Memoirs of the Hourglass Cruises: Seabasses (Pisces: Serranidae)

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MEMOIRS OF THE HOURGLASS CRUISES

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SEABASSES (PISCES: SERRANIDAE)

By

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ABSTRACT

Sixteen species of serranid fishes (*Centropristis ocyurus, C. striata, Diplectrum formosum, Epinephelus flavolimbatus, E. morio, E. niveatus, Holanthias martinicensis, Hypoplectrus unicolor, Mycteroperca microlepis, M. phenax, Serraniculus pumilio, Serranus notospilus, S. phoebe, S. subligarius, Rypticus bistrispinus,* and *R. maculatus*) were collected during Project Hourglass. *Centropristis ocyurus* ($n = 982$) and *Diplectrum formosum* ($n = 616$) were the most commonly collected species. Abundance of these fishes in our samples was partially due to their preference for low-relief bottoms, which are more efficiently sampled by trawling gear. Observations by SCUBA divers revealed that some other species, (e.g., *Serranus subligarius*), although poorly represented in trawl samples, were extremely common at rocky reefs.Thirty-one additional serranid species known to occur on the West Florida Shelf were collected by Florida Marine Research Institute personnel and are included in this treatise for completeness of taxonomic and ecological comparisons. The captures of *Epinephelus mystacinus* and *Gonioplectrus hispanus* represent the first recorded occurrences of these species in the eastern Gulf of Mexico.

Information included for each species is derived from Hourglass and other collections, current research on grouper life histories, various museum specimens, and a review of the literature. Each species account includes an abbreviated synonymy, a diagnosis, a list of distinguishing characters, and, if available, information on geographic and bathymetric distribution, seasonal abundance, reproduction, diet and feeding habits, age and growth, predation, abnormalities, parasites, size distributions, abundance, and commercial importance or potential.

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Keys to genera and species are provided for all serranids known or expected to be found on the West Florida Shelf. Diagnoses for subfamilies and genera are also presented.

Variations in ichthyofaunal composition and abundance were greater between Hourglass stations found within one transect than they were between similar stations found in different Hourglass transects separated by about 1° of latitude. Differences between northern and southern transects probably reflected differences in substrate characteristics and water temperature patterns at comparable depths.

Serranids collected during Project Hourglass were separable into three bathymetric groups: shallow-water (6–37 m), moderate water depth (18–73 m), and eurybathic (6–73 m). In many cases, the most closely related species were bathymetrically exclusive, which suggests that competitive interactions may be important in regulating species distribution and abundance.

Physicochemical features become less variable with increased depth and distance offshore in the eastern Gulf of Mexico. Certain tropical serranids are known in the eastern Gulf only from these offshore (>30 m) "environmentally buffered" areas. Many of these same species occur at much shallower depths in more southerly, tropical regions.

INTRODUCTION

The fish family Serranidae, comprising nearly 400 species worldwide (Nelson, 1976), consists of generalized perciform fishes and is thought to be similar to the ancestral stock from which most of the other perciforms evolved. The fossil record for the group dates from the upper Cretaceous (Patterson, 1964).

The serranid fauna of the eastern Gulf of Mexico (West Florida Shelf) is diverse and includes at least 47 species (Table 1). Briggs (1958) suggested that the family Serranidae has undergone a greater evolutionary radiation in Florida than in other areas of the Atlantic. He listed 58 species from Florida, 24 from the Bahamas, and 38 from the West Indies. Although many of the species have been synonymized, the differences in relative diversity remain for these three areas. C. L. Smith (1971a) also recognized the Gulf of Mexico as one of two main evolutionary centers for Western Atlantic serranid fishes. In a study of eastern Gulf of Mexico reef fishes, G. B. Smith (1976) found the Serranidae, with 16 recorded species, to be the most speciose family.

In the eastern Gulf of Mexico, most serranids occur offshore in reef or reef-like habitats (G. B. Smith, 1976); however, some species (e.g., *Mycteroperca microlepis*) may occur within bays and estuaries when they are juveniles or small adults, prior to their migrating offshore (Keener et al., 1988: off South Carolina; L. Bullock, personal observation: Tampa Bay). Other serranids (e.g., *Epinephelus itajara*) are eurybathic and may be found at offshore reefs or, when they are juveniles or adults, inshore around bulkheads and jetties. Still other species (e.g., *Epinephelus mystacinus* and *Gonioplectrus hispanus*) are primarily continental slope dwellers (Thompson and Munro, 1978).

Serranids range in size from the pygmy sea bass, *Serraniculus pumilio*, which is less than 6 cm long, to the jewfish, *Epinephelus itajara*, which reaches lengths exceeding 2 m. All serranids

TABLE 1. SERRANID FISHES REPORTED FROM THE EASTERN GULF OF MEXICO (THOSE COLLECTED DURING PROJECT HOURGLASS ARE DENOTED BY *; FISHES NOT INCLUDED IN THIS PAPER ARE DENOTED BY †).

Anthias nicholsi Firth, 1933, Yellowfin bass.
Anthias tenuis Nichols, 1920, Threadnose bass.
* *Centropristis ocyurus* (Jordan and Evermann, 1886), Bank sea bass.
Centropristis philadelphica (Linnaeus, 1758), Rock sea bass.
* *Centropristis striata* (Linnaeus, 1758), Black sea bass.
Diplectrum bivittatum (Valenciennes, 1828), Dwarf sand perch.
* *Diplectrum formosum* (Linnaeus, 1766), Sand perch.
Epinephelus adscensionis (Osbeck, 1771), Rock hind.
Epinephelus cruentatus (Lacépède, 1802), Graysby.
Epinephelus drummondhayi Goode and Bean, 1879, Speckled hind.
* *Epinephelus flavolimbatus* Poey, 1865, Yellowedge grouper.
Epinephelus fulvus (Linnaeus, 1758), Coney.
Epinephelus guttatus (Linnaeus, 1758), Red hind.
Epinephelus inermis (Valenciennes, 1833), Marbled grouper.
Epinephelus itajara (Lichtenstein, 1822), Jewfish.
* *Epinephelus morio* (Valenciennes, 1828), Red grouper.
Epinephelus mystacinus (Poey, 1852), Misty grouper.
Epinephelus nigritus (Holbrook, 1855), Warsaw grouper.
* *Epinephelus niveatus* (Valenciennes, 1828), Snowy grouper.
Gonioplectrus hispanus (Cuvier and Valenciennes, 1828), Spanish flag.
Hemanthias aureorubens (Longley, 1935), Streamer bass.
Hemanthias leptus (Ginsburg, 1952), Longtail bass.
Hemanthias vivanus (Jordan and Swain, 1885), Red barbier.
* *Holanthias martinicensis* (Guichenot, 1868), Roughtongue bass.
* *Hypoplectrus unicolor* (Walbaum, 1792), Butter hamlet.
Liopropoma eukrines (Starck and Courtenay, 1962), Wrasse bass.
† *Liopropoma rubre* Poey, 1861, Peppermint bass. (May occur only in southeastern and northwestern Gulf.)
Mycteroperca bonaci (Poey, 1860), Black grouper.
Mycteroperca interstitialis (Poey, 1860), Yellowmouth grouper.
* *Mycteroperca microlepis* (Goode and Bean, 1880), Gag.
* *Mycteroperca phenax* Jordan and Swain, 1885, Scamp.
Mycteroperca tigris (Valenciennes, 1833), Tiger grouper.
Mycteroperca venenosa (Linnaeus, 1758), Yellowfin grouper.
Paranthias furcifer (Valenciennes, 1828), Creole fish.
[1] *Pikea mexicana* Schultz, 1958, Yellowtail bass.
Plectranthias garrupellus Robins and Starck, 1961, Apricot bass.
* *Rypticus bistrispinus* (Mitchill, 1818), Freckled soapfish.
* *Rypticus maculatus* Holbrook, 1855, Whitespotted soapfish.
Schultzea beta (Hildebrand, 1940), School bass.
* *Serraniculus pumilio* Ginsburg, 1952, Pygmy sea bass.
Serranus annularis (Günther, 1880), Orangeback bass.
Serranus atrobranchus (Cuvier, 1829), Blackear bass.
* *Serranus notospilus* Longley, 1935, Saddle bass.
* *Serranus phoebe* Poey, 1851, Tattler.
* *Serranus subligarius* (Cope, 1870), Belted sandfish.
Serranus tabacarius (Cuvier, 1829), Tobaccofish.
Serranus tigrinus (Bloch, 1790), Harlequin bass.
Serranus tortugarum Longley, 1935, Chalk bass.

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[1] See addendum on page 199 for recent name change.

are carnivorous; however, feeding modes vary from suprabenthic plankton-picking (e.g., *Anthias*, *Paranthias*, *Hemanthias*, and *Schultzea*) to the engulfing of large prey (e.g., *Mycteroperca* and *Epinephelus*).

Most serranids live in close association with the bottom, with the exception of the anthiines, which spend much of the time above the bottom picking prey from the water column. Serranids are also typically sedentary, straying little, if at all, from a particular reef; tagging studies, however, indicate that some of the larger groupers (especially *Mycteroperca* spp.) are more mobile and have been recaptured more than 70 km from their release sites (Randall, 1962; Topp, 1963; Beaumariage, 1964, 1969; Beaumariage and Wittich, 1966; Moe, 1966, 1967, 1972; Moe et al., 1970). Nassau grouper, *E. striatus* (Bloch, 1792), appear capable of moving considerable distances to reach spawning sites. One tagged individual traveled upwards of 128 km to join a spawning aggregation off the southern tip of Long Key in the Bahamas (P. Colin, personal communication).

Although most serranids are basically solitary, the anthiines again are the exception. *Anthias*, for example, is gregarious and forms benthopelagic aggregations when feeding. Some serranid species (e.g., *Mycteroperca* spp.) may appear aggregated or schooled because they are so abundant at certain reef habitats, but their individual movements are usually independent of one another. Some groupers (e.g., *Epinephelus* spp.) may migrate and aggregate during spawning (C. L. Smith, 1972; Thompson and Munro, 1978; Olsen and LaPlace, 1979).

Coloration of serranid fishes may be highly variable. In many species, color varies ontogenetically, and color patterns may differ according to water depth. Certain groupers (particularly *Epinephelus* spp.) exhibit neurogenically mediated, multiple color-phases that can be "turned on and off" instantaneously. Bright yellow (xanthic) variants have been reported for *Epinephelus fulvus* (C. L. Smith, 1971a; G. B. Smith, 1976, 1978) and *E. morio* (Moe, 1963a, 1969). Ross (1988) reported xanthic coloration as the normal color pattern of juvenile *E. drummondhayi*; previously, yellow individuals were considered rare because ontogenetic color changes were unknown (Schwartz, 1978; Smith and Bullock, 1979). Moe (1963a) noted partial albinism in the red grouper, *E. morio*.

Serranids are important components of tropical and subtropical shelf ichthyofaunas. Members of the genera *Epinephelus* and *Mycteroperca* (collectively referred to as groupers) provide the basis for an intensive sports/commercial fishery. During 1975, an estimated 22,576 tons of groupers and sea basses were landed from the western Central Atlantic Ocean (C. L. Smith, 1978).

Most information on serranid life histories is based upon studies of the commercially important groupers. Moe (1969) completed a thorough investigation of age, growth, reproduction, and ecology of the red grouper, *Epinephelus morio*, in the eastern Gulf of Mexico. Burnett-Herkes (1975) completed a similar report on the red hind, *E. guttatus*, and Nagelkerken (1979) presented a comprehensive study of the graysby, *E. cruentatus*. Age and growth studies have been completed for the gag, *Mycteroperca microlepis* (McErlean, 1963; Manooch and Haimovici, 1978; P. Hood and R. Schlieder, unpublished data); the black grouper, *M. bonaci*; and the warsaw grouper, *E. nigritus* (Manooch and Mason, 1987). Thompson and Munro (1978) collected an impressive amount of distributional, biological, and ecological data on groupers significant to the Caribbean fishery. Age, growth, and general life-history studies of some noncommercial species such as the sand perch, *Diplectrum formosum* (Bortone, 1971b), and pygmy sea bass, *Serraniculus pumilio* (Hastings, 1973), have also been completed.

Serranid fishes display a variety of reproductive strategies, including simultaneous hermaphroditism (e.g., *Diplectrum, Hypoplectrus,* and *Serranus*), simultaneous hermaphroditism with larger males maintaining harems (e.g., *S. baldwini* [Petersen and Fischer, 1986] and *S. fasciatus* (Jenyns, 1840) [Hastings and Petersen, 1986]), and protogynous hermaphroditism (e.g., *Anthias, Hemanthias, Mycteroperca, Epinephelus, Paralabrax,* and *Centropristis*). At least one example of self-fertilization (under artificial conditions) by the belted sandfish, *Serranus subligarius,* was reported by Clark (1959). Several workers (C. L. Smith, 1965, 1967; Smith and Young, 1966) have studied variations in gonad structure and function to elucidate generic limits and relationships.

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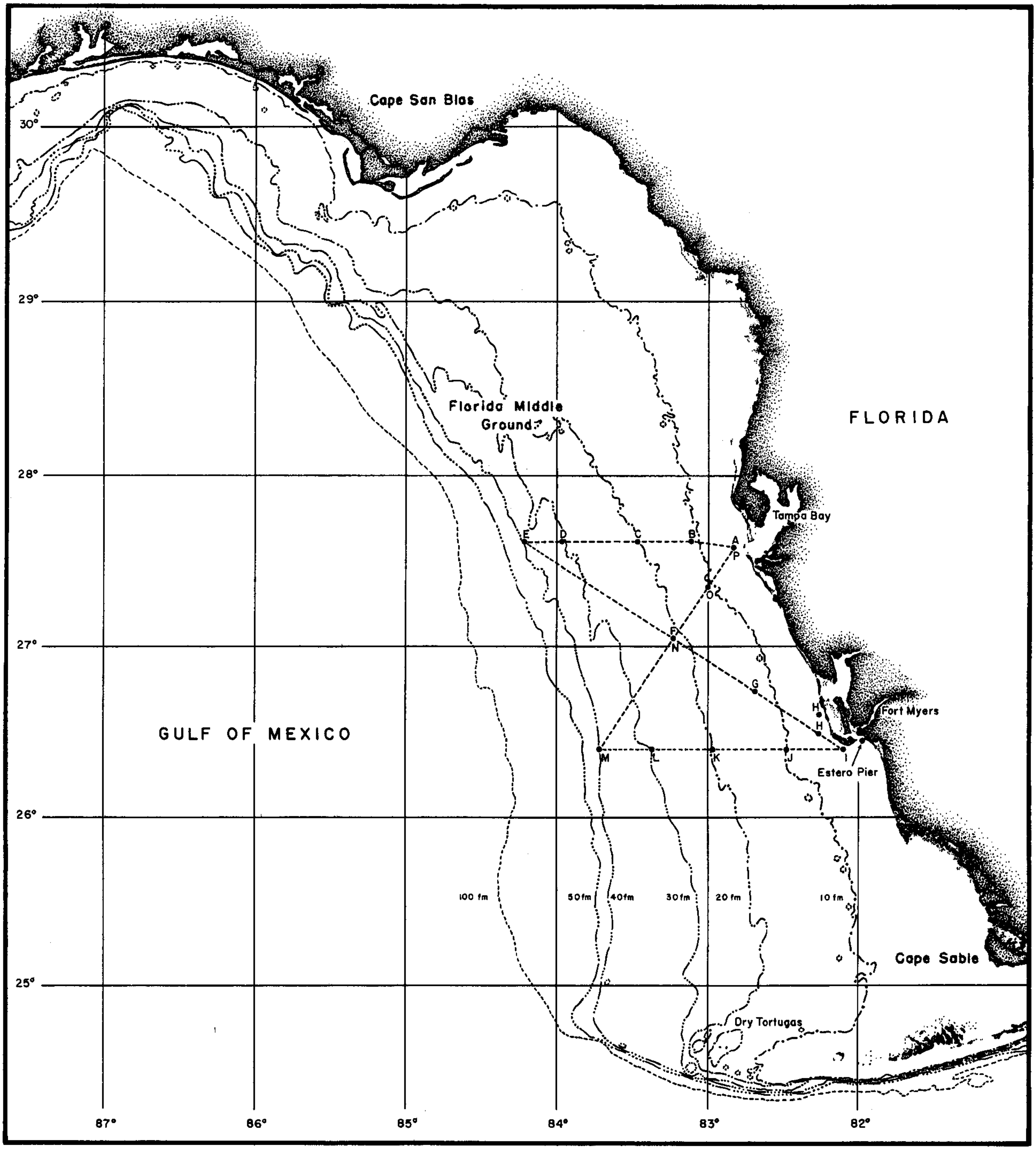

Figure 1. Hourglass cruise pattern and station locations. Isobaths are labeled in fathoms.

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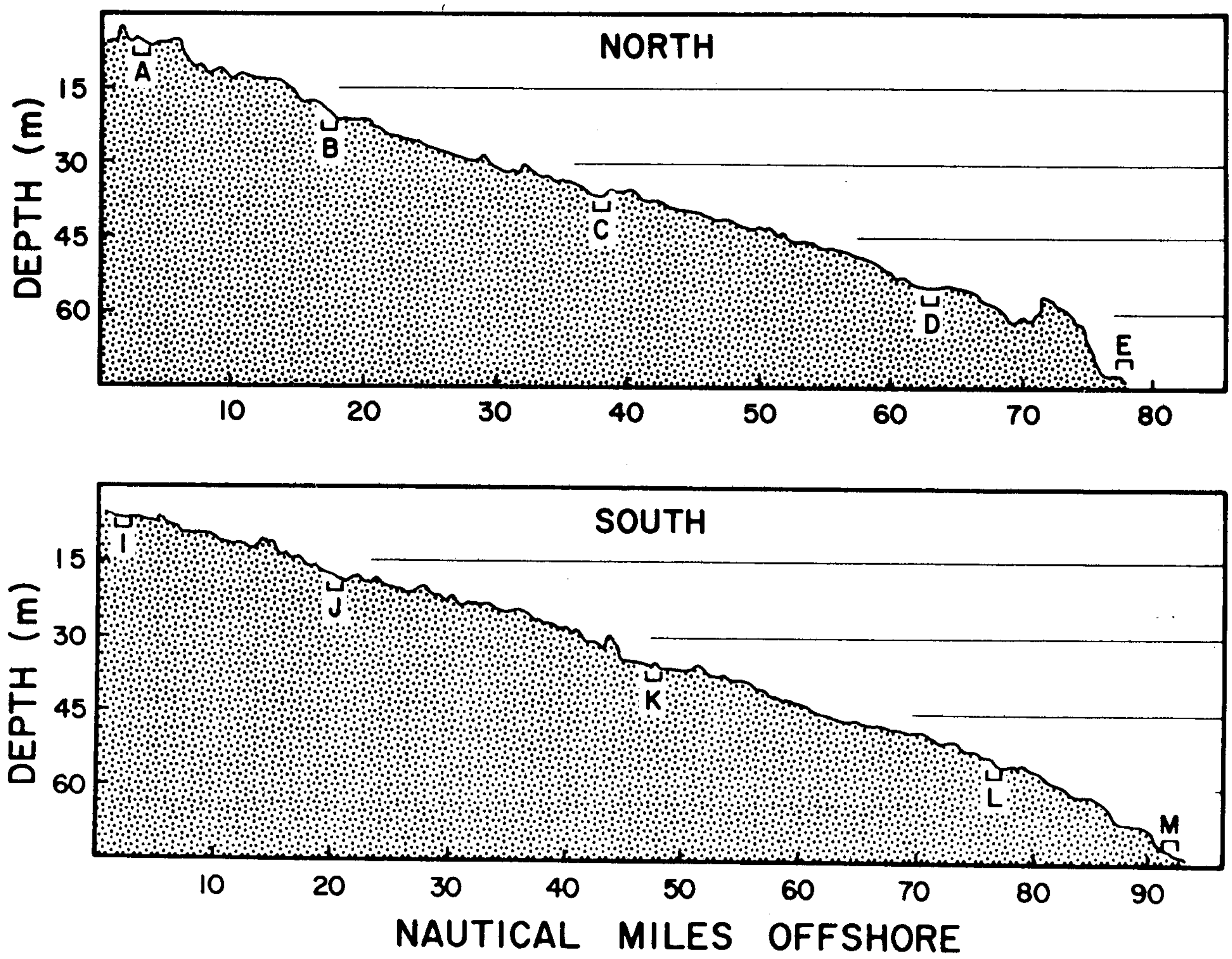

Figure 2. Bathymetry of Hourglass transects (from Huff and Cobb, 1979). For station locations, refer to Figure 1.

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MATERIALS AND METHODS

Sixteen serranid species were collected during Project Hourglass, a series of 28 monthly collections made at ten fishery stations (6–73 m deep) along transects off Tampa Bay (Stations A–E) and Sanibel Island (Stations I–M) from August 1965 through November 1967. Hourglass stations are presented in Figures 1 and 2 and Table 2. Subsequent sampling of offshore commercial catches from the eastern Gulf of Mexico conducted during 1977–1980 and ongoing sampling

TABLE 2. LOCATION AND DEPTH OF HOURGLASS STATIONS.

Station	Latitude*	Longitude*	Established Depth (meters)	Approximate Nautical Miles Offshore*
A	27°35'N	82°50'W	6.1	4, due W of Egmont Key
B	27°37'N	83°07'W	18.3	19, due W of Egmont Key
C	27°37'N	83°28'W	36.6	38, due W of Egmont Key
D	27°37'N	83°58'W	54.9	65, due W of Egmont Key
E	27°37'N	84°13'W	73.2	78, due W of Egmont Key
I	26°24'N	82°06'W	6.1	4, due W of Sanibel Island Light
J	26°24'N	82°28'W	18.3	24, due W of Sanibel Island Light
K	26°24'N	82°58'W	36.6	51, due W of Sanibel Island Light
L	26°24'N	83°22'W	54.9	73, due W of Sanibel Island Light
M	26°24'N	83°43'W	73.2	92, due W of Sanibel Island Light

*U.S. Coast and Geodetic Chart No. 1003, dated June 1966.

by Florida Marine Research Institute (FMRI) staff provided data on 31 additional serranids included in this report. The life histories of three commercially important groupers, *Mycteroperca microlepis* (gag), *M. phenax* (scamp), and *Epinephelus flavolimbatus* (yellowedge grouper), were investigated by FMRI personnel during 1977–1980. Monthly sampling was conducted at commercial fish houses throughout Pinellas County, Florida. Lengths (standard [SL], fork [FL], and total [TL]) and weights (W) were recorded in the field, and gonads and otoliths (sagittae) were returned to the laboratory for further examination. Length-frequency data were gathered for the above species and associated groupers (e.g., *E. morio* [red grouper], *E. niveatus* [snowy grouper], and *E. drummondhayi* [speckled hind]). Other species of groupers were captured primarily at the Florida Middle Ground, a reef biotope located on the outer west Florida Shelf at 28°15'–45'N, 84°00'–25'W, where depths were 26–48 m (Figure 1). Specimens of *E. adscensionis* (rock hind), *E. cruentatus* (graysby), *E. guttatus* (red hind), *M. interstitialis* (yellowmouth grouper), and *Paranthias furcifer* (creole fish) were sampled as described above from catches by anglers aboard the M/V *Florida Fisherman*, a partyboat berthed at Johns Pass, Madeira Beach, Florida. The eastern Gulf of Mexico is herein defined as extending from Cape Sable northward to Cape San Blas, Florida (Figure 1) (G. B. Smith, 1976).

Joyce and Williams (1969) described sampling rationale and procedures and presented physicochemical and hydrographic data for Hourglass Cruises. The cruises consisted of monthly nighttime collections at all fishery stations (Regular Cruises) and daytime collections at Stations B, C, and D (Post-Cruises), using a 20-ft (6.1-m) trynet towed for 30 min (bottom time; a 15-min tow was attempted during the initial half of the August 1965 cruise but was discontinued thereafter) and a 36-in (0.9-m) rectangular box dredge towed for 15 min. Supplementary collections (Special Cruises), utilizing a 45-ft (13.7-m) balloon-type otter trawl, were made during July 1966 and January 1967. Fishes were also collected with traps (angular wooden, square wooden, and heart-shaped wire), hook and line, and nekton nets. SCUBA divers used rotenone to collect fish at various localities within the Hourglass study area.

During the December 1965 and March 1966 Regular Hourglass Cruises, rough seas prevented sampling of certain southern transect stations. A subsequent trip caused Station L (December 1965) and Stations I, J, and K (March 1966) to be sampled twice during these months. To keep monthly station sampling efforts roughly comparable, data from the initial collections at these stations during those months have been excluded from this report.

Interpretation of bottom composition at fishery stations by Joyce and Williams (1969) based on fathometer traces depicted in their Figures 11 and 12 is incorrect. Broad fathometer traces are indicative of hard bottom areas (rock, coral, or broken shell), whereas narrow traces suggest softer substrates (sands and muds) rather than vice versa as intimated by Joyce and Williams (1969). Lyons (1970) also noted that at certain Hourglass stations, fathometer traces were sometimes deceptive in determining bottom types. Accordingly, re-evaluation of fathometer profiles of Hourglass fishery stations indicates the following: Stations A, D, E, I, and M are largely composed of softer substrates; Station B is predominately limestone rock with coral and only a few intervening sand lumps; and Stations C, J, K, and L are areas where a variety of soft and hard substrates exist. Because substrate is an essential parameter influencing shelf fish distributions, these distinctions are important.

All fish specimens were initially preserved in 10% formalin and subsequently transferred to 50% isopropanol for storage. Representative specimens of species collected were accessioned into the Florida Department of Natural Resources Vertebrate Collection (FSBC). Stomachs of the more common fishes were examined for fullness and content. Gonads were macroscopically examined and classified as 1) immature, 2) active-developing, 3) active-ripening, 4) ripe, 5) post-spawning spent, or 6) inactive. Reproductive tissue from additional specimens was examined microscopically after histological processing. We assigned gonad developmental classes according to Moe (1969).

Ovaries selected for fecundity analysis were weighed to the nearest 0.01 g and a weighed portion was fixed in Gilson's solution. After a period of at least six months, the oocytes were filtered, dried, and weighed. Three subsamples of 0.2–0.4 g were weighed to the nearest 0.001 g, and all of the oocytes were counted in a gridded Petri dish under a binocular dissecting microscope.

Each "Material examined" section is organized first by station, then by chronological order of capture. The number and size (or size range) in mm SL of the specimen(s) in each lot are given. In addition to catalogued FMRI material (FSBC), specimens were examined from the College of Charleston, Grice Marine Biological Laboratory (GMBL); the Indian River Coastal Zone Museum (IRCZM); the University of Puerto Rico (UPRM); the University of West Florida (UWF); the University of South Alabama (USAIC); and Texas A&M University (TCWC). Specimen fixation and analyses followed Hourglass procedures, except that gonads, in many cases, were prepared histologically for microscopic examination.

Only those species captured during Project Hourglass are figured in line drawings; each drawing is a composite taken from several specimens. All 47 species are illustrated in color plates.

Unless otherwise specified, standard length (mm SL) is the measurement employed. Meristic data (see Appendix Tables 1–5) were generally taken according to the methods of Hubbs and Lagler (1947); exceptions or additions are explained in the systematic sections in which they first arise. Gill-raker counts include all countable elements (gill rakers and rudiments) on the first gill arch of the left side.

Synonymies are usually restricted to the original description, all binomial combinations, Gulf records, and all references cited in the text. No attempt was made to repeat lengthy synonymies from major revisionary papers. Synonymies for these genera only include the original description, text citations, and literature subsequent to the revision.

SYSTEMATICS

Interpretations of the taxonomic limits of the family Serranidae and of its relationship to other basal percoid groups have undergone many changes. Boulenger (1895) placed the Percina, Serrania, and Priacanthia of Günther (1859) within the family Serranidae, excluding from it all groups without a suborbital shelf. He then divided the family into the subfamilies Serraninae, Grammistinae, Priacanthinae, and Centropominae. Jordan and Evermann (1896b) elevated the Priacanthinae and Centropominae to family status and partitioned the remaining serranids into numerous subfamilies. Katayama (1960) recognized several subfamilies, including the Grammistinae, within the Serranidae. Subsequently, Gosline (1966) restricted the Serranidae to the Serraninae, Epinephelinae, and Anthiinae and elevated the Grammistinae, among others, to family level.

Gosline (1966), Courtenay (1967), and Randall et al. (1971) agreed that specializations within the grammistine lineage warranted family distinction; however, Kendall (1976) placed the soapfishes in the serranid subfamily Grammistinae, while Johnson (1983) and Kendall (1984) relegated these fishes to the tribe Grammistini, in the subfamily Epinephelinae.

Knowledge of serranid relationships has increased greatly in recent years. Now available are revisions of the American groupers (*Epinephelus* and related genera: C. L. Smith, 1971a), the sand perches (*Diplectrum:* Bortone, 1977b), the sea bass genus *Centropristis* (Miller, 1959; Bortone, 1977a), the soapfish genus *Rypticus* (Courtenay, 1967), and other soapfishes (Randall et al., 1971; Randall et al., 1980). Robins and Starck (1961) presented preliminary materials for a revision of *Serranus* and related genera. Kendall (1976, 1984) and Johnson (1983) interpreted the phylogenetic relationships of serranid fishes based upon comparative examination of predorsal and associated bone patterns. Johnson and Keener (1984) used spine and spinelet morphology to assist in the identification of grouper larvae.

The characters that define the family Serranidae and separate it from the Percichthyidae are the presence of three opercular spines (Gosline, 1966) and three derived reductive specializations (absence of a posterior uroneural, procurrent spur, and third preural radial cartilage) (Johnson, 1983). Katayama (1960) recognized 15 subfamilies; however, Johnson (1983) believed that the family comprises only the Anthiinae, the Epinephelinae, and the Serraninae. Table 3 (after Kendall, 1984) allocates each genus to its respective subfamily following the scheme of Johnson (1983), the classification followed in this study. Only those genera known to occur in the eastern Gulf of Mexico are listed.

TABLE 3. ALLOCATION OF SERRANID GENERA TO SUBFAMILIES (AFTER KENDALL, 1984).

Subfamily	Genus	Subfamily	Genus	Subfamily	Genus
Serraninae	*Centropristis* *Diplectrum* *Hypoplectrus* *Schultzea* *Serraniculus* *Serranus*	Anthiinae	*Anthias* *Hemanthias* *Holanthias* *Plectranthias*	Epinephelinae	*Epinephelus* *Gonioplectrus* *Liopropoma* *Mycteroperca* *Paranthias* *Pikea* *Rypticus*

The following key identifies genera of Serranidae known to occur on the West Florida Shelf. Species names are included when only a single representative of that genus is found in the Gulf of Mexico. Keys are adapted from the pertinent literature and are primarily applicable to adult specimens.

KEY TO GENERA AND SELECTED SPECIES OF SERRANIDAE OF THE WEST FLORIDA SHELF

1\. Dorsal spines 2–4 .... *Rypticus* (p. 155)
1\. Dorsal spines 8–11 2

2\. No teeth on jaws .... *Schultzea beta* (p. 59)
2\. Teeth on jaws 3

3\. Body heavy, stout, neither slender and elongate nor strongly compressed; bases of soft dorsal and anal fins covered with scales and thick skin; scales small (lateral-line pored scales 60–140) and greatly overlapping (the "typical" groupers including *Paranthias*) 4
3\. Body less robust, either slender and elongate or compressed; bases of dorsal and anal fins not obscured by thick skin and scales; scales generally large (lateral-line pored scales 27–60) 6

4\. Head short, less than 35% of standard length; caudal fin deeply forked; upper and lower profiles of body equally curved .... *Paranthias furcifer* (p. 152)
4\. Head long, more than 35% of standard length; caudal fin rounded to emarginate; upper profile of body more strongly curved than lower 5

5\. Anal-fin rays 11–14; lateral skull crests (not visible externally) parallel .... *Mycteroperca* (p. 125)
5\. Anal-fin rays 7–9 (rarely 10); lateral skull crests convergent anteriorly .... *Epinephelus* (p. 80)

6\. Spinous dorsal fin interrupted by scaled-over area, with one or two free spines usually protruding (Figure 3) .... *Liopropoma* (p. 123)
6\. Spinous dorsal fin continuous 7

7\. Dorsal spines 8 8
7\. Dorsal spines 10 9

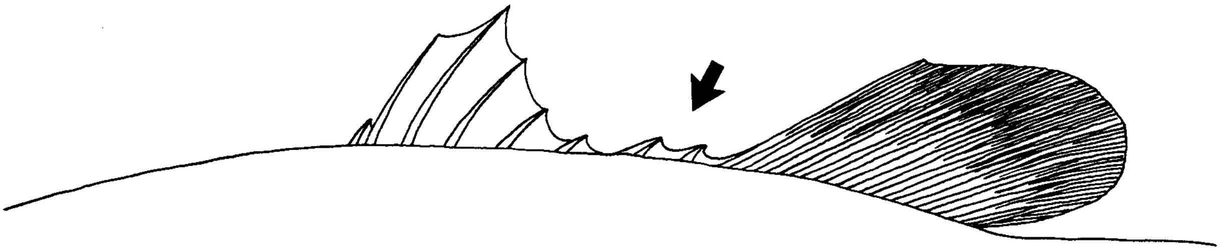

Figure 3. Dorsal fin of *Liopropoma* showing interrupted, scaled-over area.

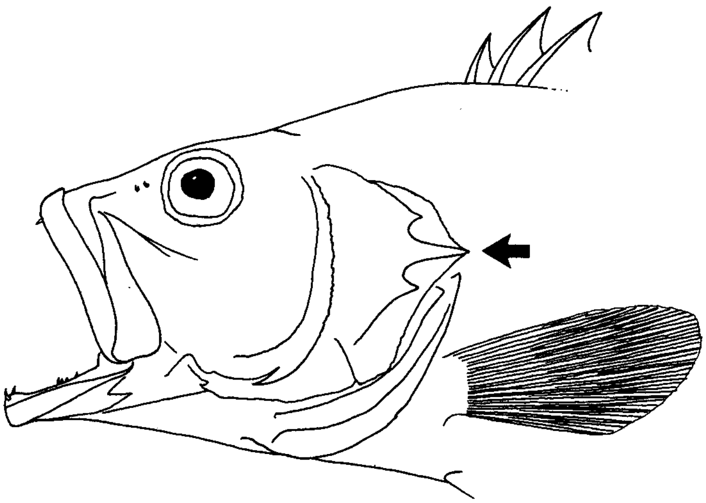

Figure 4. Knife-like spine on opercle and asymmetrical pectoral fin of *Gonioplectrus hispanus.*

8. Opercle with prominent, knife-like spine (Figure 4); pectoral fin with upper rays longest........ *Gonioplectrus hispanus* (p. 122)
8. Opercle without prominent, knife-like spine; pectoral fin symmetrical........ *Pikea mexicana* (p. 154)

9. Lateral line running very close to dorsal-fin base; enlarged curved teeth (canines) often present at sides of lower jaw........ 10
9. Lateral line not running close to dorsal-fin base; no enlarged curved teeth at sides of lower jaw........ 11

10. Total gill rakers on first arch 14–16; lateral-line scales 27–29........ *Plectranthias garrupellus* (p. 27)
10. Total gill rakers 30–42; lateral-line scales 30–60........ 12

11. Body depth greater than 40% of standard length; several antrorse serrations on the ventral edge of the preopercle........ *Hypoplectrus unicolor* (p. 56)
11. Body depth less than 40% of standard length; preopercle with either fine serrations (on ventral edge) or strong divergent spines........ 14

12. Maxilla and frontal bones naked........ *Hemanthias* (p. 17)
12. Maxilla and frontal bones with scales........ 13

13. Vomerine tooth patch with median rearward prolongation (Figure 5A); large oval patch of granular teeth on tongue; sum of left and right pectoral fin rays 32–36........ *Holanthias martinicensis* (p. 25)
13. No median rearward prolongation of vomerine tooth patch (Figure 5B); lingual teeth (if present) not in a large oval patch; total pectoral-fin rays usually 36–40........ *Anthias* (p. 13)

14. Branchiostegal rays 6; maximum size less than 60 mm (standard length)........ *Serraniculus pumilio* (p. 60)
14. Branchiostegal rays 7; maximum size much greater than 60 mm (standard length)........ 15

15. Caudal fin with 3 distinct lobes; dorsal-fin spines with fleshy tabs or filaments........ *Centropristis* (p. 29)

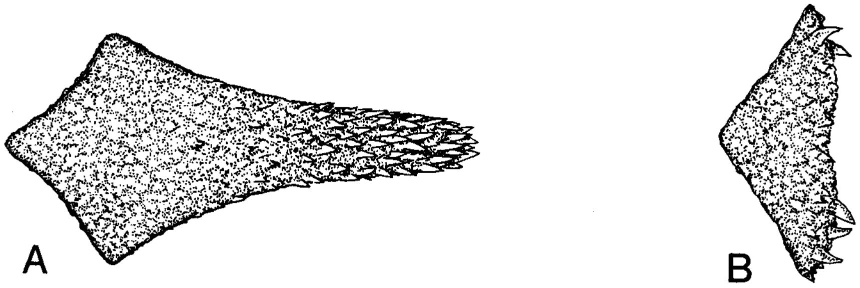

Figure 5. A. Vomerine tooth patch of *Holanthias martinicensis* showing the medial rearward prolongation; B. Vomerine tooth patch of *Anthias* spp. without the rearward prolongation.

15. Caudal fin truncate or lunate but never with 3 distinct lobes; dorsal-fin spines without fleshy tabs or filaments 16

16. Preopercle with numerous strong, divergent spines .... *Diplectrum* (p. 44)
16. Preopercle simply and finely serrated .... *Serranus* (p. 62)

Subfamily Anthiinae

Diagnosis (of Gulf of Mexico species): Body elongate, oblong, slightly compressed. Mouth large, oblique, slightly protractile. Maxilla either lacks supplementary bone or has only rudiment. Jaw teeth either villiform or cardiform, with several canines anteriorly; teeth on vomer and palatines, sometimes on pterygoid and tongue. Gill rakers usually long, slender, closely set. Dorsal fin single, either without notch or deeply notched, X, 13–16; anal fin III, 6–9. Scales ctenoid; most of head scaled. Lateral line complete (except *Anthias tenuis*), continuous, relatively high on dorsum. Shelf developed on second and third suborbitals, also occasionally on first and fourth. Preopercle serrated; opercle with three spines. Urohyal larger than ceratohyal. Branchiostegals 7, rays usually broad. Cranium short, high. Vertebrae 26.

Larvae deep-bodied, with produced, sometimes serrated spines on bones in opercular region. Tendency for head armature to develop. Long interopercular spine overlaid by larger preopercular spine. Pelvic and some dorsal spines strong, serrate in some, and not very elongate. Pigment in large blotches and dashes in characteristic trunk positions (Kendall, 1984).

Deep-water, frequently reddish or yellowish forms (Gosline, 1966).

Genus *Anthias* Bloch, 1792

Diagnosis (after Anderson and Heemstra, 1980): Single dorsal fin; dorsal X, 14–16; anal III, 6–9; pectoral fin approximately symmetrical, with 16–21 rays; pelvic I, 5; caudal fin moderately to deeply forked; branched rays 7 + 6.

Scales ctenoid, small to moderate in size. Head mostly scaled. Lateral-line scales 31–57. Scale rows above lateral line 3–6; scales below lateral line 14–20. Cheek scale rows 5–11.

KEY TO *ANTHIAS* SPECIES OF THE WEST FLORIDA SHELF
(Modified from Anderson and Heemstra, 1980.)

1. Posterior border of anterior nostril developed as a small flap; lateral line complete, with 31–34 scales; total gill rakers 39–44 .... *Anthias nicholsi*
1. Posterior border of anterior nostril with long, slender filament; lateral line interrupted (Figure 6), with 51–57 scales; total gill rakers 34–39 .... *A. tenuis*

Anthias nicholsi Firth, 1933
Yellowfin bass

Plate I, Figure A

Anthias nicholsi Firth, 1933, pp. 158, 160; Fowler, 1937, pp. 300, 301, fig. 4; Powell et al., 1972, p. 62; Anderson and Heemstra, 1980, pp. 72, 74, (key to *Anthias*); Williams and Shipp, 1980, p. 19 (northeastern Gulf of Mexico); Gilhen and McAllister, 1981, pp. 251–254 (Nova Scotia); Barans et al., 1986, pp. 91–95 (behavior, predation); Olmi, 1986, pp. 24–26 (larvae).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: FLORIDA KEYS: 1, 106.7; 24°20'N, 83°10'W, 146+ m; 12 March 1981; regurgitated by either *Epinephelus flavolimbatus* or *E. niveatus;* uncatalogued.—1, 118; south of Pelican Shoal, 183 m; February 1978; explosive; FSBC 11030.—EASTERN GULF OF MEXICO: 2, 134, 148; 25°35'N, 25°50'N, 366–427 m; 26 July 1962; trynet; FSBC 3310.—1, 116; 26°20'N, 84°40'W, 216–220 m; 19 December 1979; regurgitated by grouper; FSBC 11643.—3, 124–143; 26°20'N, 84°40'W, 216–220 m; 10 June 1980; regurgitated by *E. flavolimbatus;* uncatalogued.—10, 71–149; 26°48'N, 84°37'W, 190 m; 24 April 1981; 12.8-m semi-balloon otter trawl; FSBC 12027.

Diagnosis (modified from Anderson and Heemstra, 1980): Dorsal X, 15 (rarely 14); anal III, 7 (rarely 6 or 8); pectoral modally 19 (17–21); total gill rakers 12 or 13 (rarely 10 or 11) + 27–31 (upper + lower = 39–44); lateral-line scales 31–34. Body depth 2.3–2.9 in SL.

Interorbital region, maxilla, and most of snout scaled. Caudal forked, lobes pointed but not elongated, length of upper lobe 31–49% SL; tip of pelvic fin reaching to first soft rays of anal fin when appressed.

Body color reddish lavender; yellow markings as follows: fins; various patches on body; two stripes, one below eye from tip of snout to pectoral base, the second through eye to opercular margin. Mature fish with elongated filament from interspinous membrane of third dorsal spine; a short filament (lavender) behind other dorsal spines; delicate filaments trailing from caudal fin (Plate I, Figure A).

Larvae (size range of 2.0 mm notochord length [NL] to 24.0 mm SL, n = 86) with smooth fin spines. Third dorsal spine somewhat to quite elongate. Dark pigmentation beneath posterior base of spinous dorsal fin and with blotch beneath anterior spines of dorsal fin (Olmi, 1986).

Distinguishing characters: Anthias nicholsi can be distinguished from *A. tenuis,* the only other member of the genus known to occur in the eastern Gulf of Mexico, by its complete lateral line versus the interrupted one in *A. tenuis* (Olmi, 1986), by the lower number of lateral-line scales (31–34 vs. 51–57, respectively), by the lack of a long nostril filament, and by the difference in body depths (2.3–2.9 vs. 3.1–3.7 in SL, respectively).

Holanthias martinicensis resembles *Anthias nicholsi*, but there is a large oval patch of granular teeth on the tongue and a posteromedian prolongation of the vomerine tooth patch in *H. martinicensis*, which *Anthias nicholsi* lacks (Figure 5A, B).

Geographic and bathymetric distribution: Anthias nicholsi is known from Nova Scotia (Gilhen and McAllister, 1981) to the Straits of Florida, in the Gulf of Mexico, and from Guyana to northeastern Brazil (Anderson and Heemstra, 1980).

The first recorded specimens of *Anthias nicholsi* were taken by otter trawl in 40–50 fm (73–91 m) off Virginia (Firth, 1933); the capture depths for our (FSBC) specimens were 146–427 m.

Reproduction: Too few specimens of *Anthias nicholsi* were available to define a spawning season. However, a well-developed ovary was present in a female (FSBC 11030) taken off the Florida Keys in February; oocytes had a mean diameter of 0.7 mm. Ripe females were also taken in the eastern Gulf of Mexico during April; spent females were captured in April and June. In a limited sample (n = 18), females were 71–139 mm and males were 106–149 mm. The disparity in size of the sexes suggests that *Anthias nicholsi* may be a protogynous hermaphrodite. Further evidence of protogyny for this species includes the occurrence of male and female tissue in an 89-mm specimen.

Diet: Stomachs from 18 specimens of *A. nicholsi* contained pteropod and copepod remains.

Predation: Anthias nicholsi has been found in the stomachs of *Epinephelus flavolimbatus* and *E. niveatus.* Live specimens of both *Anthias* sp. and *Hemanthias* sp. have been regurgitated by these groupers (Capt. N. Hathaway, personal communication). Barans et al. (1986) reported five specimens of *Anthias nicholsi* from the stomach of *Seriola dumerili* (Risso, 1810).

Parasites: Parasitic copepods found on the gill filaments of a specimen of *Anthias nicholsi* were identified as *Lernanthropus sp.*

Anthias tenuis Nichols, 1920
Threadnose bass

Figure 6; Plate I, Figure B

Anthias tenuis Nichols, 1920, p. 60; Jordan et al., 1930, p. 322; Beebe and Tee-Van, 1933, pp. 137, 138 (descr.); Firth, 1933, p. 160 (comparison with *Anthias nicholsi*); Kendall, 1979, p. 16; Anderson and Heemstra, 1980, pp. 73, 74 (key), 85, 86 (comparison with *Holanthias martinicensis*); Bullock and Godcharles, 1982, p. 54 (first occurrence in eastern Gulf of Mexico); Olmi, 1986, pp. 32, 36–38, 62, 63 (generic reassignment).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 1, 83; 27°10′N, 84°00′W, 76.8 m; 6 January 1981; regurgitated by *Epinephelus drummondhayi*; FSBC 11982.

Diagnosis (after Anderson and Heemstra, 1980): Dorsal X, 15 (rarely 14); anal III, 8 (rarely 7 or 9); pectoral 19–21 (usually 20); total gill rakers on first arch 34–39; caudal-peduncle scales 25–28; tubed lateral line interrupted (Olmi, 1986), scales 51–57. Body depth 3.1–3.7 in SL. Posterior border of anterior nostril with long, slender filament (reaching or falling slightly short of

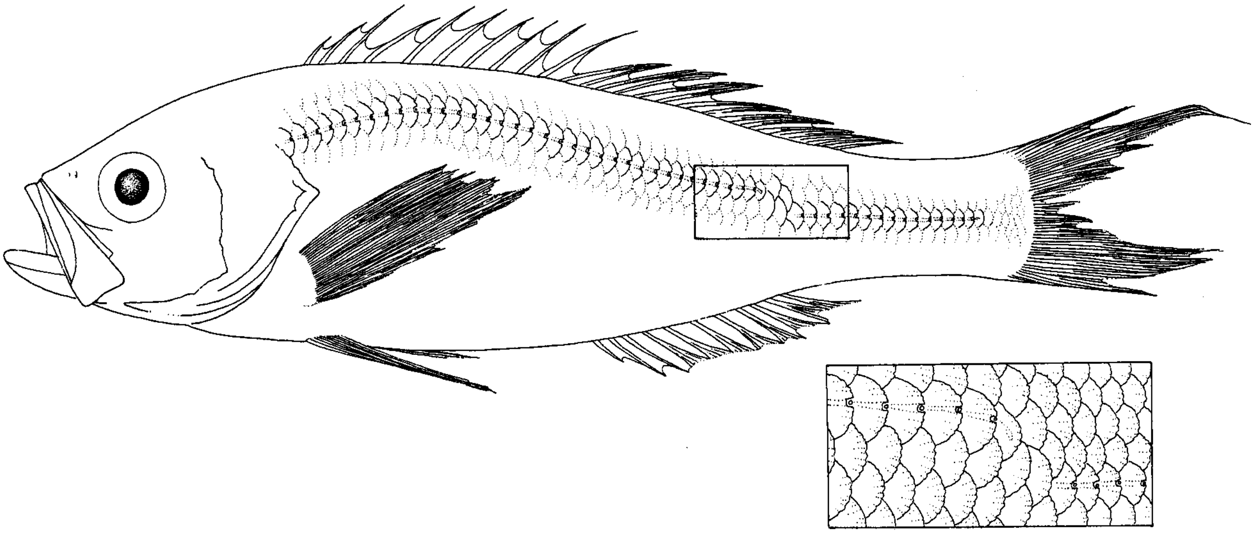

Figure 6. *Anthias tenuis*, interrupted lateral line (inset).

orbit when reflected). Caudal forked, lobes bluntly rounded, according to Nichols (1920); lobes pointed (present study).

Body rosy color with no distinct markings; iris yellow and fin membrane with a series of spots. Caudal tips and center of caudal fin scarlet.

Larvae (3.4 mm NL–15.0 mm SL; n = 12) with smooth fin spines. Internal patch of pigment beneath posterior dorsal soft rays and between dorsal midline and midbody, and with large melanophore beneath anterior dorsal soft rays usually on one side of body (Olmi, 1986).

Distinguishing characters: Anthias tenuis can be differentiated easily from *Anthias nicholsi* by the long nostril filament, an interrupted lateral line (Figure 6) (Olmi, 1986), and a more slender body.

Systematics: According to Olmi (1986), *A. tenuis*, along with *A. salmopunctatus* Lubbock and Edwards, 1981 (a central Atlantic species), should be reassigned generically; they differ from other species of *Anthias* in several aspects of larval and adult morphology.

Geographic and bathymetric distribution: Anthias tenuis was recently recorded from the eastern Gulf of Mexico (Bullock and Godcharles, 1982). This species is also known to occur from Bermuda, North Carolina, southeastern Gulf of Mexico (off Yucatan; W. Anderson, personal communication), Puerto Rico, and the southern Caribbean Sea (Anderson and Heemstra, 1980).

The speckled hind that regurgitated our specimen (FSBC 11982) was caught in 77 m of water.

Predation: Beebe and Tee-Van (1933) reported a specimen of *A. tenuis* taken from the stomach of a "hind" in Bermuda, in an incident of grouper predation similar to the one described above.

Genus *Hemanthias* Steindachner, 1874

Diagnosis (modified from Jordan and Evermann, 1896b): Dorsal X, 13–15, interspinous dorsal membranes sometimes filamentous; anal III, 8 or 9; caudal deeply forked, its lobes produced (except in large *H. leptus*). Body elongate, compressed, covered with rather large ctenoid scales; top of head and maxilla naked; mouth short and oblique, lower jaw projecting; maxilla very broad. Canine teeth usually present in front and on sides of jaws. Preopercle angular, with prominent serrations.

KEY TO *HEMANTHIAS* SPECIES OF THE WEST FLORIDA SHELF
(Modified from Heemstra, unpublished key.)

1. Specimen larger than 300 mm SL; caudal basically truncate.................... *H. leptus*
1. Specimen smaller than 300 mm SL; caudal lunate to greatly filamentous................ 2

2. No hook on postero-ventral edge of maxilla; membranes of spinous dorsal fin not forming long filaments.. *H. aureorubens*
2. Anteriorly directed hook on postero-ventral edge of maxilla (Figure 7A, B); adults with or without membranes of 3rd to 7th dorsal spines forming long filaments (small [<100 mm], sexually mature individuals of *H. leptus* without filaments)............................ 3

3. Lateral-line scales generally 43–52; gill rakers 38–43, usually 39–41............ *H. vivanus*
3. Lateral-line scales generally 54–64; gill rakers 35–40, usually 37–39 .... *H. leptus*

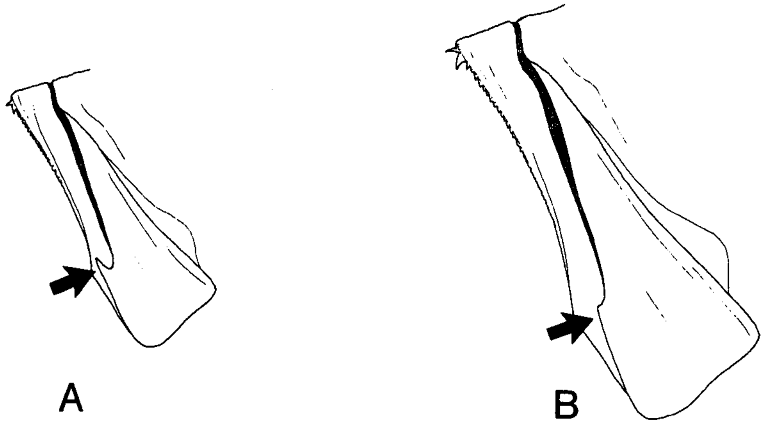

Figure 7. A. Maxillary hook of *Hemanthias leptus* (ca. 100 mm) and *H. vivanus;* B. Ontogenetic change in maxillary hook of adult *H. leptus.*

Hemanthias aureorubens (Longley, 1935)
Streamer bass

Plate I, Figure C

Pronotogrammus aureorubens Longley, 1935, p. 88 (south of the Dry Tortugas, Florida); Longley and Hildebrand, 1940, pp. 242–244, fig. 10 (south of the Dry Tortugas, Florida); 1941, p. 111 (Dry Tortugas, Florida); Manter, 1947, pp. 293, 347 (parasites); Cervigón M., 1966, p. 338 (Venezuela); Gines and Cervigón M., 1968, p. 32 (Guyana and Suriname); Struhsaker, 1969, p. 292 (southeastern U.S.); Houde, 1982, p. 514; Kendall, 1984, p. 507 (descr. of larvae); Olmi, 1986, pp. 52, 53 (taxonomic status).

Hemanthias aureorubens: Robins et al., 1980, pp. 37, 81 (common name); Robins et al., 1986, p. 145.

Pronotogramus aurorubens: Nelson, 1988, pp. 188, 191 (predation by reef fishes).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: FLORIDA EAST COAST: 1, 138; 28°39.1'N, 79°55.4'W, R/V *Delaware II* Station EJ-84-67, 274 m; 24 May 1984; 17-m trawl; FSBC 17855.—11, 65–151; 28°50.9'N, 79°59.2'W, R/V *Delaware II* Station EJ-84-69, 229 m; 24 May 1984, 17-m trawl; FSBC 17878.—FLORIDA KEYS: 1, 70; south of the Dry Tortugas, 24°18'N, 82°47'W, R/V *Hernan Cortez* Station IC-81-40, 195 m; 22 August 1981; trawl; FSBC 12141.

Diagnosis: Dorsal X, 15; anal III, 8 (rarely 9); pectoral 16 or 17; gill rakers 28 or 29 on lower limb of first arch. Preopercle serrate on horizontal and vertical borders; subopercle and interopercle serrate on free border near their articulation. Head length 2.5–2.8 in SL. No elongate dorsal fin filaments. Caudal lobes long and filamentous.

Color pinkish dorsally; scales yellow-margined; silvery belly and sides. Dorsal and caudal fins yellow; pectorals pink; other fins pale.

Larvae (10.8–26.0 mm SL, n = 6 for Olmi [1986]) completely scaled; serrations on stout spines; heavy serrate spines in opercular region. Head covered with spinous ridges including a complex supraoccipital cockscomb spine. Four dorsal pigment blotches on body: two below first dorsal fin, one below second dorsal fin, and one on caudal peduncle (Kendall, 1984, from C. Baldwin, personal communication; Olmi, 1986).

Distinguishing characters: *Hemanthias aureorubens* differs from *H. vivanus* and *H. leptus* by lacking an antrorse hook on the leading edge of the distal end of the maxilla; additionally, there are no prolongations of the interspinous dorsal membrane as found in adult *H. vivanus* or large (>200 mm) *H. leptus*. To further separate *H. aureorubens* from other anthiines, refer to the key. Small (ca. 100 mm), sexually mature individuals of *H. leptus* may resemble *H. aureorubens* but have more lateral-line scales 54–64 versus approximately 44–48).

Systematics: Previously known as *Pronotogrammus aureorubens*, this species is referable to *Hemanthias* according to Robins et al. (1980). Olmi (1986) examined larval and adult anthiine characters and concluded that *P. aureorubens*, *P. eos* Gilbert, 1890 (eastern Pacific), and *H. vivanus* were congeners that require a new generic name.

Geographic and bathymetric distribution: Cervigón M. (1966) reported the range of *Hemanthias aureorubens* as the northeastern Gulf of Mexico; the Dry Tortugas, Florida; and the coasts of Venezuela, Guyana, and Suriname. Struhsaker (1969) recorded this species from the continental shelf of the southeastern United States.

Hemanthias aureorubens has been taken in depths of 50–250 fm (91–457 m) (Cervigón M., 1966) and was noted by Longley and Hildebrand (1940) to be rather common south of the Dry Tortugas at depths of 100–200 fm (183–366 m). Gines and Cervigón M. (1968) found this species to be common in 135–150 fm (247–274 m) off Guyana and Suriname.

Reproduction: Vitellogenic oocytes were found in females (116–151 mm) captured during May (1984) off the Florida east coast.

Predation: Nelson (1988) found *H. aureorubens* in the stomach contents of *Pagrus pagrus* (Linnaeus, 1758) and *Haemulon melanurum* (Linnaeus, 1758) captured at the Flower Garden Banks off Texas.

Parasites: The digenetic trematodes *Lethadena profunda* (Manter, 1934) and *Pseudopecoelus vulgaris* (Manter, 1934) were found in *Hemanthias aureorubens* captured off the Dry Tortugas, Florida (Manter, 1947).

Size: South of the Dry Tortugas, Florida, Longley and Hildebrand (1940) collected specimens up to 290 mm TL.

Hemanthias leptus (Ginsburg, 1952)
Longtail bass

Plate I, Figure D
Plate II, Figure A

Anthiasicus leptus Ginsburg, 1952, p. 91 (off Alabama); Ginsburg, 1954, pp. 263, 264 (growth changes); Springer and Bullis, 1956, p. 79 (Texas).

Hemanthias leptus: Briggs, 1958, p. 272 (list); Briggs et al., 1964, p. 114; Cervigón M., 1973, pp. 32–34, fig. 12 (Venezuela); G. B. Smith, 1976, p. 42 (list); Hoese and Moore, 1977, p. 168; Ross et al., 1981, p. 66 (off South Carolina); Bullock and Godcharles, 1982, pp. 53, 54, fig. 1, p. 55 (eastern Gulf of Mexico); Kendall, 1984, p. 507 (descr. of larvae); Ditty, 1986, p. 945 (larvae off Louisiana); Olmi, 1986, pp. 33, 34 (descr. of larvae).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: FLORIDA EAST COAST: 2, 139, 201; 28°21.2′N, 79°56.0′W, R/V *Delaware II* Station EJ-84-61, 183 m; 23 May 1984; trawl; FSBC 17902.—EASTERN GULF OF MEXICO: 2, 71, 87; 25°17.1′N, 84°05.4′W, 179–183 m; 27 January 1978; trawl; USAIC 05175.—2, 387, 403; 26°12′N, 84°32′W, 155 m; 13 September 1980; hook and line; FSBC 11807.—1, 396; 26°12′N, 84°32′W, 216 m; 10 July 1981; bottom longline; FSBC 12114.—1, 456; 26°20′N, 84°40′W, 183 m; 10 October 1981; bottom longline; FSBC 12246.—27, 44–70; 26°42′N, 84°25′W; 3 February 1978; trawl; USAIC 05509.—1, 61; 26°50′N, 84°30′W, 176 m; 13 May 1981; hidden in limestone fragment brought to surface by hook and line; FSBC 12052.—1, 417; 27°00′N, 84°35′W, 183 m; 15 July 1981; bottom longline; FSBC 12115.—1, 370; eastern Gulf of Mexico; October 1981; bottom longline; FSBC 12247.—NORTHWESTERN GULF OF MEXICO: 1, 270; 27°59′N, 91°00′W, south of Morgan City, Louisiana, 183–219 m; 1 August 1981; bottom longline; FSBC 12125.—1, 344; 27°50′N, 91°00′–92°00′W, south of Morgan City, Louisiana, 128–247 m; 4 May 1980; bottom longline, FSBC 11650.—1, 313; 27°50′N, 93°20′W, south of Lake Charles, Louisiana, 128 m; 4 April 1981; hook and line; FSBC 12023.—1, 379; 27°50′N, 93°20′W, south of Lake Charles, Louisiana, 183 m; 4 May 1980; bottom longline; uncatalogued.—8, 96–205; 27°51′N, 94°30′W, R/V *Oregon II* Station 22303, 196 m; 30 August 1977; 12.2-m shrimp trawl; uncatalogued.—1, 133; 27°35′N, 95°58′W; R/V *Oregon II* Station 22342, 168 m; 5 September 1977; 12.2-m shrimp trawl; uncatalogued.

Diagnosis: Dorsal X, 14 (rarely 13 or 15); anal III, 8; pectoral 17–19; total gill rakers on first arch 35–40; tubed lateral-line scales 54 or more.

Mouth oblique; upper jaw indented medially with strong canine teeth on either side of indentation. Two outward-projecting canines on either side of symphysis of lower jaw; prominent canines on either side of dentary approximately midway along jaw.

Shape of dorsal, pelvic, and caudal fins varies ontogenetically (Ginsburg, 1952). Small specimens (<120 mm) with short filaments or tabs at tips of dorsal-fin spines and caudal fin deeply forked (Plate I, Figure D). Intermediate-sized individuals (160–270 mm) have moderately elongate third dorsal-spine filament and filamentous pelvic and caudal fins. Sexually transitional specimen (216 mm) with more truncate caudal fin and with both pelvic fin and third dorsal-spine filament extremely elongate. In larger specimens (>270 mm), third dorsal spine with long filament and second pelvic ray elongated; caudal fin basically truncate with medial notch (Plate II, Figure A).

General body color carmine; olive freckles; golden stripe below eye from tip of snout to middle of pectoral-fin base; second golden stripe from eye to upper base of pectoral fin; fins yellow with olive freckles.

Possible sexual dichromatism noted in small mature male (Bullock and Godcharles, 1982): burgundy dorsal-fin stripe and caudal lobes (Plate I, Figure D).

Larvae (2.0 mm NL–20.0 mm SL; n = 17 for Olmi [1986]) with serrate, spiny armature in opercular region, supraoccipital crest simple, first spines of dorsal fin and pelvic fin developing early but not becoming elongate or serrate; midlateral dashes of pigment on trunk (Kendall, 1984; Olmi, 1986).

Distinguishing characters: Hemanthias leptus is distinguished from *H. vivanus* by the greater number of lateral-line scales (54–64 vs. 43–52, respectively) and the smaller number of gill rakers (35–40 vs. 38–43, respectively). The caudal fin in *H. leptus* becomes truncated at sexual transition from female to male, unlike *H. vivanus*, which retains its filamentous caudal fin throughout life.

Geographic and bathymetric distribution: Hemanthias leptus is known from South Carolina (Ross et al., 1981) to Venezuela (Cervigón M., 1973), including the Gulf of Mexico (Briggs et al., 1964; Bullock and Godcharles, 1982).

This deep-water species has been captured in a depth range of 91–216 m (Springer and Bullis, 1956; Briggs et al., 1964; Bullock and Godcharles, 1982).

Reproduction: Evidence for protogynous hermaphroditism in *H. leptus* was found in a 216-mm specimen that possessed developing male cysts in the ovary (Figure 8A). We found other evidence supporting protogyny in a small sample (n = 11) in which only males occurred in large size-classes (270–456 mm). At small to moderate sizes (40–270 mm), there was a size overlap for the sexes (males 43.2–205 mm; females 47.8–216 mm), which might have been produced by a variety of causes (Sadovy and Shapiro, 1987), including diandry (two pathways for becoming male) and the production of primary (directly derived) males. Histological evidence suggesting diandry is found in Figure 8B. The testis cross-section taken from an 86-mm ripening male contains a central (or dorsal in other sections) sperm duct and a thin tunica albuginea, two anatomical features not usually associated with secondary male testis structure. A male that has been derived from a female (secondary male) generally has a testis with peripheral sperm-collection sinuses and a thick tunica composed of muscle and connective tissue (C. L. Smith, 1965; Sadovy and Shapiro, 1987). This structure is seen in large (>300 mm) male *H. leptus* (Figure 8C). However, in the closely related *Anthias squamipinnis* (Peters, 1855), secondary testes were surrounded by a thin tunica albuginea. Sperm was thought to exit the gonad through

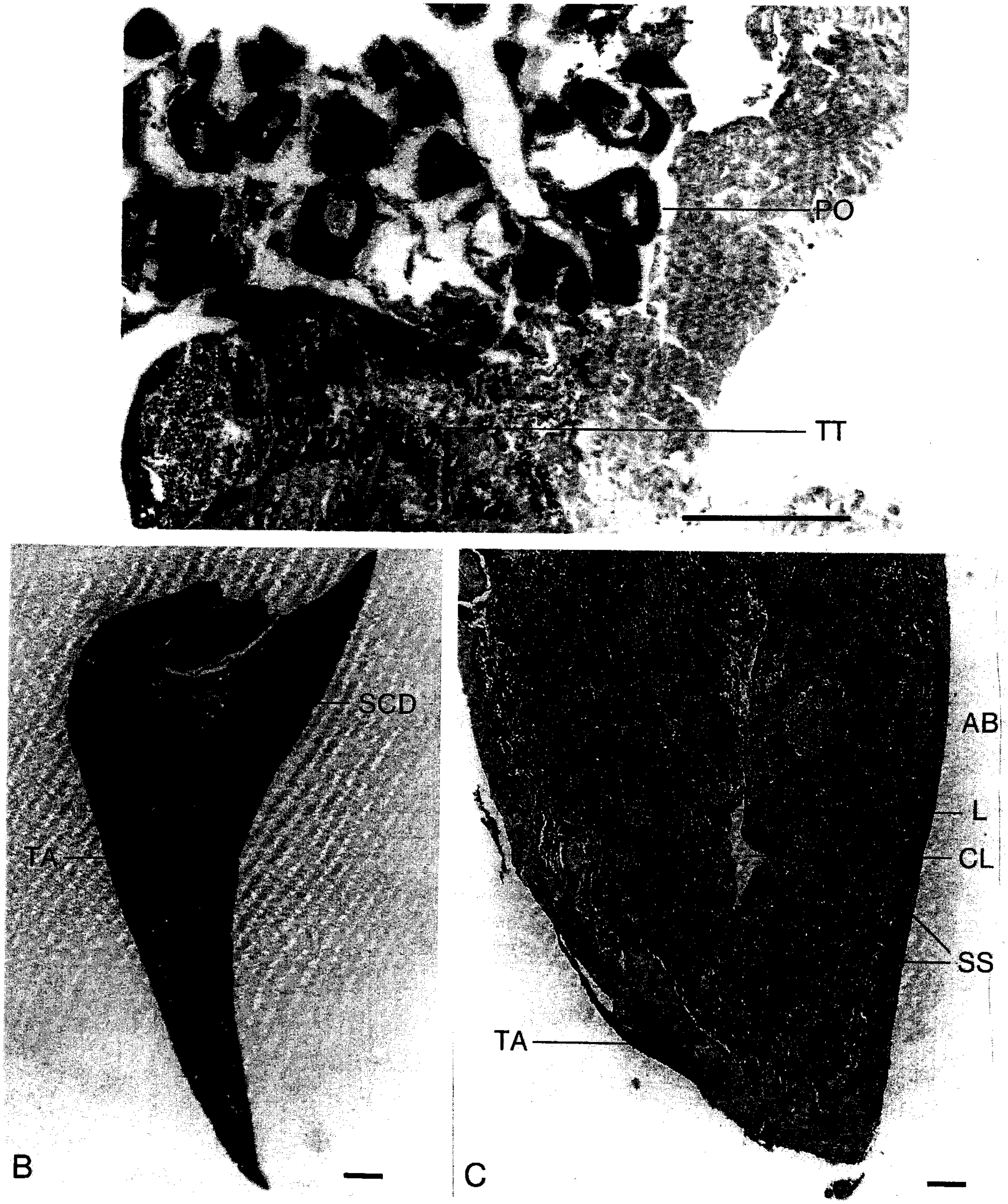

Figure 8. Histological sections of *Hemanthias leptus* gonads; A. Proliferating male tissue in a transitional gonad (uncatalogued: 216 mm); B. Primary (?) male testis (USAIC 05175-2: 86 mm) with thin tunica albuginea, alamellar structure, and central sperm collecting duct; C. Secondarily derived testis (uncatalogued: 374 mm) with thick tunica albuginea, lamellar structure, central lumen, and peripheral sperm sinuses. Atretic bodies are present but are unreliable indicators of sex change (Shapiro, 1987). AB = atretic body; CL = central lumen; L = lamella; PO = previtellogenic oocyte; SCD = sperm collecting duct; SS = sperm sinus; TA = tunica albuginea; TT = testicular tissue. Scale bar = 0.1 mm.

large confluent sinuses produced in central and peripheral parts of the testes by progressive breakdown of walls separating neighboring sperm chambers (Shapiro, 1981). The histological picture in *A. squamipinnis* is not typical of many other protogynous hermaphrodites, but its subfamilial relationship to *H. leptus* suggests that additional male specimens of *H. leptus* should be examined before concluding that *H. leptus* is diandric. Other exceptions to the typical histological picture exist: Jones (1980) found in the labrid *Pseudolabrus celidotus* (Bloch and Schneider, 1801) that 82% of the secondary testes were formed by evagination of the ovary. The evagination brought peripherally located sperm ducts to the center of the testis, causing the secondary testis to resemble a primary testis. The possibility that evagination occurs also in *H. leptus* has not been ruled out. Whether *H. leptus* is diandric is unclear at this time, but the small mature males certainly appear to be functionally analogous to primary males.

Ripe females were found in August, whereas postspawners occurred in May and August. Ripe males were captured during January, February, and April through July. Larvae were collected off Louisiana in January by Ditty (1986). Year-round sampling would aid in properly defining the spawning season.

Diet: A small male (USAIC 05175-1: 71 mm) captured in the eastern Gulf had eaten the following items: copepods (*Pleuromamma piseki* Farran, 1929, *Farranula* sp., *Oncaea* sp., and an unidentified calanoid), ostracods, amphipods, and euphausiids. Fish eyes were found in another individual captured off the Florida east coast.

Predation: Small individuals of *H. vivanus* are eaten by deep-water groupers, notably *Epinephelus flavolimbatus*, *E. drummondhayi*, and *E. nivcatus* (see next species account). Small *Hemanthias leptus* may also fall prey to these groupers. Nelson (1988) found *Hemanthias* sp. in stomach contents of the cottonwick, *Haemulon melanurum*, and the red porgy, *Pagrus pagrus*, from the Flower Garden Banks off Texas.

Parasites: A larva of the nematode *Anisakis* sp. and a caligid copepod were found in the gut cavity and gill filaments, respectively.

Size and commercial importance: Occasional captures are noted by deep-water commercial grouper fishermen. The largest specimen of *Hemanthias leptus* examined from the commercial catch was 456 mm and weighed 2.1 kg (eviscerated). Although the flesh is quite palatable, this species is of little commercial importance.

Hemanthias vivanus (Jordan and Swain, 1885)
Red barbier

Plate II, Figure B

Anthias vivanus Jordan and Swain, 1885b, pp. 544, 545 (snapper banks off Pensacola, Florida); Boulenger, 1895, p. 323.

Pronotogrammus vivanus: Jordan and Eigenmann, 1890, p. 413.

Hemianthias vivanus: Jordan and Evermann, 1896b, pp. 1223, 1224; Longley and Hildebrand, 1941, p. 111; Springer and Bullis, 1956, p. 79; Briggs, 1958, p. 272.

Hemanthias vivanus: Walls, 1975, pp. 175, 176; G. B. Smith, 1976, p. 42; Hoese and Moore, 1977, pp. 168, 169; Finucane et al., 1978, pp. 1–504; Houde et al., 1979, pp. 28, 65; Kendall, 1979, pp. 22–29; Gilmore et al., 1981, p. 25, appendix p. 14; Hastings, 1981, pp. 443–454; Darcy and Guthertz, 1984a, p. 100 (list); Kendall, 1984, p. 507 (descr. of larvae); Olmi, 1986, p. 61 (generic reassignment); Parker and Ross, 1986, p. 43 (North Carolina).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: DRY TORTUGAS: 2, 64, 92.1; 24°19.5′N, 82°44′W, south of the Dry Tortugas, Florida, R/V *Hernan Cortez* Station IC-81-38, 123.4–128 m; 22 August 1981; 6.1-m semi-balloon otter trawl; FSBC 12244.—EASTERN GULF OF MEXICO: 1, 120; 25°08′N, 83°40′W, R/V *Hernan Cortez* Station 194, 76.2 m; 5 July 1965; trawl; FSBC 3674.—3, 108–123; 25°20–25°35′N, 365.9–426.8 m; 26 July 1962; trawl; FSBC 2233.—1, 96; 26°20′N, 84°40′W, 216–219.5 m; 25 January 1980; regurgitated by *Epinephelus flavolimbatus;* uncatalogued.—1, 92; 26°20′N, 84°40′W, 216–219.5 m; 26 February 1980; regurgitated by *E. flavolimbatus;* uncatalogued.—1, 101; 26°20′N, 84°40′W, 216–219.5 m; 21 May 1980; regurgitated by *E. flavolimbatus;* FSBC 11649.—3, 97–107; 26°20′N, 84°40′W, 216–220 m; 10 June 1980; regurgitated by *E. flavolimbatus;* uncatalogued.—2, 101–102; 26°47′N, 83°55′W, R/V *Hernan Cortez* Station 129, 80.5 m; 31 May 1965; 9.1 × 12.2-m trawl; FSBC 3646.—3, 107–118; 27°29′N, 84°17′W, R/V *Hernan Cortez* Station 197, 77 m; 24 May 1965; 9.1 × 12.2-m trawl; FSBC 3636.—14, 67–107; 27°35′N, 84°31′W, R/V *Hernan Cortez* Station EJ-81-28, 125–134 m; 25 April 1981; 6.1-m semi-balloon otter trawl; FSBC 12026.—6, 83–109; 28°55′N, 85°22′W, R/V *Hernan Cortez* Station 47, 73.2 m; 12 May 1965; 9.1 × 12.2-m trawl; FSBC 3634.

Diagnosis: Dorsal X, 13 or 14; anal III, 8 or 9; pectoral 18 or 19 (modally 19); total gill rakers on first arch 38–43; tubed lateral-line scales 52 or fewer.

Mouth oblique; upper jaw indented medially, strong canines on either side of indentation. Two outward-projecting canines on either side of symphysis of lower jaw. Prominent canines on either side of dentary approximately midway along jaw.

Dorsal spines with long dermal filaments, fourth spine filament usually longest, greatly enlarged in males (Hastings, 1981). Caudal fin deeply forked, with lobes greatly extended.

Body color carmine; olive freckles on back and sides; two gold stripes on head. Anal-fin color sexually dichromic: bright yellow in males, mottled blue and olive in females (Hastings, 1981).

Larvae (3.2 mm NL–7.7 mm SL) with complex "cockscomb" ridge on supraoccipital, serrate ridge above eye, serrate spines on preopercle and interopercle; all fin spines serrate, spiny scales (Kendall, 1979, 1984).

Distinguishing characters: In addition to differences in lateral-line scale and gill-raker counts, *H. vivanus* attains a maximum length of only 250 mm TL, whereas *H. leptus* may grow to 450 mm TL (Robins et al., 1986).

Systematics: As noted previously, Olmi (1986) regarded *H. vivanus, H.* (= *Pronotogrammus*) *aureorubens,* and *P. eos* as congeners requiring a new name.

Geographic and bathymetric distribution: Hemanthias vivanus occurs in the Gulf of Mexico and along the U.S. Atlantic coast as far north as North Carolina (Hastings, 1981).

Although *H. vivanus* occurs in deep water (beyond the edge of the continental shelf), specimens have been taken in water as shallow as 73 m. Specimens in the FSBC collection were captured in depths of 73–427 m.

Parker and Ross (1986) found large schools of what seemed to be juvenile *H. vivanus* on 12 of 13 reefs they observed from a submersible in depths of 52–152 m off North Carolina.

Reproduction: Houde et al. (1979) found the majority of *H. vivanus* larvae during winter and spring between the 50- and 200-m isobaths in the eastern Gulf of Mexico. Occasional occurrences during other seasons indicated some spawning year-round over the deep shelf and slope. Our ripe specimens of this protogynous hermaphrodite were captured in April–June and August; no collections were made during winter months. Finucane et al. (1978) found larvae off Texas in July and December.

Along the Atlantic coast of Florida, Hastings (1981) found that female *H. vivanus* were 49–77 mm (SL); males were 65–96 mm. Larger individuals of both sexes were found in our samples from the eastern Gulf of Mexico. Females were 67–117 mm; males were 113–117 mm. Transitional individuals from the Gulf were 95–106 mm; east coast transitionals were 65–74 mm (Hastings, 1981). Caution is advised, however, in comparing size ranges of males and females from different areas because the size at transition may vary even from one adjacent reef site to another, as is true for *Anthias squamipinnis* and other protogynous hermaphrodites (Shapiro, 1984).

Diet: Eight of 33 specimens contained food in their stomachs. Major items were calanoid copepods (*Rhincalanus cornutus* (Dana, 1852) and *Candacia* sp.), cyclopoid copepods (*Oithona* sp. and *Oncaea* sp.), amphipods, and ostracods.

Predation: Hemanthias vivanus that are approximately 100 mm in length are eaten by *E. flavolimbatus*, *E. niveatus*, and *E. drummondhayi*. Predation by *E. drummondhayi* was noted by Jordan and Evermann (1896b). *Hemanthias vivanus* was originally described from the holotype taken from the stomach of a red snapper, *Lutjanus campechanus* (Poey, 1860).

Parasites: An unidentified digenetic trematode was observed in the gonad of one specimen of *H. vivanus*.

Genus *Holanthias* Günther, 1868

Diagnosis (modified from Anderson and Heemstra, 1980): Dorsal X, 13–16 (usually 15); anal III, 7; pectoral 16–18 (usually 17); total gill rakers on first arch 34–41; tubed lateral-line scales 35–41. Maxilla and frontals scaled; large oval tooth patch on tongue; vomerine tooth patch with well-developed posterior prolongation.

Body color reddish gold; many lustrous freckles on back; in life, small individuals (<50 mm SL) with brown saddle reaching from dorsal-fin base to at least lateral mid-line on deepest portion of body (Colin, 1974).

Larvae deep-bodied, with large heads and mouths. Serrate spines in opercular region and a simple supraoccipital spine in post-flexion larvae. Scales developed during larval stage; several spines above eye (Kendall, 1984).

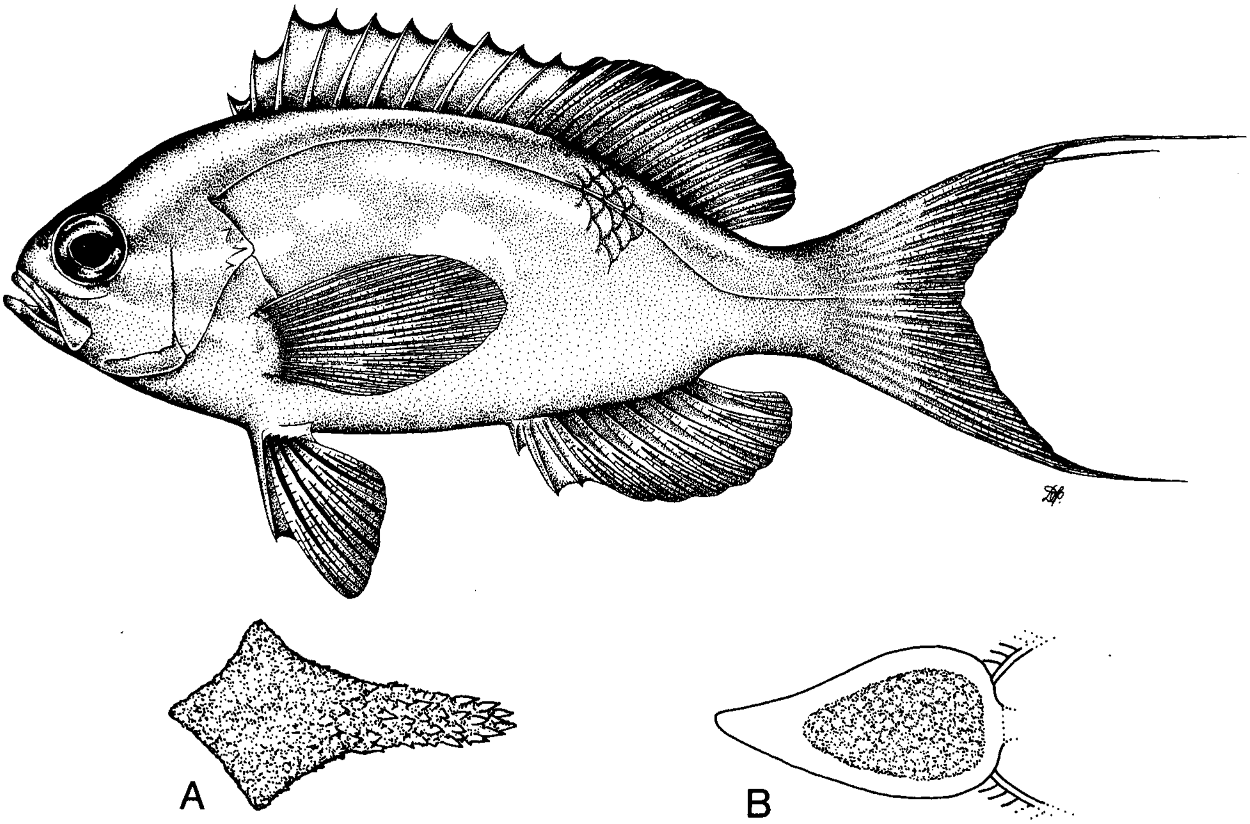

Figure 9. *Holanthias martinicensis*; A. Vomerine tooth patch; B. Lingual tooth patch.

