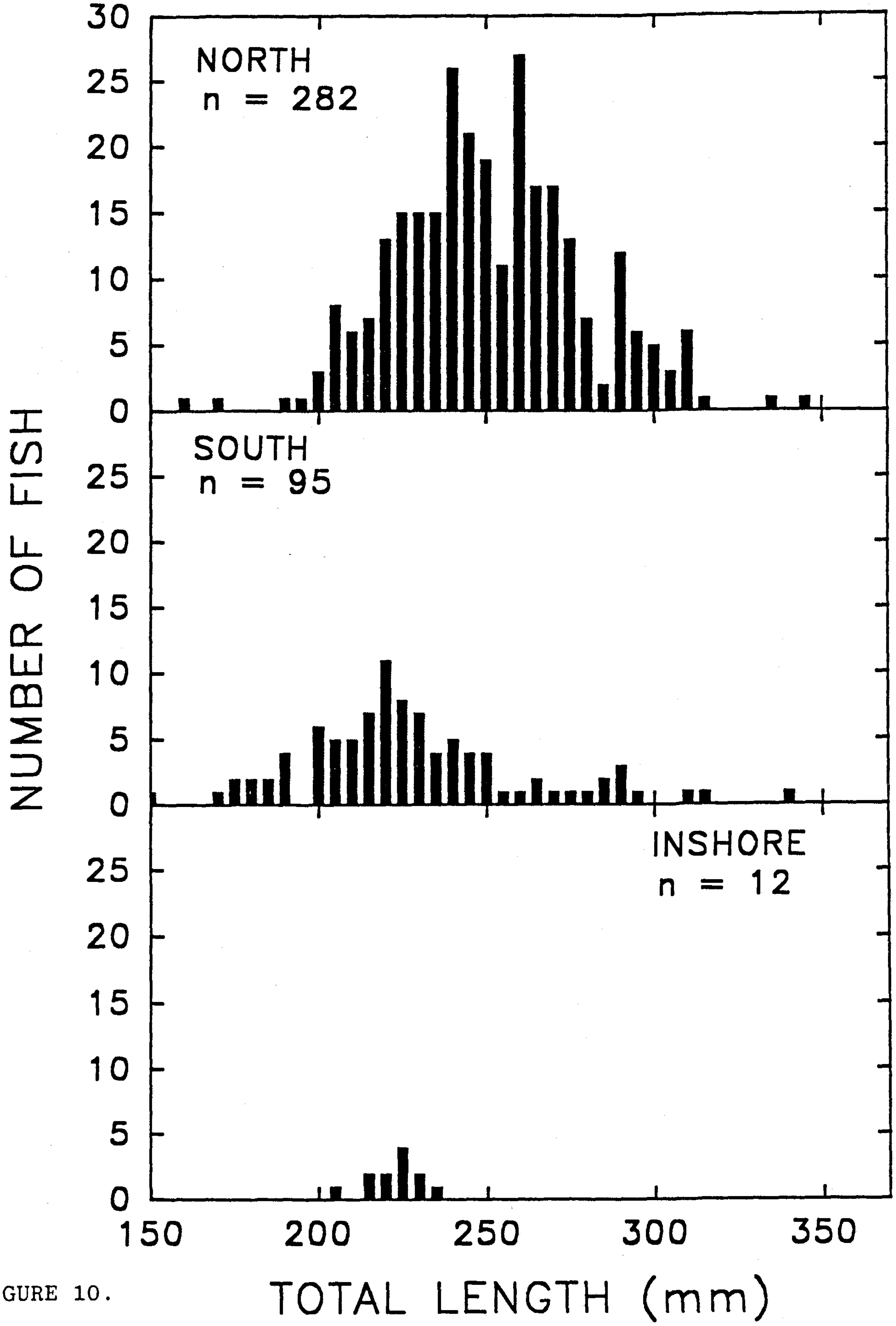


FIGURE 10.

