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VISUAL CENSUSES OF FISH POPULATIONS AT THE FLORIDA MIDDLE GROUND

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ABSTRACT: Logistical constraints and bottom-time restrictions form major impediments to visual censusing of fish populations at depths such as are found at the Florida Middle Ground. A sampling strategy which incorporated multiple short duration point-diversity counts enabled estimation of population densities of a number of species present at the Florida Middle Ground. The method described is most accurate for substratum-oriented, site tenacious species such as damselfishes, gobies, and some wrasses, as well as slow-moving or sedentary larger species such as angelfishes and groupers. Numerical classification of count data revealed that fish distribution patterns at the Florida Middle Ground were loosely defined, although differences between biotopes and stations could be discerned. Subjective indices of substratum sand, rubble, hard coral, soft coral, and sponge coverages indicated that these factors had a discrete influence on observed fish distribution patterns.

Fishes are one of the most "visible" components of biological assemblages associated with hard bottom habitats of both inshore and offshore shelf areas. Short or long-term changes in the status of fish stocks, especially for species of commercial or recreational fishery importance, are a primary concern when hard bottom habitats are designated for coastal resource development activities such as petrochemical exploration or production. Historically, however, techniques for the assessment of hard bottom fish populations have been highly qualitative or at best semi-quantitative, thus rendering detection and interpretation of changes in these fish stocks a difficult task.

Acquisition of reliable quantitative data on fish populations of hard bottom or reef habitats has been hindered by logistical and technical difficulties with both sampling and observational programs. Conventional trawling methods are largely ineffective in areas of high topographic relief (Russell *et al.*, 1978). Results of gill net, fish trap, and hand-line methods have been criticized as being inefficient or highly selective. Techniques requiring the use of piscicides, anesthetics, or explosives, although effective and relatively non-selective, are often undesirable in terms of dangers in application and potential environmental damages (Russell *et al.*, 1978). To date, workers have primarily resorted to non-destructive, direct (SCUBA or submersible based) or indirect (stationary or towed camera) visual observations to characterize reef fish communities. Details of diver-obtained fish censuses have been reported by Brock (1954), Bardach (1959), Alevizon and Brooks (1975), Thompson and Schmidt (1977), and Jones and Thompson (1978). The various methodologies employed in the above studies were modifications of standard transect sampling schemes. Other investigators have used point-count methodologies (eg. Slobodkin and Fishelson, 1974; Bohnsack, 1982; Bohnsack and Bannerot, 1983). Recently,

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workers have attempted to determine sources of bias and to estimate degrees of precision for visual census techniques (Sanderson and Solonsky, 1980; Brock, 1982; DeMartini and Roberts, 1982; Sale and Sharp, 1983) without reaching a concensus regarding comparative strengths and weaknesses of the available techniques.

Difficulties in ascertaining quantitative assessments of fish stocks on deep hard bottom or reef complexes are exacerbated by physical constraints imposed on diving operations. Visual observations involving the use of submersibles or underwater video cameras are expensive and somewhat limited by resolution of the photographic records. "Ground truthing" by direct diver observations unquestionably enhances the reliability of data acquired in these manners (Powles and Barans, 1980). Time-at-depth restrictions stipulated by no-decompression tables form the major barrier to implementation of population census methods by divers using SCUBA techniques. Whereas "deep" might be defined as depths greater than several hundred meters for submersible operations, 30 m might well be considered deep for assessments performed by SCUBA equipped divers. For example, NOAA (1975) diving guidelines restrict no-decompression bottom times for two repetitive dives to 33 m separated by a six hour surface interval to 25 and 18 minutes respectively. Simple logistics and safety factors would therefore severely hinder the effective application of time consuming census methods at comparable depths.

This paper describes efforts made to census fish populations at the Florida Middle Ground (FMG). The FMG is an extensive hard bottom area located on the outer continental shelf of the eastern Gulf of Mexico. Water depths at the FMG range approximately from 25 to 40 m. The reef complex is centered about 150 km south of the Florida panhandle coastline and 160 km northeast of Tampa Bay (Figure 1). Characteristics of prominent physical and biological features of the FMG can be found in Hopkins *et al.* (1977a, 1977b). Fish communities at the FMG have been the subject of several studies. Shipp and Bortone (1979) provided a description of demersal fishes in the area based on dredge and trawl collections. Austin (1971) reported a preliminary list of reef fishes at the FMG. This species list has since been greatly expanded by Smith *et al.* (1975), Smith (1976), and Hopkins *et al.* (1981). Ecological aspects of the FMG ichthyofauna have been reported by Smith and Ogren (1974), Smith (1976), and Livingston (1979). All of the above fish-related studies were descriptive in nature. When presented, species abundances were subjectively estimated as rare, common or abundant, or were similarly categorized. The need for quantitative data on FMG fish populations and species-habitat relationships is underscored by the fact that the FMG supports substantial snapper-grouper commercial and recreational fisheries (Smith, 1976).

METHODS

Of the stations occupied during the FMG investigations conducted as part of the Northern Gulf of Mexico Topographic Features Study (see Acknowledgments for sponsorship), six (151, 247, 481, 491, 492, and Sink Hole) were sites of the ichthyofaunal studies reported herein (see Figure 1). These stations were visited between October 1978 and July 1979.

