

NOAA Technical Report NMFS Circular 448

Synopsis of Biological Data  
on the Grunts  
*Haemulon aurolineatum* and  
*H. plumieri* (Pisces:  
Haemulidae)

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February 1983

FAO Fisheries Synopsis No. 133

U.S. DEPARTMENT OF COMMERCE

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# Synopsis of Biological Data on the Grunts *Haemulon aurolineatum* and *H. plumieri* (Pisces: Haemulidae)<sup>1</sup>

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## ABSTRACT

Information on the biology and fishery resources of two common species of western Atlantic grunts, *Haemulon aurolineatum* and *H. plumieri*, is compiled, reviewed, and analyzed in the FAO species synopsis style.

## INTRODUCTION

Grunts are often given little attention in discussions of western Atlantic marine fisheries because of their small size. Yet some species, including the tomtate, *Haemulon aurolineatum*, and the white grunt, *H. plumieri*, are among the most abundant fishes on reefs, live-bottom shelf areas, and in a variety of inshore habitats in the Caribbean Sea, the Gulf of Mexico, and along the southeastern Atlantic coast of the United States. Due to their nocturnal foraging migrations, they are important energy importers to reef communities and are probably major prey of many larger species, such as snappers and groupers. Grunts are among the fishes most caught by recreational and subsistence fishermen in this geographical area. They are quality food fish and are commercially important in areas such as Campeche Bank. Exploratory trawling in the northeastern Gulf of Mexico suggests that potentially exploitable populations of grunts may exist there. This paper summarizes information on these species.

### 1 IDENTITY

#### 1.1 Nomenclature

##### 1.1.1 Valid name

*Haemulon aurolineatum* Cuvier, in Cuvier and Valenciennes, 1829 (Fig. 1).

Tomtate, *Haemulon aurolineatum* Cuvier, in Cuvier and Valenciennes, 1829:237-238, type localities: Brazil, San Domingo. The name comes from the Greek haima (blood) and oulon (the gums), referring to the red mouth interior, and the Latin aurum (gold) and lineatus (marked with lines), referring to the yellow body stripes of adults.

*Haemulon plumieri* (Lacépède, 1802) (Fig. 2).

White grunt, *Haemulon plumieri* (Lacépède 1802:480), type locality: America. The name comes from the Greek haima (blood) and oulon (the gums), referring to the red mouth interior. Named after Father Plumier, a French naturalist who sent drawings of this species to Europe from Martinique (Jordan and Fesler 1893).

#### 1.1.2 Objective synonymy

The following synonymies are based on Courtenay (1961):

##### *Haemulon aurolineatum* Cuvier

*Haemulon chrysopteron* Cuvier, 1829 (misidentification, in part)  
*Haemulon chrysopteron*. Cuvier in Cuvier and Valenciennes, 1829 (in part)  
*Haemulon aurolineatum* Cuvier in Cuvier and Valenciennes, 1829  
*Haemulon chrysopteron*. DeKay, 1842 (misidentification, in part)  
*Haemulon jeniguano* Poey, 1860  
*Bathystoma jeniguano*. Scudder, 1863  
*Bathystoma chrysopteron*. Scudder, 1863  
*Haemulon aurolineatum*. Cope, 1871  
*Diabasis aurolineatus*. Goode and Bean, 1883  
*Diabasis chrysopterus*. Bean, 1883  
*Diabasis jeniguano*. Bean, 1883  
*Haemulon rimator* Jordan and Swain, 1884  
*Bathystoma aurolineatum*. Jordan and Evermann, 1896  
*Haemulon (Bathystoma) aurolineatum*. Metzelaar, 1919  
*Bathystoma aurolineatum aurolineatum* Ginsburg, 1948  
*Bathystoma aurolineatum rimator* Ginsburg, 1948  
*Bathystoma aurolineatum angustum* Ginsburg, 1948

##### *Haemulon plumieri* (Lacépède)

*Guabi coarca brasiliensibus* Marcgrave, 1648  
*Perca marina capite striato* Catesby, 1743  
*Perca formosa* Linnaeus, 1766 (in part)  
*Labrus plumierii* Lacépède, 1802  
*Haemulon formosum*. Cuvier, 1829 (in part)  
*Haemulon arcuatum* Valenciennes in Cuvier and Valenciennes, 1833  
*Labrus plumieri*. Cuvier, 1834  
*Haemulon formosum*. DeKay, 1843 (in part)  
*Haemulon parae*. Castelnau, 1855 (possibly misidentification)  
*Haemulon arara* Poey, 1860  
*Haemulon subarcuatum* Poey, 1861  
*Haenylum formosum*. Scudder, 1863  
*Haenylum arara*. Scudder, 1863  
*Haemulon formosum*. Cope, 1871  
*Diabasis formosus*. Goode and Bean, 1883  
*Diabasis plumieri*. Bean, 1883  
*Haemulon plumieri*. Jordan, 1884  
*Haemulon plumierii*. Meck and Hildebrand, 1925

<sup>1</sup>Contribution No. 82-30M of the Southeast Fisheries Center.