Length–frequency histograms for *Lactophrys polygoni*

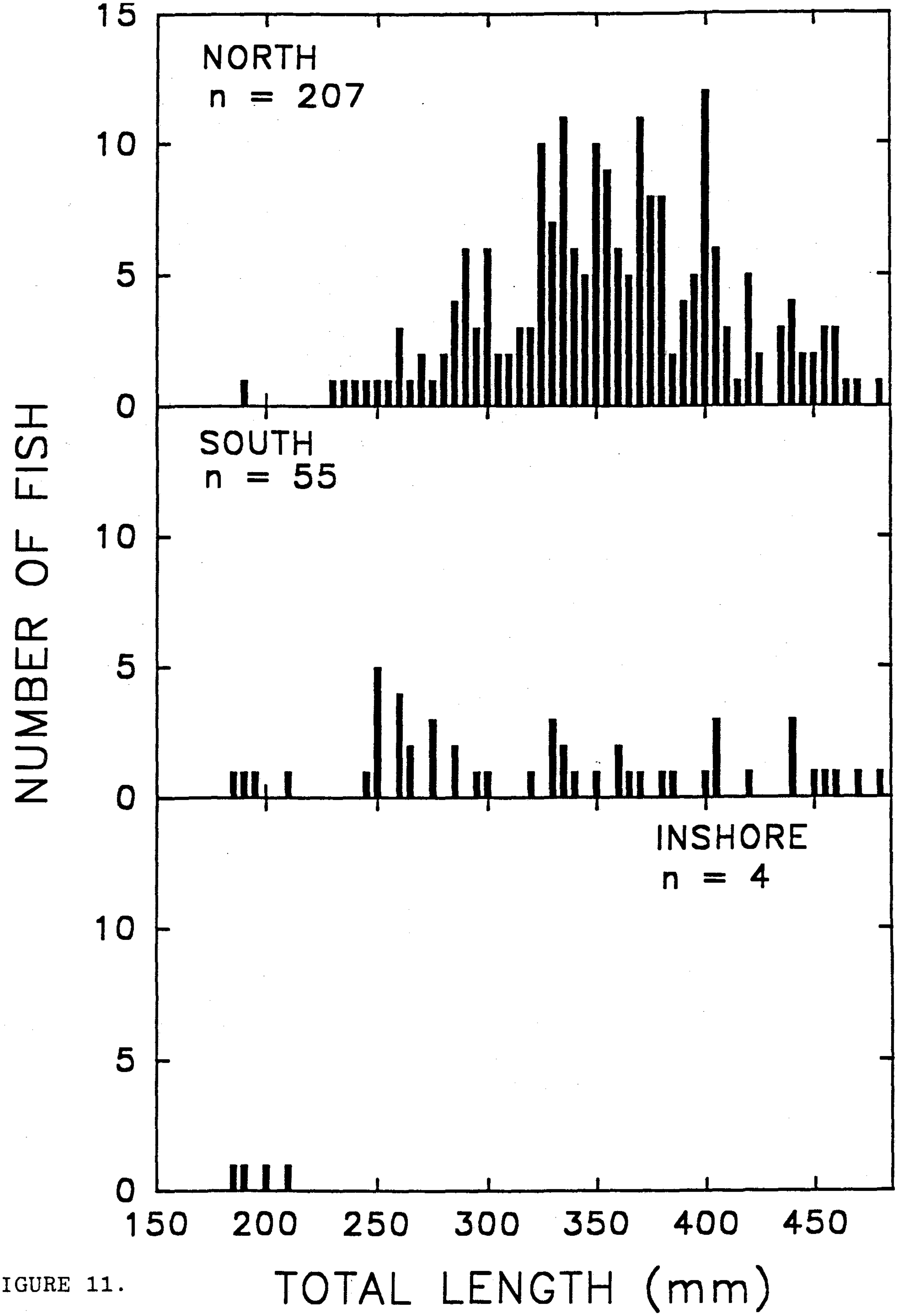


FIGURE 11. Length-frequency histograms for *Balistes vetulas*

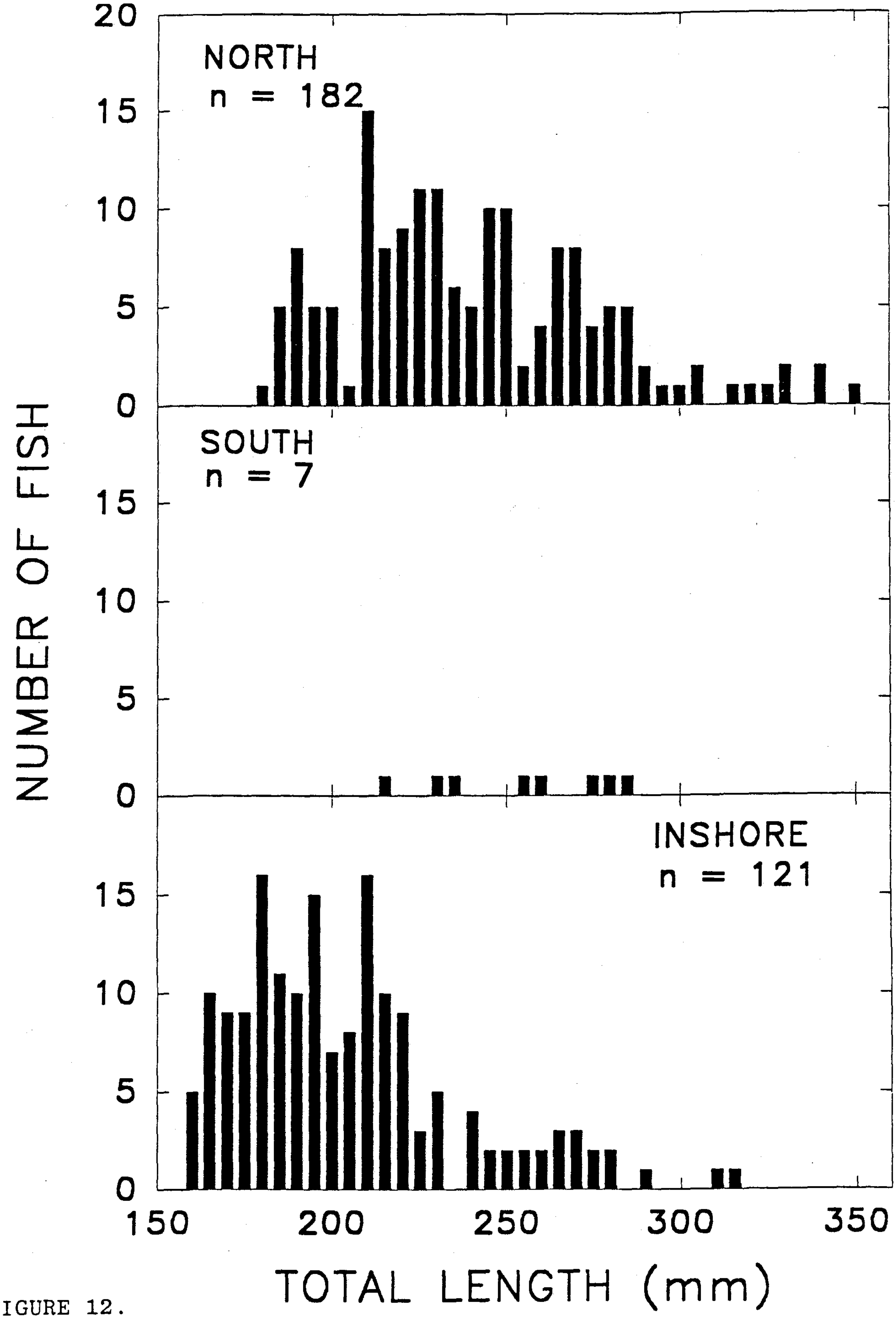


FIGURE 12.
