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Biological Report 82(11.110)
August 1989

TR EL-82-4

Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Florida)

BLACK, RED, AND NASSAU **GROUPERS**

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Fish and Wildlife Service
U.S. Department of the Interior

Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Florida)

BLACK, RED, AND NASSAU GROUPERS

by

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Vicksburg, MS 39180

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PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to one of the following addresses.

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CONVERSION TABLE

Metric to U.S. Customary

Multiply	*By*	*To Obtain*
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters (m)	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers (km)	0.5396	nautical miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters (m^3)	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons (t)	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees (°C)	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
statute miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
square miles (mi^2)	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
pounds (lb)	0.00045	metric tons
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees (°F)	0.5556 (°F - 32)	Celsius degrees

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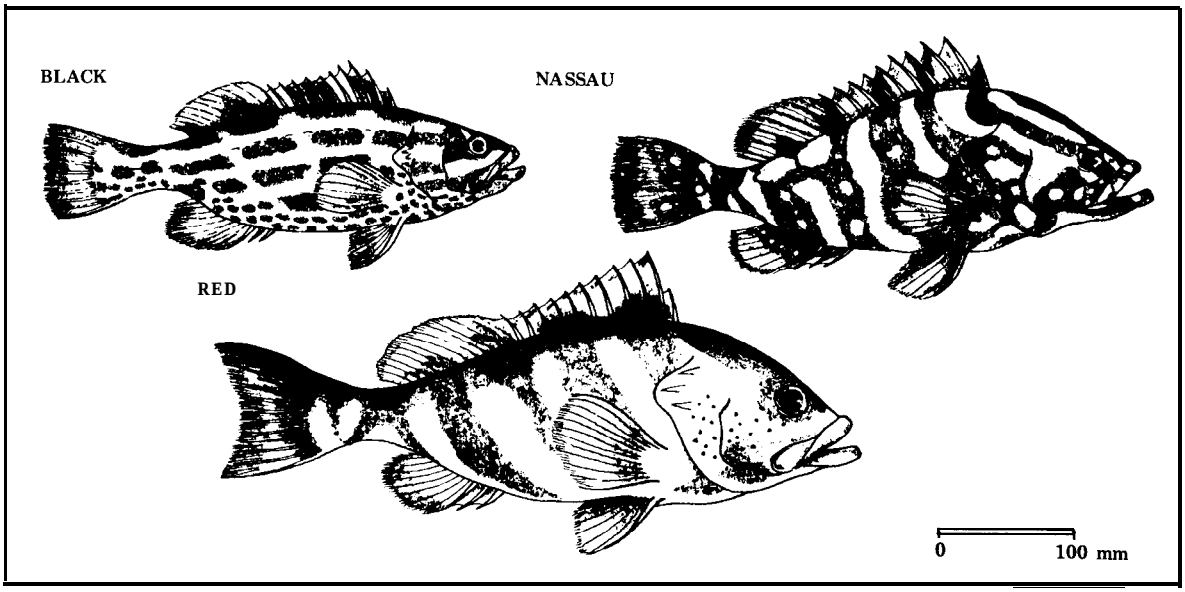

Figure 1. Black, red, and Nassau groupers.

BLACK, RED, AND NASSAU GROUPERS

NOMENCLATURE/TAXONOMY

Scientific name . . . .Mycteroperca bonaci Poey, 1860
Preferred common name....Black grouper
Other common names . ..Marbled rockfish, black rockfish, snider grouper, carbarita, junefish (Figure 1)

Scientific name . . . .Epinephelus morio Valenciennes, 1828
Preferred common name.....Red grouper (Figure 1)

Scientific name . . . .Epinephelus striatus Bloch, 1792
Preferred common name...Nassau grouper
Other common names . . . .Grouper. rockfish, hamlet (Figure 1)

Class ....Osteichthye s
Order.....Perciforme s
Family.....Serranida e

REASONS FOR INCLUSION IN THE SERIES

Black, red, and Nassau groupers are actively sought by both commercial and sport fishermen throughout their geographic ranges. The red grouper is one of the most abundant of the 17 species of grouper caught in Florida by commercial and recreational fishermen. The 1984 grouper landings for Florida totaled about 10 million lb, worth $14 million. The south Florida region (from Citrus around to Brevard Counties) contributed more than 8 million lb (81% of the total, worth more than $11 million (about 79% of the total). The 1984 Florida finfish landings were worth about $57.5 million, of which groupers contributed $14 million or nearly 25% of the total--making them the most valuable marine finfish group in Florida. However, despite their economic importance, available information on their life histories in the south Florida region--particularly for black and Nassau groupers--is

grossly inadequate for effective management of the fishery. Beaumariage and Bullock (1976) wrote that fewer than two dozen pertinent studies had then been published on the biology of groupers, and that almost half of these were based on tagging programs that described movement patterns. According to these authors "This paucity of data exemplifies the need for similar life histories studies, if sound management policies are to be adopted...."

These three species of groupers are an important component of the highly diverse reef fish community, occupying positions near the top of the food webs. Their biology, ecology, and exploitation are integral components of coral reef fisheries and management of reef fisheries (Bohnsack 1982; Bannerot 1984). Any significant change in their numbers could affect the balance of reef ecosystems (May et al. 1979). Preservation of coral reefs is essential for the perpetuation of harvestable grouper populations.

In south Florida, ciguatera (poisoning from consumption of tropical fishes) is endemic. Many of the reported cases from black grouper are really from incorrectly identified fish smuggled in from the Bahamas, where ciguatera is much more common (Jones Bohnsack, National Marine Fisheries Service, Miami, FL; pers. comm.). Life history data, especially on feeding habits, of the species implicated are needed to help prevent ciguatera. The toxin causes gastrointestinal, cardiovascular, and neurological disturbances resulting in prolonged disability and long and expensive recovery periods (de Sylva and Higman 1980; Poli 1982).

GEOGRAPHIC RANGE

The black, red, and Nassau groupers range from New England and Bermuda to southeastern Brazil, including the Bahamas, Gulf of Mexico and all of the Caribbean (Böhlke and Chaplin 1968; Smith 1971; Fischer 1978), although the three species are rare north of Florida. Reports of these species north of the Carolinas are probably a result of larval transport by currents, as suggested by Thompson and Munro (1978) for other grouper species.

