Preliminary Report
Reef Fish Size and Species Selectivity by Wire Fish Traps in South Florida Waters

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ABSTRACT

The relationship between the mesh size of fish traps and catch composition by species and size is currently being studied off south Florida. Fish traps, constructed with 8 different sizes of wire mesh (from 13 x 13 mm to 102 x 102 mm), were fished in 7 - 40 m of water off Key Biscayne, Florida. This report covers data collected from December 1986 to July 1987. The number of fish captured per trap haul decreased with larger mesh size. Mesh sizes larger than 51 x 51 mm tended to catch fewer fish by number, but larger fish by weight. Relationships were examined between individual fork length and the maximum mesh aperture that allowed escapement for various species; these relationships may be used to predict the effect of mesh sizes on catch rates. This is Contribution No. 86/87-33 of the SEFC Coastal Resources Division.

INTRODUCTION

There is concern in some segments of the recreational and commercial fisheries that wire fish traps used in federal waters off the State of Florida may be too effective in harvesting reef fish stocks. Current Gulf and South Atlantic Fishery Management Council regulations allow fish traps to have mesh sizes which retain snapper and grouper that are smaller than the minimum legal size limits and below the minimum size of first sexual maturity (Munro, 1983; Taylor and McMichael, 1983). From 38 to 50% of the fish (by number) captured in traps are species with no direct commercial importance. These non-target and sublegal sized fishes incur injury and mortality from:

1. Attempting to escape from traps.
2. Embolisms caused by changes in ambient pressure as traps are lifted to the surface.
3. Stress and handling at the surface before release.
4. Predators such as moray eels which enter traps and prey on fishes before the traps are hauled (Sutherland and Harper, 1983; Taylor and

McMichael, 1983). Lost traps (ghost traps) which continue to catch fish have also been a damaged and ineffective (Sutherland*et al.*, 1983).

Selectivity for reef fish catch composition and size by various mesh sizes used in the trap fishery is an important management consideration. Determining the effects of various mesh sizes on catch can lead to improved fish survival by reducing juvenile and bycatch mortality and lessening the chances of overfishing. Most studies of mesh selectivity have been conducted in heavily exploited areas outside of the continental U.S. (Olsen *et al.*, 1978; Stevenson and Stuart-Sharkey, 1980; Hartsuijker and Nicholson, 1981; Hartsuijker 1982; Munro 1983; Luckhurst and Ward, 1987; Ward, 1988). These studies may not be entirely applicable to the trap fishery in the southeastern U.S. due to differences in species availability, abundance, and size of fish present.

The Reef Fish Team of the Southeast Fisheries Center's (SEFC) Miami Laboratory studied the relationship of mesh size in wire fish traps to catch composition and size distribution of reef fish off Florida. The specific objectives to be accomplished by this research were:

1. Document the size distribution of individuals and species caught by different mesh sizes.
2. Determine the effects of different mesh sizes on catch of target and non-target fishes.
3. Report the selectivity of meshes so that optimum mesh sizes can be determined for management purposes based on its capacity to reduce bycatch mortality and yet retain marketable fishes.

Field activities began in December 1986 and laboratory studies commenced in January 1987. This document serves as an interim report on progress to date.

METHODS

Fish traps constructed of different sizes of wire mesh were fished off Key Biscayne, Florida to determine the species and size selectivity of catches by mesh size. Eight, rectangular-shaped, vinyl-coated wire traps measuring about 61 x 91 x 122 cm (2'h x 3'w x 4'l) were fished from December 1986 until July 1987. Each trap had a single funnel entrance in one end that terminated in a 6 x 46 cm vertical opening. The side and end panels of all traps were constructed of 25 x 51 mm (1" x 2") vinyl coated wire mesh to present the same silhouette and presumably the same amount of visual attractiveness to fish. The top and bottom panels of the traps were constructed of meshes measuring 38 x 38, 25 x 51, 51 x 51, 51 x 76, 76 x 76 51 x 102, and 102 x 102 mm. One trap was constructed of entirely of 25 x 51 mm wire mesh, but had all inside panels lined with a 13 x 13 mm (0.5" x 0.5") galvanized hardware cloth. A replicate set of eight additional traps also were fished from May until the study was terminated on 2 July 1987. Only rectangular or square mesh sizes were tested. Though traps constructed of hexagonal, galvanized poultry wire are popular in the Caribbean, they seldom are used in continental waters. The 25 x 51 mm mesh trap was considered the control mesh based on its wide popularity and usage off south Florida.

The traps were fished in trawls (strings) of four traps. Each trawl had traps attached at 50 m intervals to a 250 m groundline with a concrete or steel weight anchoring each end of the groundline. A subsurface or surface buoy was often attached to one end of each groundline to aid in relocation and retrieval of the gear. The traps were randomly attached to the groundline to prevent sampling bias and each set was fished under similar conditions of depth, bottom type and soak time to avoid confounding effects on mesh size. Soak times for the unbaited traps varied considerably due to weather. Lost, stolen or damaged fish traps were replaced or repaired as needed. The traps were fished in depths of 7 to 40 m about 5-7 km east of Key Biscayne, Florida. Each captured fish was identified, weighed, and measured to the nearest millimeter of fork length (FL). A performance curve, based on trap fishing data (Sutherland and Harper, 1983), indicated that about 50 trap hauls per year for each mesh size would be needed to reasonably estimate population parameters (Figure 1).