Length-frequency histograms for *Lutjanus synagris*

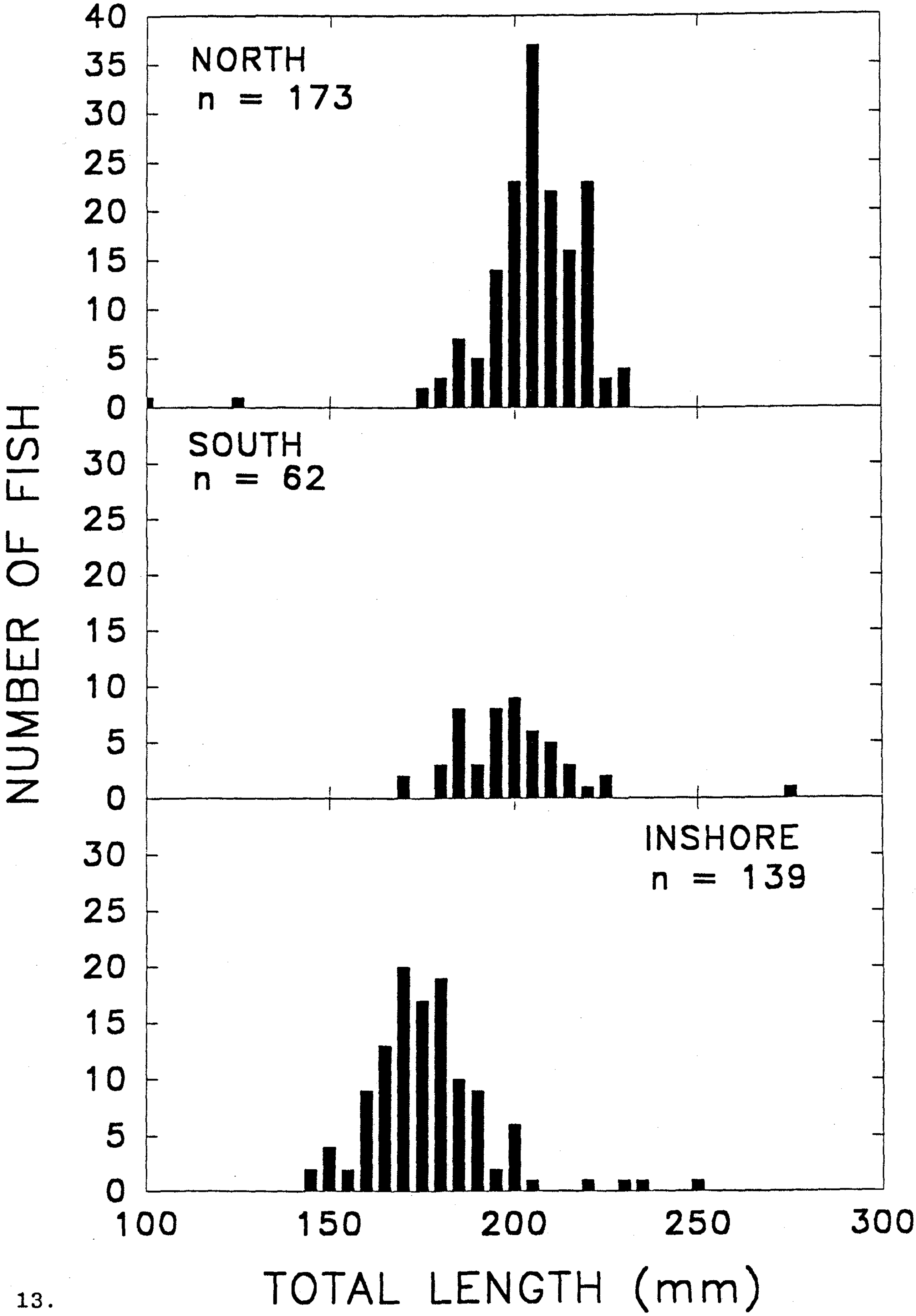


FIGURE 13.

Length-frequency histograms for *Haemulon flavolineatum*

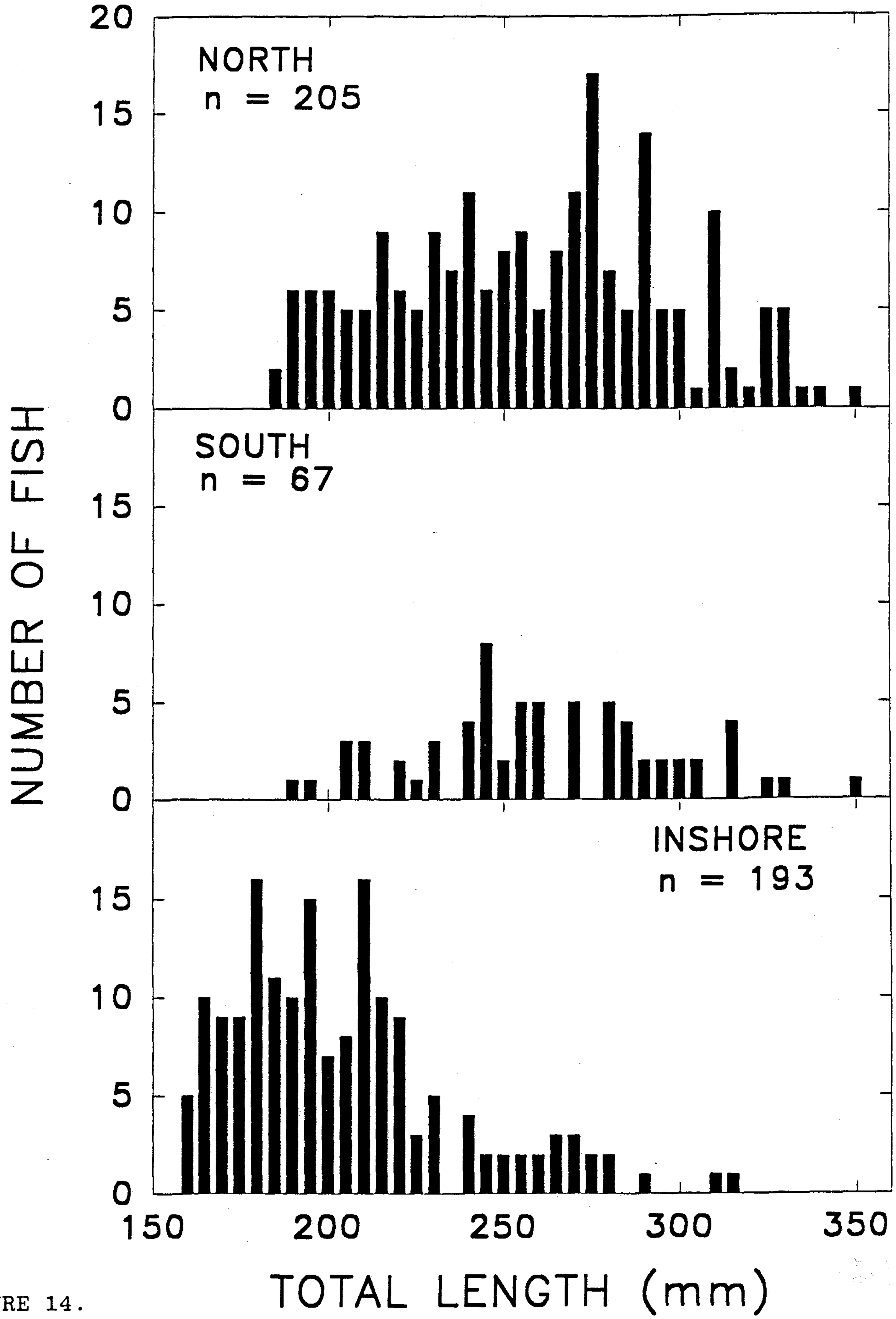


FIGURE 14.