In light of the sampling difficulties outlined above, an effort was made to

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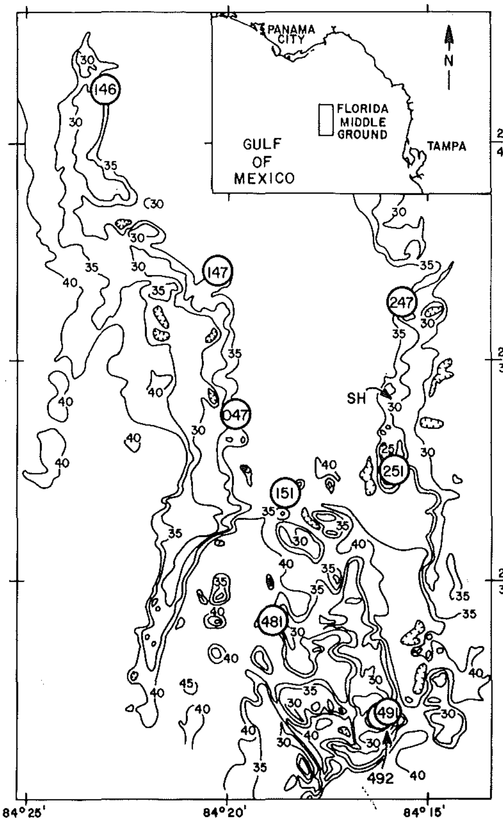

Figure 1. Station locations at the Florida Middle Ground. Bathymetric contours are in meters. SH indicates the location of a station designated the sink hole.

obtain fish census data in the most time-effective, quantitative manner feasible. SCUBA techniques were used but decompression diving was avoided whenever possible. Time-at-depth constraints precluded swimming transects at most of the FMG stations. An alternative sampling strategy was adopted which consisted of a modified version of the point-diversity count method described by Slobodkin and Fishelson (1974). In brief, fish counting procedures were as follows:

1. At each station, a reconnaissance dive was made to acquaint the diver-observers with the topographic layout of reef structure at the station. Demarcations between shallow reef flat, ridge crest, reef slope, reef base, and patch reef biotopes were noted.

2. On successive dives, count sites were selected at random within the biotope boundaries. Effort was taken to avoid prejudicial choice of count sites due to the presence of prominent coral structures or particular fish species.

3. At the actual count site, the diver-observer settled on the bottom about 2.5 m from the center of the count area. Over a five minute period records were made of the number of individuals of all fish species within a 2x2x2 m cube of water over the substratum. During preliminary counts, a PVC grid was placed on the bottom to establish dimensions of the count area. A decision was made to abandon the use of the grid because of the apparent response of several fish species to the presence of the grid. Also, with experience, a diver could visually estimate the count area with relative confidence. Data for each count were recorded on slates with inscribed species lists.

4. At the end of each count, a series of 35 mm color photographs was taken of the site. Depth, date, time, and biotope were also recorded.

A count duration of five minutes maximized the number of counts that could be taken during a single dive. Preliminary ten minute counts did not appear to increase the number of species or individuals observed per count. Durations shorter than five minutes were judged inadequate to provide accurate counts of species and their respective abundances at any given site. In contrast to transect sampling methods, point-diversity counts tend to promote inclusion of small, substrate-oriented species at the expense of mobile, transient species. A stationary rather than swimming observer has a greater opportunity to detect cryptic and site-tenacious species. This source of bias must be taken into consideration during analysis and interpretation of point-diversity data so derived.

Photographic records of the count sites were used to subjectively compare substratum features between biotopes. Individual count sites were rated according to relative substratum coverages attributable to the following categories: sand, rubble, hard coral, soft coral, and sponge. Each category was assigned a value on a scale from 0 (absence of that substratum feature) to 10 (maximum coverage). Site photographs were rated in random order without prior reference to station or biotope records. Final values for a given site represented a mean determined from four quadrant photos of each count site. Because categories varied considerably with respect to horizontal and vertical components, a sliding scale measure was considered to be more valid than expression of spatial coverages as percentages. Values across categories for a given count site therefore do not necessarily sum to 10.

A single dive of the Deep Submersible Research Vessel (DSRV) *Diaphus* was used to obtain point-count data at station 151 in November 1978. Videotape recordings were taken at nine count sites for comparison with SCUBA obtained counts.

Numerical classification (cluster analysis) was performed on the point-count data matrix to objectively compare both similarity among sites based on species occurrences (normal analysis) and similarity among species based on their distribution patterns (inverse analysis) (Clifford and Stephenson, 1975; Boesch, 1977). Count data were transformed to normalize the statistical distributions by setting:

$$z_{ij} = \ln(x_{ij} + 1)$$

in which x_{ij} is the abundance of species i at site j. The data were also standardized to minimize scaling effects of abundant versus rare species in inverse analysis. Classification was accomplished with a flexible sorting strategy at the conventional cluster intensity coefficient (Beta) of -0.25 (Boesch, 1977). Species represented by single occurrences were eliminated from the inverse analysis. Both normal and inverse analyses were computed with a modified version of a FORTRAN program package described by Bloom *et al.* (1977). Interpretation of the results of the cluster analyses was facilitated by nodal analysis as recommended by Boesch (1977). This two-way contingency table technique measures the degree of constancy (high values indicate that all members of a given species group occurred in a high proportion of counts in a particular site group), and the degrees of fidelity (high values indicate that members of a given species group are restricted to a particular site group) within classified groups.

Biotope descriptions

Five biotopes were recognized for purposes of sampling effort allotment at the study stations (Figure 2). These were:

1. Shallow Reef Flat — characterized by gently sloping bottom with scattered sand patches. Moderate to high sponge and soft coral

densities. Depths generally in the 23 to 30 m range.

2. Ridge Crest — a sharply defined break along the upper face of the reef marked by a nearly vertical escarpment of exposed rubble varying in height from 1 to 6 m. Dominated by the hard corals *Millepora alcicornis* and *Madracis decactis*. The ridge crest at station 247 in particular was extensively broken by deep crevices. Depths in the 26 to 34 m range. Not a well developed feature at stations 491 or 492.

3. Reef Slope — a steeply inclined bottom of approximately 45 to 75 degrees with numerous erosional sand-filled spillways traversing down the reef face interspersed with exposed rubble outcrops. Occasionally interrupted by narrow horizontal terraces. Hard and soft corals and sponges patchily distributed. Depths in the 29 to 38 m range.

4. Reef Base — a transition zone between the reef slope and surrounding barren sand bottoms. Widely scattered clumps of exposed rubble with attached corals and sponges. Depths generally in the 37 to 40 m range.