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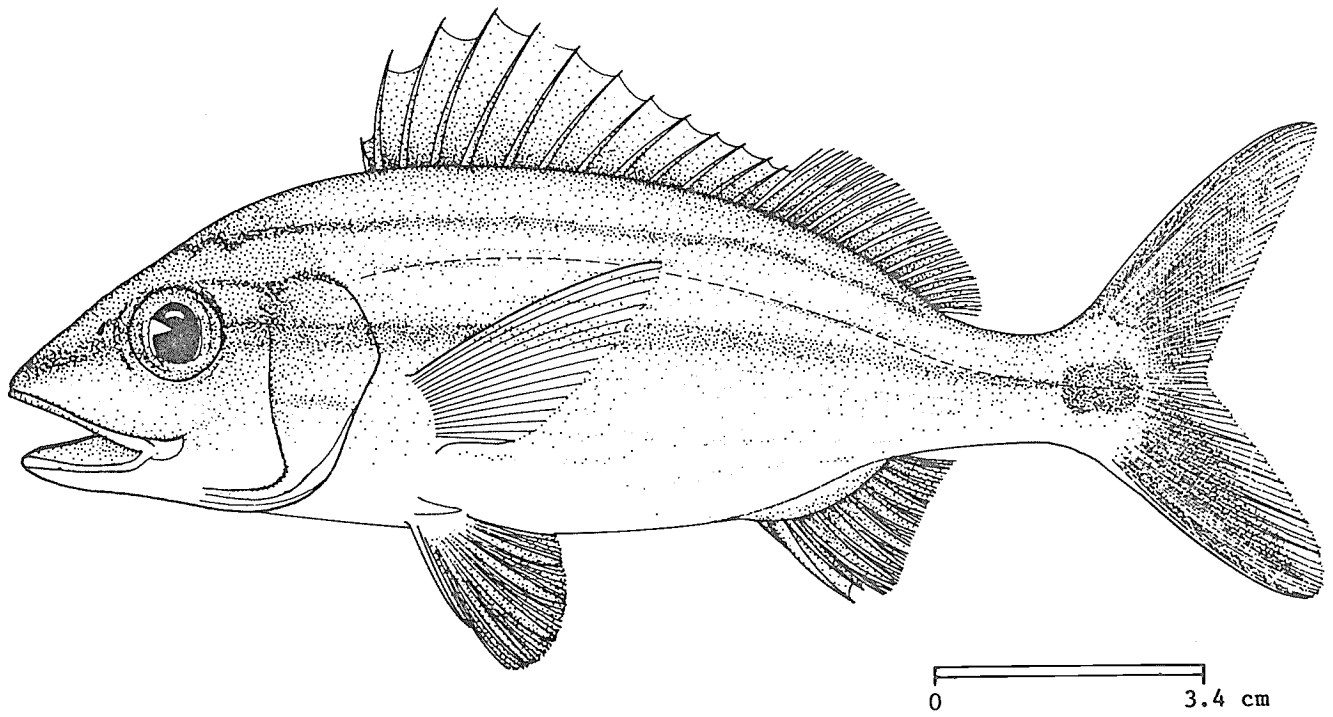


Figure 1.—Adult *Haemulon aurolineatum*. (From Courtenay and Sahlman 1978.)

