Groundfish Monitoring in Sponge-Coral Areas Off the Southeastern United States

H. POWLES and C. A. BARANS

ABSTRACT–Standard trawl survey methods alone are inadequate for assessment of "live-bottom" fish populations off the southeast coast of the United States because of rough bottom and low trawl catches of some commercially important species. Other sampling methods (trapping, underwater television, diver observations) were tested to evaluate their effectiveness for MARMAP surveys in areas characterized by sessile invertebrate communities dominated by sponges and soft corals. A mix of techniques appears to be required to achieve MARMAP objectives of assessment of commercially important species and monitoring of the marine ecosystem: Television photography for location of sponge-soft coral areas prior to sampling, trapping for evaluation of species of low vulnerability to trawls (e.g., red porgy, black sea bass), and trawling with a small mesh liner for sampling of the fish community as a whole, including juveniles.

Introduction

Many groundfish species of the southeastern United States continental shelf are found over large expanses of sandy bottom (Struhsaker, 1969) where their distribution and relative abundance can be routinely monitored by standard otter trawl procedures (Edwards, 1968). These sand bottom species are generally sparsely distributed and of low economic value (Struhsaker, 1969; Barans and Burrell, 1976). Fish species of greater economic value inhabit the sparse and patchily distributed, nearshore sponge-coral ("live bottom") habitats or the offshore rocky outcrop habitats. Fish populations of both habitats are more difficult to inventory because of obstructions to trawling and secretive behavior of the fish.

This report briefly describes the nearshore sponge-coral habitat and evaluates several methods for monitoring relative abundance of groundfish species of these nearshore habitats. The objectives of this study were to: 1) Determine the feasibility of stock inventories with underwater television, including reconnaissance of habitats, fish identifications, and fish enumerations, 2) define the effectiveness of short duration trawl tows with two different nets in sampling the fish community, and 3) identify species effectively sampled by blackfish traps and Antillean "mini-S" traps, and determine the value of trapping in fish stock assessment of selected species.

General Methods

Techniques were tested 7-25 June 1976 in three areas off Charleston, S.C. (Table 1). Diver dependent investigations, including television trials, were limited to Areas 1 and 2, approximately 45 km southeast of Charleston (7-12 June) while trawling and trapping were conducted in Area 3, about 150 km east of Charleston (20-25 June) (Fig. 1).

Table 1.—Methods used in three areas off Charleston, S.C., for study of sponge-coral habitat fauna, estimation of fish biomass, and gear evaluation.

Area and Depth	Methods
Area 1	Qualitative habitat location and mapping
(16-24 m)	SIMRAD echo-sounder survey
	Rock dredge sampling ($N=6$)
	Trawling, 3/4 Yankee #36, 10-minute tows
	Bottom inspection, underwater television ($N=17$)
	Quantitative-fish biomass, gear effectiveness
	Television drift transects ($N=8$)
	Trap fishing characteristics—three blackfish (two baited, one unbaited), three Antillean (two unbaited, one baited)
Area 2	Qualitative faunal observations
(29-32 m)	Diver observations, photography, 3/4 Yankee # 36 trawl, 10-minute tows ($N=1$)
Area 3	Qualitative-habitat location and mapping
(32-37 m)	SIMRAD echo-sounder survey
	3/4 Yankee # 36 trawl, 10-minute tows ($N = 18$)
	Quantitative-fish biomass, gear comparisons
	3/4 Yankee # 36 trawl, 10-minute tows ($N=12$ day, $N=5$ night)
	URI 60/80 highrise trawl, 10-minute tows 6 day, $N=4$ night)
	Blackfish traps 1-hour sets ($N=6$)
	6-hour sets ($N=24$)
	12-hour sets ($N=9$)
	Antillean traps 1-hour sets ($N=6$)
	6-hour sets ($N=24$)
	12-hour sets ($N=9$)

Following location and mapping of sponge-coral habitat in Area 1, drift transects were made through the area with a diver-held television camera (Table 1). The transects were monitored on deck and recorded on videotape; sections of several transects were also filmed with Super-8[1] color cinema for comparison. Bottom type was checked intermittently between transects throughout this phase. Following transect studies, fish traps (Table 1) were observed approximately every 3 hours for the first 10 hours of a 24-hour soak for analysis of trap performance. Divers recorded individual trap contents with Super-8 cinema film, still color photography, and/or underwater slates. Fish behavior in and about a baited blackfish trap was also observed with a television camera twice

H. Powles and C. A. Barans are with the Marine Resources Research Institute, South Carolina Wildlife and Marine Resources Department, Charleston, SC 29412. The present address of H. Powles is Government du Canada, Peches et Oceans, C. P. 15500, Quebec, Canada G1K 7X7. MARMAP Contribution No. 162; South Carolina Marine Resources Center Contribution No. 96. Address reprint requests to C. A. Barans.

---

[1] Mention of trade names or commercial products or firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

during the day and once at night with artificial lighting.

Qualitative observations of habitat type and faunal composition were made in Area 2 (Table 1).

Following delineation of sponge-coral habitat in Area 3, several series of 10-minute trawl tows were conducted in the area with standard Marine Resources Monitoring Assessment and Prediction (MARMAP) trawl (3/4 Yankee #36) and with a high-rise trawl designed for commercial fishing on highly mobile species (the University of Rhode Island, URI, 60/80 highrise). Early tows (*N*=6) with the highrise trawl, not included in the analysis, indicated that at 6.5 kg/hour a wire to depth scope of 5:1 was necessary to keep the 226 kg otter doors from lifting off the bottom. The 3/4 Yankee net was towed with a wire to depth scope of 3:1. Following completion of trawl studies, trapping trials were conducted for 2 days in area 3 (Table 1). Baited and unbaited traps of two types were fished day and night for varying lengths of soaks. Names of fishes reported here, except as noted, follow Bailey et al., (1970).

Surface and bottom water (temperature, salinity, nutrients, and dissolved oxygen) were sampled and expendable bathythermograph casts made at various intervals during the cruise and at 3-hour intervals over a 24-hour period in the area of trapping operations.

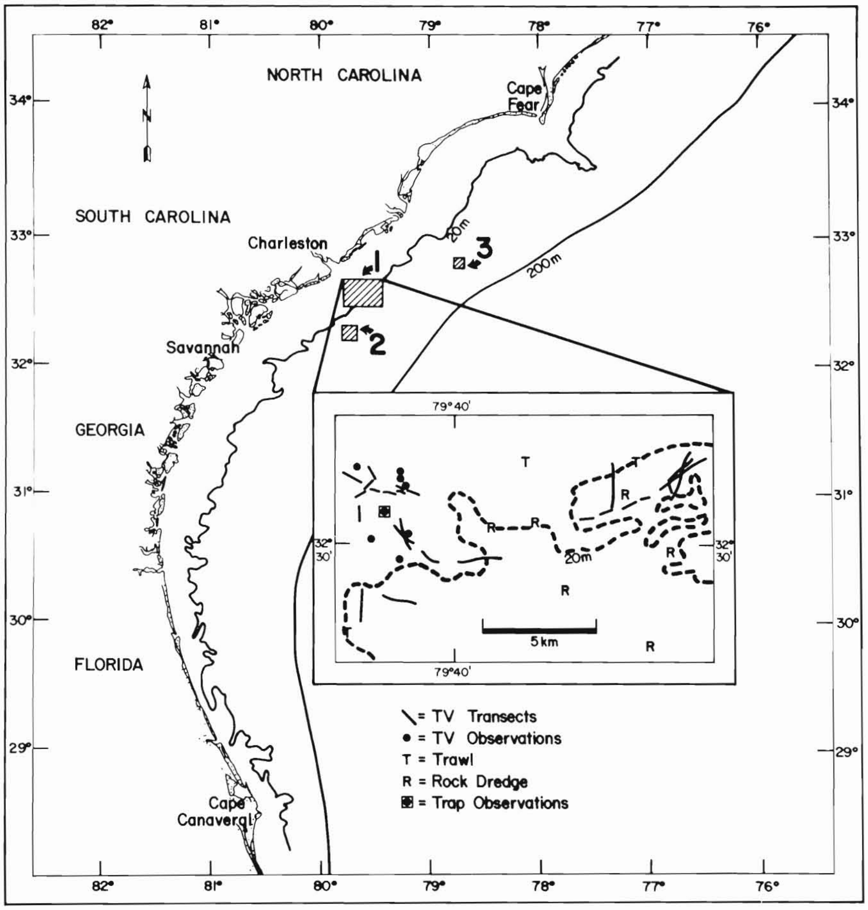

Figure 1.—Areas studied, 7-25 June 1976.

Oceanographic Observations

Observations in Area 1 during 6 days indicated that the water column was relatively homogenous, with only slight differences between surface and bottom temperatures, salinities, and dissolved oxygen (Table 2). Regular fluctuations in current velocity and direction were noticeable near surface and bottom, as inferred from ship's drift and reports from divers. With the underwater television, we often observed soft-bodied attached invertebrates bending under the influence of bottom currents. Drift of the ship progressed through two complete directional cycles each day; velocities ranged from immeasurable to 0.4 m/second during periods of light and variable winds (0-5 kn). Thus, the water column appeared to be under the influence of tidal currents. It is unlikely that transit meanders of the Florida Current affected this area, since the edge of the current was about 19 km further offshore at that time (defined by 23°C isotherm; Kundrat, 1976).

Farther offshore (Area 3, 32-37 m), fluctuations in depth of a strong seasonal thermocline suggested that internal waves of about 12 hours in period passed through the area, while two types of temporary thermoclines reflected local weather conditions. A positive temporary thermocline (temperature increased with depth) at 10-12 m was most pronounced when the temperature of surface waters was below 24.5°C. A negative temporary thermocline (temperature decreased with depth) at 0-6 m occurred when the temperatures of surface waters increased to 25°C or above (Fig. 2). In general, increased barometric pressure was followed by decreased winds and increased air and surface water temperatures. Bottom waters maintained a more constant temperature and salinity than did surface waters (Table 2).

Table 2.—Ranges in oceanographic measurements of the nearshore sponge-coral habitats during June 1976.

