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POINT COUNT CENSUSING FROM A SUBMERSIBLE TO ESTIMATE REEF FISH ABUNDANCE OVER LARGE AREAS[1]

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ABSTRACT: Point count estimates of fish abundance were taken from a research submersible at thirty-two sites on a 0.5 km² patch reef on the Florida Middle Grounds, off the West Florida Shelf. Of the fifty species recorded, nine species were selected for total population estimates based on their behavior and visibility. Data from the individual point counts were extrapolated to the entire reef.

Best estimates of total populations of these species varied from 320 for the short big eye (*Pristigenys alta*) to 307,600 for the purple reeffish (*Chromis scotti*). The estimate for the commercially important red grouper (*Epinephelus morio*) was 1,560, a concentration reasonably similar to the 960 simultaneously estimated from a mark-recapture assessment.

Censusing marine fish populations inhabiting reef areas has received increased attention in recent years. Vernon Brock's (1954) transect method has been elaborated upon during the last three decades and various methodologies have been introduced to attempt a quantification of data, including Alevizon and Brooks' (1975) comparison of Key Largo and Venezuelan reefs, Jones and Thompson's (1978) rapid visual assessment of Key Largo and Dry Tortugas populations, and point count methodologies of numerous workers (see Clarke 1986).

The techniques and results generated by these studies are heavily reliant on SCUBA observations because of the obvious detrimental environmental effects of explosives and ichthyocides, and the expense involved with submersibles, both remote and manned. Nevertheless, limitations of SCUBA derived data also exist, such as depth, area of coverage, duration, and utilization of ancillary equipment and personnel during actual episodes of assessment.

Use of manned submersibles to observe fish populations in the western Atlantic region was initiated by Bright and Pequegnat (1974), and continues in usefulness (see summary by Parker and Ross 1985). The present study utilized the availability of the research submersible R/V JOHNSON-SEA-LINK I, employed primarily for evaluating fishery techniques during a 1981 visit to the Florida Middle Grounds, to census populations of diminutive reef species. The data were recorded over three days and a large portion of reef habitat, maximizing the technical advantages of a manned submersible. In addition, the use of two observers (RSJ and RLS) in alternating positions in the submersible

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but recording data synchronously, minimized the effect of individual biases on population estimates.

These data enabled population estimates for a few species over a large expanse of reef area. With the adoption of certain assumptions, these data can be expanded to estimate total populations of these species over larger geographic areas.

MATERIALS AND METHODS

Study site selection

The Florida Middle Grounds, located on the outer West Florida Shelf, is the most extensive area of living coral habitat in the northeastern Gulf of Mexico. The biology and geology of this area were described by Smith *et al.* (1975), Grimm and Hopkins (1977), Hopkins *et al.* (1977), Shipp and Bortone (1979), and the United States Dept. of the Interior, Bureau of Land Management (1981).

The study site is located at approximately 28°32'N and 84°18'W on a pinnacle-like substrate, oriented along a northeast-southwest axis, surrounded by barren sand bottom 40 m deep (Fig. 1). The sand bottom, depauparate of fishes and corals, isolated the study reef from neighboring reef areas by at least 0.6 km. Surrounding the reef base was coral rubble and sand with occasional gorgonians. This rubble zone, or apron, ended abruptly at the bottom of a reef face which consisted primarily of the scleractinian, *Madracis decactis*, and the hydrozoan, *Millipora alcicornis*. In the reef area proper *Millepora* dominated at approximately 30 m depths. Proceeding reefward, *Millepora* and *Madracis* were replaced by *Porites* and *Dichocoenia* as the dominant hard corals on the gradually upward sloping reef face. A similar zonation of corals was noted by Grimm and Hopkins (1977) on similar reef areas on the Florida Middle Ground. Patches of coral rubble and dense, irregularly spaced stands of gorgonians were also present on the reef flat, as were the sponges *Gelas dispar*, *Ircinia* sp., and *Spheciospongia* sp. Sand patches of varying size, devoid of corals and sponges, occurred haphazardly adding to the mosaic pattern of the reef flat. At 27 and 24 m, two smaller reef faces of *Millepora* and *Madracis*, 2-3 m high, were present. These reef faces gradually rose to the reef crest at approximately 22 m deep. The benthic fauna of the reef crest appeared similar to that of the reef flat.

The study reef was defined as the area within the boundaries of the deepest reef face 35 m deep. A total area of 0.5 km^2 was determined by planimetry from an outline of the study reef obtained from a LORAN-C plotter in conjunction with a depth recorder and underwater video camera.