Holanthias martinicensis (Guichenot, 1868)
Roughtongue bass

Figure 9; Plate II, Figure C

Aylopon martinicensis Guichenot, 1868, pp. 80–87.

Odontanthias martinicensis: Jordan and Eigenmann, 1890, p. 416.

Holanthias martinicensis: Boulenger, 1895, p. 317; Colin, 1974, pp. 33, 34; Anderson and Heemstra, 1980, pp. 72, 74, 82–84; Coleman, 1981, pp. 893–895; Gilmore et al., 1981, p. 25, table 1, p. 14; Coleman, 1982, pp. 1–92; Kendall, 1984, p. 507 (descr. of larvae); Parker and Ross, 1986, pp. 35, 43 (North Carolina); Robins et al., 1986 (color); Environmental Science and Engineering, Inc. (ESE) et al., 1987, vol. 1, p. 41 (southwest Florida outer continental shelf); Dennis and Bright, 1988b, pp. 6, 7 (northwestern Gulf of Mexico).

Ocyanthias martinicensis: Jordan and Evermann, 1896b, p. 1228; Longley and Hildebrand, 1941, p. 108; Springer and Bullis, 1956, p. 79; Briggs, 1958, p. 273; Powell et al., 1972, p. 69; Huntsman, 1976, p. 18.

Anthias duplicidentatus de Miranda Ribeiro, 1903, pp. 1–53.

Anthias louisi Bean, 1912, pp. 124, 125.

Pronotogrammus martinicensis: Olmi, 1986, pp. 51, 52 (generic reassignment).

Material examined: HOURGLASS STATION M: 1, 84; 12 April 1966; trawl; FSBC 6623.—OTHER MATERIAL: DRY TORTUGAS: 1, 110; 24°20′N, 83°10′W; 1–12 March 1981; regurgitated by either *Epinephelus flavolimbatus* or *E. niveatus*; FSBC 12019.—1, 76; 24°24′N, 82°58′W, R/V *Hernan Cortez* Station IC-81-44, 76–80 m; 24–25 August 1981; 6.1-m semi-balloon otter trawl; FSBC 12242.—EASTERN GULF OF MEXICO: 1, 108; 25°00'N, 146 m; 24 September 1981; regurgitated by *E. flavolimbatus*; FSBC 12240.—1, 106; 26°05'N, 84°13'W, R/V *Hernan Cortez* Station EJ-81-14, 163–166 m; 23 April 1981; 9.1-m semi-balloon otter trawl; FSBC 12028.—2, 48, 78; 26°16.67'N, 84°04.08'W, 137 m; 6 February 1982; otter trawl; FSBC 12924.—1, 87; 26°24'N, 83°43'W, R/V *Hernan Cortez* Station EJ-80-20, 73 m; 29 July 1980; 6.1-m semi-balloon otter trawl; FSBC 11714.—1, 92; 26°48'N, 84°37'W, R/V *Hernan Cortez* Station EJ-81-18, 190.2 m; 24 April 1981; 6.1-m semi-balloon otter trawl; FSBC 12142.—1, 76; 26°48'N, 84°27'W, R/V *Hernan Cortez* Station EJ-81-18, 190.2 m; 24 April 1981; 6.1-m semi-balloon otter trawl; FSBC 12051.—1, 89; 27°35'N, 84°31'W, R/V *Hernan Cortez* Station EJ-81-28, 125–134 m; 25 April 1981; 6.1-m semi-balloon otter trawl; FSBC 12025.—NORTHWESTERN GULF OF MEXICO: 1, 87; 27°55'N, 92°00'W, 73 m; September 1980; regurgitated by *E. flavolimbatus*; uncatalogued.

Diagnosis: Because *Holanthias* is monotypic, generic characters define *H. martinicensis.*

Distinguishing characters: Holanthias martinicensis can be distinguished from *Anthias* spp. by the presence of a well-developed posterior prolongation of the vomerine tooth patch (Figure 9A). Additionally, this species has on the tongue a large oval tooth patch that is usually absent in *Anthias* spp. (*Anthias nicholsi* occasionally has lingual teeth [Anderson and Heemstra, 1980]) (Figure 9B).

Holanthias martinicensis differs from *Hemanthias* spp. by having scaled maxillary and frontal bones; these bones are naked in *Hemanthias* spp. *Holanthias martinicensis* differs from *Plectranthias garrupellus* in the number of gill rakers on the first arch (34–41 and 14–17, respectively).

Systematics: Olmi (1986) has recently shown through examination of larval and adult characters that *H. martinicensis* should be reassigned to *Pronotogrammus.* At present, we have chosen to take a conservative approach and retain *Holanthias.*

Geographic distribution: Holanthias martinicensis is found around Bermuda, along the southeastern Atlantic coast from North Carolina (Huntsman, 1976) southward to the Dry Tortugas (Longley and Hildebrand, 1941), in the Gulf of Mexico, and from the West Indies and the Caribbean Sea to southern Brazil (Anderson and Heemstra, 1980).

Bathymetric distribution and habitat: This species has been reported at depths of 60–230 m (Springer and Bullis, 1956; Colin, 1974; Huntsman, 1976; Anderson and Heemstra, 1980; Gilmore et al., 1981; Dennis and Bright, 1988b). Colin (1974) observed two to five, and occasionally 10–20, fish over rocky outcrops off Jamaica and Belize. Dennis and Bright (1988b) considered *H. martinicensis* to be a common member of the drowned reef community in depths of 57–140 m in the northwestern Gulf. Gilmore et al. (1981) reported schools of *H. martinicensis* over *Oculina* reefs in 60–100 m of water off Ft. Pierce, Florida. Single individuals were observed in association with *Oculina* or *Madrepora* clumps at depths of 75–125 m off North Carolina (Parker and Ross, 1986).

In a study by Environmental Science and Engineering, Inc. (ESE) et al. (1987), *H. martinicensis* was described as a common inhabitant of the southwest Florida outer shelf in depths of 100–200 m.

Reproduction: Ripe females (with vitellogenic oocytes) were captured by trawl in February, March, April, and July in the eastern Gulf of Mexico.

Holanthias martinicensis is a protogynous hermaphrodite, according to Coleman (1981); in the South Atlantic Bight, she found fish exhibiting female, transitional, and male stages in size ranges of 47–112 mm, 73–94 mm, and 66–132 mm, respectively. Other than the larger size of males, Coleman (1981) found no external character for determining sex.

Diet: Holanthias martinicensis stomachs contained ostracods, pteropods, and the copepods *Oncaea* sp., *Corycaeus* sp., and *Euaetideus* sp.

Predation: Individuals of this species have been regurgitated by *Epinephelus flavolimbatus* and possibly *E. niveatus. Holanthias martinicensis* has been taken from the stomach of *Seriola rivoliana* Cuvier, 1833 off Bermuda (Coleman, 1982).

Parasites: Histological examination of the gonads of several female specimens revealed didymozoid trematodes.

Genus *Plectranthias* Bleeker, 1873

Diagnosis (after Randall, 1980): Dorsal X, 13–18; anal III, 6–8 (usually 7); pectoral 12–18; gill rakers 4–9 + 9–17; vertebrae 26.

Mouth large, maxilla reaching to or posterior to a vertical line at hind edge of pupil.

Plectranthias garrupellus Robins and Starck, 1961

Apricot bass

Plate II, Figure D

Plectranthias garrupellus Robins and Starck, 1961, pp. 295–297, fig. 7b, p. 313 (off Cape Canaveral, Florida: original descr.); Houde et al., 1979, p. 29 (eastern Gulf of Mexico: distrib. of larvae); Randall, 1980, pp. 130, 131; Kendall, 1984, p. 503 (descr. of larvae); Robins et al., 1986, pp. 145, 146, pl. 63.

Plectranthias garupellus: Kendall, 1979, p. 16, fig. 15, p. 17 (descr. of larvae; misspelling); Houde, 1982, p. 514 (larvae).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: ATLANTIC SEABOARD: 1, 57; 27°50.7'N, 79°57.1'W, R/V *Gosnold*, Cruise 248, Station 736, 65–70 m; 18 September 1974; box dredge; IRCZRM 107: 4309.—1, 43; Sebastian Pinnacles, 27°46'N, 79°59'W, R/V *Johnson*, Cruise 062, Station JSL-I-583, 55–79 m; 31 August 1978; rotenone; IRCZRM 107: 5002.—2, 40, 42.5; Sebastian Pinnacles, 27°46'N, 79°59'W, R/V *Johnson*, Cruise 062, Station JSL-I-585, 76–82 m; 01 September 1978; rotenone; IRCZRM 107: 5008.—1, 46; 27°32.8'N, 79°58.8'W, R/V *Johnson*, Cruise 038, Station JSL II, Dive 163, 80 m; 07 February 1977; lockout diver; IRCZRM 107: 5470.—1, 61; 27°11'N, 79°58'W, R/V *Sea Diver*, Cruise 023, Station 008, 84–88 m; 14 June 1978; 6.1-m otter trawl; IRCZRM 107: 4874.—1, 34.4; 27°11'N, 79°58'W, R/V *Sea Diver*, Cruise 023, Station 008, 84–88 m; 14 June 1978; 6.1-m otter trawl; IRCZRM 107: 4917.—SOUTHEASTERN GULF OF MEXICO: 16, 19–53; CSA Cruise BLM-321-II, Station 38, 25°16.50'N, 84°14.77'W, 159 m; 2 August 1981; otter trawl; FSBC 12634.

Diagnosis (modified from Robins and Starck, 1961): Dorsal X, 15–16 (modally 16); anal III, 7 (rarely 6 or 8); pectoral 13 (rarely 12); vertebrae 26; branchiostegal rays 7. Preopercle with two strong, antrorse spines on lower limb. Scales large, 28 or 29 (rarely 27 or 30) in pored lateral series. Top of head scaled forward to posterior nostrils. Spinous dorsal angular, anterior spines with fleshy tabs arising from interspinous membrane.

Overall color red; each scale with underlying basal dark red blotch. Young often dusky below spinous dorsal fin contrasting sharply with unmarked region along lateral line (Robins et al., 1986).

Larvae (5.5–8.2 mm SL; n = 3 for Olmi [1986]) with elongate third dorsal spine, no serrated head or fin armature; supra-orbital ridge with only one spine throughout development; opposing caudal-peduncle pigment blotches, as well as blotch below center of first dorsal fin (Kendall, 1979, 1984; Olmi, 1986).

Distinguishing characters: Plectranthias garrupellus can be distinguished from most anthiines by the higher number of dorsal soft rays (16) and the lower number of pectoral rays (13) (Kendall, 1979).

Geographic and bathymetric distribution: Plectranthias garrupellus, the only species of the genus known from the Atlantic, occurs on the east and west coasts of Florida, off Cuba (Randall, 1980), and the Bahamas (off Bimini) (Robins and Starck, 1961). Houde et al. (1979) found larvae of *Plectranthias garrupellus* in the eastern Gulf of Mexico.

Robins and Starck (1961) reported capture of this species in depths of 45–115 fm (82–210 m). Specimens examined in the present study were found in depths of 55–159 m.

Reproduction: Vitellogenic oocytes have been observed in specimens taken off both Florida coasts during August–September (Robins and Starck, 1961: east coast; L. Bullock, personal observation: west coast), and Houde et al. (1979) found larvae during November in the eastern Gulf of Mexico.

Robins and Starck (1961) suggested that *P. garrupellus* is a protogynous hermaphrodite.

Diet: An unidentified shrimp, the crab *Munida* sp., an unidentified xanthid crab, and a worm tube were taken from the stomachs of several specimens captured west of Cape Sable, Florida, in the Gulf of Mexico.

Subfamily Serraninae

Diagnosis (after Katayama, 1960, as modified by Bortone, 1977b, for *Diplectrum*): Body elongate or oblong, slightly compressed posteriorly. Mouth large, slightly protractile, usually not oblique. Maxilla without supplemental bone. Villiform jaw teeth; canines, if present, usually on sides and front of lower jaw; few, if any, depressible jaw teeth. Gill rakers fairly short, well spaced (except for some *Diplectrum*). Scales ctenoid, either moderately large or small; maxilla naked. Lateral line low, continuous to caudal base.

Shelf developed on suborbitals 2, 3, and 4 (not always in *Diplectrum*). Preopercle serrated; opercle with 3 spines. Urohyal relatively small, shorter than ceratohyal. Cranium long and low. Branchiostegals 6 or 7. Myodome opens posteriorly. Vertebrae 24.

Basically, direct development of larval body proportions. No elongate spines in opercular region; rather, a series of blunt points. Fin spines thin and only slightly elongated in some. Most larval pigment in characteristic positions along ventral midline (Kendall, 1984).

Genus *Centropristis* Cuvier, 1829

Diagnosis (after Miller, 1959): Dorsal X, 10–12, spines bearing fleshy filaments at tips; anal III, 7; caudal 17 (1, 8, 7, 1), rounded in young, tri-lobed or double concave in adults; pelvics I, 5, inserted slightly in advance of pectorals. Preopercle serrate, ventral serrae slightly antrorse. Gill rakers long, slender. Body robust, slightly compressed, with rather large ctenoid scales. Large mouth, teeth in bands, no canines, tongue smooth. Branchiostegals 7.

Larvae with small, simple preopercular spines; no elongate or armed fin spines; most pigment in blotches in characteristic pattern (Kendall, 1984).

KEY TO *CENTROPRISTIS* SPECIES OF THE GULF OF MEXICO

(Modified from Miller, 1959.)

1. Body color dark, usually dark brown in alcohol, smoky gray to blue-black in life. Central portions of scales lighter than margins, presenting the appearance of longitudinal stripes with series of pale dots; belly only slightly paler than sides, never white; fins dark, dorsal marked with series of whitish spots and bands. Total gill rakers including rudiments 20–26 (usually 22–24) .... *C. striata*
1. Body color pale to white, with seven more or less distinct dark vertical bars on sides of body; belly noticeably paler than sides, usually white, occasionally with traces of dusky pigment; fins pale, sometimes dusky, but never black; soft dorsal and caudal fins with dark to inky spots. Total gill rakers including rudiments 17–22 (usually 19–21) 2

2. Dorsal spines with short dermal flaps rarely extending beyond spine tips; no distinct black spot at base of last three dorsal spines. Distinct dark blotch at center of fourth vertical bar immediately below lateral line; lateral bars well defined, frequently broken by two pale stripes into seven series of three dark blotches each; lowest third of bars frequently appearing as groups of small, inky spots. Pectoral rays usually 17 (16–18); body depth usually 31–34% SL (28–38% SL); interorbital width generally 6–8% SL (2–9%); pelvic fin usually 24–26% SL (20–29% SL) .... *C. ocyurus*
2. Dorsal spines with long fleshy filaments, often as long or longer than spinous tips; distinct dark spot at base of last three dorsal spines. No distinct dark blotch at center of fourth vertical bar; lateral bars poorly defined, diffuse; infrequently broken into three series. Lower third of bars never appearing as inky spots. Pectoral rays usually 18 (14–19); body depth usually 27–30% SL (25–33% SL); interorbital width generally 4–5% SL (4–6% SL); pelvic fin usually 20–22% SL (19–24%) .... *C. philadelphica*

Centropristis ocyurus (Jordan and Evermann, 1886)
Bank sea bass

Plate III, Figure A (juvenile)
Figure 10; Plate III, Figure B (adult)

Serranus ocyurus Jordan and Evermann, 1886, p. 468 (Pensacola, Florida).

Centropristes ocyurus: Miller, 1959, pp. 50–59; Springer and Woodburn, 1960, p. 34; Bright, 1968, p. 177; Camp, 1973, pp. 34, 47.

Centropristis ocyurus: Powell et al., 1972, pp. 63, 64; Smith et al., 1975, p. 6; Walls, 1975, p. 166; G. B. Smith, 1976, p. 20; Hastings et al., 1976, p. 390; Bortone, 1977a, pp. 23–33; Ogden and Brusher, 1977, p. 88 (list); Hastings, 1979, pp. 33, 34, 110, chart 119 (northwest Florida); Link, 1980, pp. 1–277; Darnell et al., 1983, pp. 43, 201, pl. 49; Darcy and Gutherz, 1984a, p. 100; Naughton and Saloman, 1985, p. 12, table 2 (predation); Matheson et al., 1986, p. 309 (predation by scamp); Parker and Ross, 1986, pp. 35, 43 (North Carolina).

Centropristis ocyura: Hoese and Moore, 1977, p. 171.

Material examined: HOURGLASS STATION B: 1, 62; 30 August 1965; trawl; FSBC 4411.—1, 87; 4 October 1965; trawl; FSBC 15563.—1, 60; 8 November 1965; trawl; FSBC 4580.—3, 58–87; 3 January 1966; trawl; uncatalogued.—1, 90; 19 January 1966; trawl; FSBC 13111.—1, 94; 3 March 1966; trawl; uncatalogued.—19, 41–57; 25 July 1967; SCUBA; FSBC 15562.—HOURGLASS STATION C: 1, 116; 8 November 1965; trawl; FSBC 11014.—2, 49, 190; 3 January 1966; trawl; uncatalogued.—1, 136; 7 February 1966; trawl; FSBC 5314.—1, 105; 3 March 1966; trawl; uncatalogued.—1, 78; 27 March 1966; trawl; uncatalogued.—2, 55, 65; 16 April 1966; trawl; uncatalogued.—8, 118–148; 2 May 1966; trawl; uncatalogued.—1, 41; 18 June 1966; trawl; FSBC 15561.—4, 115–145; 18 July 1966; trawl; FSBC 5285.—1, 30; 1 August 1966; trawl; FSBC 6520.—1, 85; 6 November 1966; trawl; uncatalogued.—2, 172, 175; 1 December 1966; trawl; FSBC 15568.—1, 50; 13 December 1966; trawl; FSBC 11008.—1, 101; 6 January 1967; trawl; FSBC 15488.—2, 82, 153; 25 January 1967; trawl; FSBC 15559.—1, 148; 5 February 1967; trawl; FSBC 15557.—2, 67, 155; 3 April 1967; trawl; FSBC 15558.—2, 37, 81; 20 May 1967; dredge; uncatalogued.—1, 44; 1 August 1967; trawl; FSBC 11009.—1, 67; 31 August 1967; dredge; FSBC 13564.—1, 49; 31 August 1967; trawl; FSBC 6530.—2, 62, 73; 11 September 1967; dredge; FSBC 13598.—2, 53, 56; 11 September 1967; trawl; FSBC 11015.—1, 81; 5 October 1967; trawl; FSBC 15457.—1, 61; 21 November 1967; trawl; FSBC 15560.—5, 35–52; 26 July 1967; SCUBA; FSBC 6190.—HOURGLASS STATION D: 4, 111–165; 3 August 1965; trawl; FSBC 15581.—1, 123; 31 August 1965; trawl; FSBC 14031.—1, 135; 5 October 1965; trawl; FSBC 15580.—11, 79–183; 21 October 1965; trawl; FSBC 4544.—4, 100–148; 9 November 1965; trawl; FSBC 15577.—14, 94–173; 20 November 1965; trawl; FSBC 15565.—4, 93–150; 4 December 1965; trawl; FSBC 15749.—8, 71–138; 4 January 1966; trawl; FSBC 11021.—4, 76–115; 8 February 1966; trawl; uncatalogued.—9, 105–153; 21 February 1966; trawl; uncatalogued.—10, 62–138; 4 March 1966; trawl; uncatalogued.—7, 80–150; 27 March 1966; trawl; uncatalogued.—6, 104–154; 7 April 1966; trawl; uncatalogued.—11, 105–177; 16 April 1966; trawl; uncatalogued.—9, 110–165; 19 May 1966; trawl; FSBC 15590.—3, 74–141; 7 June 1966; trawl; FSBC 15570.—8, 26–173; 18 June 1966; trawl; FSBC 6528.—8, 120–178; 3 July 1966; trawl; FSBC 15564.—18, 29–169; 11 July 1966; trawl; FSBC 6526.—31, 84–178; 19 July 1966; trawl; FSBC 15818.—16, 32–138; 11 August 1966; trawl; uncatalogued.—7, 96–128; 1 September 1966; trawl; FSBC 15575.—11, 25–142; 9 September 1966; trawl; FSBC 15576.—7, 19–105; 9 October 1966; trawl; uncatalogued.—1, 138; 19 October 1966; trawl; uncatalogued.—13, 63–167; 9 November 1966; trawl; FSBC 15567.—13, 39–178; 20 November 1966; trawl; FSBC 15584.—3, 137–172; 2 December 1966; trawl; FSBC 15473.—1, 138; 14 December 1966;

trawl; FSBC 15472.—1, 87; 7 January 1967; trawl; uncatalogued.—4, 113–153; 21 January 1967; trawl; uncatalogued.—69, 53–165; 26 January 1967; trawl; FSBC 15574.—3, 75–98; 6 February 1967; trawl; uncatalogued.—1, 144; 28 February 1967; trawl; FSBC 14275.—4, 86–135; 3 March 1967; trawl; FSBC 15585.—2, 131, 157; 15 March 1967; trawl; FSBC 15583.—6, 70–152; 4 April 1967; trawl; FSBC 15566.—7, 105–170; 12 April 1967; trawl; FSBC 15569.—1, 178; 12 May 1967; trawl; FSBC 15572.—1, 85; 3 June 1967; trawl; FSBC 15469.—2, 117, 127; 21 June 1967; trawl; uncatalogued.—8, 77–171; 2 July 1967; trawl; FSBC 15578.—1, 25; 2 August 1967; dredge; FSBC 6529.—12, 39–168; 2 August 1967; trawl; FSBC 15857.—1, 99; 25 August 1967; trawl; uncatalogued.—3, 88–110; 1 September 1967; trawl; FSBC 15582.—5, 51–113; 12 September 1967; trawl; FSBC 15571.—1, 96; 6 October 1967; uncatalogued.—9, 95–150; 6 October 1967; trawl; FSBC 15579.—4, 138–158; 27 October 1967; trawl; FSBC 15573.—19, 73–163; 3 November 1967; trawl; FSBC 11027.—6, 70–158; 21 November 1967; trawl; FSBC 15864.—HOURGLASS STATION E: 3, 100–125; 31 August 1965; trawl; FSBC 15593.—19, 90–160; 5 October 1965; trawl; FSBC 4507.—4, 101–166; 9 November 1965; trawl; FSBC 15591.—9, 94–126; 4 December 1965; trawl; FSBC 15595.—7, 75–123; 4 January 1966; trawl; FSBC 15588.—10, 86–160; 8 February 1966; trawl; FSBC 11013.—8, 90–162; 4 March 1966; trawl; uncatalogued.—5, 85–117; 7 April 1966; trawl; uncatalogued.—13, 84–186; 7 June 1966; trawl; FSBC 15597.—13, 20–142; 3 July 1966; trawl; FSBC 5276.—14, 93–173; 19 July 1966; trawl; FSBC 15598.—9, 25–135; 2 August 1966; trawl; FSBC 15870.—3, 42–123; 1 September 1966; trawl; FSBC 15872.—8, 87–128; 9 October 1966; trawl; FSBC 15587.—2, 107, 150; 9 November 1966; trawl; FSBC 15594.—5, 88–174; 2 December 1966; trawl; FSBC 15586.—6, 110–156; 7 January 1967; trawl; uncatalogued.—29, 81–176; 26 January 1967; trawl; uncatalogued.—5, 26–150; 6 February 1967; trawl; FSBC 6533.—7, 81–137; 3 March 1967; trawl; FSBC 15891.—6, 96–139; 4 April 1967; trawl; FSBC 11017.—3, 130–137; 12 May 1967; trawl; FSBC 15589.—2, 103, 114; 2 July 1967; trawl; FSBC 15893.—2, 106, 140; 2 August 1967; trawl; FSBC 14445.—5, 90–137; 1 September 1967; trawl; FSBC 15592.—11, 72–140; 3 November 1967; trawl; FSBC 15596.—HOURGLASS STATION I: 1, 48; 12 October 1966; dredge; FSBC 5015.—HOURGLASS STATION J: 2, 38, 80; 7 August 1967; trawl; FSBC 11010.—1, 153; 12 June 1966; trawl; FSBC 4970.—6, 48–173; 22 July 1966; trawl; FSBC 5254.—4, 87–152; 4 September 1966; trawl; FSBC 15602.—1, 137; 6 December 1966; trawl; FSBC 15600.—7, 73–124; 30 January 1967; trawl; FSBC 15599.—4, 64–155; 15 February 1967; trawl; FSBC 15486.—1, 68; 8 March 1967; dredge; FSBC 15483.—1, 85; 6 June 1967; trawl; uncatalogued.—1, 42; 6 August 1967; SCUBA; FSBC 15480.—3, 56–125; 4 September 1967; trawl; FSBC 15601.—1, 84; 11 October 1967; trawl; FSBC 15481.—2, 112, 116; 14 November 1967; trawl; FSBC 15603.—HOURGLASS STATION L: 4, 108–155; 4 September 1965; trawl; uncatalogued.—3, 150–155; 13 October 1965; trawl; FSBC 4522.—1, 147; 13 November 1965; trawl; FSBC 14997.—2, 146, 190; 13 December 1965; trawl; FSBC 11020.—3, 121–138; 14 January 1966; trawl; FSBC 15109.—2, 123, 130; 15 February 1966; trawl; uncatalogued.—3, 122–200; 22 March 1966; trawl; FSBC 5065.—5, 130–173; 12 April 1966; trawl; uncatalogued.—5, 123–194; 13 June 1966; trawl; FSBC 15607.—7, 62–165; 6 July 1966; trawl; uncatalogued.—34, 32–187; 22 July 1966; trawl; FSBC 11012.—10, 80–156; 6 August 1966; trawl; FSBC 15608.—2, 40, 104; 5 September 1966; trawl; FSBC 15945.—5, 104–185; 13 October 1966; trawl; uncatalogued.—2, 11, 145; 13 November 1966; trawl; uncatalogued.—4, 97–178; 7 December 1966; trawl; FSBC 11026.—1, 164; 13 January 1967; trawl; uncatalogued.—28, 72–184; 31 January 1967; trawl; FSBC 15606.—3, 84–112; 16 February 1967; trawl; FSBC 15605.—3, 128–168; 9 March 1967; trawl; FSBC 15604.—3, 108–127; 8 April 1967; trawl; FSBC 15485.—3, 120–174; 16 May 1967; trawl; uncatalogued.—2, 128, 138; 7 June 1967; trawl; uncatalogued.—2, 165, 175; 6 July 1967; trawl; FSBC 15701.—2, 108, 122; 8 August 1967; trawl; FSBC 11018.—8, 100–142; 5 September 1967; trawl; FSBC 11028.—4,

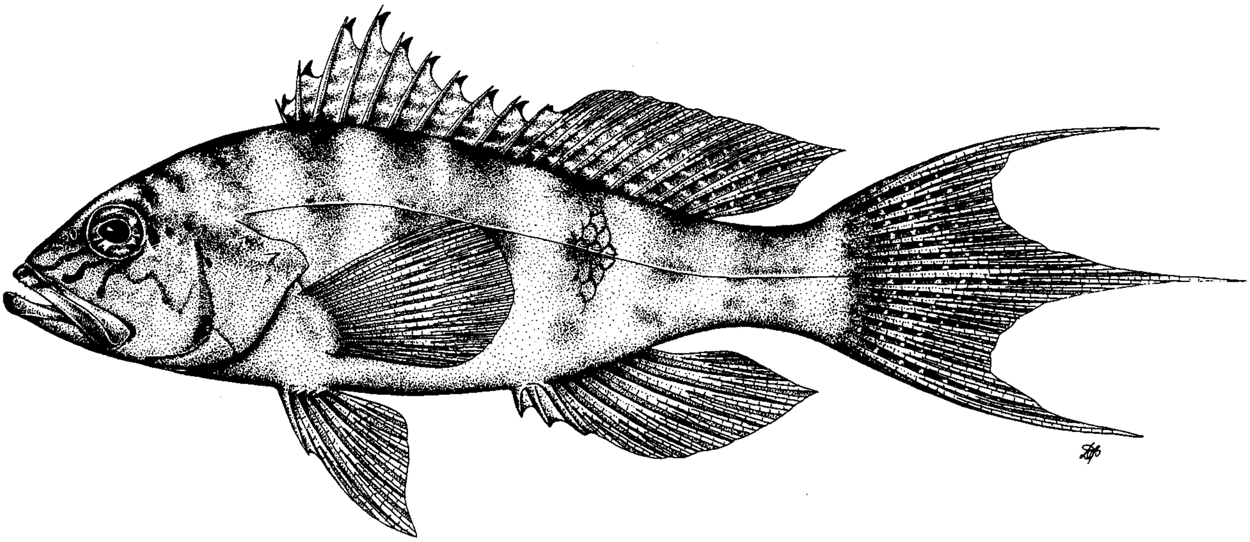

Figure 10. *Centropristis ocyurus* (Jordan and Evermann, 1886).

115–136; 12 October 1967; trawl; FSBC 15955.—8, 23–148; 15 November 1967; trawl; FSBC 15956.—HOURGLASS STATION M: 1, 188; 14 December 1965; trawl; uncatalogued.—3, 115–125; 22 March 1966; trawl; uncatalogued.—5, 15–141; 13 June 1966; trawl; FSBC 5507.—8, 118–190; 6 July 1966; trawl; FSBC 15611.—2, 123, 185; 22 July 1966; trawl; uncatalogued.—3, 33–138; 6 August 1966; trawl; FSBC 15960.—7, 29–103; 5 September 1966; trawl; FSBC 16041.—9, 112–180; 13 October 1966; trawl; FSBC 15612.—1, 23; 7 December 1966; dredge; FSBC 6531.—42, 24–170; 31 January 1967; trawl; FSBC 6532.—1, 81; 8 April 1967; trawl; FSBC 15254.—1, 115; 16 May 1967; trawl; uncatalogued.—4, 82–133; 8 August 1967; trawl; FSBC 15610.—1, 14; 5 September 1967; dredge; FSBC 15339.—2, 147, 168; 5 September 1967; trawl; FSBC 15420.—3, 75–173; 15 November 1967; trawl; FSBC 15609.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 1, 112; 26 April 1981; 27°08′N, 83°45′W, R/V *Hernan Cortez* Station EJ-81-30, 61 m; trawl; FSBC 12111.

Diagnosis (after Miller, 1959): Dorsal X, 11 (rarely 10 or 12); anal III, 7; pectoral 16–18 (modally 17) pelvic I, 5. Vertebrae 24. Lateral-line scales usually 47 (46–48); scale rows between anal-fin origin and lateral line usually 17 (14–20); predorsal scale rows usually 12 (10–14). Total gill rakers 17–22 (usually 19–21).

General body color pale to white, somewhat darker on sides and back; sides with three longitudinal rows of quadrate black blotches, uppermost series faint along dorsal-fin base; middle distinct, located immediately below lateral line; lower often black, not confluent, along side of body at level of pectoral-fin base. Blotches in each series fall in line with one another to form about seven dusky, vertical bars.

Sexual dichromatism in spawning *C. ocyurus:* upper jaw bluish purple in males, only slightly dusky in females; both sexes have bluish-purple lower jaw (Link, 1980).

Distinguishing characters: Although both *Centropristis ocyurus* and *C. philadelphica* have vertical bars, the mid-portion of the bar at the pectoral tip is extremely dark in *C. ocyurus* (especially in preserved specimens), whereas in *C. philadelphica* there is a dark blotch at the base of the last three dorsal spines. Small *C. striata* have a similar dark blotch in the dorsal fin but have a mid-lateral longitudinal stripe (Plate III, Figure D) that is absent in *C. philadelphica.*

Geographic distribution: Miller (1959) listed the range of *C. ocyurus* as Cape Hatteras, North Carolina, southward to the Yucatan Banks in the Gulf of Mexico; he believed, however, that the species was absent from most of the western Gulf.

G. B. Smith (1976) listed *C. ocyurus* as a species approximating a Carolinian warm-temperate distribution, although it occurs at the Dry Tortugas, Florida, and off Campeche, Mexico (Miller, 1959). Its centers of abundance seem to be the northern Gulf of Mexico and the southeastern United States Shelf.

Bathymetric distribution and habitat: In the eastern Gulf of Mexico, *C. ocyurus* is distributed in depths of about 11–100 m (Bright, 1968; G. B. Smith, 1976). However, adult *C. ocyurus* are extremely rare or absent in waters less than 30–35 m deep. Link (1980) noted the scarcity or absence of this species in estuarine and nearshore surveys (depths to 18 m) in the South Carolina Bight and the Gulf of Mexico. More than 89% of all *C. ocyurus* collected during Project Hourglass were taken at depths of 55 m or greater (Figure 11). In compiling literature records, Bright (1968) listed the bathymetric range of *C. ocyurus* as 17–439 m, most often 40–90 m. However, occurrences in extreme depths (such as 400 m) are questionable when the reported depth range for the genus is considered (Link, 1980). Young *C. ocyurus* are sometimes found inshore, especially if habitats are near deep-water areas. For example, Hastings (1979) found that *C. ocyurus* occurs (rarely) at shoreline jetties along the northwest Florida coast. Although *C. ocyurus* is moderately common at offshore reefs, it is most abundant on sand-shell substrates "in close proximity to reefs and wrecks" (Springer and Woodburn, 1960: 34). This may be true for juveniles and small adults, but we have found that large adults are almost exclusively confined to rocky bottoms, although they may be of low relief. In North Carolina waters, Link (1980) and Parker and Ross (1986) observed that *C. ocyurus* was commonly found on sand substrate near the edges of outcroppings. If the fish moved onto hard substrate, Link (1980) noted that its position was usually limited to the base (edge) of the hard bottom, possibly due to the presence of *C. striata* on the upper levels. In the eastern Gulf of Mexico, adult populations of *C. ocyurus* and its congener *C. striata* are largely bathymetrically exclusive, with *C. striata* being confined to depths of less than 36 m and *C. ocyurus* being common only offshore of this depth (G. B. Smith, 1976). Link (1980) and Parker and Ross (1986) indicated that the number of *C. ocyurus* sightings made from submersibles off North Carolina increased with depth, whereas those of *C. striata* decreased. Juvenile populations of these *Centropristis* species are also separated bathymetrically: *C. striata* is found in shallow-water areas within bays and along Gulf beaches, and *C. ocyurus* is found only offshore at depths greater than 6–10 m. The difference in habitat selection between *C. striata* and *C. ocyurus* probably serves as a space- and resource-sharing mechanism allowing cohabitation of the same shelf segment by two closely related species.

Reproduction: Ripe gonads of both sexes of this protogynous hermaphrodite were found in Hourglass specimens collected from November through April; the greatest frequency of ripe individuals (35.0–66.7%) occurred during January–April (Table 4). By May, fish were spent.

Off North Carolina, *C. ocyurus* is believed to be a spring spawner with a March spawning peak. Young-of-the-year (14.5–17.0 mm) were found in late April (Link, 1980). The smallest Hourglass specimens (10–19 mm) were captured during June, October, and November (Figure 12). These results agree with those of previous Gulf studies. Miller (1959) noted that specimens

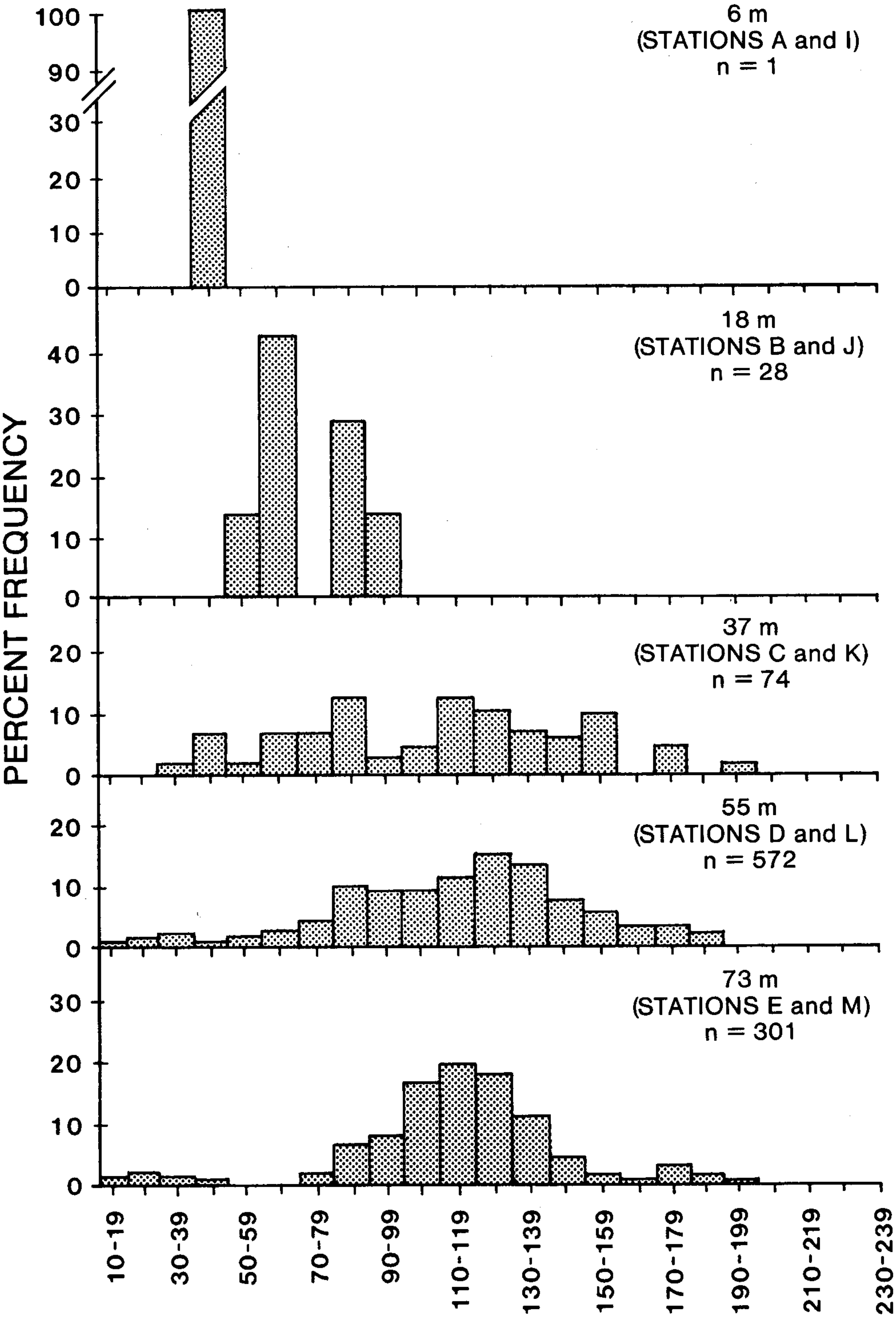

Figure 11. Length frequency distributions of *Centropristis ocyurus* according to capture depths at Project Hourglass fishery stations.

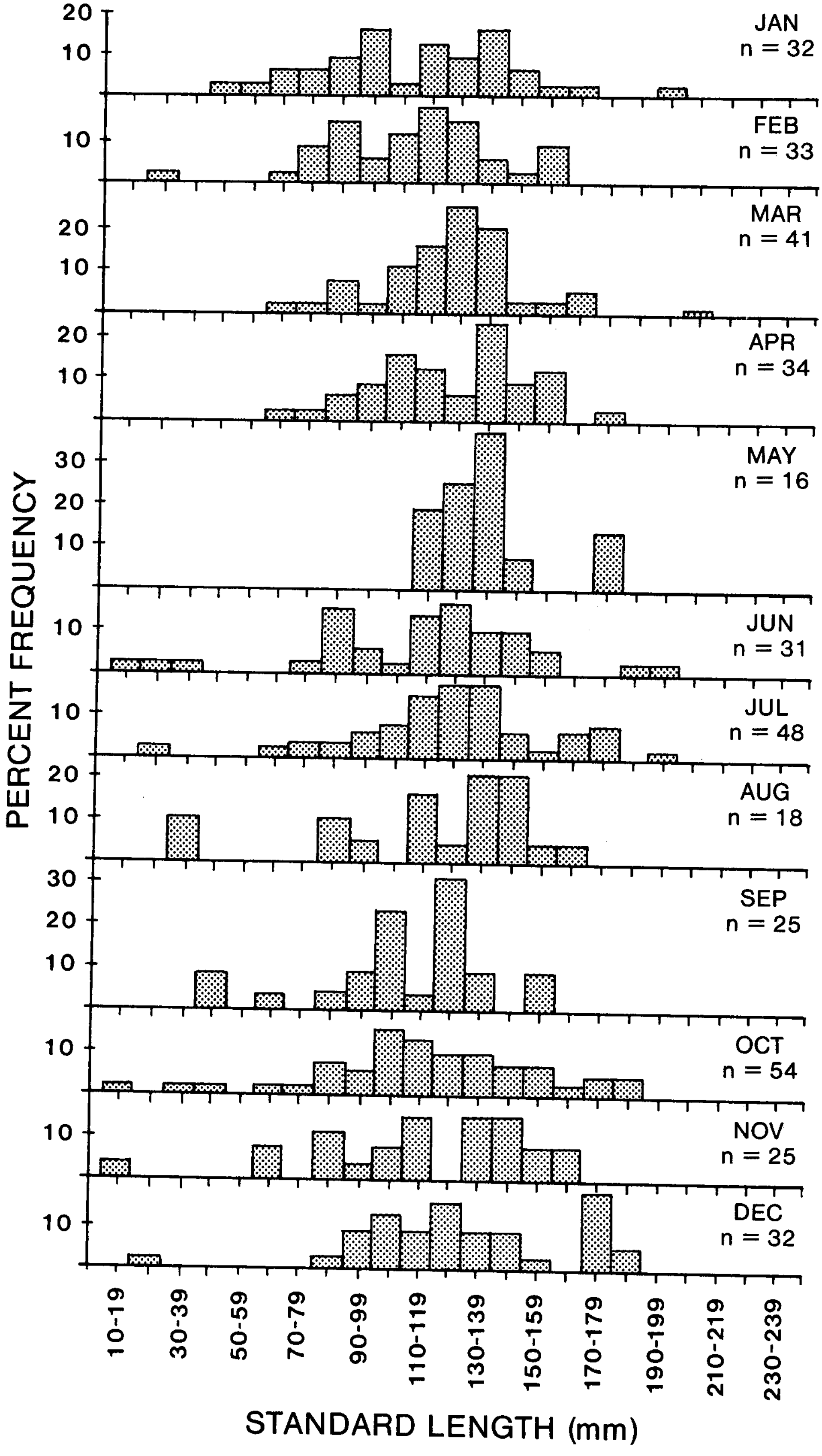

Figure 12. Monthly length frequency distributions of *Centropristis ocyurus*.

TABLE 4. FREQUENCY DISTRIBUTION OF RIPE GONADS (♂♂ AND ♀♀) FOR *CENTROPRISTIS OCYURUS* COLLECTED DURING PROJECT HOURGLASS (N = 521).

Month	Number Ripe	Total Collected	Percent Frequency
November	5	106	4.7
December	10	34	29.4
January	75	214	35.0
February	27	43	62.8
March	34	51	66.7
April	21	54	38.9
May	0	19	00.0

TABLE 5. DIET OF *CENTROPRISTIS OCYURUS* (N = 27).

Taxa	Number of Items	Percentage of Total Items	Number of Stomachs	Percentage of Total (27) Stomachs
Phylum Mollusca				
Class Scaphopoda	2	5.1	1	3.7
Class Cephalopoda				
Order Octopoda				
Octopus sp.	1	2.6	1	3.7
Phylum Annelida				
Class Polychaeta	3	7.7	3	11.1
Phylum Arthropoda				
Class Crustacea				
Order Decapoda				
Suborder Natantia				
Section Penaeidea				
Family Penaeidae	1	2.6	1	3.7
Family Sergestidae	1	2.6	1	3.7
Section Caridea	6	15.4	2	7.4
Suborder Reptantia				
Section Anomura	1	2.6	1	3.7
Section Brachyura				
Family Portunidae	2	5.1	2	7.4
Family Xanthidae	17	43.6	8	29.6
Family Majidae	1	2.6	1	3.7
	(35)	(89.9)		
Phylum Echinodermata				
Class Asteroidea	1	2.6	1	3.7
Class Ophiuroidea	2	5.1	2	7.4
Phylum Chordata				
Subphylum Vertebrata				
Class Pisces				
Family Batrachoidae	1	2.6	1	3.7
Total	39			

collected between December and March in the Gulf of Mexico have well-developed ovaries; by July, specimens are spent. G. B. Smith (1976) observed the smallest individuals (30–40 mm) at reefs off west-central Florida during late spring and summer, thus corroborating the presumed winter and early spring spawning period.

In North Carolina, Link (1980) examined 25 mature females (80–158 mm SL) and made fecundity estimates of 4,392 to 29,748 eggs/female. Link (1980: 232) induced spawning in *C. ocyurus* with human chorionic gonadotropin (HCG) and described fertilized eggs as "approximately 1 mm in diameter, clear, and buoyant, floating near the water's surface with the usually single oil droplet uppermost." He felt that some females were potential spawners after only one year of life. Link identified seven year-classes in which all females were found in Classes O–IV with the exception of one female in Class VII, which apparently did not undergo transition. Males were found in Classes I–VI. Transformation to male appeared to begin during or after the second year.

Diet: Contents of 27 *C. ocyurus* stomachs indicated that crustaceans were by far the most important food, both in numbers and in frequency of occurrence (Table 5). Xanthid crabs and caridean shrimps were the most prevalent items in the diet of *C. ocyurus.* Link (1980) found crustaceans to have a 63% frequency of occurrence in *C. ocyurus* captured off North Carolina.

Camp (1973) recorded the stomatopods *Parasquilla coccinea* Manning, 1962 and *Squilla deceptrix* Manning, 1969 from the stomachs of *C. ocyurus.*

Predation: Centropristis ocyurus was first described from a specimen taken from the stomach of a red snapper (Jordan and Evermann, 1886). Other predators include the groupers *Epinephelus morio* (L. Bullock, personal observation), *Mycteroperca microlepis* (Naughton and Saloman, 1985), and *M. phenax* (Matheson et al., 1986).

Parasites and abnormalities: Internal parasites included nematodes and plerocercoid metacestodes (Link, 1980). An unidentified leech was found in the buccal cavity of *C. ocyurus.*

Link (1980) recorded a 131-mm SL specimen with a pug head and a 125-mm individual with a stunted left pelvic fin.

Size and commercial importance: The largest specimen taken off North Carolina examined by Link (1980) was 210 mm SL; Hoese and Moore (1977) listed a maximum size of 300 mm. This species is of little commercial importance.

Centropristis philadelphica (Linnaeus, 1758)
Rock sea bass

Plate III, Figure C

Perca philadelphica Linnaeus, 1758, p. 291.

Centropristis philadelphica: Jordan and Evermann, 1896b, pp. 1201, 1202; 1904, p. 398; Hastings, 1972, pp. 155–159; Powell et al., 1972, p. 64; Dahlberg, 1975, pp. 57, 58 (Georgia); Walls, 1975, pp. 166, 167 (northern Gulf of Mexico); Hastings et al., 1976, p. 392, table 2 (northeastern Gulf of Mexico); G. B. Smith, 1976, p. 41, table 41 (western Florida Shelf); Bortone, 1977a, pp. 23–33 (osteology); Chapman, 1977, pp. 1–66 (systematics); Chittenden and Moore, 1977, pp. 108, 109, table 1

(Texas); Hoese and Moore, 1977, pp. 56, 170, fig. 179 (northwestern Gulf of Mexico); Ogren and Brusher, 1977, pp. 88, 100, tables 2, 5 (northeastern Gulf of Mexico); Hastings, 1979, pp. 34, 110 (northeastern Gulf of Mexico); Link, 1980, pp. 1–277 (North Carolina); Gilmore et al., 1981, p. 14 (Florida east coast); McCaffrey, 1981, pp. 110–113, table 10 (northeastern Gulf of Mexico); Darnell et al., 1983, pp. 43, 44, figs. 50 a–d (northwestern Gulf of Mexico); Darcy and Gutherz, 1984a, p. 100; 1984b, p. 52 (eastern Gulf of Mexico); Robins et al., 1986, p. 137, pl. 24; Darnell and Kleypas, 1987, p. 65, pls. 73 a–d (eastern Gulf of Mexico); Ross et al., 1989, pp. 139–152 (feeding habits).

Centropristes philadelphicus: Weed, 1937, p. 303 (Texas); Longley and Hildebrand, 1941, p. 103 (Dry Tortugas, Florida); Baughman, 1944, p. 89; Gunter, 1945, p. 61 (Texas); Baughman, 1950, p. 249 (Texas); Pearse, 1952b, pp. 33, 34, 40 (parasites); Hildebrand, 1954, p. 304 (Texas); Briggs, 1958, p. 271 (Florida); Miller, 1959, pp. 59–63 (complete account).

Centropritis philadelphicus: Swingle, 1971, p. 32, table 15 (Alabama: misspelling).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: NORTHERN GULF OF MEXICO: 11, 80.5–101.0; 30°06′N, 88°49′W, R/V *Oregon II* Station 20561-60, 15 m; 3 November 1976; trawl; UWF 3582.

Diagnosis (after Jordan and Evermann 1896b, and Miller, 1959): Dorsal X, 11; anal III, 7; pectoral usually 18 (15–20); pelvic I, 5. Vertebrae usually 24, rarely 22 or 23. Lateral-line scales 46–49 (usually 47); scale rows between anal-fin origin and lateral line 15–22 (usually 17–20); predorsal scale rows 11–19 (usually 13–16). Total gill rakers plus tubercles 17–22 (usually 19–21).

Nape fully scaled; vomerine tooth patch in narrow, chevron-shaped wedge; dorsal spines with fleshy filaments attached to tips, filaments in large specimens often as long as spines; large males with higher fins. Soft portion of anal short and high, hind rays long (especially in males). Caudal fin in small specimens rounded, sometimes with upper rays slightly produced; middle rays also somewhat produced in medium-sized (approximately 100 mm) specimens; large specimens with distinctly three-lobed fin.

Body color olive-gray to brown dorsally, with rusty spots (especially on head); pale (often whitish) ventrally. Seven obscure brown bars from dorsum obliquely forward to level of middle of pectorals. Dark blotch showing through upper part of opercle; large dark blotch on membrane of last spines, immediately above fourth vertical bar on sides.

Distinguishing characters: *Centropristis philadelphica* can be separated from its close congener *C. ocyurus* by the dark blotch at the base of the last three dorsal spines, the long dorsal-spine filaments, the completely scaled nape and the narrow, chevron-shaped vomerine tooth patch. *Centropristis ocyurus*, in contrast, has a distinct black blotch at the center of the fourth vertical bar, no elongated dorsal-spine filaments, an incompletely scaled nape, and a broadly triangular vomerine tooth patch. Small specimens of *C. striata* can be separated from the other two species by the presence of a mid-lateral longitudinal stripe and a wedge-shaped vomerine tooth patch.

Distribution: On the Atlantic coast, *C. philadelphica* occurs from Virginia to Palm Beach, Florida, and in the Gulf of Mexico it is found from Brownsville, Texas, to Cape Haze, Florida (Miller, 1959). *Centropristis philadelphica* is considered to be rare in the eastern Gulf, although there are records of its occurrence (Darcy and Gutherz, 1984a; Darnell and Kleypas, 1987). Miller (1959) considered *C. philadelphicus* to be a more temperate water form than *C. ocyurus* and felt that the southern tip of the Florida peninsula served as a barrier between east coast and Gulf populations.

Bathymetric distribution and habitat: Hoese and Moore (1977) stated that *C. philadelphica* was very common in the northwestern Gulf of Mexico in depths of 18–50 m. In the northeastern

Gulf, McCaffrey (1981) noted that 60% of the total number of this species was captured by trawl in depths of 28–49 m. He and others (Miller, 1959; Link, 1980; Ross et al., 1989) noted a habitat preference of soft mud/sand for *C. philadelphica*. McCaffrey (1981) felt that the preference for muddy bottom would ecologically separate this species from *C. ocyurus*. Increase in size was also positively correlated with greater depth according to McCaffrey (1981) and Ross et al. (1989).

Reproduction: Spawning in the Gulf of Mexico for this protogynous hermaphrodite is believed to occur from late March to May (or June) (Miller, 1959). Link (1980) found spawning off North Carolina between February and July with a peak in April and May.

Fecundity estimates for females captured off North Carolina ranged from 1,739 to 36,294 eggs per female (Link, 1980).

Link (1980) believed that females reached sexual maturity in their first year and that sex-inversion occurred in either the first or second year.

Age: Link (1980) found *C. philadelphica* to be short-lived, surviving at least three years. In the western Gulf of Mexico, Ross et al. (1989) found this species to have a maximum life span of 3–4 years, but a typical life span of 1–2 years.

Diet: Link (1980) characterized *C. philadelphica* as a generalized, opportunistic carnivore. The major food groups in its diet (percent frequency of occurrence) included crustaceans 75%, fishes 46%, and mollusks 35%. Among the crustaceans, crabs were found in 35% of the stomachs, shrimp in 14%, and mysids in 11%.

Ross et al. (1989) examined feeding habits of *C. philadelphica* captured by trawl off Texas and found this euryphagic, benthic carnivore to consume primarily the following, in decreasing order of importance: natantian and reptantian decapods, mysids, fishes, stomatopods, and polychaetes. Crabs and fishes made up a larger portion of the diet as individuals of *C. philadelphica* increased in size.

Parasites and abnormalities: Nematodes were observed in the gut cavity of *C. philadelphica*. Pearse (1952b) found the parasitic copepod *Naobianchia spinosa* Pearse, 1952 and the isopod *Lironeca texana* Pearse, 1952 associated with this fish. Link (1980) noted a "mummified" ophichthid eel (approximately 145 mm TL) in the gut cavity of a 160-mm female *C. philadelphica*.

Size: The largest specimen examined by Miller (1959) was 209 mm.

Centropristis striata (Linnaeus, 1758)
Black sea bass

Plate III, Figure D (juvenile)
Figure 13; Plate IV, Figure A (adult male)

Labrus striatus Linnaeus, 1758, p. 285.

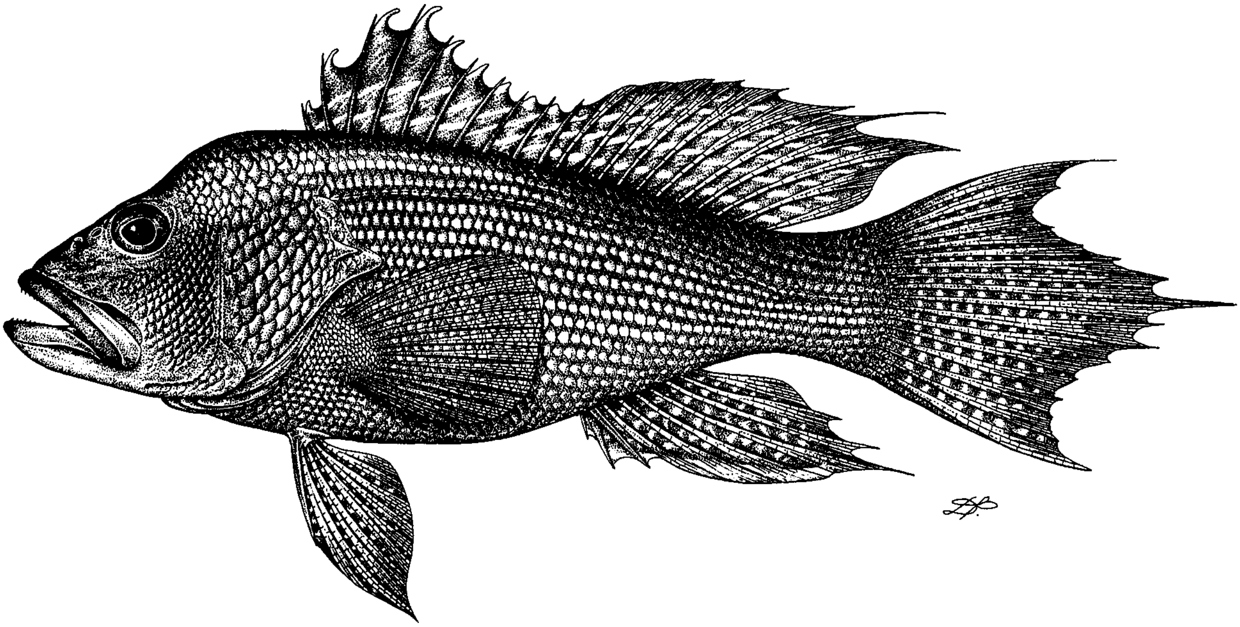

Figure 13. *Centropristis striata* (Linnaeus, 1758).

Centropristes striatus: Jordan and Evermann, 1896b, pp. 1199, 1200; Linton, 1901, p. 456; Hildebrand and Schroeder, 1928, p. 251; Jordan et al., 1930, p. 317; Lavenda, 1949, pp. 185–194; Briggs, 1958, p. 271 (Florida); Miller, 1959, pp. 43–50; Moe, 1963b, p. 102; Bullis and Thompson, 1965, p. 44.

Centropristes melanus Ginsburg, 1952, pp. 84–86; Reid, 1954, pp. 35, 36; Springer and Woodburn, 1960, p. 34; Moe, 1963b, p. 102; Bullis and Thompson, 1965, p. 43.

Centropristes striatus melanus: Moe, 1966, pp. 14–16; Godcharles, 1970, pp. 1–26; Hoff, 1970, pp. 1–17.

Centropristes striatus striatus: Moe, 1966, pp. 16, 17.

Centropristis melana: Bailey et al., 1970, p. 34 (list); G. B. Smith, 1976, p. 20; Ogren and Brusher, 1977, p. 88, table 2; G. B. Smith, 1979, p. 54, fig. 3 (eastern Gulf of Mexico); Cressey, 1981, p. 3 (parasitic copepod).

Centropristis striata: Bailey et al., 1970, p. 34; Cupka et al., 1973, pp. 1–93; Lindall et al., 1973, pp. 214, 215; International Game Fish Association, 1975, p. 23; Walls, 1975, p. 167; Chapman, 1977, pp. 1–66; Hoese and Moore, 1977, p. 170; Kendall, 1977, pp. 1–29; Musick and Mercer, 1977, pp. 12–25; Mercer, 1978, pp. 1–195; C. L. Smith, 1978 (FAO species ID sheets); G. B. Smith, 1978 (eastern Gulf of Mexico); Houde et al., 1979, pp. 29, 65; Link, 1980, pp. 1–277; Robins et al., 1980, p. 37; Low, 1981, pp. 93–103; Myatt, 1981, pp. 32–34; Saloman and Naughton, 1983, table 2, p. 12; Darcy and Gutherz, 1984, p. 100 (list); Matheson et al., 1986, p. 309 (predation by scamp); Wenner et al., 1986, pp. 723–741 (South Atlantic Bight); Grier, 1987, p. 199 (brown bodies in gonad); Sedberry, 1988, pp. 35–50 (South Atlantic Bight diet).

Centropristis striata melana: Wang and Raney, 1971, pp. 29, 30.

Centropristis striatus striatus: Briggs, 1974, p. 223.

Centropristis striatus melanus: Briggs, 1974, p. 223.

Material examined: HOURGLASS STATION B: 1, 223; 6 April 1966; trawl; FSBC 4865.—1, 194; 1 December 1966; trawl; uncatalogued.—1, 195; 14 March 1967; trawl; FSBC 15454.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 1, 79; Mullet Key, Pinellas County, Florida; 29 October 1960; FSBC 1937.—1, 78; ¼ mi E of Bunces Pass, Pinellas County, Florida; 8 January 1965; roller frame trawl; FSBC 2799.—1, 163; St. Petersburg Beach, Pinellas County, Florida; September 1964; hook and line, FSBC 2993.—1, 285; 27°55′N, 83°10′W, 15.2 m; 13 April 1967; hook and line; FSBC 4194.—2, 135, 215; approximately 3 mi west of

Anclote Key Light, Pasco County, Florida; 7 May 1959; FSBC 1328.—1, 108; 1 mi north of Anclote Key, Pasco County, Florida; 23 April 1958; FSBC 508.—2, 58, 89; 5–8 mi off Port Richey, Pasco County, Florida, 4 m; 3 June 1965; FSBC 3562.—2, 117, 139; approximately 3.5 mi off Bayport, Hernando County, Florida; 26 November 1960; spear; FSBC 1978.—1, 115; Crystal River, Citrus County, Florida; 8 September 1969; FSBC 9269.—1, 177; 35 mi west of Steinhatchee, Taylor County, Florida, 25 m; 6 August 1964; FSBC 2995.—3, 95–122; 29°30'N, 83°30'W, 6.4 m; 7–8 January 1965; trap; FSBC 2923.—3, 157–213; 29°32'N, 83°55'W, 16.5 m; 6–7 February 1965; fish trap; FSBC 2834.—1, 118; George Sound, Franklin County, Florida; 28 June 1966; trynet; FSBC 3941.

Diagnosis (modified after Miller, 1959): Dorsal X, 11 (rarely 10 or 12); anal III, 7; pectoral 14–20 (usually 16–19). Vertebrae 24. Total gill rakers 20–29 (usually 22–23). Lateral-line scales 46–49 (modally 47); predorsal-scale rows 8–17 (usually 11–15).

General body color dark to black (blue-black in life); faint traces of dark cross-areas separated by narrower, somewhat lighter interspaces. Dorsal fin dark with several series of elongate whitish spots forming oblique light stripes; pectoral fin light to dusky; pelvic and anal fins dark to almost black. Young with dark longitudinal stripe breaking up with growth; sides variously mottled or with vertical dark bands.

Sexual dimorphism/dichromatism: Nuchal hump and exserted median-fin rays in large males during spawning season (Hoff, 1970); bright blue on nape and dorsal interspinous membranes (Link, 1980). Body of female *C. striata* more slender, with more pointed snout, and narrower caudal peduncle (Lavenda, 1949). Individuals of *C. striata* often with bright golden opercular and buccal cavity linings during the breeding season (Link, 1980).

Distinguishing characters: Small individuals of *C. striata* can be confused with *C. philadelphica* because both contain a dark blotch in the posterior portion of the spinous dorsal fin. Young *C. striata,* however, have a mid-lateral longitudinal stripe (Plate III, Figure D) that is absent in *C. philadelphica.* Larger individuals of *C. striata* are distinguished by their dark ground color; both *C. ocyurus* and *C. philadelphica* have light background pigmentation.

Systematics: Ginsburg (1952) believed that Gulf and Atlantic populations of *C. striata* differed sufficiently for the Gulf population to be regarded as a distinct species, *C. melanus.* Miller (1959), however, thought the degree of difference was only of subspecific importance and referred to the Gulf population as *C. striatus melanus* and to the Atlantic population as *C. striatus striatus.* Since that time, the Gulf form has been referred to as *C. striata, C. s. melana,* or *C. melana.* Electrophoretic study of the two populations caused Chapman (1977) to regard them as a single species, *Centropristis striata,* and the most recent list of accepted taxonomic names for North America (Robins et al., 1980) reverts to Miller's conclusions.

Geographic distribution: Centropristis striata occurs from Maine to southeastern Florida and in the northeastern Gulf of Mexico (Briggs, 1958; Miller, 1959; G. B. Smith, 1976; Mercer, 1978; Link, 1980). Individuals have occasionally been reported as far south as the Florida Keys (C. L. Smith, 1978). Bullis and Thompson (1965) listed a collection of *C. striata* from off Campeche (Mexico), but we consider this record doubtful.

Although *C. striata* is considered abundant at shallow-water reefs north of Tampa Bay (Godcharles, 1970), its abundance rapidly diminishes southward; a recent occurrence of *C.*

striata off the Everglades warranted special mention (Lindall et al., 1973). The distribution of *C. striata* is basically within the Carolina warm-temperate province described by Briggs (1974).

Bathymetric distribution and habitat: In the eastern Gulf of Mexico, *C. striata* is sometimes found as deep as 30 m but is uncommon at depths greater than 18 m. Juveniles are seasonally present in bays, particularly around Gulf passes, but not at offshore reefs (G. B. Smith, 1976). Small specimens were infrequently collected by Wang and Rainey (1971) in the Charlotte Harbor, Florida, area.

Centropristis striata apparently prefers flat or gently rolling rocky bottoms of low relief; it is taken infrequently at reef ledges where larger serranids of the genera *Mycteroperca* and *Epinephelus* abound (G. B. Smith, 1976).

Susceptibility to red tide: G. B. Smith (1976) reported a dramatic decline in population densities of *C. striata* following a 1971 red tide, and the species was not observed at shallow-water reefs off west-central Florida for nearly 19 months thereafter. Smith's (1976) observations are like those of Springer and Woodburn (1960: 34), who reported that the "species was considered common by local fishermen prior to the red tide of 1957 and is just beginning (June 1959) to be caught again in numbers."

Reproduction: Centropristis striata is a protogynous hermaphrodite (Lavenda, 1949; Mercer, 1978; Link, 1980; Wenner et al., 1986). Link (1980) and Wenner et al. (1986) presented histological evidence from specimens in which testicular tissue was beginning to replace ovarian lamellae from the gonad periphery.

Histological examination of gonads from *C. striata* captured off the Florida west coast indicated a spawning season of December–April, with peak activity occurring in March (R. Barco, unpublished data).

Mercer (1978) found that *C. striata* spawned during February–May in the South Atlantic Bight (south of Cape Hatteras, North Carolina, to Florida) and June–October (peak during July–August) in the Middle Atlantic Bight (Cape Cod, Massachusetts, to Cape Hatteras, North Carolina).

In another study in the South Atlantic Bight, Wenner et al. (1986) found spawning during approximately the same time period (January–April); he also recorded a second, less intense, period of ovarian activity during September and possibly November.

Cupka et al. (1973) estimated 29,770 to 121,500 ova for 18 *C. striata* (139–250 mm) from South Carolina; Mercer's (1978) fecundity estimates for 25 black sea bass (142–214 mm) from the Middle Atlantic Bight ranged from 119,000 to 333,000 ova; and Link (1980) calculated 26,938 to 370,443 ova per female for 18 *C. striata* (137–335 mm) from off North Carolina. Mean fecundity estimated for black sea bass (ages 2–8 yr) from the South Atlantic Bight ranged from 61,846 ova at age 2 to 137,400 ova at age 8 (the highest mean fecundity was 287,350 ova at age 7) (Wenner et al., 1986). These authors found fecundity to be significantly related to SL, TL, weight, and age, although only 33% of the variation in fecundity could be explained by age.

Recently spawned eggs of *C. striata* range 0.9–1.0 mm in diameter and are spherical and smooth with a single oil droplet (Kendall, 1977).

Houde et al. (1979) found *C. striata* larvae in the eastern Gulf of Mexico during fall through spring in depths less than 50 m. Larvae were most abundant in the northern sector (north of Tampa Bay), where these authors speculated that spawning was most intense. Reid (1954) found 20–25 mm individuals at Cedar Key, Florida, during May and June.

Movements: Lavenda (1949) and Musick and Mercer (1977) detected seasonal movements of *C. striata* along the middle Atlantic and southern new England coasts, and Moe (1963b) suggested that *C. s. melana* might undergo similar but less extensive movements on the West Florida Shelf. Tagging studies, however, showed only 14% of recaptured individuals demonstrating any significant movement (Moe, 1966). G. B. Smith (1978) thought there might be local movement of *C. striata* from flat rock to ledges during the spawning season.

Age at sexual maturity: M. Godcharles (unpublished data) and R. Barco (unpublished data) found the following maturation schedule for *C. striata* in the eastern Gulf of Mexico: most females mature by age IV (190 mm SL), although some individuals may be mature by age I; males dominate in year-classes V–VII (>200 mm SL); and transitionals range from ages I to V (160–230 mm SL), although most were found between ages II and IV.

Link (1980) found a total of nine year-classes (0–VIII) off North Carolina. The oldest males were age VII, and the oldest females were age VI. As in the eastern Gulf, females predominated in the first five year-classes (0–IV). Wenner et al. (1986) identified 10 age groups in the South Atlantic Bight. Mature gonads were found in none of the females at age 0, 48.8% at age 1, 90.3% at age 2, 99.1% at age 3, and 100% at all other ages. Mature gonads were found in 15.4% of males at age 0; the relative abundance of males increased with age and size (Wenner et al., 1986).

Diet: Reid (1954) examined 38 sea bass stomachs, seven of which were empty. Various shrimps, primarily carideans and penaeids, were found in 29 of 31 stomachs containing food. Some of the stomachs contained as many as 15 shrimp ($\bar{x} = 3.75$). Crabs (possibly xanthids) were consumed by 17 sea bass; 5 of the stomachs contained fishes, including 1 specimen of *Synodus foetens* Linnaeus, 1758 (Synodontidae), 3 specimens of *Bairdiella chrysoura* (Lacépède, 1803) (Sciaenidae), and 1 specimen of *Eucinostomus gula* (Cuvier, 1830) (Gerreidae). Hildebrand and Schroeder (1928) found that the diet of *C. striata* consisted of crustaceans, mollusks, and plants, in order of decreasing importance.

Sedberry (1988: 35), studying dietary habits of black sea bass from the South Atlantic Bight, found that this fish generally ate "motile epibenthic live bottom reef species" (mainly amphipods, decapods, and fishes). Smaller black sea bass ate relatively more small crustaceans (primarily amphipods); larger fish fed more on decapods (mainly brachyurans) and fishes. Their diet was highly similar to that of southern porgy, *Stenotomus aculeatus* (Cuvier and Valenciennes, 1830); sheepshead, *Archosargus probatocephalus* (Walbaum, 1792); and pinfish, *Lagodon rhomboides* (Linnaeus, 1766) (Sedberry, 1988).

M. Godcharles (unpublished data) found the diet of *C. s. melana* captured off the Florida west coast to be composed almost entirely of shrimps, crabs, stomatopods, and fishes. Amphipods, echinoderms, ascidians, bivalves, gastropods, cephalopods, nematodes, and polychaetes were also found but were of minor dietary importance. He found xanthid crabs, caridean shrimps, and penaeid shrimps to be important dietary items inshore (in lower reaches of estuarine areas), whereas majid crabs, stomatopods, and fishes predominated in the diet of black sea bass captured offshore on low-relief limestone outcrops.

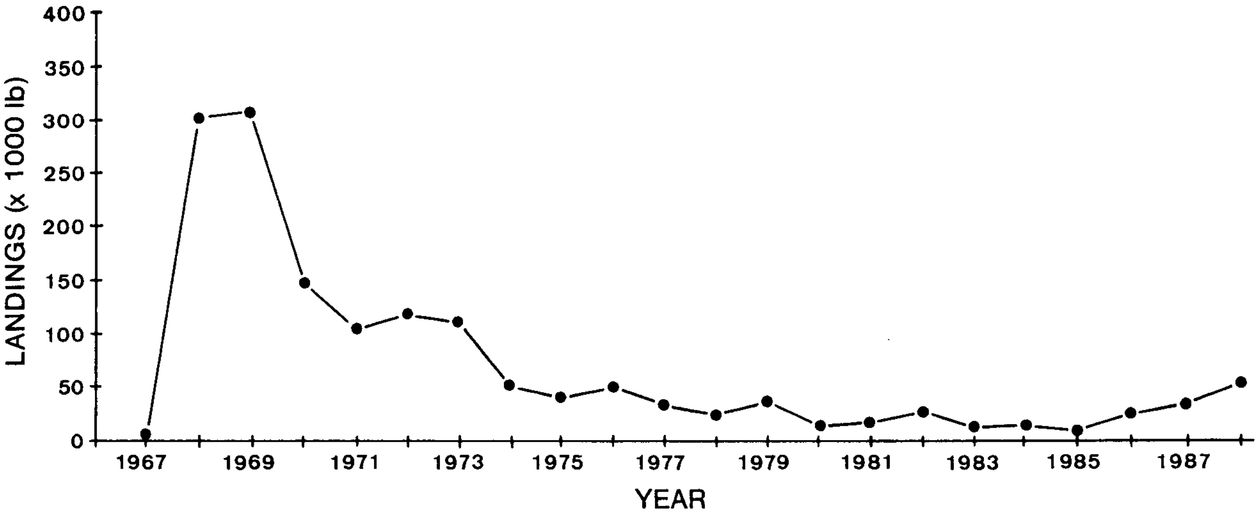

Figure 14. Florida west coast commercial landings of *Centropristis striata* (1967–1988).

Predation: Saloman and Naughton (1983) reported the infrequent occurrence of *C. striatus* in the stomach contents of king mackerel (*Scomberomorus cavalla* (Cuvier, 1829)) captured off the coasts of South Carolina and North Carolina, and Matheson et al. (1986) found scamp to prey occasionally upon black sea bass.

Abnormalities: Pug-headedness was noted in a 160-mm specimen of *C. striata* taken off North Carolina; another 109-mm individual had stunted pelvic fins (Link, 1980).

Parasites: Internal parasites include acanthocephalans, nematodes, and plerocercoid metacestodes (Linton, 1901; Link, 1980). Cressey (1981) collected the parasitic copepod *Holobomolochus centropristis* Cressey, 1981 from the gill chamber of black sea bass collected at Charlotte Harbor, Florida.

Size and commercial importance: A specimen of *C. striata* measuring 521 mm SL was recorded from the northeastern Gulf by the International Game Fish Association (1975). Link (1980) noted a record size of 535 mm TL for this species off North Carolina. *Centropristis striata* may attain a weight of 3.9 kg in the South Atlantic Bight; individuals weighing 1.4 kg are frequently landed, whereas 2.3 kg individuals are rarely captured there (Myatt, 1981).

Black sea bass was "the principal ocean demersal food fish" (by weight) landed commercially from Cape Hatteras, North Carolina, to Cape Canaveral, Florida, during 1970–1975 and was "the most important demersal reef fish for recreational anglers fishing off South Carolina (during 1979)" (Low, 1981: 93). The total catch of a commercial fishery utilizing traps and hook and line off west central Florida peaked in 1969 (Florida Landings, 1967–1984) with over 300,000 lb of fish being recorded (Figure 14), but economic problems caused a sharp decline in this fishery (M. Godcharles, personal communication). This species, however, remains a frequent component of recreational and party-boat catches off west central Florida.

Genus *Diplectrum* Holbrook, 1855

Diagnosis (after Gosline, 1966, and Bortone, 1977b): Dorsal X, 11–13; anal III, 7–8; pectoral 14–19. Body elongate, moderately compressed; snout and dorsal head surface naked forward of occiput; caudal fin lunate to slightly forked; scales relatively large, 48–88 rows in lateral line; preopercular armature consisting of one or two clusters of strong, straight, divergent spines. Branchiostegals 7.

Remarks: For more complete synonymies of the two species of *Diplectrum*, refer to Bortone (1977b).

KEY TO *DIPLECTRUM* SPECIES OF THE GULF OF MEXICO
(From Bortone, 1977b.)

1. Preopercle with 2 clusters of spines radiating from upper and lower posterior corners (Figure 15A). Scales small; cheek scale row A (Figure 16) 9–16 (modally 11); cheek scale row B, 12–18 (modally 16); 8–12 scale rows above lateral line. Pectoral rays 15–17 (modally 16) .... *D. formosum*
1. Preopercle with single cluster of spines (Figure 15B). Scales large; cheek scale row A, 7–9 (modally 8); cheek scale row B, 14 or less; 9 or fewer scale rows above lateral line. Pectoral rays 14–16 (modally 15) .... *D. bivittatum*

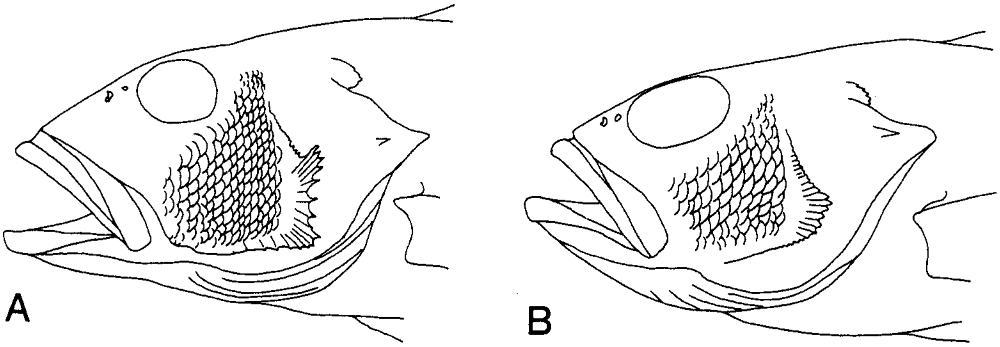

Figure 15. A. Preopercular spination in adult *Diplectrum formosum;* B. *Diplectrum bivittatum* (from Bortone, 1977b: p. 6, fig. 6).

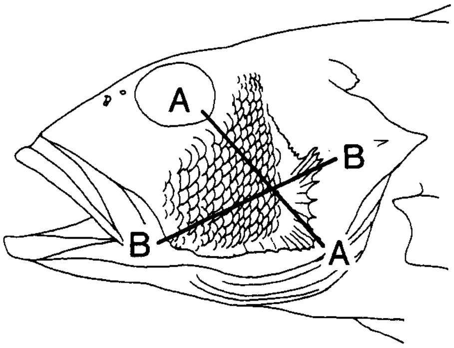

Figure 16. Cheek scale rows (A, B) for *Diplectrum formosum* as defined by Bortone (1977b: 2).

Diplectrum bivittatum (Valenciennes, 1828)
Dwarf sand perch

Plate IV, Figure B

Serranus bivittatus Valenciennes, *in* Cuvier and Valenciennes, 1828, pp. 241, 242 (Martinique and Havana: original descr.)

Diplectrum radiale: Jordan and Eigenmann, 1890, pp. 398, 399 (in part, systematics); Longley, 1932, p. 286 (Florida: biology); Baughman, 1950, p. 249 (Texas); Briggs, 1958, p. 272 (in part, distrib.); Randall, 1968, pp. 73, 76, fig. 86 (Caribbean: descr.).

Diplectrum bivittatum: Longley and Hildebrand, 1941, pp. 104, 105 (Florida: field data); Hildebrand, 1955, pp. 208, 222, 223, table 7 (Campeche: systematics); Roessler, 1965, p. 314, table 2 (Florida: field data); Moe et al., 1966, p. 32 (Florida); Starck and Davis, 1966, p. 320 (Florida); Starck, 1968, p. 19 (Florida); Walls, 1975, pp. 168, 169 (northern Gulf of Mexico); Bortone, 1977b, pp. 12, 22–26, fig. 9B (complete account); Chittenden and Moore, 1977, table 1, p. 109 (Texas); Hoese and Moore, 1977, p. 169 (northern Gulf of Mexico); Ogren and Brusher, 1977, table 1, p. 88 (northeastern Gulf of Mexico); Bortone et al., 1981, pp. 98–103 (feeding habits); McCaffrey, 1981, pp. 113, 114 (northeastern Gulf of Mexico); Yoshiyama et al., 1982, table 2, p. 67 (Texas); Darcy and Gutherz, 1984a, p. 100; 1984b, p. 53 (eastern Gulf of Mexico); Robins et al., 1986, p. 141, plate 26 (descr.); Darnell and Kleypas, 1987, figs. 73a–d, pp. 289–292 (eastern Gulf of Mexico: distrib.).

Diplectrum arcuatum: Pearse, 1952b, p. 39 (parasites).

Diplectrum bivitatum: Cervigón M., 1966, p. 324 (name only; misspelling).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: DRY TORTUGAS: 9, 91–110; 24°45′N, 82°35′W, R/V *Oregon II* Cruise 72, Station 21256, 31 m; 11 December 1976; trawl; UWF 2388.—NORTHERN GULF OF MEXICO: 1, 91; 29°35′N, 85°02′W–29°40′N, 85°21′W, 6–12 m; 6–11 March 1988; trawl; uncatalogued.—8, 70–116; 29°55.2′N, 88°13.1′W, R/V *Chapman* Cruise 62-B, Station 18420, 33 m; 29 October 1975; 12.3-m semi-balloon trawl; UWF 1194.

Diagnosis (after Bortone, 1977b, and Robins et al., 1986): Dorsal X, 12; anal III, 7 (6–8); pectoral 14–16 (modally 15); total gill rakers on the first arch 20–25. Preopercle with single prominent cluster of radiating spines. Upper caudal lobe usually filamentous.

Adult with two broad lateral stripes intersected by series of short, irregular vertical bars (usually double); a distinct caudal spot present. Opercle with pale greenish-yellow blotch. Young with two broad, dark lateral stripes: one from opercle to base of caudal fin, another above lateral line from head to top of caudal peduncle. Each stripe ending in dark, blue-edged spot.

Distinguishing characters: *Diplectrum bivittatum* has only one cluster of preopercular spines, whereas *D. formosum* has two clusters. Additionally, *D. bivittatum* usually has an elongate filament on the upper caudal lobe.

Systematics: Bortone (1977b) presented a complete synonymy, diagnosis, and description for *D. bivittatum* and separated this species into two geographic forms: one from the Gulf of Mexico (*D. b. arcuarium*) and the other (*D. b. bivittatum*) from the Caribbean and South America, with an intermediate group from south Florida (southern Florida, Florida Keys, the Dry Tortugas, and northern Cuba).