Measurements	Area 1 7-12 June Depth 16-24 m 4 observations	Area 3 20-25 June Depth 32-37 m 21 observations
Temperature °C		
Surface	22.87-22.97	24.40-25.30
Bottom	22.85-22.92	23.63-25.57
Salinity ‰		
Surface	34.58-34.61	35.08-35.72
Bottom	34.57-34.58	36.10-36.20
Dissolved O_2 ml/l		
Surface	4.41-4.65	3.92-4.34
Bottom	4.34-4.82	3.66-4.41

Habitat Observations and Description

Divers recorded observations on Formica slates, with a Nikonos II camera (35 mm lens) with strobe flash, and with a Kodak Super-8 camera in an Ikelite housing equipped with Ikelite movie lights. A Hydro Products Model TC-125 television camera (12.5 mm lens) was used, with 61 m of cable connecting it to a Hydro Products 23-cm (9-inch) monitor and control console. A Hydro Products silicon diode light attached to the TV camera and controlled from the shipboard control console was used for some night observations. Recordings were made on 13-mm (½-inch) tape on a Sony Model 3600 videotape recorder. Divers were essentially tethered to the vessel when using the television camera, and swimming with the camera was difficult in any current due to cable drag. Thus TV observations were restricted to near-vessel situations, while slates and film photography were used when greater mobility was required.

The TC-125 camera produced acceptable pictures in all daylight situations encountered, and produced usable pictures without accessory lights until about 10 minutes after sunset on one clear evening. Backscatter from suspended particulate matter impeded visibility when the light was used at night; because of this and unknown effects of lights on behavior of marine organisms, low-light intensifier cameras may provide better fish and habitat observations than light-assisted cameras in limited-light situations.

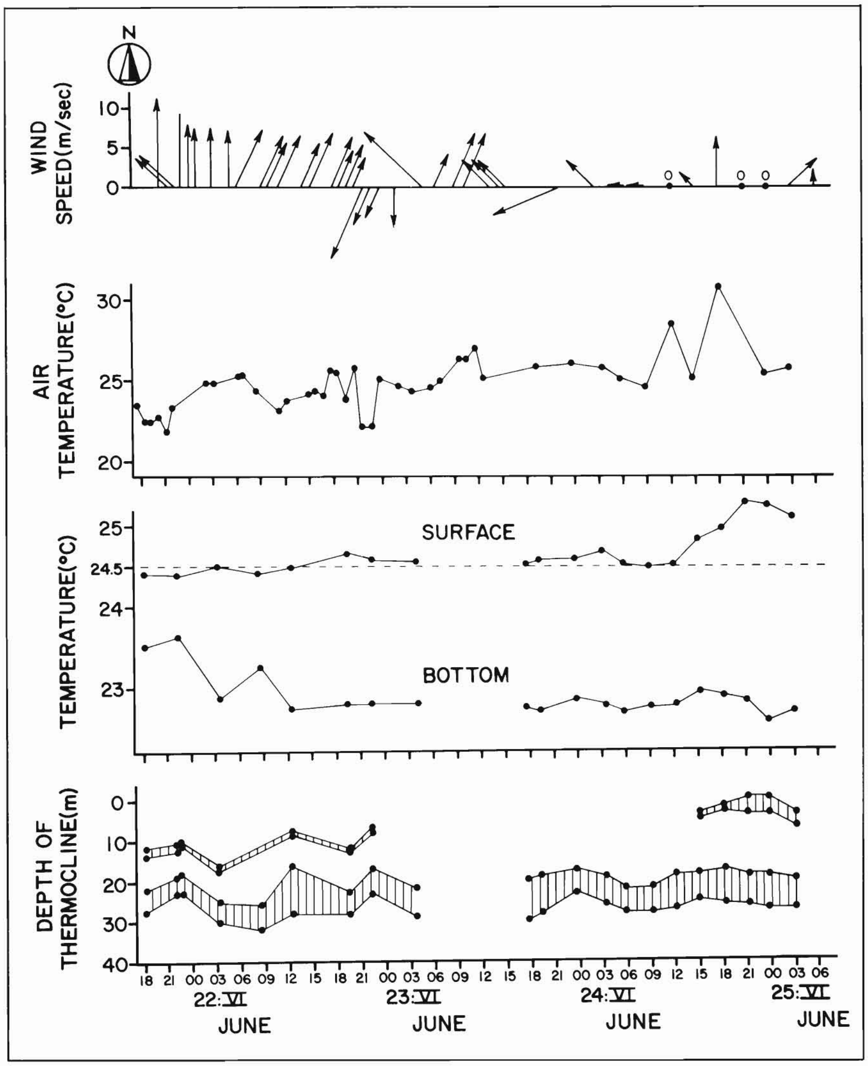

Figure 2.—Oceanographic conditions of sponge-coral habitat, 22-25 June 1976.

Bottom substrate in both Area 1 and Area 2 was generally flat sand, underlain at varying depths by rock. Occasionally the rock layer was exposed, forming flat rocky patches or low ledges up to 30 cm high. Presence of sessile organisms appeared related to presence of rock near or at the surface; at sand layer thicknesses of about 8 cm and less, organisms were attached to the rock. These organisms protruded through the sand cover, often giving the appearance of a "forest" growing from the sand. In areas of sand bottom with no sessile organism cover, no rock was found under the sand to depths of 15 cm. Rock samples from both 18 m and 30 m areas consisted of a tightly cemented limestone conglomerate of carbonate shell and quartz sand material.

Alternating areas of bare sand and organism-covered bottom usually were observed in the areas surveyed by divers and television. Patches of sand (of various sizes to 10 m in diameter) were occasionally found in areas of dense growth, and similar patches of organism growth were found in areas of sand cover. On several occasions, a gradual change from sand with no growth to an area of dense growth occurred over a distance of 10-20 m; transitional areas had interspersed clumps of sand and invertebrate growth.

At one site in Area 1, alternating bands of sand and attached organisms, each band 5 m wide, occurred; surface in the sand bands was approximately 0.5 m lower than surface in the overgrown ridges, so the bottom had a gently undulating appearance. Previous trawl catches of the MARMAP program have suggested that areas of such relatively flat "live bottom" may occur in large patches ≥1 km in extent. Thus patchiness of "live bottom" may occur

Figure 3.—White branching sponges, black sea bass and southern porgy of sponge-coral habitat.

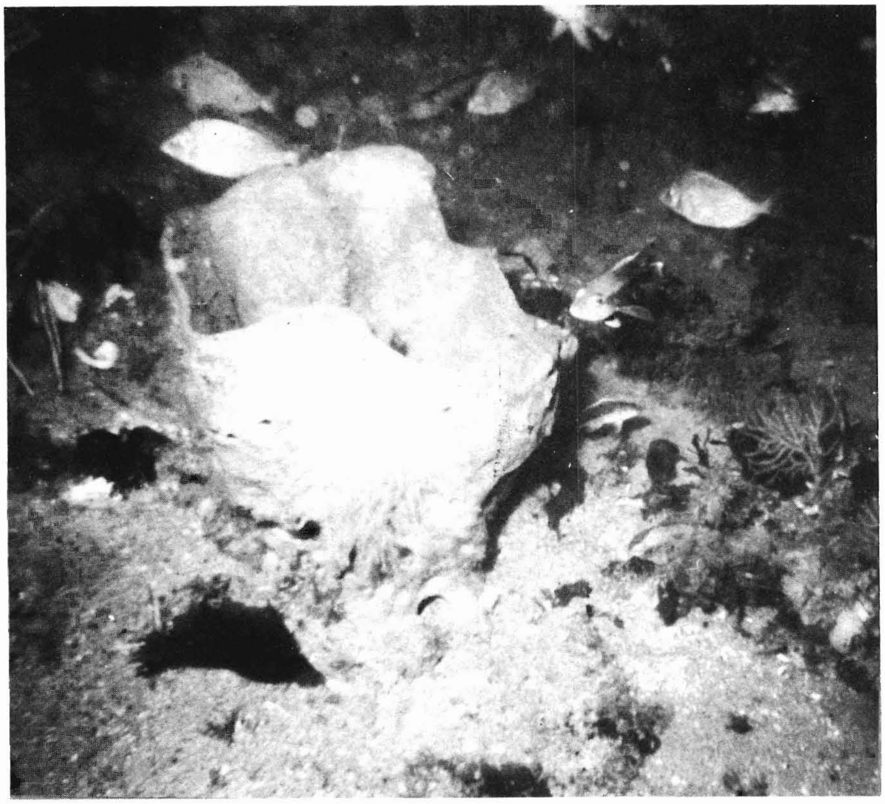

Figure 4.—Barrel sponge of sponge-coral habitat.

on several scales. Large areas, which in the past have been delineated by trawl hauls, may consist of a mosaic of interspersed sand- and organism-covered areas. Although direct observations were not made in Area 3, lack of major trawl damage and large catches of attached invertebrates in this area suggested that Area 3 was also flat with varying densities of attached invertebrates. The complex distribution of sponge-coral habitat on the continental shelf may account for some of the variability in fish abundance estimates made in this study.

Except for the fact that relief was generally low, the topography of our survey areas seems similar to inner-shelf live bottom areas described earlier. Limestone outcrops on the shelf have been known since the late 1800's (Emery and Uchupi, 1972). Off North Carolina, large areas surrounding a rocky reef consist of sand covering depressions in the underlying limestone, producing interspersed sand- and invertebrate-covered limestone areas (Pearse and Williams, 1951). Hunt (1974) found a reflecting seismic layer at 3-6 m below much of the sand surrounding Gray's Reef; this layer was continuous with the outcropping reef limestone rock. If sand layer thickness limits attached invertebrate growth, as appears probable, temporal variability of low relief live bottom areas may be significant, since sediment movement might kill established communities or open new areas for growth.

The sessile organism assemblage in the areas observed was dominated in general appearance by sponges and soft corals, with algae and hard corals occasionally present. Three principal kinds of sponges were observed: White branching sponges (Fig. 3) up to 1 m high, including *Verongia fistularis* and *Axinella polycapella*; low spreading sponges 0.1-0.2 m high and up to 1 m long (species identification not available); and barrel-shaped sponges (Fig. 4) up to 0.6 m high (including *Ircina strobilina* and *Ircinia campana*).