Visual censing methodology

The research submersible JOHNSON-SEA-LINK I, described by Fike and Dolan (1976), is a two compartment, four passenger vessel. It has a clear, acrylic sphere compartment forward and an aluminum compartment aft with port and starboard view ports. During this study, the two observers (RSJ and RLS) alternated positions in the submersible during visual censusing.

Censusing involved ten-minute stationary point counts, with both the forward and rear starboard positioned observers recording all species visible within a predefined visual field. These census data were recorded synchronously, and there was no area of overlap between fields. Observed species were recorded vocally on audio tape and manually by each observer. A visual

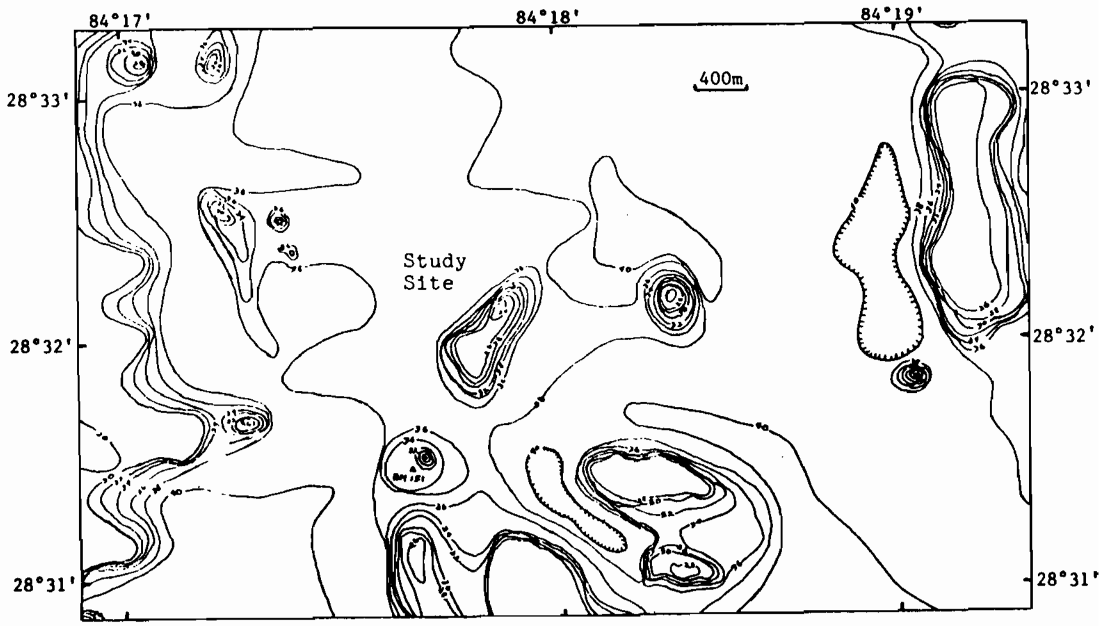

Figure 1. Bathymetry of the general area of the study site (courtesy of Texas A & M University, Department of Oceanography).

record was also generated by 12-sec intervalometer sequencing of 35mm, high speed ektachrome transparencies, filmed by externally mounted cameras scanning the field of each viewing site. In addition, a videotape recording was made by an externally mounted video camera outside the forward compartment of the submersible.

The area of visual field was approximately 250 square meters based on visibility limits (approximately 15 m) and angle of sight. There exists slight variation between fields from each viewing port due to the spherical (150° field) versus flat surface (120° field) of the viewing ports. However, preliminary population estimates not included in these analyses were made from each port by each observer to estimate the size of the observation field. Variations in area estimates were considered minimal.

Census data were recorded during three dives, each dive on a different day, at the beginning and end of 200-m transects, which were directed over the reef proper, to avoid censusing intermediate sand areas. A total of 32 censuses were made during the three dives.

More than 50 fish species were included in population counts. However, most of these were transients or only represented by a few individuals. Nine species were selected for population estimate per unit area of reef, based on their consistency of occurrence and behavior. For these species, the mean abundance per 250 m^2, based on the 32 observations, was determined. These estimates ($\hat{\mu}$) were then extrapolated to estimate total populations on the ½ km^2 reef area, following Schaeffer, Mendenhall, and Ott (1979):

$$\hat{\tau} = N\hat{\mu}$$

where:

$\hat{\tau}$ = total population estimate
N = number of units of area within the total area,

$\hat{\mu}$ = estimated mean of the populations within each unit area.