Geographic and bathymetric distribution: *Diplectrum bivittatum* occurs from the western Gulf of Mexico eastward to Pensacola, Florida, where its major abundance ends (Bortone, 1977b). Although *D. bivittatum* is considered uncommon in the eastern Gulf, Darcy and Gutherz (1984a, b) and Darnell and Kleypas (1987) noted its occurrence there. Major occurrences resume in the area of the Dry Tortugas and southern Florida. On the Florida east coast, it occurs northward to the vicinity of St. Augustine. In the Caribbean Sea, the species has been recorded from Jamaica, Puerto Rico, and throughout the Lesser Antilles. It is also found from Central America to northern Brazil.

Bortone (1977b) recorded a wide depth range of 2–110 m, but captures most frequently occur at 15–80 m.

Habitat: Gulf of Mexico specimens are often caught on a mud-silt bottom. The west peninsula Florida coast has limestone and coral substrates, which may explain the sparse occurrence of this species in this area (Bortone, 1977b).

Reproduction: Diplectrum bivittatum is a synchronous hermaphrodite (Bortone, 1977b). Limited collection data showed *D. bivittatum* to be ripe during December (in the vicinity of the Dry Tortugas) and October (near Dauphin Island, Alabama). McCaffrey (1981) and S. Bortone (personal communication) felt that *D. bivittatum* spawned during the summer in the northeastern Gulf.

Diet: Bortone et al. (1981) compared the stomach contents of *D. bivittatum* and *D. formosum* captured near the Dry Tortugas and found that both species consumed similar dietary items in the same proportion by number and volume. With regard to number, these items included amphipods, natantian shrimp, brachyuran crabs, and, to a lesser extent, fish and polychaetes. By volume, fish, shrimp, and crabs were the most important items consumed.

Predation: Diplectrum bivittatum probably falls prey to large groupers, as has been noted for its congener *D. formosum* (see next species account). Nelson (1988) found *Diplectrum* sp. in stomach contents of the cottonwick, *Haemulon melanurum*, captured on the Flower Garden Banks off Texas.

Parasites: The cymothoid isopod *Nerocila acuminata* Shioedte and Meinert, 1883 was found on *D. bivittatum* by Pearse (1952b). Unidentified nematodes were observed in the visceral cavity of one specimen captured off Apalachicola, Florida.

Size: Diplectrum bivittatum is a small species; the largest specimen recorded by Bortone (1977b) was 126 mm SL.

Diplectrum formosum (Linnaeus, 1766)
Sand perch

Figure 17; Plate IV, Figure C

Perca formosa Linnaeus, 1766, pp. 488, 489.

Serranus formosus: Jordan, 1885a, p. 125 (Key West, Florida: color notes); Adams and Kendall, 1891, pp. 292, 309; Henshall, 1891, p. 387 (Key West, Florida).

Diplectrum formosum: Goode and Bean, 1886, p. 203; Henshall, 1895, p. 215 (Key West, Florida); Jordan and Evermann, 1896b, pp. 1204, 1207, 1208; H. M. Smith, 1896, p. 175; Evermann and Kendall, 1900, p. 75; Fowler, 1903, p. 329 (color notes); Jordan and Thompson, 1905, pp. 240, 241; Fowler, 1927, p. 252; 1929, p. 453; Borodin, 1934, p. 113 (Florida Keys); Fowler, 1940, p. 14; 1941, p. 86; Longley and Hildebrand, 1941, pp. 103, 104 (Dry Tortugas, Florida: life history); Joseph and Yerger, 1956, p. 150 (Alligator Harbor, Florida); Briggs, 1958, p. 272 (listed); Springer and Woodburn, 1960, p. 34 (Tampa Bay, Florida); Tabb and Manning, 1961, p. 618 (Florida Bay); Lowe, 1962, p. 684; Tyler, 1964, p. 9; Anderson and Gehringer, 1965, table 12; Bullis and Thompson, 1965, p. 44; Gunter and Hall, 1965, p. 31; Moe and Martin, 1965, p. 138

(Florida west coast); Roessler, 1965, p. 314, table 2 (ecological data); Roithmayr, 1965, p. 20, table A-1; Cervigón M., 1966, pp. 322, 323; Moe, 1966, p. 11; Moe et al., 1966, pp. 32, 33; Starck and Davis, 1966, p. 320; Beaumariage, 1968, p. 8; Böhlke and Chaplin, 1968, p. 267; Joyce, 1968, p. 359; Starck, 1968, p. 19; Overstreet, 1969, p. 169 (parasites); Bortone, 1970, pp. 1–55 (life history, ecology); Godcharles, 1970, p. 11 (Florida west coast); Bortone, 1971a, pp. 1–27; 1971b, p. 28; Godcharles, 1971, p. 34; table 8; Grimes and Mountain, 1971, pp. 40, 41 (Crystal River, Florida); Nahhas and Powell, 1971, pp. 4, 8; Wang and Raney, 1971, p. 30; Mountain, 1972, p. 60; Powell et al., 1972, pp. 65, 66; Camp, 1973, pp. 77, 78 (table 21); Cobb et al., 1973, p. 31; Smith et al., 1975, p. 6; Walls, 1975, p. 169; G. B. Smith, 1976, pp. 20, 21; Hastings et al., 1976, p. 390; Bortone, 1977b, pp. 11, 15–22; Hoese and Moore, 1977, p. 169; Manooch, 1977, p. 781; Ogren and Brusher, 1977, p. 88 (list); Overstreet and Heard, 1978, p. 132; Branstetter, 1981, p. 24; Deardorff and Overstreet, 1981, p. 117; Darcy and Gutherz, 1984a, p. 100; Sedberry, 1988, p. 43.

Diplectrum formosus: Jordan et al., 1930, pp. 318, 319; Reid, 1954, pp. 37, 38 (Cedar Keys, Florida).

Material examined: HOURGLASS STATION A: 3, 167–172; 3 August 1965; trawl; FSBC 15494.—5, 98–180; 30 August 1965; trawl; FSBC 4407.—1, 175; 3 December 1965; trawl; FSBC 15490.—1, 133; 7 February 1966; dredge; uncatalogued.—9, 150 (smaller sizes not recorded); 3 March 1966; trawl; uncatalogued.—8, 90–158; 6 April 1966; trawl; uncatalogued.—3, 142–166; 6 June 1966; trawl; FSBC 10405.—1, 138; 2 July 1966; trawl; FSBC 10136.—1, 156; 8 October 1966; trawl; uncatalogued.—1, 116; 6 January 1967; trawl; FSBC 15492.—2, 115, 137; 5 February 1967; trawl; FSBC 15495.—1, 162; 31 August 1967; trawl; FSBC 15493.—4, 115–157; 2 November 1967; trawl; FSBC 15491.—HOURGLASS STATION B: 1, 180; 3 August 1965; trawl; FSBC 15499.—3, 100–173; 30 August 1965; trawl; FSBC 13287.—2, 174, 175; 4 October 1965; trawl; FSBC 10401.—1, 185; 20 October 1965; trawl; FSBC 10402.—6, 108–190; 8 November 1965; trawl; uncatalogued.—1, 114; 3 December 1965; trawl; FSBC 15497.—9, 43–185; 3 January 1966; trawl; FSBC 4654.—2, 110, 118; 19 January 1966; trawl; FSBC 15504.—3, 183–195; 7 February 1966; trawl; FSBC 4783.—1, 180; 15 April 1966; trawl; uncatalogued.—1, 160; 17 June 1966; trawl; FSBC 15501.—1, 177; 10 July 1966; trawl; FSBC 15498.—9, 174–194; 18 July 1966; trawl; FSBC 15503.—2, 48, 61; 31 August 1966; trawl; FSBC 10132.—1, 94; 8 October 1966; dredge; uncatalogued.—2, 93, 116; 8 October 1966; trawl; uncatalogued.—1, 175; 19 November 1966; trawl; uncatalogued.—17, 34–203; 1 December 1966; trawl; FSBC 15731.—4, 164–198; 6 January 1967; trawl; FSBC 15500.—13, 165–205; 25 January 1967; trawl; FSBC 10140.—2, 176, 201; 5 February 1967; trawl; FSBC 16064.—1, 190; 11 August 1967; trawl; FSBC 15502.—3, 60–83; 25 July 1967; SCUBA; FSBC 15496.—HOURGLASS STATION C: 1, 175; 19 November 1965; trawl; FSBC 15507.—1, 25; 3 January 1966; trawl; FSBC 4658.—9, 71–170; 3 March 1966; trawl; uncatalogued.—3, 111–160; 27 March 1966; trawl; uncatalogued.—1, 120; 16 April 1966; trawl; uncatalogued.—1, 100; 18 June 1966; trawl; FSBC 10133.—9, 146–200; 18 July 1966; trawl; FSBC 15514.—3, 155–170; 31 August 1966; trawl; FSBC 13513.—2, 102, 188; 8 September 1966; trawl; FSBC 15510.—2, 168, 184; 18 October 1966; trawl; FSBC 15511.—2, 145, 177; 6 November 1966; trawl; uncatalogued.—1, 128; 1 December 1966; trawl; FSBC 15509.—6, 90–138; 6 January 1967; trawl; FSBC 15737.—14, 103–197; 25 January 1967; trawl; FSBC 10139.—2, 183, 190; 5 February 1967; trawl; FSBC 15505.—2, 119, 152; 27 February 1967; trawl; FSBC 15508.—2, 190, 198; 14 March 1967; trawl; FSBC 15512.—6, 60–177; 3 April 1967; trawl; FSBC 15515.—5, 78–109; 12 April 1967; trawl; FSBC 13765.—1, 188; 11 May 1967; trawl; FSBC 15506.—1, 108; 21 June 1967; trawl; FSBC 15459.—2, 85, 177; 5 October 1967; trawl; uncatalogued.—5, 157–192; 2 November 1967; trawl; FSBC 15513.—HOURGLASS STATION D: 1, 177; 21 October 1965; trawl; FSBC 4545.—1, 170; 4 December 1965; trawl; FSBC 15522.—1, 163; 8 February 1966; trawl; uncatalogued.—1, 178; 21 February 1966; trawl; uncatalogued.—2, 150, 163; 4 March 1966; trawl; uncatalogued.—1, 130; 27 March 1966; trawl; uncatalogued.—1, 165; 7 April 1966; trawl; uncatalogued.—1, 140; 16 April 1966; trawl; uncatalogued.—1, 174; 3 May 1966; trawl; FSBC 15518.—1, 172; 19 May 1966; trawl; FSBC 15519.—2, 175, 182; 3 July 1966; trawl; FSBC 15525.—1, 162; 11 July 1966; trawl; uncatalogued.—2, 160, 166; 11 August 1966; trawl; FSBC 10141.—4, 155–

180; 9 September 1966; trawl; FSBC 15520.—3, 147–179; 9 November 1966; trawl; FSBC 15817.—2, 103, 108; 20 November 1966; trawl; FSBC 15819.—2, 174, 175; 2 December 1966; trawl; FSBC 15523.—1, 168; 14 December 1966; trawl; FSBC 15517.—6, 123–172; 26 January 1967; trawl; FSBC 15829.—1, 153; 6 February 1967; trawl; uncatalogued.—2, 165, 178; 4 April 1967; trawl; FSBC 15516.—1, 150; 12 April 1967; trawl; FSBC 15526.—2, 160, 175; 2 August 1967; trawl; FSBC 15524.—2, 171, 180; 6 October 1967; trawl; FSBC 15521.—HOURGLASS STATION E: 1, 161; 19 July 1966; trawl; FSBC 5214.—HOURGLASS STATION I: 5, 83–192; 6 August 1965; trawl; uncatalogued.—5, 116–167; 3 September 1965; trawl; FSBC 15531.—4, 118–133; 12 October 1965; trawl; FSBC 15539.—2, 117, 141; 12 November 1965; trawl; FSBC 15530.—3, 120–172; 6 December 1965; trawl; FSBC 15529.—7, 94–151; 13 January 1966; trawl; FSBC 4667.—1, 78; 14 February 1966; dredge; uncatalogued.—3, 90–140; 14 February 1966; trawl; uncatalogued.—15, 87–155; 9 March 1966; trawl; FSBC 4788.—3, 71–126; 21 March 1966; trawl; uncatalogued.—1, 51; 11 April 1966; dredge; FSBC 10138.—7, 102–148; 11 April 1966; trawl; uncatalogued.—1, 61; 12 November 1966; trawl; FSBC 15527.—1, 118; 6 December 1966; trawl; FSBC 14605.—2, 72, 89; 8 March 1967; dredge; FSBC 10135.—1, 87; 8 March 1967; trawl; FSBC 10135.—1, 95; 7 April 1967; dredge; FSBC 14536.—4, 113–160; 4 September 1967; trawl; FSBC 11001.—3, 105–164; 11 October 1967; trawl; FSBC 10406.—3, 106–153; 14 November 1967; trawl; FSBC 15528.—7, 51–95; 5 August 1967; SCUBA; FSBC 5340.—HOURGLASS STATION J: 5, 156–172; 6 August 1965; trawl; uncatalogued.—3, 143–158; 3 September 1965; trawl; FSBC 15538.—3, 153–165; 12 October 1965; trawl; FSBC 15534.—6, 161–177; 12 November 1965; trawl; FSBC 4590.—1, 170; 6 December 1965; trawl; uncatalogued.—2, 180, 181; 13 January 1966; trawl; FSBC 15479.—8, 155–170; 14 February 1966; trawl; uncatalogued.—9, 155–195; 9 March 1966; trawl; uncatalogued.—3, 152–190; 21 March 1966; trawl; uncatalogued.—4, 97–178; 11 April 1966; trawl; uncatalogued.—2, 153, 171; 5 July 1966; trawl; FSBC 16012.—29, 103–190; 21 July 1966; trawl; FSBC 15542.—5, 144–178; 5 August 1966; trawl; FSBC 15540.—2, 166, 184; 4 September 1966; trawl; FSBC 10404.—7, 11–17; 12 November 1966; trawl; FSBC 15537.—2, 137, 145; 6 December 1966; trawl; FSBC 15536.—6, 110–184; 12 January 1967; trawl; uncatalogued.—9, 62–194; 30 January 1967; trawl; FSBC 10403.—1, 183; 15 February 1967; trawl; FSBC 15532.—2, 160, 163; 8 March 1967; trawl; FSBC 15533.—1, 105; 15 May 1967; dredge; FSBC 10137.—12, 42–67; 6 August 1967; SCUBA; FSBC 6194.—1, 175; 11 October 1967; trawl; FSBC 15535.—1, 32; 14 November 1967; dredge; uncatalogued.—5, 148–188; 14 November 1967; trawl; FSBC 15913.—HOURGLASS STATION K: 4, 128–160; 6 August 1965; trawl; FSBC 15548.—2, 25, 172; 4 September 1965; trawl; FSBC 4459.—2, 158, 160; 13 October 1965; trawl; FSBC 16033.—5, 160–185; 12 November 1965; trawl; uncatalogued.—2, 150, 160; 13 January 1966; trawl; uncatalogued.—1, 170; 14 February 1966; trawl; uncatalogued.—1, 167; 21 March 1966; trawl; uncatalogued.—5, 153–190; 11 April 1966; trawl; uncatalogued.—13, 143–183; 12 June 1966; trawl; FSBC 15547.—6, 116–174; 5 July 1966; trawl; FSBC 15541.—25, 113–184; 22 July 1966; trawl; FSBC 16029.—1, 65; 5 August 1966; trawl; uncatalogued.—11, 145–197; 4 September 1966; trawl; FSBC 10134.—2, 132, 171; 12 November 1966; trawl; uncatalogued.—5, 57–202; 6 December 1966; trawl; FSBC 15543.—4, 119–172; 30 January 1967; trawl; FSBC 15487.—1, 172; 15 February 1967; trawl; FSBC 15546.—1, 170; 4 September 1967; trawl; FSBC 15545.—1, 158; 11 October 1967; trawl; FSBC 15544.—3, 143–176; 14 November 1967; trawl; FSBC 14867.—2, 166, 170; 13 October 1965; trawl; FSBC 15148.—HOURGLASS STATION L: 4, 177–192; 13 December 1965; trawl; FSBC 4636.—2, 175, 183; 14 January 1966; trawl; FSBC 15037.—2, 165, 171; 15 February 1966; trawl; uncatalogued.—1, 175; 22 March 1966; trawl; uncatalogued.—2, 173, 175; 12 April 1966; trawl; FSBC 11002.—1, 171; 13 June 1966; trawl; uncatalogued.—3, 167–175; 6 July 1966; trawl; FSBC 15489.—12, 155–186; 22 July 1966; trawl; uncatalogued.—2, 180, 188; 5 September 1966; trawl; FSBC

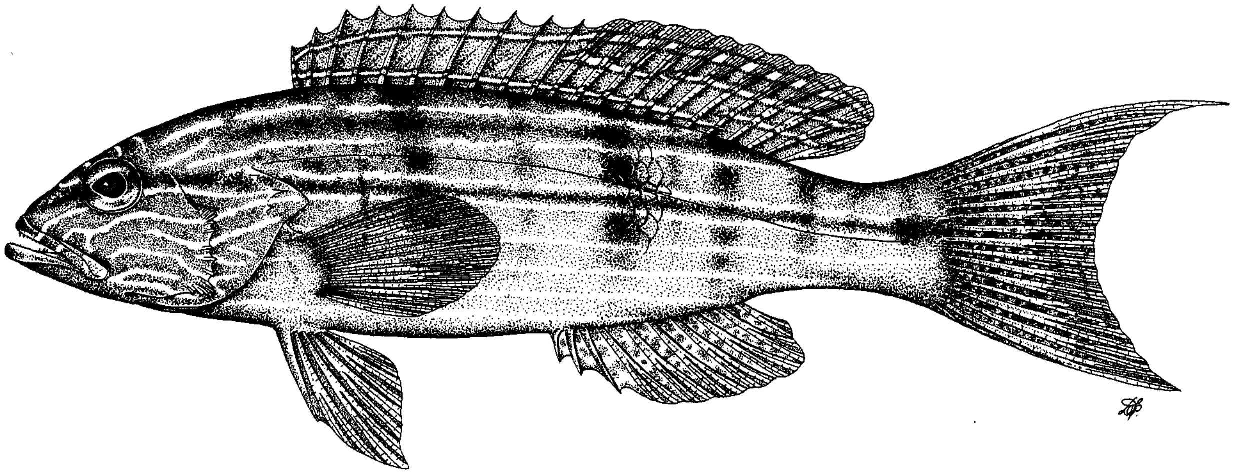

Figure 17. *Diplectrum formosum* (Linnaeus, 1766).

15550.—1, 168; 13 October 1966; trawl; uncatalogued.—2, 17, 180; 13 November 1966; trawl; uncatalogued.—3, 172–177; 7 December 1966; trawl; FSBC 15553.—13, 147–178; 31 January 1967; trawl; FSBC 15556.—1, 183; 9 March 1967; trawl; FSBC 15549.—1, 172; 8 April 1967; trawl; FSBC 15551.—1, 170; 5 September 1967; trawl; FSBC 15552.—4, 168–177; 15 November 1967; trawl; uncatalogued.—HOURGLASS STATION M: 1, 180; 6 July 1966; trawl; FSBC 5170.—3, 175–184; 31 January 1967; trawl; FSBC 15555.—1, 176; 8 April 1967; trawl; FSBC 15554.—1, 191; 8 August 1967; trawl; FSBC 11000.

Diagnosis (modified from Bortone, 1977b): Dorsal X, 12 (rarely 11 or 13); anal III, 7 (rarely 6 or 8); pectoral 15–17 (modally 16). Total gill rakers 17–24.

Adults with pattern of vertical bars with alternating narrow blue and orange stripes. Head with blue lines crossing cheek. Smaller individuals with dark spot at caudal base.

Distinguishing characters: As an adult, *Diplectrum formosum* is distinguished from its congeners by its two clusters (rather than one) of diverging spines on the preopercle (Figure 15A). Juvenile *D. formosum* can be differentiated by their smaller scales and correspondingly higher scale counts (see *Diplectrum* key) (Bortone, 1977b).

Systematics: Bortone (1977b) presented a full synonymy, diagnosis, and description for *D. formosum* and distinguished two morphological populations: a North American subspecies (*D. f. formosum*) and a South American subspecies (*D. f. radians*). All Hourglass specimens of *D. formosum* conformed to the description of the "northern form" (*D. f. formosum*) described by Bortone (1977b). Gill-raker counts were 17–21 (modally 20), similar to meristic data presented by Bortone (1977b) for west Florida populations.

Geographic and bathymetric distribution: Diplectrum formosum, mainly a continental species, is distributed from Virginia to Florida, throughout the Gulf of Mexico, and from northern South America to southern Brazil (Bortone, 1977b). Additional records exist for the Bahamas (Böhlke and Chaplin, 1968); the British Virgin Islands (Bortone, 1977b); Havana, Cuba (Jordan and Evermann, 1896a); and islands of the southern Caribbean (Randall, 1968). *Diplectrum formosum* was collected at all Hourglass stations (6- to 73-m depths). The greatest numbers were taken from 18-m (n = 182) and 37-m (n = 154) depths. Large adults (≥180 mm) were collected at all depths. Length-frequency data arranged according to depth (Figure 18) indicated that smaller individuals were found only at inshore, shallow-water stations, whereas at offshore, deep-water stations, the population consisted entirely of large (≥100 mm) individuals.

Moe and Martin (1965) found *D. formosum* to be most common between 15- and 30-m depths off the west-central Florida coast. Bortone (1977b) listed the known depth distribution of *D. formosum* as 1–80 m, with most records between 7 m and 50 m. Approximately 64% of the Hourglass specimens were collected at 18- and 37-m depths.

Habitat: *Diplectrum formosum* occurs from shallow, inshore grass flats, particularly near Gulf passes (Reid, 1954; Wang and Raney, 1971), to offshore of 73-m depths (FSBC specimens). Bortone (1971b) suggested that *D. formosum* is most commonly associated with sand bottoms peripheral to low-lying reefs and other bottom obstructions. However, G. B. Smith (1976) indicated that the sand perch was also abundant over shell and rocky-rubble bottoms some distance from rocky outcrops.

Reproduction: *Diplectrum formosum* is a synchronous hermaphrodite with a gonad similar to the *Serranus*-type gonad described by C. L. Smith (1965). The gonad consists predominantly of ovarian tissue; testicular tissue is largely confined to the posterior portion.

Ripe Hourglass specimens of *D. formosum* were collected during January, April, August, and September. Greatest observed ova diameters (0.7 mm) occurred in a specimen collected at Station M (73 m) during August. The smallest specimens (10–19 mm; n = 9) were collected during November (Figure 19). There appears to be a rather protracted spawning period from winter to early fall. Bortone (1977b) estimated a March-through-September spawning season for populations of *D. formosum* in the northeastern Gulf; most activity occurred in May.

The smallest Hourglass specimen possessing a ripe gonad was 160 mm (FSBC 10140); however, Bortone (1971b) discovered mature testes in specimens approximately 125 mm and mature ovotestes in specimens of about 150 mm.

Age structure: Bortone (1971b) examined *D. formosum* otoliths and distinguished at least seven age classes (0–VI). In age groups 0–II, there was little overlap in size at age: 0 age fish were modally 30–40 mm, age I fish were 40–50 mm, and age II fish were 80–90 mm.

Diet: Examination of stomach contents of 17 *D. formosum* (Table 6) revealed that the most numerous prey was crustaceans (69%), primarily mysids (36%) and the sergestid *Lucifer* (9.8%). However, since only a limited number of stomachs contained either mysids or sergestids, their dietary importance may be overestimated. Xanthid and portunid crabs were the most frequent prey and represented the greatest biomass.

Other studies (Longley and Hildebrand, 1941; Lowe, 1962; Cervigón M., 1966; Bortone, 1971b) have emphasized the importance of shrimps and crabs in the diet of *D. formosum*. Reid (1954) found that the bulk of *D. formosum* stomach contents consisted of caridean and palaemonid shrimp and mysids. Other dietary items include *Sicyonia brevirostris* Stimpson, 1871 (Cobb et al., 1973); *Squilla rugosa* Bigelow, 1893; and *Meiosquilla* sp. (Camp, 1973). Bortone (1971b) found that *D. formosum* occasionally preyed upon small individuals of *Centropristis* sp. Sedberry (1988) found *D. formosum* to feed on infaunal invertebrates associated with sandy substrates found adjacent to reef areas.

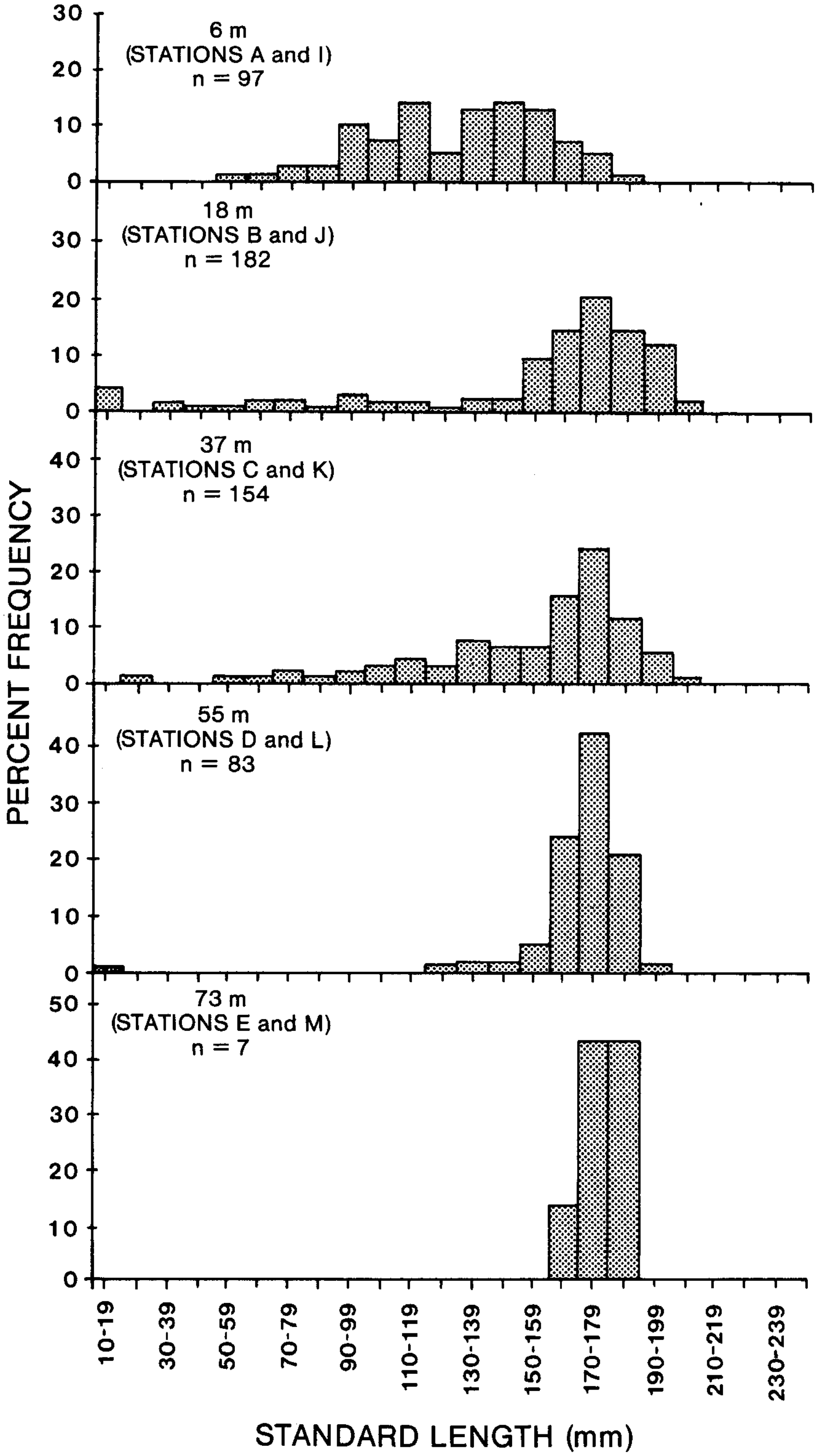

Figure 18. Length frequency distributions of *Diplectrum formosum* according to capture depths at Project Hourglass fishery stations.

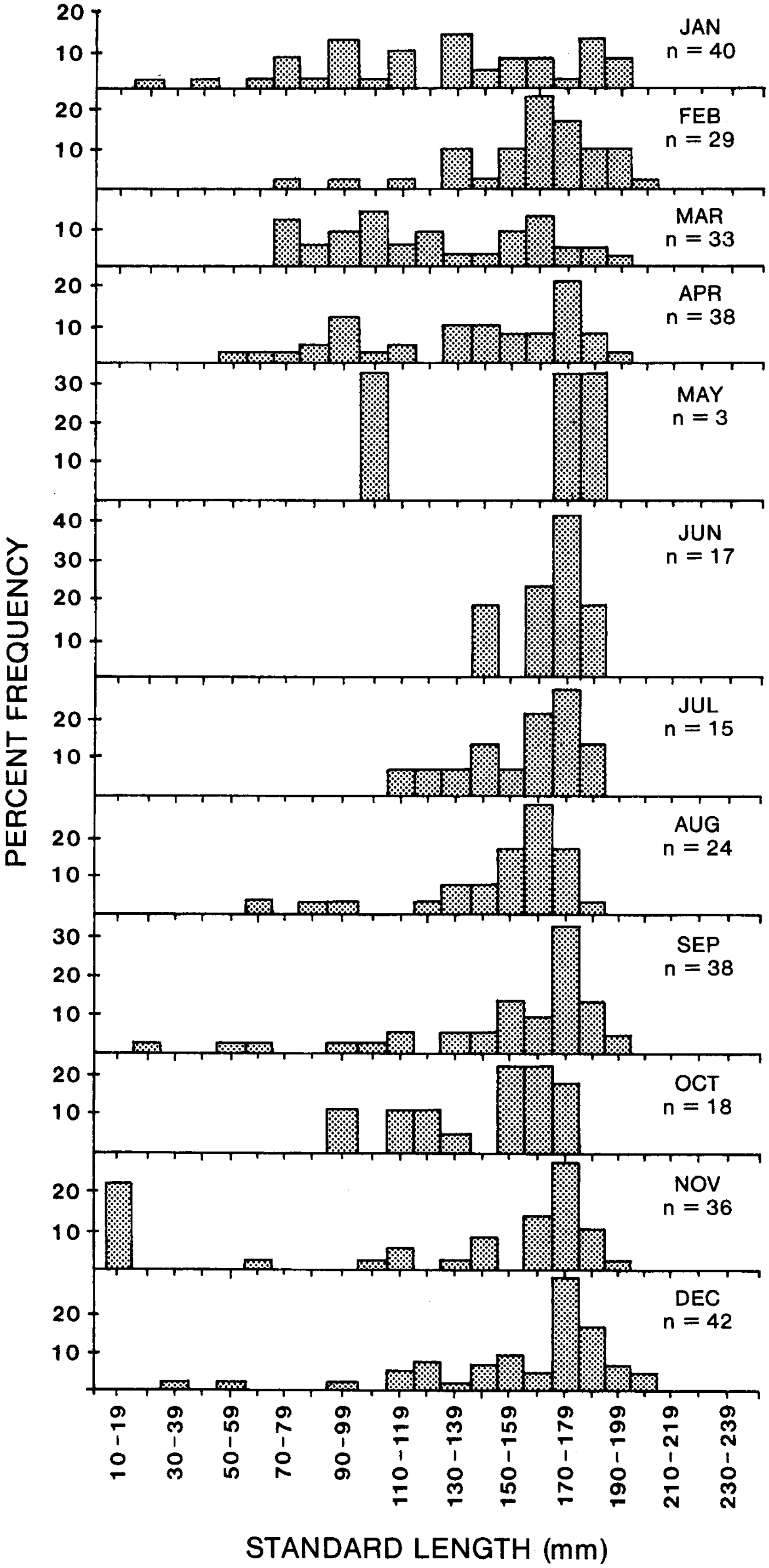

Figure 19. Monthly length frequency distributions of *Diplectrum formosum.*

TABLE 6. DIET OF *DIPLECTRUM FORMOSUM* (48–196 mm) (N = 17).

Taxa	Number of Items	Percentage of Total Items	Number of Stomachs	Percentage of Total (17) Stomachs
Phylum Mollusca				
Class Bivalvia	1	0.2	1	5.9
Class Cephalopoda				
Order Octopoda				
Octopus sp.	1	0.2	1	5.9
Phylum Annelida				
Class Polychaeta				
Family Phyllodocidae	1	0.2	1	5.9
Family Nereidae	1	0.2	1	5.9
Family Glyceridae				
Glycera americana Leidy, 1855	1	0.2	1	5.9
Unidentified polychaetes	7	1.2	3	17.6
Phylum Arthropoda				
Class Crustacea				
Subclass Malacostraca				
Order Stomatopoda	1	0.2	1	5.9
Order Mysidacea				
Suborder Mysida	200	35.5	3	17.6
Order Amphipoda				
Suborder Gammaridea	1	0.2	1	5.9
Order Decapoda				
Suborder Natantia				
Section Penaeidea				
Family Penaeidae				
Penaeus duorarum Burkenroad, 1939	1	0.2	1	5.9
Family Sicyoniidae				
Sicyonia typica (Boeck, 1864)	3	0.2	2	11.8
Unidentified	3	0.2	3	17.6
Family Sergestidae				
Lucifer sp.	55	9.8	1	5.9
Section Caridea	8	0.8	4	23.5
Suborder Reptantia				
Section Anomura				
Family Porcellanidae				
Euceramus praelongus Stimpson, 1860	13	2.3	4	23.5
Family Albuneidae				
Albunea gibbesii Stimpson, 1871	3	0.5	3	17.6
Section Brachyura				
Family Calappidae				
Osachila tuberosa Stimpson, 1871	4	7.1	1	5.9
Family Portunidae	14	2.5	6	35.3
Family Xanthidae	51	9.0	11	64.7
Family Pinnotheridae	3	0.5	1	5.9
Family Majidae				
Stenorhynchus seticornis (Herbst, 1788)	2	0.4	1	5.9
Family Parthenopidae				
Heterocrypta granulata (Gibbes, 1850)	2	0.4	1	5.9

TABLE 6. DIET OF *DIPLECTRUM FORMOSUM* (48–196 mm) (N = 17). (Continued)

Taxa	Number of Items	Percentage of Total Items	Number of Stomachs	Percentage of Total (17) Stomachs
Unidentified brachyurans	27	4.8	10	58.8
Phylum Chaetognatha	142	25.2	1	5.9
Phylum Echinodermata				
Class Ophiuroidea	1	0.2	1	5.9
Phylum Hemichordata				
Class Enteropneusta	1	0.2	1	5.9
Phylum Chordata				
Subphylum Cephalochordata				
Branchiostoma sp.	7	1.2	2	11.8
Subphylum Vertebrata				
Class Pisces				
Family Engraulidae				
Anchoa sp.	1	0.2	1	5.9
Family Synodontidae				
Synodus sp.	3	0.5	3	17.6
Family Serranidae				
Serraniculus pumilio Ginsburg, 1952	7	1.2	2	11.8
Family Haemulidae				
Haemulon aurolineatum Cuvier, 1829	1	0.2	1	5.9
Family Carangidae				
Decapterus sp.	1	0.2	1	5.9
Family Gobiidae	1	0.2	1	5.9
Family Bothidae	1	0.2	1	5.9
Total	566			

Predation: *Diplectrum formosum* has been identified from stomach contents of *Centropristis striata* (M. Godcharles, personal communication), *Sciaenops ocellatus* (Linnaeus, 1766), and *Mycteroperca microlepis* (L. Bullock, personal observation). Other predators include unspecified groupers and snappers (Jordan and Gilbert, 1883b), *Pagrus pagrus* (Linnaeus, 1758) (Manooch, 1977), *Sciaenops ocellatus* (Overstreet and Heard, 1978), and *Carcharhinus leucas* (Valenciennes, 1839) (Branstetter, 1981).

Parasites: *Diplectrum formosum* has been reported as a host for the nematode *Hysterothylacium reliquens* (Deardorff and Overstreet, 1981) and the digenetic trematodes *Lecithochirium parvum* Manter, 1947 (Nahhas and Powell, 1971) and *Sterrhurus musculus* Looss, 1907 (Overstreet, 1969).

Size and commercial importance: The largest Hourglass specimen of *D. formosum* was 206 mm. Maximum size reported by Bortone (1977b) was 223 mm (285 mm TL) in age group VI. Cervigón M. (1966) and Jordan and Evermann (1896b) recorded sand perch of approximately 300 mm TL.

Diplectrum formosum is not regarded as an important food fish because of its relatively small size; however, Beaumariage (1968) suggested its utilization for fish meal because of its abundance.

Genus *Hypoplectrus* Gill, 1862

Diagnosis (after Jordan and Evermann, 1896b): Dorsal X, 13–15; anal III, 7–8; pectoral 13–15. Branchiostegals 7. Body deeper, more compressed than other serranids. Supraoccipital crest elevated; antrorse serrae on lower preopercular limb.

Larvae (3.4–8.5 mm SL) with heavily pigmented first dorsal and pelvic spines; no ventral pigment pattern, but with several spots ventral to base of dorsal fin, several blotches ventrally at pelvic fin base, at anus, along anal fin base, on caudal peduncle, and at base of middle of caudal fin (Kendall, 1979: 10–12, fig. 12; 1984: 503).

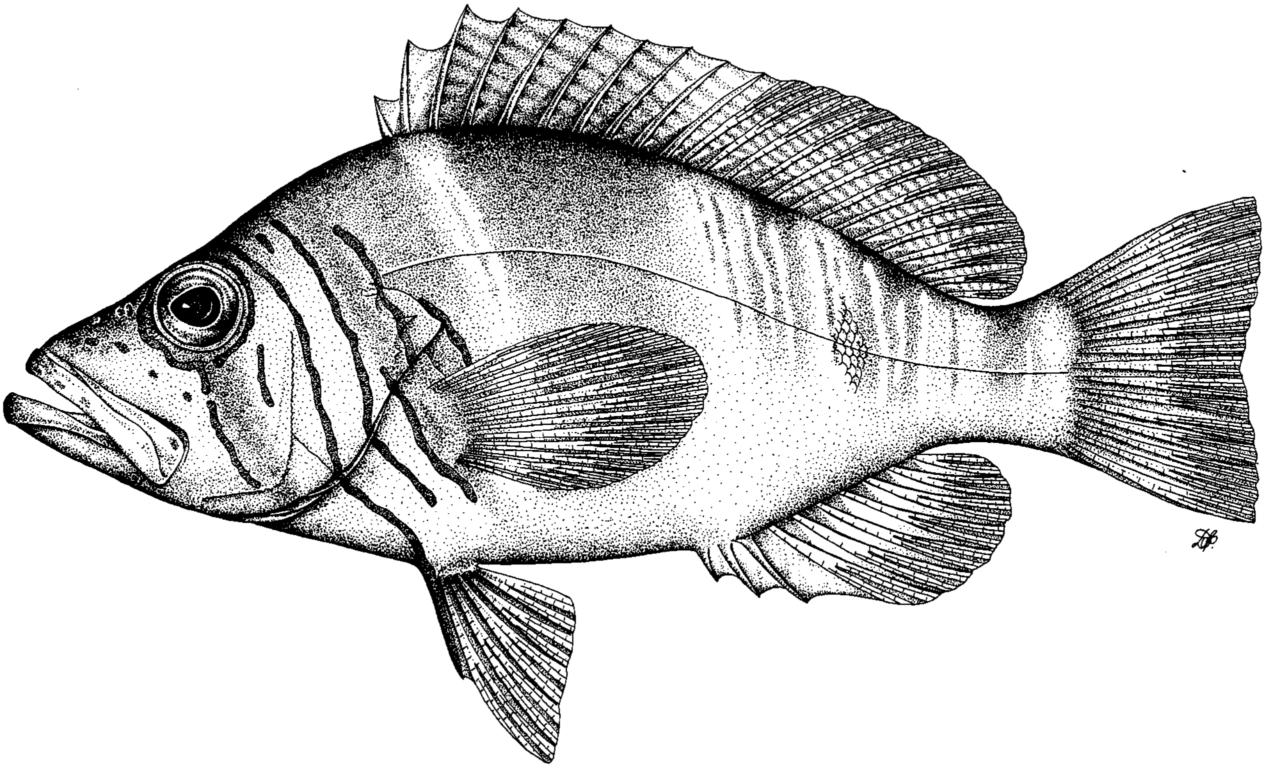

Figure 20. *Hypoplectrus unicolor* (Walbaum, 1792).

Hypoplectrus unicolor (Walbaum, 1792)
Butter hamlet

Figure 20; Plate IV, Figure D

Refer to Jordan and Evermann (1896b) for references prior to 1896.

Perca unicolor Walbaum, 1792, p. 352.

Hypoplectrus puella: Poey, 1868, p. 290; Longley and Hildebrand, 1941, pp. 109, 110 (Dry Tortugas, Florida); Briggs, 1958, p. 272; Randall, 1967, pp. 701, 702; Böhlke and Chaplin, 1968, pp. 274, 275 (illustr.); Randall, 1968, p. 72; Palacio, 1972, pp. 48, 49; Powell et al., 1972, p. 68; Smith and Tyler, 1972, p. 145; Barlow, 1975, pp. 295–300; Colin, 1975, p. 304; Smith et al., 1975, p. 6 (Florida Middle Ground: listing); Walls, 1975, pp. 176, 177; G. B. Smith, 1976, pp. 22, 23; Thresher, 1978, pp. 345–353; 1980, pp. 21, 22.

Hypoplectrus unicolor: Jordan and Evermann, 1896b, pp. 1190–1193; Graves and Rosenblatt, 1980, pp. 240–245; Robins et al., 1980, pp. 37, 81.

Material examined: HOURGLASS STATION C: 1, 93; 3 April 1967; trawl; FSBC 5147.—2, 50, 78; 11 September 1967; trawl; FSBC 5152.—1, 57; 5 October 1967; trawl; uncatalogued.—2, 47, 48; 21 November 1967; trawl; FSBC 15462.—HOURGLASS STATION K: 1, 88; 22 July 1966; trawl; FSBC 5261.—OTHER MATERIAL: FLORIDA KEYS: 1, 65; 16 July 1960; Key Largo; FSBC 1827.—EASTERN GULF OF MEXICO: 2, 55, 65; 10 October 1970; off Sarasota, Sarasota County, Florida, 32 m; FSBC 7401.—1, 102; 11 July 1968; 25°30′N, 83°51′W, 41 m; FSBC 3701.—1, 113; 3 July 1971; off Sarasota, Sarasota County, Florida; FSBC 7396.—2, 70, 121; 5 June 1965; 26°14′N, 83°06′W, 41 m; FSBC 3600.—1, 91; 2 June 1965; 26°32′N, 83°01′W, FSBC 3574.—1, 86; 1 June 1965; 26°45′N, 83°16′W; FSBC 3546.—1, 114; 4 October 1959; off Johns Pass, Pinellas County, Florida, 16 m; FSBC 1560.—1, 103; 19 October 1972; Florida Middle Ground (28°29′N, 84°19′W); FSBC 7590.—1, 91; 28 July 1961; 28°22′N, 51 m; FSBC 2080.—BAHAMAS: 1, 71; 28 July 1959; Bahamas; FSBC 1482.

Diagnosis: Dorsal X, 13–15 (modally 14); anal III, 7; pectoral 13–15 (modally 14); total gill rakers 17–20 (modally 18–19).

Twelve distinct color morphs plus intermediate forms known (Thresher, 1980). Only one color morph known from eastern Gulf: Body yellowish; broad bar narrowing ventrally on front half; smaller bar running from nape to and beyond pectoral base; three narrow bars on posterior half of body; dark bar running from eye to chest; bright blue line encircling eye and continuing as anterior border to dark bar below eye; bright blue spots on snout; three to four blue lines on operculum, one or two of which extend to chest; median fins yellowish, soft portion of dorsal with irregular blue lines. Small juveniles with two black spots at caudal base, one above the other, with squarish white, dusky edged blotch above each; larger juveniles develop dark area anterior and adjacent to upper black caudal spot (from Randall, 1968: 72 on *H. puella* (Cuvier and Valenciennes, 1828)).

Distinguishing characters: Hypoplectrus unicolor is considered to be the only species of hamlet occurring in the Western Atlantic (Robins et al., 1980) and thus possesses the characters of the genus, namely, a deep, compressed body with the lower limb of the preopercle having more than three antrorse spines (Jordan and Evermann, 1896b).

Systematics: Species relationships within *Hypoplectrus* are unclear, largely due to their broad sympatry and lack of diagnostic characters other than color pattern. In the past (Jordan and Evermann, 1896b), color morphs were treated as subspecies of *Hypoplectrus unicolor*. Böhlke and Chaplin (1968), Randall (1968), and Barlow (1975) believed that several species of *Hypoplectrus* exist. Barlow (1975) observed *Hypoplectrus nigricans* (Poey, 1852) spawning with *H. chlorurus* (Cuvier and Valenciennes, 1828) and thus synonymized them. However, he regarded *H. unicolor*, *H. puella*, and *H. chlorurus* as separate because of consistent pairing according to species.

Fischer (1979) used the Van Valen (1976) model of multispecies (a broadly sympatric complex of species, each of which exchanges genes with at least one other member of the group) to explain the presence of separate color morphs. Graves and Rosenblatt (1980) used horizontal starch gel electrophoresis to analyze water soluble enzymes from ten hamlet color types and nine nominal species. They found no evidence to support the concept of separate species but believed that the color forms represented polymorphs of the same species.

Recently, Thresher (1978) proposed that hamlets are aggressive mimics that duplicate the color patterns of common, nonpredatory reef fishes. He felt that the color variants probably arose from some ancestral stock similar to the present-day *H. puella.* Evolutionary adaptations developed a genetic system that allowed for easy chromatic variation without morphometric and meristic variability. Although the "barred hamlet" is the only color morph known from the eastern Gulf, several models for mimicry by other color morphs (e.g., *Chromis cyaneus* (Poey, 1860) by the blue hamlet and *Pomacentrus variabilis* (Castelnau, 1855) by the yellowbellied hamlet) are known to occur on the West Florida Shelf. J. Kimmel (personal communication) has observed the following color morphs at the Dry Tortugas, Florida: "black," "barred," "yellowbelly," and "yellowtail" hamlets.

Geographic and bathymetric distribution: Due to the present systematic confusion regarding species relationships within *Hypoplectrus,* many of the reported species distributions are uncertain. Randall (1968) reported the "barred hamlet" color morph, *H. puella,* from the West Indies, Bermuda, the Florida Keys, and the Gulf coast of Florida. Palacio (1972) reported this form as well as the "butter hamlet" color morph, *H. unicolor,* from the islands off Colombia. Smith et al. (1975), Walls (1975), and G. B. Smith (1976) listed the "*puella*" form as the only "species" of *Hypoplectrus* occurring in the eastern Gulf of Mexico.

Hypoplectrus unicolor is widely distributed in the eastern Gulf of Mexico over rocky substrates in depths of 12–42 m (Smith et al., 1975; G. B. Smith, 1976). During Project Hourglass, specimens of this species were taken only at depths of 37 m.

Habitat: Walls (1975) incorrectly believed this form to be an infrequent straggler in the eastern Gulf. G. B. Smith (1976) reported it as a permanent, but never abundant, resident of rocky reefs. During in situ observations, this morph was usually seen singly or paired (G. Smith, personal observation). Barlow (1975) reported that hamlets are widely spaced over reefs, presumably due to aggressive behavior.

Reproduction: Ripening or ripe gonads were found in hamlets collected during April, June, and July. Maximum observed ova diameters (0.6–0.8 mm) occurred in specimens captured during June and July, the presumed spawning period.

Fecundity estimates for five specimens ranged from 3,648 to 14,477 ova (Table 7).

Barlow (1975) observed paired fish and courtship behavior most often towards dusk, suggesting crepuscular spawning habits in this species.

Diet: *Hypoplectrus unicolor* (n = 4) was found to prey upon penaeid shrimp, unidentifiable crustaceans, and the fish *Gobiosoma oceanops* (Jordan, 1904).

TABLE 7. FECUNDITY ESTIMATES FOR *HYPOPLECTRUS UNICOLOR* (N = 5).

Collection Number	Standard Length (mm)	Fecundity
FSBC 3600	70	9,621
FSBC 3546	86	3,648
FSBC 3574	91	8,127
FSBC 3701	102	7,420
FSBC 7396	113	14,477

Predation: Hypoplectrus unicolor has been found in the stomach contents of *Epinephelus striatus* (Randall, 1967).

Genus *Schultzea* Woods, 1958

Diagnosis (modified from Woods, 1958): Dorsal X, 11–13 (modally 12); anal III, 7; pectorals 15–17; lateral-line scales to end of hypural plate 48 to 56; gill rakers 9–11 + 20–26 (total: 29–39). Branchiostegals 6. Body elongate, depth 21–24% SL. Jaws, vomer, and palatines toothless; jaws highly protrusible. Vertebrae 10 + 14.

Color orange-brown above, bluish silver below, with two orange stripes and irregular bars, brownish above and orange below; caudal peduncle and fin largely yellow.

Schultzea beta (Hildebrand, 1940)
School bass

Plate V, Figure A

Serranus beta Hildebrand, *in* Longley and Hildebrand, 1940, pp. 239–242 (type locality: south of the Dry Tortugas, Florida, probably in 30 or more fathoms; descr.); Briggs, 1958, p. 273 (compiled).

Schultzea campechanus Woods, 1958, pp. 249–252, fig. 40 (type locality: R/V *Oregon* Station 592-A, 23°39.5'N, 88°00'W in 45 fathoms, about 135 mi north of Cabo Catoche, Yucatan Peninsula, Mexico; descr.).

Schultzea beta: Robins and Starck, 1961, pp. 292–295 (syn., descr., habits, habitat); Randall, 1963b, pp. 107, 108 (Curaçao: color descr.); Böhlke and Chaplin, 1968, p. 266 (general account); Randall, 1968, pp. 81, 84 (general account); Davis and Birdsong, 1973, pp. 296–298, 301, 302, 304 (morphology); Colin, 1974, p. 31 (submersible observations); 1976, p. 604; 1978, pp. 194, 195; Anderson et al., 1979 (off the Carolinas); Kendall, 1979, pp. 3, 12 (larvae); Darcy and Gutherz, 1984a, p. 100; Johnson and Smith-Vaniz, 1987, pp. 52, 53 (table 1), 54, 55 (generic relationships).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: CARIBBEAN SEA: 1, 52; 18°47'N, 64°40'W, R/V *Oregon* Station 2622, Virgin Islands; 28 September 1959; FSBC 1554.—FLORIDA KEYS: 1, 69; 24°47.51'N, 83°41.19'W, 61 m; 24 April 1981; triangle dredge; FSBC 17508.—7, 79–95; 24°47.51'N, 83°41.19'W, 67 m; 10 February 1982; otter trawl; FSBC 17507.—1, 81; 25°16.89'N, 83°37.79'W, 1 August 1981; otter trawl; FSBC 17509.—1, 43; off Marathon, Monroe County, Florida, 40 m; 25 August 1986; handnet; FSBC 17510.

Diagnosis: Schultzea is monotypic; characters as in generic diagnosis.

Geographic and bathymetric distribution: Schultzea beta is found off the Carolinas (Anderson et al., 1979), in the Gulf of Mexico, off south Florida, around the Bahamas, and in the Caribbean Sea as far south as the Lesser Antilles (Randall, 1963b). In the eastern Gulf of Mexico, this species has been captured west of the Florida Middle Ground (G. B. Smith, personal observation).

Schultzea beta has been observed in depths of 21–170 m (Böhlke and Chaplin, 1968; Colin, 1974).

Habitat: This species occurs in small schools between coral patches; it feeds on plankton about one foot (0.3 m) above the bottom (Robins and Starck, 1961). Off Jamaica, Colin (1978) observed *Schultzea beta* in mixed groups of juvenile *Haemulon striatum* (Linnaeus, 1758) and *Serranus incisus* Colin, 1978 feeding on zooplankton.

Diet: *Schultzea beta* consumes small planktonic organisms such as copepods (cyclopoids of the families Oithonidae and Corycaeiidae, and harpacticoids), ostracods, crab (megalopa stages), and bivalve and gastropod veligers (Robins and Starck, 1961).

Reproduction: Robins and Starck (1961) found *Schultzea beta* to be hermaphroditic, presumably a simultaneous hermaphrodite. Specimens captured near the Dry Tortugas contained vitellogenic oocytes during February, April, and August (the only months in which sampling was undertaken).

Genus *Serraniculus* Ginsburg, 1952

Diagnosis (after Ginsburg, 1952): Body elongate, rather spindle shaped, depth 27–31% SL; supramaxilla absent; six branchiostegal rays; gill rakers short and few. Monotypic.

Remarks: Ginsburg (1952) stated that *Serraniculus* differed from *Serranus* and *Dules* Cuvier, 1829; however, C. R. Robins suggested that *Dules* and *Serraniculus* are inseparable but recommended no change without further study (Hastings, 1972). Accordingly, generic allocation is tentative.

Serraniculus pumilio Ginsburg, 1952
Pygmy sea bass

Figure 21; Plate V, Figure B

Serraniculus pumilio Ginsburg, 1952, pp. 88, 89; Reid, 1954, p. 37; Briggs, 1958, p. 271; Springer and Woodburn, 1960, p. 34; Cervigón M., 1966; pp. 339, 340; Palacio, 1972, p. 50; Hastings, 1973, pp. 235–242; Walls, 1975, p. 182; Hoese and Moore, 1977, p. 170; Ogren and Brusher, 1977, p. 89 (list); Collins and Finucane, 1984, p. 56; Darcy and Gutherz, 1984a, p. 100; Kendall, 1984, p. 501 (descr. of larvae); Ditty, 1986, p. 945.

Serranus pumilio: Bullis and Thompson, 1965, p. 46 (placed in *Serranus* without comment); Moe and Martin, 1965, p. 136, table 2 (apparently followed Bullis and Thompson, 1965).

Material examined: HOURGLASS STATION I: 3, 39–51; 9 March 1966; trawl; FSBC 4794.—2, 39, 50; 5 August 1967; SCUBA; FSBC 5348.—HOURGLASS STATION J: 5, 25–30; 6 August 1967; SCUBA; FSBC 5386.—OTHER MATERIAL: CARIBBEAN SEA: 3, 25.5–29.5; La Parguera, Puerto Rico, 100 m north of the center of Laurel Reef, 16 m; quinaldine; loan, uncatalogued.—FLORIDA KEYS: 1, 49; Pulaski Shoal; 2 December 1977; FSBC 10228.—1, 62; Smith Shoal; 8 September 1977; FSBC 9872.—EASTERN GULF OF MEXICO: 1, 45; off Tampa Bay, Florida; 29 October 1961; FSBC 1938.—3, 31–35; 17 December 1964; FSBC 3295.—1, 33; off Johns Pass, Pinellas County, Florida; 6 December 1958; FSBC 1053.—1, 38; off Pinellas County, Florida; 8 February 1959; FSBC 1103.—1, 53; off Madeira Beach, Pinellas County, Florida; 13 July 1958; FSBC 0679.—3, 48–50; off New Port Richey, Pasco County, Florida; 3 June 1965; FSBC 3553.—NORTHEASTERN GULF OF MEXICO: 1, 40; off St. Vincent Island, Franklin County, Florida; 20 October 1977; FSBC 9930.

Diagnosis: Dorsal X, 10–11 (modally 11); anal III, 7 (rarely 6); pectoral 14–15; gill rakers 9–

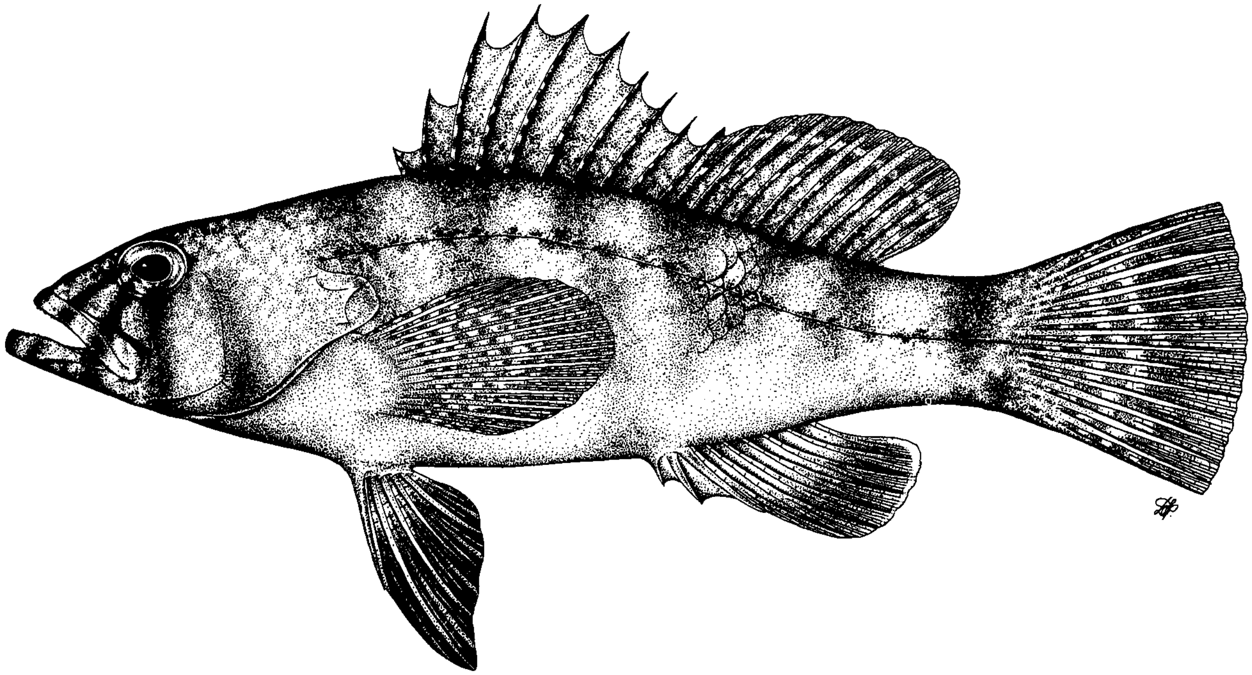

Figure 21. *Serraniculus pumilio* Ginsburg, 1952.

13. Lateral-line scales 40–46. Small species (mature at 25 mm SL), maximum size less than 60 mm SL.

Four diffuse, irregular crossbands on body, sometimes scarcely distinguishable from background; yellowish spot (occasionally 2) behind last band on caudal peduncle; ventral and anal fins black, other fins clear.

Larvae (3.1–7.3 mm SL) deeper bodied and with more lateral pigment than other serranines. Flank pigment composed of three series of dashes (one along midlateral septum and one along base of dorsal and anal fins); superficial small spots over much of trunk. Ventral midline spots small, rather uniform. Spines in fins no longer than soft rays (Kendall, 1984).

Distinguishing characters: Serraniculus resembles *Serranus* and *Centropristis* structurally and in gross appearance but differs by having six rather than seven branchiostegals and fewer gill rakers (9–13 versus 14–31 and 17–25, respectively).

Geographic distribution: Serraniculus pumilio ranges from North Carolina to Florida, throughout the Gulf of Mexico, and southward to Venezuela (Cervigón M., 1966; Hastings, 1973). Hastings (1973) believed that *S. pumilio* does not occur in the West Indies, yet this species has been collected near La Parguera, Puerto Rico (J. Kimmel, personal communication).

Bathymetric distribution and habitat: Although *Serraniculus pumilio* was captured during Project Hourglass only in 6- and 37-m depths, other records show it to be more widely distributed on the West Florida Shelf. Hastings (1973) reported that *S. pumilio* typically occurs at moderate depths (10–70 m) over the continental shelf, but it may occasionally occur in shallow (<1 m) coastal waters (also see Springer and Woodburn, 1960). Bullis and Thompson (1965) reported captures from maximum depths of 117 m in the Gulf of Mexico. Palacio (1972) reported collections of *S. pumilio* off Colombia at depths of 33–165 m.

Like many other small serranids, *S. pumilio* is primarily distributed over sand and shell bottoms peripheral to coral and rocky areas; its absence during G. B. Smith's (1976) study of West Florida Shelf limestone reefs suggests that it is not typically a reef resident. Inshore, *S. pumilio* is sometimes collected in shallow-water beds of *Thalassia* and *Syringodium*. Reid (1954) collected four specimens (32–40 mm) of *S. pumilio* from channels traversing grass flats at Cedar Keys, Florida.

Hastings (1973) believed that shallow-water populations of *S. pumilio* in the northeastern Gulf move offshore during winter.

Reproduction: Ripe ovaries were found in *S. pumilio* specimens collected from June through September. Maximum observed ova diameters (0.6–0.7 mm) were observed in three specimens collected during June (FSBC 3553). Fecundity estimates for these specimens ranged from 4,335 to 7,106 ova; two ova size classes (0.2–0.4 and 0.6–0.7 mm) were present. The smallest specimens in which "ripe" ova (diameters greater than 0.4 mm) occurred measured 25 mm SL (FSBC 5386-03 and 5386-05).

For northeastern Gulf specimens, Hastings (1973) postulated a spawning season from March through August or September. He had limited numbers of small specimens but suspected that gonadal maturity occurred when the fish reached a length of approximately 40 mm.

Collins and Finucane (1984) captured *S. pumilio* larvae during August (1971) in the Florida Everglades area, and Ditty (1986) found larvae off Louisiana during October.

Diet: Only two of the specimens of *S. pumilio* examined contained food. One specimen (FSBC 5348: 50 mm) contained two anomuran crabs; the other (FSBC 3295: 31 mm) contained a penaeid shrimp.

Hastings (1973) also found that *S. pumilio* feeds almost exclusively (91% by total number of dietary items) upon crustaceans, with amphipods numerically most important and shrimps and crabs volumetrically most important.

Behavior: Hastings (1973) described *S. pumilio* as being highly territorial, frequently flaring its dorsal fins, caudal fin, and gill covers and presenting its flank to intruders. The fish rests on the bottom and "hops" from place to place, using its pelvic fins as props.

Predation: Hastings (1973) found *Serraniculus pumilio* in the stomachs of *Lagodon rhomboides*, *Diplectrum formosum*, and *Centropristis striata*. He suggested that the cryptic coloration and sedentary habits of this small sea bass may conceal it from most predators.

Genus *Serranus* Cuvier, 1817

Diagnosis (modified from Robins and Starck, 1961): Dorsal X, (rarely IX or XI) 10–16 (modally 12); anal III, 7 (rarely 6 or 8); pelvic I, 5; pectoral 13–18; caudal 17. Vertebrae 24 (10 + 14). Synchronous hermaphrodites. Supramaxilla lacking. Teeth present on dentary, premaxillary, vomerine and palatine bones; some variously enlarged. Maxilla not sheathed by lacrimal;

second infraorbital present or absent. Preopercle serrate, serrae variously developed. Branchiostegal rays 7.

Size moderate, maximum length (SL) probably not exceeding 230 mm.

Larvae with early forming, elongate dorsal spines; body deeper than other serranids. Pigment at base of dorsal fin and membranes of first dorsal, pelvic, and anal fins (Kendall, 1984).

Remarks: For more complete synonymies for *Serranus* prior to 1961, refer to Robins and Starck (1961).

KEY TO *SERRANUS* SPECIES OF THE GULF OF MEXICO
(Modified from Robins and Starck, 1961.)

1\. Either a black lanceolate mark in inner surface of opercle or a single dark mark on base of an otherwise unpigmented soft dorsal fin; top of head scaled forward to posterior edge of interorbital region (except some specimens of *notospilus*); scales often deciduous............... 2

1\. No black "ear" mark; if a dark mark is present on soft dorsal, then smaller spots also present; top of head naked; scales strongly ctenoid, not deciduous 3

2\. Black lanceolate mark on inner surface of opercle just anterior to and slightly below midopercular spine (Plate V, Figure D), conspicuous dark band on body present or absent....... .... *S. atrobranchus*

2\. Soft dorsal fin with dark mark on base (Plate VI, Figure C), usually continued on body as dark band; sides frequently with vertical white band, sloping dorso-caudally, body generally dusky .... *S. notospilus*

3\. Caudal fin with either distinct hatch marks on leading edges or four dark marks at base (no other bold markings).. 4

3\. Caudal fin variously pigmented but not as above.. 5

4\. Caudal fin with dark hatch marks along leading edges; belly entirely white; head with blue stripes in life, no dark squares along lower side (Plate VI, Figure B); gill rakers 17–20 .... *S. chionaraia* Robins and Starck, 1961

4\. Caudal fin with four dark marks at base, no conspicuous hatch marks along leading edges of caudal fin; head not striped, lower portion of side with four dark squares each with a yellow or red bar below (Plate VI, Figure A); gill rakers 14–17.................................. .... *S. baldwini* (Evermann and Marsh, 1900)

5\. Dorsal soft rays 13 (rarely 12); pectoral rays 16 (rarely 15); caudal, soft dorsal, anal, and pectoral fins with spots forming regular rows; pored lateral-line scales 44–45; belly white, sharply defined from adjacent pattern (Plate VII, Figure A) .... *S. subligarius*

5\. Dorsal soft rays 12 or fewer (very rarely 13); pectoral rays 15 or fewer (or if 16, sides with prominent vertical white bar); pored lateral-line scales 46–52; belly sometimes white, but white area not so extensive or well defined.. 6

6\. Sides of body boldly marked with numerous irregular bands; numerous dark spots in dorsal and caudal fins; snout long, pointed (Plate VII, Figure C); gill rakers 15–19 .... *S. tigrinus*

6\. Sides of body marked but not as above; gill rakers 15–31 7

7\. Upper and lower sections of caudal fin dark, center pale (Plate VII, Figure B); pectoral rays modally 15 .... *S. tabacarius*

7\. Caudal fin uniformly pigmented, or nearly so; pectoral rays modally 13–14 or 16 8

8. Pectoral rays modally 16; sides with vertical white band just anterior to anus (except in young) (Plate VI, Figure D) .... *S. phoebe*
8. Pectoral rays modally 13–14; no vertical white band 9

9. Pectoral rays modally 13; two distinct square blotches behind eye, upper part of side with pattern suggesting inverted V's (Plate V, Figure C); total gill rakers 15–18 .... *S. annularis*
9. Pectoral rays modally 14; dorsum crossed by series of pale bands (pale blue, rarely greenish in life) (Plate VII, Figure D); total gill rakers 27 or more .... *S. tortugarum*

Serranus annularis (Günther, 1880)
Orangeback bass

Plate V, Figure C

Centropristis annularis Günther, 1880, p. 6, pl. 1c (type locality: *Challenger* Station 122, off Pernambuco, Brazil; descr.).

Serranus annularis: Jordan and Eigenmann, 1890, pp. 401, 406; Robins and Starck, 1961, pp. 266–268 (full account); Starck and Courtenay, 1962, p. 16; Randall, 1963b, p. 105, pl. IIIa; Böhlke and Chaplin, 1968, p. 272; Randall, 1968, p. 79, figs. 92, 80; Bright and Rezak, 1976, p. 256, table 1; Miller and Richards, 1979, p. 117 (South Atlantic Bight); ESE et al., 1987, p. 185, fig. 3.9.3 (southwest Florida shelf); Dennis and Bright, 1988b, p. 8 (northwestern Gulf of Mexico).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: SOUTHEASTERN GULF OF MEXICO: 3, 52.4–67.6; 24°47.41′N, 83°51.15′W, 76.1 m; 21 November 1980; otter trawl; FSBC 16217.—1, 57.8; 24°47.41′N, 83°51.15′W, 76.1 m; 25 April 1981; otter trawl; FSBC 16219.—2, 56.9, 59.8; 24°47.51′N, 83°41.19′W, 62.5 m; 10 February 1982; otter trawl; FSBC 16223.—4, 39.4–58.8; 25°16.89′N, 83°37.79′W, 70 m; 17 November 1980; otter trawl; FSBC 16220.—4, 16.8–61.1; 25°16.89′N, 83°37.79′W, 70 m; 8 February 1982; otter trawl; FSBC 16224.—1, 44.2; 25°17.26′N, 82°52.16′W, 44.2 m; 27 April 1981; otter trawl; FSBC 16218.—2, 36.0, 66.6; 25°17.26′N, 82°52.16′W, 49 m; 11 February 1982; otter trawl; FSBC 16222.

Diagnosis (after Robins and Starck, 1961): Dorsal X, 10–12 (modally 12); anal III, 7 (rarely 6); pectoral 13–14 (modally 13); total gill rakers on the first arch 15–18; pored lateral-line scales 43–50. Maximum size approximately 65 mm TL.

Entire dorsum and top of head orange or salmon colored. General pattern on dorsal half of body is a series of inverted blunt V's; first represented only by two yellow postocular marks, the next three darkened or joined to dark dorsolateral patch. Last two V's under soft dorsal fin. Color shifts from salmon-orange to yellow both posteriorly and ventrally.

Remarks: Meristic counts for examined specimens were generally within ranges cited by Robins and Starck (1961) (Tables 1–3), except for four specimens with fewer than 46 lateral-line scales and another specimen with only 6 soft rays in the anal fin.

Distinguishing characters: This species is characterized by the two dull yellow square blotches posterior to the eye.

Geographic distribution: *Serranus annularis* is known from Bermuda, the South Atlantic Bight (Miller and Richards, 1979), the Florida Keys, the southeastern Gulf, the northwestern Gulf off

Texas (Bright and Rezak, 1976; Dennis and Bright, 1988b), and the U.S. Virgin Islands southward to the Guianas and Brazil (Robins and Starck, 1961).

Although *S. annularis* is included in this report, it is not considered a typical inhabitant of the eastern Gulf, having been captured only at the extreme southern portion of this region. However, it is possible that this serranid occurs at the Florida Middle Ground.

Bathymetric distribution and habitat: This serranid occurs at depths of 30–76 m where there are areas of silty sand covered with shell and coral fragments (Robins and Starck, 1961; Randall, 1963b). In the southeastern Gulf, *S. annularis* was captured by trawl at depths of approximately 25–76 m and was considered a typical inhabitant of the mid-shelf area (depths of 60–100 m) (ESE et al., 1987). Dennis and Bright (1988b) found *S. annularis* to be one of the most abundant species occupying the algal-sponge zone in the northwestern Gulf of Mexico.

Reproduction: Specimens (n = 17) were available for only three months: November (1980), April (1981), and February (1982). Individuals of *S. annularis* (39–68 mm) possessed ovo-testes containing vitellogenic oocytes during November and April.

Diet: Robins and Starck (1961) found *S. annularis* to feed primarily on crustaceans, with caridean shrimp (mostly from the family Alpheidae) being the major prey. Copepods and fish were also consumed. Stomach contents from seven specimens collected in the southeastern Gulf consisted of a stomatopod (*Pseudosquilla ciliata* (Fabricius, 1787)), a caridean shrimp (*Periclimenes* sp.), a galatheid crab (*Munida* sp.), and a brachyuran crab.

Serranus atrobranchus (Cuvier, 1829)
Blackear bass

Plate V, Figure D

Centropristes atrobranchus Cuvier, *in* Cuvier and Valenciennes, 1829, p. 45 (type locality: Brazil; descr.).

Serranus atrobranchus: Jordan, 1887a, pp. 532, 533; Jordan and Eigenmann, 1890, pp. 401, 406; Boulenger, 1895, pp. 289, 290; Robins and Starck, 1961, pp. 284–286; Cervigón M., 1966, p. 326; Walls, 1975, p. 183; Chittenden and McEachran, 1976, p. 13; G. B. Smith, 1976, p. 42; Chittenden and Moore, 1977, pp. 106–113; Hoese and Moore, 1977, p. 170; McCaffrey, 1981, p. 120; Grizzle, 1983, p. 86, fig. 38 (parasite); ESE et al., 1987, p. 185, fig. 3.9.3. (southwest Florida shelf).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: CARIBBEAN SEA: 1, 47.5; 18°47′N, 64°40′W, R/V *Oregon* Station 2622, 43.9 m; 28 September 1959; trawl; FSBC 1552.—FLORIDA KEYS: 1, 90; south of the Dry Tortugas, Florida, 24°20.5′N, 82°41.6′W, R/V *Hernan Cortez* Station IC-81-37, 84–110 m; 22 August 1981; 6.1 m semi-balloon otter trawl; FSBC 12144.—5, 56–80; SW of the Dry Tortugas, Florida, 24°24.4′–24°24.7′N, 82°58.2′–82°58.5′W, R/V *Hernan Cortez* Station IC-81-44, 76.2–80.4 m; 24–25 August 1981; 6.1-m semi-balloon otter trawl; FSBC 12145.

Diagnosis (modified from Robins and Starck, 1961): Dorsal X, 12 (rarely 13); anal III, 7; pectoral 15–17 (modally 16); total gill rakers on first arch 15–20; pored lateral-line scales 44–47 (modally 46).

Body uniformly brown with little body pattern in specimens from northern Gulf of Mexico but displaying progressively darker transverse body band and black blotch in dorsal fin in southern specimens (Brazil); characteristic black lanceolate mark on inner surface of opercle also displaying geographic variation with regard to shape.

Transverse body band becoming progressively darker in specimens from northern Gulf of Mexico to Brazil. Intensity of this band clearly depicted in figures of Brazilian specimens (Cervigón M., 1966: 326, fig. 128). Clinal variation also exists for pectoral-fin rays (16, rarely 17 rays in northern Gulf of Mexico to 15, occasionally 16, rays in Brazil) and shape of opercular mark (from wedge-shaped in the north, more ovate in Caribbean, and roundest off Brazil) (Robins and Starck, 1961).

Distinguishing characters: *Serranus atrobranchus* is unique in having the black lanceolate mark on the inner surface of the opercle (Robins and Starck, 1961).

Geographic distribution: This species occurs in the northern Gulf of Mexico (Florida to Texas), southern Florida, and throughout the Caribbean to Brazil (Robins and Starck, 1961).

Bathymetric distribution and habitat: Robins and Starck (1961) reported a depth distribution of 20–150 fm (37–274 m), with most records between 6 and 50 fm (11–91 m). Chittenden and Moore (1977) found *Serranus atrobranchus* abundant along the 110-m isobath off south Texas, where it composed almost 17% of the fish in trawl samples on the brown shrimp grounds.

McCaffrey (1981) found *S. atrobranchus* occupying the sand-mud transition zone in the northeastern Gulf at depths of 18–119 m.

A study of the southwest Florida shelf by ESE et al. (1987) found *S. atrobranchus* in trawl samples in a depth range of approximately 70–125 m.

Reproduction: Chittenden and McEachran (1976) captured a small specimen (35 mm) during January in the northwestern Gulf of Mexico and believed that spawning in that area probably occurred in the fall and early winter. Specimens (79–90 mm) collected in August (1981) near the Dry Tortugas, Florida, contained ovo-testes with vitellogenic oocytes.

Age and growth/longevity: *Serranus atrobranchus* 60–90 mm (TL) are believed to be approaching age I, and fish 100–130 mm (TL) are about age II (Chittenden and McEachran, 1976); the largest fish they sampled was 174 mm (TL). Chittenden and McEachran (1976) concluded that the typical life span for *S. atrobranchus* in the northwestern Gulf is about two years.

Diet: An unidentified fish and crustacean remains were found in the stomachs of six specimens (56–90 mm) captured near the Dry Tortugas, Florida.

Parasites: Grizzle (1983) found unidentified nematodes in the mesentery of *S. atrobranchus* from the Flower Garden Banks off Texas.

Serranus notospilus Longley, 1935
Saddle bass

Figure 22; Plate VI, Figure C

Serranus notospilus Longley, 1935, p. 87 (south of the Dry Tortugas, Florida); Robins and Starck, 1961, pp. 286–288; Powell et al., 1972, p. 70 (list); Miller and Richards, 1979, p. 117, table 1 (South Atlantic Bight); Gilmore et al., 1981, appendix p. 14,

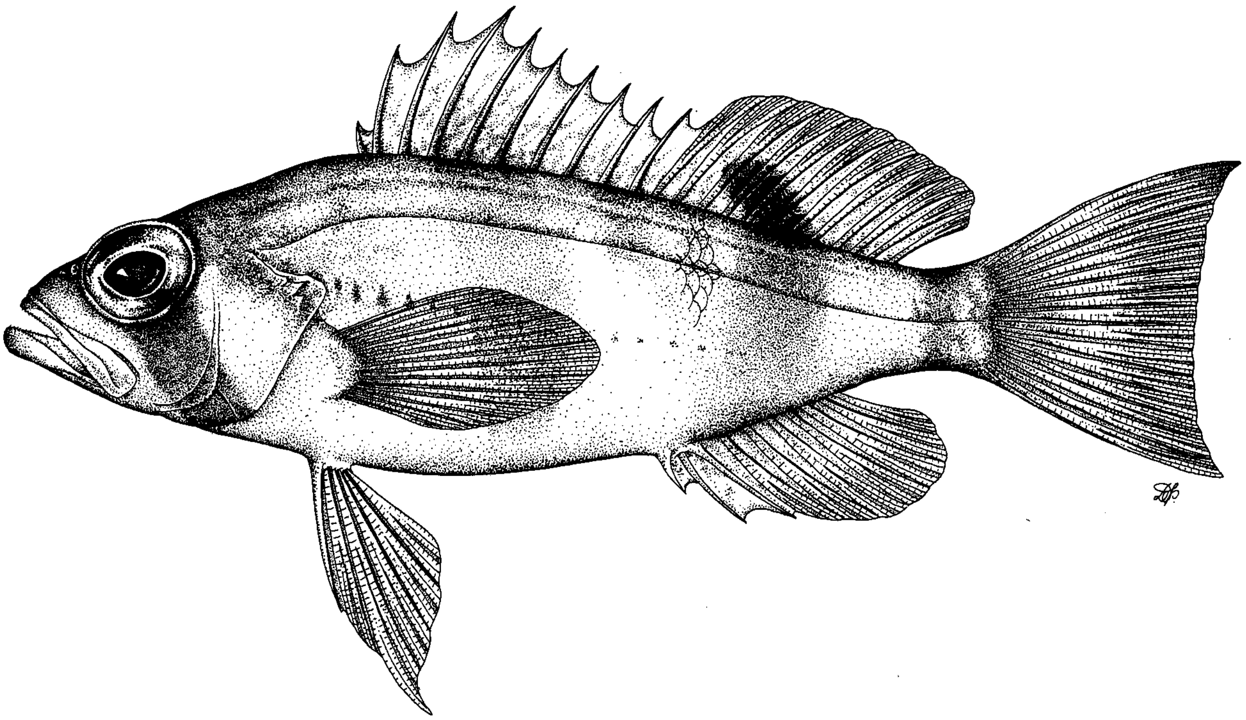

Figure 22. *Serranus notospilus* Longley, 1935.

table 1; McCaffrey, 1981, pp. 120–123 (northeastern Gulf of Mexico); Darcy and Gutherz, 1984a, p. 100, appendix table 1; ESE et al., 1987, pp. 187, 188 (diet, size, and depth).

Material examined: HOURGLASS STATION D: 1, 48; 9 November 1965; trawl; FSBC 4573.—2, 34, 48; 11 August 1966; trawl; FSBC 10014.—HOURGLASS STATION E: 5, 28–47; 2 August 1966; trawl; FSBC 10013.—1, 63; 3 June 1967; trawl; FSBC 5191.—HOURGLASS STATION M: 5, 28–39; 5 September 1966; trawl; FSBC 10015.—OTHER MATERIAL: DRY TORTUGAS: 1, 65; 24°20.5′N, 82°41.6′W, R/V *Hernan Cortez* Station IC-81-18, 84–110 m; 22 August 1981; trawl; FSBC 12457.—2, 65, 72; 24°23.5′–24°24.5′N, 80°00.9′–83°03.5′W, R/V *Hernan Cortez* Station IC-81-42, 97.5–105.2 m; 24 August 1981; trawl; FSBC 12533.—EASTERN GULF OF MEXICO: 3; 51–69; 25°35′–50′N, 150 mi offshore, 366–427 m; 26 July 1962; trawl; FSBC 2234.—4, 45–65; 26°00′N, 61–366 m; 10–15 September 1962; trawl; FSBC 2661.—9, 58–71; 26°00′N, 396 m; 25–26 July 1962; FSBC 2222.—2, 48, 52; 26°24′N, 83°43′W, 73 m; 29 July 1980; trawl; uncatalogued.—1, 70; 26°30′N, 84°37′W, R/V *Hernan Cortez* Station IC-81-10, 189–225 m; 22 April 1981; trawl; FSBC 12049.—2, 65, 80; 26°48′N, 84°27′W, R/V *Hernan Cortez* Station IC-81-18, 190 m; 24 April 1981; trawl; FSBC 12457.—4, 53–67; 27°31′N, 84°31′W, R/V *Hernan Cortez* Station IC-81-29, 136 m; 25 April 1981; trawl; FSBC 12040.—28, 52–69; 27°35′N, 84°31′W, R/V *Hernan Cortez* Station IC-81-28, 125–134 m; 25 April 1981; trawl; FSBC 12458.—18, 56–71; 27°39′N, 84°33′W, R/V *Hernan Cortez* Station IC-81-26, 126 m; 25 April 1981; trawl; FSBC 12060.