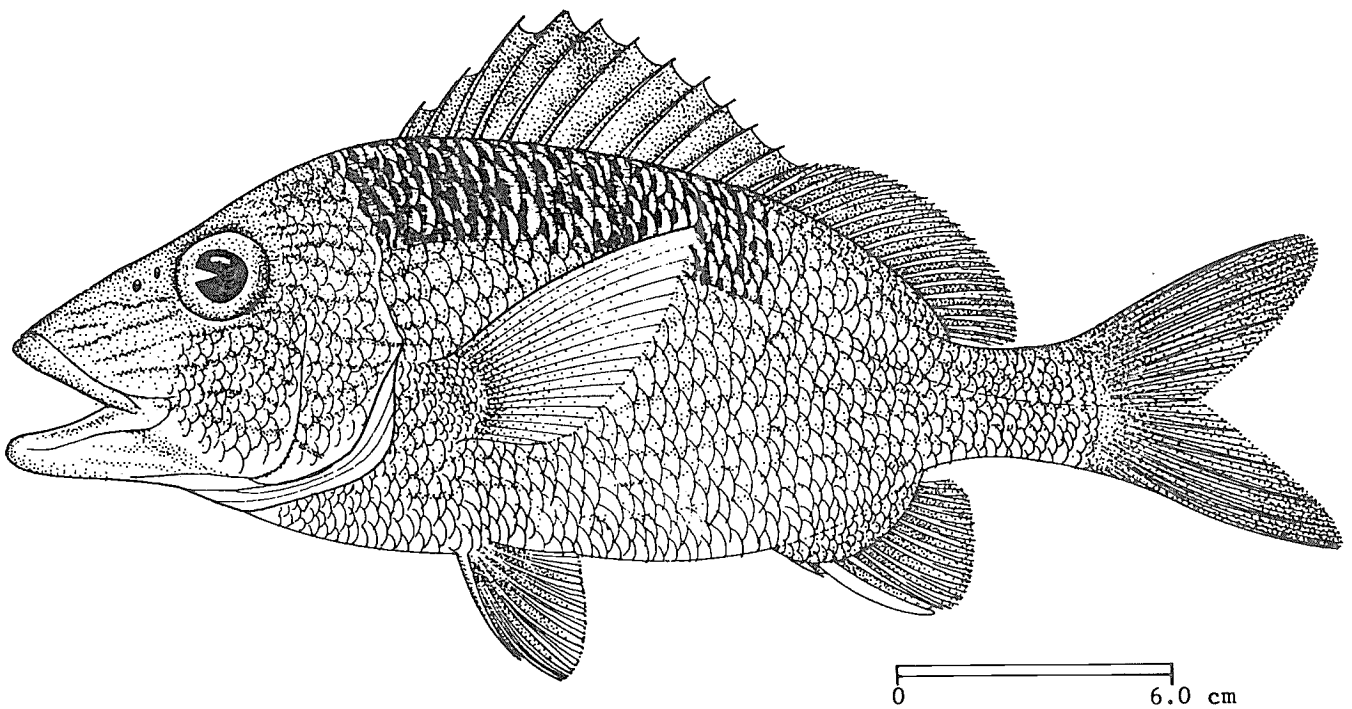


Figure 2.—Adult *Haemulon plumieri*. (From Courtenay and Sahlman 1978.)

## 1.2 Taxonomy

## Specific

### 1.21 Affinities

### *Haemulon aurolineatum*

#### Suprageneric

Phylum Chordata  
 Class Osteichthyes  
 Superorder Acanthopterygii  
 Order Perciformes  
 Suborder Percoidei  
 Family Haemulidae

Systematics and distribution of the family Haemulidae were reviewed by Konchina (1976), who listed several previously recognized families (Gaterinidae, Pomadasidae, Prispomidae, Plectorhynchidae, and Xenichthyidae) now included in Haemulidae. Although recent usage has favored the family name Pomadasyidae, Haemulidae is an earlier name which should be applied (Robins et al. 1980).

#### Generic

Several workers have reviewed the genus *Haemulon*, sensu lato. Jordan and Swain (1884) discussed the status of the genus and concluded that *Bathystoma* of Scudder (1863 as cited in Jordan and Swain 1884), in which the species *aurolineatum* is sometimes placed, should not be regarded as a distinct genus. Jordan and Fesler (1893) likewise did not recognize *Bathystoma*, but placed *Haemulon* along with lutjanids in the family Sparidae. Ginsburg (1948) reviewed the species of *Bathystoma*, a genus which he considered distinct based on a difference in number of dorsal spines (*Bathystoma* having 13 and *Haemulon*, sensu stricto, having 12). Arnov (1952) excluded *Bathystoma* from his review of *Haemulon*. Most recent authors (Courtenay 1961; Konchina 1976; Courtenay and Sahlman 1978) have considered *Bathystoma* to be a synonym of *Haemulon*.

Courtenay (1961) listed synonyms of *Haemulon* Cuvier:

*Diabasis* Desmarest, 1823 (preoccupied in Coleoptera)  
*Haemulon* Cuvier, 1829  
*Haemylum* Scudder, 1863  
*Anarsostus* Scudder, 1863  
*Bathystoma* Scudder, 1863  
*Haemulum* Cope, 1871  
*Brachygenys* Scudder, 1875

The following description of the genus *Haemulon* is derived from Arnov (1952), Courtenay (1961), and Courtenay and Sahlman (1978): body oblong, compressed, perch-like; head profile strongly convex; chin with 2 pores anteriorly and a central groove behind the symphysis of the lower jaw; teeth conical, in a narrow band in each jaw, the outer series enlarged, but no canines; no teeth on roof of mouth; posterior margin of suborbital not exposed; preopercle with posterior margin slightly concave and rather finely serrate, none of the serrae directed forward; opercle with 1 distinct spine; dorsal fin single, usually with 12 or 13 strong spines and 12-18 soft rays; pectoral fins long; pelvic fins below base of pectoral fins, with 1 spine and 5 soft rays; anal fin with 3 strong spines and fewer than 11 soft rays; soft dorsal and anal fins densely scaled to their margins; caudal fin forked; scales ctenoid, small to moderate, extending onto entire head (except front of snout, lips, and chin); mouth usually red within.