The bounds on the error of estimation at the 95% confidence limit (CI) were calculated:

$$\pm\ 2\sqrt{N^2\left(\frac{s^2}{n}\right)\left(\frac{N-n}{N}\right)}$$

where s^2 = sample variance,
N = number of samples.

The means and 95% CI are thus presented as estimates of the total population of each of nine species on the reef, plus or minus the 95% bound on the error of estimation.

RESULTS

The counts for the nine species selected for population estimation are presented in Table 1. Their population estimates for the entire one-half kilometer square reef is presented in Table 2, including the 95% CI on the population estimates.

Chromis scotti, the purple reeffish was found to be the most abundant species on the reef of the nine species deemed appropriate for point count estimation. It appeared more abundant than any of the species not included as well. A parrotfish, *Scarus* sp. (*croicensis*), appeared to be the second most abundant species on the reef, but its behavioral traits of rapid movement of small schools in and out of the visual field precluded reasonable estimates of total population. Nevertheless, even these rough estimates, which tend to be inflated, indicated totals less than one-fourth that of *Chromis scotti*.

The two commercially important species, the red grouper (*Epinephelus morio*) and the graysby (*E. cruentatus*) were of near equal abundance, occurring at about one individual/250 m^2. The scamp, *Mycteroperca phenax*, appeared to the observers to be far more abundant than the red grouper or graysby. However, their apparent attraction to the submersible (see below) precluded their inclusion in the point count estimates, and in fact, trapping data indicated they too were of about equal abundance with each of these other species.

Table 1. Point counts of nine species taken at thirty-two sites on a patch reef in the Florida Middle Grounds.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Chromis enchrysurus (yellowtail reeffish)	200	10	40	30	50	0	0	0	0	0	50	0	0	40	0	0	100	200	50	0	0	0	0	20	0	0	4	0	0	5	50	0
Chromis scotti (purple reeffish)	80	100	0	0	100	20	225	230	200	250	200	30	500	120	0	130	200	100	200	150	100	50	300	250	5	58	75	200	300	150	300	300
Pomacentrus partitus (bicolor damselfish)	13	10	0	0	0	0	4	3	8	0	10	0	3	0	3	0	0	0	4	2	0	1	0	1	0	0	2	5	1	0	0	0
Pomacentrus variabilis (cocoa damselfish)	4	10	0	0	20	4	0	20	12	0	22	7	14	22	8	7	3	0	20	3	1	2	1	4	5	4	4	9	9	3	4	12
Pristigenys alta (short bigeye)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Pareques umbrosus (cubbyu)	0	0	0	0	2	3	0	0	0	20	0	0	0	3	0	0	0	0	0	0	0	0	10	0	0	0	1	0	0	0	0	0
Epinephelus cruentatus (graysby)	0	1	0	0	3	1	0	0	0	7	1	0	2	1	0	0	1	0	0	0	0	0	2	2	0	1	1	0	0	1	1	0
Epinephelus morio (red grouper)	1	0	0	0	0	0	0	2	0	0	1	4	0	2	0	2	0	2	0	0	1	0	0	0	5	0	1	2	2	0	0	0
Hypoplectrus unicolor (butter hamlet)	1	1	0	1	2	1	5	6	3	2	4	2	0	2	0	2	4	0	3	1	4	3	1	0	1	2	3	2	3	1	3	3

Table 2. Population estimate for entire 0.5 km² patch reef located in the Florida Middle Grounds for nine species of finfish.

Pomacentridae	Total Population/ 0.5 km² of reef	95% confidence limit on error of estimation
Chromis enchrysurus (yellowtail reeffish)	53,060	± 36,386
Chromis scotti (purple reeffish)	307,600	± 81,975
Pomacentrus partitus bicolor damselfish)	3,480	± 2,460
Pomacentrus variabilis (coloa damselfish)	13,360	± 4,612
Priacanthidae		
Pristigenys alta (short bigeye)	320	± 364
Sciaenidae		
Pareques umbrosus (cubbyu)	2,440	± 2,768
Serranidae		
Epinephelus cruentatus (graysby)	1,560	± 980
Epinephelus morio (red grouper)	1,560	± 894
Hypoplectrus unicolor (butter hamlet)	4,124	± 1,072

DISCUSSION

Although nine species were selected, even most of these exhibit behavioral traits or physical characteristics which may distort true estimates of their population. The principal problem involved their movement in and out of the sample areas, in which case they were included in the count. This would tend to inflate estimates. Although an instantaneous count would eliminate this bias, such is not practical when time is needed to score each species individually, and some species may not be immediately visible until several minutes into the count. The observers were conscious of these inherent biases, and attempted to minimize the inflated counts by excluding reentering individuals where possible.