Diagnosis (modified from Robins and Starck, 1961): Dorsal X, 11–13 (modally 12); anal III, 7–8 (modally 7); pectoral 14–17 (usually 15–16); total gill rakers 16–23 (modally 19); pored lateral-line scales 44–48 (usually 46 or 47). Maximum size approximately 90 mm TL.

Top of head scaled, extent of squamation varying geographically. Northern (U.S. coast) specimens, entire upper postorbital area and top of head scaled, to point above posterior border of pupil; southern (off South America) specimens lacking interorbital scales; head scales reduced to two rows anterior to occipital line. Scales frequently deciduous.

Coloration varying ontogenetically and geographically. Smaller specimens most boldly marked, patterns of bands and stripes becoming obscured with growth. Generally, three nearly vertical bars present on body; all better developed dorsally. First bar beneath dorsal spines III–V; second under dorsal soft rays 4–7, extending onto fin as dark smudge; third bar, less distinct, occupying caudal peduncle. Juveniles with three horizontal stripes, first extending from eye across opercle to caudal peduncle slightly below lateral line. Second stripe extending from upper orbital edge to anterior base of soft dorsal; third and faintest stripe running between occipital line and base of dorsal spine IV. Pelvic and pectoral fins clear. Chest and front half of belly silvery white. In South American specimens, broad white bar extending from belly dorsad to within two or three scale rows of lateral line and bordering posteriorly the anterior of two dark bars that extend ventrally from dorsal fin (Robins and Starck, 1961: 287).

Two well-defined subspecies of *S. notospilus*, one extending from South America to the Antilles, the other in the Florida Keys and Gulf of Mexico (Robins and Starck, 1961). Meristic characters vary geographically: northern specimens with 15 (modally) pectoral fin rays and southern specimens with 16 (modally); northern specimens with (modally) 6 rows of cheek scales, southern specimens with 7 (modally).

Distinguishing characters: Serranus notospilus has a distinct black blotch on the soft dorsal fin and rear part of the body. Other members of the genus may have a similar marking, but it is in conjunction with other markings on the spinous dorsal fin.

Relationships: Serranus notospilus is closely related to *S. atrobranchus* but lacks the dark opercular mark (Robins and Starck, 1961).

Geographic distribution: Serranus notospilus has been recorded from the South Atlantic Bight, including the Florida east coast (Miller and Richards, 1979; Gilmore et al., 1981); the Florida Keys (Robins and Starck, 1961); the Florida west coast (Powell et al., 1972); throughout the Gulf to Yucatan; and southward to northern South America (Suriname) (Robins and Starck, 1961).

Bathymetric distribution and habitat: Robins and Starck (1961) reported the bathymetric distribution of *S. notospilus* as being about 24–125 fm (44–229 m), with most records citing 40–90 fm (73–165 m). McCaffrey (1981) found *S. notospilus* occupying the sand-mud transition zone in the northeastern Gulf at depths of 38–192 m and also showed a positive correlation between size and depth by noting that larger individuals occur in deeper (colder) water. ESE et al. (1987) observed a similar size/depth relationship in *S. notospilus* in the southeastern Gulf; they characterized this serranid as a common inhabitant of this region in depths of 60–100 m.

Eastern Gulf of Mexico specimens were collected in depths of 55–396 m.

Reproduction: Ripe or near-ripe specimens of *Serranus notospilus* (52–80 mm) have been collected in April, June, July, August, and September, suggesting a protracted spawning period. A protracted spawning season would seem advantageous for small sea basses, because physical constraints preclude the simultaneous maturation of a large number of oocytes. A ripe individual (66 mm) collected in August 1981 contained only 146 mature ova.

Greatest ova diameter was 0.8 mm in a ripe 58-mm specimen (FSBC 2222-08) and a ripe 69-mm specimen (FSBC 2234).

The smallest Hourglass specimens (28 mm) were collected during August and September.

Diet: Although a larval flatfish was found in the stomach of one specimen, *Serranus notospilus* feeds primarily on crustaceans. Crustaceans from the stomachs of 16 specimens were as follows: gammaridean amphipods, euphausiids, ostracods, copepods (*Candacia pachydactyla* (Dana, 1852); *Corycaeus* sp.; *Oncaea mediterranea* Claus, 1863; *Scolecithrix danae* (Lubbock, 1856)), brachyuran crabs (*Palicus* cf. *sica* (A. Milne Edwards, 1880), *Calappa* sp.), megalops, hermit crabs, caridean shrimps (*Alpheus* sp.; *Hippolyte* sp.; *Leptochela bermudensis* Gurney, 1939; *Periclimenes* sp.; *Pontophilus gorei* Dardeau, 1980), and a galatheid crab (*Munida* sp.).

Predation: *Serranus notospilus* has been found in the stomach of the red snapper, *Lutjanus campechanus* (Poey, 1860) (L. Bullock, personal observation).

Serranus phoebe Poey, 1851
Tattler

Figure 23; Plate VI, Figure D

Serranus phoebe Poey, 1851, pp. 55, 56, pl. 2, fig. 3 (Cuba, presumably Havana); Jordan, 1884b, p. 35; Robins and Starck, 1961, pp. 277–279; Moseley, 1966, p. 75; Powell et al., 1972, p. 70; Walls, 1975, pp. 183, 184; Hoese and Moore, 1977, pp. 169, 170; Shipp and Hopkins, 1978, p. 117 (off northwest Florida); Darcy and Gutherz, 1984a, p. 100; Parker and Ross, 1986, p. 43 (off North Carolina); ESE et al., 1987, pp. 187–188 (diet, reproduction).

Serranus phoeby: Moe and Martin, 1965, p. 148.

Material examined: HOURGLASS STATION D: 2, 107, 123; 9 November 1965; trawl; FSBC 13792.—1, 81; 8 February 1966; trawl; uncatalogued.—3, 46–70; 4 March 1966; trawl; FSBC 4961.—1, 140; 7 June 1966; trawl; FSBC 13782.—1, 121; 18 June 1966; trawl; FSBC 10004.—1, 97; 3 July 1966; trawl; FSBC 10003.—1, 100; 11 August 1966; found on deck; FSBC 10001.—1, 95; 11 August 1966; trawl; uncatalogued.—1, 92; 9 September 1966; trawl; FSBC 10000.—1, 133; 9 October 1966; trawl; uncatalogued.—7, 89–128; 26 January 1967; trawl; FSBC 10010.—2, 115, 123; 6 February 1967; trawl; FSBC 10009.—1, 69; 1 September 1967; dredge; FSBC 10002.—HOURGLASS STATION E: 2, 74, 113; 31 August 1965; trawl; FSBC 4437.—4, 126–143; 7 April 1966; trawl; FSBC 4806.—1, 135; 7 June 1966; trawl; FSBC 15649.—1, 138; 3 July 1966; trawl; FSBC 10006.—7, 113–143; 19 July 1966; trawl; FSBC 5282.—8, 85–136; 26 January 1967; trawl; FSBC 15897.—2, 89, 101; 3 March 1967; trawl; FSBC 15648.—1, 62; 6 October 1967; dredge; FSBC 16058.—5, 132–148; 3 November 1967; trawl; FSBC 14351.—HOURGLASS STATION M: 2, 37, 45; 14 December 1965; trawl; FSBC 4639.—4, 125–137; 22 July 1966; trawl; FSBC 5502.—2, 103, 138; 13 November 1966; trawl; FSBC 10011.—1, 97; 13 January 1967; trawl; uncatalogued.—1, 69; 7 June 1967; trawl; uncatalogued.—1, measurements unrecorded; 6 July 1967; trawl; FSBC 10008.

Diagnosis (after Robins and Starck, 1961): Dorsal X, 12; anal III, 7–8 (modally 7); pectoral 15–

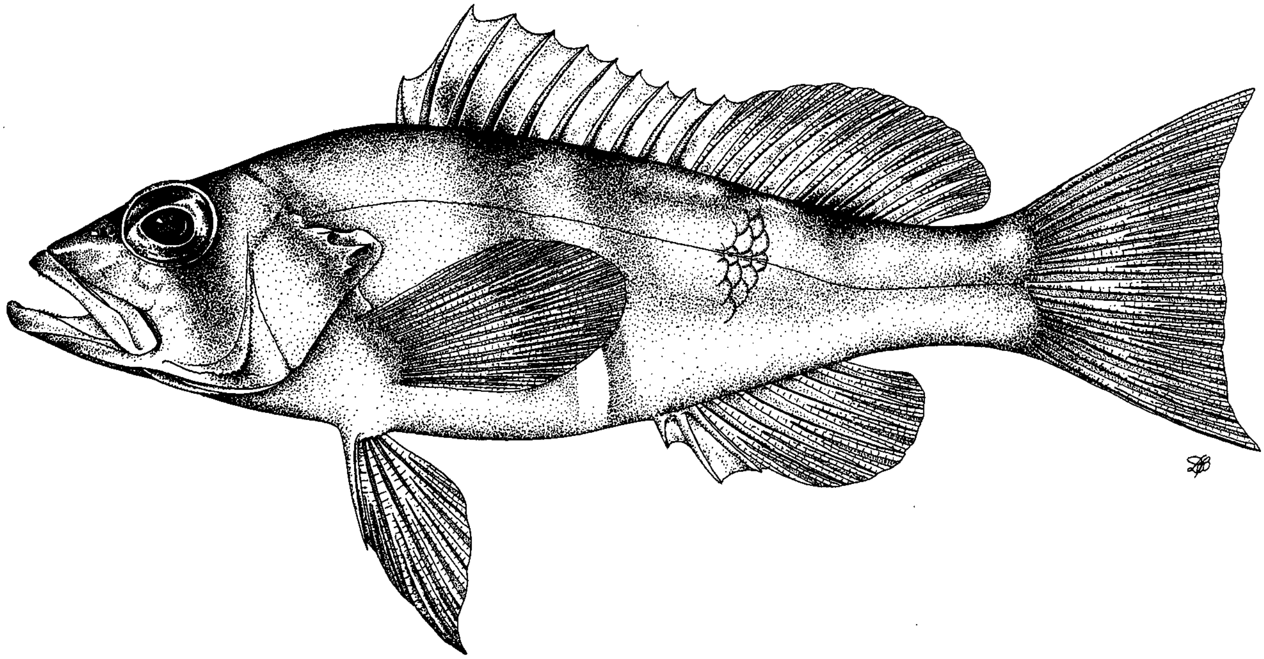

Figure 23. *Serranus phoebe* Poey, 1851.

16; total gill rakers 16–20; pored lateral-line scales 45–51. Maximum size approximately 150 mm TL.

Adult caudal fin shallowly forked; juvenile fin truncate or approximately so. Top of head naked; well-developed opercular spines. Scales strongly ctenoid, not deciduous.

Color pattern distinctive but changes with growth. Juveniles with broad dark band (black on dorsal fin to dark brown on body) extending diagonally and ventrally from distal half of second dorsal spine to basal portions of sixth spine, thence vertically across body to between anus and pelvic-fin base. Midlateral dark stripe extending from caudal-fin base toward vertical band. In adults (>100 mm) these features subdued, poorly defined, sometimes absent but silvery-white bar always present on flank, anterior to anus (immediately behind dark bar, if present).

Distinctive characters: Adult coloration in *Serranus phoebe* is distinctive (Plate VI, Figure D). There is a prominent, vertical silvery-white band anterior to the anus. Juveniles are characterized by a broad, dark diagonal band running ventrally from the anterior spinous dorsal fin to the belly (Robins and Starck, 1961).

Geographic and bathymetric distribution: Serranus phoebe occurs off Bermuda, from South Carolina to Florida, in the Gulf of Mexico to Cabo Catoche, Mexico, and southward through the West Indies to northern South America (Robins and Starck, 1961) or possibly Brazil (Hoese and Moore, 1977). This species has not been recorded from the Bahamas or the Virgin Islands, but it has been taken in fish traps in Puerto Rico (J. Kimmel, personal communication).

In the Gulf of Mexico, *S. phoebe* occurs along the Florida west coast and westward to the snapper banks off Port Aransas, Texas (Moseley, 1966), and southward along the Mexican coast.

Robins and Starck (1961) reported *S. phoebe* to be most common in 30–100 fm (55–183 m); juveniles have been taken in waters as shallow as 14–15 fm (26–27 m). The deepest record for *S. phoebe* is 220 fm (402 m) (Walls, 1975). Parker and Ross (1986) reported the occurrence of *S. phoebe* near every reef they observed from a submersible in depths of 53–125 m off North Carolina. ESE et al. (1987) described *S. phoebe* as one of the characteristic shelf species (along with other serranids) off southwest Florida in depths of 60–300 m.

All Hourglass specimens were collected at 55-m (Station D) and 73-m (Stations E and M) depths.

Habitat: Most specimens of *S. phoebe* were taken by trawl, suggesting that it is not strictly confined to reef-like habitats as are many other serranids, especially groupers of the genera *Mycteroperca* and *Epinephelus.* Robins and Starck (1961: 267) noted that *S. phoebe* frequented areas of "silty sand mixed with shell particles and numerous patches of jagged limestone" or "coral fragments" at Alligator Reef in the Florida Keys. Parker and Ross (1986) noted that *S. phoebe,* like *Centropristis ocyurus,* preferred the soft substrates surrounding reefs off North Carolina. Robins and Starck (1961) observed that small specimens usually swam near the bottom; adults were always observed near a burrow in the sand or rock.

Reproduction: Ripe or near-ripe Hourglass specimens of *S. phoebe* were collected during February (1 specimen only), April, and June through August. Greatest observed ova diameter was 0.7 mm in a 125-mm specimen captured at Station E during July 1966. The smallest specimens, 37–45 mm and 46 mm, were collected during December and March, respectively. Off southwest Florida, ESE et al. (1987) found only immature specimens in a depth of 64 m; ripening or mature individuals occurred further offshore in depths of 74 m and 125 m.

Diet: Very few specimens of *S. phoebe* contained food in their stomachs; generally, stomachs were everted as a result of the pressure changes associated with their deep-water capture. Food usually consisted of crustacean fragments, particularly crabs and shrimps; one 137-mm specimen contained two antenna codlets, *Bregmaceros atlanticus,* Goode and Bean, 1896, in its stomach. ESE et al. (1987) also found primarily crustaceans (shrimp-like decapods and others) and copepods in stomachs of *S. phoebe.*

Stomachs removed from three specimens (133–135 mm) captured off Jacksonville, Florida, in 44-m depths contained the following items: sabellid polychaetes; ampeliscid amphipods; a rock shrimp *Sicyonia* sp.; a caridean shrimp *Leptochela* sp.; a crab *Munida* sp.; remains of anomuran, galatheid, and brachyuran crabs; and unidentified fish remains.

Robins and Starck (1961) examined the stomach contents of six *S. phoebe.* All stomachs contained crustacean remains. By volume, over 90% appeared to be shrimp, about 9% were macruran crabs, and 1% were bivalve mollusks.

Serranus subligarius (Cope, 1870)
Belted sandfish

Figure 24; Plate VII, Figure A

Centropristis subligarius Cope, 1870, pp. 120, 121 (Pensacola, Florida).

Dules subligarius: Woods, 1942, pp. 191, 192; Reid, 1954, p. 38.

Serranellus subligarius: Ginsburg, 1952, p. 88; Briggs, 1958, p. 272; Clark, 1959, pp. 215, 216 (behavior); Springer and Woodburn, 1960, p. 34; Causey, 1969, pp. 40, 45, 46; Wang and Raney, 1971, p. A-4.

Serranus subligarius: Robins and Starck, 1961, pp. 273, 274; Bullis and Thompson, 1965, p. 46; Clark, 1965, pp. 22–25; Moe and Martin, 1965, p. 136; Hastings, 1972, pp. 175–180; Smith et al., 1975, p. 7; Walls, 1975, p. 184; G. B. Smith, 1976, pp. 23, 24; Hoese and Moore, 1977, p. 169; Ogren and Brusher, 1977, p. 89; Gilmore et al., 1978, p. 90; Hastings and Bortone, 1980, pp. 365–374.

Material examined: HOURGLASS STATION B: 1, 38; 20 October 1965; trawl; FSBC 13060.—1, 30; 19 November 1965; dredge; uncatalogued.—1, 28; 19 January 1966; trawl; FSBC 4781.—1, 41; 10 August 1966; dredge; FSBC 11031.—1, 25; 18 October 1966; dredge; uncatalogued.—1, 47; 11 July 1967; dredge; FSBC 16059.—37, 34–60; 25 July 1967; SCUBA; FSBC 5341.—1, 11; 11 August 1967; dredge; FSBC 6079.—2, 23, 38; 11 September 1967; dredge; FSBC 13081.—1, 30; 20 November 1967; trawl; FSBC 13224.—HOURGLASS STATION C: 1, 42; 20 January 1967; dredge; FSBC 5175.—1, 44; 11 July 1967; dredge; uncatalogued.—1, 50; 26 July 1967; SCUBA; FSBC 5366.—HOURGLASS STATION I: 1, 53; 6 June 1967; dredge; FSBC 5193.—HOURGLASS STATION J: 1, 38; 6 August 1967; SCUBA; FSBC 6188.—HOURGLASS STATION K: 1, 35; 12 November 1965; trawl; FSBC 4593.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 1, 82; off Longboat Key, Sarasota County, Florida; 11 July 1970; FSBC 7274.—5, 50–60; off Sarasota, Sarasota County, Florida; 21 June 1970; SCUBA; FSBC 7423.—2, 55, 55; off Sarasota, Sarasota County, Florida; 23 September 1970; FSBC 7479.—1, 75; Egmont Key, mouth of Tampa Bay, Pinellas County, Florida, 3 m; 4 June 1981; hand net; FSBC 12069.—1, 26; off Tampa Bay, Pinellas County, Florida; 19 January 1966; trawl; FSBC 4781.—1, 32; off Egmont Key, Pinellas County, Florida; 16 December 1964; FSBC 2556.—1, 71; off Johns Pass, Pinellas County, Florida; 7–8 April 1959; FSBC 1282.—1, 89; off Clearwater, Pinellas County, Florida; no date; FSBC 7695.—9, 29–60; artificial reef off Clearwater, Pinellas County, Florida; 16 September 1976; FSBC 9120.—1, 13; 13 November 1965; FSBC 4593.—6, 49–57; 13 June 1970; SCUBA; FSBC 7383.—3, 49–62; off Clearwater, Pinellas County, Florida; 16 September 1976; FSBC 9124.

Diagnosis (modified from Robins and Starck, 1961): Dorsal X, 11–14 (modally 13); anal III, 6–7 (modally 7); pectoral rays 14–17 (modally 16), gill rakers 15–19 (usually 16 or 17). Pored lateral-line scales 42–46. Maximum size approximately 100 mm TL.

Body light reddish brown with numerous darker bands; belly white, sharply delimited from surrounding background. Prominent black blotch on first few soft dorsal rays. Caudal and pectoral fins banded or spotted with brown.

Distinguishing characters: Distinctive features of *S. subligarius* (Plate VII, Figure A) include banded caudal and pectoral fins, the black blotch in the soft dorsal fin joined to a wedge-shaped dark bar on the body, and the white belly (Robins and Starck, 1961).

Geographic and bathymetric distribution: *Serranus subligarius* ranges from North Carolina southward to the Florida Keys and westward to Texas (Hastings and Bortone, 1980). Hoese and Moore (1977) thought its range extended further southward to somewhere off Mexico. Bullis and Thompson (1965) had listed *S. subligarius* from a collection off Honduras, but Hastings (1972) suspected that this record resulted from a misidentification of the closely related *S. flaviventris* (Cuvier and Valenciennes, 1829). Robins and Starck (1961) thought that Caribbean records also referred to *S. flaviventris*.

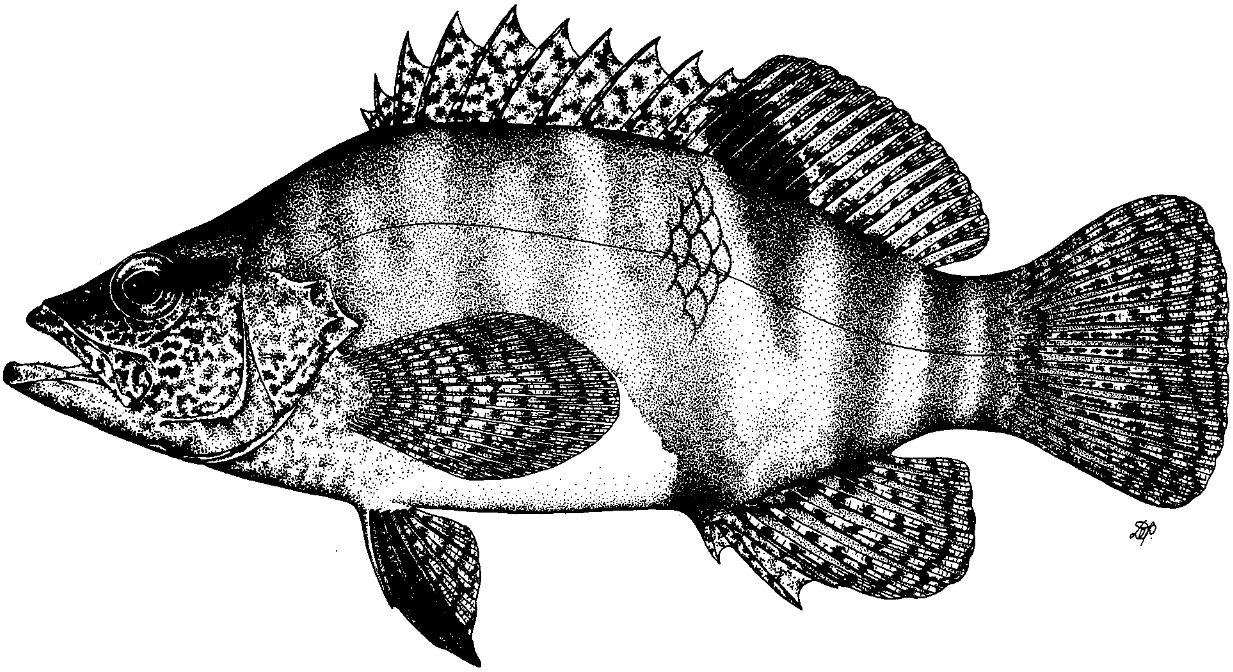

Figure 24. *Serranus subligarius* (Cope, 1870).

G. B. Smith (1976) included *S. subligarius* with a group of fishes demonstrating or approximating a Carolinian warm-temperate distribution.

Serranus subligarius has been reported as common at depths of 8–65 ft (2–20 m) in the eastern Gulf of Mexico (Clark, 1959; Springer and Woodburn, 1960; G. B. Smith, 1976). G. B. Smith (1976) extended its bathymetric distribution to depths of at least 42 m. Hastings (1972) reported *S. subligarius* as seasonally (spring–fall) common at shoreline jetties along the northwest Florida coast.

Off the east central Florida coast, *Serranus subligarius* has been observed as deep as 70–80 m on outcroppings of *Oculina varicosa* Le Sueur, 1820 (Hastings and Bortone, 1980).

Habitat: G. B. Smith (1976) reported that *S. subligarius* was abundant at shallow (12–18 m) reefs off west-central Florida. Springer and Woodburn (1960) reported that it (as *Serranellus subligarius*) was common at rocky reefs to depths of at least 18 m; these authors also collected a single specimen in Boca Ciega Bay (Tampa Bay). Wang and Raney (1971) also collected *S. subligarius* within Charlotte Harbor during fall–early winter. During fall, small specimens (<40 mm) can be found within *Thalassia* and *Syringodium* beds adjacent to Gulf passes along the Florida west coast. Offshore, *S. subligarius* resides almost exclusively at rocky ledges, away from other serranids such as *Serraniculus pumilio* and *Diplectrum formosum*, which occupy sandy areas near the outcrops.

Causey (1969) and G. B. Smith (1976), respectively, reported *S. subligarius* to be the numerically dominant serranid off Texas and one of the most abundant fishes inhabiting shallow-water reefs with depths less than 18 m off west Florida. The habitat preference of *S. subligarius* explains its relative absence in Project Hourglass trawl collections, which sampled reef fishes only

TABLE 8. GONADAL ACTIVITY OF *SERRANUS SUBLIGARIUS* (N = 49).

Month	Number of Gonads Examined	Maximum Oocyte Diameter (mm)
April	2	0.4–0.6
June	9	0.4
July	31	0.2–0.3
	1	0.6
August	1	0.2–0.3
September	5	0.2–0.4

accidentally or incidentally. Most specimens (38 of 53) were collected with rotenone at reefs by SCUBA divers.

Movements: Hastings (1972) believed *S. subligarius* probably moved offshore from shallow-water habitats (jetties) in the northeastern Gulf during winter when water temperatures were lowest and returned in spring as temperatures ameliorated. We have no knowledge of seasonal migrations in the central eastern Gulf. However, *S. subligarius* was found to be relatively cold-hardy at reefs 18 m deep off Tampa Bay, Florida, during a record cold period in January 1977, when bottom water temperatures were recorded as low as 11.6°C (Gilmore et al., 1978).

Reproduction: Serranus subligarius is a functional synchronous hermaphrodite (Clark, 1959; 1965). G. B. Smith (1976) observed well-developed ovotestes in an 80-mm specimen collected during June off Sarasota, Florida.

Specimens with ripe or ripening gonads were found during April and June through September (Table 8). Maximum observed ova diameters (0.6 mm) occurred in specimens taken during April and July. Fecundity of the largest specimen (82 mm) examined was estimated at 18,915 oocytes.

The smallest specimen (11 mm) was captured at Hourglass Station B during August, thereby reinforcing the deduction, based upon gonadal activity, that *S. subligarius* has a late spring–fall spawning period; this inference correlates well with the findings of other studies. Clark (1959) noted that during July, August, and early September (1958), all mature specimens of *S. subligarius* had slightly to greatly distended abdomens. Hastings (1972) and Hastings and Bortone (1980) concluded that spawning occurred in the northeastern Gulf from April or May to September and collected specimens with large, well-developed gonads and mature ova during May through August.

Clark (1959; 1965) described courtship and spawning behavior of this highly territorial serranid.

Age and growth: In the northeastern Gulf, *S. subligarius* lives no longer than four or five years and attains a maximum size no larger than 100 mm SL (Hastings and Bortone, 1980). When compared to other small, synchronously hermaphroditic serranids, the age and growth pattern of *S. subligarius* appears intermediate to the relatively long-lived *Diplectrum formosum* (maximum age of at least six years, maximum size of at least 300 mm TL) and the shortest-lived *Serraniculus pumilio* (maximum age of two years, maximum length of 80 mm SL) (Hastings and Bortone, 1980).

TABLE 9. DIET OF *SERRANUS SUBLIGARIUS* (N = 12).

	Number of Items	Percentage of Total Items	Number of Stomachs	Percentage of 12 Stomachs
Penaeid shrimp	4	14.8	1	8.3
Caridean shrimp	5	18.5	3	25.0
Alpheid shrimp	2	7.4	1	8.3
Shrimp (head only)	1	3.7	1	8.3
Stenorhynchus crab	2	7.4	1	8.3
Anomuran crab	1	3.7	1	8.3
Brachyuran crab	6	22.2	5	41.7
Unidentified crustacean remains	1?	3.7	1	8.3
Synodontid fish	3	11.1	3	25.0
Blennius marmoreus Poey, 1875	1	3.7	1	8.3
Fish scale	1	3.7	1	8.3
Total	27			

Diet: Twelve of the 53 Hourglass specimens examined had food in their stomachs. Caridean shrimp and brachyuran crabs were the most important items, constituting 41% by number and 67% by occurrence (Table 9). Hastings (1972) found that *S. subligarius* feeds primarily upon crustaceans, crabs being the most common item. Occasionally, *S. subligarius* may feed on prey that is quite large; the stomach of one 49-mm specimen contained a 33-mm specimen of the blenny *Blennius marmoreus* Poey, 1875. Clark (1959) noted that *S. subligarius* preyed rather heavily on the crested blenny, *Hypleurochilus geminatus* (Wood, 1824). Hastings and Bortone (1980) found *H. geminatus* to be the fish most often preyed upon by *S. subligarius* in their study in the northeastern Gulf but noted that the crested blenny actually composed a relatively small portion of the total diet of *S. subligarius.* Other fishes consumed were *Opsanus beta, Eucinostomus argenteus,* and an individual of its own species.

Hastings and Bortone (1980) concluded from their study that *S. subligarius* is a euryphagic carnivore, feeding primarily on benthic crustaceans such as amphipods and small decapods. During the first year, planktonic crustaceans (copepods) composed a portion of the diet, although the majority of items consumed were benthic organisms (amphipods and shrimp) (Hastings and Bortone, 1980).

Predation: Specimens of *S. subligarius* have been taken from the stomachs of *Epinephelus morio* (L. Bullock, personal observation) and unspecified groupers and snappers collected off Pensacola, Florida (Jordan, 1884b; Jordan and Gilbert, 1883b). This species has been found in stomach contents of *Centropristis striata* (M. Godcharles, unpublished data).

Serranus tabacarius (Cuvier, 1829)
Tobaccofish

Plate VII, Figure B

Centropristes tabacarius Cuvier, *in* Cuvier and Valenciennes, 1829, p. 44 (type locality: Martinique; descr.).

Prionodes tabacarius: C. L. Smith, 1959, pp. 112, 113.

Serranus tabacarius: Robins and Starck, 1961, pp. 280–283; Starck and Davis, 1966, p. 320; Böhlke and Chaplin, 1968, pp. 270, 271; Randall, 1968, pp. 80, 81; Collette and Talbot, 1972, p. 111; Powell et al., 1972, p. 71; Smith et al., 1975, p. 7; Miller and Richards, 1979, p. 117; Thresher, 1980, pp. 15, 16.

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 2, 95, 135; 25°30′N, 83°51′W, 42.1 m; 11 July 1965; trawl; FSBC 3702.

Diagnosis (after Robins and Starck, 1961): Dorsal X, 12 (rarely 11); anal III, 7; pectoral 15 (rarely 14); total gill rakers 21–25; pored lateral-line scales 50–52 (modally 52).

Body pale brown-orange with large yellow blotches on back, dark "V" on caudal fin; juveniles with dark markings more pronounced.

Distinguishing characters: The color pattern (brown-orange with yellow blotches; dark "V" on caudal fin) of *S. tabacarius* easily sets this species apart from its congeners (Plate VII, Figure B).

Geographic and bathymetric distribution: Serranus tabacarius has been reported from Bermuda, the South Atlantic Bight, and southern Florida southward through the Caribbean islands at least to Martinique and presumably to South America (Robins and Starck, 1961; Miller and Richards, 1979). Two FSBC specimens and a field identification at the Florida Middle Ground (Smith et al., 1975) established this species' presence in the eastern Gulf of Mexico.

Specimens of *S. tabacarius* have been taken from the Bahamas in 1- to 30-m depths (Böhlke and Chaplin, 1968), and this species occurs elsewhere in depths of up to 69 m. Robins and Starck (1961) reported this fish as common on Alligator Reef, Florida Keys, at 11- to 30-m depths on the deeper parts of the living reef.

Behavior: Serranus tabacarius is usually found swimming a short distance above the sand or perched on its ventral fins near coral outcrops (Böhlke and Chaplin, 1968; Thresher, 1980). Starck and Davis (1966) and Collette and Talbot (1972) found this species to be inactive at night.

Reproduction: Serranus tabacarius is a synchronous hermaphrodite, having sharply contrasting male and female zones in the gonad (C. L. Smith, 1959). The male portion lies in the posteroventral gonadal wall. Sperm collect in separate ducts, unlike eggs, which are found in the gonad lumen.

Our two FSBC specimens (95 mm, 135 mm) were ripe/ripening in July (1965).

Diet: Robins and Starck (1961) examined three stomachs containing food and found that 50% of the contents were crustacean remains (shrimp) and 50% appeared to be atherinid fishes.

Size: Serranus tabacarius attains sufficient size (approximately 140 mm TL) to be caught by anglers (Robins and Starck, 1961).

Serranus tigrinus (Bloch, 1790)
Harlequin bass

Plate VII, Figure C

Holocentrus tigrinus Bloch, 1790, p. 77 (type locality: East Indies, in error; descr.: based on Seba).

Prionodes tigrinus: Beebe and Tee-Van, 1928, pp. 139–141 (Haiti).

Serranus tigrinus: Robins and Starck, 1961, pp. 271–273; C. L. Smith, 1965, pp. 10, 11, fig. 9 (synchronous hermaphroditism); Randall, 1963a, p. 34; 1967, pp. 705, 706; Böhlke and Chaplin, 1968, p. 269; Randall, 1968, pp. 77, 78 (fig. 80); Collette and Talbot, 1972, p. 111 (diurnal); Smith et al., 1975, p. 7; Jones and Thompson, 1978, p. 164; Williams and Williams, 1980, pp. 578, 585, 588, 589 (parasites); Pressley, 1981, pp. 33–46 (pair formation); Colin, 1982, p. 71; Parker and Ross, 1986, p. 35, table 1 (North Carolina); Fischer, 1987, table 2, p. 147 (fecundity); Colin and Clavijo, 1988 (spawning off Puerto Rico).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: CARIBBEAN SEA: 1, 35.3; reef just north of Golding Cay, Bahamas, 4 m; 27 August 1959; rotenone; FSBC 1464.—FLORIDA EAST COAST: 1, 75.7; Riviera Beach, Palm Beach County, Florida; November 1967; FSBC 6099.—FLORIDA KEYS: 1, 75; Coffins Patch Reef off Marathon, Monroe County, Florida, 4 m; 16 September 1981; handnet; FSBC 12241.

Diagnosis (after Robins and Starck, 1961): Dorsal X, 12; anal III, 7; pectoral 14; pored lateral-line scales 48–51; cheek scale rows 11–13; total gill rakers on first arch 15–19.

Head elongate, pointed; lower jaw well projected.

Color pattern distinctive with dark, vertical markings prominent in intermediate to large individuals; young with more horizontal markings producing ladder-like pattern. Prominent dark spot near front of spinous dorsal.

Distinguishing characters: The elongate, pointed head with projecting lower jaw and the color pattern are distinctive (Plate VII, Figure C). The head length is distinctively greater than the body depth.

Geographic and bathymetric distribution: *Serranus tigrinus* is reported from Bermuda, North Carolina (Parker and Ross, 1986), the Bahamas, southeastern Florida through the Keys (Robins and Starck, 1961), and the Florida Middle Ground in the eastern Gulf of Mexico (Smith et al., 1975). This species is also known from Haiti, Puerto Rico, the Virgin Islands, Curaçao, Panama, Cuba, and Yucatan (Robins and Starck, 1961).

Serranus tigrinus can be found from the shoreline to 120 ft (37 m) in the Florida Keys (Robins and Starck, 1961). However, in the eastern Gulf it inhabits depths of at least 37 m (Florida Middle Ground).

Habitat and behavior: Adult *S. tigrinus* have been observed to form long-term pair associations to defend territories in coral rubble areas adjacent to reefs (Pressley, 1981). Randall (1963a) collected this fish in 9-m depths on an artificial reef made of concrete blocks in the U.S. Virgin Islands.

Serranus tigrinus is active only during daylight hours (Collette and Talbot, 1972), taking shelter under coral at night (Pressley, 1981).

Reproduction: Serranus tigrinus is a synchronous hermaphrodite with separate male and female portions of the gonad (C. L. Smith, 1965).

The single gonad we examined from a 75-mm individual collected in the Florida Keys during September (1981) was ripe.

Pressley (1981) noted that each adult *S. tigrinus* spawned with a conspecific in a shared territory. Spawning occurred near sunset within their territorial boundaries. One individual initiated spawning by curving its body into an "S" shape with its exposed belly facing the other pair-member. When the other pair-member approached, both fish rapidly ascended to a position 1–2 m above the bottom, where they released gametes (Pressley, 1981; Colin, 1982; Colin and Clavijo, 1988). Sexual roles were often reversed, with the former approacher initiating an S-bend display that culminated in a second spawning rush. No more than two spawning rushes were observed per day among paired individuals (Pressley, 1981).

Mean fecundity for 12 individuals captured off Panama was 1,434 ± 259 ova per gonad (Fischer, 1987).

Diet: Prey of this species in the Caribbean included shrimps (primarily carideans), fishes, stomatopods, and crabs (Randall, 1967). Shrimps and other crustaceans made up the diet of *S. tigrinus* examined off Haiti (Beebe and Tee-Van, 1928).

Pressley (1981) noted that *S. tigrinus* employed synchronized stalking behavior with its pair member. He felt that each partner's total probability of success would be increased by employing this strategy.

Parasites: The cymothoid isopods *Renocila bowmani* Williams and Williams, 1980 and *R. waldneri* Williams and Williams, 1980 have been observed to infest *S. tigrinus* (Williams and Williams, 1980).

Serranus tortugarum Longley, 1935
Chalk bass

Plate VII, Figure D

Serranus tortugarum Longley, 1935, p. 87 (type locality: south of the Dry Tortugas, Florida; original descr.); Longley and Hildebrand, 1940, pp. 238, 239, fig. 8; 1941, p. 107 (compiled); Briggs, 1958, p. 273 (compiled); Robins and Starck, 1961, pp. 279, 280 (full account); Starck and Courtenay, 1962, p. 161; Starck and Davis, 1966, p. 320; Randall, 1967, p. 706 (dietary habits); Böhlke and Chaplin, 1968, p. 270; Randall, 1968, pp. 80, 81, fig. 93; Colin, 1973, p. 89; Thresher, 1980, pp. 16–19; Darcy and Gutherz, 1984a, p. 100, appendix table 1; Fischer, 1984, pp. 143–151 (reproduction); 1987, table 2, p. 147 (fecundity).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: SOUTHEASTERN GULF OF MEXICO: 1, 77.8; 24°47.41′N, 83°51.15′W, 76 m; 25 April 1981; otter trawl; FSBC 16226.—3, 51.5–59.7; 24°47.51′N, 83°41.19′W, 67 m; 10 February 1982; otter trawl; FSBC 16225.—1, 51.5; 25°16.89′N, 83°37.79′W, 70 m; 17 November 1980; otter trawl; FSBC 16227.

Diagnosis (after Robins and Starck, 1961): Dorsal X, 12 (rarely 10); anal III, 7; pectoral 14–15 (modally 14); total gill rakers on first arch 26–31; pored lateral-line scales 46–50 (usually 48–49). Maximum size approximately 65 mm.

Body orange-brown shading to white below. Vertical bars above lateral line pale blue. Head orange with four dusky-blue transverse bands dorsally. Dorsal fin pale orange with outer edge of fin membrane between first three spines black.

Distinguishing characters: The barred color pattern on the upper half of the body distinguishes this species from *Serranus annularis*, which has bars on the lower half of the body. *Serranus tigrinus* has full-length bars, and *S. tabacarius* lacks bars.

Geographic distribution: Serranus tortugarum is known from the Bahamas, off South Florida, the eastern Gulf of Mexico, off Honduras, Panama, Jamaica, Puerto Rico, and the Virgin Islands (Robins and Starck, 1961; Darcy and Gutherz, 1984a; J. Kimmel, personal communication).

Bathymetric distribution and habitat: Serranus tortugarum has been captured most often at depths of 9–91 m. The shallowest and deepest records are 9.1 m and 402 m, respectively (Robins and Starck, 1961). Specimens taken in the eastern Gulf of Mexico were from depths of 67–76 m.

Serranus tortugarum may be found in groups of 10 to 300 or more hovering over rubble mounds, rocks, and coral outcrops that usually occur at the reef base (Thresher, 1980; Fischer, 1984). Colin (1973) found *S. tortugarum* associated with mounds of coral rubble produced by the sand tilefish, *Malacanthus plumieri* (Bloch, 1787).

Reproduction: We were unable to define a definite spawning season for this synchronous hermaphrodite due to the small number of specimens (n = 5) examined. However, one ripe individual was captured in April (1981). Longley and Hildebrand (1940) believed spawning occurred in August near the Dry Tortugas, Florida.

Thresher (1980: 19) described spawning in *S. tortugarum* as follows:

> An aggregating species, at dusk the large cluster of chalk bass spread out into individual pairs of fish, each pair a foot or two off the bottom and several feet from other pairs. Spawning is a lightening fast rush into the water column and quick s-curve by the pair; the whole sequence lasts no longer than a second. A given pair will spawn repeatedly each evening, at intervals of as little as 5 minutes.

Off Panama, pairs of *S. tortugarum* were found to spawn up to 17 times per evening. Reproductively active fish were 30–50 mm SL, and pairing was decidedly size-assortive: the size difference of individuals composing a pair was never greater than 10% (Fischer, 1984). Mean fecundity for 112 individuals was 327 ± 22 ova per gonad (Fischer, 1987).

Fischer (1984) believed *S. tortugarum* and other simultaneously hermaphroditic serranids, such as *Hypoplectrus nigricans* (=*unicolor*), engage in a reproductive strategy known as "egg trading," whereby one partner "parcels out" eggs for fertilization in exchange for fertilizing the eggs of its partner.

Diet: Adapted for planktivorous feeding by its fusiform body and numerous gill rakers, *S. tortugarum* has been found to consume amphipods as well as benthic organisms such as alpheid shrimps (Robins and Starck, 1961). Randall (1967) studied the feeding habits of this species and found calanoid, cycloid, and harpacticoid copepods constituted 92% (by volume) of the diet. Fish eggs made up the remaining 8%.

Predation: Fischer (1984) found that spawning aggregations of *S. tortugarum* attracted lizardfish, which would lie in wait to capture this serranid.

Subfamily Epinephelinae

Diagnosis: Small-scaled, large-mouthed, predaceous forms. Body oblong, robust, elongate or compressed. Maxilla large; vomerine and palatine teeth present. Dorsal spines II–XIV, rays 12–27. A maximum of two predorsals, no autogenous distal element on the first dorsal pterygiophore (Johnson, 1983). No anal spines and 13–17 rays in *Rypticus*, otherwise III, 7–13. Opercle with three spines (rarely two in *Rypticus*). Vertebrae 24–25.

Larvae of *Epinephelus*, *Mycteroperca*, and *Paranthias* (among others of the tribe Epinephelini [sensu Johnson, 1983]) with stout, elongate, serrate, and pigmented dorsal- and pelvic-fin spines, usually the second dorsal spine and pelvic spines as long as body. The first and third dorsal spines and anal spines also stout, sometimes serrate. Elongate, serrate spine at preopercular angle, with one spine on either side, sometimes serrate. Serrate supracleithral spine present (Kendall, 1984).

Body of larvae kite-shaped. Body cavity lined with pigment; large spot on caudal peduncle that migrates from ventral midline to midlateral position during flexion (Kendall, 1984).

Genus *Epinephelus* Bloch, 1793

Diagnosis (after C. L. Smith, 1971a): Anal rays III, 7–9 (occasionally 10); body somewhat compressed, deepest at dorsal-fin origin. Lateral skull crests converging anteriorly, then diverging to intercept posterior orbital rim.

Remarks: For more complete synonymies of the 14 species of *Epinephelus*, refer to C. L. Smith (1971).

KEY TO *EPINEPHELUS* SUBGENERA AND SPECIES OF THE GULF OF MEXICO
(Modified from C. L. Smith [1971] by P. Heemstra [personal communication].)

1. Dorsal spines consistently 9; head spotted 2
1. Dorsal spines 10 or 11 3

2. Caudal rounded; no pair of dark spots on lower lip or on dorsal surface of caudal peduncle; no blue spots surrounded by black rings on body and head; body with dark reddish-brown spots (approximately ⅛ inch diameter), some darker centrally; usually three or four spots below dorsal-fin base; anal fin III, 8; pectoral rays 16 . . . . *E.* (*Cephalopholis*) *cruentatus*
2. Caudal convex, but with obtuse angles at upper and lower corners; two dark spots on lower lip and a second pair on dorsal surface of caudal peduncle; body and head with small blue spots surrounded by narrow black rings (also deep-water reddish phase and chrome yellow [xanthic] variants); anal fin III, 9; pectoral rays 17–19. . . . . *E.* (*Cephalopholis*) *fulvus*

3. Strong hook-like antrorse spine on ventral edge of preopercle; body generally brownish or orange with small orange spots and dark brown blotches that tend to form vertical bars (Plate VIII, Figure B). . . . . *E.* (*Alphestes*) *afer* Bloch, 1793
3. No antrorse spine on ventral edge of preopercle; body coloration not as above 4

4. Head and body not compressed, nearly round in cross section; longest dorsal spines (for specimens greater than 300 mm SL) shorter than anterior soft rays; interorbital equal to (fish 100–150 mm) or much greater than (>200 mm) orbit diameter ..... *E.* (*Promicrops*) *itajara*
4. Head and body more or less compressed; longest dorsal spines longer than anterior soft dorsal rays; interorbital width not much greater than orbit diameter (fish <500 mm SL) 5

5. Ctenii on most body scales reduced, fish smooth, except behind pectoral fin; body deep, strongly compressed, depth greater than head length; dorsal rays 17–20 (rarely 17)......... .... *E.* (*Dermatolepis*) *inermis*
5. Scales strongly ctenoid; head and body robust, not strongly compressed; depth not greater than head length; dorsal rays 14–18 6

6. Dorsal-fin rays 15–18; pelvic-fin origin below or behind lower end of pectoral-fin base; pelvic fins shorter than pectorals 7
6. Dorsal-fin rays 13–16; pelvic-fin origin in front of lower end of pectoral-fin base; pelvic fins (of fish 100–500 mm) subequal to or longer than pectorals............................ 11

7. Anal-fin rays 8–10 (usually 9); rear margin of caudal fin truncate or concave............ 8
7. Anal-fin rays 8 or 9 (usually 8); caudal fin convex or rounded........................ 9

8. Dorsal-fin membrane distinctly notched between spines, third or fourth spine longest; head, body and median fins covered with small white spots (Plate VIII, Figure D; Plate IX, Figure A) .... *E. drummondhayi*
8. Dorsal-fin membrane not notched between spines, second spine longest; head and body dark reddish brown, with irregular white spots and blotches; black dots on snout and cheek (Plate XI, Figure D; Plate XII, Figure A).. *E. morio*

9. Head and body with dark bars or bands (but rapid color change possible from almost white to uniform dark brown); distinct black saddle blotch on top of caudal peduncle; black dots below and behind eye; dark "tuning fork" on top of head between the eyes (Plate XIII, Figure D; Plate XIV, Figure A)............................. *E. striatus* (Bloch, 1792)
9. Head and body covered with small dark reddish or orange-brown spots. 10

10. Black saddle blotch on peduncle and 3–5 dark blotches at base of dorsal fin (Plate VIII, Figure A); no blackish margin on soft dorsal fin; pectoral-fin rays 18–19 (usually 19)....... .... *E. adscensionis*
10. No black saddle blotch on peduncle; no dark blotches at base of dorsal fin; soft dorsal fin with blackish margin (Plate X, Figure D); pectoral rays 16–18 .... *E. guttatus*

11. Dorsal-fin spines 10, second longest.................................... *E. nigritus*
11. Dorsal-fin spines 11, third or fourth longest.................................... 12

12. Body brownish, with 8 or 9 subvertical dark bars, last 2 may be fused into single wide band on caudal peduncle (Plate XII, Figures B and C) .... *E. mystacinus*
12. No dark vertical bars on body 13

13. Posterior nostril 3–5 times larger than anterior (on fish larger than 150 mm SL); spinous dorsal-fin margin black (Plate XIII, Figure C)................................ *E. niveatus*
13. Nostrils subequal; spinous dorsal-fin margin yellow; pearly-blue line from eye to corner of preopercle (Plate IX, Figures B and C)................................ *E. flavolimbatus*

Epinephelus adscensionis (Osbeck, 1771)
Rock hind

Plate VIII, Figure A

Trachinus adscensionis Osbeck, 1771, p. 96 (Ascension Island: original descr.).

Epinephelus adscensionis: Henshall, 1891, p. 387 (Key West, Florida); Longley and Hildebrand, 1941, p. 93 (Dry Tortugas); Manter, 1947, p. 371 (Dry Tortugas: parasites); Springer and Woodburn, 1960, p. 34; Randall, 1962, p. 228 (Virgin Islands: tagging study); 1967, pp. 696, 697 (dietary habits); Overstreet, 1969, p. 144 (parasite); C. L. Smith, 1971a, pp. 145–148 (complete account); Smith et al., 1975, p. 6; Walls, 1975, pp. 169, 170; Bright and Rezak, 1976, p. 256 (Texas); Huntsman, 1976 (Carolina headboat fishery); Hoese and Moore, 1977, p. 172; Thompson and Munro, 1978, p. 128; Nelson, 1988, p. 180, table A2.2 (dietary items).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: FLORIDA KEYS: 1, 158; west of Loggerhead Key, the Dry Tortugas, 1.5–3.7 m; 26 April 1967; poison; FSBC 4242.—EASTERN GULF OF MEXICO: 1, 310; 265° off Johns Pass, Pinellas County, Florida, 45.7 m; April 1959; hook and line; FSBC 1292.—1, 330; 85 mi off Clearwater Pass, Pinellas County, Florida, on a heading of 285°, 31–38 m; hook and line; FSBC 7100.—2, 285, 326; 28°17′N, 84°08′W (Florida Middle Ground), 31 m; 14 November 1973; hook and line; FSBC 8013.—NORTHEASTERN GULF OF MEXICO: 1, 275; 40 mi off St. Andrew Bay, Bay County, Florida, on a heading of 205°, 45.7 m; 19 June 1965; hook and line; FSBC 4215.

Diagnosis (modified from C. L. Smith, 1971a): Dorsal XI, 16–17; anal III, 8 (rarely 9); pectoral 18–19; gill rakers 24–28. Body robust, caudal fin convex, dorsal interspinous membranes well notched.

Body with large brownish-red spots that become larger ventrally. Two or three saddle-shaped blotches along dorsal-fin base and another on caudal peduncle. Vertical fins without dark margins. Nocturnal pattern of irregular vertical bars in quiescent fish.

Distinguishing characters: The two or three dark saddles along the base of the dorsal fin and another saddle located dorsally on the caudal peduncle readily distinguish this species. Although both *E. adscensionis* and *E. guttatus* have reddish spots, these markings become larger ventrally in *E. adscensionis*, whereas they remain a uniform size in *E. guttatus*. Additionally, in *E. guttatus*, the dorsal, anal, and caudal fins have conspicuous dark margins not found in *E. adscensionis*.

Geographic and bathymetric distribution: C. L. Smith (1971a) remarked that *Epinephelus adscensionis* was one of only a few wide-ranging Atlantic groupers. This species has been reported from the Azores, the Canary Islands, and Ascension Island. In the western Atlantic, it has been documented from Bermuda, Massachusetts, North Carolina and South Carolina (Huntsman, 1976), the Dry Tortugas (Longley and Hildebrand, 1941), the Gulf of Mexico (C. L. Smith, 1971a), the Antilles, and along the northern coast of South America to Brazil.

Epinephelus adscensionis is found within a wide bathymetric range. C. L. Smith (1971a) collected this species off Bimini in water as shallow as 1 m; on the Texas continental shelf, it occurs in depths as great as 76 m (Bright and Rezak, 1976). This species is usually captured on the West Florida Shelf in depths of 30 m or more.

Reproduction: One hundred seventeen (117) specimens of *E. adscensionis* from the Florida Middle Ground were examined. The male/female ratio was 1.8:1. The sex ratio was probably affected by hook size selection (i.e., larger male rockhinds were more apt to be captured). Large hook size allowed females to reach maturity prior to being captured; no immature females were observed.

Females were 252–355 mm (0.54–1.58 kg), whereas males were 287–375 mm (0.85–2.04 kg). Although females were not found in every monthly sample, ripe females (275–355 mm) were noted during January–June. Postspawning females were observed in July and August; resting females were present during October–December. Some females exhibited early stages of vitellogenesis in December. Ripe or ripening testes were noted during April–July; spent males appeared during August–September and November.

A ripening female (352 mm; 1.36 kg), captured in June 1984 was estimated to contain 760,819 ± 13,062 vitellogenic oocytes from a gonad weighing 36.59 g (559 ± 10 oocytes/g body wt).

Diet: Randall (1967) found that the rock hind in the Puerto Rico-Virgin Islands area consumed (by volume) 66.7% crabs, 20.1% fish, and lesser amounts of other organisms. Randall (1967) noted that the rock hind readily fed on fishes captured in fish traps. Crustaceans and the pomacentrid *Chromis multilineatus* (Guichenot, 1853) composed approximately 67% and 17%, respectively, of the stomach contents of rock hind captured on the Flower Garden Banks off Texas (Nelson, 1988). Invertebrates taken from a limited number of specimens from the Florida Middle Ground included the crab *Mithrax acuticornis* Stimpson, 1871, the remains of what appeared to be the arrow crab *Stenorhynchus seticornis* (Herbst, 1788), and the cleaner shrimp *Stenopus hispidus* (Olivier, 1811).

Length-weight relationship: The relationship of weight to length for *E. adscensionis* (combined sexes) captured at the Florida Middle Ground is expressed by the following: $W = 5.28 \times 10^{-8}$ $SL^{2.905}$ ($n = 79$, $r^2 = 0.75$) (Figure 25), and $W = 1.30 \times 10^{-8}$ $TL^{3.043}$ ($n = 78$, $r^2 = 0.79$), where W is whole weight in kilograms and lengths are in millimeters.

Parasites and abnormalities: In the present study, a reddish-brown philometrid nematode was frequently found in the gonad of *E. adscensionis.* Plerocercoid metacestodes were found attached to the viscera. The trematodes *Stephenostomum dentatum* (Linton, 1900) and *Helicometra torta* Linton, 1910 have been taken from *E. adscensionis* captured off south Florida (Manter, 1947; Overstreet, 1969).

A testis was observed in which only a small portion contained spermatogenic tissue; the remainder appeared to be composed of hardened ovarian tissue. This condition would appear to greatly reduce total sperm production.

Size and commercial importance: Thompson and Munro (1978) captured an individual in Jamaican waters that was 510 mm TL. In their review of the literature, they considered 600 mm to be the maximum length attained by this species.

In the eastern Gulf of Mexico, *E. adscensionis,* captured in a size range of 252–375 mm (0.54–2.04 kg), is a minor component of charter- and party-boat catches from the Florida Middle Ground. The modal size-class for females was 305–314 mm; males were most abundant in the 335–344 mm size range.

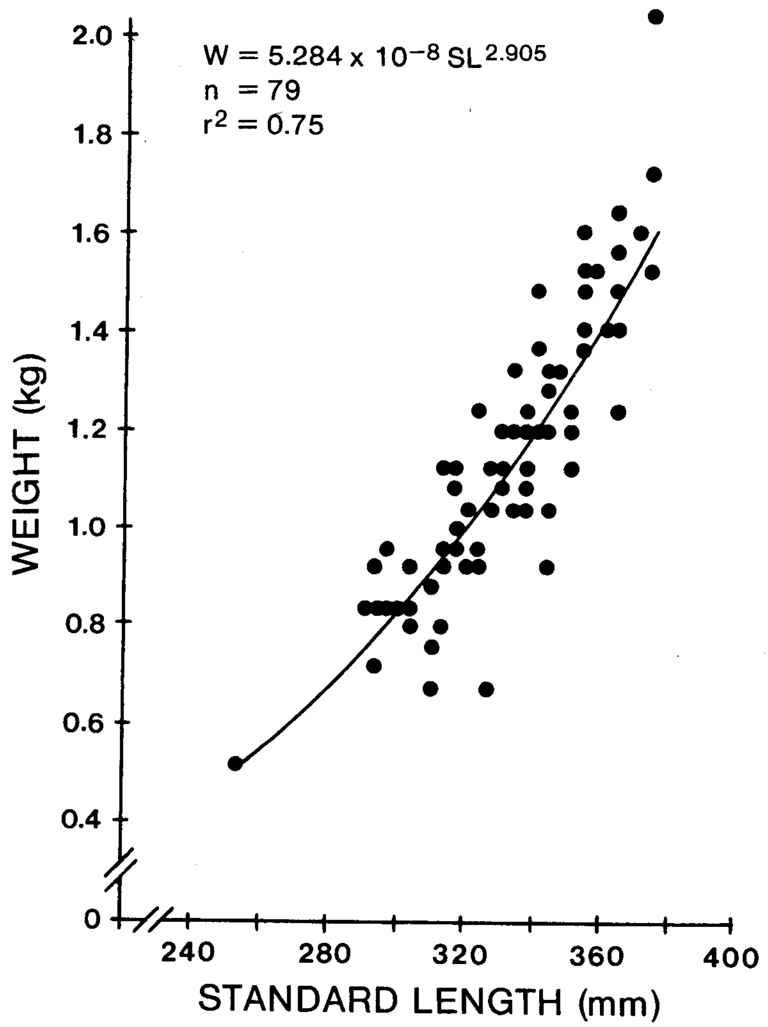

Figure 25. Length-weight relationship of *Epinephelus adscensionis* captured by hook and line at the Florida Middle Ground.

The rock hind, a component of the North Carolina-South Carolina headboat fishery, is usually captured in a weight range of 2–5 lb (0.9–2.3 kg) in depths of 15–30 fm (27.4–54.9 m) (Huntsman, 1976).

Epinephelus cruentatus (Lacépède, 1802)
Graysby

Plate VIII, Figure C

Sparus cruentatus Lacépède, 1802 (1800–1803), pp. 156, 157, pl. 4, fig. 1 (original descr.: based on Plumier).

Petrometopon cruentatus: Jordan and Evermann, 1896a, p. 371; Evermann and Kendall, 1900, p. 73 (Florida Keys); C. L. Smith, 1958, pp. 21, 42, 43, fig. 14, pl. 2 (Bermuda: biology); 1959, p. 114 (hermaphroditism); Kimmel, 1985, p. 89, table A1 (Puerto Rico).

Petrometopon cruentatum: Fowler, 1907, p. 252 (Vieques, Puerto Rico); C. L. Smith, 1959, pp. 111–118; Briggs et al., 1964, pp. 451, 452 (SE of Port Aransas, Texas); Randall, 1967, p. 705 (dietary habits); Böhlke and Chaplin, 1968, p. 265 (Bahamas); Randall, 1968, p. 64, fig. 68 (general account, color photograph); Colin, 1974, p. 31; Thompson and Munro, 1974, p. 66; Walls, 1975, pp. 181, 182; Nagelkerken, 1977, pp. 311–315; Thompson and Munro, 1978, pp. 117–120, 124.

Epinephelus cruentatus: C. L. Smith, 1971a, pp. 97–101; Collette and Talbot, 1972, pp. 107, 112; Bright and Cashman, 1974, pp. 350, 351; Smith et al., 1975, p. 6 (Florida Middle Ground); Bright and Rezak, 1976, p. 256; Kaufman, 1976, p. 377; G. B. Smith, 1976, p. 41; Sonnier et al., 1976, p. 108; Hoese and Moore, 1977, p. 171; G. B. Smith, 1978, p. 52; Nagelkerken, 1979, pp. 1–118; 1981, pp. 27–29; Williams and Williams, 1981, pp. 1009, 1012 (parasites).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: CARIBBEAN SEA: 1, 68; 27°25′N, 76°52′W, Eleuthera Island, Bahamas; 28 August 1959; FSBC 1483.—2, 32.8, 35.8; Great Stirrup Cay, Bahamas; 24 August 1959; FSBC 1443.—EASTERN GULF OF MEXICO: 2, 156, 168; 220° off Sarasota, Sarasota County, Florida, 29.0–29.9 m; 3 July 1971; spear; FSBC 7496.—2, 83.9, 86.0; 240° off New Pass, Sarasota, Florida; 14.6–15.2 m; 13 August 1972; SCUBA; FSBC 7544.—1, 222; 90 mi NW of St. Petersburg, Pinellas County, Florida; 4–6 August 1972; hook and line; FSBC 7186.—1, 258; 27°48′N, 84°34′W; 22 August 1972; hook and line; FSBC 7205.—1, 231; 27°40′N, 84°21′W; 4 September 1972; hook and line; FSBC 7217.—1, 217; 300° off Johns Pass, Pinellas County, Florida, 32.9–36.6 m; 19 May 1973; hook and line; FSBC 7670.—1, 235; Florida Middle Ground, 29.3–42.1 m; 23 January 1972; hook and line; FSBC 7577.—1, 235; Florida Middle Ground, 36.6–39.6 m; 25 September 1979; hook and line; FSBC 11640.

Diagnosis (modified from C. L. Smith, 1971a): Dorsal IX, 14; anal III, 8; pectoral 16; well-developed gill rakers 18–21; body robust, preopercle rounded, finely serrate.

Dense pattern of red or brown spots over reddish-gray background; four distinct spots (sometimes 5 evident) along base of dorsal fin varying from black to white independently of rest of body color. White stripe sometimes found running from tip of lower jaw across upper jaw and snout to near origin of dorsal fin. Quiescent ("sleep") or excitement pattern consisting of irregular vertical bars on body with longitudinal stripes on head.

Distinguishing characters: *Epinephelus cruentatus* has nine dorsal spines and a well-rounded caudal fin, which readily separate this species from all western Atlantic species of *Epinephelus* except the coney, *E. fulvus*. The coney has a color pattern of small blue or black spots on a red, brown, or yellow background, unlike the graysby's pattern of red spots on a red-gray background (C. L. Smith, 1971a).

Geographic distribution: *Epinephelus cruentatus* has been reported from Bermuda, the Bahamas, the South Atlantic Bight, and Florida, including Triumph Reef off Miami, the Dry Tortugas, the central West Florida Shelf off Sarasota, the Florida Middle Ground, and off Panama City. Other Gulf of Mexico sites include off Louisiana, Texas (including the East and West Flower Garden Banks), and Campeche, Mexico. This species also occurs throughout the Greater and Lesser Antilles, and off Belize, Honduras, Panama, Colombia, and Venezuela (Nagelkerken, 1979).

Bathymetric distribution and habitat: Thompson and Munro (1978) collected adult graysby in *Thalassia* beds in 2–4 m depths in Kingston Harbor, Jamaica. Colin (1974) found graysby to be common in depths of up to 170 m off Jamaica and up to 145 m off Belize. On a coral reef off the southwest coast of Curaçao, Nagelkerken (1979) found two abundance maxima: one at a depth of 7.5–9.0 m and a second at a depth of 30 m. These maxima were strongly influenced by the type and amount of coral structure. Juveniles were mainly found at 6-m depths. Kimmel (1985) found the graysby to be the most abundant grouper in coral reef biotopes off La Parguera, Puerto Rico.

In the eastern Gulf of Mexico, the preferred habitat of *E. cruentatus* is the rocky reef ledge at depths greater than 27 m (G. B. Smith, 1978). Prior to the 1971 summer red tide along the Florida west coast, *E. cruentatus* was never observed or collected in less than 29-m depths. Following the red tide, it was commonly found at shallow-water reefs (12–18 m), where it remained until its abrupt disappearance during the summer of 1974. The inshore occurrence and numerical abundance of this species after the red tide were undoubtedly a transient phase of reef-fish succession (G. B. Smith, 1978). Therefore, *E. cruentatus* should not be regarded as a typical member of the shallow-water eastern Gulf of Mexico reef community.

Perhaps the temporary success of *E. cruentatus* at shallow reefs after the red tide can be ascribed to reduced competition due to the elimination of larger serranids. A similar phenomenon was observed in Jamaica. Noting that *E. cruentatus* was more abundant at heavily fished Jamaican reefs, Thompson and Munro (1974: 66) speculated that it "benefits in some way from reduced competition or predation in the exploited areas." Increased catches of this species by anglers fishing the Florida Middle Ground may be an indication of reduced grouper populations in that intensively fished area.

Reproduction: C. L. Smith (1959) presented evidence that *E. cruentatus* is a protogynous hermaphrodite. There were no males in the smallest-sized groups he examined, but the largest-sized groups were exclusively males. Also, regressive oocytes were found in testes of functional males. Thompson and Munro (1978) found ripe individuals during April–June in Jamaica. In Curaçao, Nagelkerken (1979) found the spawning season to occur from May to October, with peak spawning occurring during August and September. Mature females were 160–250 mm TL and were 4–5 years old. Mature males were 215–274 mm TL and were 5–7 years old (modally 6). Transitionals occurred between 195 mm and 234 mm TL and were 4–5 years old.

Gonads from 34 individuals of *E. cruentatus* from the Florida Middle Ground were examined histologically. The male/female ratio was 2.8:1, but this value is probably a sampling artifact. Most females are too small to be captured by the large hooks used in this fishery. Size range for mature females was 165–305 mm SL, whereas males were 223–322 mm SL. Ripe males were found during May, July, and August, whereas ripe females were noted in July and August. Spent males were found in September (1979). These data, although not representing the entire year, appear to support Nagelkerken's (1979) conclusion that *E. cruentatus* is a summer spawner.

Thompson and Munro (1978) calculated that a female 290 mm TL (estimated weight 411 g) from the Caribbean contained 262,604 oocytes or 639 oocytes/gram weight.

Diet and feeding behavior: Randall (1967) found that the main prey of graysbys in the Virgin Islands was fishes (66.2% by volume), with shrimps, crabs, gastropods, and stomatopods making up the remainder of the diet. Nagelkerken (1979) found that adults showed a strong preference for *Chromis multilineatus;* juvenile graysbys fed more heavily on shrimps than on fishes. Feeding was heaviest during sunrise and sunset, especially on *C. multilineatus.* Crustaceans became a more important food during and after sunset because of their increased nocturnal availability.

Parasites: The isopod *Anilocra haemuli* Williams and Williams, 1981 has been seen attached to *E. cruentatus* inhabiting West Indian coral reefs (Williams and Williams, 1981).

Size and commercial importance: Although *Epinephelus cruentatus* does not grow to be large (maximum size of 230 mm TL recorded from Jamaican waters by Thompson and Munro [1978]), it is a food fish of some importance in areas such as the Bahamas, where it is abundant.

Graysbys are only a very minor component of headboat catches from the Florida Middle Ground in the eastern Gulf of Mexico. Fishing pressure appears concentrated on the larger individuals (mostly males) of the population. Hook-size selection appears to allow most females to reach maturity and even to transform into males prior to their recruitment into the fishery.

Epinephelus drummondhayi Goode and Bean, 1879
Speckled hind

Plate VIII, Figure D (juvenile)
Plate IX, Figure A (subadult)

Epinephelus drummond-hayi Goode and Bean, 1879, pp. 173–175 (Bermuda and Florida: original description).

Serranus drummond-hayi: Fowler 1929, p. 153 (Dry Tortugas).

Epinephelus drummondhayi: C. L. Smith, 1958, p. 51 (Bermuda); C. L. Smith, 1971a, pp. 141–145 (full account); Smith et al., 1975, p. 6 (rare at Florida Middle Ground); Walls, 1975, p. 170; Allen and Tashiro, 1976, p. 45 (commercial fishery); Huntsman, 1976, pp. 194, 217 (South Atlantic Bight bottom fishery); Huntsman and Dixon, 1976, p. 192 (recreational fishery); Roe, 1976, pp. 131, 151 (distrib.); G. B. Smith, 1976, pp. 21, 52 (distrib.); Ulrich et al., 1976, pp. 111, 112 (South Carolina commercial catch); Cupka et al., 1977, pp. 29, 32 (priority in research, list); Hoese and Moore, 1977, p. 172 (rare in northwestern Gulf of Mexico); Schwartz, 1978, pp. 62–64 (xanthochromism); Matheson, 1979, p. 66 (age and growth); Smith and Bullock, 1979, pp. 252, 253; Low and Ulrich, 1982, pp. 28–31 (off South Carolina); Bannerot, 1984, p. 33 (diet); Matheson and Huntsman, 1984, pp. 607–616 (age, mortality, yield-per-recruit models); Ross, 1988, pp. 780–784 (xanthic coloration of juveniles).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 1 (xanthic), 184; 220° off Johns Pass, Pinellas County, Florida, 45.7 m; June 1978; hook and line; FSBC 10981.—1, 223; 210° off Johns Pass, Pinellas County, Florida, 39.6–42.7 m; 22 February 1961; hook and line; FSBC 2046.—1 (xanthic), 233; 228° off Johns Pass, Pinellas County, Florida, 44.2 m; 9 June 1963; FSBC 2732.—2, 232, 363; 27°41'N, 45.7–47.6 m; 23 May 1963; FSBC 2355.—2, 285, 347; 70 mi off Madeira Beach, Pinellas County, Florida, 45.7 m; 11 July 1960; FSBC 1810.

Diagnosis (modified from C. L. Smith, 1971a): Dorsal XI, 16 (15); anal III, 9 (rarely 8); pectoral 17–18; gill rakers 25–28. Medium-sized species of *Epinephelus* with robust body; eye small; all fins rather angulate.

Ground color dark reddish-brown shading to bluish purple on underside of body and head. Creamy-white stellate spots over entire body, head, and fins. Juveniles (ca. 30 mm TL) bright yellow (L. Bullock, personal observation) developing bluish-white spots with growth (Ross, 1988).

Distinguishing characters: The distinctive color pattern can be used to distinguish this species from other western Atlantic groupers. Several species such as *E. flavolimbatus*, *E. niveatus*, and young *E. nigritus* have white spots, but these spots do not cover the entire body, head, and fins, as they do in *E. drummondhayi* (Plate IX, Figure A). Xanthic juveniles of *E. drummondhayi* could be confused with the golden phase of *E. fulvus*, but *E. fulvus* has a pair of black spots on the lower lip and on top of the caudal peduncle. Schwartz (1978) first described a xanthic speckled hind captured off North Carolina, and Smith and Bullock (1979) recorded the presence of xanthic individuals from the eastern Gulf of Mexico. Fifteen xanthic specimens, all immature females (158–234 mm), have been examined from the West Florida Shelf. Ross (1988) proposed that xanthic coloration is the normal color pattern of juvenile speckled hind. Neither Ross (1988) nor the present authors have ever observed xanthic adults.

Geographic and bathymetric distribution: The speckled hind has been reported from Bermuda, North Carolina to Florida, and the eastern and northern Gulf of Mexico (C. L. Smith, 1971a; G. B. Smith, 1976; Hoese and Moore, 1977). Hoese and Moore (1977) reported that this grouper is rare in the northwestern Gulf of Mexico.

On the West Florida Shelf, juvenile speckled hind have been captured in depths as shallow as 30 m, but most commercial catches are from depths of 50 m or more. Huntsman and Dixon (1976) recorded the depth range of speckled hind available to the headboat fishery off North Carolina and South Carolina as 15–60 fm (27–110 m), with the greatest number of fish found in 35–60 fm (64–110 m). In Bermuda, C. L. Smith (1958) stated that speckled hind were sporadically common in depths of 80–100 fm (146–183 m).

Reproduction: Ripe speckled hind (500–800 mm) were sampled from the commercial catch along the West Florida Shelf in August. Ripeness was determined by the expression of milt from the urogenital pore in males and by the presence of loose, opaque, vitellogenic oocytes in females.

Diet: Regurgitated food from 31 speckled hind caught in waters 155–174 m deep on the West Florida Shelf included the following fishes: *Anthias nicholsi*; *Bellator egretta* (Goode and Bean, 1896); *Decodon puellaris* (Poey, 1860); *Hemanthias vivanus*; *Scorpaena agassizi* Goode and Bean, 1896; an unidentified eel; a holocentrid; and *Saurida* sp. The invertebrate component of the diet included caridean shrimps, a hippolytid shrimp (*Lysmata* sp.), colonial ascidians, hermit crabs, a lobster (*Scyllarus depressus* (Smith, 1881)), squid, and octopus. Pelagic tunicates have been found in the stomachs of speckled hind according to Bannerot (1984). This limited sampling indicates a diet similar to that of yellowedge and snowy groupers.

Length-weight relationship: The relationship of weight to length for *E. drummondhayi* captured in the eastern Gulf of Mexico is expressed by the following: $W = 3.1 \times 10^{-8}\ SL^{2.99}$ ($n = 170$, $r^2 = 0.98$) (Figure 26), and $W = 1.29 \times 10^{-8}\ TL^{3.032}$ ($n = 102$, $r^2 = 0.96$), where W is gutted weight in kilograms and lengths are in millimeters.

Age and growth: Back-calculated mean lengths (mm) of speckled hind ages 1–15 from North Carolina and South Carolina were 186, 317, 408, 475, 528, 572, 613, 645, 678, 709, 739, 774, 804, 839, and 861, respectively. The von Bertalanffy growth equation was $L_t = 967\ (1-e^{-0.13(t + 1.01)})$ (Matheson and Huntsman, 1984).

Parasites and abnormalities: A reddish nematode was found in the ovary of *E. drummondhayi*. A large neoplasm (weighing 254.6 g) was removed from the visceral cavity of a speckled hind captured in the eastern Gulf of Mexico (Figure 27), but subsequent inadequate preservation of the tissue impeded efforts to identify the cell of origin (J. Harshbarger, personal communication).

Size and commercial importance: The largest speckled hind sampled from the West Florida Shelf commercial catch weighed 21.1 kg (46.5 lb), eviscerated. Huntsman (1976) reported the capture of a 20.4-kg (45-lb) individual from off South Carolina and a 17.2-kg (38-lb) specimen from off North Carolina. The average size range of speckled hind captured by the Carolina headboat fishery was 1.8–5.4 kg (4–12 lb) (Huntsman, 1976). In that fishery, speckled hind followed scamp and gag in importance (Huntsman and Dixon, 1976). Catch-curve analysis from headboats revealed an increase in instantaneous annual mortality during 1975–1979 from 0.26 to 0.40; the increase in instantaneous annual mortality fluctuated between 0.23–0.32 for the commercial hook-and-line fishery (Matheson and Huntsman, 1984). The yield-per-recruit model indicated

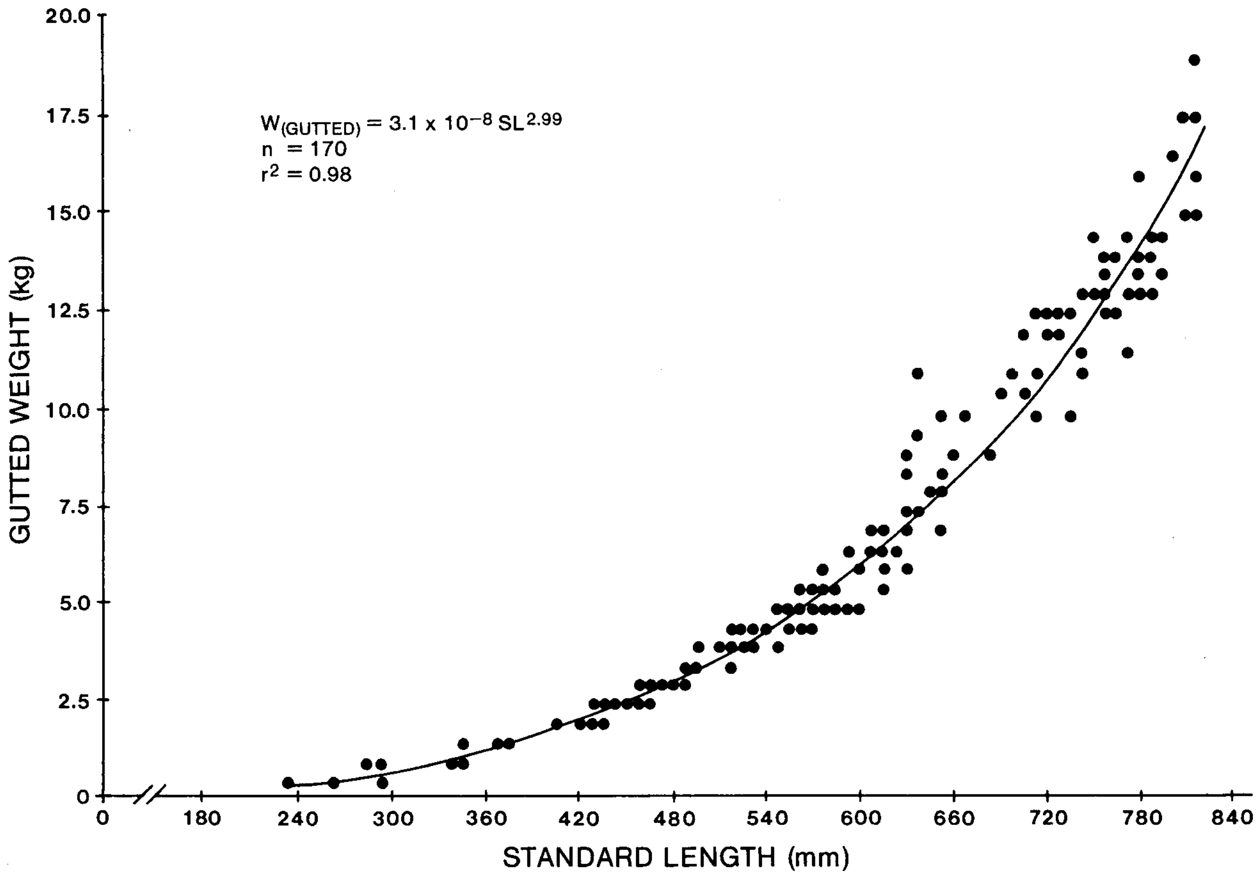

Figure 26. Length-weight (gutted) relationship of *Epinephelus drummondhayi* commercially captured by hook and line in the eastern Gulf of Mexico.

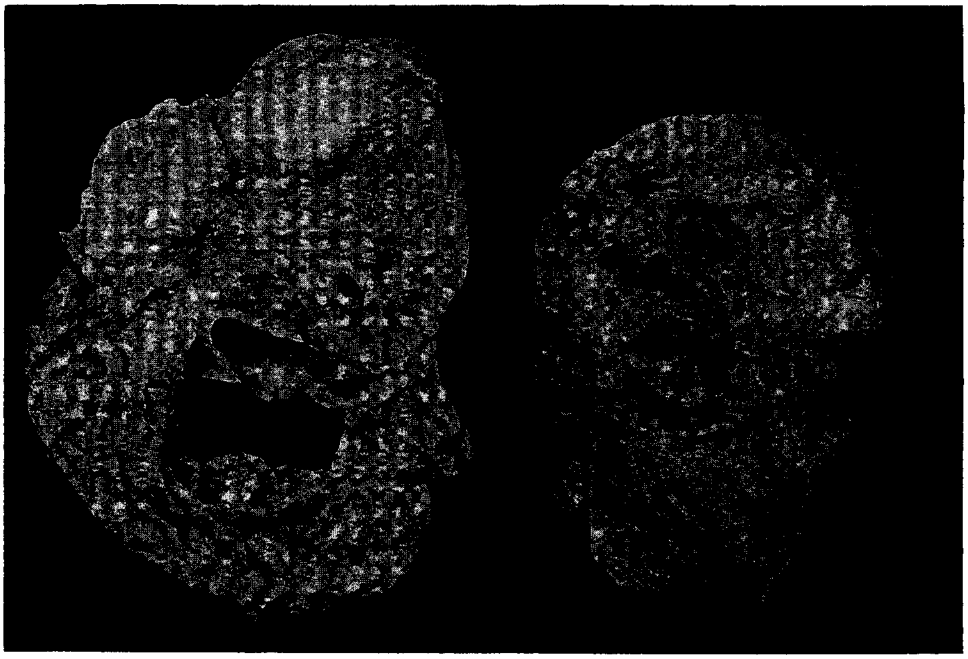

Figure 27. Cross section of neoplasm (65 × 82 mm) found in the abdominal cavity of *Epinephelus drummondhayi*.

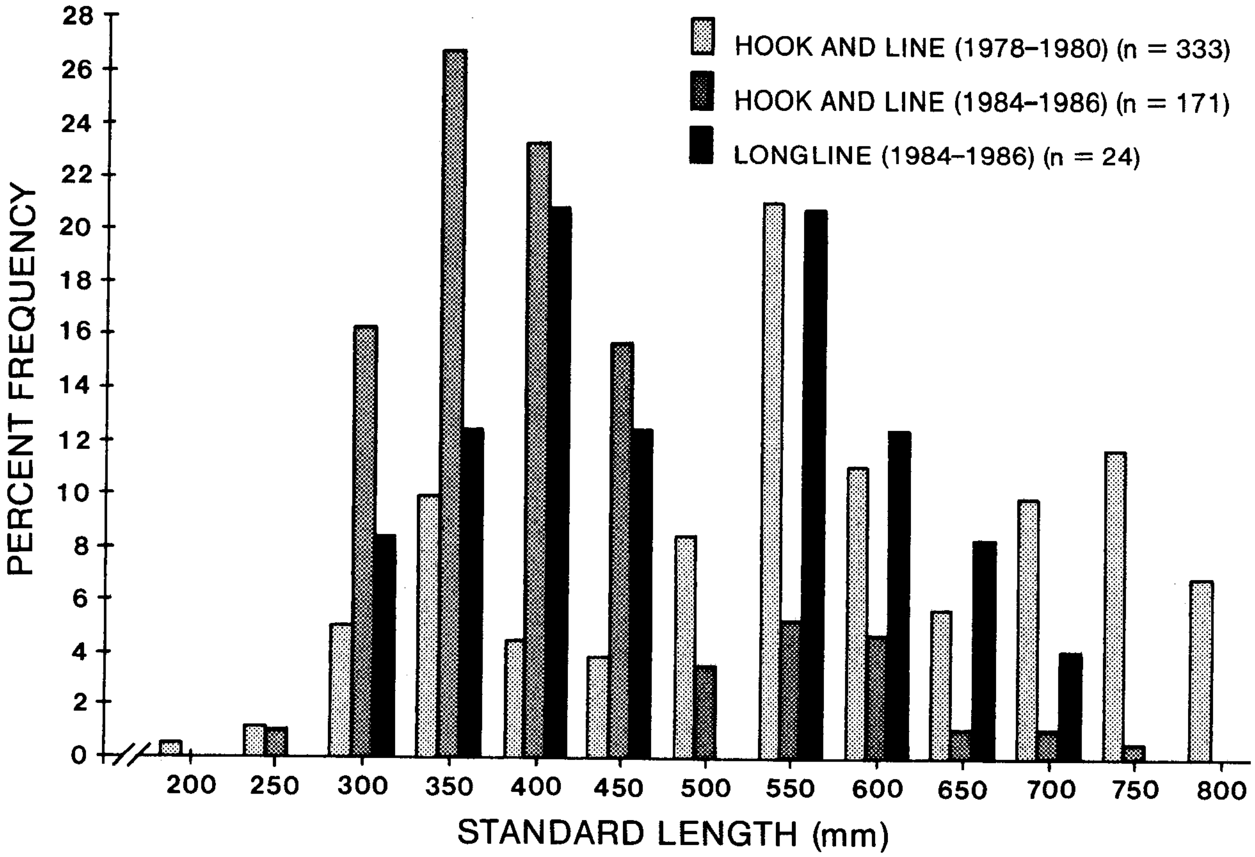

Figure 28. Length frequency distribution of *Epinephelus drummondhayi* commercially captured by hook and line from the eastern Gulf of Mexico during 1978–1980 (n = 333) versus those captured by hook and line (n = 171) and by longline (n = 24) during 1984–1986.

that headboat and commercial fisheries are harvesting between 60–80% of the maximum available yield per recruit (Matheson and Huntsman, 1984).