The following species diagnosis is from Courtenay (1961): pored lateral line scales 50-52; caudal peduncle scales 22 (9-2-11); dorsal fin XII + I, 14-15, usually 15; anal fin III, 9, rarely 8; pectoral fins 17-18, usually 17; gill rakers 24-28; longitudinal scale rows below lateral line parallel to long axis of body; body silvery-white with yellow to brown stripe from behind preopercle to black blotch at base of caudal fin; pectoral fins chalky; other fins pale gray to chalky; juveniles with lateral stripe from behind eye to caudal peduncle continuous with oval spot when young, separate from dumbbell-shaped spot in larger individuals.

Adults of *H. aurolineatum* are easily separated from most other species of *Haemulon* because they possess 13 dorsal spines. Other *Haemulon* species, except for *H. striatum* and *H. boschmae*, have 12 dorsal spines. The three species having 13 spines may be distinguished as shown in Table 1.

Table 1.—Distinguishing characters of three species of *Haemulon* from the western Atlantic. (From Courtenay and Sahlman 1978.)

Character	<i>H. aurolineatum</i>	<i>H. striatum</i>	<i>H. boschmae</i>
Scales around caudal peduncle	22	25-26	23-27
Scale rows below lateral line	parallel to body axis	oblique	mostly parallel to body axis
Gill rakers in first arch	24-28	28-34	30-36
Anal fin rays	9	7-8	7-9 (usually 8)
Body shape	compressed, depth 32-36% SL	not compressed, depth 26-30% SL	compressed, depth 26-30% SL

### *Haemulon plumieri*

The following species diagnosis is from Courtenay (1961): pored lateral line scales 48-51, usually 50-51; caudal peduncle scales 22 (9-2-11); dorsal fin XI + I, 15-17, usually 16; anal fin III, 8-9, usually 9; pectoral fins 17; gill rakers 21-27, usually 25; scales above lateral line larger than those below; body silvery-white with numerous blue and yellow stripes on head and body; pectoral fins chalky, other fins gray; black blotch often present beneath free margin of preopercle; juveniles without lateral stripe; caudal spot round, posterior to caudal base.

Adults of *H. plumieri* can be separated from all other *Haemulon* species by the larger scales above the lateral line (Courtenay and Sahlman 1978).

### 1.22 Taxonomic status

The taxonomic status of *H. aurolineatum* has not always been agreed upon. Jordan and Swain (1884) named a species, *H. rimator*, which they distinguished from *H. aurolineatum* by its deeper body shape and lighter yellow color. Jordan and Fesler (1893) perpetuated this separation. Ginsburg (1948) reviewed the species of "*Bathystoma*" and concluded that *rimator* and *aurolineatum* are subspecies of *H. aurolineatum*, sensu lato, and named a third subspecies, *angustum*. Ginsburg separated his three subspecies of *aurolineatum* on the basis of body depth. Courtenay (1961) reviewed the genus *Haemulon* in the western Atlantic and consid-

ered *rimator* to be a synonym of *aurolineatum*. Courtenay (1961) did not treat Ginsburg's subspecies as such in his review. Konchina (1976) also considered *rimator* to be a synonym of *aurolineatum* in his discussion of haemulid systematics and distribution.

*Haemulon aurolineatum* and *H. plumieri* are generally considered morphospecies in recent literature.

See 1.21

### 1.23 Subspecies

#### *Haemulon aurolineatum*

Several subspecific names have appeared in literature. Ginsburg (1948) concluded that three allopatric subspecies exist: *H. a. aurolineatum* from the West Indies and South and Central America, *H. a. rimator* from the coastal United States, and *H. a. angustum* from Bermuda, although Ginsburg placed all of these in the genus *Bathysoma* rather than *Haemulon*. Ginsburg based his separation of these subspecies primarily on body depth differences. Variations in gill raker counts, scale counts, and some fin ray counts were also noted by Ginsburg, though these appear to be clinal. Southern Florida populations, especially from Key West and the Tortugas, appear to approach the *H. a. aurolineatum* form of the West Indies (Ginsburg 1948).

Hoese and Moore (1977) mentioned that northwestern Gulf of Mexico specimens of *H. aurolineatum* are sometimes separated into the subspecies (or species) *rimator*.