5. Patch Reef — areas of low to moderate slope with large rubble outcrops and coral formations separated by sandy substratum. Depths in the 25 to 38 m range. Station 491 consisted largely of this biotope, whereas patch reef was not found at stations 151, 247, and 481.

Detailed descriptions of the algal and invertebrate faunal assemblages present on FMG reef structures can be found in Grimm and Hopkins (1977) and Hopkins *et al.* (1977a, 1977b, 1981).

Sampling adequacy

A total of 125 five minute fish counts (10.4 hrs total observation time) was completed. These were distributed among stations, seasons, and biotopes as presented in Table 1. Weather conditions and difficulties in relocating stations prevented equalization of sampling efforts.

To evaluate the adequacy of count sample sizes for each biotope (with the exception of patch reef for which only 6 counts were obtained), cumulative species curves were plotted (Figure 3). To avoid artifactual depression of the curves due to a seasonal effect by winter counts, the order of counts was randomized prior to inclusion in curve calculations. Although sample size differed substantially among biotopes, cumulative species curves for each followed essentially identical patterns. Although 52 species were observed during the counting periods, the curves began to level appreciably at 30 to 35 species, which corresponded to 15 to 20 counts. The occurrence of numerous rare species at the FMG had the effect of extending the approach of the curves toward an asymptote. Sampling effort, however, was judged adequate to account for all dominant and the majority of less common species in four of the five biotopes.

The FMG is the northernmost reef complex in the eastern Gulf of Mexico. In comparison with Caribbean reef faunas, that of the FMG is relatively impoverished. During this investigation 127 fish species were observed. This

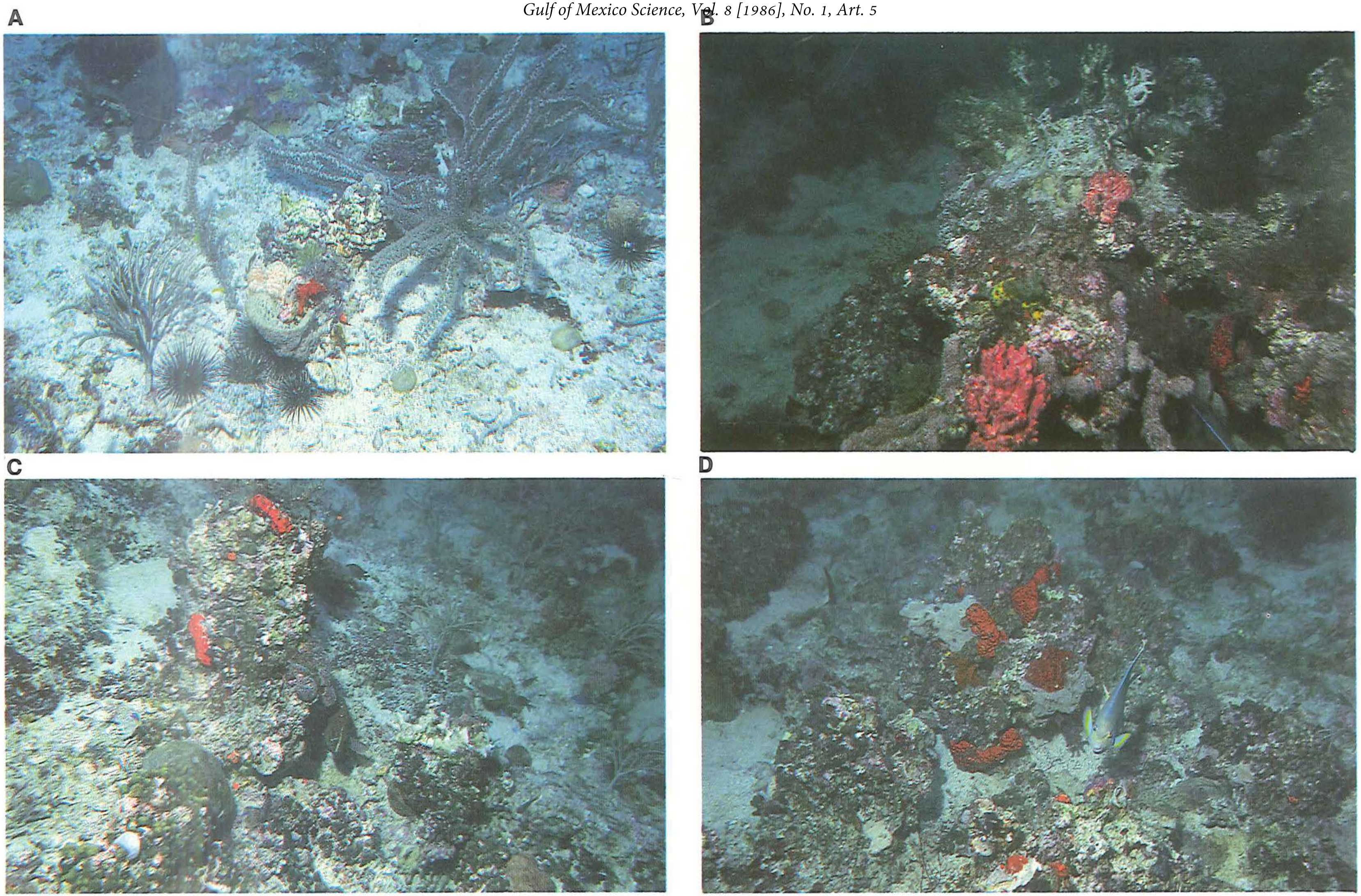

Figure 2. Point-diversity count site photographs representative of a) shallow reef flat, b) ridge crest, c) reef slope, and d) reef base biotopes. Patch reef biotope not pictured.

total includes species sighted outside of count boundaries or taken in miscellaneous algal, sponge, coral, or artificial habitat samples (as reported in Hopkins *et al.*, 1981). The 52 species accounted for by actual fish counts thus do not include a large portion of the ichthyofauna present, although missing components are predominantly pelagic, nocturnal, or highly secretive forms.