The size-frequency distributions of speckled hind captured by commercial hook and line in the eastern Gulf during 1978–1980 were compared to those of speckled hind captured by hook and line and longline during 1984–1986 (Figure 28). The distributions were found to differ significantly from one another using χ^2 analysis ($\chi^2 = 169.4$, df = 28, $p < 0.001$). The length-frequency distribution for 1978–1980 hook-and-line data differed significantly from 1984–1986 hook-and-line data ($\chi^2 = 146.9$, df = 14, $p < 0.005$) and longline data ($\chi^2 = 43.0$, df = 14, $p < 0.005$). Additionally, distributions for both fisheries in 1984–1986 differed significantly from one another ($\chi^2 = 37.8$, df = 14, $p < 0.005$).

If hook-and-line catches for the periods 1978–1980 and 1984–1986 are compared, a modal shift toward smaller fish (from 550 mm to 350 mm) is seen. A complicating factor in interpreting the results of this analysis and subsequent comparisons of length-frequency data for other commercially important groupers is the question of whether fishing depths remain relatively constant for different time periods. The decrease in modal size could be the result of a change in fishing depths because larger fish are captured at greater depths. Too few fish were sampled from the longline fishery to draw any conclusions.

South Carolina commercial grouper landings (by weight) indicate that speckled hind followed gag, scamp, and snowy groupers in 1977, and in 1978 ranked fifth, following gag, scamp, snowy, and yellowedge groupers.

Epinephelus flavolimbatus Poey, 1865
Yellowedge grouper

Figure 29; Plate IX, Figure B (juvenile)
Plate IX, Figure C (adult)

Epinephelus flavolimbatus Poey, 1865 (1865–1866), pp. 183, 184 (Matanzas Bay, Cuba: original descr.); Jordan and Eigenmann, 1890, p. 357 (Pensacola, Florida); Henshall, 1895, p. 216 (Key West, Florida); Evermann and Kendall, 1900, p. 73 (Key West and Pensacola, Florida); Rivas, 1964, p. 23; Cervigón M., 1968, pp. 191, 192 (Venezuela); Carpenter and Nelson, 1971, pp. 22–24; C. L. Smith, 1971a, pp. 123–128; Walls, 1975, pp. 170, 171; Huntsman, 1976, p. 17; G. B. Smith, 1976, p. 41; Hoese and Moore, 1977, p. 171; Ulrich, 1977, pp. 1–14; C. L. Smith, 1978 (FAO species ID sheets); Low and Ulrich, 1982, p. 31; Bannerot, 1984, p. 54 (over-exploitation); Nelson, 1988, p. 180, table A2.2 (dietary items); Jones et al., 1989, pp. 277–284 (burrow utilization).

Material examined: HOURGLASS STATION E: 1, 66; 12 May 1967; trawl; FSBC 5221.—OTHER MATERIAL: NORTHEASTERN GULF OF MEXICO: 1, 128; 5 December 1959; R/V *Oregon* Station 2704, 29°9.8'N, 88°36'W; FSBC 1608.

Diagnosis (after C. L. Smith, 1971a): Dorsal XI, 14–15 (modally 14); anal III, 9; pectoral rays 17–19 (modally 18); gill rakers 23–26.

Moderate-sized species of *Epinephelus* with large eye and robust body. Nostrils subequal.

Juveniles with body pattern of pearly-white spots in geometric pattern (these spots occasionally evident on adults); saddle on caudal peduncle limited ventrally by lateral line. Margins of dorsal, soft anal, and caudal fins yellow. Blue line from orbit to angle of preopercle.

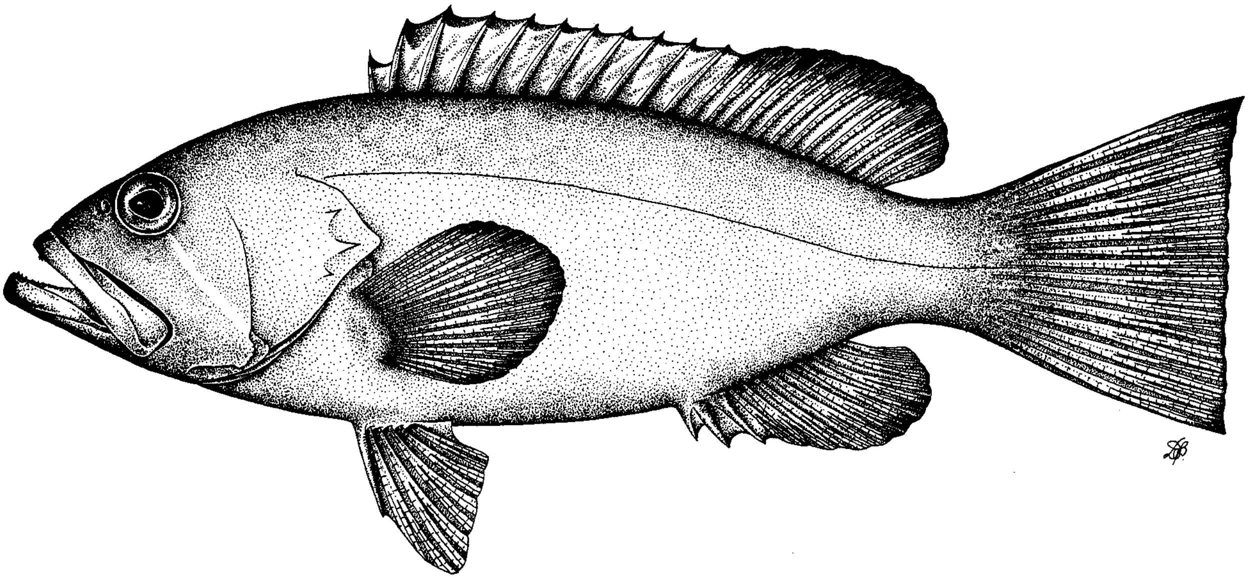

Figure 29. *Epinephelus flavolimbatus* Poey, 1865.

Remarks: Rivas (1964: 23) noted that the dark saddle on the caudal peduncle and the geometric pattern of white spots on the body "gradually disappear with age and are faint to absent in specimens about 300 mm (SL) or larger." However, live grouper as large as 600 mm have been observed to display briefly the white-spot pattern as the fish are brought from the water (L. Bullock, personal observation).

Distinguishing characters: Epinephelus flavolimbatus is the only grouper to have a bright yellow iris and yellow margins of the dorsal, anal, and caudal fins. In the young of *E. flavolimbatus*, the dark saddle on the caudal peduncle does not reach below the lateral line, whereas in juvenile *E. niveatus* the saddle extends below the lateral line.

Geographic and bathymetric distribution: Epinephelus flavolimbatus has been recorded from North Carolina and South Carolina (Huntsman, 1976) to Florida, throughout the Gulf of Mexico, in the West Indies (C. L. Smith, 1971a; 1978), off the Honduran and Nicaraguan coasts (Carpenter and Nelson, 1971), and along the northern coast of South America to Brazil (C. L. Smith, 1971a).

The yellowedge grouper is a deep-water species, caught by commercial fishermen along the West Florida Shelf in depths of 91–274 m and by the Carolina headboat fishery in depths of 35–80 fm (64–146 m) (Huntsman, 1976). The yellowedge grouper and the snowy grouper are sympatric in this deep-water habitat; however, the yellowedge grouper appears to be more abundant in the Gulf, whereas the snowy grouper is dominant along the Atlantic Coast (Jones et al., 1989). Carpenter and Nelson (1971) captured *E. flavolimbatus* in a depth range of 80–150 fm (146–274 m) in the Caribbean Sea. Cervigón M. (1968) found that the yellowedge grouper was common in depths of 50–100 fm (91–183 m) off Venezuela.

Reproduction: L. Bullock and M. Godcharles (unpublished data) found that ripe females occurred in the eastern Gulf of Mexico during May–September, with postspawners appearing in large numbers in October and November. Forty-six percent of all females (n = 708) in the size class of 525–575 mm TL had reached maturity.

Diet: The diet of the yellowedge grouper was examined using food regurgitated aboard commercial fishing vessels in the eastern Gulf of Mexico (Table 10). No attempt was made to quantify these data because many food items were lost prior to bringing the fish from the water. Major components of the diet were brachyuran crabs and other epibenthic invertebrates. Twenty-six fish species representing 17 families were consumed. Nelson (1988) found that bivalves, *Pinna* sp., and unidentified animal matter composed approximately 6%, 4%, and 90%, respectively, of the stomach contents of three yellowedge grouper captured on the Flower Garden Banks off Texas.

Competition: Because snowy and yellowedge groupers occur in similar depth ranges, there may be competition for limited rocky or hard-bottom habitat (Jones et al., 1989). In the northwestern Gulf of Mexico, yellowedge grouper were observed by Jones et al. (1989) to occupy burrows in soft sediment. It was unclear to these investigators whether these fish could actually excavate a burrow or simply occupied (and perhaps modified) burrows made by tilefish. Snowy grouper were never seen associated with burrows. If yellowedge grouper are capable of exploiting both rocky and soft-sediment habitats, they may have a competitive advantage over the snowy grouper, which appears to be limited to only one habitat type (Jones et al., 1989).

TABLE 10. DIETARY ITEMS OF *EPINEPHELUS FLAVOLIMBATUS* (NUMBER OF STOMACHS NOT RECORDED).

- Phylum Mollusca
  - Class Cephalopoda
    - Order Decapoda
      - Squid
    - Order Octopoda
      - Family Octopodidae
        - *Octopus* species
- Phylum Arthropoda
  - Class Crustacea
    - Order Stomatopoda
      - Family Pseudosquillidae
        - *Parasquilla coccinea* Manning, 1962
    - Order Decapoda
      - Section Penaeoidea
        - Family Solenoceridae
          - *Solenocera* cf. *atlantidis* Burkenroad, 1939
      - Section Caridea
        - Family Eugonatonotidae
          - *Eugonatonotus crassus* (A. Milne Edwards, 1881)
      - Section Palinura
        - Family Scyllaridae
          - *Scyllarus chacei* Holthuis, 1960
      - Section Anomura
        - Family Diogenidae
          - *Dardanus insignis* (Saussure, 1858)
        - Family Galatheidae
          - *Munida irrasa* A. Milne Edwards, 1880
      - Section Brachyura
        - Family Raninidae
          - *Ranilia constricta* (A. Milne Edwards, 1880)
        - Family Calappidae
          - *Calappa angusta* (A. Milne Edwards, 1880)
        - Family Goneplacidae
          - *Frevillea barbata* (A. Milne Edwards, 1880)
          - *Neopilumnoplax americana* (Rathbun, 1898)
        - Family Grapsidae
          - *Euchirograpsus americanus* (A. Milne Edwards, 1880)
        - Family Leucosiidae
          - *Myropsis quinquespinosa* (Stimpson, 1871)
        - Family Majidae
          - *Anasimus* species
        - Family Xanthidae
          - Xanthid species
          - Brachyuran species
- Phylum Echinodermata
  - Class Asteroidea
    - Asteroid species
- Phylum Urochordata
  - Class Ascideacea
    - Ascidian species
- Phylum Chordata
  - Class Pisces
    - Family Scyliorhinidae
      - *Scyliorhinus retifer* (Garman, 1881) (egg case)

TABLE 10. DIETARY ITEMS OF *EPINEPHELUS FLAVOLIMBATUS* (NUMBER OF STOMACHS NOT RECORDED). (Continued)

- Family Nettastomatidae
  - *Hoplunnis tenuis* Ginsburg, 1951
- Family Ophichthidae
  - *Ahlia egmontis* (Jordan, 1884)
  - *Myrichthys acuminatus* (Gronow, 1854)
  - *Myrophis punctatus* Lütken, 1851
  - *Ophichthus melanoporus* Kanazawa, 1963
  - *Ophichthus ocellatus* (LeSueur, 1825)
- Family Synaphobranchidae
  - *Ilyophis brunneus* Gilbert, 1891
- Family Synodontidae
  - *Saurida* sp.
- Family Holocentridae
  - *Ostichthys trachypoma* (Günther, 1859)
- Family Caproidae
  - *Antigonia capros* Lowe, 1843
- Family Centriscidae
  - *Macrorhamphosus scolopax* (Linnaeus, 1758)
- Family Syngnathidae
  - *Hippocampus* sp.
- Family Serranidae
  - *Anthias nicholsi* Firth, 1933
  - *Hemanthias vivanus* (Jordan and Swain, 1885)
  - *Holanthias martinicensis* (Guichenot, 1868)
- Family Priacanthidae
  - *Pristigenys alta* (Gill, 1862)
- Family Lutjanidae
  - *Pristipomoides aquilonaris* (Goode and Bean, 1896)
- Family Trichiuridae
  - *Trichiurus lepturus* Linnaeus, 1758
- Family Scorpaenidae
  - *Pontinus longispinis* Goode and Bean, 1895
  - *Scorpaena calcarata* Goode and Bean, 1882
- Family Triglidae
  - *Bellator* sp.
  - *Peristedion* sp.
  - *Prionotus stearnsi* Jordan and Swain, 1884
- Family Balistidae
  - *Xanthichthys ringens* (Linnaeus, 1758)
- Family Tetraodontidae
  - *Sphoeroides pachygaster* (Müller and Troschel, 1848)

Parasites and abnormalities: Yellowedge grouper were found to harbor didymozoid trematodes attached to the pseudobranchs; an undescribed parasitic isopod, *Tridentella* sp., in the gill filaments; a philometrid nematode in the gonad; and plerocercoid metacestodes in the visceral cavity (L. Bullock, personal observation).

Several abnormalities, including pugheadedness and complete absence of anal fin and pelvic fins (Figure 30A), were seen in yellowedge grouper. One individual had an unusual anal-fin ray count of IV, 8 in lieu of the normal complement of III, 9.

A pathological condition was noted in which a portion of the gonad was rendered nonfunctional by a hard, waxy material. One such gonad was encapsulated in a fashion similar to that of a host that has been infested by plerocercoid metacestodes (Figure 30B).

Figure 30. Abnormalities in *Epinephelus flavolimbatus*; A. Lack of pelvic fins; B. Abnormal testes.

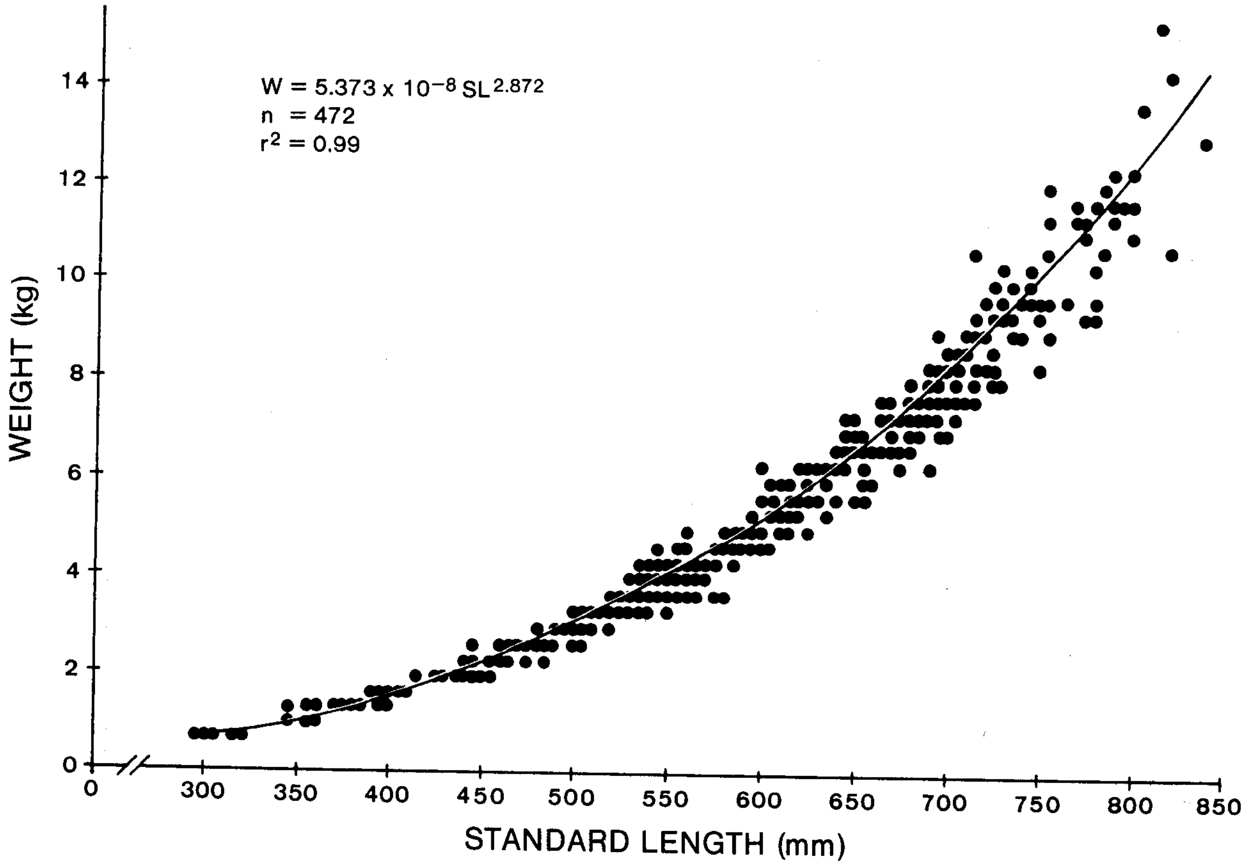

Figure 31. Length-weight relationship of *Epinephelus flavolimbatus* captured in the eastern Gulf of Mexico.

Length-weight relationship: The relationship of weight to length for *E. flavolimbatus* captured in the eastern Gulf of Mexico is expressed by the following: $W = 5.37 \times 10^{-8}\ SL^{2.872}$ ($n = 472$, $r^2 = 0.99$) (Figure 31), and $W = 2.94 \times 10^{-8}\ TL^{2.863}$ ($n = 321$, $r^2 = 0.99$), where W is whole weight in kilograms and lengths are in millimeters.

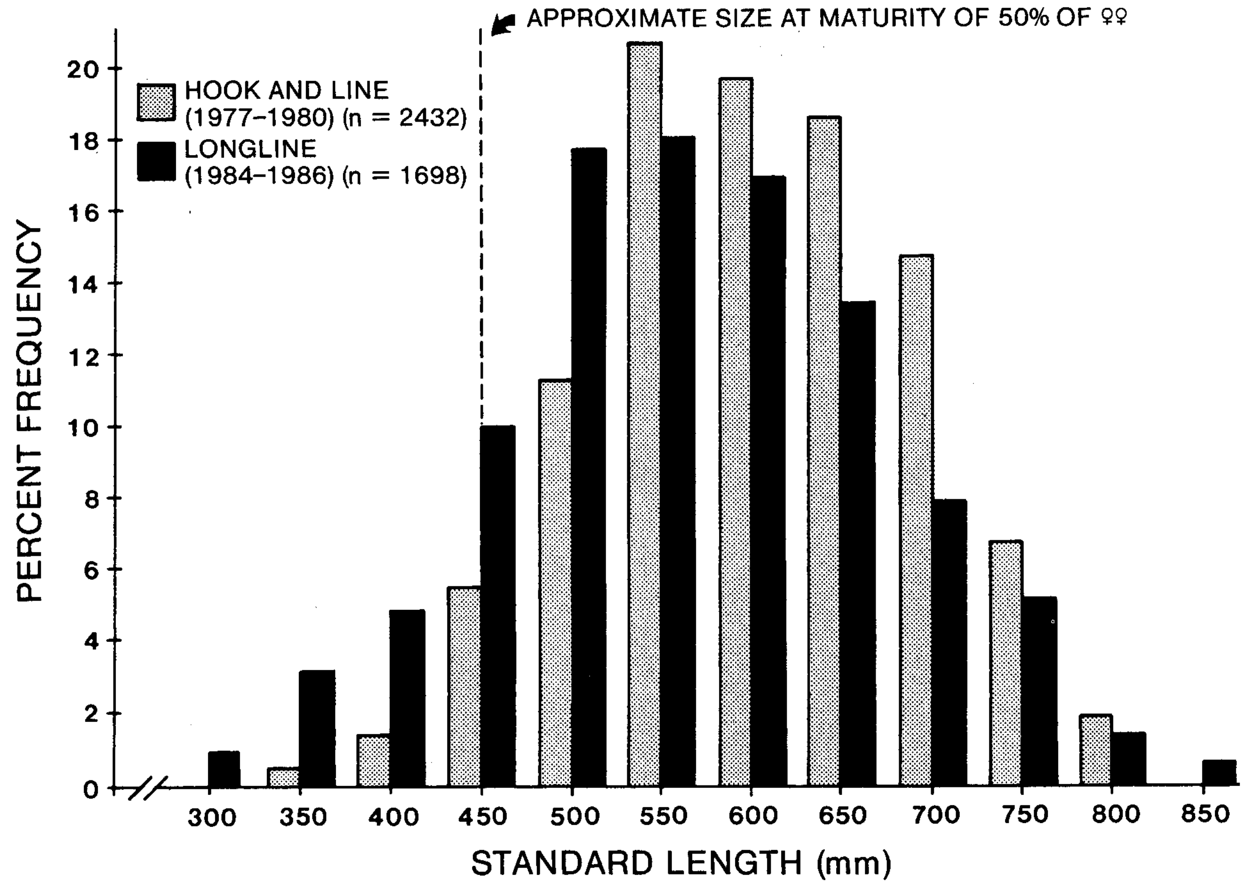

Figure 32. Length frequency distribution of *Epinephelus flavolimbatus* commercially captured by hook and line in the eastern Gulf of Mexico during 1977–1980 (n = 2,432) versus those captured by longline during 1984–1986 (n = 1,698).

Size and commercial importance: Individuals weighing in excess of 14 kg have been landed by commercial fishermen along the Florida west coast. With the advent of large-scale bottom longlining during 1980–1981 in the eastern Gulf of Mexico, landings of deep-water groupers (primarily yellowedge and snowy groupers) increased dramatically. Catches of 13,584 kg per ten-day trip were reported from vessels with home ports in Pinellas County, Florida.

The length-frequency distributions of yellowedge grouper captured commercially in the eastern Gulf of Mexico with hook and line during 1977–1980 were compared with those of yellowedge grouper captured with bottom longline during 1984–1986 (Figure 32). The distributions were found to be significantly different using χ^2 analysis ($\chi^2 = 261.3$, df = 11, $p < 0.001$). This result may be an indication that a greater percentage of immature fish are being harvested by longline (even though the modes for the two fishing methods are the same).

The Carolina headboat fishery lands yellowedge grouper in the size range of 8–16 lb. (3.6–7.2 kg) (Huntsman, 1976). Ulrich (1977) sampled the South Carolina commercial catch during June–August 1977 and found that yellowedge grouper had a mean size of 79 cm TL with a modal peak of 90–94 cm and a smaller peak at 70–74 cm TL.

Epinephelus fulvus (Linnaeus, 1758)
Coney

Plate IX, Figure D (juvenile)
Plate X, Figure A
Plate X, Figure B (bicolor)
Plate X, Figure C

Labrus fulvus Linnaeus, 1758, p. 287 (America: original descr., after Catesby).

Epinephelus fulvus: Jordan, 1885b, p. 194; C. L. Smith, 1971a, pp. 93–97; Collette and Talbot, 1972, p. 112; Burnett-Herkes, 1975, p. 24; Smith et al., 1975, p. 6; G. B. Smith, 1976, pp. 21, 41; Nagelkerken, 1981, pp. 24–27; Williams and Williams, 1981, pp. 1007, fig. 1, 1012; Colin, 1982, p. 73; Dubin, 1982, p. 230; Cordova, 1986, pp. 161, 162; Dennis and Bright, 1988b, p. 5 (northwestern Gulf of Mexico).

Cephalopholis fulvus: Jordan and Thompson, 1905, p. 239 (Dry Tortugas, Florida); Longley and Hildebrand, 1941, pp. 92, 93 (color; rare at Dry Tortugas); Springer and Bullis, 1956, p. 77 (Gulf of Mexico); Erdman, 1957, p. 321; Sparks, 1957, pp. 258, 263; Briggs, 1958, p. 272 (Florida); C. L. Smith, 1959, p. 113, table I, p. 114 (protogynous hermaphrodite).

Cephalopholis fulva: C. L. Smith, 1966, pp. 1–11 (hybridization); Randall, 1967, p. 696 (dietary habits); Böhlke and Chaplin, 1968, p. 264; Randall, 1968, pp. 61, 62, fig. 67; Brownell and Rainey, 1971, p. 46; Collette and Rutzler, 1977, p. 306; Jones and Thompson, 1978, p. 164; Thompson and Munro, 1978, pp. 117, 119–121, 123, 124, 126; Aronson and Sanderson, 1987, p. 305 (feeding association with goatfishes).

Epinephelus fulva: Alevizon and Brooks, 1975, p. 486; Colin and Clavijo, 1988, p. 254 (pair spawning off Puerto Rico).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: ATLANTIC SEABOARD: 1, 199; Jupiter Inlet, Palm Beach County, Florida, 54.9–61.0 m; 12 March 1963; jig dragged across bottom; FSBC 2321.—1, 183; off Fort Lauderdale Beach, Broward County, Florida, 24.4 m; 1961; FSBC 2074.—FLORIDA KEYS: 1, 207; 6 mi SE of Tavernier Creek, Monroe County, Florida, 7.6 m; 19 April 1980; fishtrap; FSBC 11655.—EASTERN GULF OF MEXICO: 1, 275; "Florida Bank" off Pinellas County, Florida; 1–6 October 1961; hook and line; FSBC 2099.

Diagnosis (after C. L. Smith, 1971a): Dorsal IX, 15 (rarely 14 or 16); anal III, 9; pectoral 18; gill rakers 23–27; moderately robust body; round preopercle.

Head, upper body, and sides covered with small blue spots with dark rim. Two black spots on tip of lower lip and second pair on top of caudal peduncle. Color phases include the following: red (deep water), dark brown (shallow water), xanthic (deep and shallow water), and bicolored in shallow water, with dark brown above and white below.

Quiescent ("sleep") pattern of irregular vertical bars and "tuning-fork" mark on head resembling the head color pattern of *Epinephelus striatus*.

Distinguishing characters: The two black spots on top of the caudal peduncle and on the lower lip, combined with the blue spots on the head and body, separate the coney from other species of grouper. *Epinephelus cruentatus* also has nine dorsal spines but differs in coloration.

Geographic and bathymetric distribution: *Epinephelus fulvus* has been reported from Bermuda, South Carolina, the Bahamas, and southern Florida. In the eastern Gulf of Mexico, the coney has been captured off west central Florida (off Tampa Bay) and at the Florida Middle Ground. Records for the coney in the northwestern Gulf include the Flower Garden Banks and Bright's Bank (Cordova, 1986; Dennis and Bright, 1988b). Elsewhere, the coney has been taken in the southwest Gulf of Mexico, throughout the Antilles, Panama, Colombia, and Brazil (C. L. Smith, 1971a).

G. B. Smith (1976) never observed the coney in less than 29-m depths on the West Florida Shelf; its presence at moderate depths in the eastern Gulf may be due to a preference for "clear water with little or no silt" (C. L. Smith, 1971a: 95). All specimens observed at eastern Gulf reefs by G. B. Smith (1976) were xanthic individuals: the entire fish was bright yellow. Dennis and Bright (1988b: 5) speculated that the coney may be transient in the northwestern Gulf, and its presence there may have resulted from "an unusual recruitment event outside the region." Böhlke and Chaplin (1968) stated that this fish was found in the Bahamas from near shore to 150-ft (46-m) depths and has been recorded from waters as deep as 500 ft (152 m).

Reproduction: C. L. Smith (1959) presented histological evidence (as previously stated for *E. cruentatus*) to indicate that the coney was a protogynous hermaphrodite. According to Thompson and Munro (1978), sex inversion in *E. fulvus* captured in Jamaican waters was found to occur at about 27 cm TL. They also discovered an unusual specimen with a ripe ovo-testis.

The spawning period for *E. fulvus* in the eastern Gulf of Mexico is unknown. Erdman (1956) reported spawning *E. fulvus* off Puerto Rico in December. In Jamaican waters, ripe fish were found during November–July, with peak spawning occurring during January–March; a secondary peak was observed in June and July (Thompson and Munro, 1978). In Bermuda, coneys spawn during May–early August (C. L. Smith, 1971a).

Pair spawning has been observed during January off Puerto Rico and in the Bahamas (Colin, 1982; Colin and Clavijo, 1988; P. Colin, personal communication). The presumed male had the usual bicolor pattern but also possessed two lateral white spots and a brown stripe running through the lower white portion of the body. The edges of the posterior portion of the dorsal and anal fins were black (Colin and Clavijo, 1988).

Diet and feeding behavior: Burnett-Herkes (1975: 24) observed that *E. fulvus* and other small groupers "remained partially hidden in crevices most of the time and appeared to hunt food within the interstices of the reef rather than pursue prey away from the reef."

Randall (1967) found that the main dietary item of *E. fulvus* was fishes (46% by volume) with shrimps, crabs, stomatopods, and unidentified crustaceans forming the remainder of the diet.

Behavioral interactions, believed to be feeding associations between several species of moray eels and groupers, have been documented by Fricke (1972), Montgomery (1975), Karplus (1978), Dubin (1982), and Diamant and Shpigel (1985). Dubin (1982) noted associations between *E. fulvus* and the following eels: *Gymnothorax moringa* (Cuvier, 1829) (spotted moray), *Muraena miliaris* (Kaup, 1856) (goldentail moray), and *Myrichthys acuminatus* (Gronow, 1854) (sharptail eel). The aforementioned authors hypothesized that normally inaccessible invertebrates and small fishes disturbed by the eel can be captured by the grouper.

A coney was observed off St. Croix, U.S. Virgin Islands, swimming alongside *Gymnothorax moringa* (L. Bullock, personal observation). When the moray entered a crevice, the coney remained outside until the eel reappeared, at which time they reassumed their former position and swam along together. Shpigel and Fishelson (1989: 71) categorized similar behavior between groupers (*Cephalopholis*) and moray eels in the Red Sea as "following behaviour".

Coneys, like other reef fishes, have also been found to associate with the goatfishes *Pseudupeneus maculatus* (Bloch, 1793) and *Mulloides martinicus* (Cuvier and Valenciennes, 1829) while they foraged in the sandy substrate (Aronson and Sanderson, 1987), presumably for the benefit of capturing prey exposed by the goatfishes.

Predation: *Epinephelus fulvus* has been observed in stomach contents of *E. striatus* (Randall, 1967).

Abnormalities and parasites: Two pugheaded individuals were observed by Thompson and Munro (1978). They also noted that encysted larval tapeworms commonly occurred in the viscera of *E. fulvus.* Sparks (1957) found the digenetic trematode *Helicometrina nimia* Linton, 1910 in the gonad of the coney.

Several coneys off St. Croix, U.S. Virgin Islands, were observed with large isopods attached to their heads (one fish had an isopod on each cheek) (L. Bullock, personal observation). Williams and Williams (1981) found the isopod *Anilocra haemuli* Williams and Williams, 1981 on coneys in the West Indies.

Size and commercial importance: The maximum length of the coney, recorded by Randall (1968), is 37.5 cm TL. This species is frequently taken by hook and line in the West Indies; however, it is rarely caught off the Florida west coast.

Epinephelus guttatus (Linnaeus, 1758)
Red hind

Plate X, Figure D

Perca guttata Linnaeus, 1758, p. 292 (America: original descr.).

Epinephelus guttatus: Goode, 1876, pp. 58, 59 (Bermuda): Lönnberg, 1894, p. 127 (Key West, Florida); Schroeder, 1924, p. 14 (Florida Keys); Bardach and Menzel, 1957, p. 107 (Bermuda: growth rates); Erdman, 1957, p. 320; Briggs, 1958, p. 272; C. L. Smith, 1959, p. 114, fig. 2, pl. 1, figs. 6, 7 (hermaphroditism); Menzel, 1960, pp. 216–222; Springer and Woodburn, 1960, p. 34; C. L. Smith, 1961, pp. 1:3, 1:9, 1:23, figs. 1, 2, 9; Nahhas and Cable, 1964, p. 221; Randall, 1967, pp. 697, 698 (dietary habits); Carpenter and Nelson, 1971, pp. 22, 23; C. L. Smith, 1971a, pp. 116–119; Hochberg and Ellis, 1972, p. 84; Darcy et al., 1974, pp. 376, 377; Burnett-Herkes, 1975, pp. 1–154; Smith et al., 1975, p. 6 (eastern Gulf of Mexico); Walls, 1975, pp. 171, 172; Huntsman, 1976, p. 17; G. B. Smith, 1976, pp. 21, 22 (eastern Gulf of Mexico); Sonnier et al., 1976, pp. 108, 110; C. L. Smith, 1978 (FAO species ID sheets); Thompson and Munro, 1978, pp. 117–122; Williams and Williams, 1981, pp. 1007, fig. 2, 1009, 1012 (parasites); Colin, 1982, p. 73 (Puerto Rico: reproductive behavior); Williams, 1982, table 1, p. 324 (leech); Kimmel, 1985, p. 89, table A1 (Puerto Rico); Garcia-Moliner Basora, 1986, pp. 1–104 (social spacing, reproduction, sex reversal); Colin et al., 1987, pp. 220–230 (spawning aggregations).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: FLORIDA KEYS: 1, 328; 24°29′N, 82°58′W, 24.2 m; 17–19 March 1980; fish trap; FSBC 12123.—1, 201; 2 mi SW of "G" marker, Big Pine Key, Monroe County, Florida, 15.2 m; 3 May 1962; hook and line; FSBC 12124.—EASTERN GULF OF MEXICO: 1, 384; 27°52′N, 84°21′W, 73.2 m; 24 July 1972; hook and line; FSBC 7185.

Diagnosis (after C. L. Smith, 1971a): Dorsal XI, 15–16; anal III, 8; pectoral 16–17; gill rakers 24–27. Dorsal interspinous membranes notched, fleshy tabs behind each spine; vertical fins rounded. Robust body, large eye.

Body pale to dark crimson with darker red spots not appreciably larger ventrally. No saddle-shaped blotches along back. Soft dorsal, anal, and caudal fins with distal one-third edged with black and bordered on outside with narrow white margin. Olivaceous ground color similar to *E.*

adscensionis when in association with brown algae and gorgonians (Burnette-Herkes, 1975). "Sleep"/excitement pattern consisting of irregular transverse bars.

Remarks: Meristic data for FSBC specimens agreed with data cited by C. L. Smith (1971a) except for the number of anal rays. C. L. Smith (1971a) recorded nine anal rays; all FSBC specimens contained eight. Burnette-Herkes (1975) reported eight anal rays in specimens from Bermuda, Florida, the Virgin Islands, Jamaica, the Bahamas, Venezuela, and Mexico. He postulated that Smith's numerals had inadvertently been transposed in a table and that this incorrect data was subsequently used in his diagnosis.

Distinguishing characters: Epinephelus guttatus, E. adscensionis, and *E. cruentatus* all have reddish spots on a lighter background (Plate X, Figure D, and Plate VIII, Figures A and C, respectively). However, *E. guttatus* has a black margin on the soft dorsal, anal, and caudal fins, unlike the other two species. *Epinephelus adscensionis* differs from *E. guttatus* and *E. cruentatus* by having three or four saddle-shaped blotches along the base of the dorsal fin and on the caudal peduncle, whereas *E. cruentatus* has a series of four small white or black spots at the base of the dorsal fin.

Geographic distribution: Epinephelus guttatus is most abundant off the West Indies, the Bahamas, and Bermuda (C. L. Smith, 1971a; Burnette-Herkes, 1975). This species has also been recorded from South Carolina to Panama and from the northern coast of South America (C. L. Smith, 1971a). In the Gulf of Mexico, *E. guttatus* has been recorded off Tampa Bay, Florida (Springer and Woodburn, 1960); at the Florida Middle Ground (Smith et al., 1975; G. B. Smith, 1976); off Texas (Sonnier et al., 1976); and off Campeche, Mexico (C. L. Smith, 1971a).

Bathymetric distribution and habitat: Epinephelus guttatus occupies a wide bathymetric range. Burnette-Herkes (1975) found red hinds in as little as 2 m of water off St. Croix, U.S. Virgin Islands, whereas off Jamaica, adults have been captured in depths exceeding 100 m (Thompson and Munro, 1978). The species is apparently confined to depths greater than 36 m off west Florida (Smith et al., 1975; G. B. Smith, 1976).

C. L. Smith (1971a) suggested that *E. guttatus* and *E. adscensionis* may be ecological replacements because their bathymetric distributions are somewhat exclusive at most western Atlantic localities. In the eastern Gulf of Mexico, however, both species are syntopic; commercial fishermen report catching both *E. guttatus* and *E. adscensionis* at the same reefs.

Burnette-Herkes (1975) noted that the size of red hinds increased with depth and distance offshore.

Reproduction: Spawning seasons apparently vary widely with geographic location. During an FMRI grouper study in the eastern Gulf of Mexico (Florida Middle Ground), ripe females (305–381 mm) were found during April and June–August, and ripe males (305–375 mm) were captured during May–September. In Puerto Rico, Erdman (1956) reported red hinds to be ripe in January, and Colin et al. (1987) found ripe fish in January and February. Randall, in unpublished field notes (1960–1961), recorded finding ripe individuals at St. John, U.S. Virgin Islands, during January–February and sexually inactive gonads in fish collected during March–April (Burnette-Herkes, 1975). During March 1973, Burnette-Herkes (1975) recorded spent fish at Cat Cay, Bahamas. In comparing the red hind spawning seasons off Jamaica and Bermuda, Burnette-Herkes (1975) noted Bermuda's 4–5 month lag behind Jamaica in spawning, with ripe fish appearing in Bermuda during May–July (with a peak in June).

Burnette-Herkes (1975) reported spawning aggregations in depths of 18–27 m around Bermuda and indicated that similar aggregations occurred off St. Croix, U.S. Virgin Islands. Colin (1982) and Colin et al. (1987) did not find large aggregations of *E. guttatus* off the southwest coast of Puerto Rico. Instead, these investigators found red hind in local concentrations along the shelf edge, with males patrolling regular territories that generally contained 1–5 females. The females displayed a color pattern of dark spots on a white background, whereas males had a darker, mottled pattern with vertical bars or squares behind the anus (Colin et al., 1987). Males displayed to females by swimming into the water column in an arched trajectory. A male would approach each female, and if she were ready to spawn, the pair would swim upward approximately 1 m above the bottom and release gametes (Colin, 1982).

In Bermuda, Burnette-Herkes (1975) found all spawning areas to be similar in that they were seaward of submerged ridges that rise on the perimeter of a sea mount to within 15–17 m of the surface and were characterized by well-pitted limestone with stands of gorgonian corals, principally *Pseudopterogorgia* spp. He indicated that although an aggregation may stay in a spawning area for up to one month, the precise location varied daily.

Estimates of fecundity vary considerably. Burnette-Herkes (1975) estimated that a 248-mm (TL) specimen contained 89,600 oocytes and that a 457-mm (TL) individual had 3,364,900 oocytes. C. L. Smith (1961) estimated that a 358-mm (SL) fish contained 233, 273 oocytes. Thompson and Munro (1978) calculated the number of oocytes in six red hinds that were 260–410 mm (TL). The smallest fish contained an estimated 96,982 oocytes; the largest fish had an estimated 379,350 oocytes. A 363-mm (TL) fish contained the highest number of eggs—526,358.

Colin et al. (1987) found that eggs of *E. guttatus* were nearly spherical, 0.97 × 0.96 mm in size. Eggs hatched 27 h after fertilization at 26.5°C and at about 31 h at 25.5°C.

Sexual maturity has been estimated to occur at three years (240 mm TL) (Burnette-Herkes, 1975). Thompson and Munro (1978) believed *E. guttatus* matured at or before reaching 250 mm TL (243 g).

Thompson and Munro (1978) reported a male/female ratio of 1:5.6 in the intensively exploited Port Royal reef area of Jamaica and 1:2.8 on unexploited oceanic banks near Jamaica.

Diet: Menzel (1960) found little variation in the feeding habits and no major seasonal changes in the diets of differently sized red hinds (130–1,200 g) in Bermuda. The most common organisms consumed were crustaceans (crabs of the genus *Calappa* and shrimps of the family Alpheidae), but fish were also ingested (primarily Labridae, *Thalassoma bifasciatum*) (Bloch, 1791). He concluded that the relative growth-rate of small red hinds (135–245 g) was greater than that of larger fish due to a combination of better protein utilization and greater intake of food.

Thompson and Munro (1978) examined *E. guttatus* collected from oceanic banks near Jamaica and found that grunts (*Haemulon aurolineatum* Cuvier and Valenciennes, 1830 and *H. melanurum* (Linnaeus, 1758)), crabs (mainly small *Mithrax* sp.), and scyllarid lobsters had been ingested.

Burnette-Herkes (1975) found that 76% of the red hinds had consumed crustaceans and 31% had eaten fish. In another study, Randall (1967) reported that by volume, red hinds consumed 70% crustaceans and 21% fish.

The only food found in a red hind from the eastern Gulf of Mexico was an unidentified eel.

Predation: Burnette-Herkes (1975) speculated that groupers and sharks were the most important predators of *E. guttatus* off Bermuda and that groupers, sharks, and snappers (notably *Lutjanus analis* (Cuvier and Valenciennes, 1828) and *L. jocu* (Bloch and Schneider, 1801)) were the most important predators throughout the Caribbean Sea. He also speculated that red hinds may fall prey to moray eels because both occupy crevices in the reef.

Parasites: A number of organisms, including trematodes, nematodes, cestodes, and isopods, parasitize *E. guttatus.* The leech *Trachelobdella lubrica* (Grube, 1840) was found in the gill filaments of a red hind off Puerto Rico (Williams, 1982). A digenetic trematode (*Lepidapedon levenseni* Linton, 1907) from *E. guttatus* and *E. striatus* was reported by Linton (1908). Nahhas and Cable (1964) reported the trematode *Postporus epinepheli* (Manter, 1947) in the intestine of a red hind from Curaçao. Burnette-Herkes (1975) commonly found 100–200 plerocercoid metacestodes per fish in red hinds from Bermuda. Ninety-three percent of the 301 fish he inspected were infested with *Callitetrarhynchus gracilis* (Rudolphi, 1819). Most infested specimens were greater than 200 mm SL. He also found that 13% of the specimens contained a nematode, *Philometra* sp., in at least one lobe of the gonad. The cymothoid isopod *Anilocra haemuli* Williams and Williams, 1981 was found to infest *E. guttatus* inhabiting Caribbean waters (Hochberg and Ellis, 1972; Williams and Williams, 1981).

In tank experiments Darcy et al. (1974) noted that cleaner gobies such as *Gobiosoma evelynae* (Böhlke and Robins, 1968) and *G. prochilos* (Böhlke and Robins, 1968), known to pick isopods from various fishes, elicited fin and gill-cover spreading and a head-down position from *E. guttatus* as well as *E. cruentatus* and *E. striatus.* The groupers appeared to recognize the gobies as cleaners.

Size and commercial importance: C. L. Smith (1978) reported the maximum length of the red hind to be approximately 600 mm TL.

Epinephelus guttatus is a minor component of party-boat catches from the Florida Middle Ground in the eastern Gulf of Mexico. Female red hinds captured from this area were 272–381 mm (0.59–1.56 kg; mean wt = 1.03 kg); males were 305–396 mm (0.68–1.81 kg; mean wt = 1.14 kg). The male/female ratio was 1.27:1 (n = 25). This ratio may be affected by the fact that *E. guttatus* reaches a larger ultimate size than either *E. cruentatus* or *E. adscensionis.* Therefore, smaller individuals of *E. guttatus* (i.e., females) are more capable of engulfing a large hook than are females of the other species.

Randall (1967) found *E. guttatus* to be the most abundant grouper off Puerto Rico and the Virgin Islands; Kimmel (1985), however, found *E. guttatus* to be second in abundance to *E. cruentatus* at reef biotopes off La Parguera, Puerto Rico. Thompson and Munro (1978) stated that *E. guttatus,* along with *E. striatus, E. fulvus,* and *Mycteroperca venenosa,* is one of the most important groupers in the Jamaican fishery. In this fishery, red hinds are first recruited at 180 mm (TL), with full recruitment at 350 mm (TL).

Off Puerto Rico and Bermuda, red hinds are captured on hook and line and in wire mesh arrow-head fish and lobster traps. In Bermuda, these grouper were first recruited to the fishery at 230 mm (TL) and were fully recruited at 340–359 mm (TL). When red hinds are aggregated (May–July), they are more easily captured (Burnette-Herkes, 1975).

Red hind and red grouper were the predominant groupers caught on handline in depths of 5–20 fm (9.1–36.6 m) on the Honduran-Nicaraguan Shelf in exploratory fishing by the U.S. National Marine Fisheries Services (NMFS) (Carpenter and Nelson, 1971).

Huntsman (1976) stated that red hinds were landed by North Carolina and South Carolina headboat fishermen in a size range of 2–5 lb (0.9–2.3 kg) in depths of 15–30 fm (27.4–54.9 m).

Epinephelus inermis (Valenciennes, 1833)
Marbled grouper

Plate XI, Figure A

Serranus inermis Valenciennes, *in* Cuvier and Valenciennes, 1833, pp. 436, 437 (Antilles: original descr.).

Dermatolepis inermis: Jordan and Swain, 1885a, pp. 405, 406 (Havana); Briggs, 1958, p. 271 (compiled); C. L. Smith, 1958, pp. 46, 47, pl. 5 (Bermuda: not seen); Caldwell, 1959, p. 72 (Destin, Florida); Bailey et al., 1960, p. 25 (common name); C. L. Smith, 1961, pp. 1:4, 1:14, 1:23, fig. 3.2; Caldwell, 1966, p. 39 (Jamaica: compiled); Cervigón M., 1966, pp. 934, 935, fig. 381 (La Blanquilla, Venezuela); Randall, 1968, p. 69, fig. 77 (general account, photograph); Kawaguchi, 1974, p. 16 (Caribbean Sea); Walls, 1975, p. 168 (northern Gulf of Mexico); Huntsman, 1976, p. 18 (North Carolina); Thompson and Munro, 1978, p. 128 (Jamaica).

Epinephelus inermis: Boulenger, 1895, p. 257; C. L. Smith, 1971a, pp. 157-160 (full account); Bright and Cashman, 1974, p. 351 (Flower Garden Banks off Texas); G. B. Smith, 1976, p. 56 (northeastern Gulf of Mexico); Sonnier et al., 1976, p. 108 (northern Gulf of Mexico); Hoese and Moore, 1977, p. 172 (northern Gulf of Mexico); Bullock and Godcharles, 1982, p. 53 (eastern Gulf of Mexico); Dennis and Bright, 1988b, pp. 5, 6 (northwestern Gulf of Mexico).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: FLORIDA KEYS: 1, 331; near the Dry Tortugas; hook and line; 14 April 1978; FSBC 10800.—EASTERN GULF OF MEXICO: 1, 437; SW of Johns Pass, Pinellas County, Florida, 73.2 m; hook and line; June 1978; FSBC 10817.

Diagnosis (after C. L. Smith, 1971a): Dorsal XI, 19 or 20; anal III, 9; pectoral 18 or 19; gill rakers 19–23. Pectoral elongate, 29–35% of SL. Scales without ctenii.

Young usually dark brown or black with large distinct white spots; white line through eye. Adult coloration mottled brown with small black spots that tend to form rings.

Distinguishing characters: *Epinephelus inermis* is readily distinguished from other species of *Epinephelus* by the steep head profile; deep, compressed body; large pectoral fins; and cycloid scales (Plate XI, Figure A).

Geographic distribution: *Epinephelus inermis* is known from North Carolina (Huntsman, 1976) to Jamaica, Cuba, Puerto Rico, the Lesser Antilles, and Rio de Janeiro (C. L. Smith, 1971a). In the Gulf of Mexico it has been reported from the Florida Keys, off Tampa Bay, Florida (Bullock and Godcharles, 1982), to off Destin, Florida, in the northern Gulf (Caldwell, 1959). Additional Gulf records include the Flower Garden Banks off Galveston, Texas (Bright and Cashman, 1974; Dennis and Bright, 1988b).

Bathymetric distribution and habitat: *Epinephelus inermis* is a secretive fish that hides in reef caves and crevices (Randall, 1968). It has a eurybathic distribution. This species was captured on the West Flower Garden Bank off Texas in depths of 70–160 ft (21–49 m) (Bright and Cashman, 1974). Randall (1968) reported an individual (9.1 kg) from 700 ft (213 m) off Bimini.

Parasites and abnormalities: Unidentified didymozoid digenetic trematodes were found on the pseudobranchs of several marbled grouper examined in the field.

A 460-mm specimen had only 8 of 11 dorsal spines, apparently because of an injury to the dorsum.

Size and commercial importance: The largest specimen examined by Randall (1968) (off Bimini) was 32 inches TL (813 mm) and weighed 20 lb (9.1 kg). This species is extremely rare in the commercial catch along the West Florida Shelf. It is occasionally taken by headboats fishing off North Carolina on the outer continental shelf (Huntsman, 1976).

Epinephelus itajara (Lichtenstein, 1822)
Jewfish

Plate XI, Figure B (juvenile)
Plate XI, Figure C (subadult)

Serranus itajara Lichtenstein, 1822, pp. 278, 279 (Brazil).

Promicrops itaiara: Jordan and Swain, 1885a, pp. 377–379; Schroeder, 1924, pp. 15, 16, fig. 10 (Key West, Florida); Beebe and Tee-Van, 1928, pp. 130, 131; Breder and Nigrelli, 1934, pp. 162–164 (mummified eel); Pearse, 1934, p. 113 (parasites); Longley and Hildebrand, 1941, p. 9 (Dry Tortugas, Florida); Reed, 1941, p. 76 (Texas); Baughman, 1943, pp. 771, 772 (Texas); Manter, 1947, p. 371 (parasites); Olsen, 1952, p. 182 (parasites); Caldwell, 1954, p. 183 (Cedar Key, Florida); Hildebrand, 1954, pp. 303, 304 (Padre Island, Texas); Springer and Bullis, 1956, p. 78 (Gulf of Mexico); Briggs, 1958, p. 273 (Florida).

Promicrops guttatus (*non* Linnaeus): Jordan and Eigenmann, 1890, pp. 363, 364, pl. 62 (Brazil); Henshall, 1895, p. 215 (Key West, Florida); Jordan and Thompson, 1905, p. 240 (Dry Tortugas, Florida); Fowler, 1927, p. 252 (Captiva Pass, Fort Myers, Florida); Gudger, 1929, pp. 172, 173, pl. 4, fig. 1 (Dry Tortugas, Florida).

Promicrops itajara: Schultz, 1952, p. 121; Springer and Woodburn, 1960, p. 35.

Epinephelus itajara: Bailey et al., 1960, p. 25 (common name); Tabb and Manning, 1961, p. 618; Randall, 1967, p. 698 (dietary habits); Carpenter and Nelson, 1971, p. 22 (Caribbean Sea); Odum, 1971, pp. 59, 60; C. L. Smith, 1971a, pp. 152–157 (complete account); Hastings, 1972, pp. 163, 164; Powell et al., 1972, p. 62; Lindall et al., 1975, p. 84 (juvenile habitat); Smith et al., 1975, p. 6; Walls, 1975, p. 172; G. B. Smith, 1976, pp. 17, 22, 41, 52 (eastern Gulf of Mexico); Hoese and Moore, 1977, p. 172; Thompson and Munro, 1978, pp. 116–118, 128 (Jamaica); Odum et al., 1982, pp. 52, 117 (mangrove habitat).

Epinephelus itjara: Gilmore et al., 1978, p. 82 (cold kill, misspelling).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: ATLANTIC SEABOARD: 1, 47; Westshore, St. Lucie estuary across from Sewall's Point, Port Sewall, Martin County, Florida, 1.2 m; 11 March 1959; rotenone; FSBC 1200.—EASTERN GULF OF MEXICO: 3, 59.0–72.1; Sanibel Island, off Woodring Point, Lee County, Florida, 1.5 m; December 1984; bait shrimp trawl; FSBC 16288.—1, 87.8; Sanibel Island, off Woodring Point, Lee County, Florida, 1 m; January 1985; bait shrimp trawl; FSBC 16289.—1, 45.8; Bunces Pass off Sister Key, Pinellas County, Florida, 0.6 m; 11 November 1970; roller frame trawl; FSBC 8373.—2, 51.3, 57.2; Bunces Pass, Sister Key, Pinellas County, Florida, 0.6 m; 29

December 1971; roller frame trawl; FSBC 8375.—1, 81.5; Frenchmans Creek, Pinellas County, Florida, 0.2–1.0 m; 19–21 May 1971; 254-mm cylindrical, wire fish trap; FSBC 8374.—1, 130.1; canal in northeastern St. Petersburg, Pinellas County, Florida, approximately 2 m; 18 April 1972; fish trap. FSBC 9539.

Diagnosis (after C. L. Smith, 1971a): Dorsal XI, 15–16; anal III, 8; pectoral 19; gill rakers 22–24. Very large species; body thick, almost terete; eye small; head extremely broad, flat; scales very rugose in adults; dorsal spines short, with interspinous membranes well notched.

Small black spots on head and body; ground color nearly uniform gray or green. Young with oblique, irregular vertical bars (Plate XI, Figure B).

Distinguishing characters: The jewfish, largest of the western North Atlantic groupers, is readily distinguished from other species by its terete shape, broad head, small eyes, distinctive coloration, and short dorsal spines (C. L. Smith, 1971a).

Geographic distribution (after C. L. Smith, 1971a): *Epinephelus itajara* is found along both coasts of Florida, throughout the Gulf of Mexico to Brazil, and has also been recorded from Haiti, Cuba, Jamaica, Puerto Rico, and the Bahamas. It is present on the Pacific coast from Costa Rica to Peru.

The center of abundance of *Epinephelus itajara* along the Florida west coast appears to be in the vicinity of the Ten Thousand Islands (south of Naples), where extensive habitat (mangrove swamp) exists for juveniles.

Bathymetric distribution and habitat: The jewfish inhabits the shallow shore zone (C. L. Smith, 1971a). In Jamaica, large adults are captured in Kingston Harbor, and juveniles have been collected in mangrove swamps in depths of only about 2 m (Thompson and Munro, 1978).

Along the Florida west coast, *E. itajara* ranges from shallow bays and estuarine areas to offshore. Smaller specimens are most frequently taken inshore along bulkheads, bridges (Springer and Woodburn, 1960), and even in poorly oxygenated upland canals in the Tampa Bay area (Lindall et al., 1975). These juveniles also occur in mangrove swamps where tidal currents scour out relatively deep holes (3 m) and produce undercut ledges large enough to accommodate one to several jewfish ranging in size from 0.45 kg (1 lb) to 18.1 kg (40 lbs) (D. Bellamy, personal communication; L. Bullock, personal observation). Odum et al. (1982) felt that jewfish invaded tidal streams primarily on feeding forays. Large adults prefer high-relief ledges and offshore wrecks (G. B. Smith, 1976), although large individuals have been observed in shallow water in the Everglades, Florida Bay, and the Florida Keys (D. DeMaria and J. Rhodes, personal communication).

Reproduction: C. L. Smith (1971a) found what he considered to be evidence of protogynous hermaphroditism in a 6-ft (1.8-m) male: testicular oocyte remnants. However, Sadovy and Shapiro (1987) have stated that the mere presence of oocyte remnants is not sufficient evidence to prove protogyny. Testes, however, do appear to be secondarily derived from ovarian tissue by having a lumen and peripheral sperm-collecting sinuses—anatomical structures not usually associated with gonochorists. If the testes are secondarily derived, the occurrence of relatively small (887-mm) mature males is problematical. Perhaps these males pass through an immature female stage and mature only as males.

According to Schroeder (1924), spawning occurs during July and August in waters around Key West, Florida. He noted that this species (listed as *Promicrops itajara*) was gregarious during spawning and was captured by hook and line in greater numbers during this time. The jewfish is presently the only species of grouper in the eastern Gulf of Mexico that has repeatedly been observed in what appears to be spawning aggregations. Anecdotal accounts of aggregations of other species of groupers exist but have never been confirmed. G. B. Smith (1976) observed a possible spawning aggregation of 20–30 large jewfish (45–200 kg) during a single dive in June 1971 on the *Mexican Pride*, a sunken freighter lying in 36-m depths west (260°) off Egmont Key, Pinellas County, Florida. During summer, large aggregations have been observed by divers on offshore wrecks at depths of 36–46 m (D. DeMaria and T. Reynolds, personal communications). Although actual spawning has never been witnessed, it is assumed that spawning occurs at these sites because females have advanced vitellogenic oocytes and males contain milt.

Because most commercially captured jewfish are eviscerated prior to landing, gonad samples are difficult to acquire. However, we have observed ripe females during June–October, which is consistent with Schroeder's (1924) findings off Key West.

Three small specimens, ranging 45.8–57.2 mm in length, were collected in Tampa Bay estuarine areas during November–December, and four young-of-the-year, 59–87.8 mm in length, were captured in grass beds during December and early January off Sanibel Island, Florida, further indicating a summer spawning period.

Batch fecundity estimates for two female jewfish (1,322 mm and 1,397 mm) were 38,922,168 ± 1,518,283 and 56,599,306 ± 1,866,130 oocytes, respectively.

Ecology: Large jewfish are probably sedentary; they exhibit little inter-reef movement. G. B. Smith (1976) observed the same individuals for more than a year at specific reef sites off Sarasota, Florida. During summer spawning, however, jewfish apparently aggregate around offshore wrecks.

Reef or site specificity may cause *E. itajara* to be vulnerable to physiological stresses caused by cold water or red tide. Gilmore et al. (1978) found dead jewfish on both coasts of Florida during the severe winter of 1976–1977. G. B. Smith (1976) found that the reef populations of *E. itajara* were drastically reduced during the 1971 red tide; dead individuals over 45 kg were frequently observed.

Diet: Apparently, crustaceans are important in the diet of juvenile jewfish. Tabb and Manning (1961: 618) occasionally observed a jewfish in South Florida "rooting among mangrove roots at the water's edge, with its tail above water." Odum (1971) found that two small individuals (181 mm and 232 mm) had consumed the pink shrimp *Penaeus duorarum* Burkenroad, 1939 and the xanthid crab *Rhithropanopeus harrisii* (Gould, 1841). The stomach of a juvenile jewfish (57 mm) from Tampa Bay contained the remains of an unidentified shrimp. Remains of the sea catfish *Arius felis* (Linnaeus, 1766) have been found in stomach contents of juvenile jewfish.

For nine individuals ranging 1,250–1,650 mm SL, Randall (1967) found that 68.9% (by volume) of the diet was composed of lobsters (*Panulirus argus* (Latreille, 1804) and *Scyllarides aequinoctialis* (Lund, 1793)), whereas fishes (*Dasyatis americana* Hildebrand and Schroeder, 1928 and *Diodon* sp.), crabs, and sea turtles made up 13.3%, 12.2%, and 5.6% of the diet,

TABLE 11. PARASITES ASSOCIATED WITH *EPINEPHELUS ITAJARA.*

Taxa	Site	Source
Trematoda		
Lecithochirium microstomum Chandler, 1935		Manter, 1947
Prosorhynchus promicropsi Manter, 1940		Manter, 1947
Stephanostomum promicropsi Manter, 1947		Manter, 1947
Nematoda		
Heterotyphlum eurycheilum Olsen, 1952	stomach and intestine	Olsen, 1952
**Hysterothylacium* sp.	stomach	Present study
Hirudinea		
**Trachelobdella* sp.	buccal cavity	Present study
Isopoda		
Excorallana tricornis (Hansen, 1890)	nose	Pearse, 1934
Nerocila acuminata Schioedte and Meinert, 1883		Pearse, 1952b
Rocinela signata Schioedte and Meinert, 1880	gills	Pearse, 1934
Copepoda		
Grandiungus promicrops Pearse, 1952	gills	Pearse, 1952b
Tuxophorus caligodes Wilson, 1908	head, mouth	Pearse, 1952b

*Specimens identified by R. Overstreet, Gulf Coast Research Laboratory.

respectively. Two jewfish from Campeche Bank, Mexico, had consumed large numbers of portunid crabs (C. L. Smith, 1971a). Beebe and Tee-Van (1928) found a parrotfish in the stomach of a 367-mm jewfish.

Jewfish captured in the eastern Gulf and examined for gut analysis (n = 32) contained the following food: octopus mouthparts; the gastropod *Fasciolaria tulipa* (Linnaeus, 1758); the lobsters *Panulirus argus* and *Scyllarides* sp.; the crabs *Calappa flammea* (Herbst, 1794), *Menippe mercenaria* (Say, 1818), *Ovalipes floridanus* Hay and Shore, 1918, *Callinectes* sp., and *Hepatus* sp.; the spadefish *Chaetodipterus faber* (Broussonet, 1782); the scrawled cowfish *Lactophrys quadricornis* (Linnaeus, 1758); the round herring, *Etrumeus teres* (DeKay, 1842); and the striped burrfish *Chilomycterus schoepfi* (Walbaum, 1792). Predation on relatively slow-moving fishes, such as *Diodon, C. schoepfi,* and *L. quadricornis,* and invertebrates may indicate that the jewfish's large size and sluggish nature limit its prey selection. However, this species is capable of accelerating from a resting position with explosive speed.

Parasites and abnormalities: Breder and Nigrelli (1934) reported an "ophichthid mummy," *Myrichthys acuminatus,* from the coelom of a jewfish. Catfish spines have been found embedded in mesentery outside the stomach (L. Bullock, personal observation). Apparently, these spines penetrated the stomach lining. Table 11 lists parasites found associated with *E. itajara.*

Length-weight relationship: The relationship of weight to length for *E. itajara* captured in the eastern Gulf of Mexico is expressed by the following: $W = 3.9 \times 10^{-8}\ SL^{2.965}$ ($n = 112$, $r^2 = 0.99$) (Figure 33), and $W = 1.5 \times 10^{-8}\ TL^{3.021}$ ($n = 112$, $r^2 = 0.99$), where W is gutted weight in kilograms and lengths are in millimeters.

Size and commercial importance: This species is probably long-lived, having an estimated

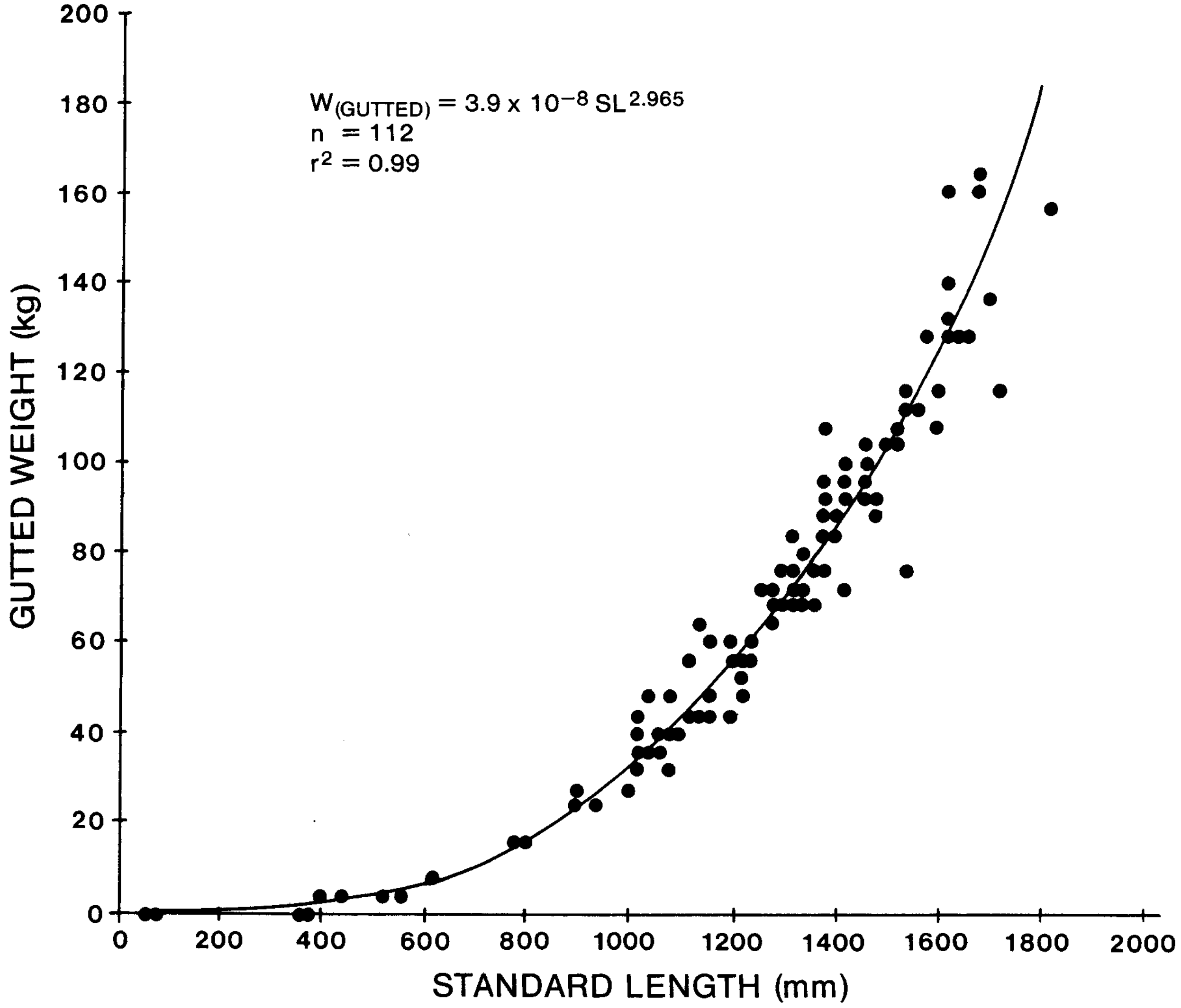

Figure 33. Length-weight relationship of gutted *Epinephelus itajara* captured in the eastern Gulf of Mexico.

longevity of more than 35 years. They can attain a weight of more than 700 lb (317 kg) (C. L. Smith, 1971a).

Before becoming a protected species in 1990, jewfish were of minor commercial importance along the west and northwest coasts of Florida; landings for 1959–1988 are presented in Figure 34 (Florida Landings, 1959–1988). Jewfish were a by-catch of commercial shrimp trawling operations. Spearfishermen found a ready target in jewfish inhabiting offshore wrecks; as many as 30 individuals weighing 90–181 kg each have been harvested on one diving trip during summer aggregations (L. Bullock, personal observation). Fishing pressure increased when market values rose. The jewfish would appear to be an excellent candidate for mariculture; these fish are extremely hardy and grow rapidly while they are young.

Carpenter and Nelson (1971) caught *E. itajara* off the coasts of Panama, western Colombia, and the Guianas in depths of 1–30 fathoms (2–55 m) during exploratory fishing in the Caribbean Sea.

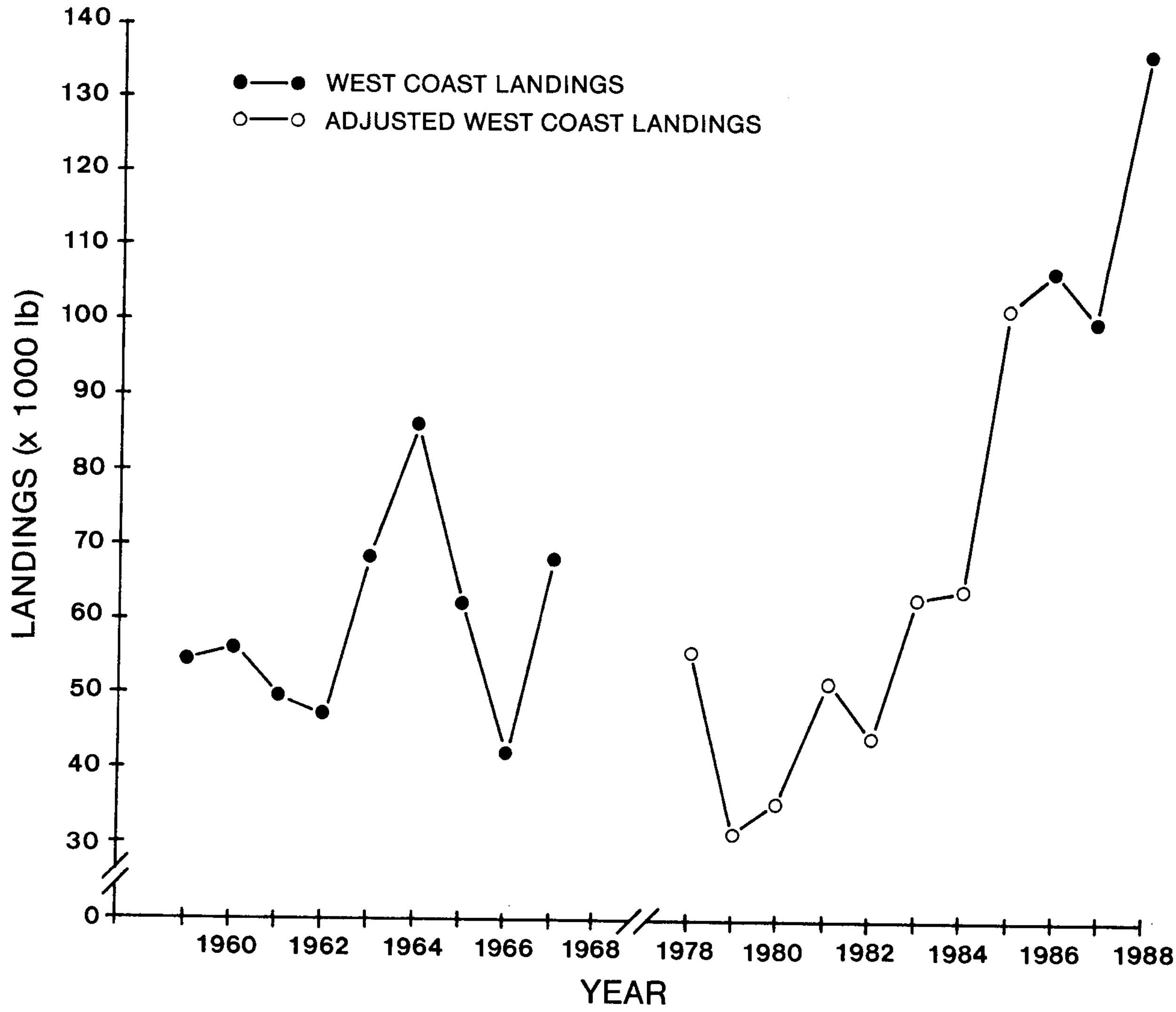

Figure 34. Florida west coast commercial landings of *Epinephelus itajara* for 1959–1988. West coast landings are adjusted for Lee County over-reporting; over-reporting for 1968–1977 could not be adjusted.

Epinephelus morio (Valenciennes, 1828)
Red grouper

Figure 35; Plate XI, Figure D (juvenile)
Plate XII, Figure A (adult)

Serranus morio Valenciennes, *in* Cuvier and Valenciennes, 1828, pp. 285, 286; Fowler, 1907, p. 255 (Key West, Florida).

Epinephelus morio: Gill, 1862, p. 30; Goode and Bean, 1880, p. 139; Jordan and Gilbert, 1883a, p. 540; Bean, 1884, pp. 446, 503; Jordan, 1884a, p. 77; Jordan and Evermann, 1887, p. 466; Henshall, 1895, p. 216; Jordan and Evermann, 1896a, p. 372; Evermann and Kendall, 1900, p. 74; Jordan and Thompson, 1905, p. 240; Fowler, 1906, p. 97; 1920, pp. 147, 153; Schroeder, 1924, pp. 14, 15, fig. 8; Gudger, 1929, pp. 171, 172; Pearse, 1934, p. 113; Delsman, 1941, p. 68; Longley and Hildebrand, 1941, pp. 96, 97; Springer, 1946, pp. 174, 175; Manter, 1947, p. 371; Springer and Bullis, 1956, p. 78; Briggs, 1958, p. 272; Springer and Woodburn, 1960, pp. 34, 35; Moe, 1963b, p. 703; Rivas, 1964, pp. 26, 27; Moe and Martin, 1965, p. 136; Randall, 1967, pp. 698, 699; Moe, 1969, pp. 1–95; C. L. Smith, 1971a, pp. 111–116; Wang and Raney, 1971, p. 31; G. B. Smith, 1975, pp. 144, 146; Smith et al., 1975, p. 6; Walls, 1975, p. 173; G. B. Smith, 1976, p. 22; Fischthal, 1977, p. 87 (digenetic trematode); Hoese and Moore, 1977, p. 172; G. B. Smith, 1978, pp. 48, table 6, 116, 182, 183; Cressey, 1981, p. 8 (parasitic copepod); Deardorff and Overstreet, 1981, pp. 117, 122 (parasites); Bannerot, 1984, p. 34 (movements); Darcy and Gutherz, 1984a, p. 100 (list).

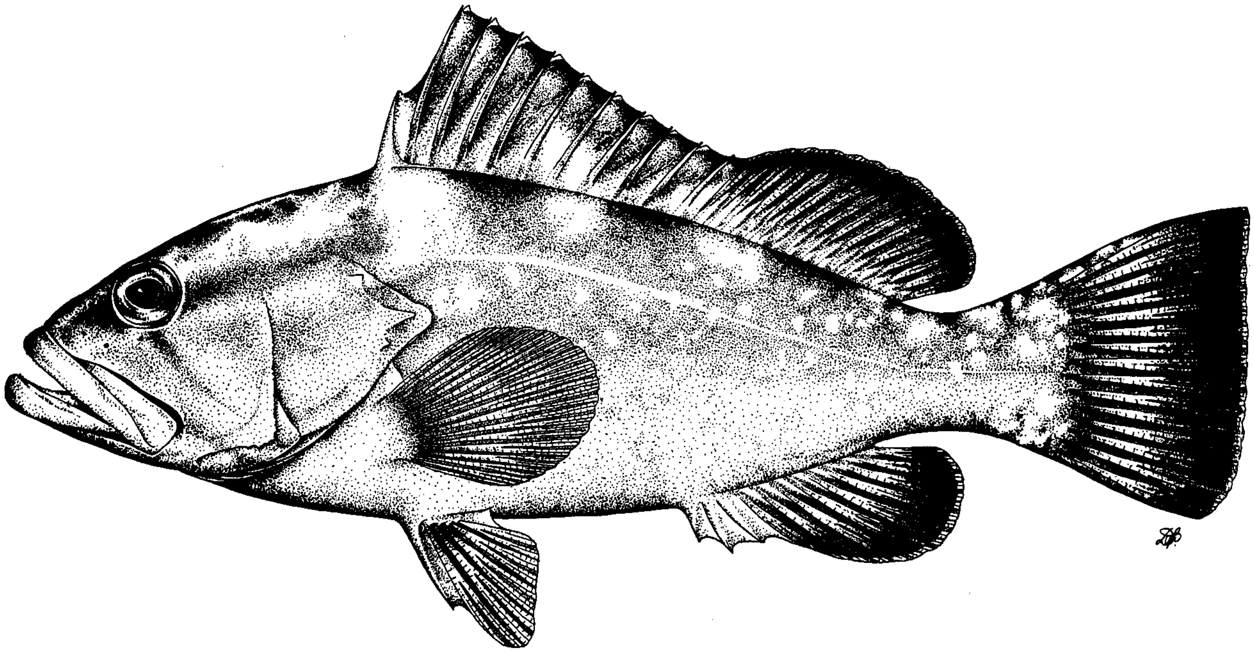

Figure 35. *Epinephelus morio* (Valenciennes, 1828).

Material examined: HOURGLASS STATION B: 1, 182; 8 November 1965; trawl; FSBC 4559.—1, 114; 18 May 1966; trawl; uncatalogued.—1, 131; 18 July 1966; trawl; FSBC 5024.—1, 178; 1 August 1966; trawl; uncatalogued.—1, 98; 5 February 1967; trawl; FSBC 16065.—1, 93; 31 August 1967; dredge; uncatalogued.—1, 240; 25 July 1967; SCUBA; uncatalogued.—HOURGLASS STATION C.—1, 48; 5 October 1965; trawl; uncatalogued.—2, 150, 230; 20 February 1966; trawl; FSBC 4897.—1, 20; 18 June 1966; dredge; FSBC 6081.—1, 167; 20 January 1967; trawl; FSBC 13539.—1, 172; 21 November 1967; trawl; uncatalogued.—HOURGLASS STATION J: 1, 256; 11 May 1966; trawl; FSBC 14704.—1, 191; 21 July 1966; trawl; FSBC 5079.—HOURGLASS STATION K: 1, 148, 14 November 1967; trawl; FSBC 5450.

Diagnosis (after C. L. Smith, 1971a): Dorsal XI, 16–17 with interspinous membrane not notched; second dorsal spine longest; anal III, 9 (rarely 10); pectoral 16–18 (modally 17); caudal fin truncate; gill rakers 23–25.

Moderate-sized *Epinephelus* with large eye, small scales, and robust body. Skull crests well developed, frontoparietal crests converging anteriorly.

Color generally reddish brown, sometimes marbled with lighter spots. A few dark pinpoint spots on cheeks in irregular row around eye; no dark saddle on caudal peduncle.

Distinguishing characters: Only *E. morio* and *E. nigritus* have their second dorsal spine longer than the third, and *E. morio* is the only grouper to have an unnotched dorsal interspinous membrane (C. L. Smith, 1971a).

Remarks: Moe (1969) treated the biology of *E. morio* in detail, including information on life history, ecology, age and growth, and population dynamics.

Geographic and bathymetric distribution: The red grouper is abundant in the Gulf of Mexico, particularly on the Florida and Yucatan Shelves, but it is also known from Massachusetts to Brazil, including the Antilles and Bermuda (C. L. Smith, 1971a).

The red grouper is distributed from nearshore to depths of at least 110 m (C. L. Smith, 1971a). Juvenile red grouper are occasionally collected from seagrass beds within bays and Gulf passes (Springer and Woodburn, 1960; Wang and Raney, 1971). As these fish increase in size, they move offshore (Moe, 1969). Larger fish (>12 kg) are frequently encountered in waters deeper than 36 m (G. B. Smith, 1976).

Habitat: Unlike most other groupers, *E. morio* is not restricted to the immediate vicinity of the reef ledge; it also utilizes extensive areas of flat, low-relief limestone bottom on the West Florida Shelf. *Epinephelus morio* occurs, almost to the exclusion of all other groupers, over flat rock perforated with solution holes. Its habitat preferences explain the reason that *E. morio* was captured more frequently than other groupers in Project Hourglass trawl and dredge hauls.

Susceptibility to red tide: The red grouper is particularly susceptible to the effects of *Gymnodinium breve* Davis, 1948 (=*Ptychodiscus brevis*) blooms. During the 1971 summer red tide, all individuals of *E. morio* were killed at shallow-water reefs in 12–15 m depths off Sarasota, Florida (G. B. Smith, 1975, 1976). Repopulation occurred seven months to one year later, through both juvenile recruitment and shoreward movement of young adults from unaffected, offshore areas (G. B. Smith, 1976, 1978).

Reproduction: Moe (1969) reported that eastern Gulf of Mexico populations of red grouper spawn from March to July, with peak activity occurring in April and May. Females mature at ages 4–6 at approximately 450 mm (Moe, 1969).

The eggs of *E. morio* are described by Moe (1969) as being less than 1.0 mm in diameter, containing an oil droplet, and lacking filaments or other appendages.

