

REEF AND ROCK OUTCROPPING FISHES OF THE OUTER CONTINENTAL SHELF OF NORTH CAROLINA AND SOUTH CAROLINA, AND ECOLOGICAL NOTES ON THE RED PORGY AND VERMILION SNAPPER

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ABSTRACT

Exploratory fishing for reeffishes from 1972 to 1977 yielded 113 species representing 43 families of predominantly tropical and subtropical fishes, adding substantially to the resident reef ichthyofauna known from North Carolina and South Carolina waters. Distinct faunal assemblages were associated with each of two reef habitats located (1) on the open shelf in 27-64 m and (2) at the shelf edge in 64-183 m. Based on catch-per-unit-effort data, red porgy were about equally abundant at both habitats, but vermilion snapper were more abundant at the shelf edge. Vermilion snapper were most common in fall and scarcest in summer samples, while red porgy were most abundant in summer and least abundant in fall samples. Both species were most abundant off southern North Carolina and South Carolina. The data indicated that red porgy were most actively feeding during the morning and late afternoon, compared with late afternoon and evening for vermilion snapper. Tagging of 2,262 red porgy and 458 vermilion snapper revealed that both species are highly residential.

It is well known that many tropical invertebrates (Cerame-Vivas and Gray, 1966; Warmke and Abbott, 1961), algae (Humm, 1969) and fishes (Briggs, 1975) inhabit the outer continental shelf (OCS) north to Cape Hatteras. Among reef-fishes various labrids, pomacentrids, sparids, lutjanids, pomadasyids, serranids, etc., characterize the fauna (Struhsaker, 1969; Miller and Richards, 1980).

This rich fauna supports a thriving recreational fishery off North Carolina and South Carolina. Headboats fishing the OCS off North Carolina and South Carolina from 1972 to 1977 landed between 590-527 MT (1.3 and 1.6 million pounds) of reeffishes annually (exclusive of black sea bass, *Centropristis striata*. The red porgy, *Pagrus pagrus*, and vermilion snapper, *Rhomboplites aurorubens*, are usually the two most frequently caught species (Huntsman, 1976). The red porgy, a moderate-sized (750 mm TL and 5 kg) sparid, ranges widely on both sides of the Atlantic, exclusive of the Caribbean Sea and Central America (Randall, 1968), but is found in the Mediterranean and Adriatic Seas (Ranzi, 1968; Soljan, 1963). The vermilion snapper, *Rhomboplites aurorubens*, a small lutjanid that attains about 600 mm TL and 2 kg, occurs in the western Atlantic throughout the West Indies and Gulf of Mexico south to southeastern Brazil (Jordan and Evermann, 1896; Breder, 1929; Cervignon, 1966).

The purpose of this paper is to present a list of reeffishes we collected at two more or less distinct habitats on the OCS of North Carolina and South Carolina during five years of exploratory fishing. We also present ecological notes on the two most frequently caught species (vermilion snapper and red porgy) gleaned from catch-per-unit-of-effort analysis of exploratory fishing data and from tagging studies that were conducted simultaneously. Major aspects of the life history of these two species are discussed in Grimes (1978; 1979), Grimes and Huntsman (1980), Manooch (1976; 1977) and Manooch and Huntsman (1977).

METHODS

Collections were made from Cape Hatteras to Cape Romain (Raleigh, Onslow and Long Bays), however, most effort was expended on Onslow Bay (Fig. 1). Reeffish occurred in two more or less