Laboratory studies to determine retention/escapement of reef fish by mesh size were conducted at the Southeast Fisheries Center's Miami Laboratory on Virginia Key (Miami), Florida. Though many of the fish used in laboratory studies were captured in fish traps during field studies, almost all of the mangrove (gray) snapper, (*Lutjanus griseus*) were fish that had been held in aquaria and ponds from prior experiments. The studies were conducted in circular, 2 m diameter, 0.8 m deep, tanks. A rectangular, plastic container (91 x 68 x 61 cm) was placed in the tanks and wire panels of different mesh sizes were fitted across the one open end of the container. Reef fish of various sizes were placed in the container and their ability to escape through the mesh noted. Though many fish passed willingly through the mesh, a few species such as angelfish (Pomacanthidae) had to be prodded or guided through the mesh by hand. During the latter half of the study, body depth and width measurements of the fish escaping from each mesh were recorded along with fork length and weight.

RESULTS

Field Study

Experimental fishing of traps with different mesh sizes was temporarily suspended during the months of July and August 1987 due to the high incidence of divers and fishermen throughout the area where traps were fished and the concomitant increase in trap loss and damage. A total of 24 traps were lost or stolen during the 7 month study. Eleven of the traps were lost and 4 traps were damaged during the two week period preceding the temporary suspension of this study.

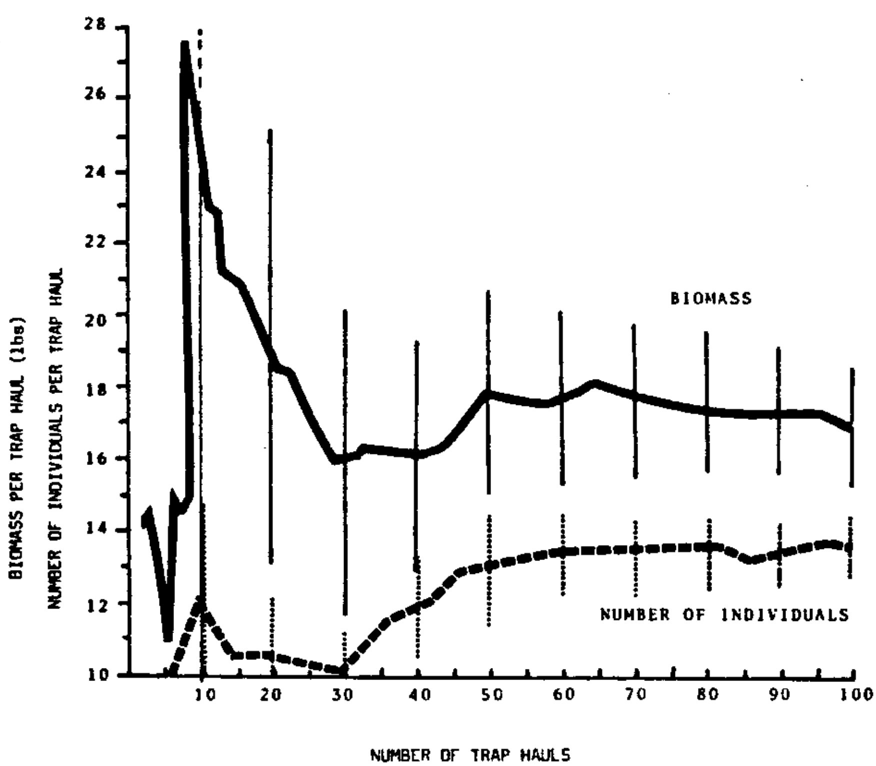

Figure 1. Changes in the cumulative mean catch as a function of the number of trap hauls made with 1" x 2" mesh. Vertical bars represent + / - one standard error of the mean. Data from: D. Sutherland and D. Harper, National Marine Fisheries Service, Southeast Fisheries Center, Miami Laboratory, 75 Virgina Beach Drive, Miami, Fla. 33149.

The catch and effort data for experimental traps are summarized in Table 1. A total of 521 fish which weighed 234 kg were caught in 131 trap hauls. The strings of traps were hauled 19 times during the study. Soak times ranged from 1 to 19 days with most traps being hauled once every 7 days. Catches varied but the mean numbers of fish caught per haul tended to be inversely related to mesh size. The highest catch rate of 7.39 fish per haul was obtained in the smallest mesh size (13 x 13 mm) that was tested and the lowest catch rate of 0.58 fish per haul was obtained in the largest mesh size (102 x 102 mm). The highest mean weight per haul was obtained in traps with a 51 x 102 mm (2" x 4") mesh while the lowest catch occurred in the 102 x 102 mm (4" x 4") mesh. Although the 13 x 13 mm mesh caught the greatest number of fish per haul, it caught the second lowest by mean weight per haul and the smallest fish based on mean weight per fish. Larger mesh sizes tended to catch heavier fish based on weight. The mean weight of individual fish was greater for meshes of 51 x 76 mm (2" x 3") or larger. Although the larger mesh sizes caught larger fish by weight, there was no consistent trend or relationship between mesh size and mean weight of fish per trap haul.

The percentage (by weight) of target, occasional (fish that were sometimes sold depending on size and market demand) and non-target species varied erratically with mesh size and shape (Figure 2). Data for square mesh traps showed that as mesh size increased the percentage of target species decreased and occasional species increased (Figure 3). The non-target species increased with mesh sizes up to 51 x 51 mm and then decreased.

Another description of mesh selectivity was based on the number of fish per weight category (Figure 4). For each mesh size, individual fish were grouped by 50-g weight intervals (regardless of species) and plotted against their frequency of occurrence. Measurements of central tendency (mean, median and mode) usually increased directly with mesh size.