ICHTHYOFAUNAL COMMUNITY STRUCTURE

Estimates of population densities based on point-count data were calculated for the 52 species observed (Table 2). In terms of actual numbers of species observed per count, the ridge crest biotope exhibited the highest mean, whereas fewest species per count occurred in the shallow reef flat counts. The ridge crest also showed the highest mean number of individuals per count, whereas the reef base had the lowest. Mean number of individuals per count largely reflected changes in the density of the purple reeffish, *Chromis scotti*, across biotopes. Dense, loosely formed schools of this planktivorous damselfish hovered within several meters of the substratum during the day. Their schools were concentrated above areas of prominent relief and aligned along the ridge crest. Abundance of *C. scotti* decreased sharply away from the ridge crest and was lowest in the reef base biotope, but was nevertheless the species of highest density in all biotopes sampled. Contributing to the high densities of purple reeffish was the presence of numerous juveniles during the summer and fall point-counts.

The slippery dick, *Halichoeres bivittatus*, was second most abundant in both the shallow reef flat and reef base biotopes, and third most abundant in the ridge crest and reef slope biotopes.

Table 1. Distribution of ichthyofaunal point-diversity counts among stations, seasons, and biotopes at the Florida Middle Ground. Absence of a biotope at a station is indicated by X. The sink hole station is donated as P. (SRF = shallow reef flat, RC = ridge crest, RS = reef slope, RB = reef base, PR = patch reef).

		BIOTOPE					
STATION	DATE	SRF	RC	RS	RB	PR	STATION TOTAL
151	OCT-NOV	6	1	6	3	X	53
	JAN-MAR	7	4	3	-	X	
	JUN-JUL	9	1	4	9	X	
247	OCT-NOV	5	2	2	-	X	38
	JAN-MAR	-	9	1	-	X	
	JUN-JUL	7	4	6	2	X	
481	OCT-NOV	2	2	-	-	X	6
	JUN-JUL	-	-	1	1	X	
491- 492	OCT-NOV JUN-JUL	- -	X X	- 16	- 3	6 -	25
P	JUN-JUL	-	X	3	-	X	3
BIOTOPE TOTALS		36	23	42	18	6	125

Although showing peak abundance in the shallow reef flat, this wrasse was relatively evenly distributed across biotopes. Distribution of the seaweed blenny, *Parablennius marmoreus*, was similar to that of the slippery dick, peaking in the shallow reef flat and fairly even throughout the remaining biotopes. Cocoa damselfish, *Pomacentrus variabilis*, showed a trend for decreasing population density with increasing depth, and were particularly abundant in the shallow reef flat. A third common pomacentrid at the FMG in addition to *C. scotti* and *P. variabilis* was the yellowtail reeffish, *Chromis enchrysurus*. In contrast to *P. variabilis*, *C. enchrysurus* was most abundant along the reef base and declined in density with decreasing bottom depth.

Due to an inability to distinguish bridled gobies, *Coryphopterus glaucofraenum*, from spotted gobies, *C. punctipectophorus*, in the field counts, data for these species were treated together. These gobies seemed to prefer sandy substrata at the bases of eroded rubble or coral formations. Their population density was highest on the reef slope and lowest on the reef base. Neon gobies, *Gobiosoma oceanops*, were also very abundant on the reef slope. Noted for their cleaning behavior, neon gobies established "stations" in the proximity of formations having substantial vertical relief or prominent overhangs. A congener, the yellowprow goby, *G. xanthiprora*, showed decreasing abundance with increasing depth. The distribution of the yellowprow goby, which is an obligate sponge inquiline, is influenced by the availability of their host sponge species. At the FMG *G. xanthiprora* is largely associated with the tubular sponge *Aplysina* (= *Verongia*) *fistularis* (Livingston, 1979).

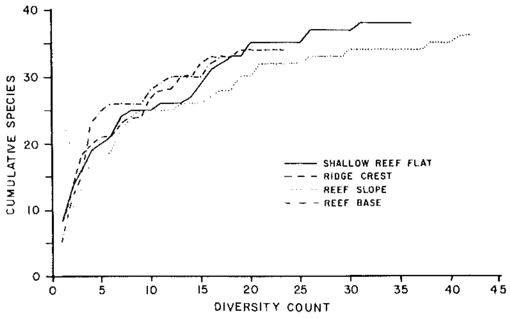

Figure 3. Cumulative species curves for point-diversity count data for the four main biotopes sampled at the Florida Middle Ground.

Biases in the population density methodology are readily apparent in the data upon inspection of Table 2. For example, the estimate for greater amberjack, *Seriola dumerili*, in the ridge crest biotope was inflated as the result of the passage of a large school through a single count site. Several species, including *S. dumerili*, showed varying degrees of attraction to the presence of a diver, thus causing overestimation of their densities. Notably, this behavior was exhibited by blue angelfish, *Holacanthus bermudensis*, gray triggerfish, *Balistes capriscus*, gray snapper, *Lutjanus griseus*, and to a lesser extent the butter hamlet, *Hypoplectrus unicolor*. All hamlets sighted or collected at the FMG were originally identified as the barred hamlet, *H. puella*, which has recently been considered a synonym of *H. unicolor* (Robins *et al*., 1980). In contrast, tomtate, *Haemulon aurolineatum*, showed a distinct avoidance of even stationary divers, thereby leading to an underestimation of their density. These data also include a number of species that were cryptic by virtue of morphological adaptations or behavior and undoubtedly were underestimated by the point count method. In this category would be the leopard toadfish, *Opsanus pardus*, southern hake, *Urophycis floridana*, spotted moray, *Gymnothorax moringa*, and the

Table 2. Population density estimates of Florida Middle Ground fishes based on 125 point counts within 5 biotopes (SRF = shallow reef flat, RC = ridge crest, RS = reef slope, RB = reef base, PR = patch reef). Table values are given as fish per 100 sq. m.