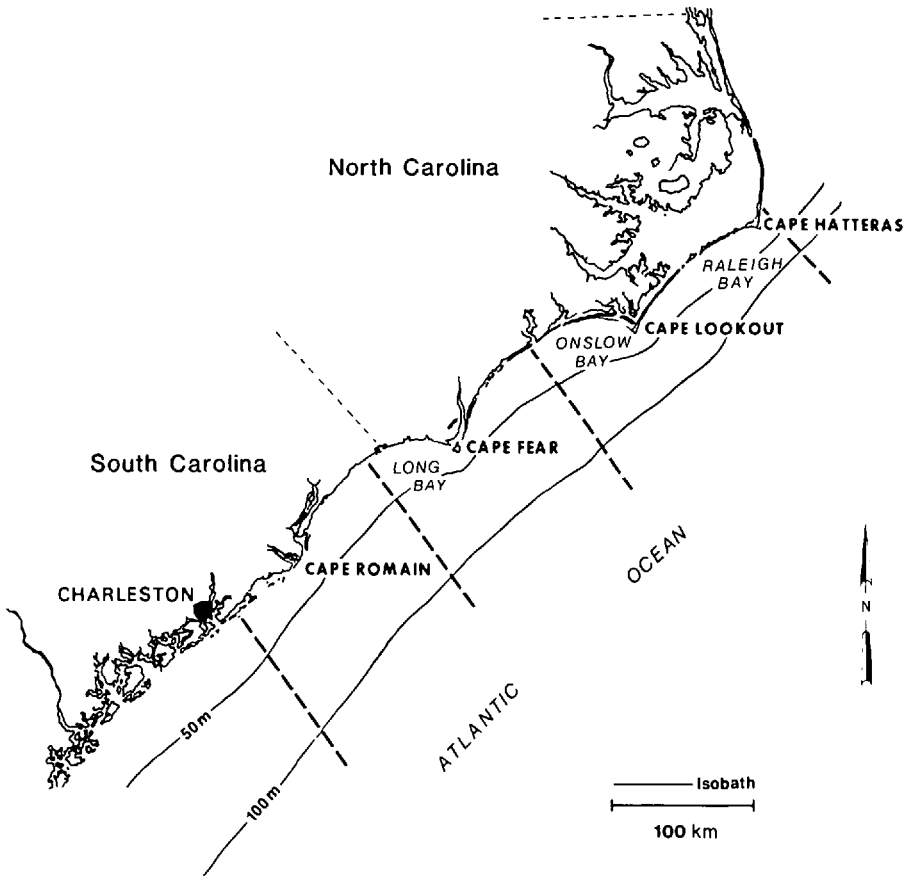


Figure 1. Map of coastal North Carolina and South Carolina showing the geographic divisions of the study area.

distinct continental shelf habitats from about 27 m seaward. The shelf-break habitat (Struhsaker, 1969), which we defined as lying between 64 and 183 m depth, is a rugged area of jagged peaks, precipitous cliffs and rocky ledges where vertical relief of 10 m is not uncommon. Live-bottom habitat (Struhsaker, 1969), located shoalward of the shelf-break habitat (30–64 m depth) consists of low rock ridges, outcroppings, coral patches, and shipwrecks. We recognize that strict delineation of these habitats is somewhat artificial because at extremes they grade into each other. However, to facilitate discussion and analysis we choose to refer to them as distinct.

From 1972–1977, 122 exploratory fishing cruises were made from R/V ONSLOW BAY and other similar chartered vessels. Although some sampling was conducted at night, most trips were during the day and consisted of a 2–4 h steam to and from the sampling site and 5–6 h of fishing. Two 5-day cruises were made aboard R/V EASTWARD (Duke University) to collect reef fish in May and November 1973. LORAN A or C enabled location of productive fishing areas, recording fathometers discerned aggregations of fish or suitable substrate, and mechanical or expendable bathythermographs were used to sense and record bottom temperature. Fish were primarily collected by bottom-rigged hook-and-line gear with electrically powered reels. However, sinking gill nets (32–275 m long with 6.4–16.5-cm stretched mesh), and trawls (6-m otter trawl and a 15-m roller trawl) were deployed from R/V EASTWARD in May 1973 with little success. Sea bass traps (modified crab traps, 75 × 45 × 45 cm) constructed of “chicken wire” were fished irregularly from R/V ONSLOW BAY and S-type traps (180 × 100 × 60 cm) constructed of hardware cloth were deployed from R/V EASTWARD in May 1973. Some species appearing in the complete species list were observed by divers from R/V ONSLOW BAY or were landed on headboats or commercial sea bass fishing vessels. All fish nomenclature follows Bailey et al. (1970).

Date, location, depth, habitat type, number of anglers and time spent fishing were recorded at most

Table 1. List of fishes occurring at reef and rock outcropping habitats on the outer continental shelf of North Carolina and South Carolina