The individual weights of fish were normalized using a log transformation and the effects of mesh size analyzed by one way analysis of variance using SPSS (Statistical Package for the Social Sciences). The null hypothesis of no difference was rejected ($F = 53.75$; $D.F.=7, 509$; $P<0.05$). Therefore, significant differences in the weights of fish by mesh size existed. A modified least-significant differences test that compared all possible pairs of group means a posteriori found catches in mesh sizes of 51 x 51 mm and smaller differed

Table 1. Summary of 1987 trap fishing catch and effort data.

Mesh Size (mm)	Trap Hauls (no.)	Total Fish (no.)	Catch /Haul (no.)	Total Weight (kg)	Mean Wt. /Haul (kg)	Mean Wt. /Fish (g)
13 x 13	18	133	7.39	24.90	1.38	187
38 x 38	7	37	5.29	12.21	1.74	330
25 x 51	19	98	5.16	41.57	2.19	424
51 x 51	23	120	5.22	42.45	1.85	354
51 x 76	15	31	2.07	31.04	2.07	1001
76 x 76	13	41	3.15	19.35	1.49	472
51 x 102	17	50	2.94	44.20	2.60	884
102 x 102	19	11	0.58	18.22	0.96	1656
Totals	131	521		233.93		

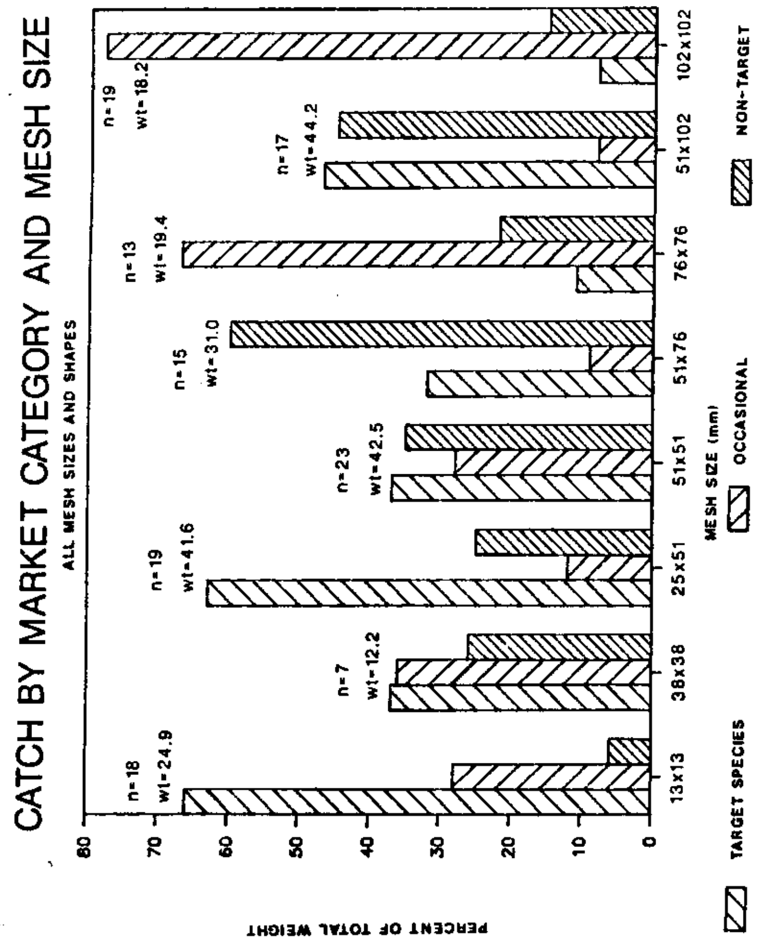

Figure 2. The 1987 trap catches (percent weight) of target, non-target and occassional target species by mesh size.

significantly ($P<0.05$) from catches of all larger mesh sizes.

Laboratory Study

A total of 222 fish of 24 species were tested in laboratory aquariums to determine their ability to escape different sized mesh. In addition to the meshes used during the field study, 51 x 152 mm and 51 x 178 mm meshes were tested for species with laterally compressed bodies. The size range of the smallest fish