The black grouper is abundant in the Florida Keys (Randall 1968), in the Bahamas, and off Cuba and Venezuela (Cervigon 1966); it is reportedly rare in the eastern Gulf of Mexico (Smith et al. 1975), the Virgin Islands, Puerto Rico, and the Colombian Caribbean (Dahl 1971).

The red grouper is primarily a continental species, having the widest distribution of all western central Atlantic groupers (Roe 1976). It is found mostly in broad shelf areas; its center of abundance is in the Florida shelf and the eastern Gulf of Mexico (Moe 1969). It is also abundant in the Colombian Caribbean (Dahl 1971), and off northeastern Venezuela (Cervigon 1966), but uncommon in the West Indies (Randall 1968).

The Nassau grouper is primarily an insular species, very common in the West Indies (Randall 1968), the Bahamas (Bohlke and Chaplin 1968), southern Gulf of Mexico (Fischer 1978), and the Colombian Caribbean (Dahl 1971). In Venezuela, it is common in the Archipelago Los Roques but rare in northeastern islands such as Margarita, Coche, and Cubagua (Cervigon 1966). Red and Nassau groupers occur sympatrically in the Florida Keys (Figure 2), although their local distribution is essentially disjunct (Moe 1969).

MORPHOLOGY AND IDENTIFICATION AIDS

Morphological Characteristics

Smith (1971) provided the following morphological descriptions.

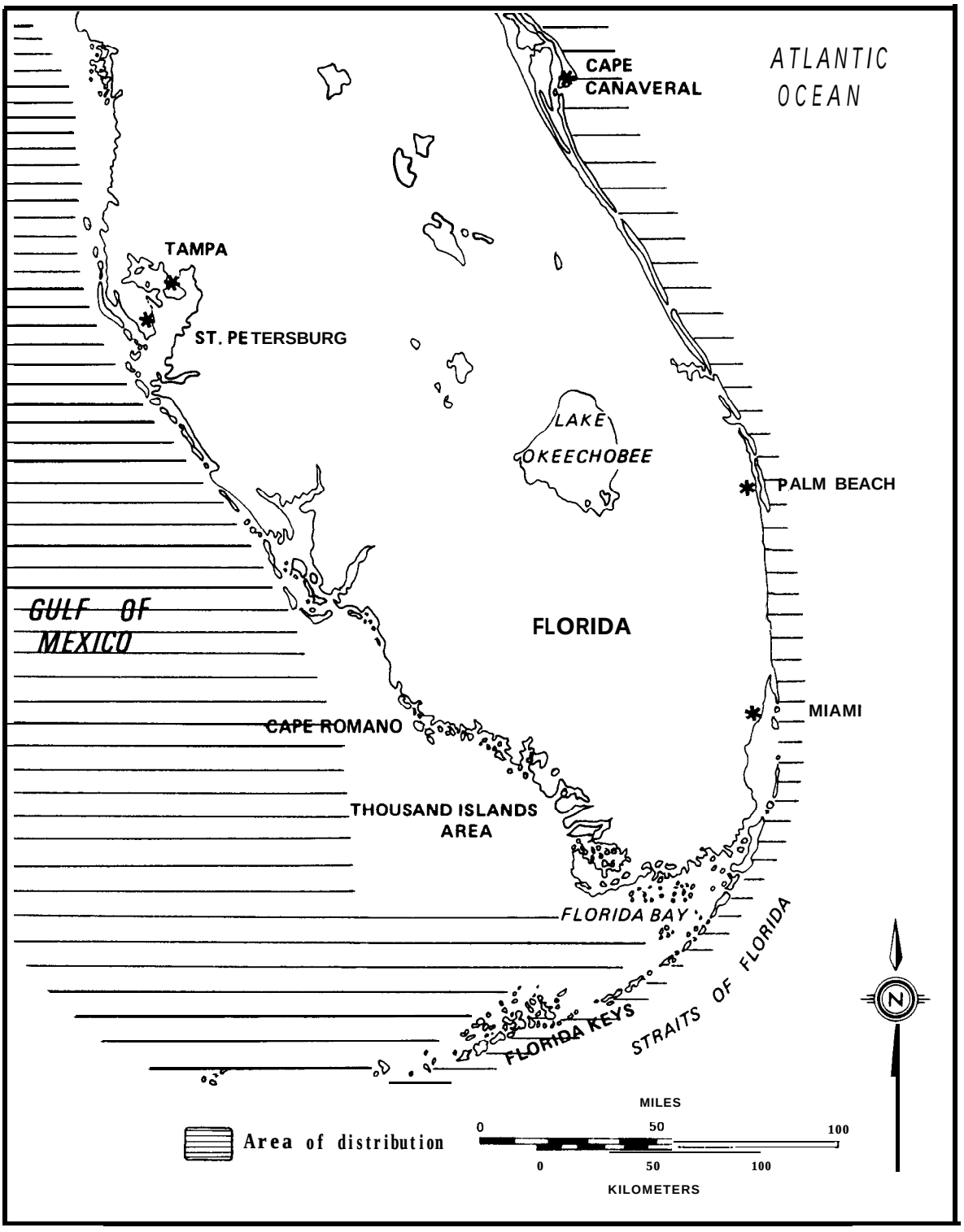

Figure 2. Approximate distribution of the black, red, and Nassau groupers in south Florida.

Black grouper. "Large species of Mycteroperca with robust body, relatively large scales, and rounded preopercle. Dorsal fin XI, 17; anal fin III, 12(13); pectoral fins 17; gill rakers 20-26. Posterior nostril not enlarged. Vertical fins without exserted rays. First three dorsal spines low, not forming an elevated lobe. Gill rakers are moderate in length. The exposed surface of the maxilla is scaled. The upper lip is broad, as wide as or wider than the shaft of the maxilla at the midpoint of the supramaxillary groove."