Length-frequency histograms for *Haemulon plumieri*

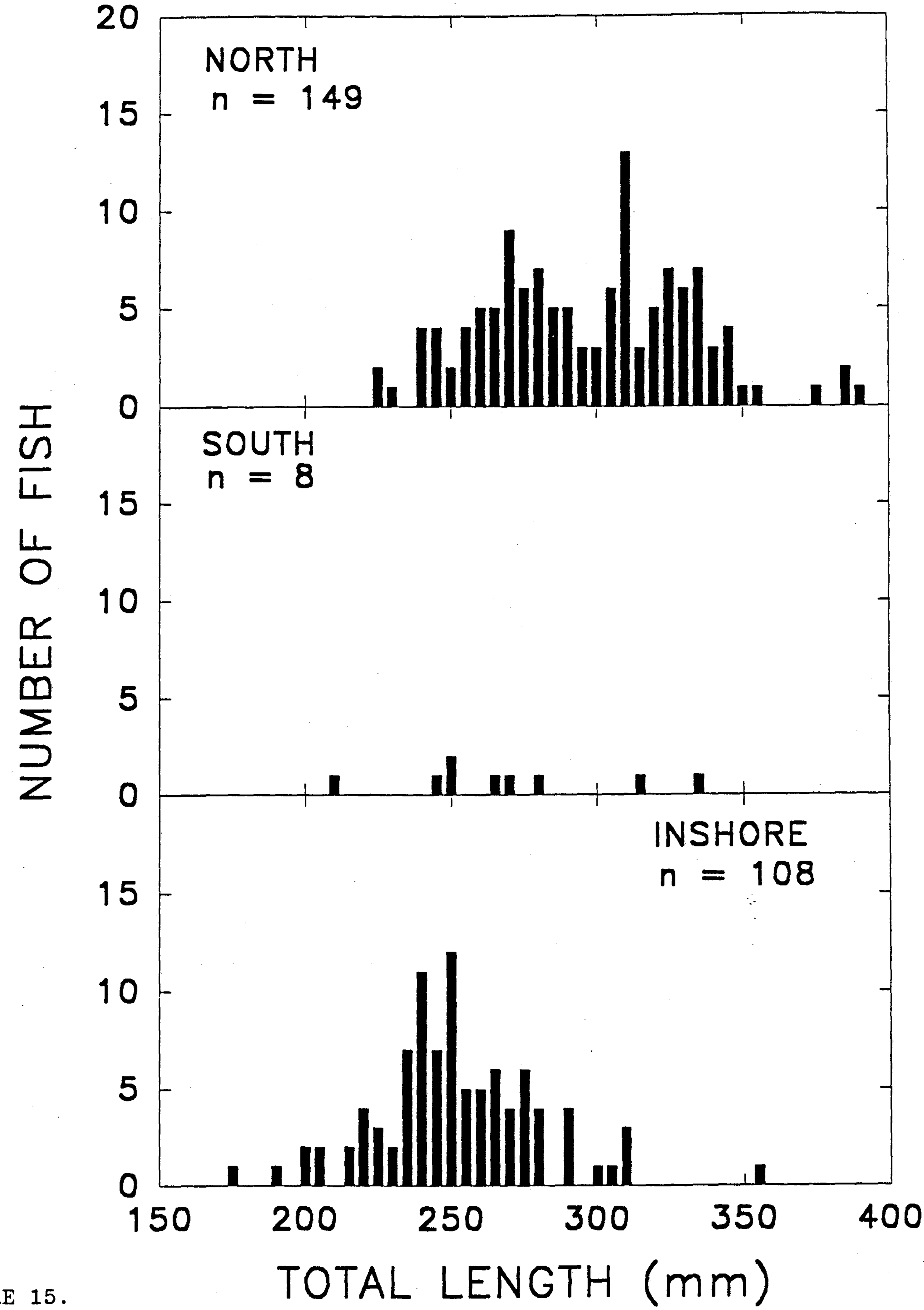


FIGURE 15.

Length–frequency histograms for *Sparisoma chrysopterum*

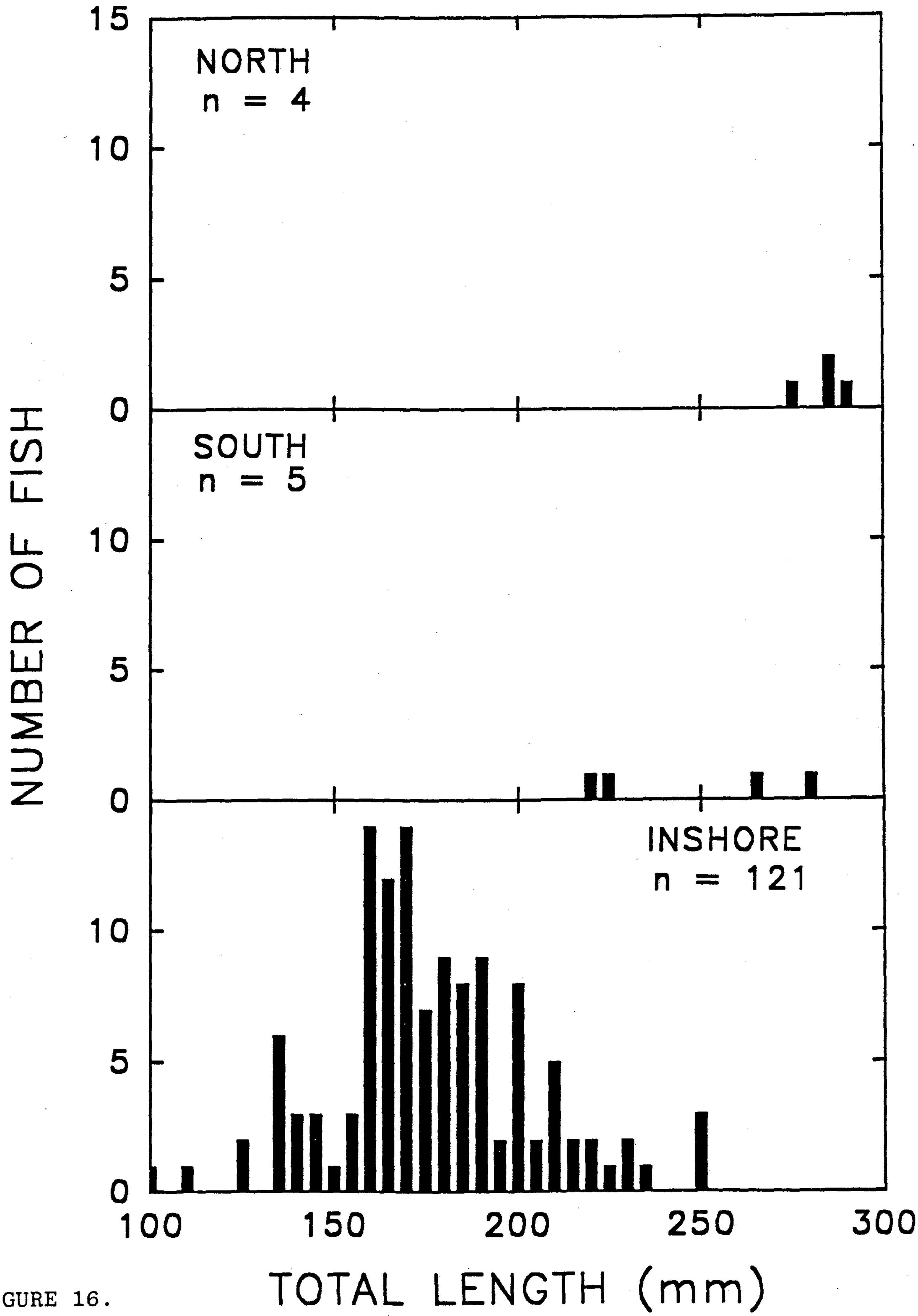


FIGURE 16.