Courtenay (1961) did not distinguish subspecies of *H. aurolineatum*. Most recent literature does not divide *H. aurolineatum* sub-specifically.

See 1.22

#### *Haemulon plumieri*

No subspecies are recognized.

### 1.24 Standard common names, vernacular names

The accepted common name of *H. aurolineatum* in the United States is tomtate (Robins et al. 1980), and standard FAO common names are: English, tomtate grunt; French, gorette tomtate; Spanish, ronco jeniguano (Courtenay and Sahlman 1978).

The accepted common name of *H. plumieri* in the United States is white grunt (Robins et al. 1980), and standard FAO common names are: English, white grunt; French, gorette blanche; Spanish, ronco margariteño (Courtenay and Sahlman 1978).

Other common names appearing in the literature are given in Table 2.

## 1.3 Morphology

### 1.31 External morphology

#### *Haemulon aurolineatum*

Courtenay (1961) and Herculano Soares and de Holanda Lima (1966, 1967) provided morphometric and meristic data as given in Table 3.

Courtenay's data were gathered from specimens from Florida, the Gulf of Mexico, the Virgin Islands, and Bermuda; Herculano

Table 2.—Common names of *Haemulon aurolineatum* and *H. plumieri* appearing in the literature.

Country or area	Name	Reference
<i>Haemulon aurolineatum</i>		
United States	Tom-tate, redmouth grunt, caesar, jeniguano	Jordan and Fesler 1893
	Tom Tate, redmouthed grunt, yellow Tom Tate	Hildebrand and Schroeder 1928 Breder 1948
	Caribbean	scize, roncador
Brazil	xira	Manooch and Barans <sup>1</sup>
Venezuela	cuji	Manooch and Barans <sup>1</sup>
Puerto Rico	mullita, mula mariquita, maruca	Erdman 1974; Manooch and Barans <sup>1</sup>
	Portuguese-speaking countries	cotinga, cotinga, chirra
<i>Haemulon plumieri</i>		
United States	grunt, black grunt, common grunt	Hildebrand and Schroeder 1928 Beebe and Tee-Van 1928
	Key West grunt, ruby red lips	Moe 1963
	flannelmouth grunt	Hastings 1972
	Puerto Rico	cachicata
Haiti	ronco-ronco	Beebe and Tee-Van 1928
Cuba	ronco arara	Sauskan and Olachea 1974
Venezuela	coro coro margariteño	Gutiérrez B. 1976
Area not specified	boar grunt, ronco grande, ronco blanco	Arnov 1952

<sup>1</sup>Manooch, C. S., III. and C. A. Barans. 1980. Distribution, abundance, age and growth of tomtate, *Haemulon aurolineatum* Cuvier, along the southeastern United States. Unpubl. manuscr.

Table 3.—Morphometric and meristic data for *Haemulon aurolineatum*.

	Courtenay (1961)		Herculano Soares and de Holanda Lima (1966, 1967)	
	Range	Mode	Range	Mode
Predorsal distance (% SL)	37-43	40		
Precanal distance (% SL)	67-74	70		
Body depth (% SL)	27-38	34		
Head length (% SL)	32-38	36	34.5-38.6	
Snout length (% SL)	11-17	13		
Length of upper jaw (% SL)	15-23	17		
No. dorsal rays	14-16	15	14-15	15
No. anal rays	7-9	9	9	9
No. pectoral rays	16-18	17	17-18	18
Scales above lateral line	6	6	6-7	6
Scales below lateral line	11-13	12	10-13	11
Scales around caudal peduncle	22	22	20-23	22
Total lateral line scales	49-52	50,51	47-51	49
Total gill rakers	24-28	26,27	26-28	27

Soares and de Holanda Limas' data were from Brazilian specimens. Other detailed morphometric data appear in Herculano Soares and de Holanda Lima (1966, 1967). Ginsburg (1948) compared meristics and morphometrics of several western Atlantic populations of *H. aurolineatum*.

Body coloration silvery white and head dusky grayish brown; yellow to bronze midlateral stripe extends length of body from behind opercle to base of caudal fin; large dark brown or black spot present at base of caudal fin; mouth red within; peritoneum black (Courtenay 1961; Böhlke and Chaplin 1968).



*Haemulon plumieri*

Body elongate, compressed, back elevated; snout long, pointed. 1.9-2.3 in head; eye 3.9-5.2 in head; mouth large, terminal, horizontal; maxillary reaching about middle of eye and 1.9-2.05 in head; gill rakers rather short, 14-15 on lower limb of first arch; scales moderate size, larger above lateral line; scale series very oblique; 4 scale rows between origin of dorsal fin and lateral line; scales extending on base of pectoral fins; soft parts of other fins densely scaled; dorsal fin long, scarcely notched; caudal fin forked, upper lobe longest; second anal spine the longest, reaching slightly past tip of third spine when deflexed; pectoral fins moderate. 1.3-1.6 in head (Hildebrand and Schroeder 1928).