Larvae are pelagic for 30–40 days and metamorphose at about 20–25 mm (Moe, 1969).

Movement and migration: Smaller red grouper generally reside at shallow-water (3–18 m) reefs off southwest Florida, but after several years they begin to appear in commercial catches from depths greater than 36 m. Analysis of tag-return data revealed that red grouper leave the nearshore reef environment at about 400 mm and five years of age, corresponding generally with the onset of sexual maturity (Moe, 1969).

Commercial fishermen have reported large aggregations of red grouper in November near Lower Matecumbe in the Florida Keys (Bannerot, 1984) and have noted seasonal movement in offshore (27–91 m depths) stocks of adult red grouper. Moe (1969) reported that 22 tagged red grouper moved 18 miles within 50 days.

Diet: Juvenile red grouper (18–25 mm) from the Tampa Bay area were found to consume the shrimp *Hippolyte zostericola* (Smith, 1873) and amphipods (K. Peters, unpublished data). Larger individuals (approximately 300–500 mm FL, n = 23) captured south-southwest of Ft. Myers, Florida, during November 1987 in 22- to 30-m depths regurgitated the following invertebrates: an octopus; a gastropod operculum; the mantis shrimp *Gonadactylus bredini* Manning, 1969; the snapping shrimp *Alpheus armillatus* H. Milne Edwards, 1837; the penaeid shrimp

Metapenaeopsis goodei (Smith, 1885); the hermit crab *Petrochirus diogenes* (Linnaeus, 1758); and the majid crabs *Mithrax pleuracanthus* Stimpson, 1871 and *M. forceps* (A. Milne Edwards, 1875).

Regurgitated fishes included the belted sandfish, *Serranus subligarius;* the tomtate, *Haemulon aurolineatum;* the blue goby, *Ioglossus calliurus* Bean, 1882; the yellowhead jawfish, *Opistognathus aurifrons* (Jordan and Thompson, 1905); the seaweed blenny, *Parablennius marmoreus* (Poey, 1875); and a cardinalfish, *Astrapogon* sp. Adult red grouper are euryphagic carnivores. Moe (1969) found that *E. morio* from the eastern Gulf consumed small fishes of many species, crabs (especially *Portunus* and *Calappa*), lobsters (*Panulirus* and *Scyllarides*), shrimps, octopuses, squids, and unidentified crustaceans. The slippery dick, *Halichoeres bivittatus* (Bloch, 1791), and the stomatopod *Gonadactylus bredini* Manning, 1969 were recorded from the stomach contents of red grouper from the same area (L. Bullock, personal observation).

A similar diet was noted by Longley and Hildebrand (1941) for red grouper captured near the Dry Tortugas, Florida. These fish had consumed fishes, octopuses, and crustaceans (including spiny lobsters, shrimps, and stomatopods). Gudger (1929), also at the Dry Tortugas, found a lutjanid and two sparids in the stomachs of three specimens. Five specimens captured in the West Indies contained (by volume) 50% unidentified crustaceans, 33.3% crabs, and 16.7% fishes (Randall, 1967).

Length-weight relationship: The relationship of weight to length for *E. morio* captured in the eastern Gulf of Mexico is expressed by the following: $W = 5.42 \times 10^{-8} SL^{2.897}$ ($n = 264$, $r^2 = 0.98$), where W is whole weight in kilograms and length is in millimeters. This equation is a recalculation of Moe's (1969: 68) length-weight formula. The new formula includes all of Moe's original variates plus 60 additional specimens; Moe calculated his formula using only 12 class means for the variates.

Predation: Red grouper have been taken from the stomachs of *Carcharhinus obscurus* (LeSueur, 1818) after the groupers had apparently been stunned by cold-water upwelling (Springer, 1946). Juvenile red grouper are preyed upon by *Mycteroperca microlepis* (L. Bullock, personal observation).

Parasites and abnormalities: A philometrid nematode is prevalent in the gonad of red grouper, and plerocercoid metacestodes abound in the visceral cavity. Larval nematodes (*Hysterothylacium* spp.) can be found in the mesentery (Deardorff and Overstreet, 1981). The isopod *Excorallana tricornis tricornis* (Hansen, 1890) was found on the gills of *E. morio* at the Dry Tortugas (Pearse, 1934). Trematodes found in red grouper captured at the same location include *Helicometra torta* Linton, 1910; *Lepidapedon levenseni* (Linton, 1907); *Opisthoporus epinepheli* Manter, 1947; and *Stephanostomum dendatum* Linton, 1900 (Manter, 1947). Fischthal (1977) noted the digenetic trematode *Postporus epinepheli* (Manter, 1947) in red grouper captured off Belize. Cressey (1981) found the parasitic copepod *Neobomolochus elongatus* Cressey, 1981 attached to *E. morio.*

A 630-mm specimen of *E. morio* possessed no pelvic fins; another individual displayed scoliosis. Moe (1969) reported the occurrence of a skeletal tumor, a deformed pelvic fin, and otolith excrescences in *E. morio.*

Size and commercial importance: C. L. Smith (1971a) estimated the maximum size of red grouper to be 25–30 lb (9.2–13.6 kg).

The red grouper and the gag (*Mycteroperca microlepis*) are the most abundant grouper species in west Florida commercial catches. At the time of Springer and Woodburn's (1960) study, the red grouper was considered to be less plentiful than the gag. Until 1958, however, local fishermen had reported that *E. morio* dominated catches. This seeming discrepancy in relative species abundance may have been real or an artifact. Since 1958, most boats have been equipped with recording fathometers and LORAN (long range aid to navigation, a positioning device) and could consistently fish reef ledges, the preferred habitat of the gag. Prior to this time, many fishermen merely fished general areas of hard bottom and were apt to catch a preponderance of red grouper. On the other hand, the shift in species abundance may have been attributable to differential mortalities sustained by these species during the 1957–1958 red tide. During the 1971 red tide, all red grouper appeared to be exterminated at shallow-water reefs, but gag survived as remnant populations, thereby gaining an initial numerical advantage during early recolonization (G. B. Smith, 1976, 1978).

Generally, red grouper are voracious feeders, and often every individual can be captured by hook and line from a small patch reef. Gag, however, are more wary and feed less frequently; consequently, fishing success is a poor estimator of their true abundance.

Length-frequency data for red grouper captured by the commercial hook-and-line fishery (and by longline for 1984) were compared for 1963–1964 (Moe, 1969), 1977–1980 (M. Godcharles and L. Bullock, unpublished data), and 1984 (M. Mitchell, unpublished data) (Figure 36). Although there are similar size modes (approximately 600 mm) for the periods of 1963–

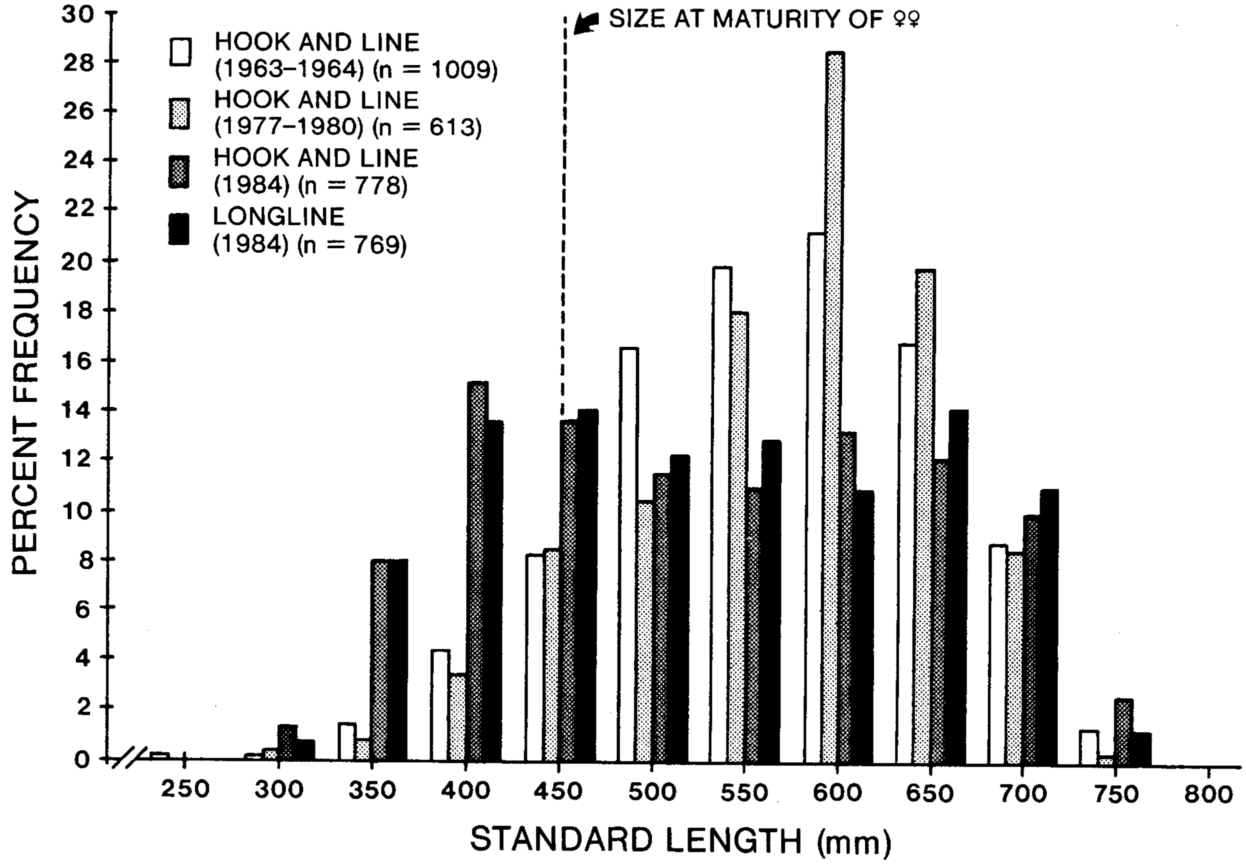

Figure 36. Length frequency distribution of *Epinephelus morio* commercially captured by hook and line in the eastern Gulf of Mexico during 1963–1967 (from Moe, 1969) (n = 1,009) versus those captured by hook and line during 1977–1980 (n = 613) and by longline (n = 769) and by hook and line (n = 778) during 1984.

1964 and 1977–1980, data for both hook-and-line and longline fisheries in 1984 reveal no clearly discernable modes. Additionally, a higher percentage of sexually immature fish were harvested in 1984. The four distributions were compared using χ^2 analysis. Distributions between samples were found to differ significantly ($\chi^2 = 389.3$, df = 22, $p < 0.001$). Length-frequency distributions for 1977–1980 differed significantly from 1963–1964 samples ($\chi^2 = 48.7$, df = 11, $p < 0.001$) and from 1984 data ($\chi^2 = 726.4$, df = 11, $p < 0.001$). Although 1977–1980 and 1963–1964 distributions were different, the magnitude was not as evident as in 1984 when the distribution was clearly shifted to the left (smaller fish). This may be evidence of growth overfishing or an artifact caused by sampling red grouper from different depths.

Epinephelus mystacinus (Poey, 1852)
Misty grouper

Plate XII, Figure B (juvenile)
Plate XII, Figure C (adult)

Serranus mystacinus Poey, 1852 (1851–1854), pp. 52, 53, pl. 10, fig. 1 (Cuba: original descr.).

Epinephelus mystacinus: Jordan and Swain, 1885a, pp. 383, 384 (Havana, Cuba); Scholander and Van Dam, 1954, p. 249 (Bimini); Briggs, 1958, p. 272 (compiled distrib.); C. L. Smith, 1958, p. 51 (spawning); 1961, p. 51 (Bermuda); Rivas, 1964, p. 22 (key, characters, common name); Robins, 1967b, pp. 838, 839 (juveniles in Florida waters); Böhlke and Chaplin, 1968, p. 278 (Bahamas); Brownell and Rainey, 1971, pp. 48, 49 (Virgin Islands); Robins, 1971, p. 252 (ecological competition with *E. nigritus*); C. L. Smith, 1971a, pp. 133–136 (complete account); Brody, 1972, pp. 108, 111, 115 (eastern Caribbean: ciguatera); Munro et al., 1973, p. 71 (Caribbean spawning); Colin, 1974, p. 33 (Jamaica: submersible observation); Roe, 1976, pp. 155, 156 (NMFS collections); C. L. Smith, 1978 (FAO species ID sheets); Thompson and Munro, 1978, pp. 115, 117 (Jamaica); Sutherland et al., 1983, p. 180 (underwater observation); Parker and Ross, 1986, p. 35, table 1 (North Carolina); Nelson and Appeldoorn, 1985, p. 27 (Puerto Rico: submersible observations).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: SOUTHEASTERN GULF OF MEXICO: 3, 415–492; 37 mi west of the Dry Tortugas, 168 m; 25 April 1987; commercial hook and line; uncatalogued. EASTERN GULF OF MEXICO: 2, 392, 439; 26°46′N, 83°52′W, 88 m; 2 May 1989; commercial hook and line; uncatalogued and FSBC 18000, respectively.—2, 330, 382; 26°46′N, 83°52′W, 149 m; 26 May 1989; commercial hook and line; uncatalogued. SOUTHWESTERN GULF OF MEXICO: 1, 343 m; off Yucatan, Mexico, 155.4 m; 30 November 1978; commercial hook and line; FSBC 11732.

Diagnosis (modified from C. L. Smith, 1971a): Dorsal XI, 13–15; anal III, 9; pectoral 18 or 19; gill rakers 22–26; posterior nostril greatly enlarged, diameter 4–7 times that of anterior nostril; numerous pyloric caeca.

Color pattern consisting of 8 or 9 vertical bars on light chocolate-brown background. Black mark above upper lip ("maxillary moustache") prominent.

Distinguishing characters: The enlarged posterior nostril of *E. mystacinus* and *E. niveatus* sets these species apart from other groupers (Rivas, 1964). *Epinephelus mystacinus* has a barred body pattern, whereas adult *E. niveatus* has no distinct body pattern other than a series of white spots on the sides. Young *E. niveatus* also have this spotted pattern.

Geographic distribution: The misty grouper has been reported from off Bermuda, North Carolina (Parker and Ross, 1986), the Bahamas, Florida, the Florida Keys, the Dry Tortugas, Yucatan, Cuba, Jamaica, Puerto Rico, the Virgin Islands, and the Leeward Islands to Brazil (C. L. Smith, 1971a).

Robins (1967b) stated that ecological competition with the warsaw grouper might prevent the misty grouper from becoming established around Florida. However, two individuals of *E. mystacinus* were captured in 88-m depths by commercial hook and line at 26°46′N, 83°52′W on 2 May 1989, and on 26 May 1989 two additional specimens were landed at the same location. The capture of these fish is positive evidence of this species' presence in the eastern Gulf of Mexico.

Another Florida west coast commercial fisherman reported catching three large (27–32 kg), vertically barred groupers in August 1979 at approximately 25°48′N in 157 m of water (Capt. B. Banks, personal communication). There also appears to be a northern Gulf population of misty grouper: specimens captured off Texas and Louisiana appeared in commercial landings at St. Petersburg, Florida.

Bathymetric distribution and habitat: Robins (1967b: 838) characterized the misty grouper as "a large gamefish of slope and deep shelf waters (on rocky pinnacles and ledges) from 80 to about 300 fathoms (146–549 m)." Parker and Ross (1986) sighted this species off North Carolina at a depth of 98–152 m. In Bermuda, C. L. Smith (1958) found the misty grouper quite common in 80 fm (146.3 m) or more. This species is taken at depths of 500–1,000 ft (152–305 m) in the Bahamas (Böhlke and Chaplin, 1968). Off Bimini, on the edge of the Florida current, misty grouper have been taken in 320–400 m (Scholander and Van Dam, 1954). Apparently, misty grouper are not confined to areas of high relief; solitary individuals have been captured on hard and soft bottoms in a region of decreased slope off the Leeward Islands in depths of 55–160 fm (100.6–292.6 m) (Brownell and Rainey, 1971).

A juvenile misty grouper was observed around a derelict fish trap in water 27 m deep approximately 5 km SW of Looe Key in the Florida Keys (Sutherland et al., 1983).

Reproduction: One ripe female was found in August and another in November in Jamaican waters (Thompson and Munro, 1978). C. L. Smith (1958) thought that this species spawned in July in Bermuda. Brownell and Rainey (1971) found a female (690 mm FL) in spawning condition in the Virgin Islands, but they did not specify the time of year.

The only gonad examined histologically was from a mature male (1,150 mm) captured at 25°00′N, 84°00′W in 219.5-m depths on 21 January 1981.

Diet: A misty grouper (382 mm) from the eastern Gulf contained a hermit crab, *Dardanus insignis* (Saussure, 1858) and a xanthid crab *Pseudomedaeus* sp. in the stomach. Thompson and Munro (1978) reported a misty grouper taken in 200-m depths off Jamaica that had consumed an eel and eight caridean shrimps. Brownell and Rainey (1971) recovered a sargassum triggerfish, *Xanthichthys ringens* (Linnaeus, 1758), and a squid from misty groupers in the Virgin Islands.

Parasites: Most specimens examined internally by Brownell and Rainey (1971) contained parasites believed to be plerocercoid metacestodes; parasitic isopods commonly occurred in the nostrils of this species.

Size and commercial importance: C. L. Smith (1958) stated that in Bermuda, misty grouper attain a weight of at least 120 lb (54.3 kg) and probably considerably more. For this species in the Bahamas, Böhlke and Chaplin (1968) recorded a maximum length of approximately three feet (0.9 m). The largest specimen we examined was from a commercial catch off Dry Tortugas, Florida; it was 1,150 mm long and weighed 48.9 kg (eviscerated).

Apparently, misty grouper have some commercial importance in Bermuda (C. L. Smith, 1958) and are considered a gamefish in the Bahamas along the edge of the Florida Current. C. L. Smith (1958) mentioned the possibility of this species being vulnerable to pot fishing. Colin (1974) observed a misty grouper exiting and re-entering a lost fish trap in 285-m depths off Jamaica.

Epinephelus nigritus (Holbrook, 1855)
Warsaw grouper

Plate XII, Figure D (juvenile)
Plate XIII, Figure A

Serranus nigritus Holbrook, 1855, p. 173, pl. 25, fig. 2 (Charleston, South Carolina: original descr.).

Epinephelus nigritus: Gill, 1862, p. 30; Goode and Bean, 1878, pp. 182–184 (Pensacola, Florida); Goode, 1879, p. 50 (Pensacola, Florida); Goode and Bean, 1883, p. 238 (Gulf of Mexico); Henshall, 1891, p. 387 (southern Florida); Schroeder, 1924, p. 15 (Key West, Florida); Moe, 1963b, p. 103 (Florida); Rivas, 1964, pp. 21, 22 (characters, *A. scholanderi* not this species); Robins, 1967b, pp. 838, 839 (continental species); Nelson and Carpenter, 1968, p. 61; Causey, 1969, pp. 40, 80 (Texas); Strusaker, 1969, p. 292 (southeastern U.S.); Brownell and Rainey, 1971, p. 50 (continental shelf species); Cervigón M., 1971, pp. 21, 22 (Venezuela); Robins, 1971, p. 252 (continental species); C. L. Smith, 1971a, pp. 128–132 (full account); Schwartz, 1972, p. 252 (North Carolina); Irby, 1974, p. 14 (northeastern Gulf of Mexico); Kawaguchi, 1974, p. 15 (Caribbean experimental fishing); Walls, 1975, pp. 173, 174 (northern Gulf of Mexico); Allen and Tashiro, 1976, p. 45 (U.S. fishery); Hastings et al., 1976, p. 390 (list); Huntsman, 1976, pp. 17, 22 (North Carolina-South Carolina headboat fishery); G. B. Smith, 1976, p. 22, 54 (mideastern Gulf of Mexico); Ulrich et al., 1976, p. 111 (South Carolina); Hoese and Moore, 1977, p. 171 (Texas); G. B. Smith, 1978, pp. 183, 184; Miller and Richards, 1979, p. 117 (South Atlantic Bight); Manooch, 1984, p. 232; Manooch and Mason, 1987, pp. 65–75 (age and growth).

Garrupa nigrita: Brice, 1898, p. 283 (Key West, Florida); Evermann and Kendall, 1900, p. 74 (Florida); Reed, 1941, pp. 76, 77 (Texas coast); Schultz and Reid, 1942, pp. 29, 30 (Grande Isle, Louisiana); Baughman, 1943, p. 771 (Texas); Hildebrand, 1954, p. 303 (Obregón, Mexico); 1955, p. 208 (off Campeche, Mexico); Springer and Bullis, 1956, p. 78 (Gulf of Mexico records); Briggs, 1958, p. 272 (compiled distribution).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 1, 530; 26°30'N, 83°40'W, "Christmas Ridge," 76.8 m; 21 January 1981; commercial hook and line; FSBC 12003.

Diagnosis (after C. L. Smith, 1971a): Dorsal X, 14–15 (second spine in adults greatly elongated and interspinous membrane deeply cleft); anal III, 9; pectoral 19; gill rakers 22–25. Large, robust species of *Epinephelus*; eye medium-sized; vertical fins rounded.

Body uniformly dark red to nearly black; young with yellow pectoral and caudal, scattered white spots on sides.

Distinguishing characters: *Epinephelus nigritus* is the only grouper in the western North Atlantic with ten dorsal spines, of which the second is the longest (at least in individuals over 400 mm). *Epinephelus nigritus* resembles *E. niveatus* and *E. flavolimbatus* in possessing white spots on the body, but the white spots are scattered as opposed to being in the precise pattern of vertical and horizontal rows found in those two species (C. L. Smith, 1971a).

Geographic distribution: The warsaw grouper is found from Massachusetts (rarely as young) to Brazil, including the Gulf of Mexico (C. L. Smith, 1971a; Manooch and Mason, 1987). This species is also found off Haiti but is unrecorded from the western Caribbean Shelf (Cabo Catoche to the Gulf of Venezuela) and insular areas of the West Indies (G. B. Smith, 1976). Robins

(1971) believed that *Epinephelus nigritus* would not become established in insular areas because of competition with *E. mystacinus.*

Bathymetric distribution and habitat: Although warsaw grouper have been observed off jetties and reefs in shallow water off northwest Florida and Texas (Causey, 1969; Hastings, 1972), this species has not been recorded off west Florida in less than 35-m depths and generally occurs at 55-m depths or greater (G. B. Smith, 1976, 1978). Perhaps its shallow-water occurrence in the northeastern Gulf is attributable to clear water near shore and the proximity of natural deep-water reefs, a combination absent along the Florida west-central coast.

Manooch and Mason (1987) characterized the habitat of warsaw grouper off the Atlantic coast as irregular bottom (steep cliffs and rocky ledges) at the continental shelf break at depths of 76–219 m.

Reproduction: The spawning season for warsaw grouper in the eastern Gulf of Mexico has not been determined. The occurrence of postspawning females in November (1977) may be an indication of late summer spawning, but this remains strictly conjectural until adequate sampling is undertaken.

Diet: The lobster *Scyllarides nodifer* (Stimpson, 1866) was found in the stomach of a 778-mm individual captured in August 1982.

Length-weight relationship and age and growth: A length-weight relationship for *E. nigritus* collected from Beaufort, North Carolina, to Panama City, Florida, was developed by Manooch and Mason (1987) as follows: $W = 2.097 \times 10^{-5}\ TL^{2.9797}$ ($r = 0.96$, $n = 108$), where W = weight in grams and TL = total length in millimeters.

Average total lengths for fish aged at 1, 5, 10, 25, and 41 years (oldest fish aged) are 292, 920, 1,194, 1,879, and 2,328 mm, respectively (Manooch and Mason, 1987). These authors estimated longevity to be approximately 44–46 years.

The von Bertalanffy growth equation according to Manooch and Mason (1987) is the following: $L_t = 2394\ (1-e^{-0.0544(t\ +\ 3.616)})$, where t = age in years and L = total length in millimeters.

Parasites and abnormalities: A large individual (1,000 mm) from a commercial catch was examined and found to have an injury to the dorsum involving loss of approximately half of the spinous dorsal fin and adjacent musculature.

Didymozoid digenetic trematodes were observed on the pseudobranchs of *E. nigritus* (L. Bullock, personal observation).

Size and commercial importance: Warsaw grouper weighing 45 kg are common off west-central Florida, and commercial fishermen in the northeastern Gulf of Mexico regularly capture individuals exceeding 160 kg. Florida west coast landings are presented in Figure 37 (Florida Landings, 1952–1988).

Huntsman (1976) stated that the North Carolina-South Carolina headboat fishery captured 23–40 lb (10.4–18.1 kg) individuals of this species in depths of 30–60 fm (55–110 m).

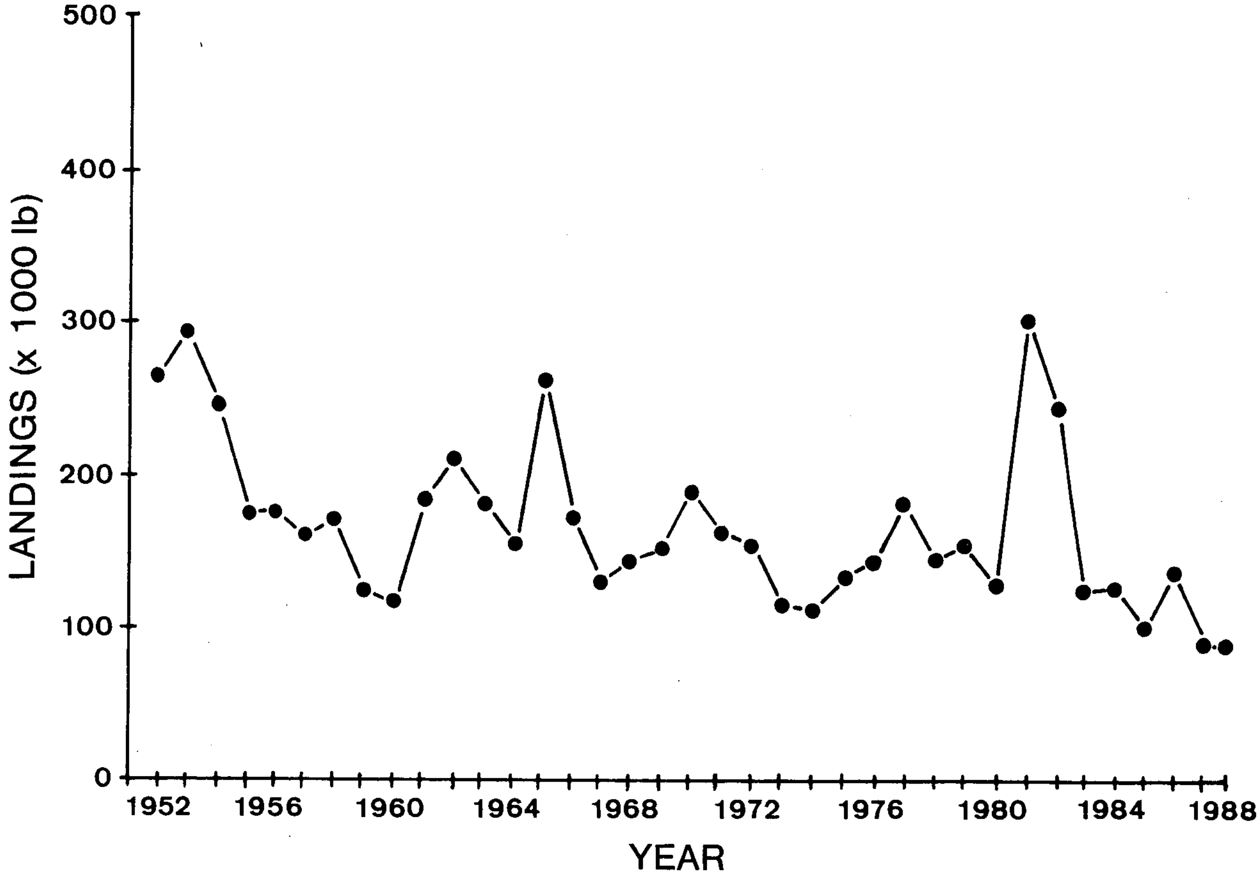

Figure 37. Florida west coast commercial landings of *Epinephelus nigritus* (1952–1988).

Epinephelus nigritus is the largest grouper available to Carolina headboat anglers; warsaw groupers weighing in excess of 300 lb (135.8 kg) have been reported (Huntsman, 1976).

During exploratory longlining by NMFS (formerly Bureau of Commercial Fisheries) in the western Gulf of Mexico, warsaw grouper were rated second in importance to yellowedge grouper off Texas and on Campeche Bank off Mexico at depths of 100–125 fm (183–229 m) (Nelson and Carpenter, 1968). The average catch per 100 hooks for the two areas weighed 10 and 12 lb (4.5 and 5.4 kg), respectively (Nelson and Carpenter, 1968). In the southern Caribbean Sea during similar exploratory fishing, NMFS found warsaw, yellowedge, and snowy groupers to be prevalent from north of Venezuela to French Guiana (Kawaguchi, 1974).

Epinephelus niveatus (Valenciennes, 1828)
Snowy grouper

Figure 38; Plate XIII, Figure B (juvenile)
Plate XIII, Figure C (subadult)

Serranus niveatus Valenciennes, *in* Cuvier and Valenciennes, 1828, p. 380 (Brazil: original descr.).

Epinephelus niveatus: Poey, 1865 (1865–1866), p. 202 (Cuba); Evermann and Kendall, 1900, p. 73 (Florida); Longley and Hildebrand, 1941, pp. 93, 94 (Dry Tortugas, Florida: some of these specimens are *E. flavolimbatus*); Manter, 1947, p. 371 (Dry Tortugas, Florida); Briggs, 1958, p. 272 (Florida); Loret, 1962, pp. 21, 22 (New York); Rivas, 1964, pp. 19, 23, 24 (characters); Böhlke and Chaplin, 1968, p. 277 (Bahamas); Presley, 1970, pp. 1–6 (Florida Straits: descr. of larvae); Bearden and McKenzie, 1971, pp. 10, 13 (South Carolina); Carpenter and Nelson, 1971, p. 22 (Caribbean Sea); C. L. Smith, 1971a, pp. 119–123 (full account); Powell et al., 1972, p. 67; Kawaguchi, 1974, p. 15 (Caribbean Sea); Walls, 1975, p. 174, pl. 202, p. 274; Huntsman, 1976, p. 17 (North Carolina, South Carolina); Huntsman and Dixon, 1976, p. 192 (Carolinas); Roe, 1976, p. 149 (distr.); G. B. Smith, 1976, p. 42 (West Florida Shelf); Ulrich et al., 1976, p. 112 (South Carolina); Cupka et al., 1977, p. 29; Hoese and Moore, 1977, p. 171 (Texas); Ulrich, 1977, p. 9; C. L. Smith, 1978 (FAO species ID sheets); Fitch and Schultz, 1978, pp. 87, 88 (California: age and growth); Bielsa, 1982, pp. 1–33 (diet); Low and Ulrich, 1982, pp. 31–33; Moore, 1982, pp. 1–41; Taylor and McMichael, 1983, p. 7; Matheson and Huntsman, 1984, pp. 607–616; Moore and Labisky, 1984, pp. 322–329; Parker and Ross, 1986, p. 43 (North Carolina); Bielsa and Labisky, 1987, pp. 77, 78, 81–87 (dietary habits).

Material examined: HOURGLASS TRAP STATION: 1, 102; 26°08'N, 82°52'W, 37 m; 28 September 1966; angle trap; FSBC 4936.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 1, 269; 64 mi west of Johns Pass, Pinellas County, Florida, 54.9 m; 15 June 1979; commercial hook and line; FSBC 11641.—1, 111; 29°40'N, 85°45'W, 27.4–30.5 m; 25 August 1966; FSBC 5403.

Diagnosis (modified from C. L. Smith, 1971a): Dorsal XI, 13–15 (modally 14); anal III, 9; pectoral 17–19; gill rakers on the first arch 23–26; caudal fin truncate; interspinous membrane of dorsal fin notched. Body robust; eye large; posterior nostril 3–5 times larger than anterior.

Adult coloration brownish bronze, body covered with pearly-white spots in regular geometric pattern (not evident after fish has been brought from water). Prominent dark moustache over maxillary. Juveniles with spotted body pattern and black saddle on caudal peduncle usually reaching below lateral line. Dorsal-fin margin black.

Distinguishing characters: Epinephelus niveatus is distinguished from *E. flavolimbatus*, with which it often has been confused, by color pattern. In *E. niveatus* the spinous dorsal-fin membrane is edged with a narrow dark band; *E. flavolimbatus* has a yellow margin on the spinous and soft dorsal fin. The saddle on the caudal peduncle in small *E. niveatus* reaches below the lateral line, whereas in small *E. flavolimbatus*, the saddle reaches only to the line (Rivas, 1964). Small specimens of *E. nigritus* may resemble those of the aforementioned two species, but *E. nigritus* lacks the dark peduncular saddle at all sizes; although it has white spots on its sides,

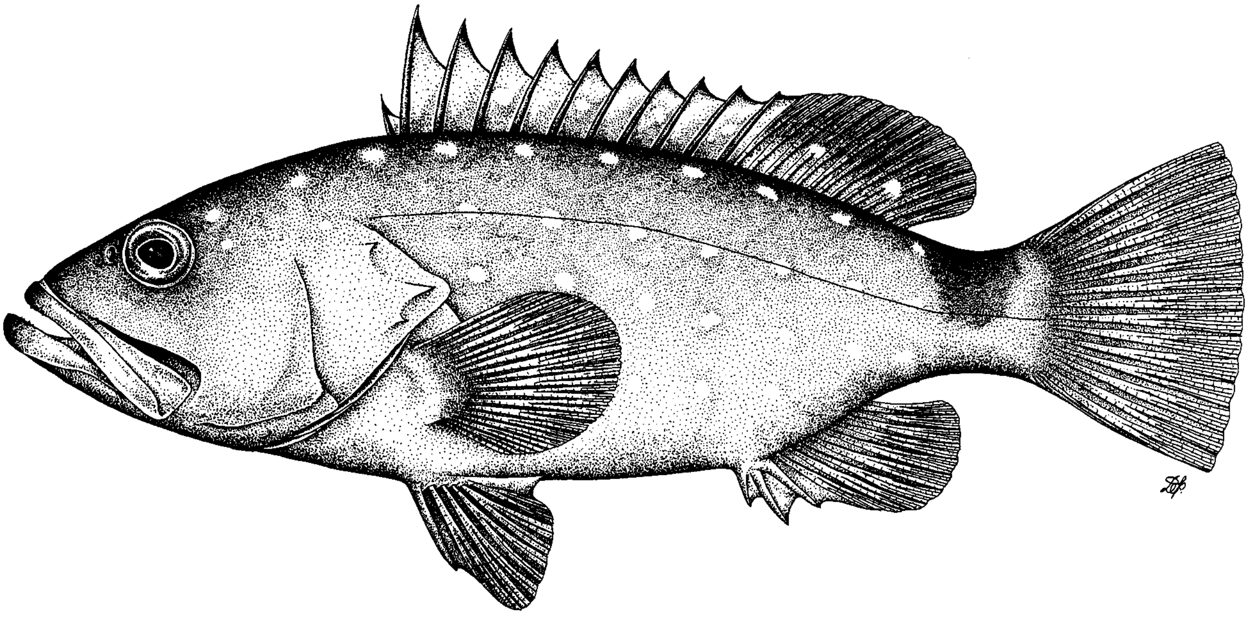

Figure 38. *Epinephelus niveatus* (Valenciennes, 1828).

these spots are not in a definite geometric pattern as in *E. niveatus* or *E. flavolimbatus* (C. L. Smith, 1971a).

Geographic and bathymetric distribution: *Epinephelus niveatus* features an amphi-American distribution. In the western Atlantic, this species is known from New York and New Jersey to southern Florida, throughout the Gulf of Mexico, the Bahamas, Cuba, along the Central American coast, and across northern South America to Brazil (C. L. Smith, 1971a, 1978).

Epinephelus niveatus is generally found in deep water (>60 m and as deep as 256 m) throughout its range; however, juvenile specimens have been found in moderate depths (18 m) in the northern Gulf of Mexico (Walls, 1975), and small (young-of-the-year) specimens (88.9 mm) have been seined in eel grass at a depth of only 3 ft (1 m) at Fire Island Inlet, New York (Loret, 1962). A juvenile snowy grouper (ca. 70–75 mm TL; Plate XIII, Figure B) was captured in waters 17 m deep off La Parguera, Puerto Rico, one week after the passage of Hurricane Allen in 1980 (J. Kimmel, personal communication). Moore (1982) collected juvenile snowy grouper from lobster traps in depths of 43–46 m near the Marquesas Keys. Off Looe Key National Marine Sanctuary in the Florida Keys, juvenile snowy grouper (<100 mm), along with *E. drummondhayi*, are captured in juvenile spiny lobster settlement-traps (B. Blonder, personal communication). Taylor and McMichael (1983) reported that small snowy grouper were occasionally taken by the wire fish-trap fishery in the Florida Keys. This species is infrequently captured by hook and line at the Florida Middle Ground in depths of 30–40 m.

Reproduction: Ripe snowy grouper were sampled from the Florida west coast commercial catch in May, June, and August. Moore and Labisky (1984) found snowy grouper off the Florida Keys to be ripe from April to July—further evidence for a protracted spring–summer spawning season.

Moore and Labisky (1984) found that most females (81%) become sexually mature by age IV or V; males appeared at age VI but constituted 40% of all fish by age VIII or older.

Length-weight relationship, age, growth, and mortality: During a life history study of snowy grouper and speckled hind off North Carolina and South Carolina, Matheson and Huntsman (1984) found the overall length-weight relationship for snowy grouper to be $W = 7.0 \times 10^{-8}\ TL^{2.755}$, where weight is in kilograms and length is in millimeters. Mean lengths for this species that were determined from back-calculated data ranged from 210 mm (TL) at the end of the first year to 958 mm (TL) at the end of year 17. The von Bertalanffy growth equation was $L_t = 1255\ (1\text{-}e^{-0.074(t\ +\ 1.92)})$. Catch curve analysis from headboats showed an increase in annual mortality during 1972–1978 from 0.19 to 0.57, as opposed to a relatively stable commercial mortality rate during 1977–1979 of 0.24–0.25 (Matheson and Huntsman, 1984). Apparently, intense fishing pressure by recreational fishermen significantly increased the total mortality of snowy grouper.

Matheson and Huntsman (1984) found the growth coefficient (K) for Carolina snowy grouper to be 0.074. Moore and Labisky (1984), in a similar age and growth study of snowy grouper caught off the lower Florida Keys, found K to be slightly higher at 0.087 and found full recruitment into the fishery to occur at 575–600 mm TL and at ages VIII or older. These authors estimated annual mortality to be 16%.

Diet: Snowy grouper, speckled hind, and yellowedge grouper all appear to prey heavily on fishes and epibenthic invertebrates. In studying the dietary habits of *E. niveatus* and the blueline tilefish, *Caulolatilus microps* Goode and Bean, 1878, Bielsa (1982) and Bielsa and Labisky (1987) found fishes (Osteichthyes) to be the most important prey item for snowy grouper. Fishes constituted 43% of the number and 47% of the volume; they occurred in 69% of the intestines. Gastropods were another common item in smaller specimens (<510 mm TL). The importance of cephalopods in the snowy grouper's diet increased with fish size; brachyuran crustaceans were numerically important in the diet of the largest groupers (>683 mm TL).

Bielsa and Labisky (1987), in summarizing the feeding habits of snowy grouper and blueline tilefish, found the tilefish to be benthic and euryphagic, whereas *E. niveatus* was more pelagic and relatively stenophagic.

Parasites: Snowy grouper from the Florida west coast were highly infested with plerocercoid metacestodes. Pseudobranchs contained didymozoid digeneans, and unidentified "worms" were found subcutaneously on the cleithrum.

Size and commercial importance: Böhlke and Chaplin (1968) reported that snowy grouper reach a maximum length of approximately 4 ft (1.4 m). The largest specimen examined from the Florida west coast commercial grouper fishery was 970 mm and weighed 24 kg.

In the eastern Gulf of Mexico, commercial fishermen reported catches of snowy grouper in depths of 146–274 m, where they occurred with yellowedge grouper (*E. flavolimbatus*) and the tilefishes *Lopholatilus chamaeleonticeps* Goode and Bean, 1879 and *Caulolatilus microps.* These fishes are harvested by bottom longline or conventional electric reels. Length-frequency distributions for snowy grouper captured commercially by hook and line were compared for the periods of 1978–1981 and 1984–1988 (Figure 39) and were found to be significantly different using χ^2 analysis ($\chi^2 = 26.6$, df = 14, $p < 0.025$). A modal shift from 700 mm during 1978–1981 to 550 mm in 1984–1988 is apparent. Additionally, fewer large snowy groupers ($\geq$ 800 mm) appear in the catch for the latter time period. Although greater numbers of immature fish were landed during 1984–1988, their contribution to the total catch is very slight. These comparisons, of course, are valid only if the same depth ranges were fished during both time periods.

Carpenter and Nelson (1971), in their investigation of the fishery potential of the Caribbean and the Guianas, reported major catches of snowy grouper in a depth range of 50–100 fm (91–183 m) on the Honduran-Nicaraguan shelf and off Panama, Colombia, and Venezuela.

Commercially exploitable stocks of snowy grouper exist off North Carolina and South Carolina (Huntsman, 1976; Huntsman and Dixon, 1976; Ulrich, 1977). Huntsman (1976) stated that North Carolina-South Carolina offshore headboats caught snowy grouper weighing 6–12 lb (2.7–5.4 kg) in 30–60 fm (55–110 m). Ulrich (1977) pointed out that along the south Atlantic coast, commercial fishermen caught snowy grouper in a size range of 25–100 cm TL (with a primary mode at 70–74 cm and a secondary mode at 40–44 cm). This species is quite abundant in 80–100 fm (146–183 m) and has been reported as deep as 140 fm (256 m) Ulrich (1977).

Genus *Gonioplectrus* Gill, 1862

Diagnosis (modified from Jordan and Evermann, 1896b): Dorsal VIII, 13; anal III, 7; pectoral 16–17, with upper rays longest.

Preopercle serrate, with large, antrorse hook at angle on ventral edge; opercle ending in 3 spines, second long, blade-like. Gill rakers 20–24, long, slender; lateral line arched, running high,

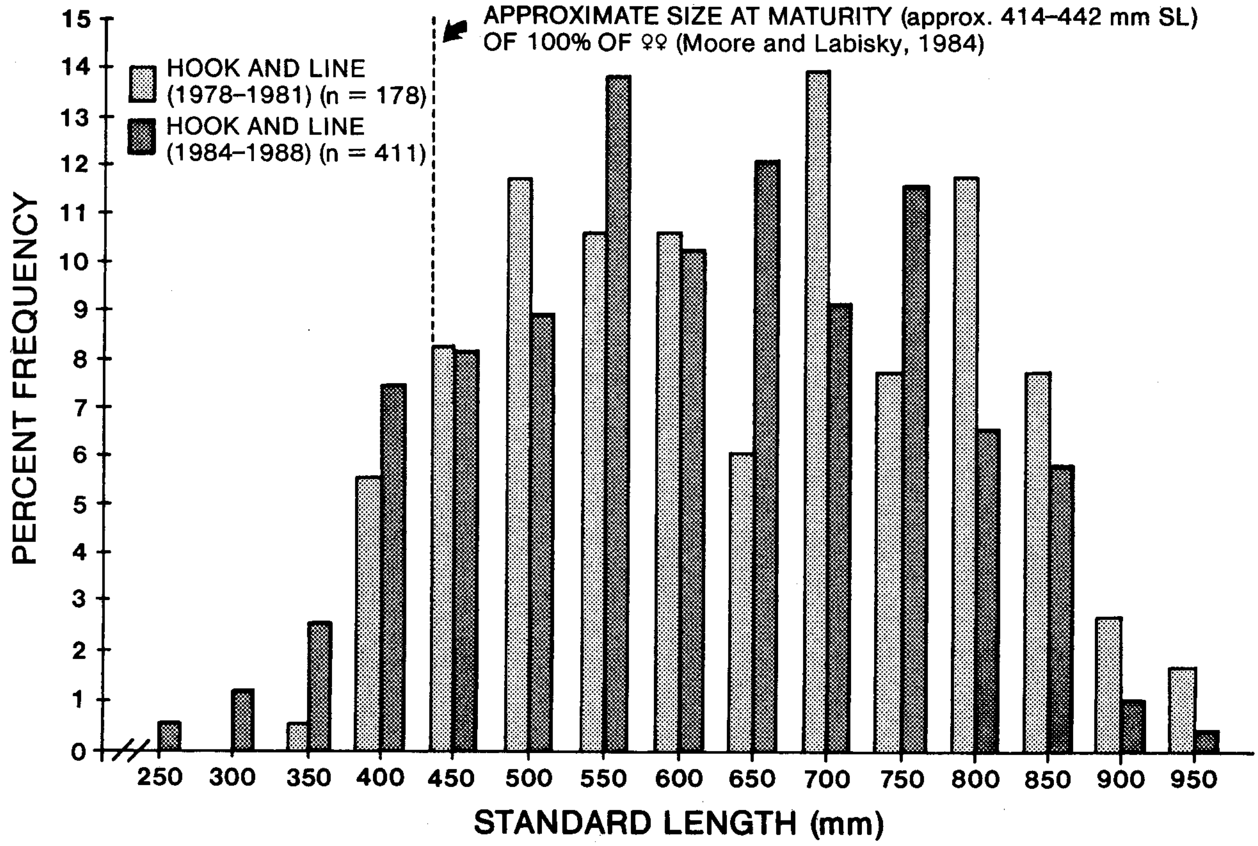

Figure 39. Length frequency distribution of *Epinephelus niveatus* commercially captured by hook and line during 1978–1981 (n = 178) versus 1984–1988 (n = 411).

close to middle of spinous dorsal, then curving abruptly downward. Caudal truncate. Branchiostegals 7; vertebrae 24.

Color yellow with six stripes (rose to salmon colored) from head to base of caudal or soft dorsal. Dorsal yellow, with salmon stripe at base. Anal rosy with large red spot at base. Snout rosy with yellow markings. Belly yellow grading to pinkish purple ventrally, with white blotch above anus (Robins et al., 1986).

Larvae (ca. 13 mm) with deeper, more robust body and with less elongate dorsal and pelvic spines than other epinephelines. Stout second dorsal spine with bump-like spinelets. Configuration of second and third dorsal spine identical; shape of these spines unique among epinephelines (see Johnson and Keener, 1984; Kendall, 1984).

Gonioplectrus hispanus (Cuvier and Valenciennes, 1828)
Spanish flag

Plate XIV, Figure B

Plectropoma hispanum Cuvier and Valenciennes, 1828, p. 396 (Martinique).

Gonioplectrus hispanus: Poey, 1868, p. 289; Jordan and Evermann, 1896b, pp. 1139, 1140; Briggs, 1958, p. 272 (northeastern Gulf of Mexico); Briggs et al., 1964, p. 114 (off Texas); Gilbert, 1969, p. 301 (Grand Cayman); Cervigón M., 1971, p. 24, fig. 11

(Venezuela); Briggs, 1974, p. 220 (illustr.); Colin, 1974, p. 33 (Belize and Jamaica); Instituto Nacional de Pesca, 1976, p. 329 (Mexico: color plate); G. B. Smith, 1976, p. 42 (northeastern Gulf of Mexico); Hoese and Moore, 1977, pp. 167, 168 (off Texas and Florida Panhandle); Thompson and Munro, 1978, p. 115 (Jamaica); Kendall and Fahay, 1979, pp. 117–121 (descr. of larvae); Johnson and Keener, 1984, pp. 129–132 (larval spine morphology); Kendall, 1984, p. 508 (characters of larvae); Robins et al., 1986, p. 143, plate 26 (descr.).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: SOUTHEASTERN GULF OF MEXICO: 1, 170; 24°36'N, 83°35'W, 110–128 m; 28 August 1980; hook and line; FSBC 11805.—EASTERN GULF OF MEXICO: 1, 227; 27°24'N, 84°10–15'W, 135 m; 7 July 1987; hook and line; uncatalogued.

Diagnosis: Because *Gonioplectrus* is monotypic, characters of the genus also define the species.

Distinguishing characters: The antrorse spine on the preopercle, the knife-like spine on the opercle (Figure 4), the crimson spot at the base of the anal fin (Plate XIV, Figure B), and the eight dorsal-fin spines easily serve to distinguish this fish from other serranids.

Geographic and bathymetric distribution: This species has been recorded from off North Carolina (larva), the Bahamas, the Dry Tortugas, the Florida Panhandle, off Texas, and throughout the Greater and Lesser Antilles to Venezuela (Briggs, 1958; Briggs et al., 1964; Gilbert, 1969; Cervigón M., 1971; Colin, 1974; Thompson and Munro, 1978; Johnson and Keener, 1984).

Gonioplectrus hispanus was recently discovered in the eastern Gulf in deep water off Sarasota, Florida (see *Material examined*).

This species is usually found on rocky ledges at depths of 60–365 m (Robins et al., 1986).

Reproduction: The two specimens examined (170 and 227 mm), captured in August and July, respectively, were both mature active males; their testes were in early recrudescence and contained large atretic bodies.

Genus *Liopropoma* Gill, 1861

Diagnosis (after Randall, 1963b): Dorsal VIII, 11 or 12 (last ray composite), posterior part of spinous portion deeply indented, with spine tips slightly protruding from scaly basal sheath, or dorsal fin separated into two portions by scaled area between fifth and eighth spines (intermediate spines either embedded or with tips just protruding); anal III, 8 (last ray composite); pelvic I, 5; pectoral 13–16; lateral line complete, pored scales 44–50; vertebrae 10 + 14. Opercle with 3 flattened spines, central one strongest. Body moderately elongate, depth 2.9–3.8 in SL; snout pointed, lower jaw projecting. Maxillary reaches back to center of eye but not beyond rear of eye; supramaxillary present. Teeth small, in villiform bands in jaws. Small fishes, rarely exceeding 65 mm SL.

Larvae (6.3–7.0 mm SL) with two elongate, thin, delicate dorsal spines pigmented distally (Kendall, 1979, 1984).

KEY TO *LIOPROPOMA* SPECIES FROM OFF FLORIDA
(See Plate XIV, Figures C and D.)

1. Body without stripes.. *L. mowbrayi*

1. Body marked with one or more longitudinal stripes.. 2

2. Body with one dark longitudinal stripe.. *L. eukrines*
2. Body with five darkish longitudinal stripes 3

3. Dark spot on anal fin; two black spots on caudal fin connected medially by narrow dark region .... *L. rubre*
3. No dark spot on anal fin; two black spots on caudal fin distinctly separated....... *L. carmabi*

Remarks: Only one species of *Liopropoma* is known from the West Florida Shelf.

Liopropoma eukrines (Starck and Courtenay, 1962)
Wrasse bass

Plate XIV, Figure D

Chorististium eukrines Starck and Courtenay, 1962, pp. 159–161.

Liopropoma eukrines: Robins, 1967a, pp. 591–595; Powell et al., 1972, p. 68; Bright and Cashman, 1974, pp. 343, 351, 382 (fig.); Hoese and Moore, 1977, p. 168; Shipp and Hopkins, 1978, p. 117 (off northwestern Florida); Miller and Richards, 1979, p. 117; Gilmore et al., 1981, p. 25, appendix p. 14; Clarke, 1986, p. 73, table 2 (Florida Middle Ground); Parker and Ross, 1986, p. 35 (North Carolina).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: FLORIDA KEYS: 1, 46; 24°38′N, 81°05′W, 40 m; 25 August 1986; SCUBA with handnet; FSBC 17512.—EASTERN GULF OF MEXICO: 1, 66 (paratype); offshore of St. Petersburg, Pinellas County, Florida; 19 August 1961; from a grouper stomach; UF 44857.—NORTHWESTERN GULF OF MEXICO: 1, West Flower Garden Bank, Texas, 27°52.6′N, 93°49′W, 25.9 m; 13 January 1972; TCWC 4972.1.

Diagnosis (after Starck and Courtenay, 1962): Dorsal VI-I-I, 12 (last ray composite); anal III, 8; pectoral 13 or 14; branched caudal rays 15. Single, dark, median-lateral stripe from snout almost to posterior edge of caudal fin, stripe darkened near tip of caudal fin. Brown pigment spot present at symphysis of lower jaw.

Distinguishing characters: Liopropoma eukrines can be separated from other members of the genus by the dark mid-lateral stripe; it can be distinguished from *Pikea* by the divided spiny and soft dorsal fin, which is continuous in *Pikea.*

Geographic distribution: Liopropoma eukrines is recorded from the South Atlantic Bight (Miller and Richards, 1979; Parker and Ross, 1986) and off Ft. Pierce on the Florida east coast (Gilmore et al., 1981). In the Gulf of Mexico, this species is found in the Florida Keys, off Tampa Bay, Florida (Starck and Courtenay, 1962), on the Florida Middle Ground (Clarke, 1986) from DeSoto Canyon off northwest Florida (Shipp and Hopkins, 1978), from offshore reefs off Louisiana, and on the West Flower Garden Bank off Galveston, Texas (Hoese and Moore, 1977).

Bathymetric distribution and habitat: In their original description, Starck and Courtenay (1962) noted that *Liopropoma eukrines* occurred in an area within the Florida Current boundaries. They believed this fish may have a preference for clear, flowing waters as do many other fishes with tropical affinities. Capture depths were 150–234 ft (46–71 m). Parker and Ross (1986) commonly observed *L. eukrines* on reefs off North Carolina in a depth range of 30–116 m. Individuals usually occurred singly under ledges, which is perhaps an expression of their strong territorial requirements (Shipp and Hopkins, 1978).

Reproduction: C. L. Smith (1971b) suggested that *Liopropoma rubre* Poey, 1861 and *L. mowbrayi* Woods and Kanazawa, 1951 are secondary gonochorists (i.e., derived from an hermaphroditic ancestor) and believed that other congeners (including *L. eukrines*) would show similar gonad structure. However, he examined only five specimens each of *L. rubre* and *L. mowbrayi*. Additionally, Y. Sadovy (personal communication) has found possible indications of protogyny in a female specimen of *L. rubre* and stresses that more extensive sampling for all three species of *Liopropoma* is needed before their sexual pattern(s) can be established.

Male *L. eukrines* possess a sperm reservoir at the base of the urogenital papilla that is unique among perciforms (C. L. Smith, 1971b).

Predation: *Liopropoma eukrines* has been taken from the stomach of an unspecified grouper (Starck and Courtenay, 1962).

Genus *Mycteroperca* Gill, 1864

Diagnosis (modified from C. L. Smith, 1971a): Dorsal XI, 15–18; anal III, 10–13. Skull with well-developed skull crests; frontoparietal crests parallel and uniting supraorbital ridge. Upper preopercular limb serrate. Caudal fin square or lunate.

Moderate to large groupers, elongated body, dorsal profile arched more strongly than ventral. Larvae with melanophore at cleithral symphysis (Johnson and Keener, 1984).

Remarks: For more complete synonymies of the six species of *Mycteroperca*, refer to C. L. Smith (1971a).

KEY TO *MYCTEROPERCA* SPECIES OF THE WEST FLORIDA SHELF

(Modified from C. L. Smith, 1971a.)

1. Preopercle gently rounded, its upper and lower limbs uniting in broadly obtuse angle or gentle curve, its notch more or less obsolescent, no definite lobe below (Figure 40B, D) 2
1. Preopercle angulate, upper and lower limbs forming angle somewhat greater than 90°; distinct notch usually above angle; definite, more or less serrate lobe below notch (Figure 40A, C) ... 4

2. Developed gill rakers on lower limb of first arch 4–8; body dark dorsally, with about 9 oblique pale stripes usually evident.. *M. tigris*
2. Developed gill rakers on lower limb 11–16; body pattern otherwise....................... 3

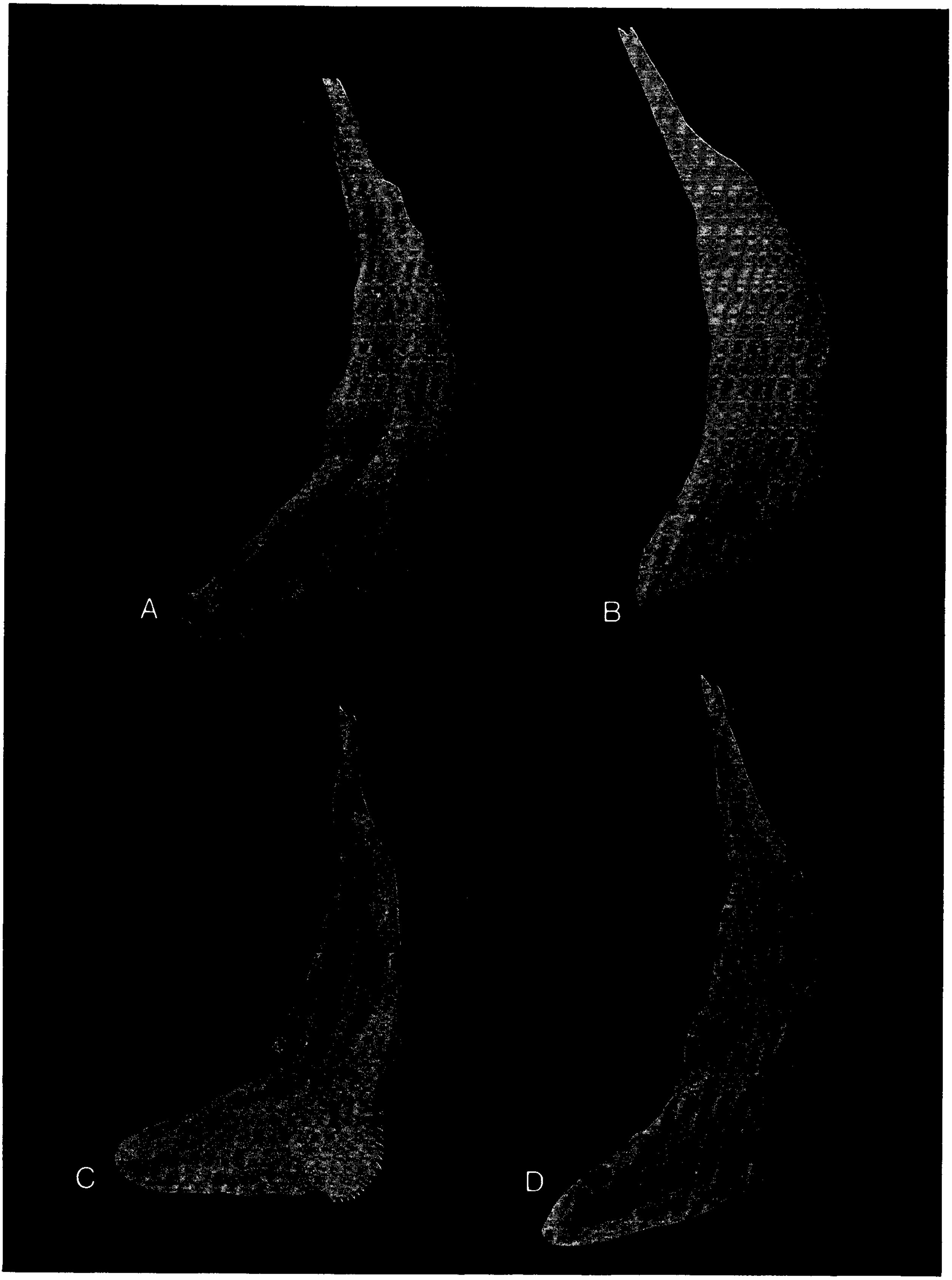

Figure 40. Preopercles of: A. *Mycteroperca phenax*; B. *M. venenosa*; C. *M. microlepis*; and D. *M. bonaci*.

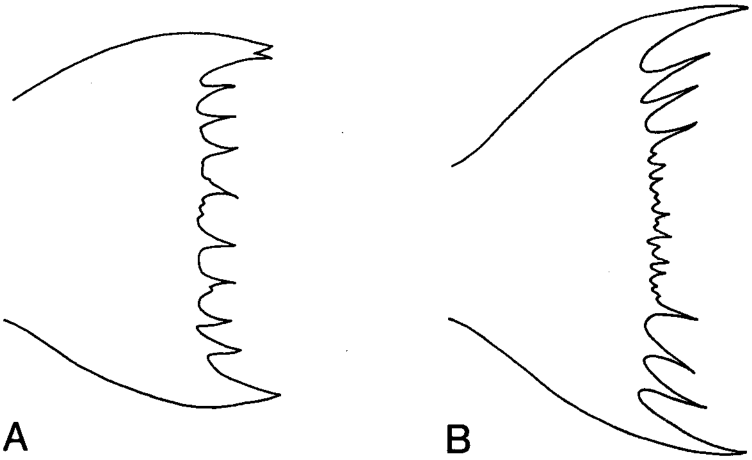

Figure 41. Caudal fin profiles of: A. *Mycteroperca interstitialis;* and B. *M. phenax.*

3. Distal third of pectoral abruptly bright yellow in life, remaining fin variously marked with small dark spots; large individuals with small, bright red spots on lower body and head.. *M. venenosa*
3. Pectoral with narrow orange margin (about ⅕ fin length) shading gradually into basal dark color pattern lacking distinct spots; no bright red spots although head and body with brassy yellow spots in all but juveniles .... *M. bonaci*

4. Median fins without produced rays; color largely gray, sides with darker vermiculations.. *M. microlepis*
4. Some median fin rays produced in large specimens; color brownish gray with pattern of spots or blotches 5

5. Body dark reddish brown, occasionally broken into small spots separated by paler yellow reticulations; exserted mid-caudal rays regular (Figure 41A; Plate XV, Figure D); greenish submarginal band on caudal distinct; total gill rakers 23–27 .... *M. interstitialis*
5. Body and fins light grayish brown with small brownish-red spots; exserted middle caudal rays irregular (Figure 41B; Plate XVII, Figure B); green submarginal band on caudal indistinct; total gill rakers 26–31 .... *M. phenax*

Mycteroperca bonaci (Poey, 1860)
Black grouper

Plate XV, Figure A (juvenile)
Plate XV, Figure B (adult)

Serranus bonaci Poey, 1860 (1858–1861), pp. 129–131 (Cuba: original descr.).

Mycteroperca bonaci: Jordan and Swain, 1885a. pp. 370, 371; Henshall, 1891, p. 387 (Key West, Florida); Evermann and Kendall, 1900, p. 74 (Florida); Fowler, 1920, p. 153 (Key West and Charlotte Harbor, Florida); Mowbray, 1950, p. 30; Pearse, 1952a, pp. 204, 216 (parasites); Springer and Bullis, 1956, p. 78; Bardach and Menzel, 1957, p. 108 (Bermuda: growth rates); Erdman, 1957, p. 321; Briggs, 1958, p. 272; C. L. Smith, 1958, pp. 16, 22, 56, 57, figs. 8, 16, pls. 13, 14 (Bermuda: biology); 1959, p. 114, fig. 8 (hermaphroditism); 1961, pp. 1:6, 1:18, 1:19, 1:23, fig. 17; Springer and McErlean, 1962, p. 393 (Key Largo, Florida: ecology); Cervigón M. and Velasquez, 1966, pp. 86–89 (Venezuela: full account); Randall, 1967, p. 702 (dietary habits); Böhlke and Chaplin, 1968, p. 286 (Bahamas); Randall, 1968, pp. 64, 65, fig. 71; Causey, 1969, pp. 40, 69 (off Padre Island, Texas); Overstreet, 1969, p. 171 (digenetic trematodes); C. L. Smith, 1971a, pp. 177–182 (complete account); Hastings, 1972, pp. 169, 170 (confusion over common name "black grouper"); C. L. Smith, 1972, p. 260 (spawning in Bahamas); Powell et al., 1972, p. 68; Kawaguchi, 1974, p. 16; Alevizon and Brooks, 1975, p. 486 (Florida Keys); Smith et al., 1975, p. 6; Walls, 1975, p. 178 (not common off Texas); Allen and Tashiro, 1976, p. 45 (U.S. commercial fishery); Beaumariage and Bullock, 1976, p. 90 (compiled); Klima, 1976, p. 13 (off Texas); Nakamura, 1976, p. 78 (Gulf of Mexico recreational fishery); G. B. Smith, 1976, p. 23 (Florida Middle Ground); Fischthal, 1977, p. 88 (digenetic trematode); Hoese and Moore, 1977, p. 174 (not verified off Texas); Tashiro and Coleman, 1977, p. 2 (list); Thompson and Munro, 1978, pp. 116, 118, 121, 129; G. B. Smith, 1979, pp. 52–54 (eastern Gulf of Mexico); Darcy and Gutherz, 1984a, p. 100; Manooch and Mason, 1987, pp. 65–75 (age and growth).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: ATLANTIC SEABOARD: 1, 240; Ft. Pierce Inlet, St. Lucie County, Florida; 3 February 1962; FSBC 2109.—FLORIDA KEYS: 1, 390; west side of Loggerhead Key, the Dry Tortugas, Florida; 26 April 1967; FSBC 988.—1, 94.2; patch reef approximately ¼ mi NE of Mosquito Beacon off Key Largo, Monroe County, Florida; 13 June 1960; FSBC 1796.—1, 216; same as previous location; 16 June 1960; FSBC 1797.—EASTERN GULF OF MEXICO: 1, 335; 8.5 nmi off Pass-a-Grille, Pinellas County, Florida, 14–15 m; 18 November 1973; FSBC 8017.

Diagnosis (modified from C. L. Smith, 1971a): Dorsal XI, 16–17; anal III, 11–13 (usually 12); pectoral 17; gill rakers 19–27; posterior nostril not enlarged; preopercle rounded; vertical fins without exserted rays. Large species of *Mycteroperca* with robust body.

Head and lower body with brassy spots; upper side of body with rectangular blotches that may fade; outer third of vertical fins black.

Distinguishing characters: Juveniles and subadults of *M. bonaci* and *M. microlepis* closely resemble each other but can be separated by color pattern and number of anal fin rays (usually 12 in *M. bonaci* and 11 in *M. microlepis*). *Mycteroperca bonaci* has more of a geometric pattern of quadrate blotches on its sides, whereas *M. microlepis* has a mottled pattern composed of dark vermiculations (Plate XV, Figure B, and Plate XVI, Figure C, respectively). Larger individuals of *M. bonaci* can be distinguished by the brassy yellow spots on the side and head not found in *M. microlepis*.

The color pattern of *M. bonaci* is also similar to that of *M. venenosa*, but individuals of *M. venenosa* can easily be separated by the brilliant yellow coloration of the outer portion of the pectoral fin (Plate XVIII, Figure B).

Geographic distribution: Springer and Bullis (1956) reported *M. bonaci* from scattered localities in the northern Gulf of Mexico, but C. L. Smith (1971a) suspected that these records were erroneous and outside the verified range of the species, which included Bermuda, southern Florida, the southwestern Gulf of Mexico, the West Indies, Panama, northern South America, and southern Brazil. Subsequently, Smith et al. (1975) and G. B. Smith (1976) documented the occurrence of *M. bonaci* in moderate depths on the West Florida Shelf.

The black grouper may be considered a rare inhabitant of the West Florida Shelf; the common species of *Mycteroperca* off west Florida is the gag. Hastings (1972: 170) pointed out that "much of the confusion in the literature regarding the distributions of *M. bonaci* and *M. microlepis* stems from the fact that the name 'black grouper' has been applied to *M. microlepis*, more properly referred to as the gag. Many misidentifications have been generated in the literature because of the assumption that only one species of black grouper occurs in a given area, especially when the identifier is not familiar with all species of groupers."

Bathymetric distribution and habitat: *Mycteroperca bonaci* is usually found at depths of 30 m or greater in the eastern Gulf. However, juveniles have been captured infrequently in estuarine areas, and this species appeared at shallow-water (12–18 m) reefs off Sarasota, Florida, after the 1971 red tide. Florida west coast charter boat captains occasionally report the occurrence of black grouper in moderate depths; several black grouper (3.2–4.5 kg) were captured in 18-m depths southwest of Johns Pass, Pinellas County, Florida, in November 1978 (L. Bullock, personal observation).

The black grouper's habitat is irregular bottom such as coral reefs, drop-off walls, and rocky ledges (Manooch and Mason, 1987).

Reproduction: In January 1971 off Cat Cay in the Bahamas, C. L. Smith (1972: 260) caught a black grouper approximately 1 m long (TL?) that had "fully mature ova in the follicles." Erdman (1957) reported that *M. bonaci* spawned in Puerto Rican waters in February (only one ripe male was examined). On the Campeche Bank, C. L. Smith (1961) observed black grouper in spawning condition during July and August.

In the eastern Gulf of Mexico, ripe female black grouper (495–1,005 mm) have been observed from December to August; nine ripe males (956–1,160 mm) were captured from January through April (L. Bullock, personal observation). However, the total number of specimens was insufficient to accurately determine the spawning season. In the Florida Keys, black grouper are in spawning condition during March and April, with some postspawning females occurring in April (R. Taylor and R. McMichael, personal communication).

Diet and feeding: Two juvenile black grouper (17 mm and 21 mm) from Tampa Bay consumed unidentified shrimp and amphipods (K. Peters, unpublished data). Randall (1967: 704) stated that members of the genus *Mycteroperca* are "less intimately associated with the bottom than those of *Epinephelus*. They feed almost exclusively on fishes. They are more slender-bodied (hence probably more rapid in their feeding rushes) and have better developed canine teeth. Both of these characteristics would be expected of a predominately piscivorous group of serranid fishes." He reported finding *Fistularia tabacaria* Linnaeus, 1758 and *Haemulon flavolineatum* (Desmarest, 1823) in the stomachs of six adult individuals of black grouper examined in the West Indies.

Parasites: Philometrid nematodes were found in the gonads. Isopods removed from the nostrils of *Mycteroperca bonaci* captured west of the Dry Tortugas were identified as *Aega tenuipes* Schioedte and Meinert, 1880; *Alcirona krebsii* Hansen, 1890; and ?*Tridentalla virginiana* (L. Williams, personal communication). The digenetic trematodes *Prosorhynchus pacificus* Manter, 1940; *Lecithochirium parvum* Manter, 1947; *L. microstomum* Chandler, 1935; and *Neolepidapedon macrum* Overstreet, 1969 were found in the digestive tract of black grouper from south Florida (Overstreet, 1969). Fischthal (1977) also noted the occurrence of *P. pacificus* in black grouper captured off Belize. Pearse (1952) found the copepods *Lernanthropus wilsoni* Pearse, 1952 and *Lepeophtheirus bonaci* Pearse, 1952 in the gills of a black grouper (although the species may actually have been *M. microlepis*).

Length-weight relationship: The relationship of weight to length for *M. bonaci* captured in the eastern Gulf of Mexico is expressed by the following: $W = 1.17 \times 10^{-8}\ SL^{3.111}$ ($n = 47$, $r^2 = 0.99$) (Figure 42), and $W = 3.42 \times 10^{-9}\ TL^{3.210}$ ($n = 46$, $r^2 = 0.99$), where W is whole weight in kilograms and lengths are in millimeters.

Age and growth: The average size (mm TL) at ages 1, 5, 10, and 14 are 260, 664, 975, and 1,110, respectively (Manooch and Mason, 1987). The maximum age was estimated to be ap-

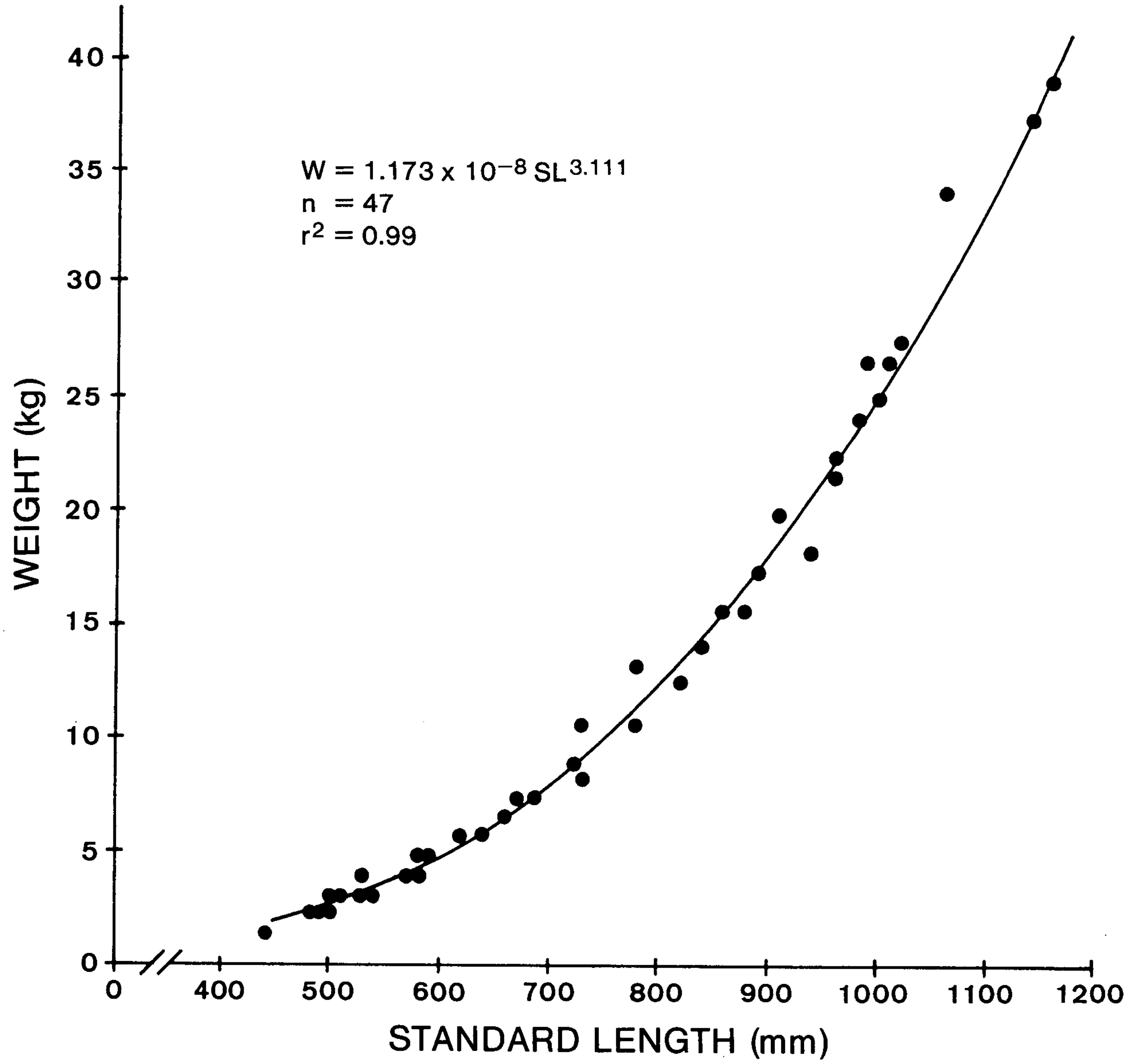

Figure 42. Length-weight relationship of *Mycteroperca bonaci* captured by hook and line in the eastern Gulf of Mexico.

proximately 17–19 years. The von Bertalanffy growth equation according to Manooch and Mason (1987) is $L_t = 1352\ (1\text{-}e^{-0.1156(t\ +0.927)})$. These authors found that most rapid growth occurred in the first 3–4 years.

Size and commercial importance: Mowbray (1950) reported that at Bermuda black grouper may reach a weight of 180 lb (81.5 kg). Off the Florida west coast, 22.6–40.8 kg specimens are common.

The largest black grouper from Jamaican waters recorded by Thompson and Munro (1978) was 133 cm TL. The largest specimen sampled from the Florida west coast was 1,260 mm (50.9 kg).

During a fish-trap study conducted by FMRI during the period of November 1979–June 1980 in the Florida Keys, the average individual weight of black grouper caught was 4.8 kg (n = 361) (R. Taylor and R. McMichael, personal communication).

The black grouper is an important commercial fish in Bermuda (C. L. Smith, 1971a) and off Venezuela (Cervigón M. and Velasquez, 1966). In the eastern Gulf of Mexico this species is not frequently landed.

Mycteroperca interstitialis (Poey, 1860)
Yellowmouth grouper

Plate XV, Figure C (juvenile)
Plate XV, Figure D (adult)

Serranus interstitialis Poey, 1860 (1858–1861), pp. 127–129 (Cuba: original descr.).

Mycteroperca interstitialis: Jordan and Swain, 1885a, pp. 365, 366; Briggs, 1958, p. 272 (Florida); C. L. Smith, 1961, pp. 1:6, 1:20, 1:21, 1:23, figs. 4.3, 5.1, 19; Randall, 1967, p. 702 (dietary habits); Böhlke and Chaplin, 1968, p. 284 (Bahamas: general account); Randall, 1968, p. 66 (Caribbean: general account); Brownell and Rainey, 1971, p. 52 (Virgin Islands); Carpenter and Nelson, 1971, p. 22 (Caribbean); C. L. Smith, 1971a, pp. 192–196 (complete account); 1972, p. 260 (egg and larval stage time of development); Smith et al., 1975, p. 61 (Florida Middle Ground); Allen and Tashiro, 1976, p. 45 (U.S. commercial fishery, listed); Bright and Rezak, 1976, p. 352 (Texas Flower Garden Banks: possible occurrence); Roe, 1976, pp. 131 (listed), 159; C. L. Smith, 1978 (FAO species ID sheets); Jones and Thompson, 1978, p. 164 (Florida Keys and Dry Tortugas, Florida); Miller and Richards, 1979, p. 117; Dennis and Bright, 1988a, pp. 294, 297, table 5.

Mycteroperca falcata: C. L. Smith, 1958, p. 58, plate 16 (Bermuda).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: FLORIDA KEYS: 1, 185; Little Davis Reef, 6 mi SE of Tavernier, Monroe County, Florida, 10 m; 12 June 1978; pole spear; FSBC 11504.—EASTERN GULF OF MEXICO: 1, 566; western edge of the Florida Middle Ground, 26–38 m; 26–30 April 1973; hook and line; FSBC 7657.—1, 576; Florida Middle Ground; May 1973; commercial hook and line; FSBC 7686.—NORTHWESTERN GULF OF MEXICO: 1, 464; 27°50′N, 93°20′W, south of Lake Charles, Louisiana, 59 m with a rapid dropoff to 128 m; 31 March 1981; commercial hook and line; FSBC 12022.

Diagnosis (modified from C. L. Smith, 1971a): Dorsal XI, 16–18; anal III, 11 (12); pectoral 17; gill rakers 23–28; posterior nostril greatly enlarged in large fish. Vertical fins with exserted rays in adult.

Color generally brownish gray with close-set, brownish-gold spots (occasionally absent); yellow around mouth. Juveniles bicolored: dark above, light below.

Distinguishing characters: Juvenile *M. interstitialis* may resemble the young of *M. tigris*, as both are bicolored with dark above and light below. *Mycteroperca tigris*, in the bicolored phase, always retains the oblique vertical bars on the dorsum that are lacking in *M. interstitialis* (C. L. Smith, 1971a).

Large individuals of *M. interstitialis* are similar in appearance to *M. phenax*, but the caudal fin of *M. interstitialis* has exsertions that are approximately even, while in *M. phenax* these exsertions are irregular (Figure 41; Plate XV, Figure D; Plate XVII, Figure B, respectively).

Geographic and bathymetric distribution: *Mycteroperca interstitialis* is known from Bermuda, the South Atlantic Bight (Miller and Richards, 1979), throughout the Bahamas, the Antilles and Caribbean south to Bahia, Brazil (C. L. Smith, 1971a). In the Gulf of Mexico, this species has been reported from the Florida Middle Ground (Smith et al., 1975) in the eastern Gulf, from the Flower Garden Banks off Texas (Dennis and Bright, 1988a), and off the Campeche Banks, Mexico (C. L. Smith, 1971a).

C. L. Smith (1958) stated that juvenile yellowmouth grouper were common in shallow water in Bermuda during late summer. He further observed that *Mycteroperca interstitialis* was usually the most frequently captured species in 12 fm (22 m) or deeper and occurred out to 90 fm (165 m).

A juvenile yellowmouth grouper was speared in shallow water (5-m depths) in the Florida Keys (D. Nickerson, personal communication), but in the eastern Gulf of Mexico, this species has been reported only from depths of 30 m or greater.

Reproduction: C. L. Smith (1971a) reported that spawning in Bermuda lasted from June to the first of August and that juveniles were common in shallow waters in August. Thompson and Munro (1978) found four ripe individuals during April (1972) in Jamaican waters.

Although gonadal material was unavailable for each month of the year, ripe females (357–605 mm) were sampled from the eastern Gulf of Mexico (primarily the Florida Middle Ground) during December and March–September; hydrated eggs were found in April, May, July, and August. Ripe males (400–620 mm) were found during December and June–September. A transitional male (415 mm) was captured during August; male tissue appeared to be proliferating throughout the gonad, which contained previtellogenic oocytes. Spent females were found in August and September, the latter month possibly representing the termination of the spawning season. A 425-mm (2 kg) female captured in May (1984) on the Florida Middle Ground contained ovulated eggs that measured 0.80–1.20 mm in diameter. Batch fecundity estimates for six females are presented in Table 12.