Length–frequency histograms for *Holacanthus ciliaris*

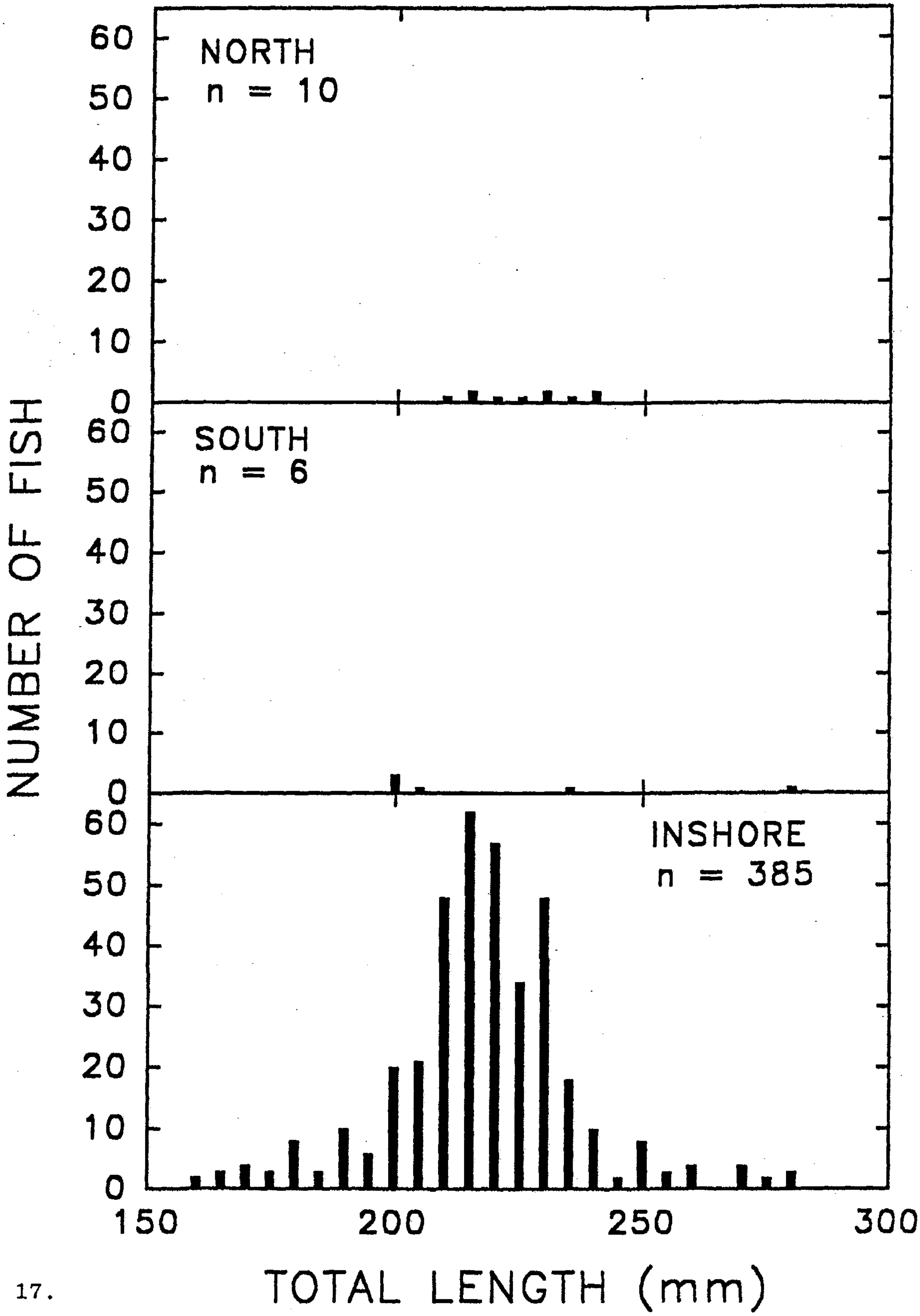


FIGURE 17.