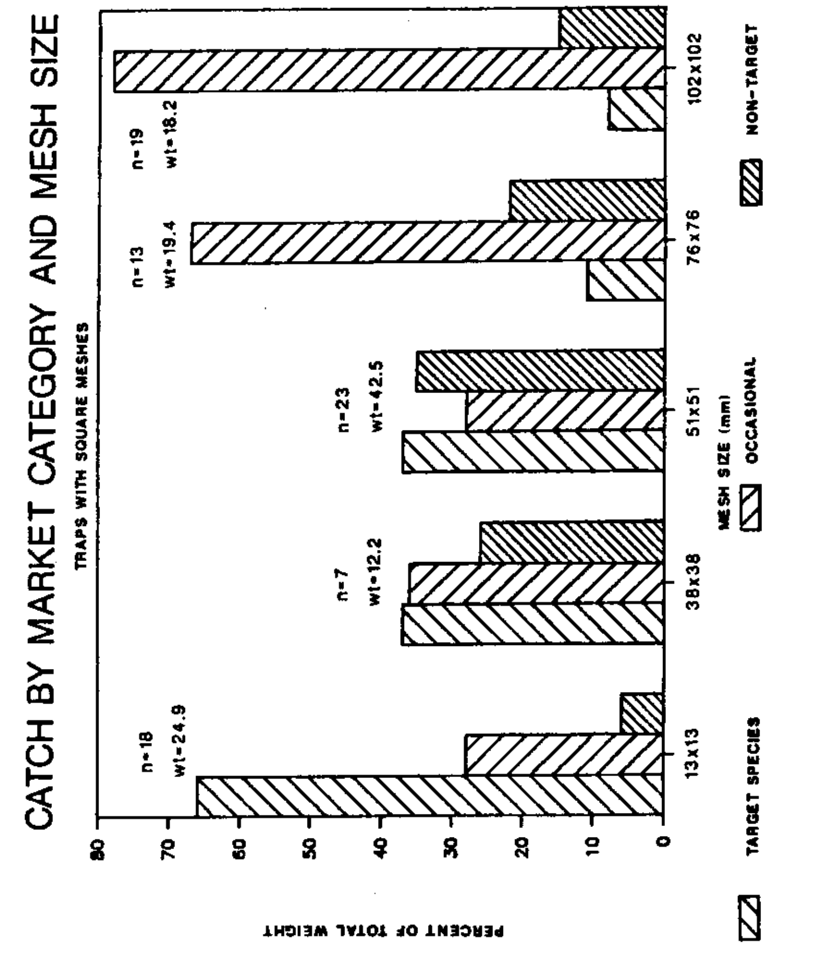

Figure 3. The 1987 catches (percent weight) of target, non-target and occassional target species by fish traps with square-shaped wire meshes.

retained by each mesh size are indicated in Table 2. There was often a overlap in the size range of fish that were retained by a given mesh size and the next larger or smaller mesh sizes. For instance, white grunts from 195 to 248 mm FL usually were retained by 51 x 51 mm mesh, but some fish as large as 211 mm sometimes escaped through this mesh and were retained only by 25 x 51 mm mesh. Conversely, some white grunts as small as 216 mm could not (or would not) escape through a 25 x 76 mm mesh.

Table 2. Size ranges and species of fish retained by various sizes of wire mesh.

Scientific Name	Common Name	Fish (No)	Size Range (mm)	Fork Lengths (mm) of the Smallest Fish Retained by Each Mesh Mesh Size (mm)								
				13 x13	25 x51	51x51	51x76	76 x 76	51 x 102	102 x 102	51 x152	51 x178
Acanthurus coeruleus	blue tang	1	214					214				
Archosargus rhomboidalis	sea bream	2	218-237				278 -396					
Caranx latus	horse-eye jack	1	196		196							
Chaetodon ocellatus	spotfin butterflyfish	3	123-161				123-161					
Chaetodon striatus	banded butterflyfis	1	142			142						
Epinephelus morio	red grouper	3	288-344			288-327	344					
Gerres cinereus	yellowfin mojarra	1	257				257					
Haemulon aurolineatum	tomtate	19	126-168	126-168								
Haemulon flavolineatum	French grunt	4	162-215		162-173	215						
Haemulon plumieri	white grunt	67	150-269	150	159-211	195-248	216-269					
Haemulon sciurus	bluestriped grunt	3	135-201	135	174-201							
Holocentrus ascensionis	squirrelfish	2	237-263			237-263						
Holocanthus ciliaris	queen angelfish	1	214				214					
Holocanthus tricolor	rock beauty	1	86	86								
Lactophrys quadricornis	scrawled cowfish	1	250					250				
Lachnolaimus maximus	hogfish	2	209-371			209-371						
Lutjanus griseus	gray snapper	68	134-380	134-192	190-249	239-283	315-380					
Monacanthus hispidus	planehead filefish	22	140-218			140-208	207-218					
Mulloidichthys martinicus	yellow goatfish	1	223		223							
Pomacanthus arcuatus	gray angelfish	7	189-300						189	249-255	249-294	292-300
Pomacanthus paru	French angelfish	2	258-269								258-269	
Sparisoma viride	stoplight parrotfish	4	232-305			232	285-305					

The behavior of fish in traps varied by individuals as well as species, and was somewhat dependent on how long the testing took. Some fish literally forced their way through the mesh, bending and distorting it in their efforts to escape. Other fish such as gray angelfish (*Pomacanthus arcuatus*) made no effort to pass through the mesh and could only be induced to swim through when prodded or pushed. The efforts and vigor of fish trying to escape through the wire mesh panels usually diminished in proportion to the number of trials that were conducted. It usually was not necessary to test more than three meshes sizes with each individual fish.

The critical fork length at which 50% of the fish were retained or escaped different mesh sizes was estimated for three common species: white grunt, gray snapper and planehead filefish (Figures 5, 6, and 7, respectively). The percentage of fish retained by each mesh size were plotted against fork length by 10 mm intervals. The 50% retention size for planehead filefish in 25 x 51 mm mesh (Figure 7) was assumed to be 145 mm based on the fact that smaller fish rarely were caught in 25 x 51 mm mesh traps during this study or during sampling of the commercial fishery in 1980 (Sutherland and Harper, 1983). Critical sizes for 50% retention were regressed against maximum mesh aperture for these three species (Figure 8). Below are formulae for determining critical fork lengths from maximum mesh aperture and determining maximum mesh aperture for any fork length.