Distance from dorsal fin origin to pectoral fin origin 4.0-4.3 in SL; least depth of caudal peduncle 8.5-9.6 in SL; diameter of orbit 3.2-5.2 in head; length of pectoral fin 3.4-4.0 in SL; scales below lateral line in pectoral region not enlarged; preopercular serrae embedded in membranous border of preopercle (Arnov 1952). De Lamater and Courtenay (1974) examined *H. plumieri* scales using scanning electron microscopy.

Body silvery-white, head bronze to yellow above; belly and underside of head white; series of dark blue stripes, margined with bronze on the head, run back onto the body; margin of each scale bronze, posterior edge often gray; in a darker phase, silvery-white in center of each scale may become bronze; membranes of spinous dorsal fin chalky to yellowish-white; soft dorsal, caudal, soft anal fins brownish gray; mouth bright red within; peritoneum black (Courtenay 1961).

Coloration changeable, except that alternating blue and yellow stripes always present on head; pattern on upper third of body dominated by white or blue spot on each scale resulting in a checkerboard pattern with yellow between the spots; often a broad dusky region on mid-side of body, and rarely a phase with several indistinct dark lateral stripes may be observed; a black blotch may be present beneath free edge of preopercle (Böhlke and Chaplin 1968).

See 1.21.

1.33 Protein specificity

Cequea R. and Pérez (1971) conducted electrophoretic studies of hemoglobin, esterases, and general plasma proteins of several species in three genera of haemulids from Venezuela. Although hemoglobins and esterases can be used to separate the genera *Haemulon*, *Anisotremus*, and *Orthopristis*, species of *Haemulon* could not be detected electrophoretically. Intraspecific variations in proteins were observed in *H. aurolineatum*.

2 DISTRIBUTION

2.1 Total area

*Haemulon aurolineatum*

*Haemulon aurolineatum* is distributed in waters of the continental shelf from Cape Cod, Mass., to Brazil, including Bermuda and the Gulf of Mexico (Fig. 3). Although several authors (Courtenay 1961; Randall 1968; Böhlke and Chaplin 1968) listed Cape Cod as the northern end of its range, this species is apparently not common north of Chesapeake Bay (Hildebrand and Schroeder 1928; Courtenay and Sahlman 1978), though it is the most northerly ranging *Haemulon* species (Courtenay 1961). The southern limit of the

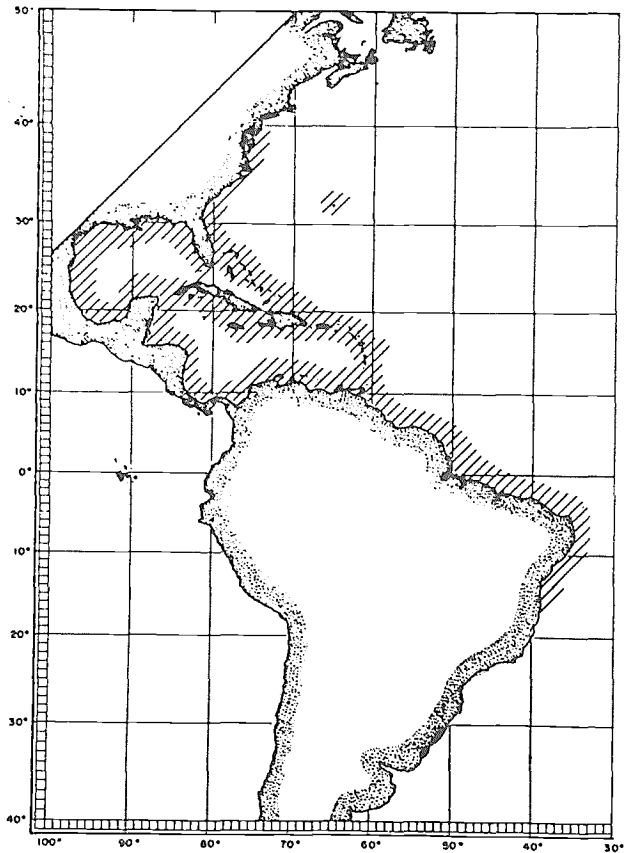


Figure 3.—Distribution of *Haemulon aurolineatum*. (Based on Courtenay 1961; Courtenay and Sahlman 1978.)

range lies between Cape Branco and San Sebastian Island, Brazil (Konchina 1976).