Soft corals were relatively slender and averaged some 0.5 m high; two types have been tentatively identified as *Titanideum* and *Leptogorgia*. Occasional sea fans, *Muricea pendula*, were present. Mound-shaped hard coral colonies, usually 0.3 m high and 0.3 m in base diameter (tentatively, *Solenastrea hyades*) and low, branching hard coral, *Oculina varicosa*, colonies occurred infrequently.

Table 3.—Fish species sampled by traps and observed on videotapes and by divers.

	Blackfish traps (39 sets)		Antillean traps (39 sets)		Television	Divers
Species	Wt (kg)	No.	Wt (kg)	No.	(4.14 km)	(50 dives)
Black sea bass	95.2	287	39.7	121	205	A[1]
Red porgy	52.4	160	58.2	146	—	—
Tomtate	4.5	26	6.9	46	11	R
Bank sea bass	4.8	24	4.8	25	—	R
Southern porgy	1.2	11	2.6	22	294	A
Vermilion snapper	0.6	3	3.9	15	—	R
Gray triggerfish	1.4	3	12.6	9	—	—
Moray eel	0.7	3	—	—	—	R
Toad fish[2]	0.4	1	—	—	—	—
Banded rudderfish	—	—	219.3	87	15	O
Planehead filefish	—	—	1.8	14	—	—
Sand perch	—	—	1.3	6	—	C
Bermuda angelfish[2]	—	—	0.1	2	—	R
Cubbyu[2]	—	—	0.1	1	—	—
Conger eel[2]	—	—	2.6	1	—	—
Round scad	—	—	—	—	A[3]	A
Seabasses (*Serranus* spp.)	—	—	—	—	3	O
Wrasses (*Halichoeres* spp.)	—	—	—	—	3	C
Sheepshead	—	—	—	—	5	R
Lizard fish (*Synodus* sp.)	—	—	—	—	1	R
Flounder (Bothidae)	—	—	—	—	—	R
Cobia	—	—	—	—	1	R
Cardinalfishes (*Apogon* spp.)	—	—	—	—	—	O
Blennies (Clinidae)	—	—	—	—	—	O
Combtooth blennies (Blenniidae)	—	—	—	—	—	O
Reef butterflyfish	—	—	—	—	—	R

[1] A=Abundant (numerous on all transects/dives); C=Common (present on most transects/dives); O=Occasional (present on few transects/dives); and R=Rare (total 1-2 specimens on all transects/dives).
[2] Species caught only during one set.
[3] Could not be enumerated from television observations.

Colonies of bryozoans and ascidians were frequently observed, often associated with the bases of sponges or soft corals. Attached algae formed a minor part of the community. Although sessile invertebrate assemblages of Area 1 and Area 2 appeared generally similar, Area 2 (29-32 m depth) appeared to have a higher proportion of branching sponges and a lower proportion of soft corals than Area 1 (16-24 m). Several large barrel sponges, *Spheciospongia vesparia*, (up to 1.5 m high) were present in Area 2.

Similar types of attached organisms have been collected from or observed in other ''live bottom'' areas in the South Atlantic Bight. Struhsaker (1969) noted that sponges and sea fans characterized trawl catches from live bottom areas. Sessile invertebrates identified by Pearse and Williams (1951) included 25 species of sponges, as well as hydrozoans, soft corals, and bryozoans, taken from rocky reefs in 4-17 m depth off the Carolinas. Attached algae were abundant in these areas, but appeared to be less common in our survey area. Coral heads, sea fans, algae, and sponges characterize the ''coral patches'' of Onslow Bay (Huntsman and MacIntyre, 1971); hard corals of the genera *Solenastrea* and *Oculina* occur there as in our survey area. On Gray's Reef off Georgia, the most abundant sessile organisms are soft corals (sea fans and sea whips) and sponges (Hunt, 1974). *Oculina varicosa* is abundant on shelf-edge prominences off eastern Florida (Avent et al., 1977). Hunt (1974) noted that sessile organisms were occasionally attached to rock covered with a thin layer of sand, similar to the situation often observed in our area.

Diver observations and photographs in Areas 1 and 2 showed a fish assemblage numerically dominated by round scad, *Decapterus punctatus*; black sea bass, *Centropristis striata*; and southern porgy, *Stenotomus aculeatus*[2]. All three species were observed on essentially every dive in areas of attached organism growth. Round scad occurred in schools varying from 20 to several hundred fish, and swam slowly 1-2 m off the bottom. They were the only fish commonly observed in areas lacking invertebrate growth. Round scad schools were observed to follow and circle divers. Black sea bass occurred singly, swimming near bottom amongst attached organisms. Southern porgy occurred singly or in groups of several individuals, also near bottom amongst attached organisms. Both black sea bass and southern porgy followed divers, apparently attracted by sediment clouds stirred up; divers collected increasing numbers of such followers as a dive progressed.

Other species observed included small, slow-moving fishes and large roving species (Table 3). Sand perch were fairly common, occurring singly near bottom. Small sea basses, *Serranus* sp., and wrasses, *Halichoeres* sp., were occasionally seen near bottom. Three schools of 6-8 amberjacks, *Seriola* sp., moving rapidly 1-2 m off bottom, and one cobia, *Rachycentron canadum*, were observed. Sheepshead (four individuals together), two lizardfish, and a flounder were also seen in Area 1.

In addition to the species listed (Table 3), a school of several thousand juvenile fish, each some 2.5 cm long, was seen in an area of dense growth in Area 1. These appeared to be juvenile sand perch. This suggests that sand perch may aggregate during the juvenile stage, in contrast to adults which, from diving observations and trawl survey data, appear to be dispersed.

None of the fishes observed showed noticeable reactions to the divers within their field of view (average visibility was some 7.5 m). It is possible, however, that some species or life history stages of species observed may have avoided or been attracted to the divers outside their field of visibility. More kinds of fish were observed at Area 2 (29-32 m) than at Area 1 (16-24 m), despite the shorter time spent making

---

[2] Taxonomic revision by R. H. Dawson (1979).

observations, and several fishes characteristic of warm water (cardinalfishes, blue angelfish, and reef butterflyfish) were seen at the deeper site (Table 3). Several goby-like fish (tentatively, *Ioglossus calliurus*) about 8 cm long were seen hovering about 0.5 m off bottom. These fish dove into the substrate at the approach of a diver.

The lack of fish sightings on sand bottom areas and the relatively high numbers seen over areas of invertebrate growth correspond well with our own earlier trawling observations during 6 years of MARMAP trawling studies in the South Atlantic Bight and with Struhsaker (1969) that fish abundance and diversity are substantially greater in sponge-soft coral habitat areas than in sand bottom areas. Most of the species observed by us were listed by Struhsaker (1969) as "live-bottom" species, including the large, roving amberjacks and cobia which might have been expected to occur independently of bottom cover. Several "tropical" species seen in Area 2 in the present study are also found in "coral patches" in Onslow Bay (Huntsman and MacIntyre, 1971), although a greater diversity of such fishes is present in Onslow Bay than was seen during the limited observation time of our survey.

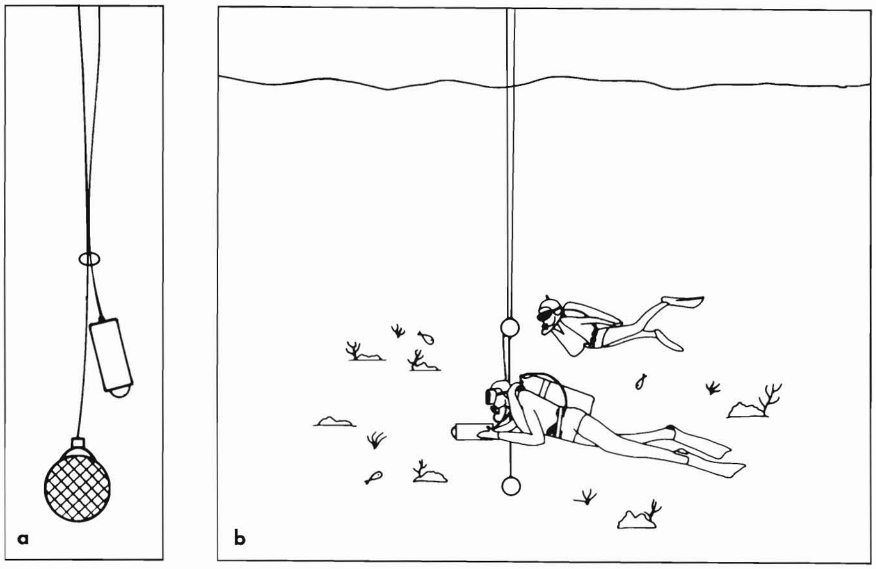

Figure 5a.—Underwater television camera in vertical position above 45.4 kg ball. Figure 5b.—Underwater television camera being panned along horizontal transect by divers.

Television Transect Studies

Bottom type and proportion of substrate covered by sessile organisms were observed and fish counts were made by letting the ship drift with the television camera down. A first series of observations was made with the camera, weighted with a 45-kg weight, suspended 2 m off bottom and pointing vertically downward (Fig. 5a). A second series of transects was made with divers holding the camera near horizontal 1.5 m off bottom and slowly panning it 45° on either side of their line of progress (Fig. 5b). Drift speed due to wind and current in both series was approximately 0.25-0.5 m/second.

Habitat type and sessile organism density could be assessed with the vertically directed camera, but this technique was not suitable for making fish counts. Proportion of bottom covered by sessile organisms could be estimated, and slow-moving mobile invertebrates (e.g., crab, sea stars) were observed. However, we found it impossible to identify attached organisms even to major taxonomic groups. No fishes were observed except for several small black sea bass following the camera and weight along the bottom; probably other fish avoided the limited field of view.

This technique was usable in swells or waves up to 1.5 m high and winds up to 12 m/second. In rougher conditions camera movement due to ship's roll and risk of equipment damage precluded making observations. Since vertically directed television is simple to operate and usable in moderately rough weather conditions, this technique will be suitable for rapid identification of sponge-coral habitat in future studies.