SPECIES	SRF	RC	RS	RB	PR
Chromis scotti	447	1,130	591	175	571
Halichoeres bivittatus	147	87	95	96	67
Parablennius marmoreus	73	38	53	31	50
Pomacentrus variabilis	69	29	21	18	58
Coryphopterus spp.	56	40	72	24	29
Gobiosoma oceanops	40	48	96	28	108
Gobiosoma xanthiprora	35	17	10	8	-
Holacanthus bermudensis	31	46	48	25	29
Scarus sp.	20	8	21	14	88
Mycteroperca phenax	9	21	14	18	-
Hypoplectrus unicolor	9	8	15	11	17
Balistes capriscus	7	29	16	8	4
Pagrus pagrus	6	38	29	28	13
Lachnolaimus maximus	5	15	1	1	17
Ioglossus calliurus	5	-	-	68	-
Emblemaria atlantica	4	2	-	-	-
Mycteroperca microlepis	3	10	7	1	-
Canthigaster rostrata	3	1	1	3	-
Chaetodon ocellatus	3	2	1	13	-
Lutjanus griseus	2	13	21	17	-
Serranus subligarius	2	-	-	-	-
Chaetodon sedentarius	2	4	7	-	8
Chromis enchrysurus	2	7	26	54	21
Seriola dumerili	2	225	-	3	-
Pomacentrus partitus	1	-	-	-	-
Apogon pseudomaculatus	1	2	2	14	4
Equetus lanceolatus	1	-	1	1	-
Centropristis ocyurus	1	-	-	44	-
Apogon maculatus	1	1	1	-	-
Epinephelus guttatus	1	1	-	-	-
Epinephelus morio	1	1	1	-	-
Calamus nodosus	1	7	11	28	-
Opistognathus aurifrons	1	-	-	1	-
Synodus intermedius	1	-	1	1	-
Labrisomus haitiensis	1	-	-	-	-
Hippocampus erectus	1	-	-	-	-
Gymnothorax moringa	1	-	-	-	-
Epinephelus cruentatus	1	3	3	-	-
Holocentrus ascensionis	-	7	-	1	8
Holocentrus bullisi	-	-	2	1	-
Halichoeres caudalis	-	-	2	6	4
Halichoeres pictus	-	-	-	1	-
Equetus umbrosus	-	38	10	6	-
Rypticus maculatus	-	8	1	3	-
Opsanus pardus	-	-	1	-	-
Pristigenys alta	-	-	2	-	-
Liopropoma eukrines	-	-	1	-	-
Urophycis floridana	-	-	1	-	-
Sphoeroides spengleri	-	-	1	-	-
Haemulon aurolineatum	-	8	-	-	-
Haemulon plumieri	-	8	-	-	-
Starksia ocellata	-	1	-	-	-
TOTAL # SPP.	38	34	36	33	17
TOTAL # INDS./100 sq m	993	1,903	1,182	753	1,096
MEAN # SPP./COUNT	8.2	10.5	9.4	9.4	9.5
MEAN # INDS./COUNT	39.8	75.9	47.6	30.1	43.8

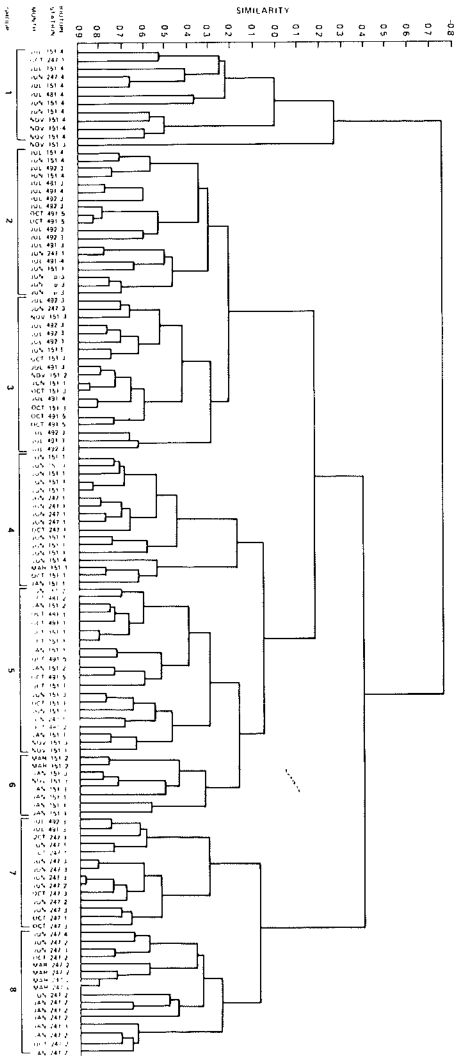

Figure 4. Station classification (normal analysis) of Florida Middle Ground point-diversity count data. Station P = sink hole. All November counts were taken from a submersible. (similarity coefficient = Czekanowski Quantitative, data log transformed, flexible sorting with Beta = -0.25).

apogonids and clinids. Counts of banner blennies, *Emblemaria atlantica*, which utilized dead, gaping *Spondylus* shells for refuges, were clearly inadequate to achieve an accurate density estimate. Nocturnal species such as the twospot cardinalfish, *Apogon pseudomaculatus* (although this species was not particularly secretive during daylight hours), and flamefish, *A. maculatus*, were also most certainly underestimated.