Family, Genus and Species	Common Name	Collection Method*	Habitat Type†
Carcharhinidae:			
<i>Carcharhinus falciformis</i>	Silky shark	HL	SE, ILB
Sphyrnidae:			
<i>Sphyrna lewini</i>	Scalloped hammerhead	GN	SE
Rhinobatidae:			
<i>Rhinobatos lentiginosus</i>	Atlantic guitarfish	TWL	SE
Rajidae:			
<i>Raja</i> sp.	Skate	TWL	SE
Dasyatidae:			
<i>Dasyatis</i> sp.	Stingray	TWL	SE
Muraenidae:			
<i>Gymnothorax nigromarginatus</i>	Blackedge moray	HL	SE, ILB
<i>Muraena retifera</i>	†Reticulate moray	HL	SE
Congridae:			
<i>Conger oceanicus</i>	Conger eel	HL, T	SE
<i>Paraconger caudilimbatus</i>	‡Margintail conger	HL	SE
Ophichthidae:			
<i>Ophichthus ocellatus</i>	Palespotted eel	HL, SC	SE, ILB
Engraulidae:			
<i>Anchoa</i> sp.	Anchovy	SC	ILB
Synodontidae:			
<i>Synodus foetens</i>	Inshore lizardfish	HL	ILB
<i>S. synodus</i>	Red lizardfish	TWL	SE
<i>Trachinocephalus myops</i>	Snakefish	HL, TWL	SE, ILB
Batrachoididae:			
<i>Opsanus pardus</i>	Leopard toadfish	T	ILB
Antennariidae:			
<i>Antennarius ocellatus</i>	Ocellated frogfish	T	ILB
Ogcocephalidae:			
<i>Halieutichthys aculeatus</i>	Pancake batfish	TWL	SE
<i>Ogcocephalus</i> sp.	Batfish	TWL, SC	SE
Gadidae:			
<i>Urophycis earlii</i>	Carolina hake	HL	ILB
Ophidiidae:			
<i>Rissola marginata</i>	Striped cusk-eel	SC, TWL	ILB
Holocentridae:			
<i>Holocentrus ascensionis</i>	Squirrelfish	HL	SE
<i>H. rufus</i>	Longspine squirrelfish	HL	SE
Fistulariidae:			
<i>Fistularia villosa</i>	‡Red cornetfish	HL	SE
Syngnathidae:			
<i>Hippocampus erectus</i>	Lined seahorse	SC	SE, ILB
<i>Syngnathus</i> sp.	Pipefish	SC	SE, ILB
Serranidae:			
<i>Centropristis ocyurus</i>	Bank seabass	HL, TWL	ILB
<i>C. striata</i>	Black seabass	HL, T, SC	ILB

Table 1. Continued

Family, Genus and Species	Common Name	Collection Method*	Habitat Type†
<i>Dermatolepis inermis</i>	§Marbled grouper	HL	ILB
<i>Diplectrum formosum</i>	Sand perch	HL, SC, TWL	ILB
<i>Epinephelus adscensionis</i>	§Rock hind	HL	ILB
<i>E. drummondhayi</i>	Speckled hind	HL	SE, ILB
<i>E. flavolimbatus</i>	Yellowedge grouper	HL	SE
<i>E. fulva</i>	§Cooney	HL	ILB
<i>E. guttatus</i>	‡Red hind	HL	ILB
<i>E. morio</i>	Red grouper	HL	SE
<i>E. mystacinus</i>	‡Misty grouper	HL	SE
<i>E. nigritus</i>	Warsaw grouper	HL	SE
<i>E. niveatus</i>	Snowy grouper	HL	SE
<i>Mycteroperca microlepis</i>	Gag	HL	SE, ILB
<i>M. phenax</i>	§Scamp	HL	SE, ILB
<i>M. venenosa</i>	‡§Yellowfin grouper	HL	ILB
<i>Ocyanthias martinicensis</i>	Roughtongue bass	TWL	SE
<i>Petrometopon cruentatum</i>	‡§Grasby	HL	ILB
<i>Paranthias furcifer</i>	Creolefish	HL	SE
<i>Serranus phoebe</i>	Tattler	AC	SE
Grammistidae:			
<i>Rypticus saponaceous</i>	Greater soapfish	T	ILB
Priacanthidae:			
<i>Pristigenys alta</i>	Short bigeye	TWL	ILB
<i>Priacanthus cruentatus</i>	Glasseye snapper	TRP	ILB
Apogonidae:			
<i>Apogon pseudomaculatus</i>	‡Twospot cardinalfish	TWL	ILB
Branchiostegidae:			
<i>Caulolatilus microps</i>	‡Gray tilefish	HL	SE
<i>C. chrysos</i>	‡Atlantic golden-eyed tilefish	HL	SE
Malacanthidae:			
<i>Malacanthus plumieri</i>	‡Sand tilefish	HL	SE
Rachycentridae:			
<i>Rachycentron canadum</i>	Cobia	HL	SE
Carangidae:			
<i>Alectis crinitus</i>	¶ African pompano	T	ILB
<i>Caranx ruber</i>	‡Bar jack	D	ILB
<i>Decapterus punctatus</i>	Round scad	SC, TWL	ILB
<i>Seriola dumerili</i>	Greater amberjack	HL	SE, ILB
<i>S. rivoliana</i>	Almaco jack	HL	SE, ILB
Ephippidae:			
<i>Chaetodipterus faber</i>	Atlantic spadefish	D	ILB
Lutjanidae:			
<i>Lutjanus cyanopterus</i>	‡Cubera snapper	HL	SE
<i>L. buccanella</i>	Blackfin snapper	HL	SE
<i>L. campechanus</i>	Red snapper	HL	SE, ILB
<i>L. synagris</i>	§Lane snapper	TWL	ILB
<i>L. vivanus</i>	Silk snapper	HL	SE
<i>Ocyurus chrysurus</i>	§Yellowtail snapper	HL	ILB
<i>Rhomboplites aurorubens</i>	Vermilion snapper	HL	SE, ILB
Pomadasyidae:			
<i>Haemulon aurolineatum</i>	Tomtate	SC, HL, TWL	SE, ILB
<i>H. melanurum</i>	‡§Cottonwick grunt	HL	ILB
<i>H. plumieri</i>	White grunt	HL, TWL	ILB