Horizontal scanning of the camera produced pictures of sessile organisms suitable for identification to major taxonomic groups, and permitted identifying and counting fishes. As with the vertically directed camera, proportion of bottom cover could be estimated. Identification of more abundant fishes to species was possible; for very small, rare, or morphologically similar species, identifications to the genus level were made. This technique was more weather-restricted than the vertically-directed unmanned camera, since divers were not used in winds over 5 m/second. Depth limitations for research diving, as well as weather, would preclude using this technique for routine fish assessment throughout the South Atlantic Bight; however, use of a towed vehicle to orient the camera horizontally would permit similar photography under conditions unsuitable for research diving.

Eight television transects made with the panned camera were videotaped, and fish counts were made from the tapes ashore, using a 48-cm (19-inch) monitor (Table 4). This method is similar to the swimming transect method of Brock (1954) and the cinetransects of Alevizon and Brooks (1975). Data from three transects (275, 276, 280) were pooled since these were short and made close together.

Three teams of three people each identified and counted fishes from the tapes. Individual black sea bass and southern porgy, being relatively slow-moving, could generally be identified using bottom features; thus multiple counting of individuals was minimized. Individual species counts varied somewhat between teams. The two counts for each transect which

Table 4.—Estimated numbers and biomasses of southern porgy and black sea bass on television transects.

	Transect					
Item	275,276, 280	281	282	283	309	313
Transect Data						
Length (m) (Loran-A)	1,070	440	930	630	410	660
Area (m^2)	10,700	4,400	9,300	6,300	4,100	6,600
Length (m) (Diver-estimated)	3,000	611	704	648	611	611
Southern porgy						
Number of fish	102	50	47	7	40	48
(Average of counts in parenthesis)	(93,110)	(62,34)	(36,58)	(8,6)	(40,39)	(43,52)
Number/ha	95	114	51	11	98	73
Biomass (kg/ha)	9.5	11.4	5.1	1.1	9.8	7.3
Black sea bass						
Number of fish	66	29	31	[1]27	14	38
(Average of counts in parenthesis)	(55,78)	(28,30)	(29,33)		(15,14)	(33,44)
Number/ha	62	66	33	43	34	58
Biomass (kg/ha)	9.3	9.9	5.0	6.4	5.1	8.7

[1] Only one count available.

agreed most closely were averaged to give an estimate of number of fish present on the transect. Agreement was best on rare species, poorest on the most abundant species (scads and southern porgy).

Numbers and biomass per unit area of southern porgy and black sea bass were estimated from television transect data (Table 4). Accurate counts of round scad, the most abundant species numerically, were impossible due to their great abundance and to their circling of divers. Other species occurred so rarely that biomass estimates would have little meaning. Width of the TV transect was estimated at 10 m, from visibility measurements (average approximately 7.5 m) and panning angle (45° each side of the line of progress). Transect length was estimated by start and finish LORAN-A bearings. Transect lengths from LORAN-A bearings were checked using average drift speed as estimated by the divers (0.25-0.50 m/second) and lengths of time spent on the transects (Table 4). Agreement was good on two transects, fair on three, and relatively poor on one (transects 275, 276, 280 combined). Both methods of transect length estimations are quite imprecise and this would represent the major source of error in our biomass estimates. Although LORAN bearings taken during drift transects suggested that drift may have been zigzag, drifts did not appear to cover any area more than once. Individual fish weights (100 g for southern porgy, 150 g for black sea bass) were estimated from the mean weight of specimens from trawl and trap hauls in the same area. Estimated densities ranged from 11 to 114 fish/ha for southern porgy and from 33 to 66 fish/ha for black sea bass, while estimated biomass ranged from 1.1 to 9.8 kg/ha for southern porgy and from 5.1 to 9.9 kg/ha for black sea bass (Table 4). Thus density and biomass for southern porgy were more variable (varying by a factor of 10) than for black sea bass (varying by a factor of 2). Total biomass for these two species combined ranged from 7.5 to 21.3 kg/ha.

Preliminary number and biomass estimates made in this survey were subject to several sources of error, but we believe that these can be minimized and that television transects justify further study as a means of estimating demersal fish populations in sponge-soft coral areas. The fact that black sea bass and southern porgy followed divers did not appear to affect counts, since these accumulations of fishes remained behind the divers and thus out of the field of view of the camera. Neither attraction to nor avoidance of divers was observed in front of the camera, although it is possible that these fish responses may have occurred outside the field of visibility. Identification of fish from videotapes may prove difficult in an area of high species diversity. This problem might be solved by using divers, or remotely operated color still photography in depths beyond diving capability, for "ground-truth" identification. Transect length measurements, based on LORAN-A, were probably the major source of error. Accuracy could be increased by using radar ranges from a buoy dropped at the beginning of a transect. Transect width measurements could be made more precise by measuring visibility at the beginning and end of each transect rather than using an average for all transects as was done in the present study. Mean fish size in a given area could be more accurately estimated from more complete catch sampling within the area of the TV observations.

Total biomass estimates of the two predominant demersal fish species calculated from our observations (7.5-21.3 kg/ha) are low compared with fish biomass estimates from other marine habitats (summarized by Russell, 1977). Values of less than 50 kg/ha have been found in soft-bottom demersal fishing areas off New England and in the English Channel, on sand bottoms off Texas, and in sand or low-relief shallow reef areas off New Zealand and near coral reefs. Biomass estimates for high-relief rocky reefs off New Zealand, kelp beds off California, and coral reefs are characteristically from 10 to 100 times greater than our estimates. Russell (1977) found that fish standing crop was higher on topographically complex sites than on flat-bottom sites on New Zealand rocky reefs, so that the flat nature of the habitat we surveyed may account for the apparently low standing crops observed.

Trawl Catch Comparisons

Short duration (10 minutes) bottom trawl tows were used in an attempt to reduce the damage to gear and loss of valuable information that is normally encountered during standard (30 minutes) trawling over areas of bottom relief and/or attached benthic organisms. The 3/4 version of a Yankee 36 trawl net with 1.3-cm cod-end liner (Wilk and Silverman, 1976) has been used for

Table 5.—Numbers of fish caught (mean/variance) in trawl and trap collections 20-25 June 1976, Area 3.

	Baited trap sets (6 hours)				Trawl tows (10 minutes)			
	Blackfish		Antillean Mini-S		3/4 Yankee 36		URI Highrise	
Item	Day (12)	Night (12)	Day (4)	Night (4)	Day (12)	Night (5)	Day (6)	Night (4)
Numbers								
Tomtate	[1]$0^+/0^+$	1/1	2/7	4/15	28/1,261	41/153	22/743	47/278
Southern porgy	$0^+/0^+$	0/0	2/5	0/0	17/314	8/78	9/199	101/3,266
Black sea bass	8/64	9/44	8/83	8/6	$0^+/0^+$	1/0	$0^+/1$	5/16
Red porgy	10/85	1/1	16/26	6/16	$0^+/0^+$	$0^+/0^+$	29/4.296	2/2
Total	19/56	12/43	35/226	21/18	105/7,747	149/1,744	75/4,002	226/4,760
Weights (kg)								
Tomtate	1/1	$0^+/0^+$	$0^+/0^+$	1/0	2/4	5/2	3/12	6/8
Southern porgy	$0^+/0^+$	0/0	$0^+/0^+$	0/0	1/2	1/1	$0^+/1$	9/32
Black sea bass	2/5	3/6	2/6	3/2	$0^+/0^+$	$0^+/0^+$	$0^+/0^+$	2/2
Red porgy	3/9	$0^+/0^+$	6/10	3/4	$0^+/0^+$	$0^+/0$	15/1,152	$1/0^+$
Total	6/7	4/6	12/81	8/5	12/77	18/24	38/2,665	32/80

[1] 0^+ = value $>0<<1$

monitoring fish populations in the South Atlantic Bight for over 8 years. The URI 60/80 highrise net without cod-end liner (Hillier, 1974) has been used by commercial fishermen in the area since 1976 (Ulrich et al., 1976). Both nets were believed to sample different segments of the sponge-coral groundfish community.

The number of replicate trawl tows completed under each set of conditions (Table 5) reflected greater available time during daylight periods and greater difficulty/time needed for handling the URI net. Collections made near (±1 hour) sunrise or sunset were excluded from analysis because of their small number.

The numbers (Table 5) and weights of fish caught by the trawls were highly variable with a negative binomial frequency distribution ($S^2>>\bar{x}$), therefore a log $(x+1)$ transformation was made to the data prior to comparison of results with a one-way analysis of variance. Mean numbers of fish (all species) and numbers of selected priority species were chosen for primary statistical analysis for ease of comparison with counts of fish from TV transects.

Few statistically significant differences between catches by trawl type (day and night) or between catches day and night by the same trawl type could be demonstrated due to the high variance.

Although the 3/4 Yankee trawl caught a greater diversity of species (Table 6), it caught significantly fewer fish ($P=0.05$) than the URI highrise trawl during night. Differences between mean number of fish caught by the two gear types during the day were insignificant. The URI highrise trawl caught significantly more fish at night than during the day, while the 3/4 Yankee did not.

The 3/4 Yankee trawl, probably because of its small-mesh liner, caught smaller species of fishes than the URI net. The five most abundant small species caught by the 3/4 Yankee but not by the URI net were tattler, *Serranus phoebe*; seaweed blenny, *Blennius marmoreus*; offshore lizardfish, *Synodus poeyi*; checkered blenny, *Starksia ocellata*; and pearly razorfish, *Hemipteronotus novacula* (Table 6). Many of the less abundant species taken by the 3/4 Yankee trawl but not by the URI trawl (Table 6) are also small as adults. Juveniles of commercially important species and prey organisms are small, and a groundfish community assessment program should sample both of these community components.

Groundfish species of particular interest in our trawl comparisons include black sea bass and southern porgy, which were identified as abundant in sponge-coral areas by divers and underwater TV, and red porgy which have commercial value and tomtate which were relatively abundant in trawl catches.

Southern porgy was the most abundant species in URI highrise catches and fourth most abundant in 3/4 Yankee catches (Table 6). Mean catch was greatest (101 per tow) at night with a URI net (Table 5). This mean catch of southern porgy at night was significantly different from the mean URI day catch ($P=0.01$) and significantly greater than mean night catch with the 3/4 Yankee trawl ($P=0.01$).

Black sea bass catches by both trawl types were low (Table 5) and differences between the catches of the 3/4 Yankee and URI highrise for the same time period were not significant. Mean catch (numbers) of black sea bass at night was significantly greater than day catch for both gear types ($P=0.05$).