Red grouper. "Moderate-sized species of Epinephelus with large eyes, small scales, robust body. Nostrils subequal, posterior little larger than anterior. Dorsal fin XI, 16-17 with interspinous membrane not notched. Second dorsal spine longest. Vertical fins angulate in large fish. Anal fin III, 9; pectoral fins 17; gill rakers 23-25."

Nassau grouper. "Moderate-sized species of Epinephelus with large eyes, medium-sized scales, robust body. Nostrils subequal, posterior slightly enlarged, comma-shaped in adults. Dorsal fin XI, 16-17 with interspinous membranes notched; anal fin modally III, 8; pectoral fins 18; gill rakers 24-25. Vertical fins rounded."

Morphological Differences

Morphological differences among grouper species were cited by Fischer (1978).

Black grouper. This grouper can be distinguished from species of the genus Epinephelus by its more elongated body, which is not deepest at the origin of the dorsal fin, and in having 12, sometimes 13, soft anal-fin rays (8-9 in Epinephelus spp.). It differs from other species of Mycteroperca in having a gently rounded preopercle, with no definite lobe and only a slightly emarginated notch, and from other serranids in having the bases of the soft dorsal and anal fins covered by scales and thick skin.

Red grouper. This grouper can be distinguished from other species of the genus Epinephelus by its dorsal fin, in which the second spine is the longest and the interspinous membrane is not notched. In E. nigritus, E. flavolimbatus, E. mystacinus, and E. niveatus, the pelvic fins are longer than the pectoral fins and are inserted anterior to the pectoral-fin base, whereas in the red grouper the pelvic fins are shorter than the pectorals and are inserted slightly behind the ventral end of the pectoral fin base. The red grouper differs from Mycteroperca species in having a less elongated body, and in having nine soft anal-fin rays. The red grouper differs from other serranids in having a more robust body, having the bases of the dorsal and anal fins covered by scales and thick skin, and in having 11 dorsal fin spines.

Nassau grouper. This grouper can be distinguished from other species in the genus Epinephelus by the third spine of the dorsal fin which is longer than the second, and in having a slightly indented interspinous membrane. The caudal fin is slightly emarginated. In Nassau groupers the pelvic fins are shorter than the pectorals and are inserted below or behind the ventral end of the pectoral fin base. In E. mystacinus, E. nigritus, E. flavolimbatus, and E. niveatus, the pelvic fins are longer than the pectorals and are inserted anterior to the ventral end of the base of the pectoral fins. In addition, E. mystacinus has greatly enlarged, equal-sized posterior nostrils, whereas in the Nassau grouper the nostrils are subequal. The Nassau grouper can be distinguished from Mycteroperca spp. by its less elongated body and eight soft anal fin rays. Other serranid species have less robust bodies, soft dorsal and

anal fin bases that are not covered by scales or thick skin, and 10 or fewer dorsal fin spines.

Color and Pigmentation

As a rule, groupers can undergo rapid and dramatic changes in color and pattern, which are under nervous and hormonal control. The extent of change depends on their surroundings and the grouper's own activity. Life color can be used to distinguish different species, but specific color and distinctive markings such as bars and spots fade soon after the fish dies, and undergo further discoloration when the fish is preserved in Formalin or alcohol.

The following coloration and pattern descriptions were compiled from Rivas (1964), Cervigon (1966), Böhlke and Chaplin (1968), Fischer (1978), and the Source Document for the Snapper-Grouper Fishery of the South Atlantic Region (1983).

Black grouper. This species can change its body coloration and color pattern over a wide range, from light tan or gray ground color with rows of rectangular darker blotches, to dark reddish gray with short dark bands, to whitish with a few dusky bars on the fin margins. In general appearance the black grouper resembles the yellowfin grouper (M. venenosa) and the gag (M. microlepis), but the black grouper can be distinguished by its straighter posterior caudal margin and rows of rectangular dark blotches on the body. Blotches are larger and more quadrangular and regularly aligned in the black grouper than in the yellowfin grouper; in addition, each pectoral fin of the black grouper has a narrow orange margin, whereas each of those in the yellowfin grouper has a broad yellow margin that sharply contrasts with the spotted basal portion.

Red grouper. This grouper has one of most variable color patterns among fishes. The body generally is uniformly brownish red with a lighter ventral coloration and a transient pattern of whitish spots. While inactive it may have a banded pattern that matches its surroundings and is similar to that of the Nassau grouper.

Nassau grouper. In this species the body around color can be tawny to pinkish and red, with five dark vertical bars; the third and fourth bars divide above the lateral line and their adjacent branches join to form a w-shaped mark. The Nassau and red groupers are somewhat similar in general appearance, but can be distinguished because the Nassau grouper has a black saddle on top of the caudal peduncle, distinctive black spots below and behind the eyes, and a characteristic "tuning fork" shaped mark on top of the head, all of which are lacking in the red grouper.

Moe (1963) reported the collection of a xanthic specimen of red grouper off Fort Myers, Florida, that agreed in general morphology and meristic counts with published descriptions of the red grouper, and appeared normal in all respects except coloration. Overall body coloration was a brilliant orange-yellow on the dorsal and upper lateral surfaces, shading into reddish-pink on the lower lateral and ventral surfaces.

Size

Black groupers can reach total lengths greater than 1 m and weights over 65 kg, but most of those caught range up to 70 cm TL and about 26 kg in weight. During the 1977 and 1978 Metropolitan South Florida Fishing Tournaments, several black groupers of 22 to 36 kg were caught in the Florida Keys (Official Entry Forms, unpubl.). Male red groupers are reported up to 72 cm TL and females up to 70 cm TL; most fish in commercial catches range from 45 to 70 cm TL. Nassau groupers can grow to about 1.2 m TL

and 20 kg, but most of those marketed weigh 2 to 10 kg (Böhlke and Chaplin 1968; Fischer 1978).

LIFE HISTORY

Habitat

Like most species of groupers, the black, red, and Nassau groupers are secretive, occupying caves, ledges and crevices on reefs and shipwrecks (Smith 1961); the larger fish generally occupy the lower part of the depth range (Thompson and Munro 1978).