Table 1. Continued

Family, Genus and Species	Common Name	Collection Method*	Habitat Type†
Sparidae:			
<i>Calamus leucosteus</i>	Whitebone porgy	HL	SE, ILB
<i>C. nodosus</i>	Knobbed porgy	HL, TWL	SE, ILB
<i>Diplodus holbrooki</i>	Spottail pinfish	HL	ILB
<i>Pagrus pagrus</i>	Red porgy	GN, HL, SC T, TWL	ILB, SE
<i>Stenotomus caprinus</i>	‡Longspine porgy	HL	ILB
Sciaenidae:			
<i>Equetus acuminatus</i>	‡High-hat	D	ILB
<i>E. lanceolatus</i>	Jacknife fish	TWL	ILB
<i>E. umbrosus</i>	‡Cubbyu	HL	SE
Mullidae:			
<i>Pseudupeneus maculatus</i>	Spotted goatfish	TWL	ILB
Kyphosidae:			
<i>Kyphosus sectatrix</i>	‡Bermuda chub	D	ILB
Chaetodontidae:			
<i>Chaetodon sedentarius</i>	Reef butterflyfish	D	ILB
<i>C. ocellatus</i>	Spotfin butterflyfish	D, TWL	ILB
<i>Holacanthus bermudensis</i>	Blue angelfish	TWL	ILB
Pomacentridae:			
<i>Abudefduf saxatilis</i>	‡Sergeant major	D	ILB
<i>Chromis enchrysurus</i>	§Yellowtail reeffish	TWL	ILB
<i>Microspathodon chrysurus</i>	‡¶Yellowtail damselfish	TWL, SC	ILB
<i>Pomacentrus leucostictus</i>	Beaugregory	D	ILB
<i>P. partitus</i>	‡Bicolor damselfish	D	ILB
<i>P. fuscus</i>	‡Dusky damselfish	SC, D, TWL	SE
Labridae:			
<i>Bodianus pulchellus</i>	§Spotfin hogfish	HL	SE
<i>B. rufus</i>	‡§Spanish hogfish	HL	SE
<i>Halichoeres bivittatus</i>	Slippery dick	D	ILB
<i>H. garnoti</i>	‡Yellowhead wrasse	SC, D	SE
<i>Hemipteronotus novacula</i>	Pearly razorfish	HL, SC	SE
<i>H. splendens</i>	‡¶Green razorfish	HL	SE
<i>Lachnolaimus maximus</i>	§Hogfish	HL	SE
<i>Tautoga onitis</i>	Tautog	HL	ILB
Sphyraenidae:			
<i>Sphyraena barracuda</i>	Great barracuda	HL	SE
Uranoscopidae:			
<i>Astroscopus y-graecum</i>	Southern stargazer	TWL	SE
Scorpaenidae:			
<i>Pontinus nematophthalmus</i>	‡Spinythroat scorpionfish	SC, TWL	SE
<i>Neomeinthe hemmingwayi</i>	‡Spinycheek scorpionfish	HL	SE
<i>Scorpaena brasiliensis</i>	Barbfish	HL, TWL	SE, ILB
<i>S. plumieri</i>	‡West Indian scorpionfish	T, HL	ILB
Triglidae:			
<i>Prionotus carolinus</i>	Northern searobin	HL, TWL	ILB
Bothidae:			
<i>Bothus ocellatus</i>	Eyed flounder	TWL	ILB
<i>Paralichthys dentatus</i>	Summer flounder	HL	SE
<i>Syacium papillosum</i>	Dusky flounder	HL, TWL	ILB

Table 1. Continued

Family, Genus and Species	Common Name	Collection Method*	Habitat Type†
Balistidae:			
<i>Aluterus schoepfi</i>	Orange filefish	SC	ILB
<i>Balistes capricus</i>	Gray triggerfish	HL	SE, ILB
<i>B. vetula</i>	Queen triggerfish	T, D	ILB
<i>Monacanthus ciliatus</i>	Fringed filefish	TWL	ILB
<i>M. hispidus</i>	Planehead filefish	TWL	ILB
Tetraodontidae:			
<i>Sphoeroides dorsalis</i>	§Marbled puffer	TWL	ILB
<i>S. spengleri</i>	§Bandtail puffer	TWL	ILB

* HL = hook and line, T = trap, TWL = trawl, GN = gill net, SC = stomach contents, D = observed by divers.