A single large catch of red porgy (165 fish) in the URI trawl greatly increased the catch variability; generally both trawls caught low numbers of red porgy (Table 5). No more than a single red porgy was caught in any 3/4 Yankee tow. The URI trawl caught significantly more fish than the 3/4 Yankee during the night but not during the day. No significant differences existed between day and night catches of red porgy within gear types.

Tomtate were the most abundant species in 3/4 Yankee catches and were third in abundance in URI catches (Table 5). Between-trawl catch differences were insignificant for a given period, and day-night differences were insignificant for a given gear.

Fish abundance and biomass estimates of particular species or the total fish community based on bottom trawl catches in Area 3 must be regarded as minimum estimates due to the selectivity of the gear. Both abundance and biomass estimates were calculated by expansion of the number or weight of fish caught on the average area covered by the trawl, assuming: 1) The density

Table 6.—Mean number of fish caught by trawls and traps in Area 3.

Rank	Common and Scientific Names[1]	3/4 Yankee trawls (18) Mean catch/tow	URI trawls (13) Mean catch/tow	Antillean traps (8) Mean catch/6 h	Blackfish traps (24) Mean catch/6 h
1	Tomtate[2], *Haemulon aurolineatum*	33.72	25.08	3.0	0.875
2	Planehead filefish, *Monacanthus hispidus*	15.56	26.15	1.125	
3	Vermilion snapper[2], *Rhomboplites aurorubens*	15.17	1.92	0.375	0.0833
4	Southern porgy, *Stenotomus aculeatus*	13.67	35.46	1.00	0.0833
5	Blue angelfish, *Holacanthus bermudensis*	7.94	3.38	0	
6	Twospot cardinalfish, *Apogon pseudomaculatus*	7.89			
7	Whitebone porgy[2], *Calamus leucosteus*	5.00	2.38		
8	Bank sea bass, *Centropristis ocyurus*	2.22	0.15	1.25	0.5417
9	Cubbyu, *Equetus umbrosus*	2.06	0.69	0.125	
10	Barbfish, *Scorpaena brasiliensis*	1.78	0.54		
11	Tattler, *Serranus phoebe*	1.72			
12	Spotfin butterflyfish, *Chaetodon ocellatus*	1.67	1.62		
13	Knobbed porgy, *Calamus nodosus*	1.22	0.23		
14	Reef butterflyfish, *Chaetodon sedentarius*	1.17	0.38		
15	Round scad, *Decapterus punctatus*	1.11			
16	Seaweed blenny, *Blennius marmoreus*	0.94			
17	Deepwater squirrelfish, *Holocentrus bullisi*	0.94			
18	Sand perch, *Diplectrum formosum*	0.83	0.08	0.50	
19	Bigeye, *Priacanthus arenatus*	0.56	0.54		
20	Short bigeye, *Pristigenys alta*	0.56			
21	Offshore lizardfish, *Synodus poeyi*	0.39			
22	Black sea bass[2], *Centropristis striata*	0.33	1.62	8.375	8.458
23	Yellowtail reeffish, *Chromis enchrysurus*	0.33	0.15		
24	Jackknife-fish, *Equetus lanceolatus*	0.33	0.85		
25	Scrawled cowfish, *Lactophrys quadricornis*	0.33	0.15		
26	Dotterel filefish, *Aluterus heudeloti*	0.28	0.38		
27	Checkered blenny, *Starksia ocellata*	0.28			
28	Red porgy[2], *Pagrus sedecim*	0.22	14.54	11.125	5.667
29	Bandtail puffer, *Sphoeroides spengleri*	0.22			
30	Shrimp flounder, *Gastropsetta frentalis*	0.17	0.08		
31	White grunt[2], *Haemulon plumieri*	0.17	0.31		
32	Pearly razorfish, *Hemipteronotus novacula*	0.17			
33	Dusky flounder,*Syacium papillosum*	0.17	0.38		
34	Sand diver, *Synodus intermedius*	0.17			
35	Spotted burrfish, *Chilomycterus atinga*	0.11			
36	Conger eel, *Conger oceanicus*	0.11		0.125	
37	Clearnose skate, *Raja eglanteria*	0.11			
38	Lantern bass, *Serranus baldwini*	0.11			
39	Inshore lizardfish, *Synodus foetens*	0.11			
40	Snakefish, *Trachinocephalus myops*	0.11			
41	Orange filefish, *Aluterus schoepfi*	0.06			
42	Bridle cardinalfish, *Apogon aurolineatus*	0.06			
43	Bronze cardinalfish, *Astrapogon alutus*	0.06			
44	Eyed flounder, *Bothus ocellatus*	0.06	0.38		
45	Spotfin flounder, *Cyclopsetta fimbriata*	0.06			
46	Skilletfish, *Gobiesox strumosus*	0.06			
47	Slippery dick, *Halichoeres bivittatus*	0.06			
48	Fringed filefish, *Monacanthus ciliatus*	0.06			
49	Reticulate moray, *Muraena retifera*	0.06			
50	Blackbar soldierfish, *Myripristis jacobus*	0.06			
51	Lesser electric ray, *Narcine brasiliensis*	0.06			
52	Emerald parrotfish, *Nicholsina usta*	0.06			
53	Roughback batfish, *Ogcocephalus parvus*	0.06			
54	Polka-dot batfish, *Ogcocephalus radiatus*	0.06			
55	Bank cusk-eel, *Ophidion holbrooki*	0.06			
56	Oyster toadfish, *Opsanus tau*	0.06			
57	Polka-dot cusk-eel, *Otophidium omostigmum*	0.06			0
58	Summer flounder, *Paralichthys dentatus*	0.06	0.08		
59	French angelfish, *Pomacanthus paru*	0.06	0.08		
60	Bandtail searobin, *Prionotus ophryas*	0.06	0.15		
61	Greater soapfish, *Rypticus saponaceus*	0.06			
62	Smoothhead scorpionfish, *Scorpaena calcarata*	0.06			
63	Bluehead, *Thalassoma bifasciatum*	0.06			
64	Scrawled filefish, *Aluterus scriptus*		0.08		
65	Southern stargazer, *Astroscopus y-graecum*		0.08		
66	Gray triggerfish, *Balistes capriscus*		0.08	0.875	.04167
67	None *Bothus robinsi*		0.08		
68	Flying gurnard, *Dactylopterus volitans*		0.08		
69	Roughtail stingray, *Dasyatis centroura*		0.08		
70	Spottail pinfish, *Diplodus holbrooki*		0.23		
71	Naked sole, *Gymnachirus melas*		0.08		
72	Lancer stargazer, *Kathetostoma albigutta*		0.15		
73	Hogfish[2], *Lachnolaimus maximus*		0.08		
74	Yellowmouth grouper[2], *Mycteroperca interstitialis*		0.08		
75	Gag[2], *Mycteroperca microlepis*		0.08		
76	Scamp[2], *Mycteroperca phenax*		0.08		
77	Atlantic midshipman, *Porichthys porosissimus*		0.08		
78	Bluespotted searobin, *Prionotus roseus*		0.08		
79	*Gymnothorax saxicola*		0.00		0.04167
80	Banded rudderfish, *Seriola zonata*		0.00	10.875	
	Total number of species	63	42	13	9

[1] Names of fishes follow Bailey et al. (1970) except for southern porgy (text footnote 2).

[2] Species of commercial interest.

Table 7.—Groundfish abundance and biomass estimates in Area 3 from largest mean trawl catch values.

Species	Largest value	Abundance (No./ha)	Biomass (kg/ha)
Tomtate	3/4 Yankee/night	44	5.1
Southern porgy	URI/night	72	6.5
Black sea bass	URI/night	3	1.1
Red porgy	URI/day	21	10.6
Total (all species combined)	URI/night	190	27.3

of fish was similar throughout the habitat, 2) the distance covered by each trawl, at 6.5 km/hour, was 1.08 km per 10 minutes, 3) the 3/4 Yankee net spread was 0.0087 km (Azarovitz[3]), and 4) the URI highrise net spread was 0.0129 km (the same proportion to total footrope length as the 3/4 Yankee). To reduce the variability in both abundance and biomass estimates, we have asumed that all values for a given time period or gear type less than the maximum value were the result of fish avoidance or gear selectivity, and did not adequately reflect the abundance or biomass of the area. Therefore, the largest mean value (3/4 Yankee/URI highrise and day/night) were selected as maximal estimates of the fish populations (Table 7). The total groundfish abundance estimate (all species) for Area 3 was 190 fish/ha, while the total biomass estimate was 27.3 kg/ha. Southern porgy were most abundant (72 fish/ha). Red porgy were greatest in biomass (10.6 kg/ha) due to their large mean size, although they were low in trawl-based estimates of abundance (21 fish/ha).

In general, television estimates of southern porgy and black sea bass density and biomass were greater than trawl estimates (Table 8). In a specific comparison, 10-minute trawl hauls were made adjacent to two television transects. Biomass estimates for TV density values were expanded from mean weights of fish caught by hook and line in the area, and trawl estimates were made as above. In this comparison, the trawl density estimates were lower than TV estimates except for

---

[3] T. Azarovitz, Northeast Fisheries Center, NMFS, NOAA, Woods Hole, MA 02542. Pers. commun.

Table 8.—Fish density and biomass estimates from television transects and trawl hauls. Comparisons of adjacent samples and general ranges in mean estimates.

	Area 1		Area 1				
Item	TV 309	Trawl 106	TV 313	Trawl 107	Area 1 (TV, range of 6)	Area 3 (3/4 Yankee, range of means for 12 day 5 night)	Area 3 (URI, range of means for 6 day 4 night)
Southern porgy							
number/ha	98	6	73	694	11-114	8-18	6-72
kg/ha	9.8	0.4	7.3	39.1	1.1-11.4	0.7-1.3	0.4-6.5
Black sea bass							
number/ha	34	0	58	31	33-66	<1-1	1-3
kg/ha	5.1	0.0	8.7	3.2	5.0-9.9	0.1-0.2	0.1-1.1

Table 9.—Times (EDT) that traps were observed to define fish attraction and escapement responses.