The black grouper lives over rocky bottoms, coral reefs, and drop-off walls; fish longer than about 65 cm TL are generally restricted to water deeper than 20 m and small young of the year are usually in shallower water (Fischer 1978). During monthly collections on a shallow grass flat on Matecumbe Key, Florida, Springer and McErlean (1962) reported collecting what appeared to be two young black groupers (20 and 24 mm in standard length, SL). In Venezuela, Cervigon (1966) reported that black groupers up to 350 cm SL frequently occur over muddy bottoms of mangrove-fringed coastal lagoons, and that fish longer than 65 cm SL are generally at depths greater than about 20 m. Moe (1966) reported this species to a depth of 151 m, at bottom temperatures of 16 to 28 °C (mean 20 °C).

The red grouper occurs mainly over rocky bottoms, but also lives over muddy bottoms (Cervigon 1966; Fischer 1978). In the eastern Gulf of Mexico it has been reported as occurring only over rocky reef bottoms at depths of 3 to 122 m, frequently occupying crevices, ledges, and caverns in limestone reefs (Moe 1969). Juveniles may be widely dispersed over hard bottoms at depths of at least 37 m, being extremely cryptic and thus relatively invulnerable to most collecting gear. Fish 1 to 6 years old (under 50 cm SL) commonly inhabit nearshore reefs (Beaumariage and Bullock 1976). It has been reported to depths of 189 m, at bottom temperatures from 15 to 30 °C, but most are collected at 19 to 25 °C (Roe 1976).

The Nassau grouper is generally found near high-relief coral reefs and rocky bottoms. from the shoreline to a depth of at least 90 m (Fischer 1978; Bannerot 1984). Cervigon (1966) reported that large fish occur at depths greater than about 50 m. In Bermuda, Bardach (1958) reported a marked size segregation: fish less than 40 cm SL were on inshore banks and larger ones were on offshore banks. The species may be resistant to changing salinities: in the old New York Aquarium, several Nassau groupers reportedly lived for several years in water that occasionally became almost fresh and was rather polluted (Townsend 1905).

Sex Reversal and Spawning

Most serranids are protogynous hermaphrodites (fish are first females and then change into males), and the sex of an individual cannot be accurately determined unless it is ripe. There is differential distribution by sex in black and Nassau groupers, but not in red groupers (Bannerot 1984).

Smith (1959) reported histological and field observations that strongly suggested protogynous hermaphroditism in black groupers. The black grouper has been reported to spawn off Puerto Rico in February (Erdman 1956), and has been observed in spawning condition in the Campeche Bank area in July and August (Smith 1961). Off Bermuda, spawning extends from May to early August; females may weigh up to 22.7 kg, but larger fish are usually males (Smith 1971).

Red groupers change from female to male between the ages of 5 and 10 years, at a rate of about 15% annually* The transition occurs at any length greater than about 275 mm SL,

but is most common after 500 mm SL is reached. Females are mature at 4-6 years, but reach their greatest reproductive potential at 8-12 years of age. Males do not compose more than 10% of a year class until after age 9 (over 500 mm SL), and the sex ratio is not equal until about age 15, or 625 mm SL (Moe 1969; Beaumariage and Bullock 1976). Males are reproductively significant in the population in age groups 10 years old and older (Beaumariage and Bullock 1976).

Female red groupers usually do not spawn until they are about 450 mm SL. Off the west coast of Florida, spawning peaks in April and May in waters 20-90 m deep and at water temperatures between 19 and 21 °C. Gonadal activity has been observed as early as January, and culminates in spawning in late spring. The only environmental factor that correlates significantly with gonadal development is photoperiod (Moe 1969).

The Nassau grouper changes from female to male at a length between 300 and 800 mm, which presumably indicates that an individual fish can spend more than one spawning season as a functional female. Off Bermuda, 3.2 kg fish are just reaching maturity (Bardach and Menzel 1957). Spawning near Bermuda occurs between early May and mid-August (Smith 1971). In the Caribbean, ripe fish were collected between February and May, and sexually inactive ones were collected in October and November (Munro et al. 1973). Nassau groupers form spawning aggregations of as many as 100,000 fish off Bimini, Bahamas, for 1 week during the full moon in January (Smith 1972). Similar aggregations have been reported by Miller (1984) in Belize; by Bannerot (1984) off the southern Berry Islands, Bahamas (both also during the full moon in January); by Burnett-Herkes (1975) off Bermuda; and by Olsen and LaPlace (1978) in the Virgin Islands. Nassau groupers have been observed to spawn at night in tanks, with no formation of mating pairs (Manday and Fernandez 1966).

Eggs and Larvae

Groupers produce planktonic eggs that are fertilized externally, and predators and currents affect their survival (Smith 1961; Colin 1982). Fecundity has been estimated to be over 5 million eggs at 805 mm SL in black groupers; over 785,000 at 445 mm SL for Nassau groupers (Smith 1961); and 1,469,000 (range 312,000-5,735,700) for red groupers 495 to 667 mm SL (Moe 1969). Calculated individual egg weights ranged from 12 to 22 mg.

Moe (1969) described the eggs of the red grouper as having no filaments or other appendages, containing an oil droplet, and being less than 1 mm in diameter. Manday and Fernandez (1966) reported that the eggs of the Nassau grouper were between 0.9 and 1.024 mm in diameter, and described the species' embryological and larval development until the yolk sac was absorbed.

The distribution of grouper larvae is poorly known. Larval red grouper probably leave the plankton and become benthic at about 20-25 mm SL (Beaumariage and Bullock 1976).

Johnson and Keener (1984) reported that the different patterns of serration on the long second dorsal and pelvic fin spines that characterize grouper larvae are consistent features that can be used to identify larvae of certain species groups. These patterns can identify larvae of some grouper species at lengths as short as 5-6 mm, in lieu of ranges of meristic counts, where considerable overlap exists among many American grouper species. In the genus Mycteroperca, which includes the black grouper, species separation of the larvae based on spinelet morphology is not possible. However, larvae of the

genus can be distinguished from larvae of other grouper genera by the following characteristics: "higher number of anal soft rays (10-13, usually 11, vs. 7-10, usually 8 or 9), characteristic spine morphology...and presence of a cleithral pigment spot." Larvae of the red grouper, the red hind (Epinephelus guttatus), and the speckled hind (E. drummondhayi) can be separated from larvae of other epinepheline species with the exception of the mutton hamlet (E. afer), but cannot be distinguished among themselves because they have similar body form, spinelet morphology and relative spine length. Larvae of the Nassau grouper and the rock hind (E. adscensionis) can be separated from all other western Atlantic grouper larvae by their fin ray counts, with the exception of the jewfish (E. itajara), which has a particular spine morphology.