† SE = shelf-edge, and ILB = inshore live-bottom.

‡ indicates species not recorded by Struhsaker (1969).

§ indicates species only recorded for southern Onslow Bay and Long Bay.

|| indicates reef species not listed by Miller and Richards (1980).

hook-and-line sites. This latter information allowed calculation of catch-per-unit of fishing effort (CPUE) as catch-per-angler hour. Frequency of occurrence and relative abundance data (Table 2) represent 80 exploratory hook-and-line trips, 47 to shelf-edge habitat and 33 to inshore live bottom. To consider variation in abundance (CPUE) of red porgy and vermilion snapper with latitude, we stratified the hook-and-line catch data according to three fishing areas: Cape Lookout, Cape Fear, and Cape Romain (Fig. 1).

Tagging operations were conducted simultaneously with exploratory fishing. Three types of vinyl tags were used: 13-cm barb or dart tags, 13-cm "t" anchor tags designed for magazine application, and 13-mm diameter Peterson disc tags. Each tag bore the legend "Reward-NMFS-Beaufort, N.C., U.S.A." and a number. All tags were applied according to standard methods at the base of the dorsal fin (Stott, 1968). The tagging program was advertised throughout coastal North Carolina and South Carolina by posters on docks, piers, restaurants, and post offices.

RESULTS AND DISCUSSION

We identified 113 species representing 43 families (Table 1). Virtually all species listed in Table 1 were adults or large juveniles and were represented by more than one specimen, indicating resident populations for most species. These results are in general agreement with Struhsaker's (1969) conclusion that shelf-edge and live-bottom ichthyofauna consists mostly of tropical and subtropical reeffishes, although warm temperate species were also collected. Our list contains 28 species not recorded by Struhsaker (1969) and, therefore, adds considerably to the list of resident reeffishes known from the OCS of the Carolinas. Miller and Richards (1980) present a list of reeffishes only for the entire South Atlantic Bight. Naturally their list contains species we did not collect off the Carolinas, but we identified eight reef species they do not list for the South Atlantic Bight.

More or less distinct species assemblages were associated with each habitat type, however some species overlapped (Table 2). The most frequently occurring species were not necessarily the most numerous. For example, at live-bottom stations red porgy were the most frequently encountered but second most numerous species, and similarly vermilion snapper ranked seventh by frequency of occurrence but fourth numerically. To better characterize the ichthyofauna at each habitat, we multiplied percentage frequency of occurrence and percentage number and ranked the results (Table 3). Only 3 of the dominant (highest index ranking) species at either habitat were common to both, an indication of the difference between faunal assemblages. The 10 dominant species accounted for 97.2 and 94.3% of all fish collected at shelf-edge and live-bottom habitats.

Table 2. Fishes collected by hook and line expressed as percent frequency of occurrence on cruises, and percent of total number of fish.