Trap	Time set	Observation times/type[1], 9 June				Time hauled, 10 June
Baited blackfish #1	0815	0932/8mm	1115/DC		1742/8mm	0655
Baited blackfish #2	0820	1005/8mm	1133/DC		1717/8mm	0650
Unbaited blackfish	0752	1053/DC	1256/8mm	1555/35mm	1825/DC	0703
Baited Antillean	0810	0932/8mm	1155/DC		1730/8mm	0650
Unbaited Antillean	0759	0849/TV	1044/DC	1239/8mm	1837/DC	0700
Unbaited Antillean	0805	1106/DC	1316/DC	1545-35mm	1816/DC	0705

[1] The types of observations include: DC = diver's count; 8mm = 8mm film; 35mm = 35mm film; and TV = television videotape.

southern porgy on one occasion (Table 8). In comparisons of TV estimates in Area 1 and trawl estimates in Area 3, TV estimates were again greater, particularly for black sea bass where the difference was by a factor of 10 (Table 8). The direct trawl-TV differences may have been due to small-scale habitat patchiness; trawl and television estimates were made close together but not on identical areas. However, particularly for black sea bass, it appears that TV provides higher density and biomass estimates than the trawl. Further comparative sampling, with number of samples adequate for statistical comparison or direct attachment of TV onto the trawl to enable sampling the same area at the same time, would be required for more precise comparison of trawl and television standing crop estimates.

The 3/4 Yankee net with a cod-end liner caught a greater number of species, and fish of smaller sizes, than the URI highrise, and should be an acceptable gear to routinely monitor the groundfish community, including juveniles and prey species. Although the URI net caught more adults of commercial species than the 3/4 Yankee, catches were not large enough to justify selecting it as a survey gear over the 3/4 Yankee. There were no significant differences between trawls in day catches of four major fish species, but the URI trawl at night caught significantly more red porgy and southern porgy than did the 3/4 Yankee trawl.

Values of total fish abundance estimated for both gears were similar during daytime, but varied by a factor of 2 at night. Since the URI trawl was catching primarily larger specimens and the 3/4 Yankee was catching primarily small individuals, each net was missing a significant part of the groundfish community by daytime avoidance and gear selectivity. The ideal situation might be to routinely have underwater TV camera and trawl operate simultaneously to evaluate the habitat types throughout each trawl tow and estimate a vulnerability factor for each species during each tow.

Trap Catch Comparisons

Trapping has been evaluated extensively in the Caribbean to define optimum fishing conditions (Wolf and Chislett, 1974), but not as a method of assessing abundance of fish within populations. Although a winter commercial trap fishery for black sea bass exists in shallow waters of the continental shelf off the Carolinas (Rivers, 1966), no information is available on trapping as a method of measuring the relative abundance of fish species in this area. This study describes groundfish attraction and escapement responses from observations of fish behavior near and in traps and identifies optimum catch conditions (trap type, period of soak, time of day, and presence or absence of bait) in an attempt to establish a standard sampling procedure for determining the relative abundance of several fish species.

Two trap types were used throughout. The first was a "blackfish trap" (Rivers, 1966), with dimensions of $60 \times 60 \times 52$ cm and volume about 0.19 m^3. Each had four lower external funnels into a lower compartment and two internal funnels into the upper trap. The second, an Antillean S-trap, was our modification of a trap commonly used off Cuba (Munro et al., 1971), with dimensions of $65 \times 125 \times 110$ cm and volume about 0.89 m^3. This trap had two large funnels on opposite sides of the trap. Both types of traps were constructed of galvanized wire netting with hexagonal mesh ($5 \times 4 \times 4.5$ cm).

Observations of fish behavior in and near the two types of traps were conducted on 9 June 1976 in Area 1. Three baited and three unbaited traps were positioned around the anchored ship at distances ≥ 100 m from each other. Traps were set between 0752 and 0820 hours EDT and observed approximately every 3 hours throughout the remaining daylight hours (Table 9). Number of fish within each trap and fish behavior were recorded on slates and by Super-8 cinema and 35 mm still photography (Fig. 6). During the 22 hours, 30 minutes to 23 hours, 11 minutes soak times, the area was exposed to almost two complete tidal cycles with associated cycles of current direction and velocity. Traps were retrieved between 0646 and 0705 hours EDT on 10 June 1976.

Black sea bass and southern porgy, which were most abundant in trap catches during the fish behavior experiment, were also the two demersal species most commonly observed by divers in Area 1. Other species occasionally caught included bandtail puff-

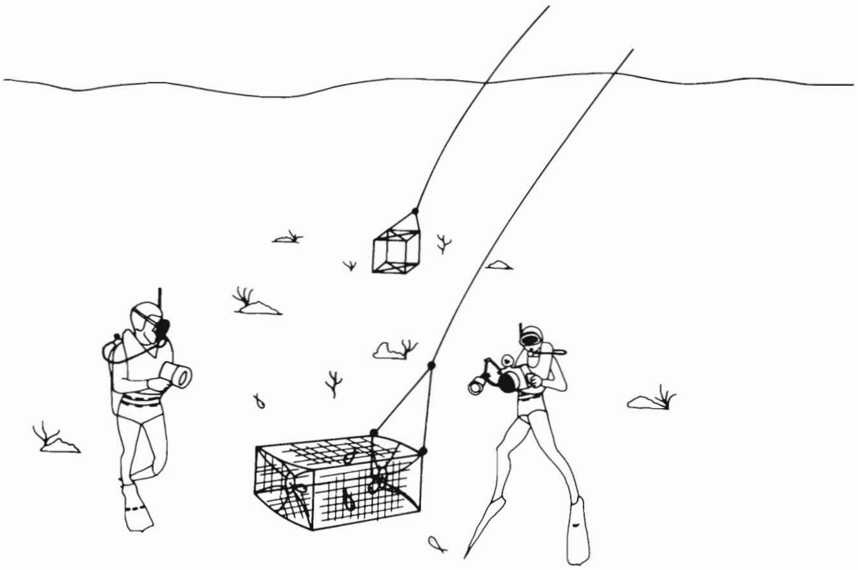

Figure 6.—Divers recording fish behavior and trap catches.

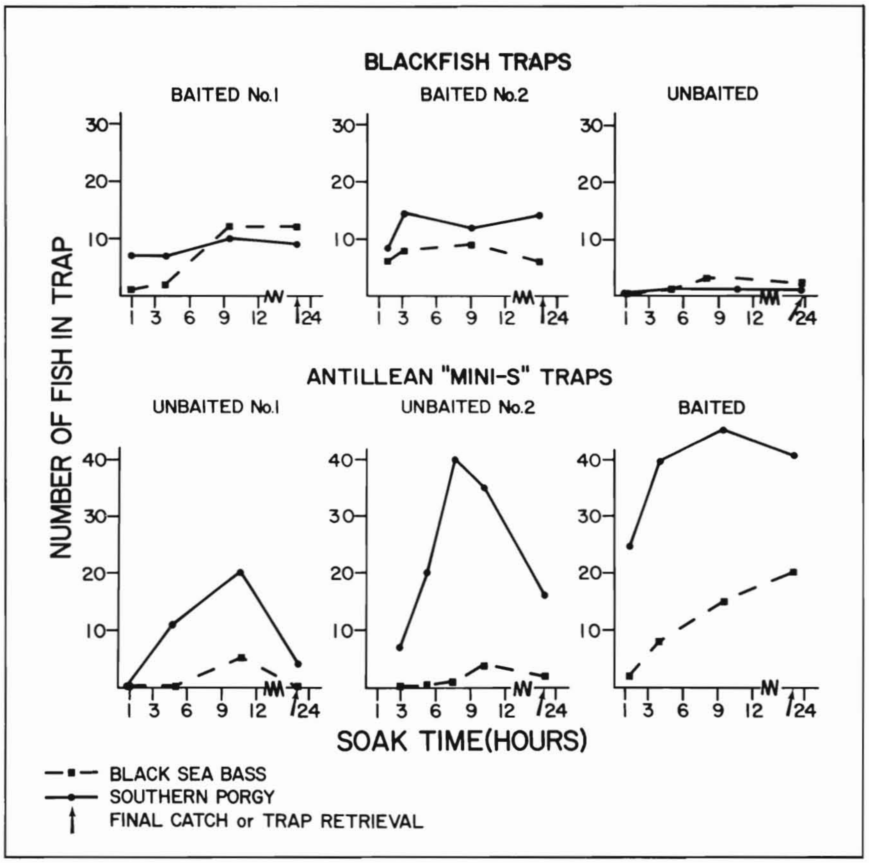

Figure 7.—Temporal change in numbers of fish in each trap, as recorded by divers.

er, *Sphoeroides spengleri*; planehead filefish, *Monacanthus hispidus*; and tomtate.

Baited blackfish traps caught moderate numbers of black sea bass and southern porgy, while the baited Antillean trap caught larger numbers of both species during the same time period (Fig. 7). The unbaited blackfish trap caught low numbers of both species and the unbaited Antillean trap caught many southern porgy and few black sea bass. Numerous small black sea bass (15-20 per trap) would swim freely through the trap mesh and actively feed on fresh bait, especially in the blackfish traps. Small individuals were not taken in final catches, thus were not included in diver counts (Fig. 7). These juveniles became less abundant with time of soak and with increase in number of larger individuals in the trap, and were not observed at unbaited traps.

Escapement, represented by a decrease in the numbers of fish in a given trap, occurred primarily during night, between the last diver observation and trap hauling (Fig. 7). The disoriented behavior of most species during trap retrieval suggests that escapement probably did not occur during that procedure. Also during the night, large numbers of southern porgy escaped from the Antillean traps, particularly unbaited traps.

Although small numbers of black sea bass escaped from unbaited Antillean traps, escapement in less than 24 hours from baited traps was minimal. The number of black sea bass in the baited Antillean trap increased during the night. With this exception, there was generally no increase in catch during the night period.

Both species actively swam upcurrent toward a freshly baited trap until entering the funnel or becoming part of the mixed species aggregation near the trap. There was much less activity near an unbaited trap, where smaller numbers of fish approached and slowly milled about all sides of the traps. Fish inside the traps, with the exception of the small free-moving black sea bass, appeared to move slower than those outside.