Results of normal cluster analysis (site classification) revealed a substantial degree of station integrity and grouping of counts by biotope (Figure 4). Station 247 was most distinctive, contributing primarily to site groups 7 and 8. Site group 8 consisted largely of ridge crest counts, an association that was maintained across seasons. A small subgroup of station 247 counts, all taken in the reef slope, were classified with other slope biotope counts from station 151 to form the larger portion of site group 4. Station 151 counts contributed primarily to site groups 1, 4, 5, and 6. Station 151 reef base counts sorted within group 1, whereas shallow reef flat counts fell into group 4. Site group 6 contained only Station 151 counts, but showed little biotope consistency. Seasonal effects may have been a factor in formation of site group 6, as counts taken in winter months were prominent. Site group 5 showed little consistency with respect to season, station, or biotope. Counts for stations 491 and 492, which were located within a relatively short distance from one another at the southern extent of the FMG, sorted predominantly into site groups 2 and 3, with reef slope counts forming the major portion of group 3. All three counts taken at the sink hole site (taken during a single dive) clustered intensely in site group 2. A single count, taken in November from the submersible DSRV *Diaphus*, was unclassified. This "outlier" contained a unique combination of high numbers of both cubbyu, *Equetus umbrosus*, and neon gobies, *Gobiosoma oceanops*. The latter species was attracted to the presence of the submersible and congregated on the surface of the submersible's forward skids soon after it had settled on the bottom.

Inverse analysis (species classification) indicated that distribution patterns of most FMG count species were loosely defined at best. Nine species groups based on 44 count species were identified (Figure 5). Results of nodal analysis are presented in Figure 6 and used below to interpret group formation.

The majority of numerically dominant species comprised a single group (G) which exhibited high constancy but relatively low fidelity, i.e. these species occurred together in a high proportion of counts within site groups but were not restricted to any particular site group or groups. As indicated by the species density estimates, these species were widely distributed across biotopes. Their association was less well-developed in the reef base biotope.

Species group A contained several less common species which were generally observed in the shallow reef flat biotope (site group 4) and sporadically in ridge crest and slope biotopes (site group 6). Species group B represented a "default" group which formed as an artifact of the sorting technique. These were very rare species fused at the 0.0 similarity level, which reflected the fact that they had no co-occurrences in any count. Two groupers, the red hind, *Epinephelus guttatus*, and the red grouper, *E.*

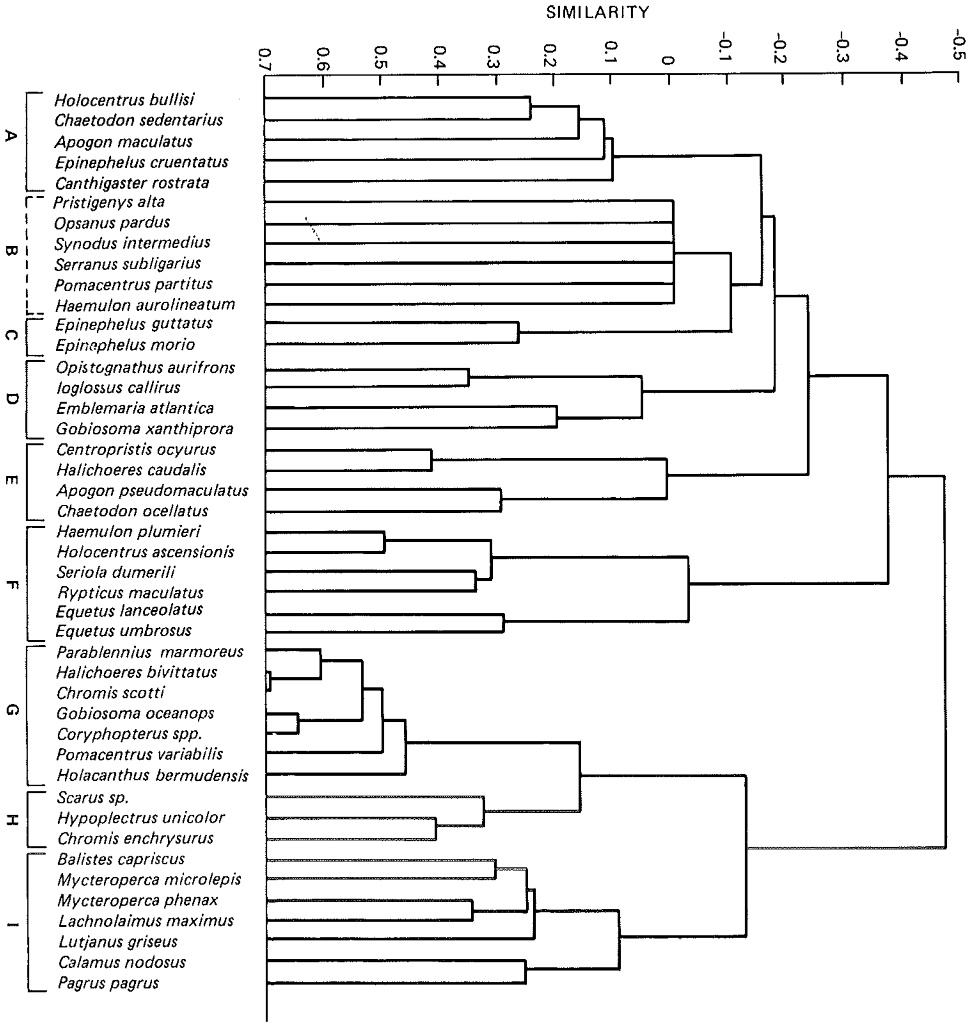

Figure 5. Species classification (inverse analysis) of Florida Middle Ground point-diversity count data. (similarity coefficient = Czekanowski Quantitative, data log transformed, double standardized, flexible sorting with Beta = -0.25).