Species	Shelf edge habitat			Inshore live-bottom habitat			
	Frequency	Relative frequency (%)	Number	Frequency	Relative frequency (%)	Number	Relative number (%)
Red porgy	47	100.0	1379	27	81.8	1082	33.2
Gray tilefish	37	78.7	205	1	3.0	1	tr
Vermilion snapper	33	70.2	280	16	48.5	164	5.0
Speckled hind	27	57.5	73	3	9.1	6	0.2
Snowy grouper	19	40.4	77	0	0.0	0	0.0
Greater amberjack	18	38.3	51	5	15.2	6	0.2
Gray triggerfish	16	34.0	52	21	63.6	129	4.0
Almaco jack	15	31.9	33	3	9.1	7	0.2
Sharks	14	29.8	19	4	12.1	4	0.1
Silk snapper	11	23.4	21	0	0.0	0	0.0
Tattler	9	19.1	14	0	0.0	0	0.0
Red snapper	9	19.1	15	0	0.0	0	0.0
Blackedge moray	7	14.9	8	12	36.4	28	0.9
Gag grouper	6	12.8	8	6	18.2	16	0.5
Bank sea bass	5	10.6	6	22	66.7	100	3.1
Warsaw grouper	4	8.5	4	0	0.0	0	0.0
Atlantic goldeneye tilefish	4	8.5	9	0	0.0	0	0.0
Sand tilefish	4	8.5	5	0	0.0	0	0.0
Yellowedge grouper	3	6.4	3	0	0.0	0	0.0
Black sea bass	3	6.4	27	25	75.8	1301	39.9
Barbfish	2	4.2	2	0	0.0	0	0.0
Knobbed porgy	2	4.2	2	0	0.0	0	0.0
Sand perch	2	4.2	2	6	18.2	8	0.2
Scamp grouper	2	4.2	2	23	69.7	92	2.8
Snakefish	2	4.2	2	6	18.2	25	0.8
Whitebone porgy	1	2.1	1	3	9.1	4	0.1
Tomtate	1	2.1	3	7	21.2	11	0.3
Red cornetfish	1	2.1	1	8	24.2	20	0.6
Red grouper	1	2.1	1	0	0.0	0	0.0
Conger eel	1	2.1	1	0	0.0	0	0.0
Cubbyu	1	2.1	1	0	0.0	0	0.0
Wenchman	1	2.1	1	0	0.0	0	0.0
Blackfin snapper	1	2.1	1	0	0.0	0	0.0
Squirrelfish	1	2.1	10	0	0.0	0	0.0
Cobia	1	2.1	1	0	0.0	0	0.0
Great barracuda	1	2.1	1	0	0.0	0	0.0
Pearly razorfish	1	2.1	1	0	0.0	0	0.0
White grunt	0	0.0	0	25	75.8	230	7.1
Dusky flounder	0	0.0	0	9	27.3	18	0.6
Longspine porgy	0	0.0	0	3	9.1	3	0.1
Striped searobin	0	0.0	0	0	0.0	0	0.0
Summer flounder	0	0.0	0	1	3.0	1	tr
Spottail pinfish	0	0.0	0	0	0.0	0	0.0
Blue runner	0	0.0	1	0	0.0	1	tr
Reticulate moray	1	2.1	1	0	0.0	0	0.0
Marginal conger	1	2.1	1	0	0.0	0	0.0
Inshore lizardfish	0	0.0	1	1	3.0	1	tr
Palespotted eel	1	2.1	1	0	0.0	0	0.0
Totals	47		2325	33		3262	

Table 3. Ranking of 48 fishes collected by hook-line aboard R/V ONSLOW BAY and vessels chartered by the NMFS, differentiating between shelf edge and inshore habitats

Shelf Edge		Inshore Live Bottom	
Species	Index Rank*	Species	Index Rank*
Red porgy	1	Black sea bass	1
Vermilion snapper	2	Red porgy	2
Gray tilefish	3	White grunt	3
Speckled hind	4	Gray triggerfish	4
Snowy grouper	5	Vermilion snapper	5
Greater amberjack	6	Bank sea bass	6
Gray triggerfish	7	Sand perch	7
Almaco jack	8	Blackedge moray	8
Sharks	9	Dusky flounder	9
Silk snapper	10	Tomtate	10
Red snapper	11	Scamp grouper	11
Tattler	12	Gag grouper	12
Black sea bass	13	Whitebone porgy	13
Blackedge moray	14	Knobbed porgy	14
Gag grouper	15	Greater amberjack	15
Sand tilefish	16	Almaco jack	16
Bank sea bass	17	Speckled hind	17
Atlantic golden-eyed tilefish	18	Sharks	18
Warsaw grouper	19	Snakefish	19
Squirrelfish	20	Longspine porgy	20
Yellowedge grouper	21	Searobin	21
Scamp grouper	22	Summer flounder	22
Sand perch	22	Spottail pinfish	22
Knobbed porgy	22	Blue runner	22
Snakefish	22	Gray tilefish	22
Barbfish	22	Inshore lizardfish	22
Tomtate	23		
Red cornetfish	24		
Red grouper	24		
Whitebone porgy	24		
Conger eel	24		
Cubby	24		
Wenchman	24		
Cobia	24		
Great barracuda	24		
Blackfin snapper	24		
Pearly razorfish	24		
Reticulate moray	24		
Margintail conger	24		
Palespotted eel	24		

* Index rank = % occurrence on cruises \times % of total number of fish for each species.

Although sampling efforts were not equal at live-bottom and shelf-edge habitats (47 sampling trips at shelf-edge compared to 33 for live-bottom), our results suggest that live-bottom fauna was less diverse (26 species) than shelf-edge fauna (40 species). Black sea bass, red porgy, white grunt, gray triggerfish, and vermilion snapper were the highest ranking species at live-bottom habitats. Struhsaker (1969) found that red porgy, vermilion snapper, tomtate, and gray triggerfish accounted for 36% by weight of live-bottom catches off South Carolina, and noted that black sea bass predominated at live-bottom habitats shoreward of 18 m (10 fm). Similarly, Bearden and McKenzie (1971) reported that red porgy and vermilion snapper were the numerically most abundant species (i.e., 30 and 6%, respectively) in trap and trawl catches off South Carolina. Struhsaker (1969) also

reported that he found no live-bottom in Raleigh Bay and we agree; he additionally stated that there were no extensive live-bottom areas in Onslow Bay and that catches of reeffishes made there were probably seasonal migrants from shelf-edge habitat. We found that extensive live-bottom areas of Onslow Bay, especially the southern portion, produced consistent good catches of reeffishes year round.