Length–frequency histograms for *Sparisoma aurofrenatum*

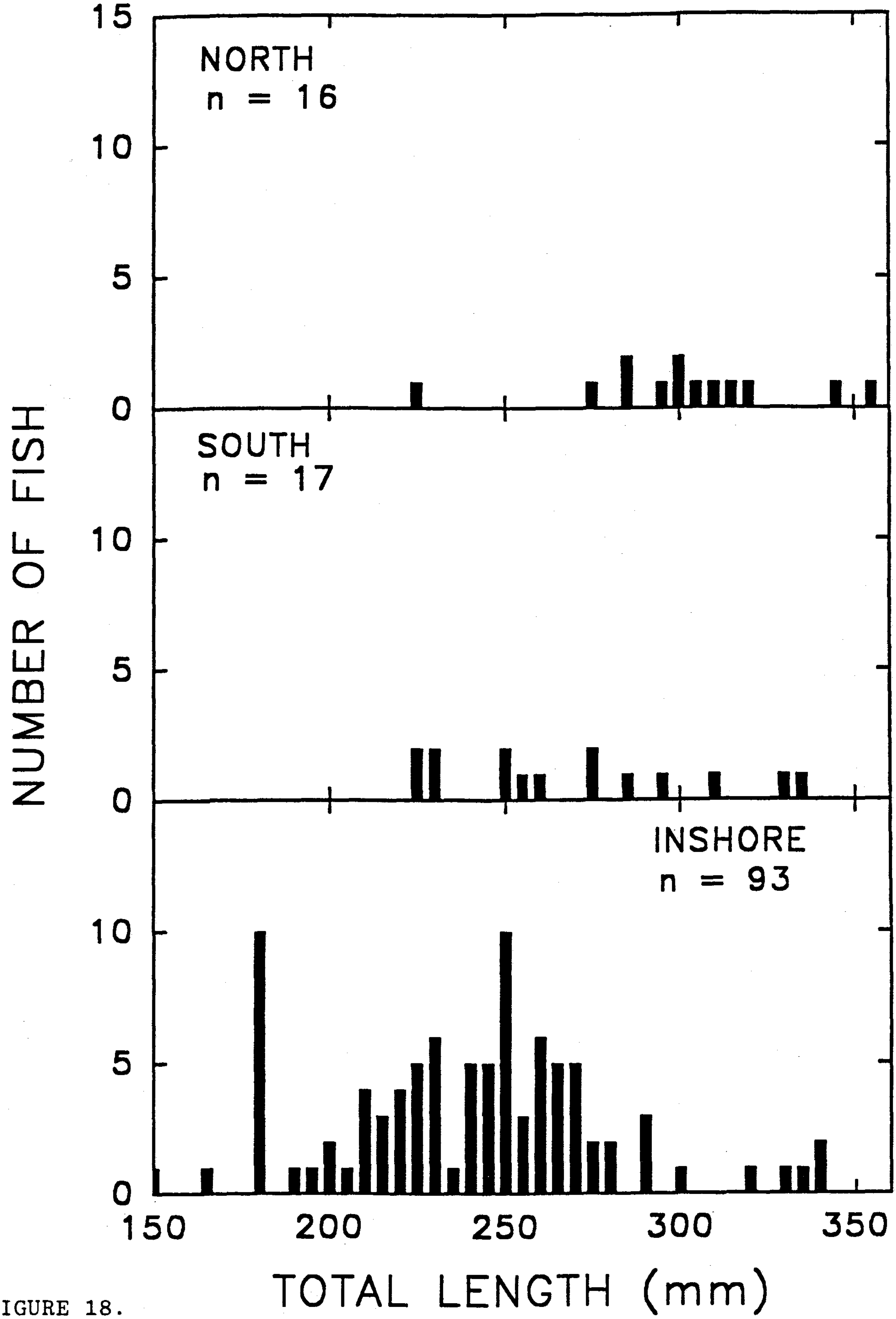


FIGURE 18.
Length-frequency histograms for *Sparisoma viride*

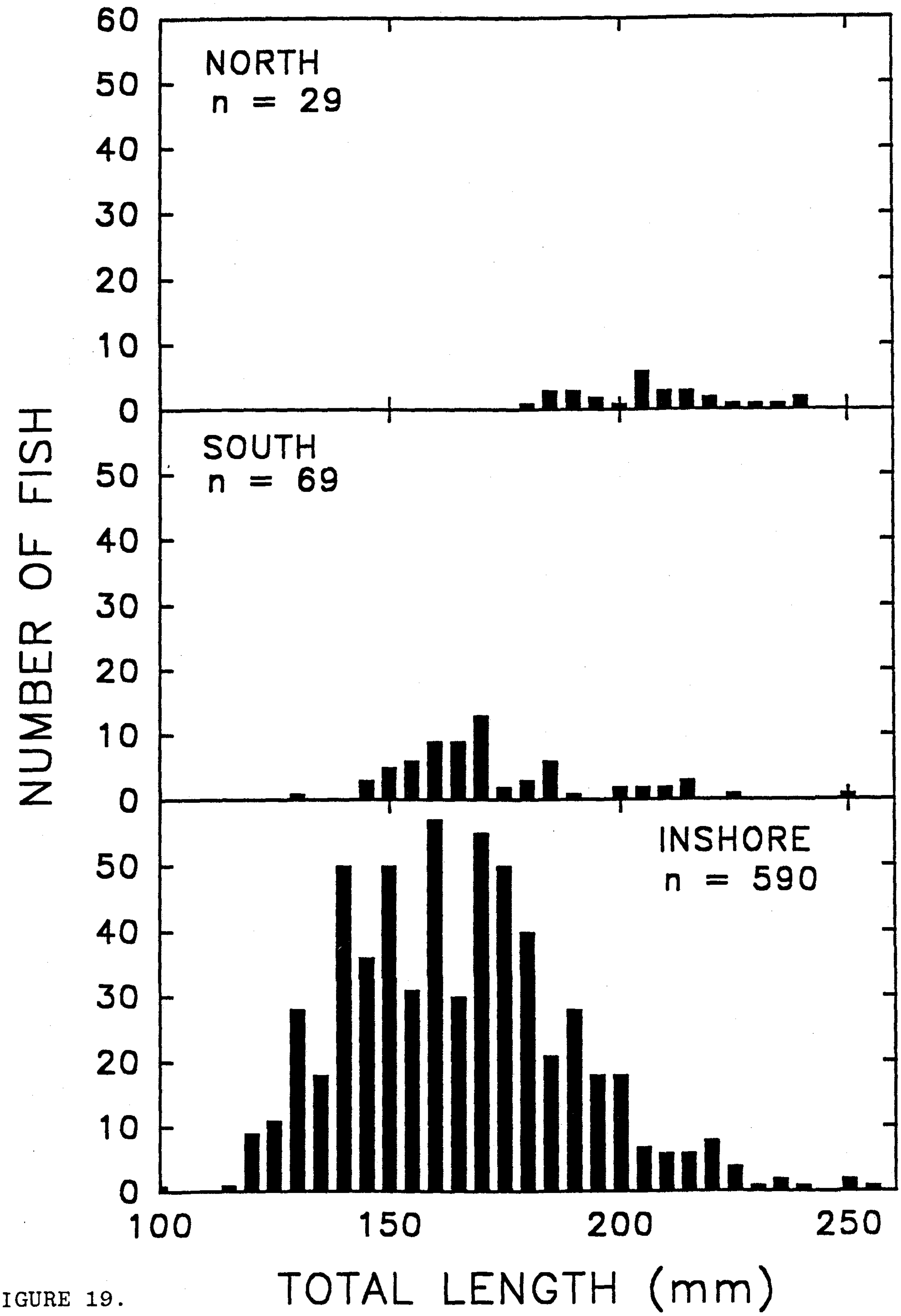


FIGURE 19.