Haemulon plumieri - Mesh aperture $= -0.877 + 0.349FL$
- Fork length $= 2.603 + 2.862Aper.$

Lutjanus griseus - Mesh aperture $= 9.611 + 0.235FL$
- Fork length $= -26.034 + 4.0$

Monacanthus hispidus - Mesh aperture $= 21.226 + 0.323FL$
- Fork length $= -65.8 + 3.1Aper.$

A less precise evaluation of minimum fish size for mesh retention was done for all species tested in the laboratory (Figure 9). Here the fork length of smallest sized individuals retained in a particular mesh were plotted against mesh aperture. Single points represent species where only one individual was tested or species where several individuals were tested but all were retained by one mesh size. Lines connect points for one species. Sizes plotted can be considered conservative in that smaller individuals (if tested) could be retained by a particular mesh. Longer fishes for each species tend to be retained in larger meshes as shown by the positive slopes of most lines. For any mesh, fishes with more rounded (fusiform) body forms (longer fork lengths) tend to fall to the

the 50% retention lines of *Lutjanus griseus* (gray snapper) by mesh size.

right of fishes with compressed (or depressed) body forms (shorter body lengths). Figure 9 can be used to approximate what sized fishes would be retained by a given mesh size for various trapable species. Thus, it can be estimated what sized individuals and species would be added or dropped out of

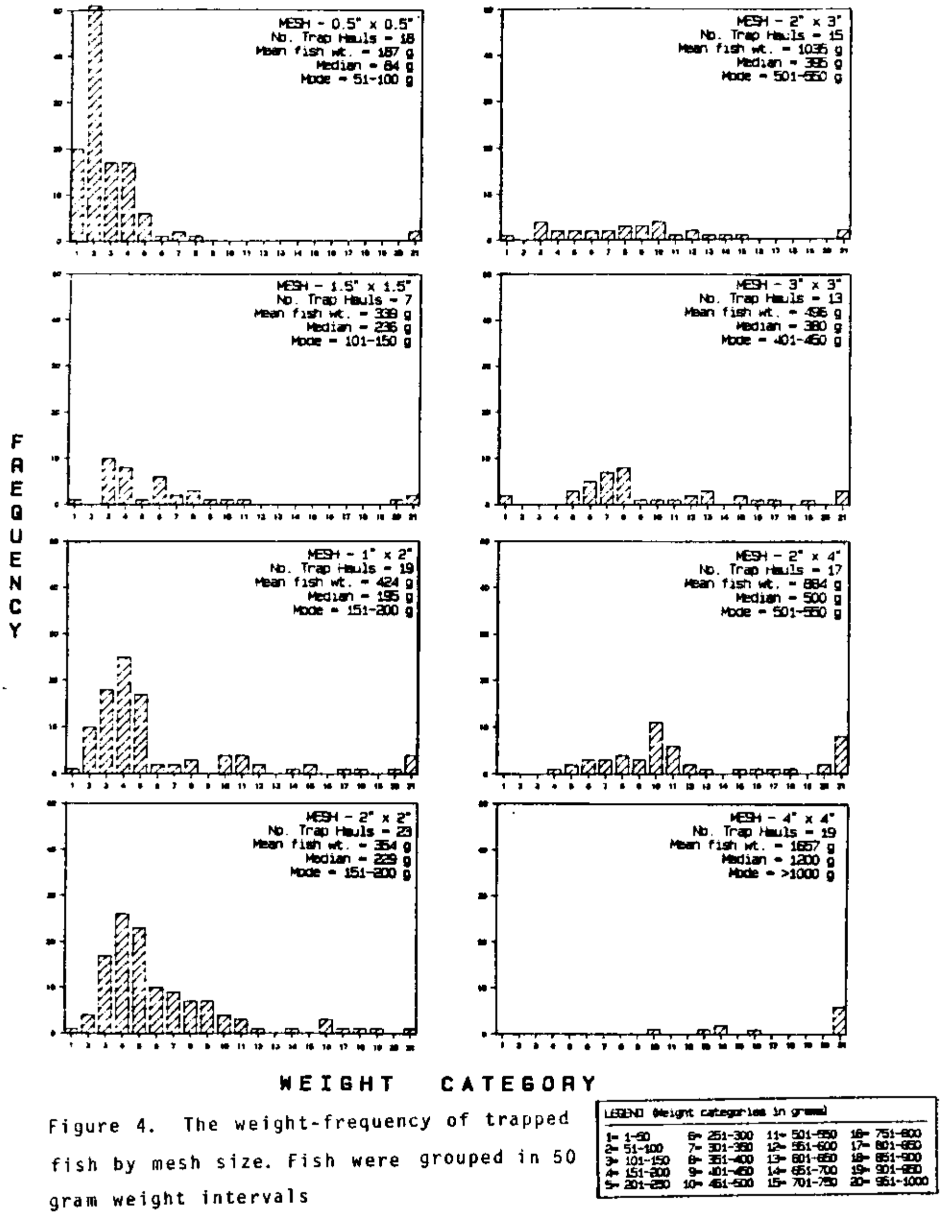

Figure 4. The weight frequency in 1987 of trapped fish by mesh size. Fish were grouped in 50-g weight intervals.