Diet: Randall (1967) examined stomach contents of eight yellowmouth grouper from shallow waters in the West Indies and found that this species consumed only fishes, namely *Chromis multilineata* (Guichenot, 1853); *Scarus croicensis* Bloch, 1790; and atherinids. Nelson (1988) examined stomachs from 22 scamp/yellowmouth grouper (the species were not separated) from the Flower Garden Banks off Texas. The major food items (by occurrence) were as follows: fish, 54%; crustacean plankters and mysids, approximately 13%; unidentified animal matter, approximately 13%; serranids, 8%; *Chromis multilineata*, 8%; *Priacanthus cruentatus* (Lacépède, 1802), an ophidiid, *Holocentrus ascensionis* (Osbeck, 1765), *Decapterus punctatus*

TABLE 12. BATCH FECUNDITY ESTIMATES FOR *MYCTEROPERCA INTERSTITIALIS* CAPTURED AT THE FLORIDA MIDDLE GROUND.

Capture Date	Standard Length (mm)	Ovary Weight (g)	Oocytes/Ovary ± SE
May 1986	372	50.22	350,733 ± 19,055
May 1986	373	46.79	508,574 ± 39,163
April 1985	420	66.56	786,784 ± 22,007
June 1984	424	72.13	632,274 ± 46,146
May 1984	425	84.10	470,905 ± 24,462
March 1985	455	178.07	2,458,520 ± 31,808

(Agassiz, 1829), and *Anchoa hepsetus* (Linnaeus, 1758), 4% each. Yellowmouth grouper from the Florida Middle Ground were found to feed on *Haemulon aurolineatum* Cuvier and Valenciennes, 1830; small *Rhomboplites aurorubens* (Cuvier, 1829); *Synodus intermedius* (Spix, 1829); *Chromis scotti* Emery, 1968; *Scarus* sp.; and an unidentified apogonid.

Length-weight relationship: The relationship of weight to length for *M. interstitialis* captured in the eastern Gulf of Mexico is expressed by the following: $W = 4.7 \times 10^{-8}\ SL^{2.893}$ ($n = 97$, $r^2 = 0.95$) (Figure 43), and $W = 1.56 \times 10^{-8}\ TL^{2.970}$ ($n = 121$, $r^2 = 0.95$), where W is whole weight in kilograms and lengths are in millimeters.

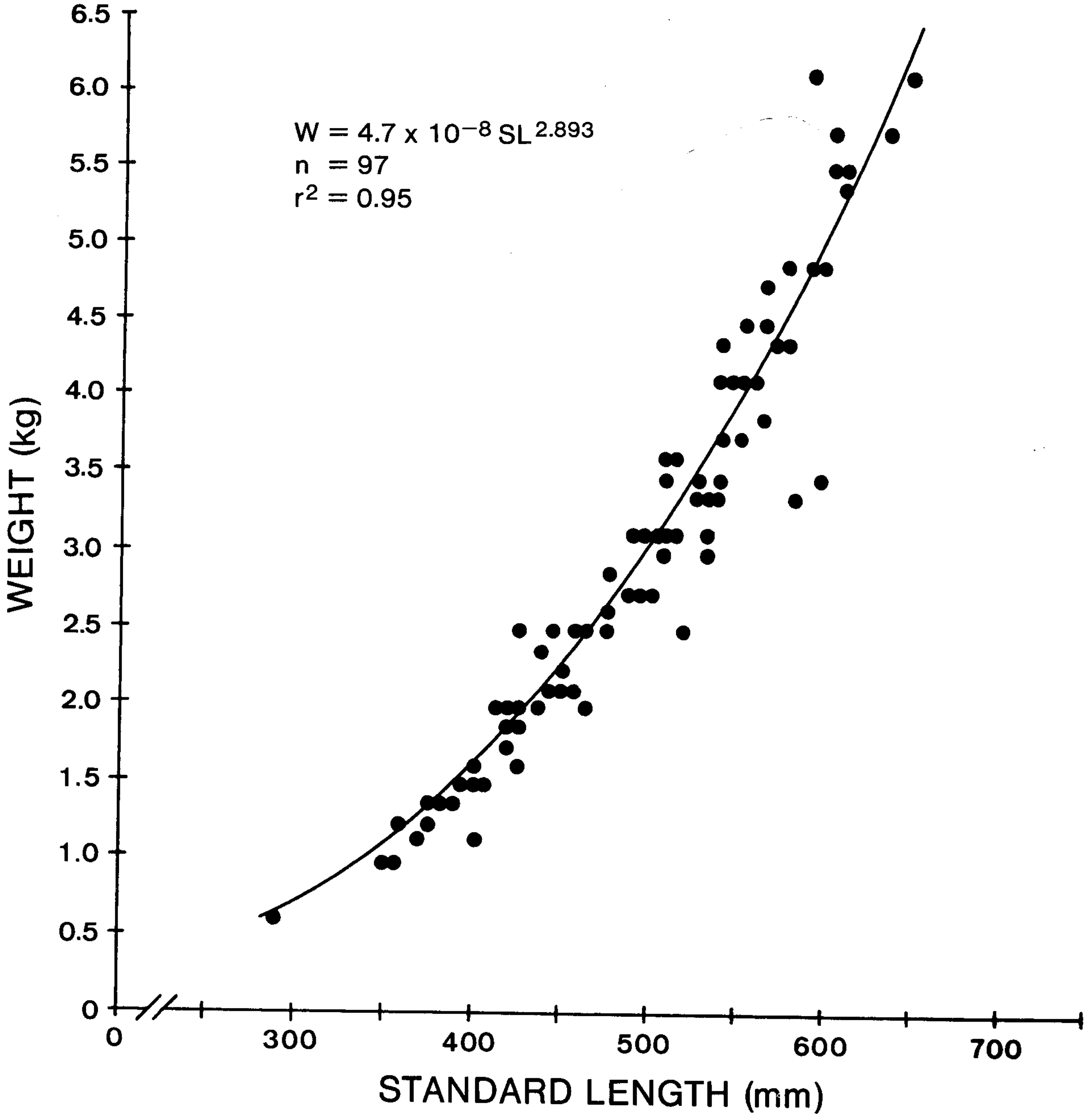

Figure 43. Length-weight relationship of *Mycteroperca interstitialis* captured by hook and line in the eastern Gulf of Mexico (primarily the Florida Middle Ground).

Parasites: Plerocercoid metacestodes have been observed in the viscera and reddish philometrid nematodes in the ovary of yellowmouth grouper from the eastern Gulf. Brownell and Rainey (1971), in addition to noting similar tapeworms, found a gill parasite and numerous parasitic isopods on the skin of *M. interstitialis* from the Virgin Islands. The isopods *Rocinela signata* Schioedte and Meinert, 1880 and *Alcirona krebsii* Hansen, 1890 were found in the gill region of a yellowmouth grouper from the Florida Middle Ground.

Size and commercial importance: C. L. Smith (1978) gave the maximum size of *M. interstitialis* as approximately 500 mm TL. He noted that 400-mm individuals were common in Bermuda. Female yellowmouth grouper sampled from party boats and commercial vessels in the eastern Gulf of Mexico (primarily the Florida Middle Ground) were 290–605 mm (n = 66) and weighed 0.59–5.69 kg (n = 53), whereas males were 400–646 mm (n = 42) and weighed 1.61–6.14 kg (n = 35). The modal size class for combined sexes was 500–549 mm (Figure 44).

C. L. Smith (1978) stated that *M. interstitialis* was an important commercial grouper in Bermuda. He also noted that it was common in local Venezuelan fish markets. Along the Florida west coast, the yellowmouth grouper is usually marketed as scamp because of the two species' similar appearance.

Mycteroperca microlepis (Goode and Bean, 1880)
Gag

Figure 45; Plate XVI, Figure A (postlarva)
Plate XVI, Figure B (juvenile)
Plate XVI, Figure C (subadult)
Plate XVI, Figure D (male)

Trisotropis microlepis Goode and Bean, 1880, pp. 141–143 (holotype: USNM 5137; western Florida: original descr.); Lönnberg, 1894, p. 126 (Key West, Florida); Reed, 1941, p. 76 (Texas coast).

Mycteroperca microlepis: Jordan, 1887a, p. 84; 1887b, p. 27 (Beaufort, North Carolina); Henshall, 1891, p. 387 (Key West, west coast of Florida); Schroeder, 1924, p. 16 (Pensacola, Florida; Beaufort, North Carolina); Longley and Hildebrand, 1941, pp. 100, 101 (Dry Tortugas: habits); Baughman, 1943, p. 772 (Texas); Springer, 1946, pp. 174, 175 (predation); Manter, 1947, p. 373 (parasites); Reid, 1954, pp. 38, 39 (Cedar Key, Florida); Springer and Woodburn, 1960, p. 35; McErlean, 1963, pp. 1–29; McErlean and Smith, 1964, pp. 301, 302 (protogyny); Cervigón M. and Velasquez, 1966, p. 93; Overstreet, 1969, p. 171 (digenetic trematodes); Lyons, 1970, p. 62 (dietary habits); C. L. Smith, 1971a, pp. 188–192 (full account); Smith et al. 1975, p. 6; Walls, 1975, pp. 178, 179; Huntsman, 1976, p. 17 (North Carolina); Huntsman and Dixon, 1976, pp. 185, 187, 188 (North Carolina, South Carolina); Roe, 1976, p. 160; G. B. Smith, 1976, pp. 1, 23, 42, 47–51, 54, 58, 59, 66 (eastern Gulf of Mexico); Ulrich et al., 1976, pp. 102, 111, 112, 116 (South Carolina); Hoese and Moore, 1977, p. 173; Ogren and Brusher, 1977, p. 88 (list); Gilmore et al., 1978, p. 82 (cold mortality); Manooch and Haimovici, 1978, pp. 234–240 (age, growth); G. B. Smith, 1978, p. 53; Hastings, 1979, p. 35 (northeastern Gulf of Mexico); Roberts and Schlieder, 1983, pp. 639–649 (induced spawning); Bannerot, 1984, p. 35 (movements); Darcy and Gutherz, 1984a, p. 100 (list); Naughton and Saloman, 1985, pp. 1–36 (dietary habits); Collins et al., 1987, pp. 648–653 (South Atlantic Bight: age, growth, reproduction); Keener et al., 1988, pp. 376–396 (South Carolina: postlarval ingress); Nelson, 1988, p. 180, table A2.2 (diet).

Material examined: HOURGLASS STATION C: 1, 35; 18 June 1966; trawl; FSBC 6080.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 1, 59.5; San Carlos Bay between Estero and Bayou Passes, Lee County, Florida; 7 July 1960; seine; FSBC 3139.—7, 33.5–44.8; southeastern tip of Siesta Key adjacent to Midnight Pass, Sarasota County, Florida; 24 May 1960; FSBC 1768.—1, 52.7; east of Sunshine Skyway Bridge in Tampa Bay, Pinellas County, Florida; 1 June 1960; FSBC 1775.—4, 186–265; 8 mi offshore between Indian Rocks Beach and Clearwater, Pinellas County, Florida, 7.6 m; 14 February 1958; speared; FSBC 394.—1, 110.5; off Hudson, Pasco County, Florida; 20 September 1956; FSBC 2495.

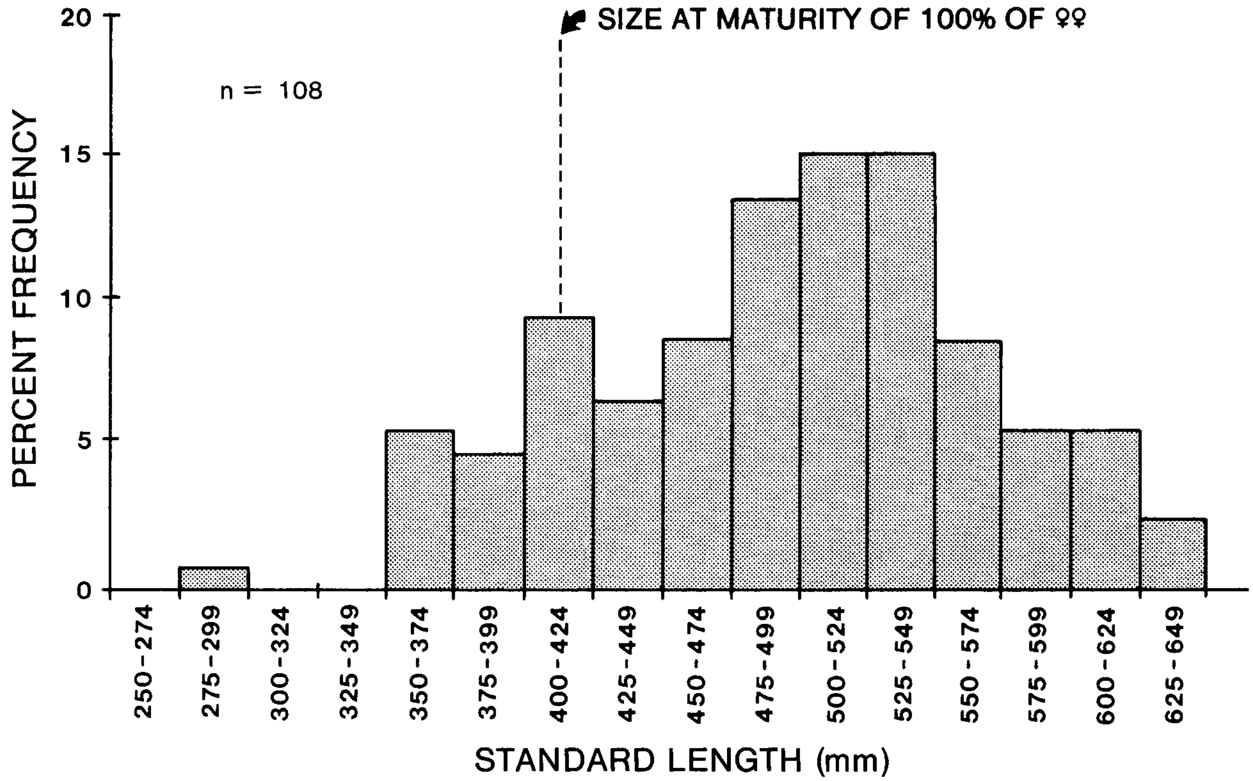

Figure 44. Length frequency distribution of *Mycteroperca interstitialis* captured by hook and line in the eastern Gulf of Mexico (primarily the Florida Middle Ground; n = 108).

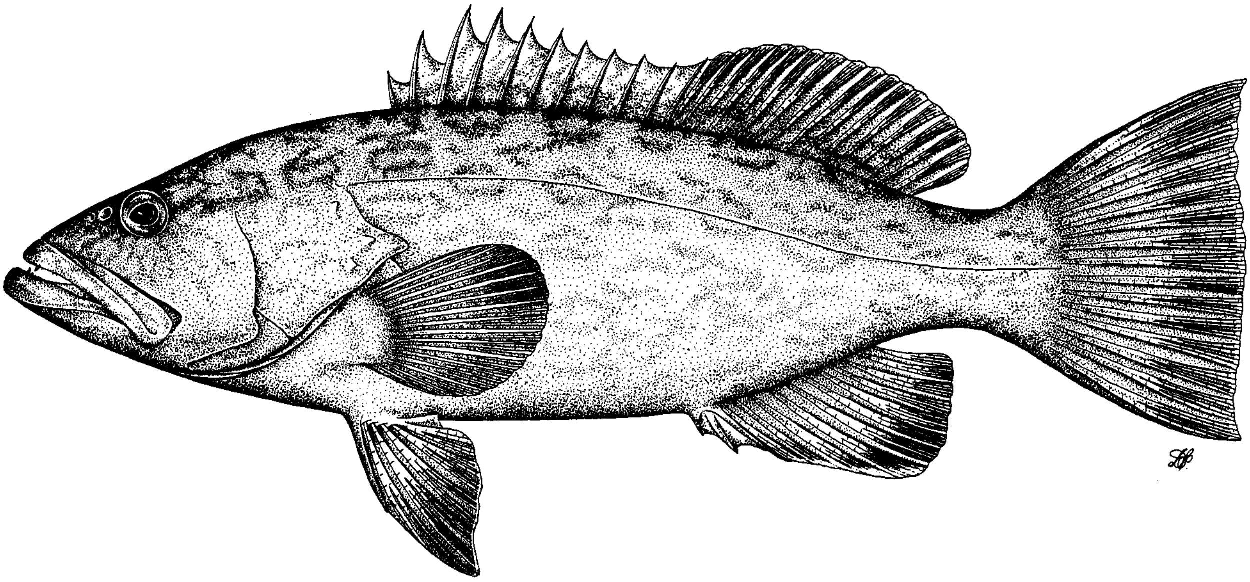

Figure 45. *Mycteroperca microlepis* (Goode and Bean, 1880).

Diagnosis (modified from C. L. Smith, 1971a): Dorsal XI, 16–19 (usually 17); anal III, 10–12 (usually 11); pectoral 16–18; total gill rakers 21–29; posterior nostril enlarged in large specimens (>600 mm SL); preopercle with pronounced lobe below notch; vertical fins without exserted rays. Moderate-sized species of *Mycteroperca*.

Olive-gray background with darker gray vermiculations ("kiss marks") on sides. Large individuals (>13.6 kg) frequently with broken patches of black pigmentation on belly; outer portion of pectoral, soft dorsal, and anal fins also dark.

Distinguishing characters: Juvenile *M. microlepis* and *M. bonaci* closely resemble each other, but *M. microlepis* has a less definite pattern of blotches on the sides than *M. bonaci* (Plate XVI, Figure B; Plate XV, Figure A, respectively). Additionally, *M. microlepis* and *M. bonaci* modally have 11 and 12 anal rays, respectively.

Larger individuals of *M. microlepis* and *M. bonaci* can be distinguished by the salient serrated lobe at the angle of the preopercle in *M. microlepis; M. bonaci* has a broadly rounded preopercle (see Figure 40C, D). Also, *M. bonaci* has brassy spots on the head and body, which are lacking in *M. microlepis.*

Geographic and bathymetric distribution: The reported range of *M. microlepis* is from Massachusetts southward to Florida, including the Gulf of Mexico, Bermuda, and, based upon a single specimen, Brazil (C. L. Smith, 1971a). Cervigón M. and Velasquez (1966) failed to find this species along the Venezuelan coast, and C. L. Smith (1971a) believed it to be absent from the West Indies.

The reported depth range for the species is 1–110 m (Roe, 1976; G. B. Smith, 1976). Florida west coast commercial fishermen report infrequent catches of gag in depths as great as 152 m. During late spring and summer, juveniles of *M. microlepis* can be found in grass beds and rock piles within estuarine areas, particularly along the edges of channels and passes leading to the Gulf of Mexico (G. B. Smith, 1976). Larger juveniles are often caught on hook and line from bridges and sea walls within the Tampa Bay area. G. B. Smith (1976) observed several 100–150 mm individuals in 36.6 m at a wreck 59 km off the west central Florida coast. In the eastern Gulf of Mexico, mature fish are primarily confined to offshore reefs.

Habitat: The gag characteristically inhabits rocky ledges, platforms, and wrecks (G. B. Smith, 1976). Larger individuals are typically found in deeper waters. This pattern, however, may be influenced by heavy fishing pressure and selective removal of larger individuals at inshore, shallow-water reefs. G. B. Smith (1976) observed large (10–15 kg) gag at shallow-water (12–18 m) reefs located away from heavily fished areas; fish of this size are rarely seen at reefs frequented by party boats.

Reproduction: According to Hood and Schlieder (in preparation), *Mycteroperca microlepis,* a protogynous hermaphrodite, spawns from late December to April, with peak spawning during February–March in the eastern Gulf of Mexico. Hood and Schlieder (in preparation) found that females range in age from 0 to 15 years, with most females reaching maturity at ages 5–7. The number of males began to increase at age nine.

Spawning aggregations have never been observed for *M. microlepis* in the eastern Gulf of Mexico. No ripe females were discovered in 37-m depths in hook-and-line and spearfishing samples taken southwest of Tampa Bay during the 1978–1980 spawning seasons. It is assumed that spawning in larger, older fish occurs further offshore. Large numbers of gag have been observed during late fall–early winter in shallow water (14 m); however, this activity appeared to be related to feeding because gonads were immature and stomachs contained large numbers of bait fish such as *Decapturus punctatus* (Cuvier, 1829).

Roberts and Schlieder (1983) induced sex inversion of female *M. microlepis* with oral application of methyl testosterone. They successfully spawned this species and described embryonic and early larval stages. Spawned eggs were spherical with a mean diameter of 920 μm. Larvae hatched after 45 h at 21 °C.

Abundance: Mycteroperca microlepis is by far the most common and regularly observed grouper inhabiting rocky ledges of the West Florida Shelf. Hastings (1979) reported that this species was commonly seen during dives off Panama City and Destin reefs in the northeastern Gulf of Mexico.

Movements: Gag demonstrate a gradual offshore movement with increased size (age); however, seasonal movements between reefs are probably slight. Because gag are poorly represented in inshore catches during winter, fishermen have suspected a seasonal migration offshore to deeper waters. However, in situ studies at selected shallow-water reef sites (G. B. Smith, 1976) showed *M. microlepis* to be present in similar numbers throughout the year. Possibly a shift in feeding behavior or activity accounts for this discrepancy between actual and apparent abundance. Hastings (1979) noted that populations at reefs in the northeastern Gulf of Mexico did not undergo appreciable seasonal fluctuations in abundance.

Bannerot (1984) noted that gag became abundant along the offshore margin of the Florida reef tract of the Florida Keys between January and March, but this species was not caught with any regularity at other times of the year. He stressed the need for a tagging study to test the hypothesis that large numbers of gag migrate along the southeastern U.S. coast during winter.

Habits: Gag are more gregarious than red grouper and commonly forage in small groups far from the reef (ledge) (G. B. Smith, personal observation). Gag are also less benthic-oriented than red grouper and frequently are observed 5–15 m above the reef. G. B. Smith (1976) reported that gag occasionally swim to the surface from depths of 18–24 m.

Diet: Large numbers of juvenile (year class 0) gag become recruits in shallow grass beds within the Tampa Bay area and elsewhere along the Florida west coast during late spring and summer. There they find ample cover and food and become part of a complex food web. In a study of the feeding habits of juvenile gag (16–192 mm) in Tampa Bay (K. Peters, unpublished data), crustaceans, which are common inhabitants of the grass flats, made up the majority of the diet until these fish reached a length of approximately 25 mm (Figure 46). At this size, fish appeared in the diet (although one specimen that measured only 17 mm contained fish remains). *Hippolyte zostericola* (Smith, 1873) was the dominant shrimp taken; other shrimp species included *Periclimenes* sp.; *Tozeuma carolinense* Kingsley, 1878; *Palaemonetes pugio* Holthuis, 1949; and unidentified penaeids. Reid (1954) also found that juvenile gag (25–153 mm) at Cedar Key, Florida, consumed penaeid shrimp and fish.

Stomachs were examined from 53 gag (400–600 mm) caught in October–November 1978 in depths of 19–23 m southwest of Pass-a-Grille, Pinellas County, Florida. Prey included *Diplectrum formosum; Haemulon aurolineatum; H. plumieri; Epinephelus morio* (ca. 100 mm); *Halichoeres bivittatus* (Bloch, 1791); *Stephanolepis hispidus* (Linnaeus, 1758); *Decapterus punctatus; Brevoortia patronus* Goode, 1879; *Hippocampus* sp.; a synodontid; assorted fish remains (scales, spines, and otoliths); and the crab *Portunus spinimanus* Latreille, 1819.

Naughton and Saloman (1985) found that gag of comparable size (400–599 mm FL) from west-central Florida consumed primarily *Sardinella aurita* Valenciennes, 1847; with increased

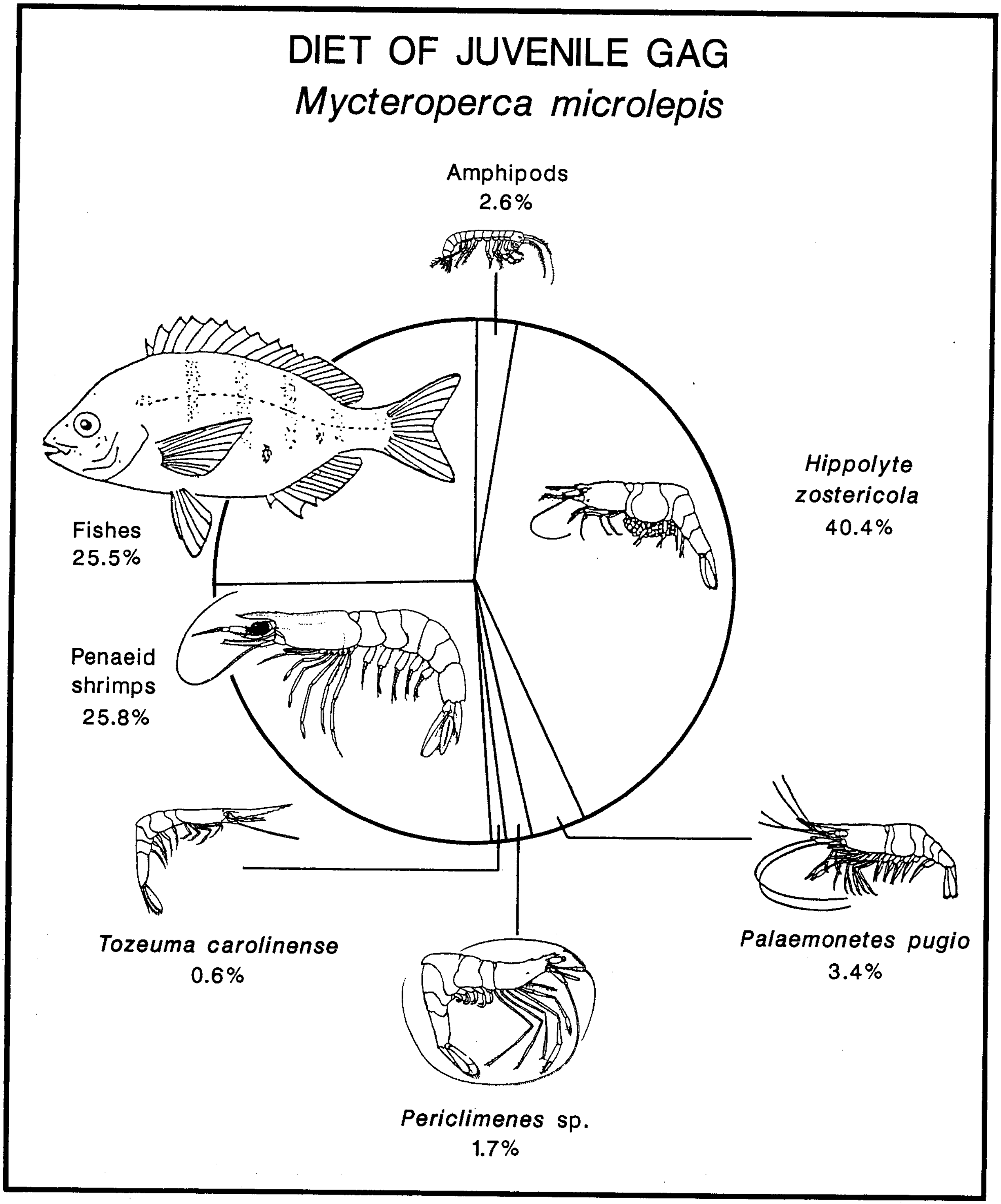

Figure 46. Diet of juvenile *Mycteroperca microlepis* (16–192 mm) depicted as the percentage of the number of items (n = 134; K. Peters; derived from FMRI unpublished data).

size, gag consumed a wider range of fishes in the families Clupeidae, Mugilidae, Dasyatidae, and Ostraciidae. *Echiophis intertinctus* (Richardson, 1844) (spotted spoon-nose eel); *Scorpaena brasiliensis* Cuvier, 1829; *Sicyonia brevirostris* Stimpson, 1871 (rock shrimp); *Chloeia viridis*

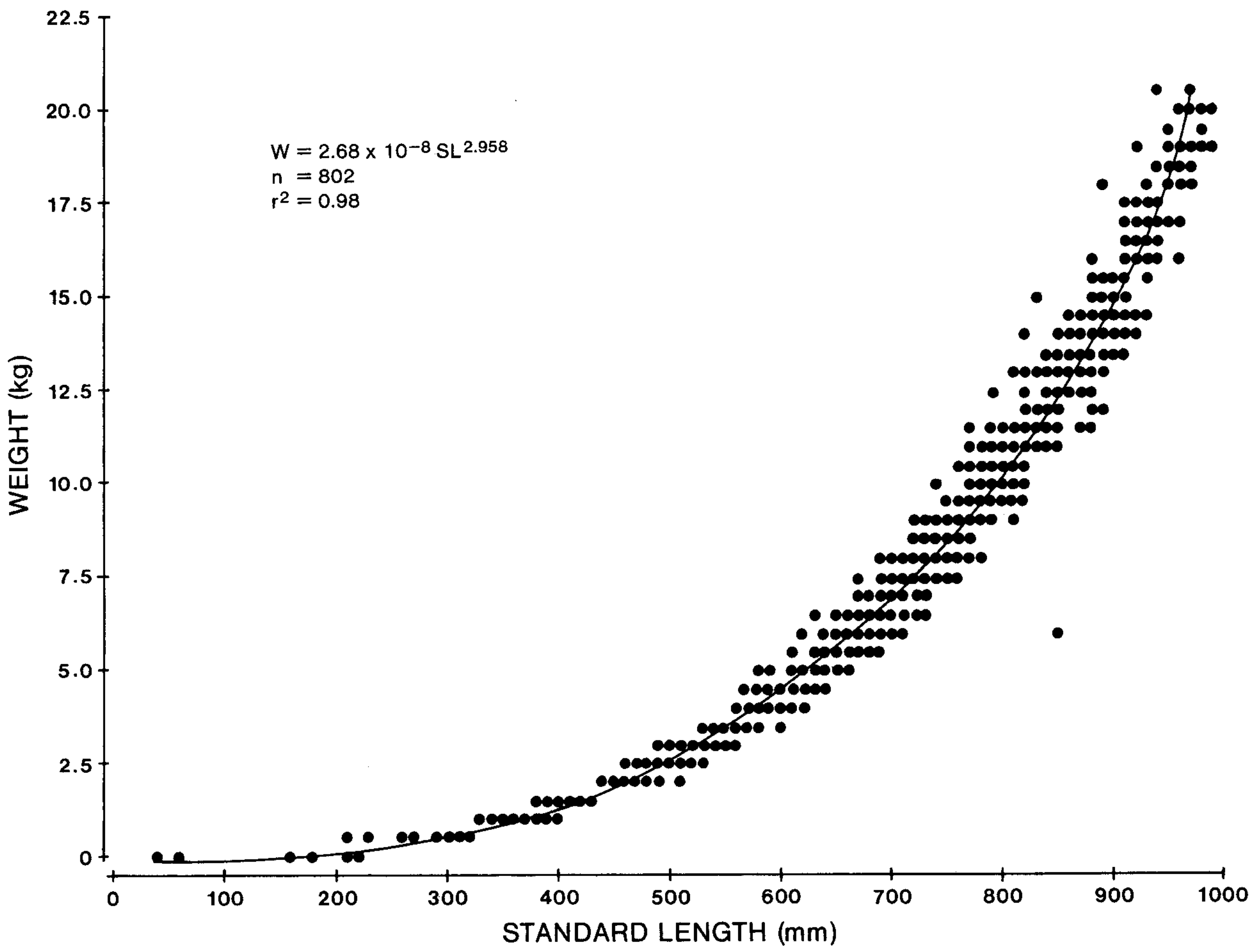

Figure 47. Length-weight relationship of *Mycteroperca microlepis* captured by hook and line in the eastern Gulf of Mexico.

Schmarda, 1861 (bristleworm); a portunid crab; squid; octopus; and a colonial ascidian were noted from incidental samples of gut contents taken from gag commercially captured at depths greater than 40 m. Lyons (1970) recorded a lobster, *Scyllarides nodifer* (Stimpson, 1866), as part of the gag's diet; Nelson (1988) found the red goatfish *Mullus auratus* Jordan and Gilbert, 1882 in the stomach of a gag captured on the Flower Garden Banks off Texas.

Susceptibility to cold and red tide: Gilmore et al. (1978) reported occasional mortalities of *M. microlepis* due to extremely low water temperatures (6°C) during 19–24 January 1977 in the Indian River Lagoon on the Florida east coast. Springer (1946) speculated that gag found in the stomachs of the dusky shark, *Carcharhinus obscurus* (LeSueur, 1818), had been stunned by cold-water upwelling before being eaten.

Unlike red grouper, the gag at inshore reefs survived the 1971 red tide (G. B. Smith, 1976, 1978). Perhaps this species' survival was due in part to its ability to move above the oxygen-depleted bottom waters.

Length-weight relationship: The relationship of weight to length for *M. microlepis* captured in the eastern Gulf of Mexico is expressed by the following: $W = 2.68 \times 10^{-8}\ SL^{2.958}$ ($n = 802$, $r^2 = 0.98$) (Figure 47), and $W = 8.15 \times 10^{-9}\ TL^{3.059}$ ($n = 802$, $r^2 = 0.98$), where W is whole weight in kilograms and lengths are in millimeters (P. Hood and R. Schlieder, unpublished data).

Parasites and abnormalities: Manter (1947) found the trematode *Prosorhynchus atlanticus* in a gag captured near the Dry Tortugas, Florida. In gag from Biscayne Bay, Florida, Overstreet (1969) found *Lecithochirium parvum* Manter, 1947; *Neolepidapedon macrum* Overstreet, 1969; and *Prosorhynchus pacificus* Manter, 1940. Other parasites observed during an FMRI grouper study during 1978–1980 included the isopods *Rocinella signata* and an unidentified subadult cymothoid found in the gill region; the isopod *Alcirona krebsii* on the dorsal fin; trypanorhynch plerocercoid metacestodes in the visceral cavity; and philometrid nematodes in the gonad.

An unidentifiable mummified eel was removed from the coelomic cavity of a commercially captured gag.

Size and commercial importance: Gag weighing in excess of 24.5 kg have been landed along the Florida west coast. The largest gag sampled was 1,050 mm.

Juvenile *Mycteroperca microlepis* are subjected to recreational fishing pressure at sizes below the current 20-in (508 mm TL) legal size limit. These fish are readily captured by hook and line from inshore jetties and seawalls within estuarine areas such as Tampa Bay. Party boats fishing in depths of 12–15 m west of Tampa Bay also land gag of minimum legal size. Small gag are a by-catch of the bait shrimp fishery.

According to Hood and Schlieder (in preparation), six-year-old gag may be the first age group fully vulnerable to commercial hook-and-line fishing in the eastern Gulf. Survival of the entire population was calculated by Hood and Schlieder (in preparation) to be 69%, indicating a healthy fishery. However, Manooch and Haimovici (1978) warned that gag are especially vulnerable to overexploitation because their growth rate is slow, their trophic position of top carnivore limits their numbers, and their preferred habitat (rocky ledges) is easy for fishermen to locate. Although Manooch and Haimovici (1978) limited their discussion to stocks of *M. microlepis* off the southeastern United States, these factors also apply to eastern Gulf of Mexico stocks. Additionally, Hood and Schlieder's data were collected before the advent of widespread bottom longlining in the eastern Gulf during 1981. Effects of this highly efficient method of fishing need evaluation.

Figure 48 depicts length-frequency data of *Mycteroperca microlepis* captured commercially in the eastern Gulf of Mexico. The three distributions (1977–1980 hook and line, 1985 hook and line, and 1985 longline) were found to differ significantly using χ^2 analysis ($\chi^2 = 217.5$, df = 16, $p < 0.001$).

As the graph illustrates, a greater percentage of smaller (immature) fish are captured by longline than by hook and line, perhaps because many longliners fish at shallower depths where smaller fish occur. Because the majority of smaller fish are females, a fishery that heavily exploits the younger, smaller fish could reduce the population's reproductive capacity.

The modal size of fish taken by hook and line did not change between the period of 1977–1980 and the year 1985; however, a greater percentage of larger fish were captured during 1977–1980. Complicating this issue is the question of whether fishing depths have changed since 1980.

Gag is an important recreational and commercial species along the Eastern Seaboard. Huntsman and Dixon (1976) reported gag to be second only to scamp in numbers of grouper caught by the Carolina headboat fishery and the most important grouper by weight. Huntsman

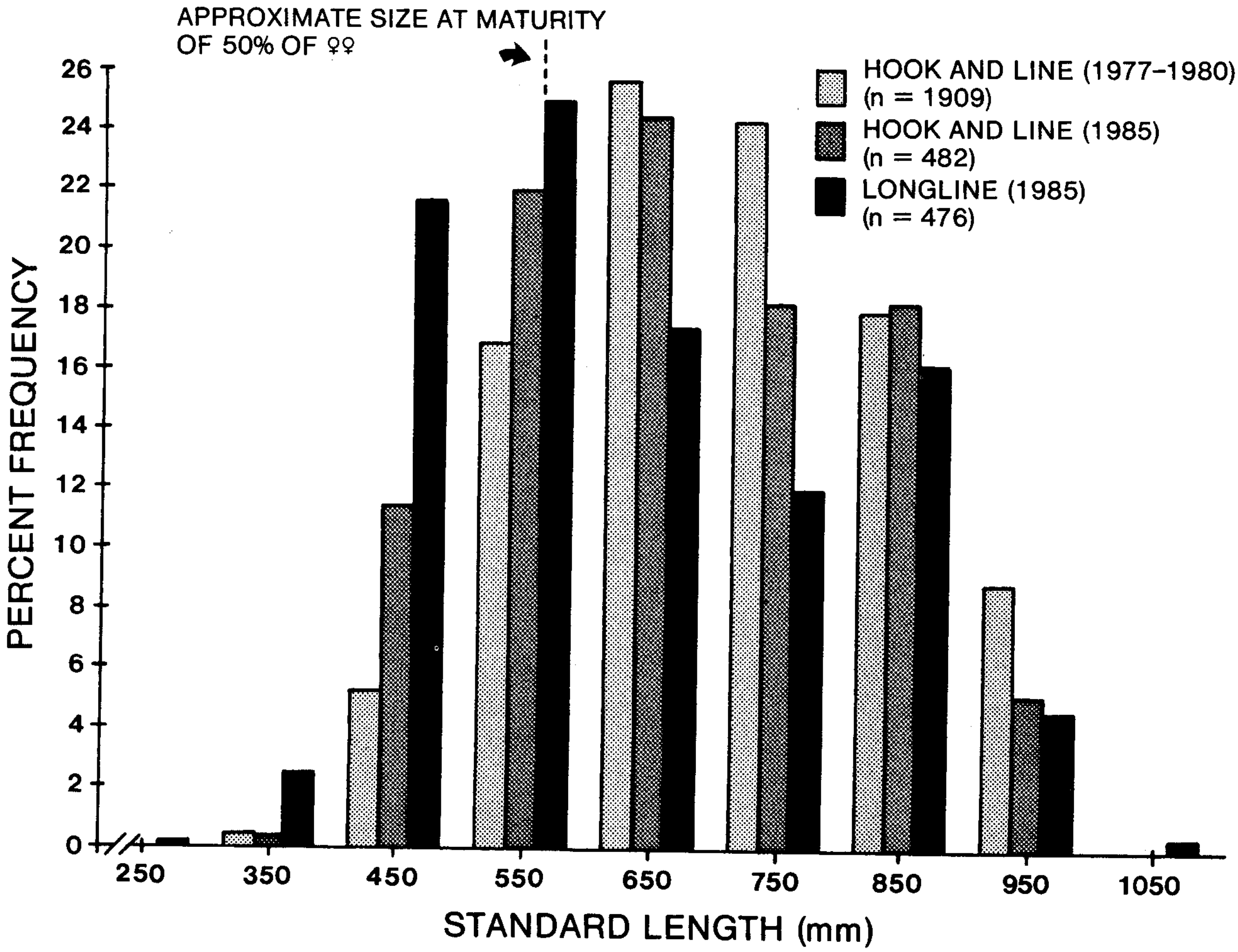

Figure 48. Length frequency distribution of *Mycteroperca microlepis* commercially captured by hook and line during 1977–1980 (n = 1,909) versus those commercially captured by hook and line (n = 482) and by longline (n = 476) in 1985.

(1976) found that the usual weights of gag were 3–6 lb (1.4–2.7 kg) inshore (27 m) and 12–40 lb (5.4–18.1 kg) offshore out to 55 fm (101 m). Manooch and Haimovici (1978) found that the average fish landed by the recreational fishery was 825 mm TL and 6.6 kg. Ulrich et al. (1976), in describing the South Carolina commercial hook-and-line fishery, found gag to compose 32% of the total catch by weight.

Mycteroperca phenax Jordan and Swain, 1885
Scamp

Figure 49A, B; Plate XVII, Figure A (subadult)
Plate XVII, Figure B (adult)

Mycteroperca falcata: Bean, 1884, p. 503; Henshall, 1895, p. 215; Parr, 1930, p. 50; Springer and Bullis, 1956, p. 78; Briggs, 1958, p. 272 (in part); Springer and Woodburn, 1960, p. 35; Carpenter and Nelson, 1971, p. 22.

Mycteroperca falcata var. *phenax* Jordan and Swain, 1885a, pp. 363, 364; Jordan and Evermann, 1896b, p. 1185; H. M. Smith, 1896, p. 175; Evermann and Kendall, 1900, pp. 74, 75; Schroeder, 1924, p. 17.

Mycteroperca falcata phenax: Jordan 1887a, p. 84; Henshall, 1891, p. 387 (Key West, Ironwood Key, and Key Largo, Florida); Evermann and Kendall, 1900, pp. 74, 75; Schroeder, 1924, p. 17 (Key West, Florida).

Mycteroperca interstitialis (*non* Poey): H. M. Smith, 1899, p. 880; Longley, 1935, p. 283 (part); Longley and Hildebrand, 1941, p. 100, pl. 7, fig. 2.

Mycteroperca phenax: Jordan and Evermann, 1920, p. 394; Jordan et al., 1930, p. 315; Briggs, 1958, p. 272; Cervigón M., 1966, pp. 298–300; Cervigón M. and Velasquez, 1966, p. 99; C. L. Smith, 1971a, pp. 196–199 (full account); Smith et al., 1975, p. 6 (Florida Middle Ground); Walls, 1975, p. 179 (general account); Huntsman, 1976, pp. 194, 203 (North Carolina-South Carolina headboat fishery); Huntsman and Dixon, 1976, pp. 186–188, 190, 191 (North Carolina-South Carolina headboat fishery); G. B. Smith, 1976, p. 23 (eastern Gulf of Mexico); Sonnier et al., 1976, p. 109 (northern Gulf of Mexico); Hoese and Moore, 1977, pp. 173, 174 (general account); Grizzle, 1983, p. iii (cestode infestation); Fournie et al., 1985, pp. 551–555 (haemangioma); Matheson et al., 1986, pp. 300–312 (North Carolina, South Carolina).

Material examined: HOURGLASS STATION E: 1, 217; 19 July 1966; trawl; FSBC 5283.—HOURGLASS STATION M: 1, 196; 14 December 1965; trawl; FSBC 4641.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 1, 218; SW of Sarasota, Sarasota County, Florida; 4 September 1970; uncatalogued.—1, 368; 28°45′N, 84°27′W, 37 m; 14 March 1962; FSBC 2496.—1, 136; off Sarasota, Sarasota County, Florida, 23 m; FSBC 7445.—1, 305; SW of Madeira Beach, Pinellas County, Florida, 17 m; FSBC 2125.—1, 186; SW of Madeira Beach, Pinellas County, Florida, 11 m; FSBC 0676.—1, 212; off Madeira Beach, Pinellas County, Florida, 30 m; FSBC 2047.—1, 202; Florida Middle Ground, 25 m; FSBC 7095; 1, 541 (multiple haemangiomas); Florida Middle Ground, 40 m; August 1983; hook and line; uncatalogued.

Diagnosis (modified from C. L. Smith, 1971a): Dorsal XI, 17–19; anal III, 11; pectoral 16 (occasionally 17); gill rakers 22–31. Moderate-sized, deep-bodied species of *Mycteroperca* with medium-sized scales and prominent preopercular lobe. Vertical fins with greatly exserted rays in adults (Figure 49A).

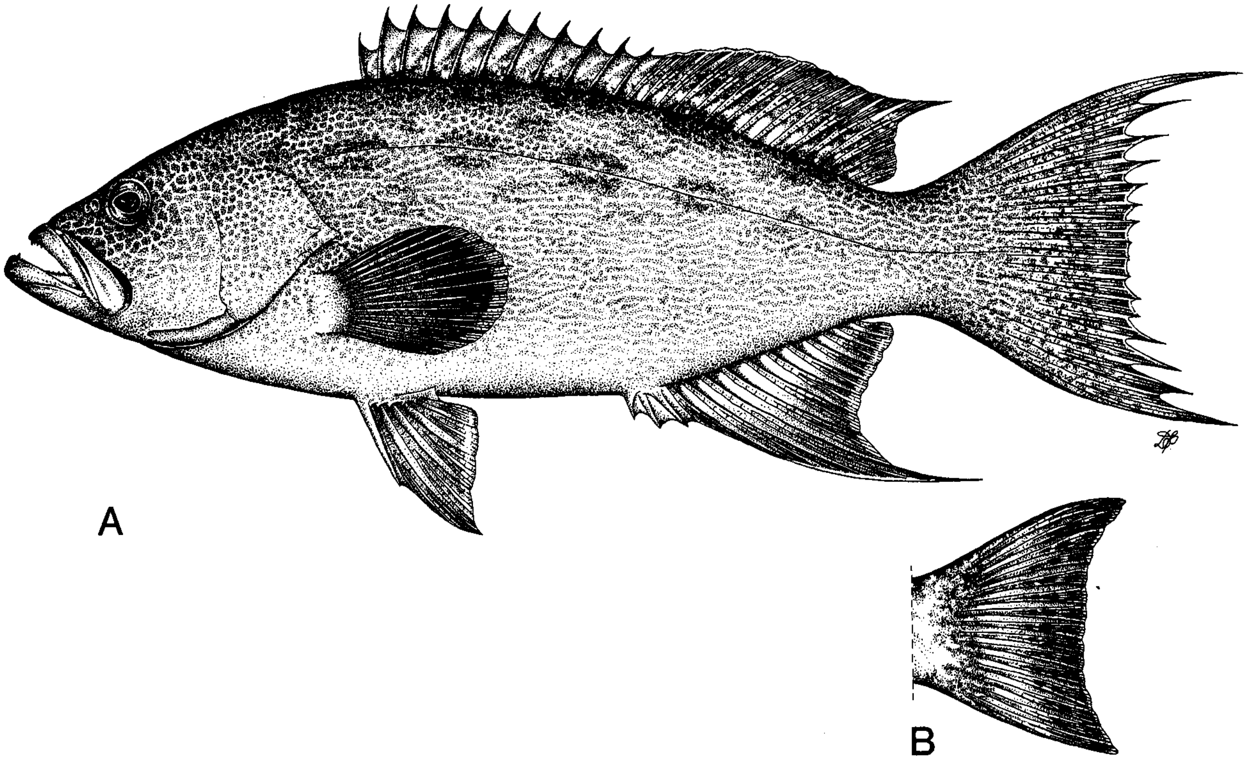

Figure 49. *Mycteroperca phenax* Jordan and Swain, 1885; A. Adult; B. Caudal fin of juvenile.

Color light brown, freckled with irregular, well-separated dark spots. Pectoral dark with narrow, pale margin. In life, capable of a variety of color phases (G. Gilmore, personal communication).

Distinguishing characters: *Mycteroperca phenax* and *M. interstitialis* are difficult to distinguish from each other; meristic and morphometric data are similar for both species (C. L. Smith, 1971a: tables 31, 32, and 37).

Color patterns of eastern Gulf of Mexico specimens of *M. interstitialis* and *M. phenax* were compared. Specimens of *M. phenax* were light brown, slightly countershaded, and freckled with irregular, widely scattered dark spots (2–4 mm diameter) (Plate XVII, Figures A and B). Two large specimens of *M. interstitialis* were almost entirely brown with only a faint pattern of darker areas (Plate XV, Figure D). C. L. Smith (1971a) suggested that adult *M. phenax* is distinguished from *M. interstitialis* by its longer and more irregular exsertions of the caudal-fin rays (Figure 41).

Juveniles of *M. interstitialis* are easily distinguished from *M. phenax* by their distinctive bicolored pattern (Plate XV, Figure C).

Geographic distribution: C. L. Smith (1971a) reported that *M. phenax* is widely distributed throughout the Gulf of Mexico and along the southeastern coast of the United States to North Carolina. Juvenile scamp range as far north as Massachusetts. Sonnier et al. (1976) found scamp around ledges and oil platforms off Louisiana. Along the coast of Venezuela around Margarita and adjacent islands, Cervigón M. and Velasquez (1966) noted that *M. phenax* was relatively common.

Mycteroperca phenax has basically a continental distribution; it is largely replaced throughout the West Indies by *M. interstitialis*. Both species occur on the Campeche Bank, Mexico (C. L. Smith, 1971a), in the northern Gulf (L. Bullock, personal observation of commercial catches taken from off Louisiana and sold in Florida), and on the West Florida Shelf (Smith et al., 1975).

Bathymetric distribution and habitat: According to C. L. Smith (1971a), *M. phenax* is frequently taken in 35–50 fm (65–90 m) on Campeche Bank, Mexico. G. B. Smith (1976) reported *M. phenax* to be common in 12–42 m depths on the West Florida Shelf, and captures of this species during Project Hourglass indicate that the species occurs there to at least 73-m depths. Off North Carolina and South Carolina, scamp are most commonly taken by hook and line by headboat fishermen in depths of 20–55 fm (37–101 m) (Huntsman, 1976). In the eastern Gulf of Mexico, the scamp almost exclusively inhabits ledges or high-relief rocky bottoms; only rarely is this species found over low-relief rocky bottoms. In Venezuela, Cervigón M. (1966) noted small individuals in mangrove lagoons. Scamp have also been observed in shallow water at rocky jetties at St. Andrew State Park near Panama City, Florida (L. Bullock, personal observation).

Reproduction: A life history study of *M. phenax* conducted by FMRI in the eastern Gulf of Mexico (M. Godcharles and L. Bullock, unpublished data) showed that this species is a spring spawner. Vitellogenic oocytes occurred from March through May. A 411-mm (1.7-kg) female captured during March 1985 on the Florida Middle Ground contained hydrated eggs that were transparent and contained a single oil droplet (Figure 50). Eggs ranged in diameter from 0.75 to 1.23 mm. All females greater than 350 mm (SL) were found to be mature.

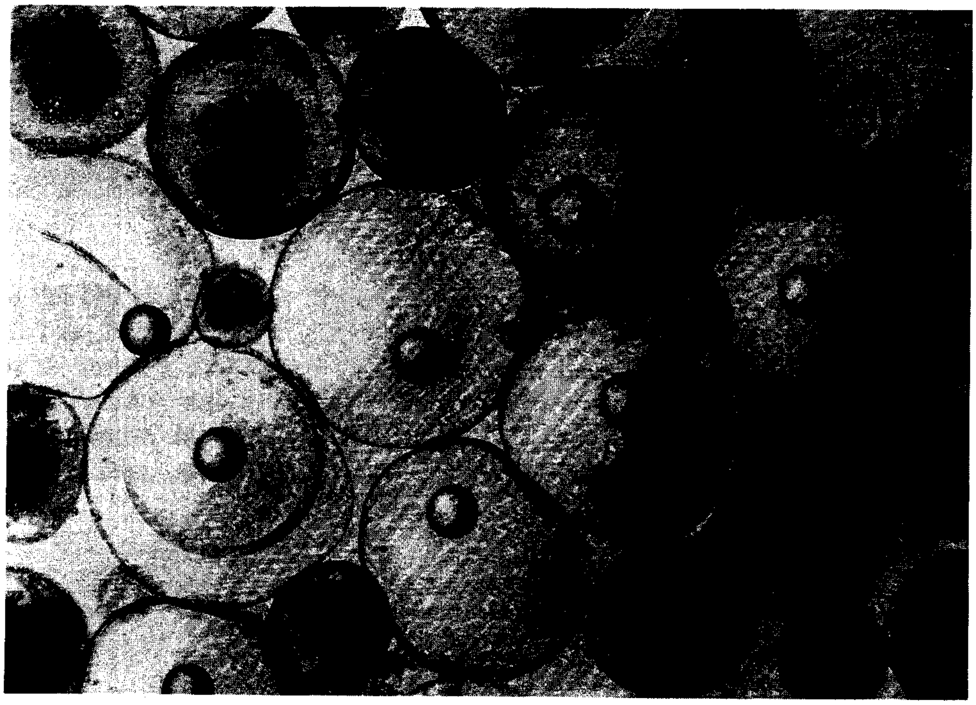

Figure 50. Photomicrograph of hydrated eggs of *Mycteroperca phenax.*

Off North Carolina and South Carolina, *M. phenax* appear to spawn slightly later in the year—from April through August with a peak during May and June (Matheson et al., 1986).

Age and length-weight relationship: Matheson et al. (1986) determined the ages of scamp caught off North Carolina and South Carolina; the oldest fish they examined was 21 years old and measured 893 mm FL. These authors believed scamp attained their ultimate size slowly with a K value calculated to be 0.092. The length-weight relationship for scamp captured in the eastern Gulf is expressed as $W = 1.10 \times 10^{-7} SL^{2.740}$ ($n = 1216$, $r^2 = 0.95$), where W is expressed in kilograms and SL is in millimeters (Figure 51) and $W = 8.995 \times 10^{-9} FL^{3.067}$ ($n = 1092$, $r^2 = 0.98$) (P. Hood, L. Bullock, M. Godcharles, unpublished data).

Diet: The stomachs of a 218-mm specimen and a 305-mm specimen contained unidentified fish remains. *Rhomboplites aurorubens, Haemulon aurolineatum,* and synodontids have been found in the stomachs of commercially captured scamp. Matheson et al. (1986) similarly found that the most frequently occurring items in the stomachs of scamp captured off North Carolina and South Carolina were unidentifiable fishes, *Decapterus punctatus, Haemulon aurolineatum,* unidentifiable serranids, and *Rhomboplites aurorubens.*

Parasites and abnormalities: Commercially landed scamp were found to host the following: didymozoid digenetic trematodes on the pseudobranchs; a leech and the parasitic isopods *Rocinela signata* and an undescribed species of *Tridentella* on the gill filaments; trypanorynch cestode plerocercoids in the viscera; and reddish philometrid nematodes in the gonad. Of 23 species of reef fishes examined at the Flower Garden Banks off Texas, *M. phenax* had the highest prevalence of gross lesions (75%), most related to cestode infestation (Grizzle, 1983).

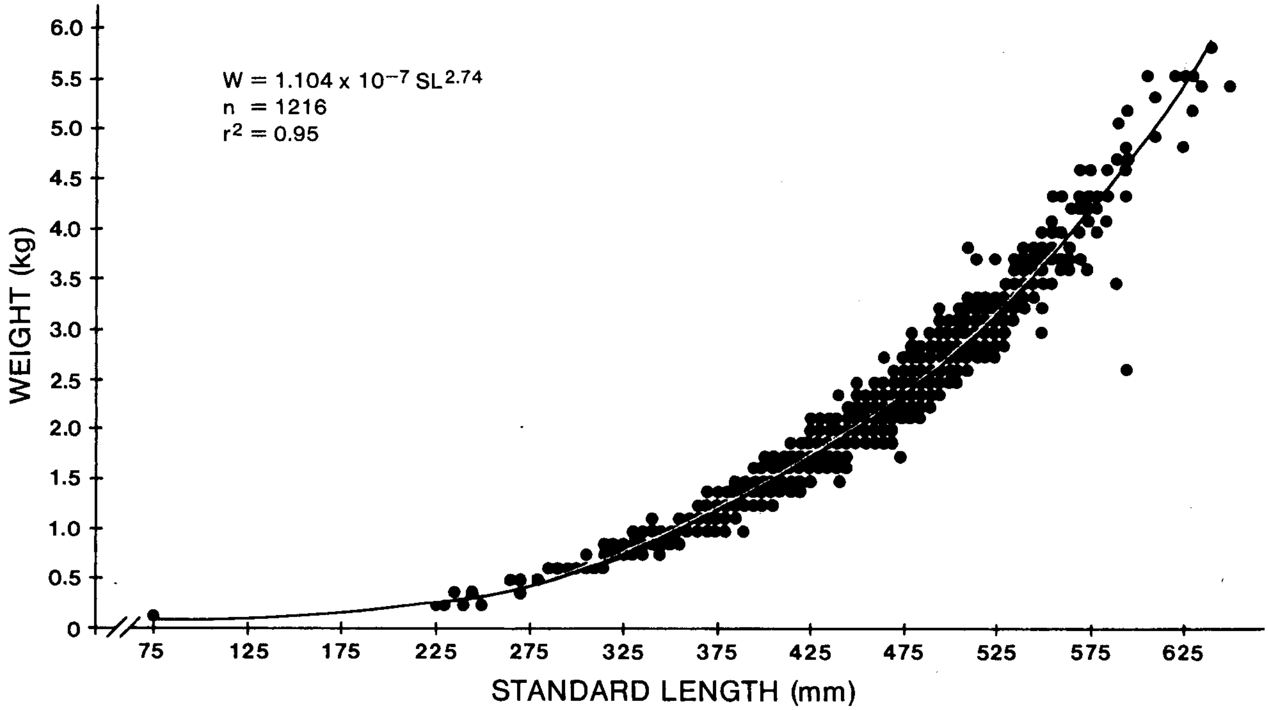

Figure 51. Length-weight relationship of *Mycteroperca phenax* commercially captured by hook and line in the eastern Gulf of Mexico.

Deformities observed in three scamp specimens were abnormal curvature of the vertebral column; dwarfed pelvic fins; and cleavage of the anal fin, apparently the result of entanglement with monofilament fishing line.

Several testes contained remnants of late stage vitellogenic oocytes that had not been resorbed but that had been segregated and encapsulated with connective tissue (possibly a pathogenic condition).

Fournie et al. (1985) reported the occurrence of multiple capillary haemangiomas in *M. phenax* (Figure 52) from the Florida Middle Ground.

Size and commercial importance: The scamp is an important commercial species in the Gulf of Mexico. Although scamp are not usually captured as frequently as other commercial species, its flesh is highly esteemed and brings slightly higher dockside prices.

At certain shallow-water eastern Gulf reefs, the abundance of the scamp approaches that of the gag, *Mycteroperca microlepis* (G. B. Smith, 1976). The abundance of scamp at these sites may be due to the fact that other groupers are more readily captured by fishermen. Intensive fishing pressure at these shallow reefs causes the depletion of disproportionate numbers of gag and red grouper, both of which are less wary than the scamp. Scamp are more readily caught at deep-water (>30 m) reefs, where individuals of 6–8 kg are common. Individuals seldom exceed 1–2 kg at reefs that are located in less than 18-m depths.

The size-frequency distribution of commercially landed scamp captured in the eastern Gulf during 1977–1981 was compared to similar data collected during 1984–1986 (M. Mitchell,

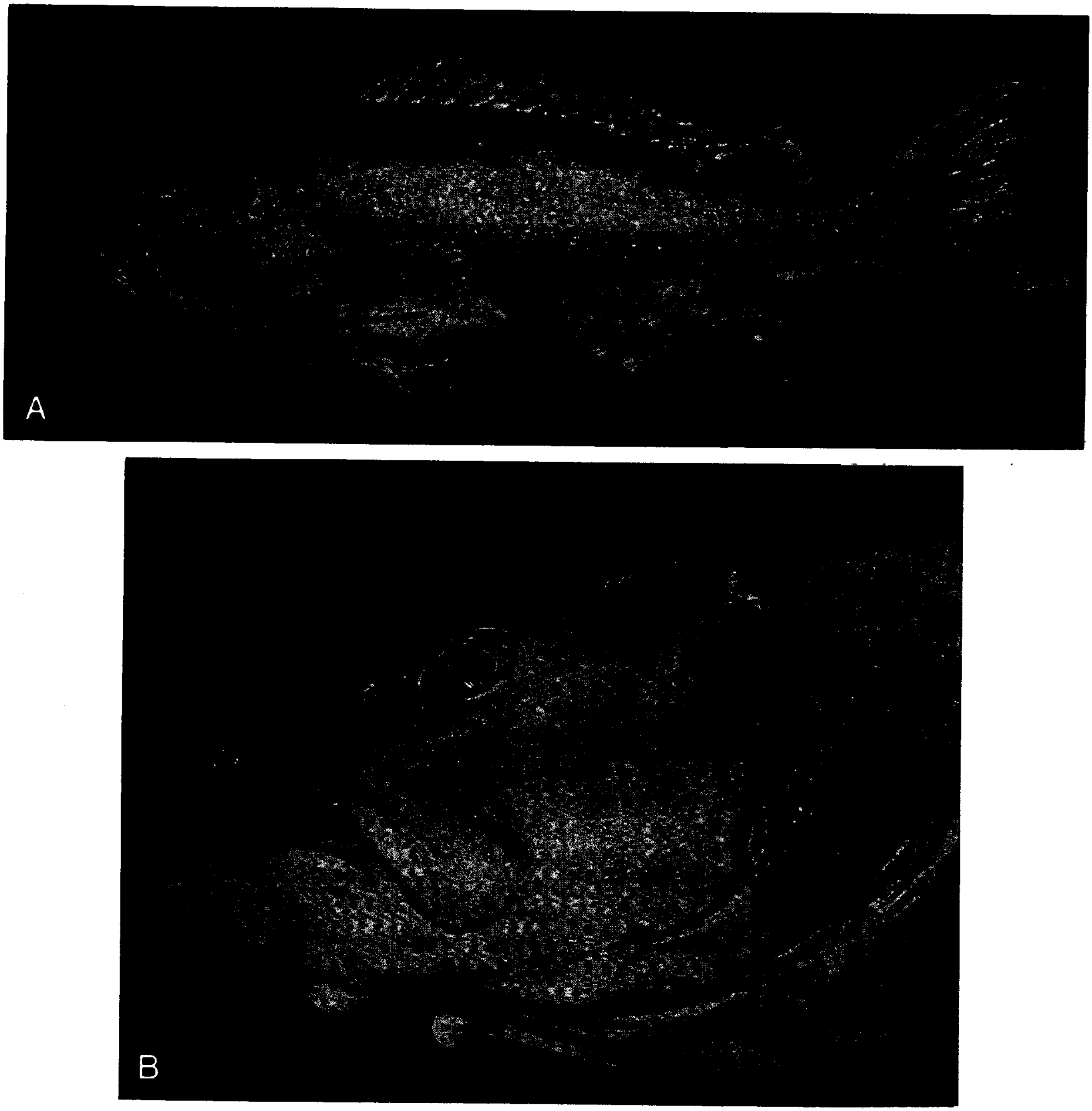

Figure 52. A. Multiple capillary haemangiomas in *Mycteroperca phenax* (541 mm); B. Close-up of head region.

personal communication) (Figure 53). The modal size for both time periods appears to be around 450 mm. According to Ulrich (1977), mean size of commercially landed scamp off South Carolina was 760 mm TL, with a mode of 800–840 mm TL; these fish were an average of approximately 200 mm larger than scamp from the eastern Gulf (M. Godcharles, personal communication).

Huntsman (1976) reported that Carolina headboat fishermen captured scamp in a size range of 15–20 lb (6.8–9.1 kg). Scamp was the most frequently captured grouper in this headboat fishery. From 1973 to 1979, scamp contributed 34% of the total weight of grouper (348 mt) taken by the headboat fishery in the South Atlantic Bight (Matheson et al., 1986).

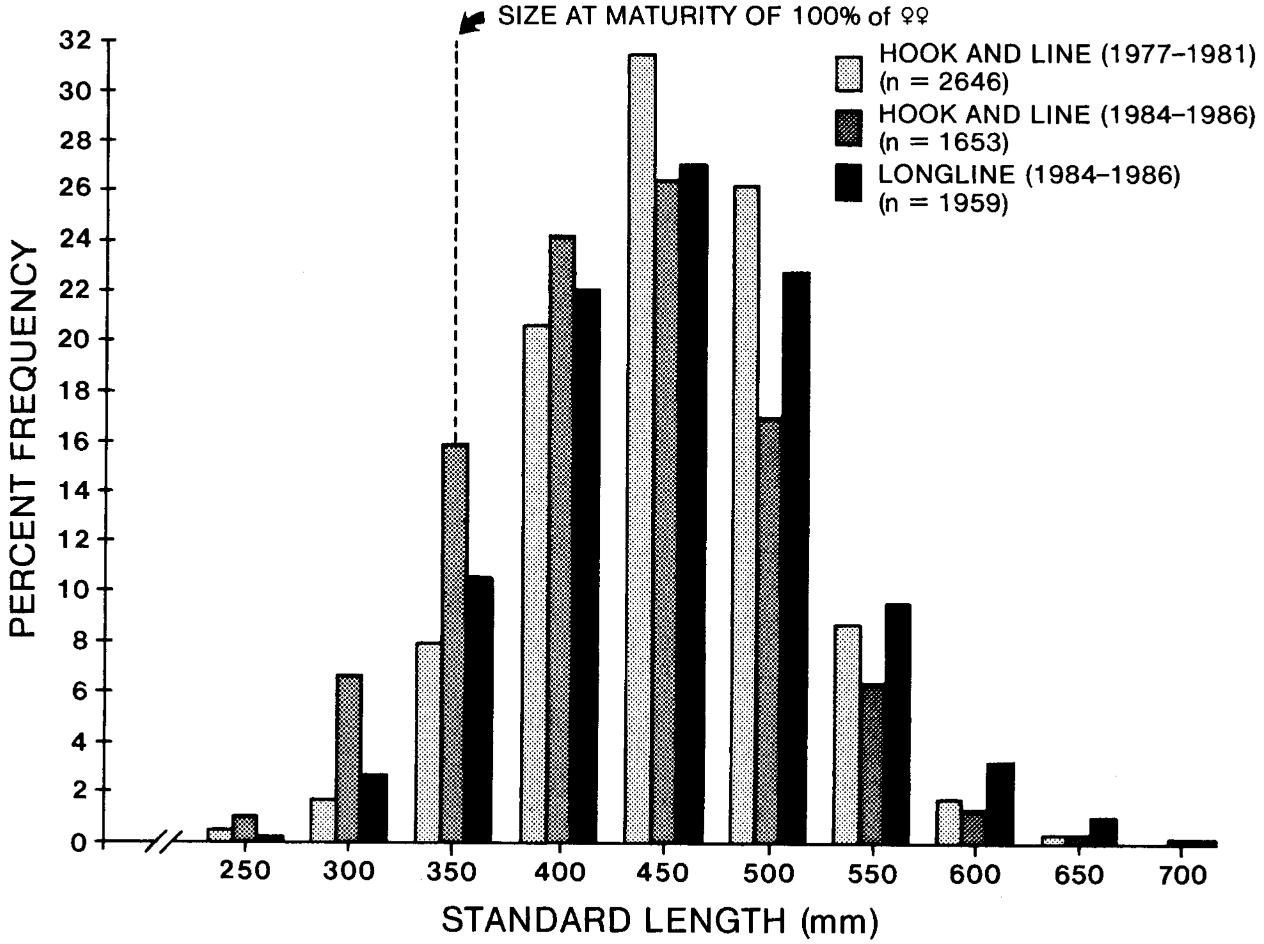

Figure 53. Length frequency distribution of *Mycteroperca phenax* commercially captured by hook and line in the eastern Gulf of Mexico during 1977–1981 (n = 2,646) versus those commercially captured by hook and line (n = 1,653) and by longline (n = 1,959) during 1984–1986.

Mycteroperca tigris (Valenciennes, 1833)
Tiger grouper

Plate XVII, Figure C (juvenile)
Plate XVII, Figure D (juvenile)
Plate XVIII, Figure A (adult)

Serranus tigris Valenciennes, *in* Cuvier and Valenciennes, 1833, pp. 440, 441 (Santo Domingo: original descr.).

Mycteroperca tigris: Longley and Hildebrand, 1941, p. 101 (rare at the Dry Tortugas; photograph); Bardach et al., 1958, p. 54; Briggs, 1958, p. 272; C. L. Smith, 1958, pp. 8, 12, 21, 54, 55, figs. 2a, 4, 15, pl. 11 (Bermuda: biology); 1959, p. 114, fig. 1 (hermaphroditism); 1961, pp. 1:6, 1:19, 1:20, 1:23, fig. 18; Randall, 1962, pp. 209, 237, 240; 1963b, p. 37 (Virgin Islands: ecology); Cervigón M. and Velasquez, 1966, pp. 89–92; Randall, 1967, pp. 702, 703 (dietary habits); Böhlke and Chaplin, 1968, p. 285; Randall, 1968, p. 65 (photograph, general account); C. L. Smith, 1971a, pp. 184–187 (complete account); Collette and Talbot, 1972, pp. 107, 108; Instituto Nacional de Pesca, 1976, p. 173; Jones and Thompson, 1978, p. 164; C. L. Smith, 1978 (FAO species ID sheets); Thompson and Munro, 1978, p. 285; Bullock and Godcharles, 1982, p. 53; Taylor and McMichael, 1983, p. 7; Dennis and Bright, 1988b, pp. 7, 8 (northwestern Gulf of Mexico).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: 1, 90; Florida Keys between Looe Key and American Shoals, 15 m; 8 August 1989; handnet; FSBC 18001.—1, 578; Dry Tortugas, Florida, 24°32′N, 82°59′W, 24.4 m; 23 April 1980; fish trap;

FSBC 11990.—EASTERN GULF OF MEXICO: 1, 611; Florida Middle Ground, 28°21'–28°29'N, 84°03'–84°19'W, 36.6–39.6 m; 25 September 1979; commercial hook and line; FSBC 11989.

Diagnosis (modified from C. L. Smith, 1971a): Dorsal XI, 16–17; anal III, 11; pectoral 17; developed gill rakers very few, 9–15 on the first arch; posterior nostril enlarged in individuals over 300 mm long; vertical fins exserted in large adults; preopercle rounded; strong canine teeth. Moderate-sized species of *Mycteroperca* with robust body.

Adult coloration dark greenish to black with hexagonal spots on the head and lower sides of body. Eleven pale diagonal bars on back (only about 8 bars easily discernable). Inside of mouth dusky orange-yellow.

Small juveniles either lemon yellow with brown longitudinal stripe (Plate XVII, Figure C) or bicolored (dark above and light below with a yellow cast), with pattern of diagonal bars present on back (Plate XVII, Figure D).

Distinguishing characters: Both *M. tigris* and *M. interstitialis* have a bicolored phase when young, but *M. interstitialis* lacks the pattern of stripes sloping downward and forward across the back that is found in *M. tigris* (C. L. Smith, 1971a). The reduced number of gill rakers (8) on the lower limb of the first gill arch distinguishes *M. tigris* from other species of *Mycteroperca* (C. L. Smith, 1971a). There may be exceptions in young fish; a juvenile tiger grouper (FSBC 18001, 90 mm), contained 12 developed gill rakers on the lower limb.

Geographic and bathymetric distribution: This species is known from Bermuda, the Bahamas, South Florida, Texas (Dennis and Bright, 1988b), Cuba, Haiti, the Dry Tortugas, the Campeche Banks, Puerto Rico, Arcas Cay, Barbados (C. L. Smith, 1971a), Venezuela, and Brazil (Cervigón M. and Velasquez, 1966). Dennis and Bright (1988b) postulated that the tiger grouper was a transient in the northwestern Gulf, recently becoming quite abundant on the Flower Garden Banks. The 611-mm specimen captured at the Florida Middle Ground is the first tiger grouper recorded in the eastern Gulf of Mexico (Bullock and Godcharles, 1982).

In reef areas, the tiger grouper is found from the shoreline to depths of at least 30 m (C. L. Smith, 1978). The Florida Middle Ground specimen came from depths of 37–40 m.

Reproduction: In Bermuda, C. L. Smith (1958) considered the spawning peak to be in early June, although ripe males were found as late as August (1956). He found that all individuals less than 370 mm were females and those over 450 mm were males. Cervigón M. and Velasquez (1966) found females as large as 625 mm (SL) in Venezuela.

Diet: Randall (1967) found that fishes composed by volume 100% of all food consumed by 59 (153–572 mm SL) tiger groupers examined from the West Indies. The fishes included *Acanthurus* sp.; *A. bahianus* Castelnau, 1855; *A. coeruleus* Bloch and Schneider, 1801; atherinids; *Cantherhines pullus* (Ranzani, 1842); *Haemulon* sp.; *H. flavolineatum; Jenkinsia* sp.; *Odontoscion dentex* (Cuvier and Valenciennes, 1830); *Ophioblennius atlanticus* (Cuvier and Valenciennes, 1836); *Pomacentrus fuscus* (Cuvier and Valenciennes, 1830); *P. planifrons* (Cuvier and Valenciennes, 1830); scarids; and *Sparisoma* sp.

Behavior: Behavioral observations indicate that the tiger grouper is vulnerable to at least three fishing methods: trolling, trapping, and spearfishing. These fish readily take trolled lures of sport fishermen (Böhlke and Chaplin, 1968), and spearfishermen find them to be easily approached underwater (C. L. Smith, 1971a). Randall (1962) commented on the proclivity of tiger grouper to enter fish traps (one individual was captured 21 times).

Size and commercial importance: C. L. Smith (1958) noted that in Bermuda this fish may attain a weight of approximately 20 lb (9.1 kg). Randall (1968) mentioned that it reaches a length of nearly 40 inches (1,016 mm) in Bermuda waters. Thompson and Munro (1978) recorded a maximum length of 670 mm (TL) for Jamaican specimens.

In Venezuela, the tiger grouper is caught almost exclusively in traps (Cervigón M. and Velasquez, 1966). Although Longley and Hildebrand (1941) observed *M. tigris* around the Dry Tortugas, Florida, and Jones and Thompson (1978) noted this species in the Dry Tortugas and Key Largo, Florida, only two tiger groupers were captured out of more than 10,000 fishes taken in fish traps in a year-long study in the Florida Keys (Taylor and McMichael, 1983).

Mycteroperca venenosa (Linnaeus, 1758)
Yellowfin grouper

Plate XVIII, Figure B

Perca venenosa Linnaeus, 1758, p. 292 (America: original descr.).

Mycteroperca venenosa: Henshall, 1895, p. 216 (Florida Keys); Evermann and Kendall, 1900, p. 74 (Florida); Longley and Hildebrand, 1941, p. 99, pl. 6, fig. 1 (Dry Tortugas: ecology); Springer, 1946, pp. 174, 175; Manter, 1947, p. 373 (parasites); C. L. Smith, 1958, pp. 54, 55 (Bermuda: ecology); Springer and Woodburn, 1960, p. 35; C. L. Smith, 1961, pp. 1:5, 1:17, 1:18, 1:23 (Bermuda: ecology); Cervigón M. and Velasquez, 1966, pp. 82–85 (Venezuela: general account, osteology); Randall, 1967, pp. 703–704 (dietary habits); Böhlke and Chaplin, 1968, p. 267 (Bahamas); Brownell and Rainey, 1971, p. 53 (Virgin Islands); Carpenter and Nelson, 1971, p. 22 (Caribbean Sea); C. L. Smith, 1971a, pp. 174–177 (full account); Smith et al., 1975, p. 6 (eastern Gulf of Mexico); Walls, 1975, p. 180; Huntsman, 1976, p. 18 (North Carolina); Fischthal, 1977, p. 88 (digenetic trematodes); Hoese and Moore, 1977, p. 174; Thompson and Munro, 1978, pp. 118, 119, 121, 123, 125 (Jamaica); Taylor and McMichael, 1983, p. 7 (Florida Keys); Bannerot, 1984, p. 27 (spawning locations).

Micteroperca venenosa: Borodin, 1928, p. 19 (Florida: misspelling).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 1, 742; Florida Middle Ground, approximately 28°30′N, 84°20′W, 36.6 m; 30 September 1979; hook and line; FSBC 11631.—1, 377; Florida Middle Ground, 28°21′N, 84°12′W, 30.5 m; 6 October 1979; hook and line; FSBC 11637.

Diagnosis (modified from C. L. Smith, 1971a): Dorsal XI, 15–16; anal III, 11 (rarely 10 or 12); pectoral 16–17; gill rakers 23–27. Preopercle rounded, posterior nostril not enlarged in small individuals, but posterior nostril as much as 2 times size of anterior nostril in specimens over 500 mm TL (Cervigón M. and Velasquez, 1966). Vertical fins lack exserted rays.

Two color phases: deep-water red and shallow-water greenish-brown phase. Irregular rows of rounded dark blotches on sides of body. Outer third of pectoral abruptly delimited, brilliant yellow. Lower part of body and head of large individuals with small, bright red spots.

Distinguishing characters: Mycteroperca venenosa resembles *M. bonaci*, but in *M. venenosa* the spots on the body are smaller, more numerous, and less regularly aligned; however, in *M. bonaci* the quadrate blotches are in more uniform rows. The most distinctive color feature of *M.*

venenosa is the bright yellow margin of the pectoral fin; the pectoral fin of *M. bonaci* has an orange edge.

Geographic and bathymetric distribution: The yellowfin grouper is known from Bermuda, North Carolina (Huntsman, 1976), southern Florida, the Gulf of Mexico, throughout the Bahamas, the Antilles, on the Campeche Bank off Mexico, and south to Brazil (C. L. Smith, 1971a). The yellowfin grouper occurs (rarely) at the Florida Middle Ground in the eastern Gulf.

Thompson and Munro (1978) collected juvenile *Mycteroperca venenosa,* along with *M. rubra* (Bloch, 1793), on *Thalassia testudinum* beds in 2–4 m of water in Kingston Harbor, Jamaica. Brownell and Rainey (1971) captured yellowfin grouper in the Virgin Islands in a depth range of 10 ft (3 m) to 75 fm (137.2 m). Carpenter and Nelson (1971) reported catches of yellowfin grouper off Honduras-Nicaragua and Jamaica in depths of 1–30 fm (1.8–54.9 m). Although yellowfin grouper are found in shallow water in the Florida Keys, this species occurs only in depths of 30 m or greater in the eastern Gulf of Mexico.

Reproduction: The sex ratio of mature *Mycteroperca venenosa* on relatively unexploited oceanic banks around Jamaica was reported by Thompson and Munro (1978) to be M:F = 1.18:1. They also found that most spawning of yellowfin grouper occurred between February and April. C. L. Smith (1961) noted several yellowfin grouper that appeared to be in spawning condition on Argus Banks off Bermuda in July. In Puerto Rico, C. L. Smith (1961; with personal communication from D. S. Erdman) indicated that for this species spawning occurred during April. Spawning aggregations have been observed during the full moon in March in the southern Berry Islands, Bahamas, and off Belize (Bannerot, 1984).

Ripe males and females were collected during March in the Florida Keys (24°29′N, 82°58′W) during an FMRI fish-trap study (Taylor and McMichael, 1983). Active females were sampled from the Florida Middle Ground during March, May, June, July, and August, whereas ripe males (milt exuding from the urogenital pore) from the same area were taken in April and July.

Two females (696 mm, 8.2 kg and 725 mm, 10.4 kg) captured in June at the Florida Middle Ground contained ovulated eggs (0.80–1.16 mm in diameter) that were transparent and contained a single oil droplet. Batch fecundity estimates (vitellogenic oocytes) for these two fish were 1,994,740 ± 26,734 oocytes for the 696-mm female and 2,874,665 ± 12,996 oocytes for the 725-mm individual.

Although Thompson and Munro (1978) indicated sexual maturity (presumably female) at or before 510 mm TL in the Caribbean, ripe males were found as small as 540 mm SL in the Florida Keys (R. Taylor and R. McMichael, personal communication).

Diet and feeding: Randall (1967) sampled 127 specimens from the West Indies and found that fishes made up 95.3% of the diet by volume; the remainder of the diet included squids and shrimps. Fishes included *Abudefduf saxatilis* (Linnaeus, 1758); *Acanthurus bahianus* (Castelnau, 1855); atherinids; *Aulostomus maculatus* Valenciennes, 1842; *Caranx ruber* (Bloch, 1793); *Chromis cyanea* (Poey, 1860); *C. multilineata* (Guichenot, 1853); *Haemulon flavolineatum* (Desmarest, 1823); holocentrids; *Holocentrus* sp.; monacanthids; *Pomacentrus* sp.; *P. fuscus* (Cuvier and Valenciennes, 1830); *P. planifrons* (Cuvier and Valenciennes, 1830); scarids; *Scarus croicensis* Bloch, 1790; *Synodus intermedius* (Spix, 1829); and *Thalassoma bifasciatum*

(Bloch, 1791). Randall (1967: 704) commented, "That yellowfin grouper can capture such swift-swimming fishes as the bar jack (*Caranx ruber*) would seem to indicate that it is more active than the more robust groupers such as species of *Epinephelus*."

Scorpaena dispar Longley and Hildebrand, 1940, *Synodus intermedius* (Agassiz, 1829), and *Halichoeres* sp. have been found in the stomachs of yellowfin grouper captured in the eastern Gulf.

Predation: Springer (1946) found yellowfin grouper in the stomachs of *Carcharhinus obscurus* (LeSueur, 1818). The author theorized that the groupers had been stunned or possibly killed by cold-water upwelling and had been consumed by the sharks.