Length-frequency histograms for *Acanthurus bahianus*

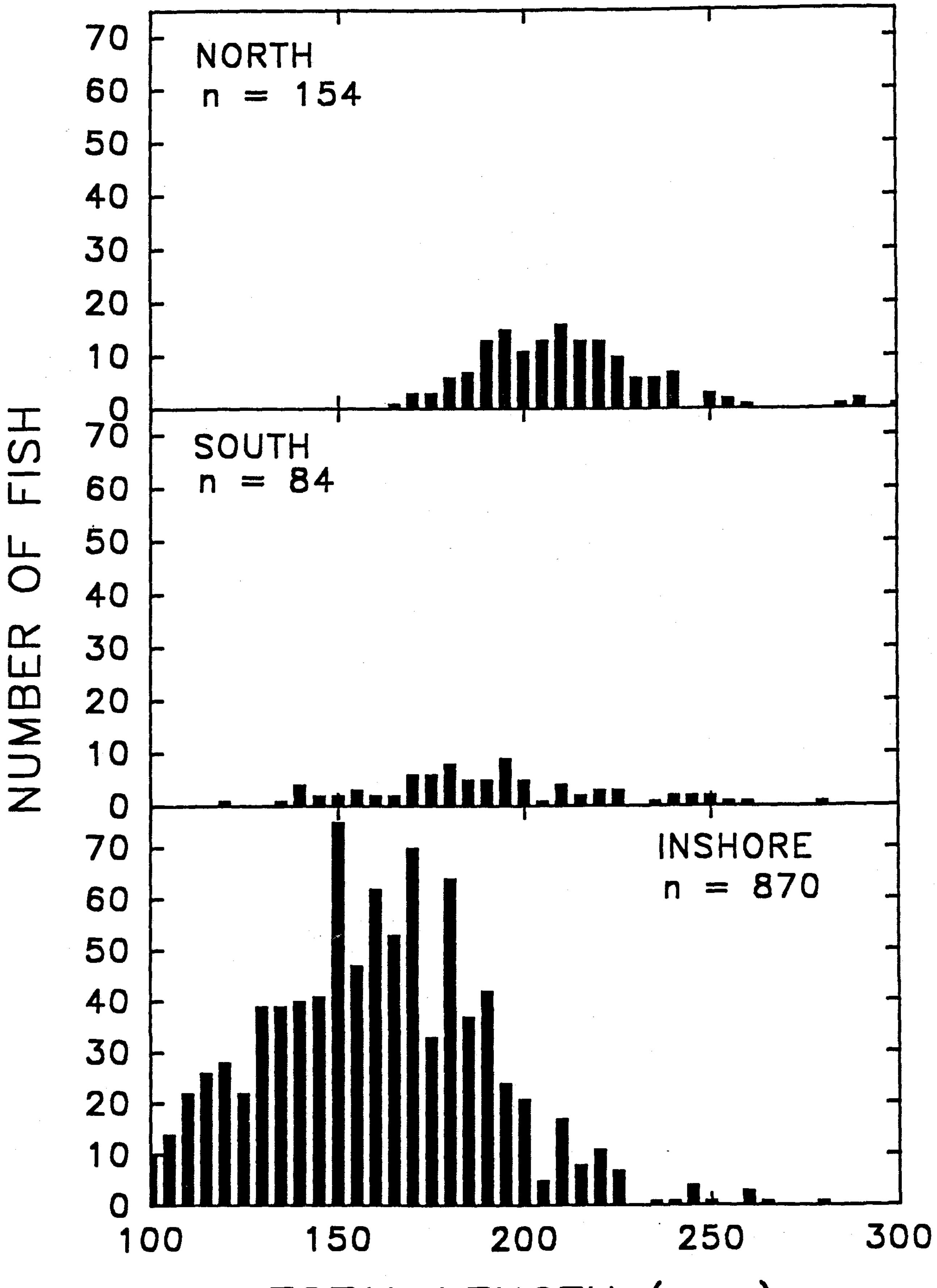


FIGURE 20.

Length–frequency histograms for *Acanthurus coeruleus*

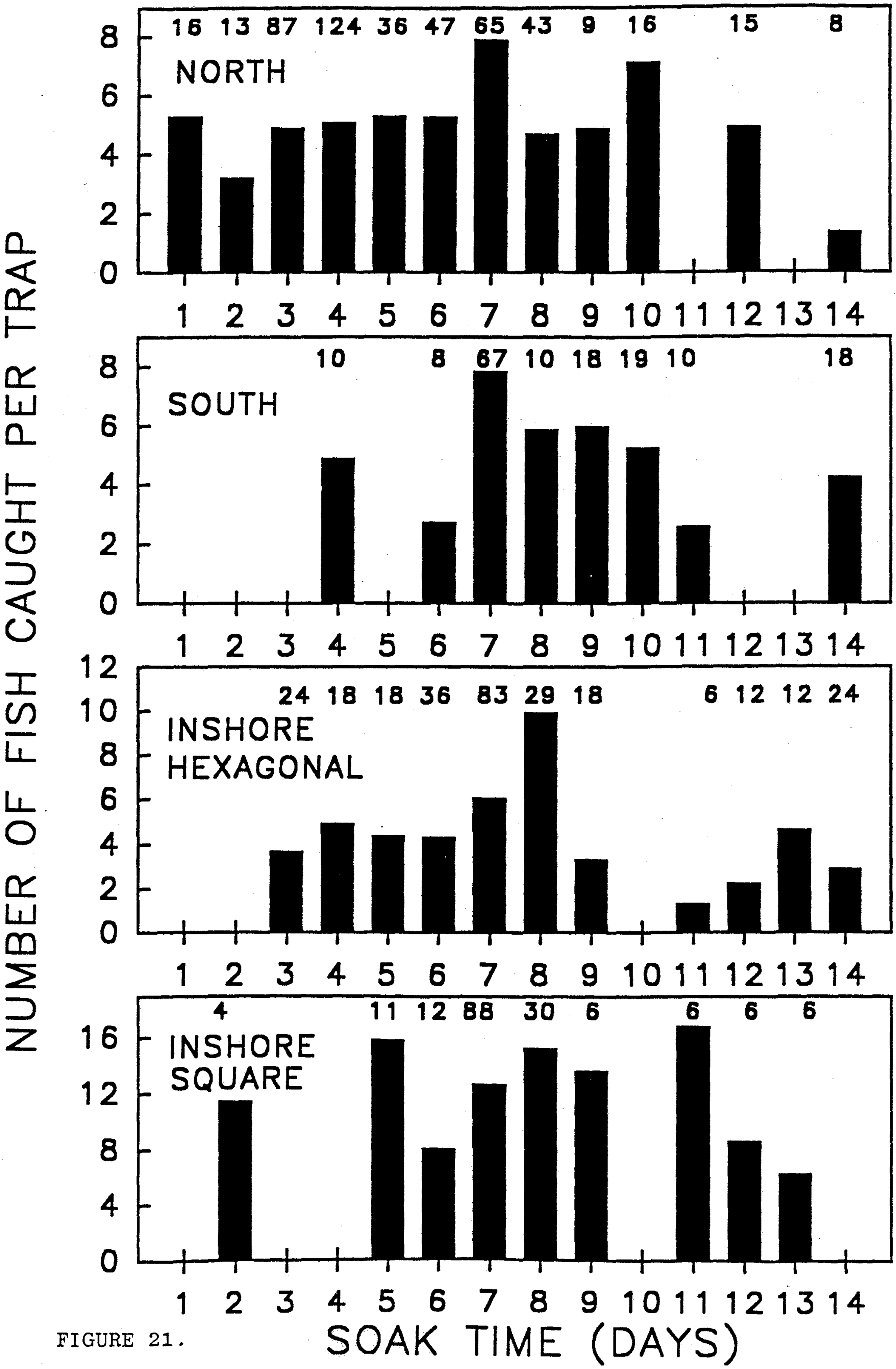

NUMBER OF FISH CAUGHT PER TRAP
NORTH
16 13 87 124 36 47 65 43 9 16 15 8
SOUTH
10 8 67 10 18 19 10 18
INSHORE HEXAGONAL
24 18 18 36 83 29 18 6 12 12 24
INSHORE SQUARE
4 11 12 88 30 6 6 6 6
SOAK TIME (DAYS)

FIGURE 21.