The species assemblage associated with the shelf-edge habitat was even more predominated by tropical and subtropical species. Although the ubiquitous temperate red porgy was the highest ranking species, more reeffishes were collected at the shelf-edge habitat.

Several species were abundant in the southern portion of the study area (southern Onslow Bay and Long Bay), but do not rank very high (Table 3) because most exploratory trips were made to northern and central Onslow Bay. These fishes included *Mycteroperca* groupers (*M. microlepis*, gag, and *M. phenax*, scamp), rock hind, *Epinephelus adscensionis*, and red hind, *E. guttatus*, which were totally absent from our hook-and-line catches, but were commonly landed on headboats fishing in southern Onslow Bay and Long Bay.

Species composition of our catches from the shelf-edge did not vary seasonally. Warm relatively stable bottom temperatures provided by the Gulf Stream are undoubtedly an essential environmental factor for tropical and subtropical species. Steffanson and Atkinson (1967) reported that bottom temperatures in central Raleigh Bay seldom fall below 20°C. Mathews and Pashuk (1977) showed pools of 20 and 23°C bottom water and that water cooler than 16°C bathed only very small areas of the continental shelf in southern Onslow and Long Bays in winter (February–March 1973). We never recorded temperatures less than 16°C at any shelf-edge habitat station from 1972 to 1976. Miller and Richards (1980) suggested that cold water intrusions from the eastern side of the Gulf Stream may occasionally make temperatures too cool for reef species. This contention is supported by occasional mass mortalities of grouper and snapper, such as the one which occurred off Morehead City, N.C. in 1958 (Fahy, unpublished ms)¹.

In contrast to shelf-edge stations, bottom-water temperatures at live-bottom areas can be seasonally cooler and more variable and may act to temporarily reduce the tropical and subtropical component of the live-bottom ichthyofauna. For example, from November 1975 to February 1976 bottom water temperatures at a regularly visited live-bottom station declined from 22 to 8°C. This drastic decrease in temperature was accompanied by an equally marked change in faunal composition (i.e., from an assemblage predominated by red porgy, vermilion snapper, and white grunt to a fauna dominated by black sea bass, Atlantic spade-fish, and tautog). Presumably, the porgies, snappers, etc. had moved offshore to warmer shelf-edge habitats. The porgy-snapper-grunt-predominated fauna had returned to this station when it was sampled again in April 1976. This was the only occasion that we observed this apparent cold-induced change in the fauna. Similarly, Miller and Richards (1980) suggested that cold winter air influenced the landward distribution of tropical and subtropical fishes throughout the entire South Atlantic Bight.

Both live-bottom and shelf-edge habitat probably serve as a reservoir of recruits to the tropical and subtropical fauna at shallow (less than 30 m) live-bottom habitats and the temporary summer tropical and subtropical fauna (juveniles) commonly found among rocks and jetties along Carolina beaches.

¹ W. E. Fahy. A mass mortality of red snapper, *Lutjanus campechanus*, off Morehead City, N.C. Univ. of North Carolina, Inst. of Mar. Sci., Morehead City, N.C.

Table 4. Variation in CPUE (angler-hours), number of angler hours (AH) and number of fish caught (N) with habitat, season and collection area

	Red Porgy			Vermilion Snapper		
	AH	N	CPUE	AH	N	CPUE
HABITAT						
Live bottom	145.3	340	2.34	350.7	310	
Shelf-edge	501.8	1,139	2.27	544.1	210	0.39
SEASON						
Spring	109.9	221	2.01	197.8	124	0.63
Summer	329.2	885	2.69	377.2	153	0.41
Fall	152.6	244	1.60	245.4	207	0.84
Winter	61.4	142	2.31	74.4	36	0.48
FISHING AREA						
Cape Lookout	654.4	1,492	2.28	556.3	221	0.40
Cape Fear	110.3	535	4.85	261.5	168	0.64
Cape Romain	46.6	273	5.86	77.0	131	1.70

Red Porgy and Vermilion Snapper

Red porgy and vermilion snapper were the numerically most abundant fishes at both habitats (exclusive of black sea bass at live-bottom habitat), and there were variations in abundance (CPUE) with habitat, season, and latitude. Red porgy were about equally abundant at either habitat, but vermilion snapper were slightly more numerous in the shelf-edge habitat (Table 4). CPUE for red porgy was highest in summer and lowest in the fall. CPUE for vermilion snapper was highest in fall and lowest in summer (Table 4). It is unclear if seasonal CPUE variations reflect actual changes in abundance or differential catchability related to life history phenomena. For example, vermilion snapper spawn May through September (Grimes and Huntsman, 1980), and lower CPUE in summer could result from altered behavior during the reproductive season. We do not believe that CPUE data simply mirror seasonal variations in sampling conditions. Most favorable sampling conditions were in summer and fall, and poorest in winter, but CPUE was lowest in fall for red porgy and in summer for vermilion snapper. Both species were indicated to be most abundant in the most southern geographic area (Cape Romain) (Table 4). Our findings agree with Struhsaker's (1969), that these species were more abundant at both live-bottom and shelf-edge habitats off South Carolina than North Carolina.