*Haemulon aurolineatum* is seldom taken on brown shrimp grounds in the western Gulf of Mexico (Hildebrand 1954), yet it is the most common fish on the Campeche pink shrimp grounds (Hildebrand 1955). It also occurs offshore in areas of bottom relief, such as the West Flower Garden Bank off Texas (Cashman 1973), the Florida Middle Grounds (Smith et al. 1975), on rocky reefs off Tampa Bay, Fla. (Springer and Woodburn 1960), and on shelf-edge and live-bottom habitats off the southeastern United States (Struhsaker 1969).

*Haemulon plumieri*

*Haemulon plumieri* is distributed in coastal waters from Chesapeake Bay to Natal, Brazil, including Bermuda, where it has been introduced (Beebe and Tee-Van 1933), the Bahamas, and the eastern Gulf of Mexico (Fig. 4).

*Haemulon plumieri* occurs on offshore live bottom along the southeastern Atlantic coast of the United States (Anderson and Gehringer 1965; Struhsaker 1969; Bearden and McKenzie 1972; Barans and Burrell 1976), and in the Gulf of Mexico, where it also occurs on offshore natural and artificial reefs (Smith et al. 1979), around offshore platforms (Hastings et al. 1976), and near rock reefs (Springer and Woodburn 1960). It is only occasionally found on the Florida Middle Grounds (Smith et al. 1975). The distribution of *H. plumieri* in the northern Gulf of Mexico closely resembles that of *H. aurolineatum* (Hastings 1972). *Haemulon plumieri*

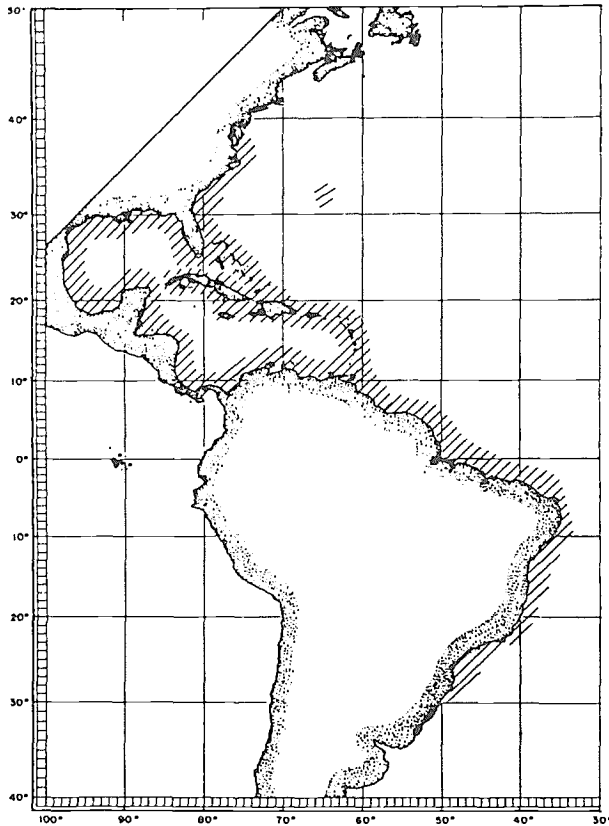


Figure 4.—Distribution of *Haemulon plumieri*. (Based on Courtenay 1961; Courtenay and Sahlman 1978.)

also occurs in shallow inshore areas of the eastern Gulf of Mexico (Courtenay 1961; Roessler 1970; Grimes 1971; Grimes and Mounttain 1971; Wang and Raney 1971; Hastings 1972; Livingston 1976; Smith 1976), southeastern Florida (Davis 1967), in the Bahamas (Courtenay 1961; Böhlke and Chaplin 1968), and in the West Indies (Randall 1968; Billings and Munro<sup>3</sup>).

## 2.2 Differential distribution

### 2.2.1 Spawn, larvae and juveniles

#### *Haemulon aurolineatum*

Areas of spawn and larval concentration are not well known. Sauskan and Olaechea (1974) reported that *H. aurolineatum* spawns mainly offshore on Campeche Bank, at depths > 50 m, and the eggs are carried by currents from east to west across the Bank. Larvae apparently settle in shallow water during metamorphosis (Billings and Munro footnote 3). Although not identified to species, many haemulid larvae (probably *Haemulon* spp.) were collected by Houde et al.<sup>4</sup> during plankton sampling in the eastern Gulf

of Mexico. These larvae were most common in late winter and spring and at stations where water depth was < 50 m.

Juveniles are locally common and are found in a wide variety of habitats. Randall (1963) and Stone et al. (1979) reported them very abundant on artificial and natural patch reefs in the Virgin Islands and Florida, respectively. They are also found along rocky shores, jetties, and pilings (Jordan and Fesler 1893; Davis 1967; Wang and Raney 1971; Hastings 1972; Smith 1976), on grass flats or back-reef areas (Reid 1954; Tabb and Manning 1961; Billings and Munro footnote 3), and in deeper water over live bottom and rock ridges, such as off the Carolinas (Manooch and Barans<sup>5</sup>).