Parasites: Didymozoid digenetic trematodes were observed attached to the pseudobranchs, and digenetic trematodes were found in the gonad of yellowfin groupers captured in the eastern Gulf. Fischthal (1977) found the digenetic trematodes *Paracryptogonimus americanus* Manter, 1940 and *Prosorhynchus pacificus* Manter, 1940 in *M. venenosa* captured off Belize.

Size and commercial importance: Böhlke and Chaplin (1968) indicated that the maximum size for yellowfin grouper is approximately three ft (0.9 m). During a grouper study by Thompson and Munro (1978) on oceanic banks near Jamaica, the largest yellowfin grouper sampled (n = 198) was 860 mm TL (modally 650 mm TL). Out of 73 individuals caught in traps in the Florida Keys during an FMRI fish-trap study, the largest yellowfin grouper was 810 mm FL (range of 355–810 mm FL, mean of 632 mm) (Taylor and McMichael, 1983).

In the eastern Gulf of Mexico (Florida Middle Ground), *Mycteroperca venenosa* is infrequently captured by hook and line on commercial and party boats with home ports located in Pinellas County, Florida.

Carpenter and Nelson (1971) caught yellowfin grouper around Jamaica and off Honduras and Nicaragua. Cervigón M. and Velasquez (1966) remarked on this species' abundance around Islas Los Roques and Blanquilla off the coast of Venezuela, and C. L. Smith (1958) noted its commercial importance in Bermuda. In areas of abundance, this fish is apparently vulnerable to trapping, surface trolling, and spearfishing.

Genus *Paranthias* Guichenot, 1868

Diagnosis (after C. L. Smith, 1971a): Dorsal IX, 18 or 19; anal III, 9 or 10; pectoral rays 19–21. Gill rakers 35–41. Head short, 26–30% of SL. Caudal fin deeply forked. Small groupers, moderately compressed; dorsal and ventral profiles about equally curved.

Color reddish brown, a series of three small, widely separated white spots along back above the lateral line.

Larvae (size of specimens: 7.2–7.6 mm) with unique spinelet pattern on dorsal fin spines and internal notochord pigment not found in other epinephelines (Kendall, 1984; Johnson and Keener, 1984: 129, 130, fig. 14).

Paranthias furcifer (Valenciennes, 1828)
Creole fish

Plate XVIII, Figure C

Serranus furcifer Valenciennes, *in* Cuvier and Valenciennes, 1828, p. 264 (Brazil: original descr.).

Paranthias furcifer: Guichenot, 1868, p. 87; Schroeder, 1941, p. 45 (Pensacola, Florida); Springer and Bullis, 1956, p. 80 (Gulf of Mexico); Briggs, 1958, p. 273; C. L. Smith, 1961, pp. 1:1, 1:2, 1:8, 1:23, fig. 6; 1966, pp. 1–11 (hybridizes with *Cephalopholis fulva*); Randall, 1967, pp. 704, 705 (dietary habits); C. L. Smith, 1971a, pp. 86–90; Powell et al., 1972, p. 69; Bright and Cashman, 1974, pp. 343, 352, 383, figs. 27a, b; Smith et al., 1975, p. 7; Walls, 1975, pp. 180, 181; G. B. Smith, 1976, p. 42; Hoese and Moore, 1977, p. 168; Thompson and Munro, 1978, pp. 116, 118, 124, 126; Williams and Williams, 1981, pp. 1009, 1012 (parasites); Boland et al., 1983, pp. 206, 207, 208 (fig. 6–31), 209 (fig. 6–32), 210, 211 (fig. 6–33) (Flower Garden Banks, Texas); Johnson and Keener, 1984, pp. 129, 130 (identification of larvae); Thresher, 1984, p. 68; Rand, 1986, pp. 143–146 (parasite); Nelson, 1988, pp. 178, 179 (diet).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 2, 241, 292; 27°43′N, 84°09′W, 45.7 m; 1 May 1965; FSBC 3457.—1, 254.5; 27°41′N, 84°11′W, 75 nmi west of Pass-a-Grille, Pinellas County, Florida, 44.2 m; hook and line; FSBC 7817.—1, 253; Florida Middle Ground, approximate center, 32.0–45.7 m; hook and line; FSBC 8011.—1, 271; Florida Middle Ground, 33.5–39.6 m; 7 October 1979; hook and line; FSBC 11642.—NORTHERN GULF OF MEXICO: 1, 251; 130° off Pensacola Sea Buoy, Florida, 34.7 m; 13 May 1963; hook and line; FSBC 2492.—SOUTHWESTERN GULF OF MEXICO: 1, 251; eastern edge of Campeche Bank, Mexico; 3 April 1963; FSBC 2328.—PUERTO RICO: 3, 59–66; R/V *Oregon* Station 2623, 18°47′N, 64°46′W, 64 m; 28 September 1959; 12.3-m flat trawl; FSBC 1553.

Diagnosis: Because *Paranthias* is monotypic, characters of the genus also define the species.

Distinguishing characters: The deeply forked tail and short head length of *Paranthias furcifer* distinguish this species from all other groupers (Plate XVIII, Figure C).

Geographic and bathymetric distribution: In the western Atlantic, *P. furcifer* is recorded from Bermuda, South Carolina, Florida, the Gulf of Mexico, throughout the Antilles, and from Panama to Brazil. In the Pacific, it is found from lower California to Peru and around the Galapagos Islands (C. L. Smith, 1971a).

Bright and Cashman (1974) found *P. furcifer* in aggregations from 80–180 ft (24–55 m) on the West Flower Garden Bank off Texas. The FSBC specimens were collected in depths of 105–210 ft (32–64 m).

Reproduction and hybridization: *Paranthias furcifer* supposedly hybridizes with *Epinephelus fulvus* (C. L. Smith, 1966). The hybrid, previously known as *Menephorus dubius* (Poey, 1860), has been collected in traps at Morant Bank in Jamaica (Thompson and Munro, 1978). The fish is reddish brown with small blue spots (less numerous than those on *E. fulvus*) on the head and dorsum; the caudal fin is moderately forked (Thompson and Munro, 1978).

Although collection data are not available for all months of the year, ripe females were noted from the Florida Middle Ground during May–September; ripe males were found during April–October. Post-spawning males were observed during November and December. Batch fecundity estimates for a 218-mm and a 289-mm female were 177,378 ± 4,039 and 640,066 ± 9,734 oocytes, respectively.

Thompson and Munro (1978) stated that their results regarding protogyny in *P. furcifer* were inconclusive, although they noted that no small males were found and that the proportion of males increased with age. Thresher (1984) hypothesized that *P. furcifer* may be a secondary gonochorist (i.e., a gonochore derived from an hermaphroditic ancestor).

A histological examination of *P. furcifer* gonads revealed the following features: 1) testicular luminae, 2) peripheral testicular sperm-collecting sinuses, and 3) a testis exhibiting advanced stages of spermatogenesis with simultaneous breakdown of perinucleolar-stage and yolk-vesicle-stage oocytes. Although there was some overlap in size ranges of the sexes (females: 223–292 mm; males: 263–304 mm), the largest individuals were male. These features could be indicative of protogyny, but the only definitive proof would be the capture of transitional individuals.

Diet and ecological niche: According to Randall (1967), *Paranthias furcifer* occurs in aggregations and feeds on copepods, tunicates and their larvae, amphipods, mysids, fish larvae, gastropod larvae, unidentified crustaceans, and eggs. At the Flower Garden Banks off Texas, the principal food consumed by *P. furcifer* was calanoid copepods (among a variety of other foods) (Boland et al., 1983). In the same area, Nelson (1988) found 252 creole fish to consume the following (by occurrence): unidentified animal matter, 31%; siphonophores, 16%; chaetognaths, 10%; crustacean plankters, 54%; calanoid copepods, 53%; *Candacia* sp., 17%; hyperiid amphipods, 20%; mysid larvae, 10%; scyllarid phyllosome larvae, 11%; thaliaceans, 29%; salps, 23%; fish eggs, 11%; and fish scales, 28%. Stomach contents from two specimens caught at the Florida Middle Ground included a colonial tunicate in one stomach and a small specimen of *Haemulon aurolineatum* in the other.

C. L. Smith (1971a: 87) stated that "in both habits and morphology it [the creole fish] holds among groupers the same position that the yellowtail, *Ocyurus chrysurus*, does among snappers." Both species have specializations that enable them to feed principally on zooplankton and to lead a more active pelagic existence; these specializations include a small mouth, small teeth, numerous gill rakers, a fusiform body, and a deeply forked caudal fin.

Predation: Nelson (1988) found *P. furcifer* in stomach contents of *Lutjanus campechanus* (Poey, 1860) and *Pagrus pagrus* captured on the Flower Garden Banks off Texas.

Parasites: In the eastern Gulf, *Paranthias furcifer* have been found with plerocercoid metacestodes in the visceral cavity. The cymothoid isopod *Anilocra haemuli* Williams and Williams, 1981 has been seen attached to creole fish in the Caribbean (Williams and Williams, 1981). Rand (1986) described the histopathology of infestation of *P. furcifer* by the cymothoid isopod *Nerocila acuminata* Schioedte and Meinert, 1883.

Size and commercial importance: The maximum size, according to C. L. Smith (1971a), is slightly over 1 ft (0.3 m).

Paranthias furcifer is occasionally found in party boat catches from the Florida Middle Ground. The recorded size range for 44 specimens from this area was 223–304 mm; mean weight was 0.6 kg. The creole fish is often marketed as snapper because of its superficial resemblance to the vermilion snapper *Rhomboplites aurorubens* (Cuvier, 1829).

Genus *Pikea* Steindachner, 1874

Diagnosis (after Schultz, 1958): Dorsal spines VIII; spiny dorsal fin continuous with soft dorsal by ridge of scales along sides of connecting dorsal spines; no scaled area separating spiny and soft dorsal rays.

As in *Liopropoma*, larvae with two elongate, delicate dorsal spines pigmented distally (Kendall, 1984).

Pikea mexicana Schultz, 1958
Yellowtail bass

Plate XVIII, Figure D

Liopropoma aberrans (*non* Poey): Longley and Hildebrand, 1941, p. 101.

Pikea mexicanus mexicanus Schultz, 1958, pp. 323–326.

Pikea mexicanus atlanticus Schultz, 1958, p. 326.

Pikea mexicana: Bailey et al., 1970, p. 35; Chittenden and Moore, 1977, p. 109 (abundance off Texas and Louisiana); Hoese and Moore, 1977, p. 167; Feeney et al., 1979, p. 51 (gonad morphology); Gilmore et al., 1981, appendix p. 14, table 1; McCaffrey, 1981, p. 118 (northeastern Gulf of Mexico); Darnell et al., 1983, pp. 43, 201, pl. 49 (off Louisiana and Texas); Darcy and Gutherz, 1984a, p. 100.

Liopropoma mexicana: C. L. Smith, 1978 (FAO species ID sheets).

Pikea mexicanus: Nelson, 1988, p. 191, Table A2.2 (predation by *Pagrus pagrus*).

Material examined: HOURGLASS MATERIAL: None.—OTHER MATERIAL: DRY TORTUGAS: 3, 48.6–58.5; 24°21'N, 82°05'W, R/V *Hernan Cortez* Station IC-81-37, 110 m; 22 August 1981; 6.1 m semi-balloon otter trawl; FSBC 12143.—NORTHEASTERN GULF OF MEXICO: 5, 18–121; 29°40.8'N, 86°46.5'W, R/V *Chapman* Cruise 19, haul 72, 192 m; 22 August 1987; trawl; FSBC 17904.

Diagnosis (modified after Schultz, 1958): Dorsal VIII, 14 (rarely 15); anal III, 8; pectoral 14–15 (modally 15); total gill rakers on first arch 18–23; pores in lateral line 45–47; spiny dorsal fin continuous with soft dorsal by ridge of scales along sides of connecting dorsal spines; no scaled area separating spiny and soft dorsal rays; 2½ to 5½ scales in row from lateral line to base of last dorsal spine, 16 to 21 predorsal scales to occiput.

Color reddish with more or less regular rows of yellow spots on sides and yellow margins to dorsal and anal interspinous membranes; caudal fin yellow (Hoese and Moore, 1977).

Distinguishing characters: Whereas *Pikea* has a spiny dorsal fin continuous with the soft dorsal fin, the closely related genus *Liopropoma* has either a deeply notched dorsal fin or two completely separate dorsal fins.

Systematics: Schultz (1958) noted that northern Gulf of Mexico specimens had 21–23 gill rakers on the first arch, while specimens from off the Guianas and Venezuela had 18–21 gill rakers. He designated the Gulf form as *Pikea mexicanus mexicanus* and the form from off the coasts of Venezuela and the Guianas as *P. m. atlanticus*.

Geographic and bathymetric distribution: *Pikea mexicana* has been reported from the Florida east coast (Gilmore et al., 1981), off the Dry Tortugas (Schultz, 1958), from the eastern Gulf of Mexico (Schultz, 1958; Darcy and Gutherz, 1984a), from the northeastern Gulf off the Florida Panhandle (McCaffrey, 1981), and from the northern Gulf off Texas and Louisiana (Chittenden and Moore, 1977; Darnell et al., 1983). Elsewhere, *P. mexicana* has been recorded from the Guianas and Venezuela (Schultz, 1958).

This is a deep-water species recorded from 48–150 fm (87.8–274.4 m). *Pikea mexicana* is common along the 110-m contour off Texas and Louisiana (Chittenden and Moore, 1977).

Reproduction: S. Bortone (personal communication) has found evidence to indicate that *Pikea mexicana* is a sequential hermaphrodite.

Spawning in the northern Gulf takes place from late spring to October, with most females possessing mature oocytes during June–August (Feeney et al., 1979).

Predation: Nelson (1988) found *P. mexicana* in stomach contents of *Pagrus pagrus* from the Flower Garden Banks off Texas.

Genus *Rypticus* Cuvier, 1829

Diagnosis (after Courtenay, 1967): Dorsal II–IV; 2 or 3 opercular spines; 1–3 preopercular spines; body scales embedded; teeth on jaws, vomer, and palatines in villiform bands; fleshy dorsal and anal fins; operculum joined to skull by membrane above; inner pelvic ray with membranous attachment to abdomen. Skin with thick mucus containing a toxin (grammistin) distasteful to predators (Figure 54).

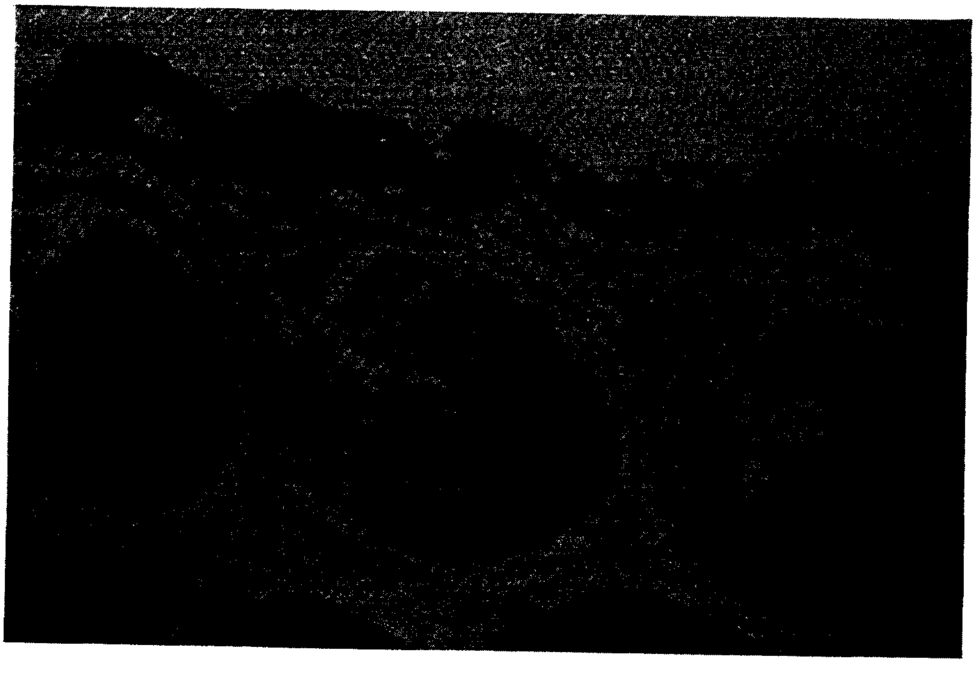

Figure 54. Dermal mucous glands of *Rypticus maculatus* (FSBC 7431-3; 117 mm). E = epidermis; MG = mucous gland; S = scale; H & E stain. Scale bar = 0.1 mm.

Larvae (ca. 6.0 mm SL) with first dorsal spine produced, flexible, and surrounded by pigmented sheath; large pectoral fin; relatively undeveloped pelvic fin (Kendall, 1979, 1984).

Remarks: For more complete synonymies of the two species of *Rypticus*, refer to Courtenay (1967).

KEY TO *RYPTICUS* SPECIES OF THE WEST FLORIDA SHELF

(After Courtenay, 1967.)

1. Ochre to dark red-brown spots small and closely set on head and body; markings darker than background coloration. Preopercular spines 3; caudal vertebrae 15............ *R. bistrispinus*
1. White spots on sides of body, some distinct, some coalesced; markings lighter than background coloration. Preopercular spines 1–3 (modally 2); caudal vertebrae 14–15 (rarely 15) .... *R. maculatus*

Rypticus bistrispinus (Mitchill, 1818)

Freckled soapfish

Figure 55; Plate XIX, Figure A

Bodianus bis-trispinus Mitchill, 1818, p. 247 ("straits of Bahama").

Rypticus arenatus Cuvier, *in* Cuvier and Valenciennes, 1829, p. 48, pl. 46 (good figure; dorsal spine count probably in error); Jordan and Evermann, 1896a, p. 379; 1896b, pp. 1232, 1233; Longley and Hildebrand, 1941, p. 102; Briggs, 1958, p. 273; Moe and Martin, 1965, p. 148.

Rypticus bistrispinus: Jordan and Evermann, 1896a, p. 380; Breder, 1927, p. 45; Longley and Hildebrand, 1941, pp. 102, 103; Courtenay, 1967, pp. 263–268; Powell et al., 1972, pp. 71, 72; Darcy and Gutherz, 1984a, p. 100 (list).

Material examined: HOURGLASS STATION C: 2, 60, 63; 21 November 1967; dredge; FSBC 5165.—HOURGLASS STATION D: 1, 0; 20 November 1965; trawl; FSBC 4601.—2, 72, 77; 7 April 1966; trawl; FSBC 10022.—1, 79; 18 June 1966; trawl; FSBC 10021.—2, 68, 70; 2 August 1966; trawl; FSBC 4998.—1, 73; 9 September 1966; trawl; FSBC 10016.—1, 84; 14 December 1966; trawl; FSBC 10017.—1, 25; 21 November 1967; trawl; FSBC 6012.—HOURGLASS STATION L: 1, 78; 4 September 1965; trawl; FSBC 4466.—2, 71, 90; 13 October 1965; trawl; FSBC 15130.—2, 90, 97; 13 December 1965; trawl; FSBC 4635.—1, 68; 15 February 1966; trawl; uncatalogued.—2, 77, 87; 12 April 1966; trawl; uncatalogued.—1, 76; 22 July 1966; trawl; FSBC 15015.—2, 81, 88; 6 August 1966; trawl; FSBC 10018.—1, 64; 31 January 1967; trawl; FSBC 15647.—1, 75; 16 February 1967; dredge; FSBC 15016.—1, 85; 9 March 1967; trawl; uncatalogued.—1, 84; 8 April 1967; trawl; FSBC 10019.—1, 88; 16 May 1967; trawl; uncatalogued.—HOURGLASS STATION M: 3, 62–82; 14 January 1966; trawl; FSBC 4778.—1, 97; 15 February 1966; dredge; uncatalogued.—2, 85, 89; 22 March 1966; trawl; uncatalogued.—1, 57; 13 June 1966; dredge; uncatalogued.—1, 72; 22 July 1966; trawl; uncatalogued.—1, 67; 6 August 1966; trawl; FSBC 15344.—2, 68, 87; 13 October 1966; dredge; FSBC 15298.—1, 85; 13 October 1966; trawl; FSBC 10020.—1, 72; 16 May 1967; dredge; uncatalogued.—1, 85; 12 October 1967; trawl; FSBC 15360.—OTHER MATERIAL: SOUTHEASTERN GULF OF MEXICO: 2, 58.0, 66.8; 24°47.11′N, 83°13.08′W, 58.6 m; 11 February 1982; otter trawl; FSBC 12943.—EASTERN GULF OF MEXICO: 1, 69.8; 25°16.83′N, 83°57.35′W, 127 m; 2 August 1981; otter trawl; FSBC 12937.—1, 73.7; 25°16.83′N, 83°57.35′W, 127 m; 9 February 1982; otter trawl; FSBC 12927.—4, 49.1–61.5;

25°16.89'N, 83°37.79'W, 70 m; 17 November 1980; otter trawl; FSBC 12939.—2, 60.0, 66.1; 25°16.89'N, 83°37.79'W; 70 m; 22 April-5 May 1981; otter trawl; FSBC 12942.—1, 77.0; 25°45.58'N, 83°20.24'W, 58.5 m; 29 April 1981; otter trawl; FSBC 12934.—1, 86.1; 25°45.89'N, 82°31.62'W, 31.5 m; 2 February 1982; otter trawl; FSBC 12930.—1, 66.1; 26°16.72'N, 83°46.82'W, 77.7 m; 30 April 1981; otter trawl; FSBC 12932.—1, 62.0; 26°16.72'N, 83°46.82'W, 85 m; 6 February 1982; otter trawl; FSBC 12935.—1, 33.6; 26°16.73'N, 83°42.81'W, 71.3 m; 30 April 1981; otter trawl; FSBC 12936.—1, 65.7; 26°16.82'N, 82°44.02'W, 30 m; 6 November 1980; otter trawl; FSBC 12931.—5, 49.6–79.4; 26°16.82'N, 83°44.02'W, 30.4 m; 3 May 1981; otter trawl; FSBC 12933.—3, 74.8–88.2; 26°16.83'N, 83°23.81'W, 55 m; 5 November 1980; otter trawl; FSBC 12928.—1, 30.5; 26°16.83'N, 83°23.81'W, 55.5 m; 4 May 1981; otter trawl; FSBC 12941.—1, 52.5; 26°16.83'N, 83°23.81'W, 55.5 m; 19 July 1981; otter trawl; FSBC 12940.—3, 23.5–63.6; 26°16.83'N, 83°23.81'W, 60 m; 5 February 1982; otter trawl; FSBC 12938.—4, 75.3–81.8; 26°16.83'N, 83°23.81'W, 55.5 m; 5 February 1982; otter trawl; FSBC 12929.—1, 65.2; 26°10–13'N, 83°52–53'W, 104–107 m; 8 July 1980; otter trawl; FSBC 12946.

Diagnosis (modified from Courtenay, 1967): Dorsal II, 24–27 (modally 25–26); anal 15–17 (usually 15–16); pectoral 13–16 (usually 13–15); pelvic I, 5; vertebrae 10 + 15 = 25. Preopercular spines typically 3, rarely 2; opercular spines 3. Fully formed gill rakers 7–10. Small- to moderate-sized *Rypticus*, adults averaging 80–115 mm SL.

Overall color of adults yellow to cream with dark spots (red-brown to pale brown, sometimes ochre) on dorsum. Belly white to cream.

Juveniles (below 10 mm SL) with broad brown stripe along sides of body. Stripe breaks up into spots when individuals reach 15 mm (SL) or greater (Courtenay, 1967: 266, fig. 11).

Distinguishing characters: Rypticus bistrispinus is unique within the genus because it has the combination of 2 dorsal spines, 3 preopercular spines (typically), and 15 caudal vertebrae (Courtenay, 1967).

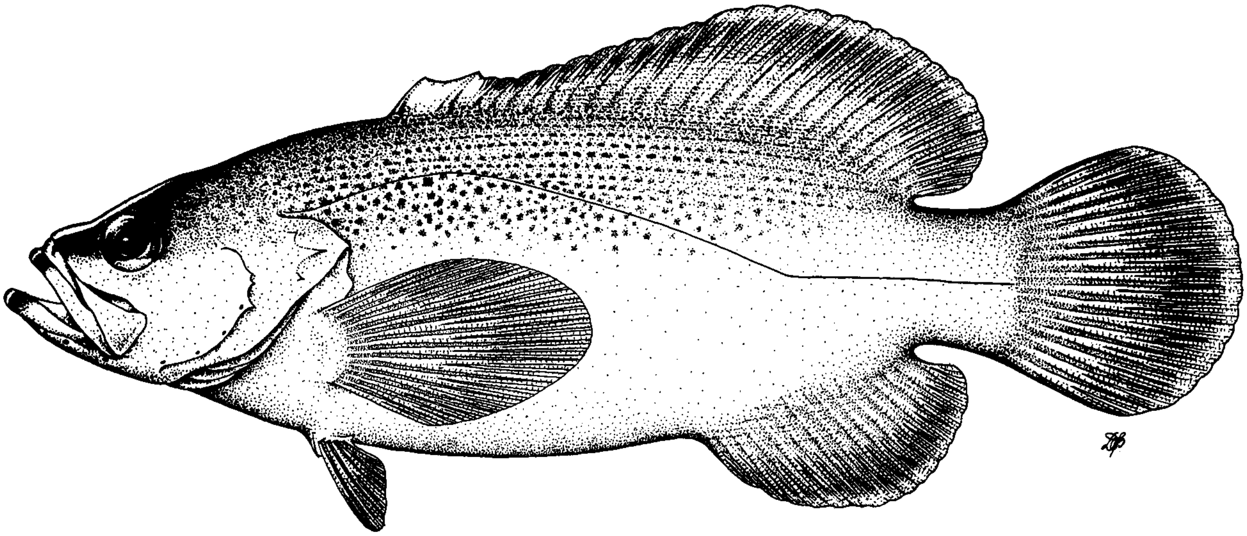

Figure 55. *Rypticus bistrispinus* (Mitchill, 1818).

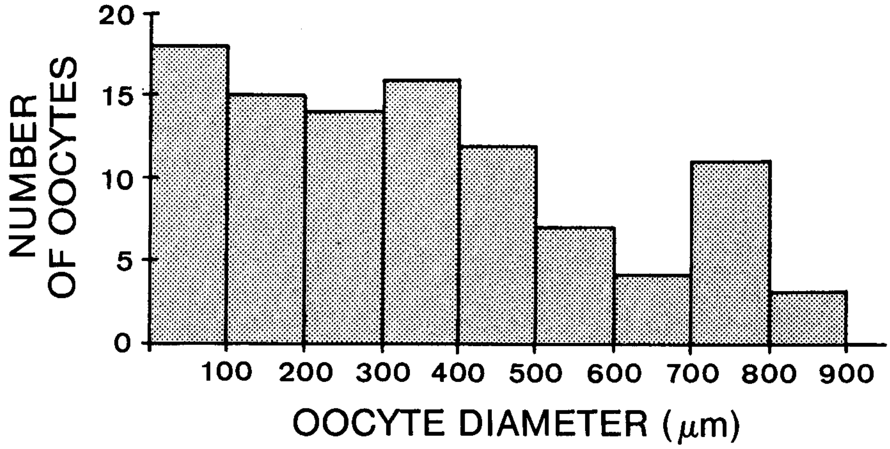

Figure 56. Size frequency distribution of oocyte diameters in a ripe ovary of *Rypticus bistrispinus* (79.2 mm). Horizontal axis labelled with upper-range values.

Geographic and bathymetric distribution: Rypticus bistrispinus occurs along the Florida east coast in the vicinity of Cape Canaveral, in the Bahamas, the eastern Gulf of Mexico, and from Jamaica eastward and southward through the West Indies to Brazil (Courtenay, 1967).

Courtenay (1967) indicated that *R. bistrispinus* prefers shallow, clear waters. However, in the eastern Gulf of Mexico, *R. bistrispinus* inhabits waters of 37 m or deeper.

Reproduction: Gonads from 17 females (30.5–86.1 mm) and six males 66.1–88.2 mm) were examined histologically to determine reproductive condition. Generally, ripe or ripening gonads were found during April–July, but one ripe female was captured in November and another in February. Houde (1982) found most *Rypticus* spp. larvae in the eastern Gulf during July–September. These data suggest that peak spawning activity occurs in spring and summer.

Figure 56 depicts the size frequency distribution of oocytes from a single ripe ovary (FSBC 12933-1). The asynchrony in oocyte development suggests that females spawn more than once in a season.

Diet: Rypticus bistrispinus appears to feed primarily upon small crabs and shrimps. The following crustaceans were identified from 11 specimens: a species of caridean shrimp, *Processa* sp.; alpheid and palaemonid shrimps; a species of amphipod, *Leucothoe* sp.; and the anomuran crab *Munida* sp.

Predation: Rypticus secretes a mucus that is thought to deter predation; however, one specimen was recovered from the stomach of an unidentified grouper.

Parasites: An unidentified species of nematode and an acanthocephalan were found attached to the mesenteries of the gonad and intestine in several specimens.

Rypticus maculatus Holbrook, 1855
Whitespotted soapfish

Figure 57; Plate XIX, Figure B

Rypticus saponaceus (in part): Storer, 1846, p. 37; Jordan and Evermann, 1896b, p. 1232; Springer and Woodburn, 1960, p. 35 (color descr. of young); Powell et al., 1972, p. 72; Walls, 1975, p. 185.

Rypticus maculatus Holbrook, 1855, pp. 39–42, pl. 6, fig. 2 (Cape Romain, South Carolina); Courtenay, 1967, pp. 271–274; Smith et al., 1975, p. 7; G. B. Smith, 1976, pp. 24, 25; Hastings et al., 1976, p. 394 (list); Hoese and Moore, 1977, p. 175; Hastings, 1979, p. 36; Ditty, 1986, p. 945.

Material examined: HOURGLASS STATION B: 1, 105; 26 August 1965; trawl; FSBC 4397.—1, 125; 8 November 1965; trawl; FSBC 4555.—3, 107–125; 1 December 1966; trawl; uncatalogued.—1, 93; 1 July 1967; trawl; uncatalogued.—8, 86–138; 25 July 1967; SCUBA; FSBC 5357.—HOURGLASS STATION C: 1, 148; 27 February 1967; trawl; FSBC 5222.—HOURGLASS STATION D: 2, 80, 86; 20 November 1965; trawl; uncatalogued.—HOURGLASS STATION J: 1, 149; 12 June 1966; trawl; FSBC 5246.—1, 122; 21 July 1966; trawl; FSBC 5310.—1, 32; 6 August 1967; SCUBA; FSBC 5364.—OTHER MATERIAL: EASTERN GULF OF MEXICO: 1, 102; 25°31.6'N, 81°32.7'W, 7.6 m; 22 August 1971; FSBC 11543.—1, 88.9; 25°45.81'N, 82°31.62'W, 31.5 m; 28 April 1981; trawl; FSBC 12947.—1, 53.1; 25°45.93'N, 82°09.35'W, 19.8 m; 28 April 1981; otter trawl; FSBC 12949.—3, 50.3–92.7; Point of Rocks, Siesta Key, Sarasota County, Florida, 1.5–3.0 m; 16 June 1968; snorkeling; FSBC 9192.—1, 78.8; 26°45.77'N, 82°43.11'W, 24 m; 18 July 1981; otter trawl; FSBC 12948.—5, 88.5–128.9; 27°06.4'N, 82°44.8'W, 18.3–19.2 m; 4 September 1970; rotenone; FSBC 7482.—6, 86.0–137.6; 27°14.8'N, 82°43.3'W, 12.2–13.7 m; 13 June 1970; handnet; FSBC 7518.—1, 114; off Sarasota County, Florida; 3 October 1970; SCUBA; FSBC 7357.—1, 118; off Longboat Key, Sarasota County, Florida; 11 July 1970; SCUBA; FSBC 7279.—4, 34–131; off Sarasota, Sarasota County, Florida; 21 June 1970; SCUBA; FSBC 7431.—4, 102.5–129.6; off Sarasota, Sarasota County, Florida; 19 July 1970; SCUBA; FSBC 7350.—1, 108.8; "Whistler" Sea Buoy, off Pinellas County, Florida, 16.8 m; 5 November 1982; FSBC 12950.—1, 156.5; Tampa Bay Ship Channel Cut "C", 6.7 m; 30 May 1967; FSBC 4153.—1, 142.5; 28°21'W, 64 m; September 1972; FSBC 7220.—1, 122; off Johns Pass, Pinellas County, Florida; 31 January 1959; hook and line; FSBC 1082.—1, 192; off Clearwater, Pinellas County, Florida; March 1973; hook and line; FSBC 7918.—1, 135; Florida Middle Ground, 28°04'N, 84°21'W, 1 August 1972; hook and line; FSBC 7216.

Diagnosis (modified from Courtenay, 1967): Dorsal II–III (rarely III), 22–27 (usually 24 or 25); anal 13–17 (usually 15–16); pectoral 13–16; pelvic I, 5; vertebrae 10 + 14 = 24. Preopercular spines 2–3, rarely 1; opercular spines 2–3, rarely 2. Total fully formed gill rakers 7–10, usually 8

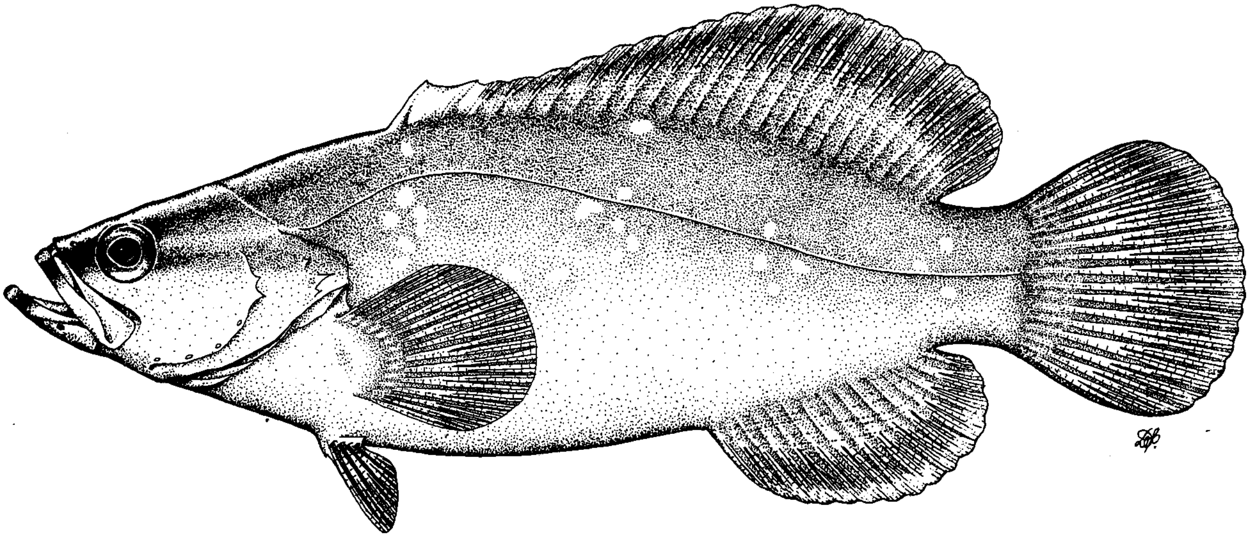

Figure 57. *Rypticus maculatus* Holbrook, 1855.

or 9. A moderately large species of *Rypticus*, adults average 70–170 mm but reach at least 192 mm SL.

Body brown with scattered, sometimes coalesced, white spots; ventral half of head (except lower jaw tip), pectoral and pelvic fins, and most of belly yellowish white to cream in color. Young (ca. 14 mm) with two white lines from orbit, one extending to mid-dorsal base and another to ventral margin of caudal peduncle; area between lines solid black, with this pigmentation forming triangle on caudal. Dorsal, anal, and area surrounding triangle on caudal yellow (Springer and Woodburn, 1960).

Distinguishing characters: *Rypticus maculatus* is frequently confused with *R. saponaceous* (Bloch and Schneider, 1801), although it is morphologically more similar to *R. randalli* Courtenay, 1967 and *R. brachyrhinus* Courtenay, 1967. *Rypticus maculatus* usually has two dorsal spines (sometimes 3), and *R. saponaceous* always has three. Juvenile and adult *R. maculatus* have large single pores on the dentary and posterior preopercular margin, but specimens of *R. saponaceous* have a pattern of numerous small scattered pores arranged in patches (Courtenay, 1967).

Rypticus maculatus differs in coloration from *R. saponaceous* because it has distinct, sometimes coalesced, white spots, while *R. saponaceous* has pale blotches on the sides.

Geographic and bathymetric distribution: *Rypticus maculatus* exhibits a Carolinian (warm-temperate) distribution (G. B. Smith, 1976). It occurs from Cape Hatteras, North Carolina, to the Florida Keys. In the Gulf of Mexico, it is found from off the Dry Tortugas to Texas (Courtenay, 1967).

Specimens reported as *R. saponaceous* from the eastern Gulf by Springer and Woodburn (1960) and by Powell et al. (1972) were examined and found to be *R. maculatus*. Walls (1975) reported *R. saponaceous* from the northern Gulf, and Darcy and Gutherz (1984a) reported this species from the eastern Gulf. These records probably are also misidentifications, because there are no confirmed records of adults from this area, and none of the authors also listed *R. maculatus*. However, Houde (1982) found six larval specimens that he positively identified as *R. saponaceous* from the eastern Gulf.

Courtenay (1967) indicated that *R. maculatus* was most common in depths of 15–50 fm (27.4–91.4 m). In the eastern Gulf of Mexico, *R. maculatus* prefers rocky ledges in as little as 8–9 m of water and has been captured in water as shallow as 1.5–3.0 m (FSBC 9192) where suitable rocky habitat occurs (Point of Rocks, Siesta Key, Sarasota County, Florida). In Hourglass collections, *R. maculatus* occurred most frequently at Station B (18 m), which had the greatest amount of rocky habitat. On eastern Gulf reefs deeper than 46 m, *R. maculatus* may be replaced in relative abundance by its congener, *R. bistrispinus*.

Habitat: Courtenay (1967: 274) noted that *R. maculatus* preferred "cooler deeper waters and a sandy rather than calcareous marl or mud." In the eastern Gulf of Mexico, however, *R. maculatus* resides almost exclusively on rocky reefs, where it hides in holes or under ledges. Hastings (1979) reported finding *R. maculatus* at nearshore rock piles and shoreline jetties along the northwest Florida coast. Hoese and Moore (1977) found *R. maculatus* on hard bottoms and reefs and around oil platforms in the northern Gulf of Mexico.

Susceptibility to red tide: In the eastern Gulf, *R. maculatus* suffered a drastic decline in abundance during the 1971 red tide (G. B. Smith, 1976), but some individuals survived.

Reproduction: Histological examination of gonads from 13 females (53.1–122.0 mm) and four males (128.5–173 mm) showed evidence of ripening during June–August. The most advanced oocytes encountered were vitellogenic and were 350–600 μm in diameter.

G. B. Smith (personal observation) noted large adult *R. maculatus* hovering, head downward, 1–2 m above the reefs off west Florida in June 1970. Causey (1969) reported a similar phenomenon for *R. saponaceus* at Texas reefs and attributed the behavior to courtship or spawning activities. According to G. B. Smith, juvenile *R. maculatus* (15–25 mm) appeared 6–8 weeks later at eastern Gulf reefs.

In a study off Louisiana, Ditty (1986) found *R. maculatus* larvae to occur in July; the single larva that Houde et al. (1979) examined from the eastern Gulf of Mexico was captured in August. The smallest Hourglass specimen (32 mm) was collected during August (Station K).

Oocyte remains were evident in the testis of a 173-mm specimen, and proliferating sperm cysts were found in the ovary of an 88.9-mm individual.

Diet: Rypticus maculatus apparently feeds heavily on shrimps and crabs. The following decapods were identified from the stomachs of six spotted soapfish: an unidentified penaeoid shrimp; an alpheid shrimp (?*Synalpheus*); a hippolytid shrimp (?*Lysmata*); the anomuran crab *Porcellana* sp.; the xanthid crab *Pilumnus sayi* Rathbun, 1897; and a majid crab. The bronze cardinalfish, *Astrapogon alutus* (Jordan and Gilbert, 1882), was taken from one specimen's stomach.

Parasites: Most of the *R. maculatus* specimens examined for parasites (n = 22) contained heavy infestation of the peritoneum by blackish nematodes and acanthocephalans.

Abundance: The whitespotted soapfish is one of the most common inhabitants of shallow-water eastern Gulf reefs. G. B. Smith (1976) reported that it was probably the third most abundant fish on Florida's shallow-water reefs (12–18 m), second only to *Serranus subligarius* and *Halichoeres bivittatus* (Bloch, 1791) (Labridae). Only *S. subligarius* was more abundant than *R. saponaceus* on a shallow-water study reef off Padre Island, Texas (Causey, 1969).

Size: The largest specimen of *Rypticus maculatus* sampled was 192 mm (FSBC 7918). Large specimens are captured infrequently on hook and line over rocky bottom.

DISCUSSION

ZOOGEOGRAPHY

Eastern Gulf of Mexico fishes exhibit six main patterns of distribution: 1) Gulf of Mexico (endemic), 2) warm-temperate (Carolinian), 3) tropical West Indian (insular), 4) tropical Caribbean (continental), 5) eurythermic-tropical for species ranging northward into warm-temperate latitudes, and 6) broadly eurythermic-tropical for species ranging into cold-temperate waters (see Robins, 1971; Gilbert, 1972; Briggs, 1974; and G. B. Smith, 1976).

G. B. Smith (1976) found that the eastern Gulf of Mexico reef ichthyofauna included a large number of widely ranging species and a few warm-temperate species but, on the basis of faunal distinctness, was most closely allied to that of the tropical western Atlantic reefs. Species diversity increased with increasing offshore depth on the West Florida Shelf. Local environmental conditions such as those that occur at the Florida Middle Ground (well-defined currents, irregular bottom topography, and low environmental variability) are likely to provide conditions suitable for tropical ichthyofaunas, which may include species of the tropical West Indian region.

Examination of the distributional patterns of serranids collected during Project Hourglass confirms G. B. Smith's (1976) conclusions on zoogeography of fishes in the eastern Gulf of Mexico. Of the 16 species collected, most (10) are tropical and rather wide-ranging (*Diplectrum formosum*, *Serranus notospilus*, *Serranus phoebe*, *Serraniculus pumilio*, *Hypoplectrus unicolor*, *Epinephelus flavolimbatus*, *E. morio*, *E. niveatus*, *Holanthias martinicensis*, and *Rypticus bistrispinus*), two species are subtropical (*Mycteroperca phenax* and *M. microlepis*), and four species are primarily warm-temperate in distribution (*Serranus subligarius*, *Centropristis ocyurus*, *C. striata*, and *Rypticus maculatus*). Of the tropically derived species, one is essentially insular in its distributional preference (*Rypticus bistrispinus*) and two are almost exclusively continental (*Mycteroperca phenax* and *M. microlepis*). At least one species (*Rypticus bistrispinus*) demonstrates a pattern of bathymetric submergence onto the West Florida Shelf. Of the temperate species, three are most abundant on the inner shelf (*Serranus subligarius*, *Centropristis striata*, and *Rypticus maculatus*). The remaining temperate species, *C. ocyurus*, is found only in depths greater than 37 m as an adult; its ability to coexist with the more tropical offshore serranid fauna probably reflects its selection of habitats that are peripheral to main reef areas where tropical species reside.

BATHYMETRIC DISTRIBUTION

The West Florida Shelf is a broad carbonate platform extending to more than 180 km off Tampa Bay. A number of studies on invertebrates (e.g., Camp, 1973; Huff and Cobb, 1979; Myers, 1981; Menzies and Kruczynski, 1983; Dardeau, 1984, and others), demersal fishes (G. B. Smith, 1976, 1978; Darovec, 1983), and demersal communities in general (Phillips et al., 1990) have shown that these organisms prefer particular depth intervals on this shelf. G. B. Smith (1976) proposed that bathymetric distributional patterns of eastern Gulf of Mexico reef fishes reflected 1) a species' tolerance of or selection of inshore-offshore gradients in environmental conditions and/or 2) spatial displacement through competitive interactions between congeners and/or ecologically equivalent species. In support of the second hypothesis is the observation that certain moderate-depth fishes temporarily invaded shallow-water reefs after a 1971 red tide eliminated or decimated their presumed ecological replacement species from the shallow reefs (G. B. Smith, 1976, 1978). As the typical shallow-water reef faunas were reconstituted, the moderate-depth species were displaced to their original habitat.

G. B. Smith (1976) found the greatest ichthyofaunal change between 18- and 30-m depths off west-central Florida and attributed this change to a transition from terrigenous quartz-sand to biogenic carbonate sediments and to a dynamic interface between offshore Gulf and coastal water masses within this depth range. Buffered environmental conditions associated with offshore Gulf water masses encourage the existence of the tropical facies of the moderate-depth reef ichthyofauna.

Analysis of the local distribution patterns of serranid fishes collected during Project Hourglass confirms the findings of earlier investigations that indicated that shelf ichthyofaunal composition varies according to depth and offshore distance (Moe and Martin, 1965; G. B. Smith, 1976). Figure 58 depicts the bathymetric ranges of the more abundant serranids collected within the Hourglass study area (i.e., depths of 6–73 m). These distributions fall into three general categories: 1) primarily shallow-water, 2) primarily moderate-depth water, and 3) eurybathic. The shallow- and moderate-depth designations also correlate to warm-temperate and warm-tropical environmental regimes, respectively.

In the *Serranus-Serraniculus* complex, several interesting distributional patterns suggest that spatial partitioning of species exists. Two species (*Serranus notospilus* and *S. phoebe*) occurred exclusively at the 55-m and 73-m stations; both were most abundant at the 73-m depth, and their center of abundance lies well offshore of these depths. The remaining *Serranus* species (*S. subligarius*) was not collected deeper than 37 m and was most abundant in 18 m or less. The closely related *Serraniculus pumilio* (not in Figure 58) was collected at 6- and 18-m depths, although other Gulf studies have shown that it occurs to depths of at least 117 m (Bullis and Thompson, 1965). Its rarity in Hourglass collections was undoubtedly due to its small size. Of these four species, two were found in moderate depths (55 m or greater), one was found exclusively in shallow water (less than 37 m), and the other was found in shallow and moderate depths sampled (6 m and 55 m). G. B. Smith (1976) assigned *S. subligarius* to a group of fishes exhibiting a warm-temperate (Carolinian) distribution. This explains its absence from (or at least rarity in) the moderate-depth stations, which are decidedly tropical in character. Habitat selection of sand and shell bottoms by *Serraniculus pumilio* probably permits its coexistence with the other *Serranus* species, which are attracted to hard substrate areas.

The two species of *Centropristis* also show bathymetric exclusion. Adult *C. striata* inhabit shallow reefs and rocky bottoms in depths of 6–37 m, with maximum abundance at 10–18 m. Juvenile *C. striata* are often found nearshore and inshore within bays and Gulf passes. *Centropristis ocyurus*, however, ranges from 6 m to at least 112 m. Juveniles are found at depths of 6–73 m; adults are generally restricted to about 37 m or deeper. The fact that *Centropristis striata* is essentially a warm-temperate species probably explains its absence from offshore regions, which are usually inhabited by tropical species.

The soapfishes *Rypticus maculatus* and *R. bistrispinus* are also largely allopatric in their shelf distributions. Hourglass specimens of *R. maculatus* occurred at 18- and 37-m depths (mostly 18 m); *R. bistrispinus* was collected at 37-, 55-, and 127-m depths. Again, the inshore *Rypticus maculatus* is a warm-temperate species (G. B. Smith, 1976), whereas the offshore *R. bistrispinus* is tropical.

We cannot test G. B. Smith's (1976) hypothesis on the importance of competitive exclusion in the partitioning of congeners using Hourglass data, but the preceding examples clearly support the idea that separate ranges of species are a response to environmental conditions (both biotic and abiotic).

The eight remaining Hourglass serranids (*Diplectrum formosum*, *Epinephelus flavolimbatus*, *E. morio*, *E. niveatus*, *Holanthias martinicensis*, *Hypoplectrus unicolor*, *Mycteroperca microlepis*, and *M. phenax*) were represented by too few specimens to permit analysis and discussion of distributional patterns.

Many other serranids, in addition to those collected during Project Hourglass, occur in the eastern Gulf at greater depths than they occupy in more tropical waters. This "bathymetric

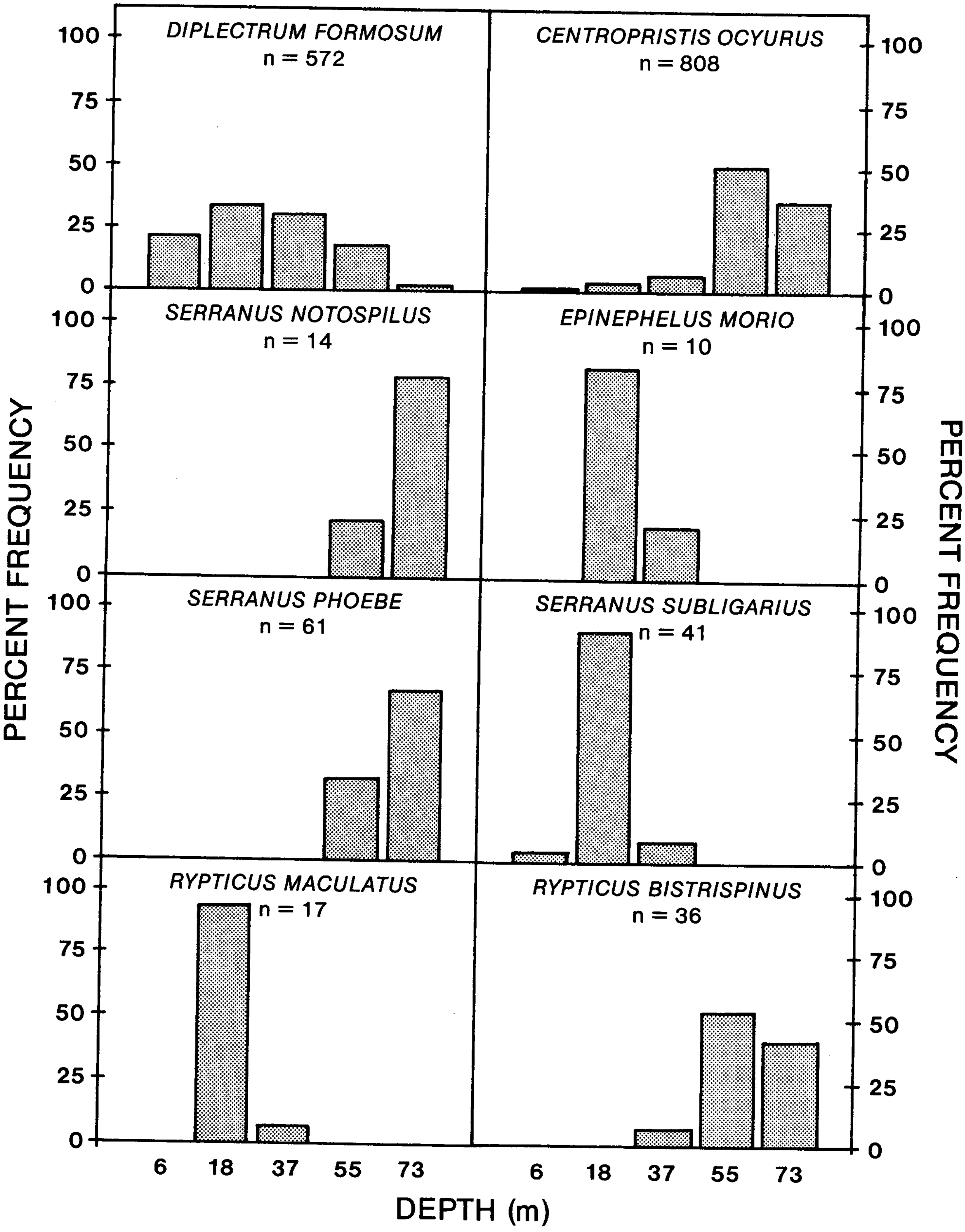

Figure 58. Relative frequency distribution, by depth, of selected serranids.

TABLE 13. MEAN BOTTOM TEMPERATURES FOR HOURGLASS STATIONS.

Stations	Temperature (°C)	Stations	Temperature (°C)
A (north, 6 m)	23.4	D (north, 55 m)	21.7
I (south, 6 m)	25.7	L (south, 55 m)	21.8
B (north, 18 m)	23.0	E (north, 73 m)	20.4
J (south, 18 m)	24.7	M (south, 73 m)	23.5
C (north, 37 m)	20.8		
K (south, 37 m)	21.2		

submergence" (*sensu* Courtenay, 1967) accounts for the offshore occurrence (>30 m depths) of *Epinephelus cruentatus, E. fulvus, E. guttatus, Mycteroperca bonaci, M. interstitialis, M. tigris, M. venenosa, Paranthias furcifer,* and *Serranus tigrinus.* Many of these species can be found at shallow depths (5–6 m) in the Florida Keys.

LATITUDINAL DISTRIBUTION

The northern (Tampa Bay) and southern (Charlotte Harbor) transects are separated by about 1° latitude (approximately 111 km). Consequently, one might expect differences in faunal composition and abundance due to presumed differences in local conditions. Two major features that vary according to transect latitude are water temperature and substrate characteristics. Mean bottom water temperature values for Hourglass station pairs (Table 13) were 0.1°–3.1°C higher at southern stations. Rocky reef substrates are far more prevalent along the northern transect, particularly inshore of 37 m (see Joyce and Williams, 1969).

Of the seven species more common at northern transects, three are considered elements of the Carolinian (warm-temperate) fauna (*S. subligarius, C. ocyurus,* and *R. maculatus*); these three species are found in decreasing abundance southward (Table 14). All have only rarely been collected at the Dry Tortugas (Longley and Hildebrand, 1941) and are absent from the Florida Keys fauna (Starck, 1968). Three other species (*E. morio, S. phoebe,* and *H. unicolor*) more common to the north are primary reef species dependent on the rocky bottoms more prevalent in that area. Although more individuals of *S. notospilus* were taken in the northern transect, the data may not reflect an actual abundance difference.

Of the two species having a greater abundance to the south, one (*R. bistrispinus*) is a tropical form that has extended its distribution onto the West Florida Shelf through bathymetric

TABLE 14. HOURGLASS SERRANID FISHES LISTED ACCORDING TO THEIR GREATER ABUNDANCE AT EITHER NORTHERN OR SOUTHERN TRANSECTS.

Northern:	*Centropristis ocyurus*	Southern:	*Rypticus bistrispinus*
	Serranus phoebe		*Diplectrum formosum*
	Serranus notospilus		
	Epinephelus morio		
	Rypticus maculatus		
	Serranus subligarius		
	Hypoplectrus unicolor		

TABLE 15. SERRANIDS COLLECTED DURING PROJECT HOURGLASS IN ORDER OF ABUNDANCE.

Species	Number	Species	Number
Centropristis ocyurus	982	*Serraniculus pumilio*	10
Diplectrum formosum	616	*Hypoplectrus unicolor*	7
Serranus phoebe	65	*C. striata*	3
S. subligarius	53	*Mycteroperca phenax*	3
Rypticus bistrispinus	40	*M. microlepis*	1
R. maculatus	22	*E. flavolimbatus*	1
Epinephelus morio	16	*E. niveatus*	1
S. notospilus	15	*Holanthias martinicensis*	1

submergence (Courtenay, 1967; G. B. Smith, 1976, 1978); the other (*D. formosum*) typically inhabits sand or shell bottoms, which are more common to the south.

These distributional patterns seem to confirm Reid's (1954: 89) observation that "the transition from the temperate fauna of the northern Gulf coast to the tropical, West Indian complex of the southern Gulf coast of Florida is a gradual one in which the southern forms began to appear somewhat irregularly and seasonally while the species density of the northern fishes decreases."

ABUNDANCE AND SEASONALITY

The two most abundant species captured during Project Hourglass were *Centropristis ocyurus* (n = 982) and *Diplectrum formosum* (n = 616) (Table 15). Because they occur over flat bottom composed of sand and shell hash, these fishes are probably vulnerable to sampling by trawl. Conversely, other serranids such as the groupers and anthiines were poorly represented. Net avoidance and the grouper's habitat selection of rocky ledges not suitable for trawling probably account for its low abundance; anthiines, however, which have been successfully captured by trawl at limestone ledges in the eastern Gulf (L. Bullock, personal observation), occur mainly beyond the depth range sampled during this study.

Seasonal patterns of species abundance or composition were not tested in Hourglass collections because for many species, too few specimens were collected to determine seasonal changes. In general, no trends were obvious. However, other studies (e.g., G. B. Smith, 1976, 1978) have indicated that eastern Gulf offshore reef fish communities vary little over time (except following red tides). G. B. Smith (1978) did notice a slight increase in both numbers of individuals and fish species diversity at reefs during warm-water months because of juvenile recruitment and the irregular occurrence of certain displaced tropical species.

DIEL ACTIVITY

Most studies have shown that the larger serranids (*Epinephelus* and *Mycteroperca*) are active during any portion of the diel cycle; however, most demonstrate a pronounced peak of activity. Hobson (1965, 1968), Starck and Davis (1966), and Randall (1967) all noted that the larger groupers are primarily crepuscular in their feeding activity. Collette and Talbot (1972) found that many groupers rested or slept at night. Grouper fishermen off west Florida, however,

TABLE 16. COMPARISON OF DIURNAL AND NOCTURNAL CATCHES OF *CENTROPRISTIS OCYURUS* AT STATIONS B, C, AND D.

Station	Number of Specimens		Total	Chi-Square
	Day Trawls	Night Trawls		
B	26	1	27	23.14*
C	31	12	43	8.40*
D	256	157	413	23.74*

*Significant difference, $P < 0.005$.

know that groupers may feed at any time; in fact, they have noted that if the waters are clear and the moon is full, fishing during the night may be more successful than fishing in daytime. Randall and Brock (1960) found that groupers in Tahitian waters were primarily diurnal feeders but also fed nocturnally, especially on bright, moonlit nights. Contrary to some studies, Longley and Hildebrand (1941) felt that groupers were acyclic in diel feeding habits.

Collette and Talbot (1972) found members of the genera *Serranus* and, usually, *Hypoplectrus* to be strictly diurnal, usually seeking shelter at night. G. B. Smith (1976) reported that *Rypticus maculatus* was secretive, generally concealing itself within the reef structure by day. Hobson (1965) reported that another *Rypticus* species, *R. bicolor*, remained under cover among rocks by day; at night the solitary fish would emerge but stay close to the bottom while swimming. Thus, it would appear that *Rypticus* species are generally nocturnal in their activities.

To estimate activity preferences, diurnal (B_1, C_1, and D_1) and nocturnal (B_2, C_2, and D_2) collections at Hourglass Stations B, C, and D were numerically compared. Only two species were captured in sufficient numbers to allow comparison. *Centropristis ocyurus* was more frequently captured by day; only 170 specimens were taken by night. Chi-square tests indicated highly significant differences in day and night catches at Stations B, C, and D (Table 16). Greater catches by day indicated that this species was less active and therefore less available to collection gear by night. Similarly, *Diplectrum formosum* was better represented in daytime collections (166 day, 44 night) (Table 17). Differences between diurnal and nocturnal catches were highly significant at Stations B and C but not significant at Station D.

REPRODUCTION

The life histories of only four species of groupers in the eastern Gulf (*Epinephelus flavolim-*

TABLE 17. COMPARISON OF DIURNAL AND NOCTURNAL CATCHES OF *DIPLECTRUM FORMOSUM* AT STATIONS B, C, AND D.

Station	Number of Specimens		Total	Chi-Square
	Day Trawls	Night Trawls		
B	78	8	86	56.98*
C	62	20	82	21.51*
D	26	16	42	2.38 n.s.

*Significant difference, $P < 0.005$.

TABLE 18. MONTHS IN WHICH RIPE FEMALES WERE COLLECTED.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Anthias nicholsi		X		X								
Hemanthias aureorubens[a]					X							
H. leptus					X[b]			X				
H. vivanus				X	X	X		X				
Holanthias martinicensis		X	X	X			X					
Plectranthias garrupellus								X	X			
Centropristis ocyurus	X	X	X	X							X	X
C. striata	X	X	X	X								X
Diplectrum bivittatum										X		X
D. formosum	X			X				X	X			
Hypoplectrus unicolor				X		X	X					
Pikea mexicana								X				
Schultzea beta		X		X				X				
Serraniculus pumilio						X	X	X	X			
Serranus annularis				X							X	
S. atrobranchus								X				
S. notospilus				X		X	X	X	X			
S. phoebe		X		X		X	X	X				
S. subligarius				X		X	X	X	X			
S. tabacarius							X					
S. tigrinus									X			
S. tortugarum				X								
Epinephelus adscensionis	X	X	X	X	X	X						
E. cruentatus							X	X				
E. drummondhayi								X				
E. flavolimbatus					X	X	X	X	X			
E. guttatus				X		X	X	X				
E. itajara						X	X	X	X	X		
E. morio			X	X	X	X	X					
E. niveatus					X	X		X				
Mycteroperca bonaci	X	X	X	X	X	X	X	X				X
M. interstitialis			X	X	X	X	X	X	X			X
M. microlepis	X	X	X	X								X
M. phenax			X	X	X							
M. venenosa			X		X	X	X	X				
Paranthias furcifer					X	X	X	X	X			
Rypticus bistrispinus		X		X	X	X	X				X	
R. maculatus						X	X	X				

[a] All specimens from the Florida east coast.

[b] Two specimens from the Florida east coast.

No ripe females were observed, and hence no spawning period could be determined for the following species: *Anthias tenuis, Plectranthias garrupellus, Liopropoma eukrines, Epinephelus fulvus, E. inermis, E. mystacinus, E. nigritus,* and *Mycteroperca tigris.*

batus, E. morio, Mycteroperca microlepis, and *M. phenax*) have been studied sufficiently to determine periods of reproductive activity (refer to individual species accounts for details). Table 18 summarizes the periods in which ripe female serranids with late vitellogenic oocytes were captured either during the Hourglass Cruises or as a result of ancillary collections. The information presented, in most cases, is not based upon continuous year-round sampling or on an abundance of samples because many of these fishes are rarely captured. These data, however, should give an indication of the periods in which spawning occurs.

Several broad trends in reproductive activity of serranids in the eastern Gulf seem apparent, although exceptions do occur. It appears that most *Serranus* spp., *Hemanthias leptus*, *H. vivanus*, *Holanthias martinicensis*, *Serraniculus pumilio*, *Diplectrum formosum*, *Rypticus bistrispinus*, and *R. maculatus* restrict their spawning activities to spring and summer, which is a time characterized by a comparatively long photoperiod and warm water temperatures. An exception was noted for *D. formosum*, which was ripe also in January. The two species of *Centropristis* spawn during winter and early spring, when these physical parameters show an opposite trend. The deep-water groupers (>90-m depths), including *Epinephelus drummondhayi*, *E. flavolimbatus*, and *E. niveatus*, appear to spawn during spring–late summer. Other groupers, which inhabit a variety of depths, also spawn during this time; they include *E. cruentatus*, *E. guttatus*, and *Paranthias furcifer*. In contrast, *M. microlepis* and probably *E. adscensionis* spawn during winter and early spring (or early summer for *E. adscensionis*), followed by *M. phenax*, *M. interstitialis*, and *M. venenosa* (although ripe female *M. interstitialis* have been captured in September and December), which are reproductively active mainly during spring and summer. No definite spawning season could be established for *M. bonaci* because females contained ripe oocytes during a major portion of the year (December–August).

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ADDENDUM

While this manuscript was in press, it came to our attention that Randall and Taylor (1988) synonymized *Pikea* with *Liopropoma* and noted that *Bathyanthias* seemed to be available for *mexicanus* and its allies. The American Fisheries Society Committee on Names of Fishes accepted this change (Robins et al., 1991).

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APPENDIX TABLE 1. FREQUENCY DISTRIBUTION OF DORSAL SPINES AND RAYS.

Species	Dorsal Spines							Dorsal Soft Rays																		
	II	III	VI–I–I	VIII	IX	X	XI	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Anthias nicholsi	–	–	–	–	–	18	–	–	–	–	–	–	3	15	–	–	–	–	–	–	–	–	–	–	–	–
A. tenuis	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Holanthias martinicensis	–	–	–	–	–	12	–	–	–	–	–	–	1	10	1	–	–	–	–	–	–	–	–	–	–	–
Hemanthias aureorubens[a]	–	–	–	–	–	12	–	–	–	–	–	–	–	12	–	–	–	–	–	–	–	–	–	–	–	–
H. leptus	–	–	–	–	–	42	–	–	–	–	–	1	40	1	–	–	–	–	–	–	–	–	–	–	–	–
H. vivanus	–	–	–	–	–	33	–	–	–	–	–	–	33	–	–	–	–	–	–	–	–	–	–	–	–	–
Plectranthias garrupellus	–	–	–	–	–	15[b]	–	–	–	–	–	–	–	4[c]	11[d]	–	–	–	–	–	–	–	–	–	–	–
Centropristis ocyurus	–	–	–	–	–	67	–	1	–	64	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. philadelphica	–	–	–	–	–	11	–	–	–	11	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. striata	–	–	–	–	–	21	–	–	1	19	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diplectrum bivittatum	–	–	–	–	–	18	–	–	–	1	17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diplectrum formosum	–	–	–	–	–	41	–	–	–	1	38	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gonioplectrus hispanus	–	–	–	2	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hypoplectrus unicolor	–	–	–	–	–	19	–	–	–	–	–	1	14	4	–	–	–	–	–	–	–	–	–	–	–	–
Liopropoma eukrines	–	–	3	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pikea mexicana	–	–	–	8	–	–	–	–	–	–	–	–	8	–	–	–	–	–	–	–	–	–	–	–	–	–
Schultzea beta	–	–	–	–	–	11	–	–	–	1	9	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Serraniculus pumilio	–	–	–	–	–	22	–	–	2	20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Serranus annularis	–	–	–	–	–	14	–	–	–	3	11	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. atrobranchus	–	–	–	–	–	6	–	–	–	–	5	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. notospilus	–	–	–	–	–	80	–	–	–	1	77	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. phoebe	–	–	–	–	–	39	–	–	–	–	39	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Serranus tabacarius	–	–	–	–	–	2	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. tigrinus	–	–	–	–	–	4	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. subligarius	–	–	–	–	–	70	–	–	–	1	8	56	5	–	–	–	–	–	–	–	–	–	–	–	–	–
S. tortugarum	–	–	–	–	–	5	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

APPENDIX TABLE 1. FREQUENCY DISTRIBUTION OF DORSAL SPINES AND RAYS. (Continued)

	Dorsal Spines							Dorsal Soft Rays																		
Species	II	III	VI–I–I	VIII	IX	X	XI	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Epinephelus adscensionis	–	–	–	–	–	–	6	–	–	–	–	–	–	–	4	2	–	–	–	–	–	–	–	–	–	–
E. cruentatus	–	–	–	–	13	–	–	–	–	–	–	–	13	–	–	–	–	–	–	–	–	–	–	–	–	–
E. drummondhayi	–	–	–	–	–	–	7	–	–	–	–	–	–	1	6	–	–	–	–	–	–	–	–	–	–	–
E. flavolimbatus	–	–	–	–	–	–	51	–	–	–	–	–	39	12	–	–	–	–	–	–	–	–	–	–	–	–
E. fulvus	–	–	–	–	4	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–
E. guttatus	–	–	–	–	–	–	7	–	–	–	–	–	–	1	6	–	–	–	–	–	–	–	–	–	–	–
E. inermis	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	1	4	–	–	–	–	–	–	–	–
E. niveatus	–	–	–	–	–	–	4	–	–	–	–	1	3	–	–	–	–	–	–	–	–	–	–	–	–	–
E. itajara	–	–	–	–	–	–	10	–	–	–	–	–	–	7	3	–	–	–	–	–	–	–	–	–	–	–
E. morio	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–
E. mystacinus	–	–	–	–	–	–	11	–	–	–	–	1	5	5	–	–	–	–	–	–	–	–	–	–	–	–
E. nigritus	–	–	–	–	–	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Mycteroperca bonaci	–	–	–	–	–	–	5	–	–	–	–	–	–	–	1	4	–	–	–	–	–	–	–	–	–	–
M. interstitialis	–	–	–	–	–	–	8	–	–	–	–	–	–	–	2	5	1	–	–	–	–	–	–	–	–	–
M. microlepis	–	–	–	–	–	–	15	–	–	–	–	–	–	–	4	8	2	1	–	–	–	–	–	–	–	–
M. phenax	–	–	–	–	–	–	11	–	–	–	–	–	–	–	–	7	3	1	–	–	–	–	–	–	–	–
M. tigris	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–
M. venenosa	–	–	–	–	–	–	3	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–
Paranthias furcifer	–	–	–	–	10	–	–	–	–	–	–	–	–	–	–	–	8	2	–	–	–	–	–	–	–	–
Rypticus bistrispinus[e]	30	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	6	19	4
R. maculatus[e, f]	23	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	8	13	1	1

[a] All specimens from the Florida east coast.
[b] Nine additional specimens from the Florida east coast had 10 dorsal spines.
[c] Two additional specimens from the Florida east coast had 15 dorsal soft rays.
[d] Seven additional specimens from the Florida east coast had 16 dorsal soft rays.
[e] Counts taken from radiographs.
[f] One specimen damaged; no dorsal soft ray count.

APPENDIX TABLE 2. FREQUENCY DISTRIBUTION OF ANAL SOFT RAYS.

Species	Anal Soft Rays											
	6	7	8	9	10	11	12	13	14	15	16	17
Anthias nicholsi	–	18	–	–	–	–	–	–	–	–	–	–
A. tenuis	–	–	1	–	–	–	–	–	–	–	–	–
Holanthias martinicensis	–	12	–	–	–	–	–	–	–	–	–	–
Hemanthias aureorubens[a]	–	–	11	1	–	–	–	–	–	–	–	–
H. leptus	–	–	42	–	–	–	–	–	–	–	–	–
H. vivanus	–	–	33	–	–	–	–	–	–	–	–	–
Plectranthias garrupellus	2	12[b]	1	–	–	–	–	–	–	–	–	–
Centropristis ocyurus	–	67	–	–	–	–	–	–	–	–	–	–
C. philadelphica	–	11	–	–	–	–	–	–	–	–	–	–
C. striata	–	21	–	–	–	–	–	–	–	–	–	–
Diplectrum bivittatum	–	18	–	–	–	–	–	–	–	–	–	–
Diplectrum formosum	–	41	–	–	–	–	–	–	–	–	–	–
Gonioplectrus hispanus	–	2	–	–	–	–	–	–	–	–	–	–
Hypoplectrus unicolor	–	21	–	–	–	–	–	–	–	–	–	–
Liopropoma eukrines	–	–	3	–	–	–	–	–	–	–	–	–
Pikea mexicana	–	–	8	–	–	–	–	–	–	–	–	–
Schultzea beta	–	11	–	–	–	–	–	–	–	–	–	–
Serraniculus pumilio	1	21	–	–	–	–	–	–	–	–	–	–
Serranus annularis	1	15	–	–	–	–	–	–	–	–	–	–
S. atrobranchus	–	6	–	–	–	–	–	–	–	–	–	–
S. notospilus	–	78	2	–	–	–	–	–	–	–	–	–
S. phoebe	–	37	2	–	–	–	–	–	–	–	–	–
S. subligarius	3	67	–	–	–	–	–	–	–	–	–	–
S. tabacarius	–	2	–	–	–	–	–	–	–	–	–	–
S. tigrinus	–	4	–	–	–	–	–	–	–	–	–	–
S. tortugarum	–	5	–	–	–	–	–	–	–	–	–	–
Epinephelus adscensionis	–	–	6	–	–	–	–	–	–	–	–	–
E. cruentatus	–	–	13	–	–	–	–	–	–	–	–	–
E. drummondhayi	–	–	1	6	–	–	–	–	–	–	–	–
E. flavolimbatus	–	–	1	42	–	–	–	–	–	–	–	–
E. fulvus	–	–	–	4	–	–	–	–	–	–	–	–
E. guttatus	–	–	7	–	–	–	–	–	–	–	–	–
E. inermis	–	–	–	5	–	–	–	–	–	–	–	–
E. itajara	–	–	10	–	–	–	–	–	–	–	–	–
E. morio	–	–	–	3	–	–	–	–	–	–	–	–
E. mystacinus	–	–	–	11	–	–	–	–	–	–	–	–
E. nigritus	–	–	–	1	–	–	–	–	–	–	–	–
E. niveatus	–	–	–	4	–	–	–	–	–	–	–	–
Mycteroperca bonaci	–	–	–	–	–	1	14	–	–	–	–	–
M. interstitialis	–	–	–	–	–	16	2	–	–	–	–	–
M. microlepis	–	–	–	–	1	13	1	–	–	–	–	–
M. phenax	–	–	–	–	–	11	–	–	–	–	–	–
M. tigris	–	–	–	–	–	2	–	–	–	–	–	–
M. venenosa	–	–	–	–	2	–	–	–	–	–	–	–
Paranthias furcifer	–	–	–	10	–	–	–	–	–	–	–	–
Rypticus bistrispinus	–	–	–	–	–	–	–	–	–	1	26	3
R. maculatus	–	–	–	–	–	–	–	–	–	24	2	–

[a] All specimens from the Florida east coast.

[b] Nine additional specimens from the Florida east coast had 7 anal soft rays.

APPENDIX TABLE 3. FREQUENCY DISTRIBUTION OF PECTORAL RAYS (LEFT SIDE ONLY).

Species	12	13	14	15	16	17	18	19	20	21
Anthias nicholsi	–	–	–	–	–	1	1	15	1	–
A. tenuis	–	–	–	–	–	–	–	–	–	1
Holanthias martinicensis	–	–	–	–	–	11	1	–	–	–
Hemanthias aureorubens[a]	–	–	–	–	2	8	2	–	–	–
H. leptus	–	–	–	–	–	3	31	8	–	–
H. vivanus	–	–	–	–	–	–	8	21	–	–
Plectranthias garrupellus	1	15[b]	–	–	–	–	–	–	–	–
Centropristis ocyurus	–	–	–	–	5	56	4	–	–	–
C. philadelphica	–	–	–	–	–	–	10	1	–	–
C. striata	–	–	–	–	–	13	8	–	–	–
Diplectrum bivittatum	–	–	–	9	9	–	–	–	–	–
Diplectrum formosum	–	–	–	7	31	1	–	–	–	–
Gonioplectrus hispanus	–	–	–	–	1	1	–	–	–	–
Hypoplectrus unicolor	–	–	19	2	–	–	–	–	–	–
Liopropoma eukrines	–	–	3	–	–	–	–	–	–	–
Pikea mexicana	–	–	1	7	–	–	–	–	–	–
Schultzea beta	–	–	–	1	8	1	–	–	–	–
Serraniculus pumilio	–	–	17	5	–	–	–	–	–	–
Serranus annularis	–	16	–	–	–	–	–	–	–	–
S. atrobranchus	–	–	–	1	5	–	–	–	–	–
S. notospilus	–	–	1	77	2	–	–	–	–	–
S. phoebe	–	–	–	17	22	–	–	–	–	–
S. subligarius	–	–	2	17	46	5	–	–	–	–
S. tigrinus	–	–	4	–	–	–	–	–	–	–
S. tabacarius	–	–	–	2	–	–	–	–	–	–
S. tortugarum	–	–	5	–	–	–	–	–	–	–
Epinephelus adscensionis	–	–	–	–	–	–	2	4	–	–
E. cruentatus	–	–	–	–	13	–	–	–	–	–
E. drummondhayi	–	–	–	–	–	2	5	–	–	–
E. flavolimbatus	–	–	–	–	–	5	29	6	–	–
E. fulvus	–	–	–	–	–	–	4	–	–	–
E. guttatus	–	–	–	–	1	6	–	–	–	–
E. inermis	–	–	–	–	–	–	2	3	–	–
E. itajara	–	–	–	–	–	–	–	10	–	–
E. morio	–	–	–	–	–	3	–	–	–	–
E. mystacinus	–	–	–	–	–	–	3	8	–	–
E. nigritus	–	–	–	–	–	–	–	1	–	–
E. niveatus	–	–	–	–	–	1	2	1	–	–
Mycteroperca bonaci	–	–	–	–	–	5	–	–	–	–
M. interstitialis	–	–	–	–	–	8	–	–	–	–
M. microlepis	–	–	–	–	3	11	1	–	–	–
M. phenax	–	–	–	–	9	2	–	–	–	–
M. tigris	–	–	–	–	–	2	–	–	–	–
M. venenosa	–	–	–	–	2	1	–	–	–	–
Paranthias furcifer	–	–	–	–	–	–	–	2	6	2
Rypticus bistrispinus	–	1	30	3	–	–	–	–	–	–
R. maculatus	–	–	–	24	2	–	–	–	–	–

[a] All specimens from the Florida east coast.

[b] Eight additional specimens from the Florida east coast had 13 pectoral rays.

APPENDIX TABLE 4. FREQUENCY DISTRIBUTION OF TOTAL NUMBER OF GILL RAKERS (INCLUDING RUDIMENTS).

Species	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
Anthias nicholsi	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	3	7	4	1	–	–	–
A. tenuis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
Holanthias martinicensis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	3	1	1	–	–	–	–	–	–	–	–
Hemanthias aureorubens[a]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	4	4	3	–	–	–	–	–
H. leptus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	4	6	18	9	1	–	–	–	–	–	–
H. vivanus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	10	12	6	4	–	–	–	–
Plectranthias garrupellus	–	–	–	–	–	–	–	2	9	3	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Centropristis ocyurus	–	–	–	–	–	–	–	–	–	–	1	9	27	14	14	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. philadelphica	–	–	–	–	–	–	–	–	–	–	–	–	1	4	5	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
C. striata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	8	10	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Diplectrum bivittatum	–	–	–	–	–	–	–	–	–	–	–	–	–	2	4	7	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
D. formosum	–	–	–	–	–	–	–	–	–	–	1	3	13	19	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gonioplectrus hispanus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hypoplectrus unicolor	–	–	–	–	–	–	–	–	–	–	3	8	7	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Liopropoma eukrines	–	–	–	–	–	–	–	–	1	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pikea mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Schultzea beta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	1	–	1	4	3	–	–	–	–	–	–	–	–	–	–
Serraniculus pumilio	–	–	1	7	5	3	7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Serranus annularis	–	–	–	–	–	–	–	–	1	4	6	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. atrobranchus	–	–	–	–	–	–	–	–	–	–	–	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. notospilus	–	–	–	–	–	–	–	–	–	1	6	11	24	11	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. phoebe	–	–	–	–	–	–	–	–	–	1	6	14	8	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. subligarius	–	–	–	–	–	–	–	–	9	24	21	9	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. tabacarius	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. tigrinus	–	–	–	–	–	–	–	–	–	3	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. tortugarum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	1	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Epinephelus adscensionis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	4	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. cruentatus	–	–	–	–	–	–	–	–	–	–	–	4	4	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. drummondhayi	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	4	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. flavolimbatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	31	23	19	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. fulvus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. guttatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. inermis	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. itajara	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	5	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. morio	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. mystacinus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	7	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. nigritus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
E. niveatus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mycteroperca bonaci	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M. interstitialis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	3	6	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M. microlepis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	3	3	3	3	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M. phenax	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	1	4	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M. tigris	–	–	1[b]	–	–	–	–	1[b]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M. venenosa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Paranthias furcifer	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	2	2	1	–	–	–	–	–
Rypticus bistrispinus	1	14	15	4	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. maculatus	–	6	13	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

[a] All specimens from the Florida east coast.
[b] Developed gill rakers only.

APPENDIX TABLE 5. FREQUENCY DISTRIBUTION OF LATERAL LINE SCALES.

Species	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
Anthias nicholsi	–	–	–	–	–	8	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
A. tenuis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Holanthias martinicensis	–	–	–	–	–	–	–	–	–	2	1	4	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hemanthias aureorubens[a]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	3	3	1	3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
H. leptus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	1	2	3	6	7	4	6	3	3	1
H. vivanus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	2	2	13	5	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Plectranthias garrupellus	1	5[b]	7[c]	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Liopropoma eukrines	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pikea mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Schultzea beta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–	4	1	–	1	–	–	–	–	–	–	–	–
Serraniculus pumilio	–	–	–	–	–	–	–	–	–	–	–	–	–	2	2	3	2	2	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Serranus annularis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	3	8	1	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. atrobranchus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. notospilus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	3	9	4	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. phoebe	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	5	4	23	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. subligarius	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	2	15	16	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. tabacarius	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–
S. tigrinus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. tortugarum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–

[a] All specimens from the Florida east coast.

[b] One additional specimen from the Florida east coast had 28 lateral line scales.

[c] Five additional specimens from the Florida east coast had 29 lateral line scales.

COLOR
PLATES

PLATE I

Figure A. Yellowfin bass, *Anthias nicholsi*, FSBC 12027-8, 115 mm.

Figure B. Threadnose bass, *A. tenuis*, FSBC 11982, 83 mm.

Figure C. Streamer bass, *Hemanthias aureorubens*, 242 mm FL.
(Photograph by Donald D. Flescher.)

Figure D. Longtail bass, *H. leptus*, FSBC 12052, sexually mature male, 61 mm.