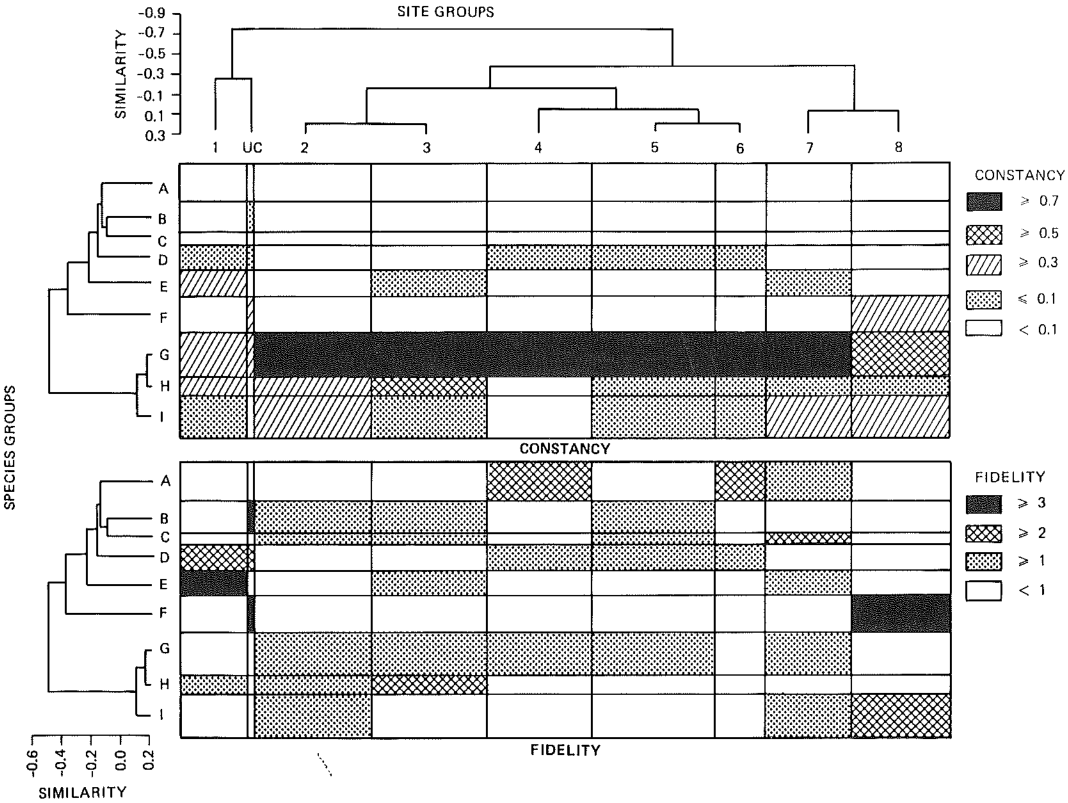

Figure 6. Nodal analysis of station and species groups for Florida Middle Ground point-diversity count data. Nodal constancy depicted in the upper table, nodal fidelity depicted in the lower table. (UC = unclassified).

morio, formed group C, which had low constancy but high fidelity within site group 7. This indicates that their abundances were comparatively higher at station 247 than at other stations, but their distribution was not restricted to a given biotope. Species group D consisted of four substratum oriented fishes, the yellowhead jawfish, *Opistognathus aurifrons*, blue goby, *Ioglossus calliurus*, banner blenny, *Emblemaria atlantica*, and yellowprow goby, *Gobiosoma xanthiprora*. Observations made during reconnaissance dives supported the high fidelity value for the two former species in the reef base biotope. Collections of the latter two species with coral and sponge samples, however, indicated that they were more evenly distributed across biotopes. Species group E showed a combination of fairly high constancy and fidelity for site group 1, reef base counts. General observations supported this pattern, especially for the bank sea bass, *Centropristis ocyurus*, and painted wrasse, *Halichoeres caudalis*.

Six species associated with the ridge crest biotope (site group 8), characterized by fairly high constancy and very high fidelity, formed species group F. Four of the species, squirrelfish, *Holocentrus ascensionis*, whitespotted soapfish, *Rypticus maculatus*, jackknife-fish, *Equetus lanceolatus*, and cubbyu, *E. umbrosus*, spent the daylight hours within crevices which indented the near vertical face of the ridge crest at station 247.

Species group H, comprising a

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parrotfish of uncertain identity, *Scarus* sp., butter hamlet, *Hypoplectrus unicolor*, and yellowtail reeffish, *Chromis enchrysurus*, were widely distributed among site groups, but showed peak constancy and fidelity values for site group 3 (reef slope counts at stations 491 and 492). These species displayed a definite affinity for deeper biotopes, although *Scarus* sp. was also seen to move in small schools over the shallow reef flat.

Seven species were sorted into group I, which was characterized by relatively high constancies among site groups 2, 7, and 8, and high fidelity for site group 8. Species in this group were large, mobile fishes such as the scamp, *Mycteroperca phenax*, gag, *M. microlepis*, gray snapper, *Lutjanus griseus*, and hogfish, *Lachnolaimus maximus*, which ranged freely over the reef complex but seemed to congregate in areas of high relief.

Results of numerical classification can be summarized by the statements that a) station 247 harbors the most distinctive ichthyofauna sampled by the point-count method, whereas other FMG station are less well-defined in terms of their predominant fishes, and b) biotope is a somewhat stronger determinant of ichthyofaunal composition at the FMG than station location. The observed degree of sorting by biotope was remarkable in that the distances separating the boundaries of the shallowest and deepest biotopes were quite short. For example, reef base counts could often be obtained within 50 m swimming distance of shallow reef flat count sites.

To examine the extent to which substratum features other than depth and slope could be used to characterized site groups, means and standard deviations of photographic record coverage index values were calculated (Table 3). Site group 1, predominantly composed of reef base counts, had the highest mean sand coverage index and the lowest mean sponge coverage index of all site groups. Highest mean hard coral coverage index was obtained for site group 3, which contained a high proportion of reef slope counts. Highest mean sponge coverage index, as well as lowest indices for both rubble and hard coral, were noted for site group 8, which largely contained shallow reef flat counts. Site group 8, a cluster mainly of ridge crest counts taken at station 247, had the

Table 3. Substratum feature coverage indices for site groups at the Florida Middle Ground. Means and standard deviations were calculated from values estimated from four photographs per point-diversity count site. (n = number of count sites in a group for which photographs were obtained).