The function of the spinelets is not known. According to Johnson and Keener (1984) they may be involved in interspecific recognition, but this is not likely because the spinelets are relatively transparent and lack pigmentation. The purpose of these structures may be to repel or hook attacking predators.

Juveniles

Juveniles of the three species of groupers treated here are commonly found in inshore seagrass beds in south Florida, and are often caught in shallower waters than those occupied by adults. Juvenile red groupers do not wander far away from their reefs of residence and are scattered in low densities over hard bottoms in water at least 36 m deep, where they are difficult to collect due to their cryptic behavior (Moe 1969). Juvenile red groupers are "exact miniatures" of the adults in form and color, and they were often collected in seagrass beds in water shallower than 15 m (Smith '1971). Small Nassau groupers are also common in seagrass beds (Randall 1968).

Movement and Migration

Most grouper species apparently migrate vertically as they grow, the larger fish living at progressively greater depths. However, adult groupers may stay in the vicinity of specific reefs for long periods. Black groupers tagged and released in inshore reefs in the Florida Keys displayed strong home-reef specificity, and "even a hurricane failed to disrupt their residence" (Beaumariage and Bullock 1976).

Using evidence from tag and recapture studies of red groupers, Moe (1969) summarized their offshore movement. During their early years they remain in shallow water, usually 3 to 18 m deep. Later, at about 400-450 mm SL and 4-6 years, they leave the nearshore reef environment and move to depths greater than 36 m. Evidence supporting the tagging and recovery data was given by size and age analyses of onshore and offshore fishes. The offshore movement seems to coincide with the onset of sexual maturity. Commercial fishermen have reported seasonal movement of adults in offshore waters 27 to 91 m deep; some schooling or group movement among adults has been evidenced by commercial catches of tagged individuals (Source Document for the Snapper-Grouper Fishery of the South Atlantic Region 1983). Although no alongshore migrational patterns were noted, a few individual red groupers moved 28 to 72 km from tagging locations.

Beaumariage and Bullock (1976) reported that tagged Nassau groupers in the Florida Keys, transported to other nearby reefs, promptly returned to their original reef, showing a "strong home-reef specificity." Randall (1962) reported that tagged Nassau groupers in the Virgin Islands moved at most about 820 m from the site of release. From results of

tagging studies, Springer and McErlean (1962) reported that the Nassau grouper tends to become established in an area.

Nassau groupers have been reported to form enormous spawning aggregations and undergo spawning migrations. A large aggregation of Nassau groupers was observed in the Bahamas by Smith (1972). The fish congregated as a school of perhaps as many as 100,000 in water about 27 m deep. Analyses of gonad samples indicated that fish of both sexes were present and ripe. Some individuals in the aggregation displayed an unusual color pattern; they were dark above and light below and their characteristic head markings were reversed. Similar spawning aggregations were observed by Bannerot (1984), Miller (1984), and others.

GROWTH CHARACTERISTICS

Mean back-calculated total lengths for black groupers aged 1, 5, 10, and 14 years were 260, 664, 975, and 1,110 mm (Manooch and Mason 1987). Growth in length was most rapid for the first 3 to 4 years, and then gradually slowed.

The rate of growth of male and female red groupers is believed to be similar, though males reach a larger ultimate size than females. Their effective fishable life span is about 17 years, but life span may reach 30 years (Moe 1969; Beaumariage and Bullock 1976). Data from the Schlitz tagging program indicated that the red grouper grows at about 5.8 to 10.3 mm per month (Moe 1966, 1967). For Nassau groupers in the Virgin Islands, and based on results from tagging studies, Randall (1962) reported the following mean growth rates: fish 175-250 mm TL grow about 4.55 mm/month; 251-325 mm TL about 3.5 mm/month; and 326-451 mm TL about 1.92 mm/month. Table 1 presents theoretical growth parameters for red and Nassau groupers.

FISHERIES

Recreational and Commercial Fisheries

Estimated grouper landings and fishing effort from 1983 to 1986 by U.S. sport fishermen are sown in Table 2. Recreational grouper fishermen use a variety of boats in pursuit of their sport. Boats are a necessity since grouper catches from shore and dock fishing are rare. Boats used vary from 3.7 m long, privately-owned skiffs with outboard motors to "party boats," also known as head boats, up to 26 m long and powered by diesel engines. Party boats take groups of fishermen to fishing reefs for a fee. Boat numbers have increased greatly recently. Conventional types of fishing rods and reels are used routinely, and occasionally electric reels are used. Minor catches are made by spear fishermen, who most often use scuba gear. Fish traps were used sporadically in Florida beginning in 1919 (Schroeder 1924). They were prohibited in Florida State waters in 1980, but are still legal to use in all Federal waters.

Since 1948, commercial grouper landings have been significantly larger in Florida than in several other States combined (Figure 3). Allen and Tashiro (1976) estimated that about 96% of commercial grouper catches were made with handlines. Incidental catches were made in shrimp trawls, spiny lobster traps, fish pots, haul seines, trammel and gill nets, and longlines. Longlines became a major gear (in terms of pounds landed) in the gulf grouper fishery in the early and mid-1980's and accounted for the increase in commercial landings then (Goodyear 1988). Vessels are usually 7.9 to 24 m long, and frequently use a small steadying sail while fishing over reefs. Some boats are multi-purpose, used in shrimp and lobster fisheries when not used for groupers.

Additional information on the reef fish fisheries in the gulf is provided by Waters (unpubl.). Fishermen, like

Table 1. Yield-per-recruit parameters for black, red, and Nassau groupers. N.D. = no data available; t = age at length of first capture; t_0 = age at length 0; K = von Bertalanffy growth coefficient; Z = total mortality; L_{00} = length at infinity; TL = total length; SL = standard length.