FIGURE 24

PROPORTIONAL TRAP CATCH OF GROUPERS & SNAPPERS

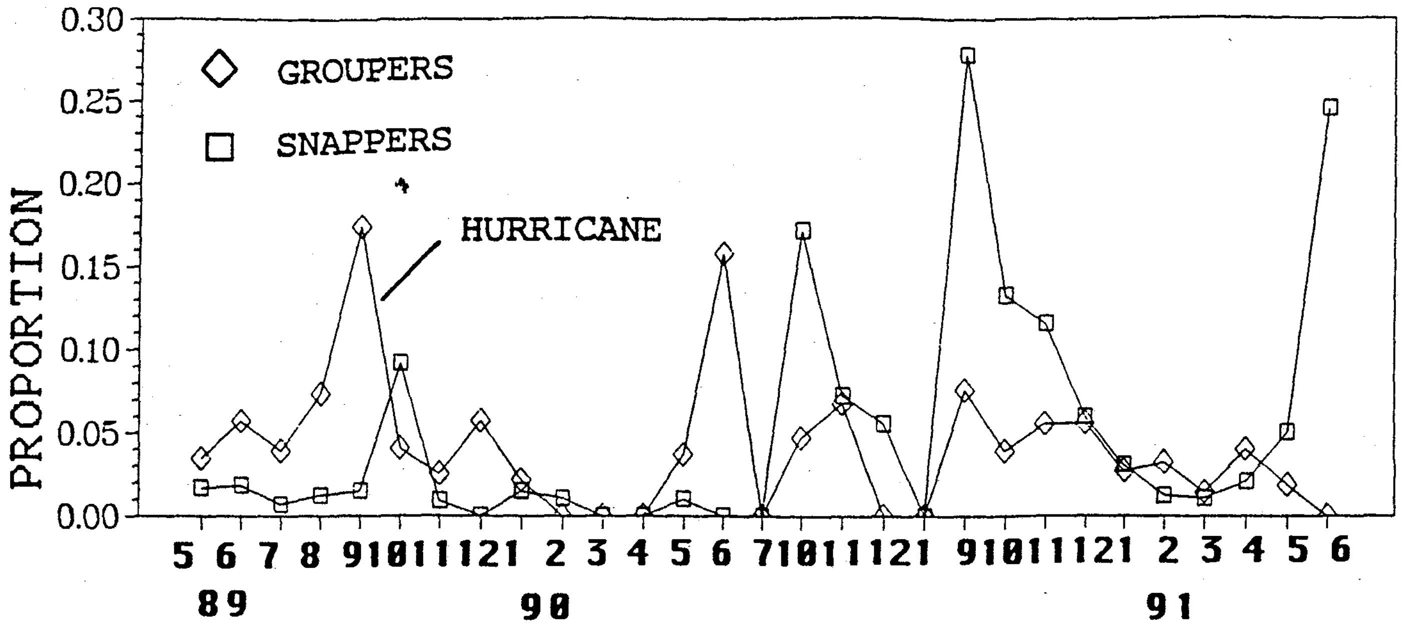
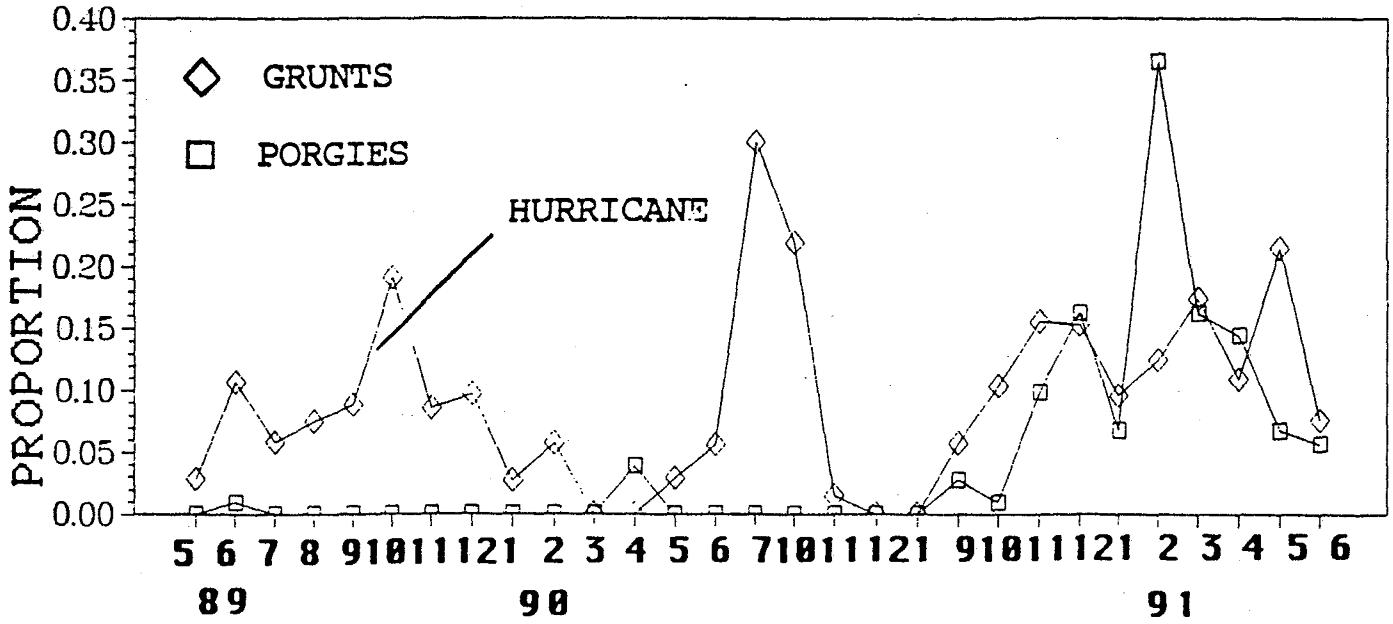


FIGURE 25

PROPORTIONAL TRAP CATCH OF GRUNTS AND PORGIES



SAMPLING DATE