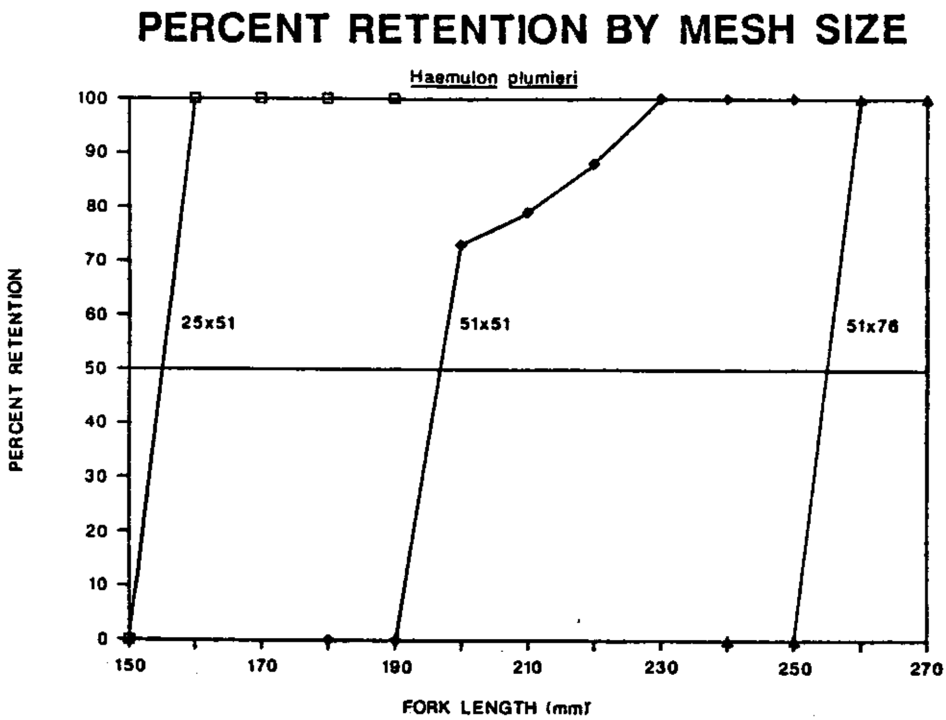

Figure 5. The 50% retention lines of *Haemulon plumieri* (white grunt) by mesh size.

the fishery by particular mesh size regulations.

A third, less precise, prediction of sizes retained by different mesh sizes is provided (Figure 10). Munro (1983) noted that body depth for more fishes was a good predictor of mesh size retention. Based on his data from Jamaica, we have plotted regressions of body depth versus fork length and show mesh sizes. This figure provides a prediction of sizes that would be retained by any given mesh size, assuming that maximum body depth equals maximum mesh aperture. Note that regressions for more compressed (or depressed) body forms fall to the left of species with more fusiform body shapes.

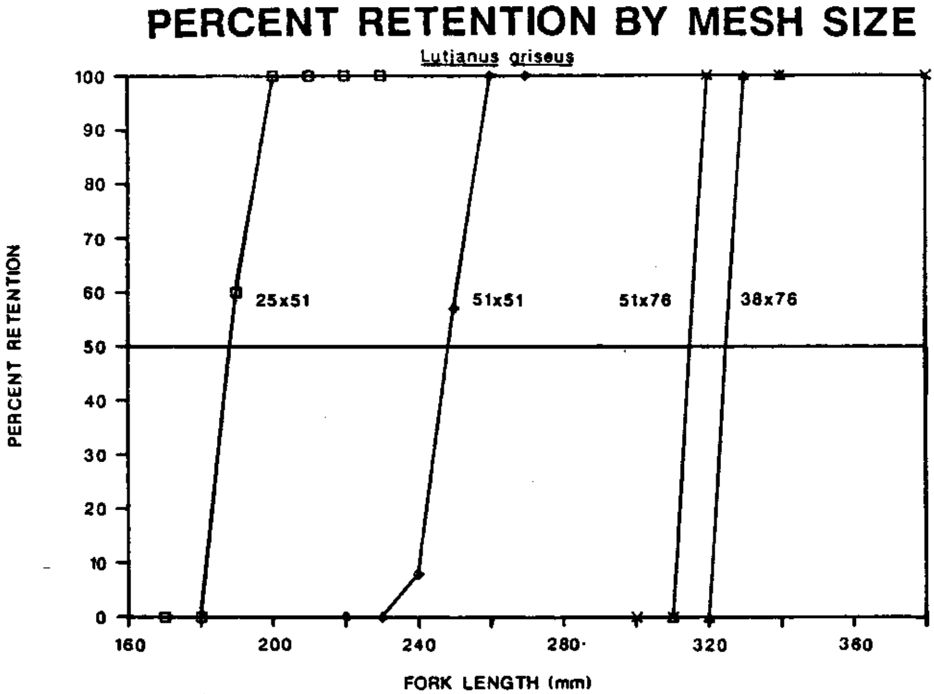

Figure 6. the 50% retention lines of *Lutjanus griseus* (gray snapper) by mesh size.

DISCUSSION

Luckhurst and Ward (1987) noted mesh selectivity could be biased by fish attraction to different trap silhouettes. This should not have been a major problem in this study because seven of the eight mesh sizes tested had the same 25 x 51 mm mesh wall panels and therefore presented the same silhouette. Only the floor and ceiling panels differed in mesh size. One of the eight traps tested was lined with 13 x 13 mm mesh hardware cloth which appeared more distinct