Species	t_c	t_o	K	Z	L_{00}	Length-weight relationship	Area	Source
Black	5-7	-0.927	0.116	0.49-053	1352	$W=5.55x10^{-6}$ $TL^{3.141}$	Mostly South Florida	Manooch and Mason (1987)
Red	1	-0.449	0.179	0.322	672	$W=4.34x10^{-5}$ $SL^{2.93}$	West Florida	Moe (1969)
Nassau	4	-0.488	0.185	N.D.	974	$W=0.1393$ $SL^{3.11}$	U.S. Virgin Islands	Olsen & LaPlace (1978)

the fishing vessels they use, may work only part time fishing for grouper, often working in other fisheries or jobs.

Manooch and Mason (1987) present a yield-per-recruit fishery model for black grouper.

Marketing

Data from a telephone survey reported by Cato and Prochaska (1976) showed that Gulf of Mexico groupers were usually sold by fish dealers fresh and iced (82% by volume); 16% were filleted and only about 2% were frozen whole. The principal markets are in the Southeastern United States, relatively close to the important fishing grounds, thereby permitting shipments of a fresh, iced product. Most dealers sold their fish to other wholesalers (52%); about 35% went to retail markets or agents. The rest were sold to New York agents.

Groupers probably do not contribute substantially to the export market; perhaps only 1% by volume of both groupers and snappers are exported. The strong import market for groupers, which are imported into south Florida from throughout the Caribbean and from as far away as Brazil, implies a weak export market.

Regulations

The minimum size for any species (including species such as scamp and gag) is 18 inches total length. New gear restrictions prohibit use of longline nets and stab nets (also called sink nets) off the Atlantic coast of Florida.

Artificial Reefs

Artificial reef programs designed to improve recreational fishing in the ocean have become popular in recent years; most activity in United States waters has been in Florida. Artificial reefs consisting of a wide variety of materials, ranging from abandoned vessels to designed and prefabricated structures and even junk (debris, large appliances, etc.), have been placed on the coasts of Florida (greatest activity has been in Dade County).

Table 2. Recreational statistics (catch and effort) for groupers in Florida, 1983-86.[1]

Year	Florida (east coast) Number of fish caught	Florida (east coast) Effort (number of trips)[1]	Florida (west coast) Number of fish caught	Florida (west coast) Effort (number of trips)[2]
1983	182,000	7,793,000	2,189,000	10,224,000
1984	187,000	9,891,000	2,429,000	11,451,000
1985	355,000	12,493,000	2,851,000	13,372,000
1986	87,000	10,298,000	2,196,000	13,346,000

[1]From National Marine Fisheries Service (1984-87).
[2]Trips for all sport fish.

A controversy exists as to the best depths for artificial reefs. Among the recreational fishermen, there seems to be a consensus favoring water about 73 m deep, where diving and spear-fishing are discouraged and reefs tend to attract large fish. The long-term effect of artificial reef placement would seem to be that recreational catches of groupers would improve, perhaps in some proportion to the numbers and kinds of artificial reefs installed (Cardozo and Hirsch 1985). It is not known if artificial reefs increase fish populations or just redistribute them (Bohnsack, in press).

Contaminants

Red grouper from the Southeastern United States had an average of 0.008 ppm DDT and undetectable levels of PCB's. Levels for black grouper were 0.009 ppm DDT and up to 0.059 ppm PCB's compared to other fish, low levels of these contaminants are correlated with low lipid content (Stout 1980).

ECOLOGICAL ROLE

Food and Feeding Habits

Groupers are unspecialized and opportunistic carnivores, feeding on a variety of fishes and crustaceans (Thompson and Munro 1978) during the day and at night. Generally, feeding is most active at dawn and dusk (Randall 1967). Foods include cephalopods, crustaceans and other invertebrates, and fishes. By opening the mouth and rapidly dilating the gill covers to draw in water, groupers can generally engulf prey whole (Bardach et al. 1958). The usual collection method (baited handlines) may bias results of food studies in groupers because these fish frequently regurgitate while being brought to the surface and may also contain fishing bait (Randall 1967; Moe 1969). Spearfishing has been regarded as the collection method most likely to assure unbiased evaluations of stomach contents (Randall 1967).

Black groupers are less intimately associated with the bottom, and have more slender bodies and better developed canine teeth than do the red or the Nassau groupers, suggesting a predominately piscivorous diet (Randall 1967). Reported stomach contents include clupeoid fishes (Cervigon 1966), grunts, and cornet-fish (Randall 1967). Both black and red groupers have been reported to prey on pink shrimp, Penaeus duorarum (Costello and Allen 1970).

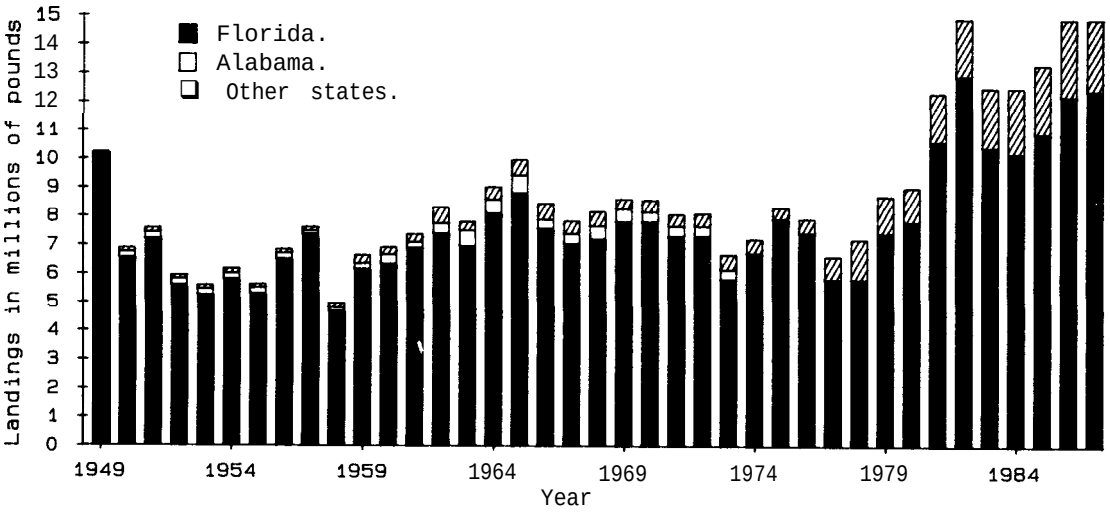

Figure 3. U.S. grouper landings (primarily dressed weights) by States. "Other States" includes North Carolina, South Carolina, Georgia, Alabama, Mississippi,Louisiana, and Texas. From Allen and Tashiro (1976).