We compiled CPUE by one-hour intervals (Table 5) of time spent fishing to index diurnal feeding periodicity (a wider array of intervals could not be evaluated because of the 4-h trip to and from the fishing grounds). Red porgy fed most actively in the morning and afternoon. Commercial fishermen also report that fishing is best in early morning and evening, and Austin² reported the same temporal trends in CPUE for Gulf of Mexico red porgy. Red porgy are benthic carnivores concentrating primarily on macroinvertebrates and fish (Manooch, 1976); therefore, the indicated crepuscular activity pattern is consistent with re-

² Austin, H. M. 1971. Ecology of fishes of the Florida Middle Ground. Unpublished Manuscript. Florida State Univ., Dept. of Oceanog., Tallahassee, Florida.

Table 5. Temporal variation in CPUE (angler-hours), number of angler hours (AH) and number of fish (N), for red porgy and vermilion snapper

Time Interval	Vermilion Snapper			Red Porgy		
	AH	N	CPUE	AH	N	CPUE
0900-1000	4.6	1	0.22			
1001-1100	8.9	12	1.36	6.5	62	9.54
1101-1200	16.9	9	0.53	13.2	75	5.69
1201-1300	20.8	8	0.38	10.5	42	3.98
1301-1400	19.2	10	0.52	11.8	51	4.32
1401-1500	13.8	1	0.07	9.3	98	10.51
1501-1600	3.9	3	0.77			
1801-1900	3.3	13	3.9			
1901-2000	2.7	14	5.24			
>2001	9.3	10	1.07			

ported activity patterns of other benthic carnivores in reef environments (Hobson, 1975). CPUE varied temporally for vermilion snapper as well (Table 4), and greatest feeding activity was during late afternoon and evening, suggesting that they are nocturnally active. These data support an earlier conclusion from food habit data that vermilion snapper were nocturnal macroplanktivores (Grimes, 1979).

Meager mark-recapture data indicated that both red porgy and vermilion snapper are highly residential species. We tagged 2,262 red porgy and 458 vermilion snapper at live-bottom habitats between Charleston, S.C., and Cape Hatteras, N.C., although the vast majority were tagged in Onslow Bay, N.C. The headboat fishery throughout the area provided most tag returns.

Only 16 red porgy and 2 vermilion snapper were returned. Of the two types of tag used on red porgy (116 with disc and 2,146 with dart), dart tags provided the poorest return rate, 3.5% compared to 0.56%. The generally low return rate for both species, and especially vermilion snapper, may be associated with raising fish through the large hydrostatic pressure changes. Many tagged fish undoubtedly died after release or were weakened and exceptionally susceptible to predation. Average time at liberty for red porgy was 120 days; however three fish were free for over 400 days (i.e., 436, 438, and 444). Although the average length of time at liberty was 120 days, there was a marked difference in days of freedom for disk and dart tags; disk tags were at liberty much longer (i.e., 337, 436, 438 and 444 days). The longest release time for a dart-tagged fish was only 57 days. The poor return rate and disparity in days of freedom no doubt indicated short-term loss of dart tags. Randall (1962) evaluated dart and disk tags and obtained a much lower return rate for dart tags (i.e., by a factor of four), and tag evaluation experiments at the NMFS Beaufort Laboratory indicated a 60% loss of dart tags after 2 months on red porgy retained in large holding tanks (R. O. Parker, pers. comm.).³ The average distance traveled between tagging and recovery for red porgy was 6 km (3.67 mi.), and the greatest distance traveled was 24 km (14.75 mi.). Movements were in a northeast-southeast direction along the ridges, terraces, and troughs associated with the shelf-edge habitat. The two vermilion

³ R. O. Parker. Fishery Biologist. NMFS, Southeast Fishery Center, Beaufort Laboratory, Beaufort, N.C.

snapper that were recaptured were at liberty 54 and 28 days, and were recaptured at what was essentially their release site. Beaumariage (1964) and Beaumariage and Whittach (1966) reported tagging vermilion snapper with similar results. All their recaptures were at the identical site of their release with one fish being tagged 450 days previously.

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