Intensive comparative trap studies

were made 23-25 June 1976 in Area 3 (33-35 m depth). Traps were set in groups of six with approximately 100 m between traps. Each group contained three baited blackfish traps, one baited mini-S trap and two unbaited mini-S traps. Sets were for periods of 1, 6, and 12 hours and included day and night soaks, for a total of 78 individual soaks representing 516 hours (Table 10). Bait consisted of either menhaden or round herring.

Table 10.—Number of traps fished/mean number of fish caught per trap in Area 3.

Hours of soak	Baited				Unbaited Antillean	
	Blackfish		Antillean			
	Day	Night	Day	Night	Day	Night
1	3/1.00	3/3.67	1/3.00	1/20.00	2/0.00	2/0.50
6	12/19.42	12/12.08	4/35.00[1]	4/20.75	8/0.88	8/0.38
12	3/11.00	6/15.33	1/65	2/37.00	2/1.50	4/0.75

[1] A single catch of 87 banded rudderfish was omitted from the average.

One-hour soak periods were eliminated after the first day and night sets due to time limitations. All trap catches in Area 3 were standardized to number of fish caught per hour soak per cubic meter trap volume. Standardized catches were compared to indicate most efficient use of vessel time and deck space. A one-way analysis of variance was used to compare results of nonstandardized catches between sets of trap conditions.

The results of intensive trapping trials in Area 3 differed with each combination of trap conditions (day, night, length of soak) but appeared relatively consistent within replicates (baited blackfish traps and unbaited Antillean S-traps). Conclusions should be considered preliminary due to the small number of replicates of several trap conditions (Table 10).

The Antillean traps collected a total of 13 species, the blackfish traps a total of 9 (Table 6). The five most abundant species collected in both trap types were red porgy, black sea bass, tomtate, southern porgy, and bank sea bass (a single catch of 219.3 kg, 87 individuals, of banded rudderfish, *Seriola zonata*, in an Antillean trap excluded); other species were caught in considerably lower numbers than these five (Table 6). A total of 15 species was caught in both trap types.

Baited traps of both types were more effective in catching fish than unbaited traps during short periods (<24 hours) in the inshore sponge-coral habitat. Unbaited Antillean traps caught significantly less fish (Table 10) than baited traps under all conditions ($P = 0.01$), so were excluded from further comparisons. Munro et al. (1971) found that unbaited traps fished for long periods (≥7 days) caught more fish than baited traps on shallow Jamaican reefs (although baited traps caught greater weights of fish), and Wolf and Chislett (1974) report unpublished observations that unbaited traps work as well as baited traps on shallow Caribbean reefs (this may be due to the Caribbean practice of leaving noncommercial fish in the traps when reset, thus effectively baiting the trap). Our results are closer to those observed on deep Caribbean reefs by Wolf and Chislett (1974); their unbaited traps caught little or nothing, at soak lengths of less than 24 hours.

Standardized catches of black sea bass were highest in both baited trap types with 6-hour soaks during the day (Fig. 8). At night, catches of black sea bass increased to a high at the 6-hour soak in the blackfish trap but decreased from a high at 1 hour to a low at 12 hours in the Antillean trap.

Catches of red porgy were greatest in 6-hour soaks of the Antillean traps during the day. At night, catches of red porgy declined from a high at 1 hour to a low at 12 hours in the Antillean traps and remained low and relatively constant in the blackfish traps.

The largest standardized catches for all species combined were made by both trap types at night with 1-hour soak periods (Fig. 8). Baited Antillean traps made the largest single catch and the largest catch per set of conditions (night, 1-hour soak) but baited blackfish traps caught more fish under most conditions (night, 6- and 12-hour soaks; day, 1- and 6-hour soaks). During night trapping, standardized catches from both types of traps decreased from a high catch at 1 hour progressively to a low at 12 hours, while day catches of both trap types were least at 1 hour and greatest for 6 hours.

Absolute catches (not standardized) differed between trap types and soak periods. Mean number of fish caught in a baited blackfish trap varied significantly with soak length during both day and night. Mean 6-hour catches were significantly greater than 1-hour and 12-hour catches during day ($P = 0.05$) while at night mean 12-hour catches were significantly greater than 1-hour and 6-hour catches. There was no difference between mean day and night catches for 1-hour sets.

The mean numbers of fish caught by baited Antillean traps could only be compared for 6-hour sets and between 6- and 12-hour sets at night because of insufficient replicates (Table 10). Although the mean catch from 6-hour sets during day was greater than the catch during night, the difference was not significant. The 12-hour set at night caught significantly greater numbers of fish than the 6-hour set at night.

The baited Antillean trap caught significantly more fish than the baited blackfish trap during each of the comparable periods (6-hour day, 6- and 12-hour night).

The two predominant fish species (black sea bass and southern porgy) of Area 1 were actively attracted to baited traps. Trapping can and should be used as a method of estimating the relative abundance of black sea bass because they are missing or relatively rare in trawl catches in these areas. A representative sample of the fish lengths in the entire local population might be obtained by trapping with a trap of 0.5-cm mesh; use of this small mesh would preclude escapement of small juveniles as observed in this study, although the

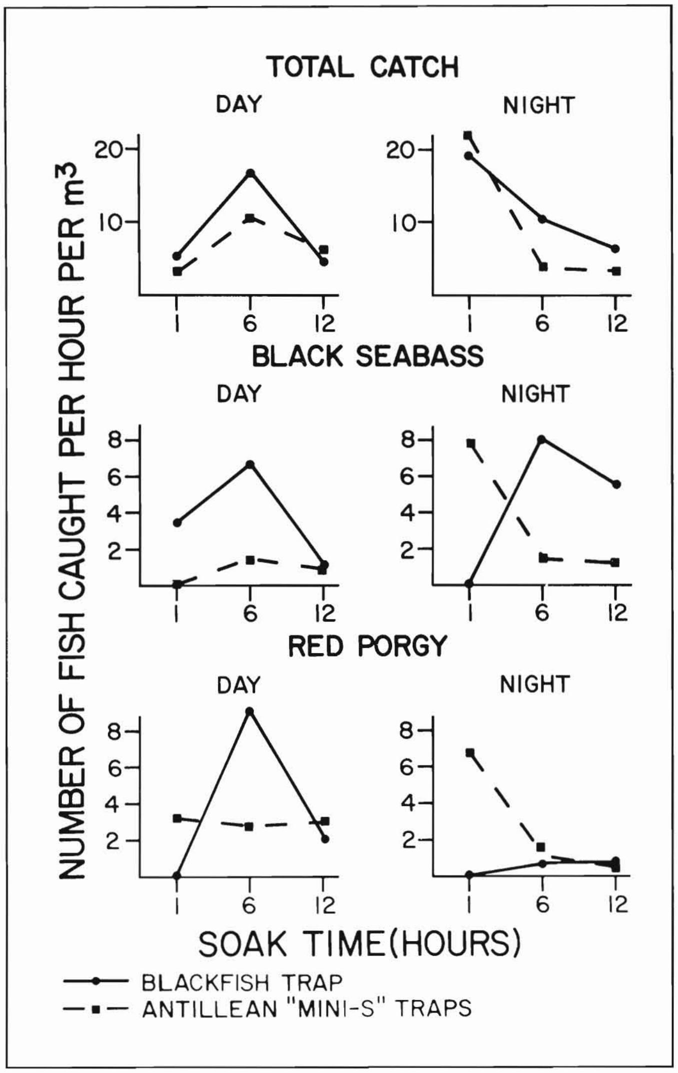

Figure 8.—Standardized catches (number of fish per hour per m^3 trap volume) of traps from Area 3.

use of smaller mesh may have effects on the catches of larger fish.

Although southern porgy were abundant in trap catches, they are also present in large numbers in trawl catches. Since the trawl catch is presently considered a more quantitative sample, results from trawl and trap catches should be compared for an extended period prior to selection of either gear for assessment of southern porgy populations.

In Area 3, traps consistently collected red porgy, which were second only to black sea bass in total weight of catch. Red porgy was collected by groundfish trawls only sporadically. The variability of trawl catches of red porgy may indicate that trap collections would provide a better estimate of relative abundance for this species. Red porgy avoid observation by most divers and remain at the outside edge of a diver's visual range (Parker[4]), thus direct observation methods may be inadequate for assessment. Comparisons of trawl catches with trap catches of the other major species collected (Table 6) suggest that relative abundance could be estimated with either a standardized trap set or trawl.

The total numbers of fish caught in both types of traps increased between the 1- and 6-hour sets, and continued to increase at the 12-hour sets, with the one exception of baited blackfish traps fished during day. However, standardized catches decreased with length of set for both trap types at night and peaked at 6 hours for both trap types during day. Trap saturation in less than 6 hours appears insignificant in stock assessment over a large habitat area, but may be great enough to account for blackfish trap fishermen's short soak periods (Rivers, 1966) in areas of large commercial concentrations.

The Antillean traps caught more fish than the blackfish traps, but standardized catches (per unit volume) were greater in the blackfish traps. This suggests that blackfish traps would provide more efficient use of limited trap storage space on survey vessels than Antillean traps. Wolf and Chislett (1974) found that a large "Z" trap (120 feet^3 volume) caught greater average weight of fish than a smaller "Z" trap (72 feet^3); however, mean catches per unit volume were identical for the two traps (0.25 pounds/foot^3). Munro (1974) reported that baited traps of several types fished off Jamaica caught fish in proportion to the area covered by the trap.

Trap catch information from standardized gear and soak can be used as indices of relative abundance for some species, but biomass estimates from trap catch results require several assumptions. The mean size of fish in the area must be estimated remembering the selectivity of trap and trawl collections. The habitat area effectively fished by a trap type can be estimated for some species from the visual count results of TV transects or trawl collections.

Comparison of three 24-hour baited trap sets (1 Antillean, 2 blackfish) in Area 1 with nearby TV transects (275, 276, 280, 281, 309; Table 3) permits

---

[4] P. Parker, Beaufort Laboratory, Southeast Fisheries Center, NMFS, NOAA, Beaufort, NC 28516. Pers. commun.

Table 11.—Estimates of the area sampled by 6-hour trap sets for four species in Area 3 from largest mean trawl catch values.