Off the Dry Tortugas, Florida, red groupers were reported to feed on lutjanid and sparid fishes (Gudger 1929) and on various other fishes, octopuses, shrimps, stomatopods, and spiny lobsters (Longley and Hildebrand 1941). Randall (1967) reported unidentified crustaceans, crabs, and fishes in the stomachs of two specimens collected off the Virgin Islands. In the stomachs of red groupers collected by commercial and sport fishermen off the Florida west coast, Moe (1969) found small fish of several species, octopuses and squids, crabs (particularly Portunus spp. and Calappa spp.), panulirid and scyllarid lobsters, shrimps, and unidentified crustaceans. Moe (1969) also indicated that red groupers seemed to feed more on invertebrates, particularly crustaceans, than on fish, but that feeding habits may change in large groupers, which probably consume a greater proportion of fish. Longley and Hildebrand (1941) reported no difference in feeding habits of red groupers between day or night, but Moe (1969)indicated that fishermen on the west coast of Florida generally made their better catches during daylight. Cuban commercial boats fishing in the Campeche Bank area reported catching more and larger red groupers at night than during the day (Zupanovich and Gonzalez 1975).

Randall (1965) reported that the stomach contents of 150 Nassau groupers collected during daylight off the Virgin Islands and Puerto Rico consisted of about 53% fish, 39% crustaceans, 5% cephalopods, 2% gastropods, and 2% pelecypods. The most abundant families of fish in the diet, listed in order of occurrence, were parrot-fishes (Scaridae), wrasses (Labridae), damselfishes (Pomacentridae), squirrelfishes (Holocentridae), snappers (Lutjanidae), and grunts (Haemulidae). Crustaceans dominated the diet of smaller fish, whereas fish predominated in the stomach contents of larger Nassau groupers (over 300 mm SL). Crustaceans included crabs (Majidae, Portunidae, Calappidae, Porcellanidae, and Xanthidae), stomatopods (Squillidae), hermit crabs (Paguridae), panulirid lobsters, and caridean and penaeid

shrimp. Mollusks included octopuses and squids, arks (Arcoida), and queen conchs (Strombus gigas),. Randall (1964) suggested that despite their lacking the dentition to crush the shells, Nassau groupers may consume queen conchs after other predators have made soft parts available. In Bahamian waters, however, Nassau groupers have been observed forcefully pulling conchs out of their shells (B. Rose, commercial fishernan, Freeport, Bahamas; pers. comm.) Moray eels (Muraenidae) have been reported in stomachs of Nassau groupers collected in the Virgin Islands and Puerto Rico (Randall 1965) and Jamaica (Thompson and Munro 1978). Cervigon (1966) reported that Nassau groupers in Venezuela fed mostly on crustaceans.

Comoetitors and Predators

Interspecific competition for food and shelter among groupers is likely because of the overlap in habitat, distribution, size, and food habits (Thompson and Munro 1978). Adults of most grouper species occupy high levels in the complex trophic webs of reef communities. These webs include many species of generalized, opportunistic predators (Bohnsack 1982; Bannerot 1984), including groupers, which can be assumed to constantly compete with, and prey upon, similar species. Other competitors for food probably include various species of jacks (Carangidae), snappers (Lutjanidae), barracudas (Sphyraenidae), and sharks (Carcharhinidae, Sphyrinidae).

According to Thompson and Munro (1978) "nothing is known of the causes of natural mortality in groupers." Small, cryptic individuals probably fall prey to fishes such as moray eels (Muraenidae), which can attack them in their hiding places. Large groupers of several species are also reported to readily feed on smaller groupers (Smith 1961). Thompson and Munro (1978) mentioned the lack of published information on grouper predators, and suggested that groupers are probably preyed upon by sharks and other large fishes. Large groupers are probably preyed upon only by certain shark species. Only two species of sharks were reported by Compagno (1984) to prey on groupers: the sandbar shark (Carcharhinus Dlumbeus) and the great hammerhead (Sphyrna mokarran), but other species of sharks undoubtedly feed on groupers.

Parasites and Diseases

Black, red, and Nassau groupers are hosts for a number of parasites (Table 3). The effect of these parasites on the health of their hosts is unknown. Groupers from the Tortugas Islands, Florida, were hosts for several species of digenetic trematodes (Manter 1947). Overstreet (1968), who surveyed species of fish in Biscayne Bay, Florida, reported digenetic trematodes from black and Nassau groupers. In waters off Campeche, Mexico, Fajer et al. (1979) found larval cestodes and nematodes in red groupers, and noted that males tended to have more parasites than females. They also observed that the larger groupers (specimens that ranged from 320 to 500 mm TL) tended to be more heavily parasitized than smaller ones--an observation that has been made for a wide range of host species.

Observations on grouper parasites were made by Thompson and Munro (1978) from specimens caught around Jamaica. Parasites were not identified and only general groups were reported. In Nassau groupers, they found parasitic isopods in the nostrils, encysted larval tapeworms commonly in the viscera, and nematodes in the ovaries. They observed, "Heavy infection by this (nematode) parasite can drastically reduce the number of eggs produced by an individual." The gonads of male fish were not infected.

The only report on grouper diseases that we found in the literature was an account by Moe (1969) of a large skeletal tumor removed from a red grouper. The fish was caught about

Table 3. Parasite species in black, red, and Nassau groupers.