Assumptions

Several assumptions must be made in assessing the validity of these results, especially regarding their application over widespread areas.

Avoidance of or attraction to the submersible must be considered a potential bias. There were numerous species, including scamp, *Mycteroperca phenax*, and amberjacks (*Seriola* spp.), which demonstrated obvious attraction to the submersible. However, the species included in the results appeared to the observers to disregard the R/V JOHNSON-SEA-LINK. At most they cast a "wary" eye at its approach, but only responded when direct contact was imminent. This assessment of behavioral response is supported by careful examination of more than 10 hours of videotape recorded during these dives.

Visibility of species is obviously critical in determination of estimates. Several species, especially *Epinephelus* spp. exhibited some cryptic behavior, however their large size and the 10 min. duration of the census tended to insure a more accurate scoring of their numbers. However, the smaller species such as the pomacentrids were less visible toward the perimeter of the fields of view and thus estimates of these species may be lower than their actual numbers. It should be noted that no young juveniles of any species were included in the counts, and the population estimates apply to subadult and adult individuals.

Site selection is a potential source of bias. To avoid this, sites were located at the end of transects of predetermined length, and thus were taken without regard to faunal richness or diversity. However, open sandy and grassy areas were avoided, and only transects ending on reef biotope were considered. The high number of sites (32) provides some assurance that representative microhabitats were included.

Seasonality is doubtless a factor in population size. These counts were made in mid September and assumed to represent typical late summer abundance.

In considering these estimates as bases for comparisons with other areas, it should be noted that the 0.5 km^2 applies to reef biotope exclusively with no extraneous substrate included.

Comparison with other estimates

The population estimates generated herein differ in scope from those of most other investigators (see Clarke, 1986 for discussion of previous studies) in that very few species were treated here, but the estimates were for relatively large areas of the reef.

Simultaneous with this study, a mark-recapture estimate was performed by Tyler (1983), on the same reef biotope. In that study, 23 species were captured, tagged, and released. Only red grouper, *E. morio*, was recaptured in adequate numbers (9 recaptured of 72 marked), to provide reasonable population estimates. However, it is noteworthy that Tyler's total population estimate for this species, using the Schnabel method, was 904 individuals, with a 95% confidence interval on the total population of 476 to 2035. The present study estimated 1,560 individuals present with an interval of 666 of 2454. The similarity of these independent estimates, using different methods, lends credence to their validity. In addition, because the estimate in the present study included smaller individuals than in the mark-recapture assessment, slightly higher estimates are expected.

Extrapolation of estimates

Establishment of a reasonable estimate for one or several species offers the possibility of extending those estimates to other species with similar life history parameters for which relative numbers are available. For example, the graysby (*Epinephelus cruentatus*) occurred in numbers nearly equal to the red grouper (*E. morio*) based on direct visual censusing (see Table 2) although it avoided traps, and thus provided no reliable data from mark-recapture efforts. Likewise, the scamp, *Mycteroperca phenax*, was of about the same abundance as *E. morio* (174 to 167) based on trap data, but was excluded from visual censusing due to its attraction to the submersible. These three species, taken together, represent the major component of the population of large grouper species from the reef. The data indicated a total population of these three to be 4,000 to 5,000 per 0.5 km^2 of reef.

Behavioral considerations

Of the other species included herein, the relatively concise estimates of the hamlet, *Hypoplectrus unicolor*, result, in part, from the predictable behavior of this species. Their population distribution indicates a territorial behavior and individuals seem spaced in a non random, somewhat regular pattern. This results in a lower variance in their numbers from site to site, and thus potentially a more reliable population estimate is possible. Much the same could be said of the short big eye, *Pristigenys alta*, however its very low numbers required a relatively wide bound on the confidence intervals, including populations theoretically less than zero.

The pomacentrid species are abundant on the reef, and their regular occurrence provided estimates of very high numbers, including a population estimate of over 300,000 for the purple reeffish, *Chromis scotti*. Comparison with data from the several dozen species included here indicates this species was the most abundant on the entire reef, except possibly young juvenile/post larval populations of some unidentifiable species.

Application to their areas

Each reef, whether natural or artificial, regardless of substrate, might be expected to support its own unique assemblage of fish species. Nevertheless, data on total numbers of individuals of definable ecological categories (e.g., large carnivores) are useful in the ultimate attempt to estimate total species populations and standing crops. These data should be used with caution, especially in areas of non comparable relief, latitude, or during different seasons. However, they provide some concrete number on which to base estimates in areas of comparable character.

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