SITE GROUP	n	SAND $\bar{X}$ (SD)	RUBBLE $\bar{X}$ (SD)	SOFT CORAL $\bar{X}$ (SD)	HARD CORAL $\bar{X}$ (SD)	SPONGE $\bar{X}$ (SD)
1	7	6.71 (1.50)	3.86 (1.77)	0.71 (1.11)	1.86 (1.35)	1.57 (0.79)
2	18	3.17 (1.65)	5.94 (2.10)	1.00 (0.91)	3.72 (1.74)	1.67 (0.84)
3	14	2.83 (1.34)	7.17 (1.19)	0.75 (0.75)	4.25 (1.60)	1.83 (1.03)
4	12	5.17 (1.47)	3.75 (1.49)	1.75 (0.96)	1.50 (1.17)	3.17 (0.94)
5	13	3.15 (1.57)	5.15 (2.08)	2.15 (1.77)	3.92 (2.33)	2.39 (1.33)
6	4	6.00 (1.56)	4.25 (2.63)	2.25 (1.26)	2.00 (1.63)	3.00 (0.82)
7	13	2.85 (1.52)	7.92 (1.12)	0.31 (0.48)	2.00 (1.68)	2.31 (1.03)
8	12	1.00 (1.65)	8.83 (1.40)	0.00 (0.00)	1.75 (0.97)	1.67 (1.07)

highest mean rubble coverage index, the lowest mean sand coverage index, and was devoid of soft corals. Site groups 2, 5, 6 and 7, each of which consisted of a mixture of biotope counts, generally had intermediate coverage indices for all categories.

Although based on subjective data, the coverage indices reinforced the supposition that FMG fish distribution was related to substratum features. For example, the only non-reef base count included in site group 1 was taken in a sand patch on the shallow reef flat at station 247. This particular count site contained few species, one of which was the blue goby, *Ioglossus calliurus*, which was commonly seen hovering over its burrows in sandy substrata along the reef base.

CONCLUSIONS

In shallow waters, most workers attempting to census reef fish populations have adopted some variation of a swimming visual transect methodology. This strategy, however, is not a viable option for most investigations of reef complexes deeper than 20 to 25 meters. Stationary point-count methods offer an operational alternative through which useful information can be acquired with acceptance of the caveat that inherent sampling biases are recognized. Ultimately, selection of a census method and the value of the data derived hinge upon the specific objectives of the study. During planning for the present study, a decision was reached that for purposes of a baseline monitoring program, emphasis upon an accurate assessment of small, resident, site tenacious species at the expense of large, transient, pelagic species was appropriate. In future evaluations of fish populations at the FMG, detection of changes in stocks could be focused upon those components of the overall ichthyofauna that would be most likely to respond to chronic as well as acute environmental perturbations. Subtle fluctuations in stocks of very abundant species, such as the purple reeffish, *Chromis scotti*, would be exceedingly difficult to quantify against a background of normal seasonal and annual variation. Potentially suitable target species for monitoring efforts at the FMG would include the yellowprow goby, *Gobiosoma xanthiprora* (identified as *G. horsti* by Smith *et al.*, 1976), a sponge inquiline yet highly visible, or the territorial cocoa damselfish, *Pomacentrus variabilis*. Populations of these two species appear to be relatively stable at the FMG, in marked contrast with several other species which show large year-to-year changes in abundance. For example, the bluehead wrasse, *Thalassoma bifasciatum*, has previously been reported to be common at the FMG (Smith, 1976), whereas only rare juveniles were observed during the present effort.

Large fluctuations in FMG species abundances may be induced by incursions of red tide outbreaks (Smith, 1976), tropical storms, or harsh winter conditions. Lying at the northern extent of reef growth in the eastern Gulf of Mexico, the FMG fish fauna is impoverished in comparison with Caribbean reef fish communities of comparable depths. Standing stocks of herbivorous scarids and acanthurids, often dominant biomass constituents of Caribbean fish faunas, are severely reduced at the FMG, perhaps reflecting marginal water temperature regimes there. Individuals of the most numerous parrotfish at the FMG, here identified as *Scarus* sp. (*Scarus croicensis* in Smith *et al.*, 1976), were much smaller in average body size than their Caribbean counter-

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parts, especially terminal phase males, and may represent a stunted growth phenomenon or possibly a new species.

More speciose ichthyofaunas may require a greater number of replicate counts than was achieved in this study. This does not imply that a level of effort beyond the capability of most field investigations would be necessary. Ninety-four of the 125 counts obtained during this study were obtained by a single diver (DGC) while his diving partner was collecting habitat samples down-current from the count site. Teams of four trained divers taking simultaneous counts could equal the sampling effort of this entire study in ten working days or less. At this level of effort a more rigorous program of count allocation to biotopes could be maintained and difficulties in obtaining sufficient samples for a seasonal analysis minimized.

Neither swimming transect nor stationary point-count methods can be considered "better" under all circumstances. Each method examines a different, but incomplete portion of the fish assemblages present, thus each yields a relative rather than absolute characterization of those assemblages. Other authors (Russell *et al.*, 1978) have alluded to the need for systematic sampling programs to augment visual censuses. Collections of sponges, corals, algae, rubble, and artificial habitats at the FMG produced a variety of diminutive, cryptic species (gobiids, clinids, brotulids, apogonids, etc.) which were not apparent during diving observations. Results of these collections will be reported elsewhere.

Compensation for reduced observation time per count by large numbers of replicate short-duration counts entails the generation of a large data matrix. Analysis and interpretation of such data sets are greatly facilitated by multivariate statistical techniques. Numerical classification and nodal analysis, as employed in this study, can provide insight into and help discern patterns in the data which would otherwise be impossible or extremely laborious to detect. A cautionary note, however, should be given in that numerical classification tehcniques are exploratory in nature and not ends in themselves. They do not determine causal relationships for the observed patterns or species-site associations. Additional emphasis needs to be placed on concurrently sampling physical parameters of the reef complex in order to develop correlation matrices for species/site count and habitat parameter/site data sets. Although the subjectivity of the photographic records used in this study precluded in-depth analysis of species-habitat parameter relationship, additional multivariate statistical techniques are available to carry fish population census data to informative conclusions.

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