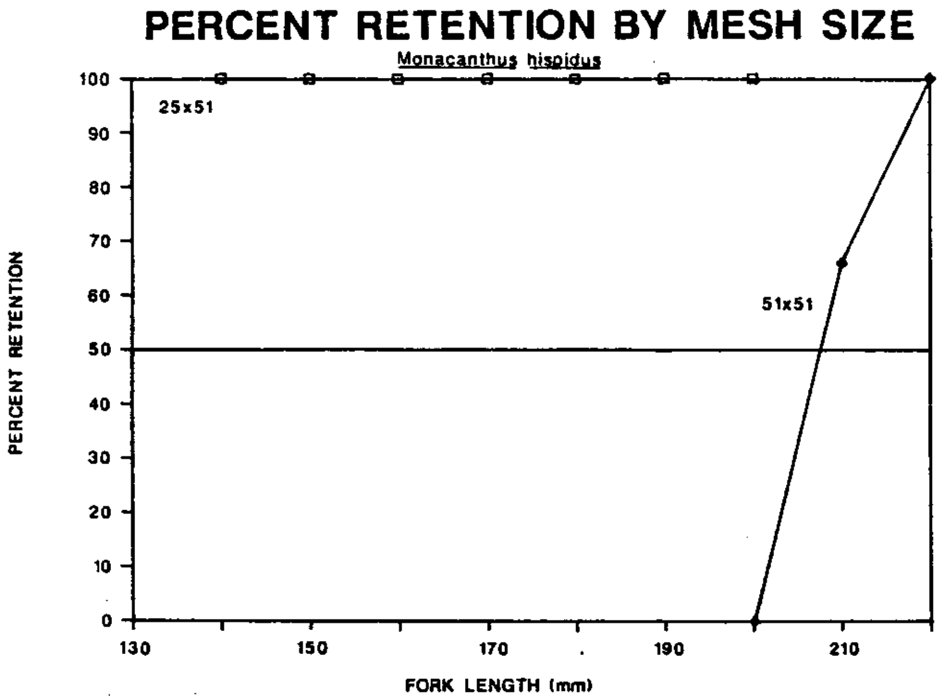

Figure 7. The 50% retention lines of *Monacanthus hispidus* (planehead filefish) by mesh size.

underwater and had the highest mean catch rate by number. Whether these traps caught more fish because they were more visually distinct or because they had the smallest mesh size tested cannot be completely ascertained. However, they retained many small fishes, such as the tomtate (*Haemulon aurolineatum*) and slippery dick (*Halichoeres bivittatus*), that could escape all larger mesh sizes. Other, size-related behavioral responses that effect recruitment to traps (Hartsuijker and Nicholson, 1981) should have equally affected catches by different mesh sizes.

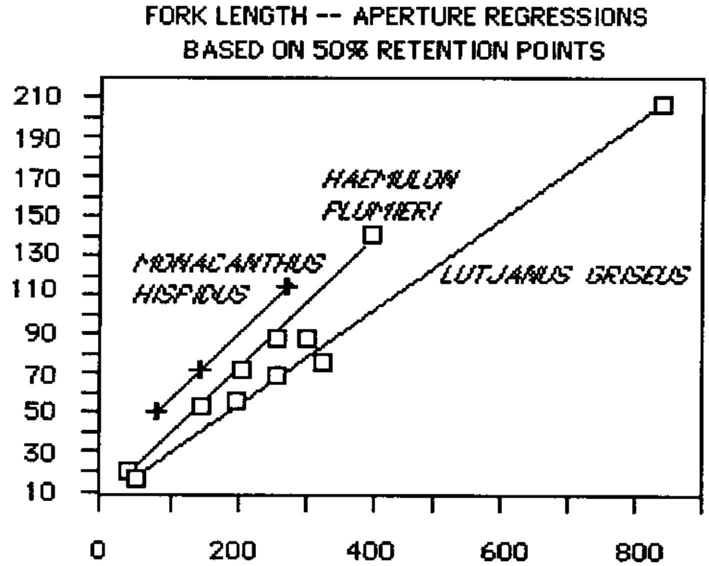

Figure 8. Regressions of maximum mesh aperature (= body depth) on fork length for three common reef fish species. Bottom points on lines indicate the smallest sized fishes projected to be retained by the smallest mesh tested. Upper points show the largest sized individuals expected for each species.

About 85% (24) of the traps used during this study were lost or stolen. Most losses probably were due to theft rather than misplacement because multiple, accurate methods (including the use of divers) were used to relocate traps. In some instances, SEFC divers relocated the anchors and groundline of a trawl, but the traps and bridle lines were missing. Trap losses by commercial fishermen off southeastern Florida average from 20% to 100% annually (Sutherland and Harper, 1983).

Few definitive statements concerning mesh selectivity and catch rates can be made because of the small sample sizes. Only about one-third of the estimated trap hauls needed to adequately estimate population parameters have been obtained. Few trap hauls were obtained for 38 x 38 mm mesh because of trap losses and subsequent inadvertent replacement with a trap having a 51 x 51 mm mesh.