Species	Maximum species abundance from trawl data (Table 6)	Mean catch (N = 4) Antillean traps	Area sampled Antillean trap	Mean catch (N = 12) blackfish traps	Area sampled blackfish trap
Tomtate	44/ha	3.75D[1]	0.09ha	1.17N[1]	0.03ha
Southern porgy	72/ha	2.00D	0.03ha	0.17D	0.00^{+}ha
Black sea bass	3/ha	8.50N	2.83ha	9.17N	3.06ha
Red porgy	21/ha	16.00D	0.76ha	10.50D	0.50ha

[1] D = Day set max. value; N = night set max. value.

preliminary estimation of the area sampled by baited traps. Similar calibration of traps for crab stock assessment has been done by Miller (1975), who compared trap catches with biomass estimates from underwater photography transects. Mean fish density estimates from these television transects were 100 southern porgy/ha and 54 black sea bass/ha (Table 4). The Antillean trap caught 41 southern porgy and 35 black sea bass, corresponding to areas sampled of 0.41 ha and 0.65 ha, respectively. Mean catches of the two blackfish traps were 11.5 southern porgy and 9.0 black sea bass, corresponding to areas sampled of 0.12 ha and 0.17 ha, respectively. If areas sampled by each trap are standardized to unit volume of the trap, the Antillean trap sampled 0.46 ha/m^3 for southern porgy and 0.73 ha/m^3 for black sea bass, while the blackfish traps sampled 0.63 ha/m^3 for southern porgy and 0.89 ha/m^3 for black sea bass.

Similar estimates of the area sampled by the two trap types in Area 3 were made assuming that the maximum mean trawl catch values (3/4 Yankee/URI and day/night) were most representative of species abundance (Table 7). In Area 3, the highest estimate (3.06 ha) of area sampled by blackfish traps for black sea bass (Table 11) was unrealistically large due to the low mean catches of black sea bass by trawls. The low values (0.00±0.03 ha sampled) estimated for southern porgy were influenced by large mean trawl catches and relatively small mean trap catches of this species. Therefore, comparisons of trap catches with TV transect counts for black sea bass and southern porgy may give more reasonable estimates of the areas effectively fished by the traps.

Both comparisons suggest that a baited trap may sample a wider area for black sea bass than for southern porgy; this seems reasonable since black sea bass were observed to feed more actively in traps than southern porgy and took baited hooks more readily during incidental handlining on the cruise. More data are needed to confirm the validity of such observations; however, it appears that trap catches can be used to estimate biomass of selected fish species of the nearshore sponge-coral habitats.

Our results suggest that abundance information from TV transects may be more representative than that from trawl collections for black sea bass, while trap collections may be best for red porgy. Southern porgy were estimated to be equally abundant by TV and trawls.

Summary and Conclusions

The sampling scheme planned for MARMAP assessment and monitoring of the groundfish of the sponge-coral habitat areas includes 10-minute tows of the 3/4 Yankee trawl and short ($\leq$6-hour) sets of baited blackfish traps in sponge-coral areas located by reconnaissance with the vertically-directed television camera. Vertically-directed underwater television, with the camera attached to the ship's hydro wire, offered a quick and simple method of identifying sand and sponge-coral areas. Although television transects with the camera panned horizontally permitted identification and enumeration of the most abundant demersal fish species, and thus standing crop estimates, areas of bottom sampled per unit time was less than with trawling, and the necessity of using divers made the use of television more weather and depth limited than trawling. Television transect standing crop estimates were useful for comparison with trap and trawl data, and further comparative studies would be of value. Uzmann et al. (1977) suggested that a combination of visual data and trawl data may be best for assessment in canyon areas, but cost considerations may limit several alternatives (submersible surveys).

Ten-minute trawl tows sampled the greatest numbers of species of the three methods investigated, thus contributing to the MARMAP objective of community rather than single-species sampling. Although the URI high-rise trawl sampled presently important commercial species (groupers, red porgy) better than the 3/4 Yankee trawl, the 3/4 Yankee trawl sampled both a greater variety and smaller sizes of fishes, thus providing better information on juveniles and possible prey organisms. The 3/4 Yankee trawl was easier to handle than the URI high-rise, permitting more efficient use of ship time.

Two important sponge-coral habitat fishes apparently poorly sampled by the 3/4 Yankee trawl, black sea bass and red porgy, were well sampled by traps. Blackfish trap catch per unit volume was equal to or greater than that in larger Antillean S-traps; limited deck space for trap storage would thus favor use of blackfish traps. Catch per unit time was generally greater in short sets ($\leq$6 hours) than in long sets (12 hours). At present in the South Atlantic Bight, trap data are inadequate for generating standing crop estimates of demersal fishes, because area effectively sampled is unknown, but yearly trap surveys should provide data on annual population changes. Further studies of area effectively sampled, by comparison of trap and television data, appear justified from our preliminary results and the more definitive results of Miller (1975).

Acknowledgments

A team of divers and seagoing handymen worked hard to collect the data: J. Batey, C. Boardman, R. Keiser, R. McEachern, D. Myatt, O. Pashuk,

J. Porcher, W. Ripley, K. Rooney, W. Roumillat, B. Stender, G. Ulrich, K. Ward. Some of the above plus P. Keener and C. Floyd counted fishes from videotapes. Captain J. Causby, Mate R. Mellette, and crew of the RV *Dolphin* assisted in many ways. We are grateful to the following for identifications and/or aid: B. Boothe, benthic invertebrates; W. Jaap, hard corals; W. Roumillat, fish; J. Smith, soft corals; F. W. Stapor, rocks; R. C. Work, sponges; O. Pashuk, oceanographic summary; Karen Swanson, illustrations; P. Eldridge, P. Sandifer, G. Ulrich, and C. Wenner, manuscript review. This work is a result of research sponsored by the National Marine Fisheries Service (MARMAP Program Office) under Contract 6-35147 and by the South Carolina Wildlife and Marine Resources Department.

Literature Cited

Alevizon, W. S., and M. G. Brooks. 1975. The comparative structure of two western Atlantic reef-fish assemblages. Bull. Mar. Sci. 25:482-490.

Avent, R. M., M. E. King, and R. H. Gore. 1977. Topographic and faunal studies of shelf-edge prominences off the central eastern Florida coast. Init. Rev. Gesamtan. Hydrobiol. 62:185-208

Bailey, R. M., J. E. Fitch, E. S. Herald, E. A. Lachner, C. C. Lindsey, C. R. Robins, and W B. Scott. 1970. A list of common and scientific names of fishes from the United States and Canada. Am. Fish. Soc., Spec Publ. 6, 3d ed., 149 p.

Barans, C. A., and V. G. Burrell, Jr. 1976. Preliminary findings of trawling on the continental shelf off the southwestern United States during four seasons (1973-1975). S.C. Mar. Resour. Cent., Tech. Rep. 13, 16 p.

Brock, V. E. 1954. A preliminary report on a method of estimating reef fish populations. J Wildl. Manage. 18:297-308.

Dawson, R. H. 1979. A systematic revision of the sparid genus *Stenotomus* (Pisces: SPARIDAE). Master's Thesis, Coll. Charleston, 73 p.

Edwards, R. L. 1968. Fishery resources of the North Atlantic area. *In* D. Gilbert (editor), The future of the fishing industry of the United States, p. 52-60. Univ. Wash. Publ. Fish., New Ser. 4.

Emery, K. O., and E. Uchupi. 1972. Western north Atlantic Ocean: Topography, rocks, structure, water, life, and sediments. Am. Assoc. Petrol. Geol. Mem. 17, 532 p.

Hillier, A. J. 1974. URI highrise series bottom trawl manual. Univ. Rhode Island, Mar. Bull. 20, 6 p.

Hunt, J. L., Jr. 1974. The geology and origin of Gray's Reef, Georgia continental shelf. Master's Thesis, Univ. Georgia, Athens, 83 p.

Huntsman, G. R., and I. G. MacIntyre. 1971. Tropical coral patches in Onslow Bay. Underwater Nat. 7(2):32-34.

Kundrat, J. J., Jr. (editor). 1976. Gulfstream. U.S. Dep. Commer., NOAA, Natl. Weather Serv. 2(6):1-7.

Miller, R. J. 1975. Density of the commercial spider crab, *Chionoecetes opilio*, and calibration of effective area fished per trap using bottom photography. J. Fish. Res. Board Can. 32:761-768.

Munro, J L. 1974. The mode of operation of Antillean fish traps and the relationships between ingress, escapement, catch and soak. J. Cons. Int. Explor. Mer 35:337-350.

————, P. H. Reeson, and V. C. Gaut. 1971. Dynamic factors affecting the performance of the Antillean fish trap. *In* Proc. Gulf Caribb. Fish Inst., 23rd Annu. Sess., p. 184-194.

Pearse, A. S., and L. G. Williams. 1951. The biota of the reefs off the Carolinas. J. Elisha Mitchell Sci. Soc. 67:133-161.

Rivers, J. B. 1966. Gear and technique of the sea bass trip fishery in the Carolinas. Commer. Fish. Rev.28(4):15-20.

Russell, B. C. 1977. Population and standing crop estimates for rocky reef fishes of northeastern New Zealand. N.Z. J. Mar. Freshwater Res. 11:23-36.

Struhsaker, P. 1969. Demersal fish resources: Composition, distribution, and commercial potential of the continental shelf stocks off southeastern United States. Fish. Ind. Res. 4:261-300.

Ulrich, G. F., R. J. Rhodes, and K. J. Roberts. 1976. Status report on the commercial snapper-grouper fisheries off South Carolina. *In* Proc. Gulf Caribb. Fish. Inst., 29th Annu. Sess. Nov. 1976, p. 102-125.

Uzmann, J. R., R. A. Cooper, R. B Theroux, and R. L. Wigley. 1977. Synoptic comparison of three sampling techniques for estimating abundance and distribution of selected megafauna: submersible vs camera sled vs otter trawl. Mar. Fish. Rev. 39(12):11-19.

Wilk, S. J., and M. J. Silverman. 1976. Fish and hydrographic collections made by the research vessels *Dolphin* and *Delaware II* during 1968-72 from New York to Florida. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-697, 159 p.

Wolf, R. S., and G. R. Chislett. 1974. Trap fishing explorations for snapper and related species in the Caribbean and adjacent waters. Mar. Fish. Rev. 36(9):49-60.