Species of parasite	Location in host	Geographic location	Source
BLACK GROUPER			
Digenetic trematode			
Lecithochirium microstomum	Stomach	Biscayne Bay, Fl	Overstreet (1968)
Lecithochirium parvum	"	"	"
Postporus epinepheli	Intestine	"	"
Prosorhynchus pacificus	Intestine & pyloric caeca	"	"
RED GROUPER			
Digenetic trematodea			
Helicometra torta	N.D.	Tortugas, Fl	Manter (1947)
Lepidapedon levenseni	Intestine & caecum	"	"
Stephanostomum dentatum	Intestine	"	"
Cestoda			
Callotetrarhynchus sp. (larvae-encysted)	Muscles Digestive tract Liver Abdominal cavity Gonads	Campeche Bank (Mexico)	Fajer et al. (1979)
Nematoda			
Anasakis (larvae-encysted)	Digestive tract Liver Gonads	"	"
NASSAU GROUPER			
Digenetic trematode			
Helicometra torta	N.D.	Tortugas, Fl	Manter (1947)
"	Pyloric caeca	Biscayne Bay, Fl	Overstreet (1968)
Lecithochirium microstomum	Stomach	Biscayne Bay, Fl	Overstreet (1968)
Lecithochirium parvum	"	Tortugas, Fl	Manter (1947)
Sterrhurus musculus	"	Biscayne Bay, Fl	Overstreet (1968)

[a]C.L. Smith (1961) reports *Opistñoporus epinephely* occurring in red grouper, based on a report by Manter (1947). No record of this trematode was found in Manter's report.

43 km southwest of Venice, Florida, in May 1967. No information on length, age, or sex of the fish was recorded. Otolith abnormal growths have been reported in red groupers by Moe (1969) and in Nassau groupers by Thompson and Munro (1978).

Ciauatera

Ciguatera is a toxin transmitted by hundreds of species of tropical fishes. It causes gastrointestinal, cardiovascular, and neurological disturbances in persons who eat toxic fish, resulting in prolonged disability and long and expensive recovery periods. Several species of Western Atlantic groupers, including the back and the red groupers, are routinely reported to be ciguatoxic, whereas others such as the Nassau grouper seem to be uniformly nontoxic, throughout their range. In south Florida ciguatera is endemic, and of all grouper species the black grouper is the most often implicated; this species is considered toxic throughout the Caribbean, except near St. Croix, U.S. Virgin Islands (de Sylva and Higman 1980; Poli 1982).

The occurrence of the toxin is usually restricted to large predatory species associated with reefs. The larger older fish are generally more toxic than small younger fish because the old fish have had time to accumulate the toxin. Even within certain species the distribution of toxic fish is not geographically continuous, occurring in some areas and not in others (Olsen et al. 1984). In a study based on interviews (Poli 1982), "groupers" were responsible for the largest number of recorded cases of ciguatera intoxication in Florida during two periods, "pre-1978" and 1978-1980. Many times the species responsible were not identified due to the processing procedures used for marketing the fish.

Behavior

Groupers can generate sound in different ways, particularly by vibrating their thin-walled swim bladder by sudden contraction of axial muscles, such as the single pair of bilateral muscles behind the opercles. Various sounds have been attributed to all three species: low-frequency, high-amplitude "mooing-like" sounds, deep booms, and sustained rumbles, vibrant grunts (single or in rapid series), and long noises from grinding of teeth when fighting for food. Sound may have many functions, including warning, intimidation, orientation, and recognition (Hazlett and Winn 1962; Fish and Mowbray 1970). Nassau groupers are diurnal or crepuscular in their movements (Collette and Talbot 1972) and do not usually move far from cover (Starck and Davis 1966). They are often wary of divers and quickly retreat into hiding places, producing a series of grunting sounds (Hazlett and Winn 1962). Black and Nassau groupers were reportedly attracted by irregularly pulsed signals during experiments designed to attract and film sharks off Bimini, Bahamas. The groupers approached slowly, came to rest in front of the sound projector, and slowly moved away after 10-30 seconds (Myrberg et al. 1969). Randall (1962) reported that Nassau groupers have a tendency to re-enter fish traps; some tagged fish were recaptured several times, presumably re-entering to feed on other fish in the traps.

Nassau groupers are often involved in symbiotic cleaning behavior at "cleaning 'stations" on coral reefs. Species most often reported involved include several species of gobies (Gobiosoma spp.) and shrimp that mainly remove gnathiid isopods from the bodies, fins, gill chambers and mouths of groupers (Bohlke and McCosker 1973; Darcy et al. 1974; Sargent and Wagenbach 1975).

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16. Abstract (Limit: 200 words)
Black, red, and Nassau groupers (Mycteroperca bonaci, Epinephelus morio, and E. striatus, respectively) are widely distributed on rocky bottoms and reefs along the south Florida coast. They are the most valuable marine finfish group in Florida, comprising about 25% of the total value of landings in 1984. The three species can be distinguished by morphometric, meristic, and body color characteristics. Younger fish are typically found in shallow, inshore grass beds, and larger, older fish are generally restricted to deep waters. The three species are protogynous hermaphrodites. Sexual transition can occur at any length over about 300 mm SL. An offshore movement apparently coincides with the onset of sexual maturity. Spawning aggregations have been observed throughout the year, but occur mostly between late spring and early summer. Fecundity estimates range from about 800,000 to over 5,000,000 eggs per female. Both the eggs and the larvae are planktonic. Their early life history is poorly known. Larvae probably leave the plankton and become benthic at around 20-30 mm SL. Growth rates range from about 2 to 10 mm/month. The three species are unspecialized carnivores, feeding on a variety of fishes, crustaceans, and mollusks. Interspecific competition for food and shelter may be common because of the overlap in distribution, habitat, size, and food habits. For the three species, a number of predators and parasites have been reported. Both the black and red groupers have been implicated in ciguatera poisonings in south Florida.

17. Document Analysis a. Descriptors

Marine fishes	Life cycles	Parasites
Fisheries	Growth	Spawning
Feed habits	Competition	Predators

b Identifiers/Open-Ended Terms

Black Grouper (Mycteroperca bonaci)
Red Grouper (Epinephelus morio)
Nassau Grouper (Epinephelus striatus)

c. COSATI Field/Group

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