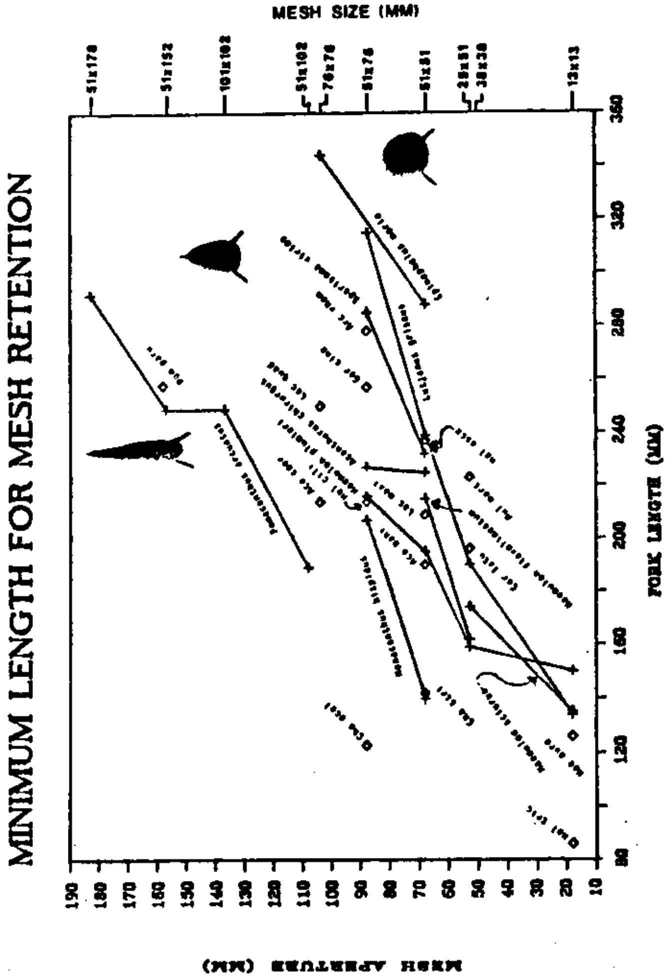

Figure 9. Fork lengths of smallest sized individuals retained in a particular mesh. Single points (□) represent species where only one individual was tested or species where several individuals were tested but all were retained by one mesh size. Lines connect multiple points (+) for one species. Sizes plotted can be considered conservative in that smaller individuals (if tested) could be retained by a particular mesh. Abbreviated scientific names are: *Acanthurus bahianus, Acanthurus coeruleus, Archosargus rhomboidalis, Caranx latus, Chaetodon ocellatus, Chaetodon striatus, Gerres cinereus, Haemulon aurolineatum, Holacanthus ciliarus, Holacanthus tricolor, Holocentrus ascensionis, Lachnolaimus maximus, Lactophrys quadricornis, Mulloidichthys martinicus* and *Pomacanthus paru.*

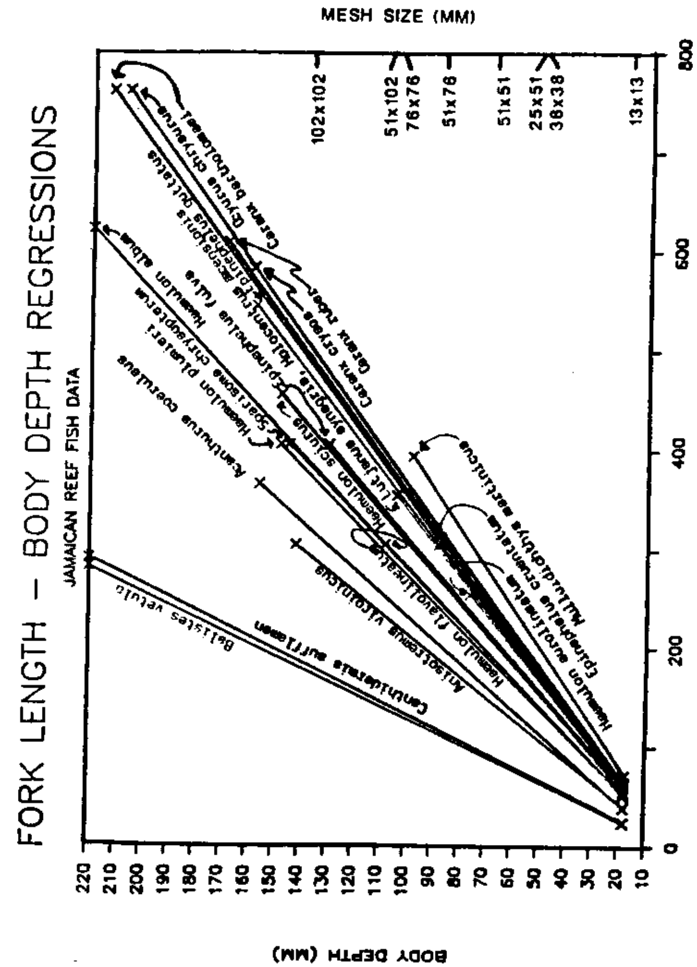

Figure 10. Regressions of body depth on fork length for Jamaican reef fishes. Mesh sizes shown on the right side can be used to predict fork length and body depth of species that would be retained by a particular mesh. Bottom points on lines show the smallest sized fish projected to be retained by the smallest sized mesh. Upper points show the largest sized individuals expected for each species. Regression data were from Munro (1983).

Catch data for traps with different mesh sizes confirm earlier studies by Olsen *et al.* (1978), Stevenson and Stuart-Sharkey (1980), and Munro (1983) that mesh size is directly related to fish size. Mesh sizes larger than 51 x 51 mm tended to catch larger fish but fewer species and individuals. However, variances were large because of the small sample sizes. The mean weight per trap haul was lowest for the smallest and largest mesh sizes tested.

Results show fish size and body shape are important factors explaining differences in retention by a given mesh size between species (Figures 8 and 9). As predicted, slender (terete) fishes (*e.g.*, eels, lizardfishes, cobia) of a given length (or weight) are much more likely to escape a particular mesh than are compressed (*e.g.*, angelfishes, triggerfishes, butterflyfishes) or depressed (*e.g.*, stingrays, flatfishes) fishes of the same length. Rounded (fusiform) fishes fall between the two extremes. Thus, mesh size regulations aimed at optimizing one species may greatly affect capture of other species due to differences in body shape.

SUMMARY

Mesh selectivity of wire fish traps equipped with 8 different mesh sizes ranging from 13 x 13 mm to 102 x 102 mm was studied from December 1986 to July 1987. A total of 521 fish of weighing 234 kg were caught in 131 trap hauls. Based on these limited data, significant differences were noted in catches by mesh size. Traps with mesh sizes of 51 x 76 mm and larger caught the fewer fish per haul and larger fish based on individual size. In the laboratory 222 fish were tested to determine the maximum size of mesh that could retain them. Retention curves were calculated for the three common species and these data were used to calculate fork lengths where 50% of the fish would be retained by a given mesh size.

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