Although the basic distributions of juvenile and adult *H. aurolineatum* are the same (Manooch and Barans footnote 5), some differences may exist, at least seasonally, in response to depth and temperature. Sokolova (1965) reported that juveniles were not caught with adults on eastern Campeche Bank, and Sauskan and Olaechea (1974) found that juveniles were more common and farther offshore on western Campeche Bank than on the eastern side. Manooch and Barans (footnote 5) noted that more juveniles appeared in trawl catches north of lat. 32°30'N off the southeastern United States than south of it, and that juveniles occupied warmer water in the winter and cooler water in the summer than adults.

#### *Haemulon plumieri*

Areas of spawn and larval concentration are not well known. Although some spawning may occur throughout the year, most individuals appear to spawn in spring. Eggs are probably planktonic and hatch within 20 h at 24.2°C (Saksena and Richards 1975). Haemulid larvae were collected near shore by Houde et al. (footnote 4) in the eastern Gulf of Mexico.

Juveniles may be abundant in shallow water in a variety of habitats. Courtenay (1961) reported that juveniles are particularly abundant over grass beds at the edge of sand flats; Springer and Woodburn (1960) found young on grass flats north of Clearwater, Fla., in summer and fall. Tabb and Manning (1961) found juveniles up to 53 mm FL in Whitewater Bay, Fla., most commonly in clear water over *Thalassia*. Reid (1954) collected young *H. plumieri* at Cedar Key, Fla., from September to November on moderately deep flats with muddy sand bottom and on shallower flats from July to October.

Juveniles are also found in association with hard substrates. Davis (1967) reported juveniles common among rocky shorelines in the Florida Keys, and Beebe and Tee-Van (1928) found young up to 100 mm SL on shallow reefs in Port-au-Prince Bay, Haiti. In St. Croix, U.S. Virgin Islands, juveniles up to 150 mm SL are found in heterotypic schools with *H. flavolineatum* on patch reefs and are usually associated with the corals *Porites porites* and *Acropora palmata*; larger juveniles (120-150 mm SL) often form roaming schools on reefs and are less closely associated with particular corals than are smaller juveniles (Ogden and Ehrlich 1977). Billings and Munro (footnote 3) observed small schools of unidentified juvenile haemulids throughout the year in Jamaica, but particularly in April, May, and August at 2-25 m depths in reef areas, especially above heads of *Montastrea* sp. and *Madracis* sp. corals, on sand flats among *Diadema antillarum* spines, over *Thalassia* beds, among mangrove roots, and near jetties. The smallest juveniles observed were 10-20 mm FL. Young *H. plumieri* change to adult color pattern and body form at about 40 mm SL (Billings and Munro footnote 3).

<sup>3</sup>Billings, V., and J. Munro. 1974. The biology, ecology, and bionomics of Caribbean reef fishes. Ve. Pomadasysidae (grunts). Univ. West Indies. Sci. Rep. ODA/UWI Fish. 3, 128 p.

<sup>4</sup>Houde, E. D., J. C. Leak, C. E. Dowd, S. A. Berkeley, and W. J. Richards. 1979. Ichthyoplankton abundance and diversity in the eastern Gulf of Mexico. Report to Bureau of Land Management under Contract No. AA550-CT7-28, 546 p.

<sup>5</sup>Manooch, C. S., III, and C. A. Barans. 1980. Distribution, abundance, age and growth of tomtate, *Haemulon aurolineatum* Cuvier, along the southeastern United States. Unpubl. manuscr., 18 p. Southeast Fisheries Center Beaufort Laboratory, National Marine Fisheries Service, NOAA, Beaufort, NC 28516.

Sec 2.3 and 3.22.

## 2.22 Adults

### *Haemulon aurolineatum*

Like the juveniles, adult *H. aurolineatum* have been found to occupy a wide variety of habitats:

Habitat	Source
Artificial reefs	Smith et al. 1979
Offshore man-made platforms	Hoese and Moore 1977
Rocky shores, rock reefs, jetties	Springer and Woodburn 1960; Hastings 1972; Courtenay and Sahlman 1978
Coral reefs	Davis 1967; Billings and Munro (footnote 3); Smith 1976; Hoese and Moore 1977; Courtenay and Sahlman 1978
Grass beds	Beebe and Tee-Van 1928; Davis 1967; Böhlke and Chaplin 1968
Shell bottom, pink shrimp grounds	Hildebrand 1954
Broken relief, brown shrimp grounds	Chittenden and McEachran 1976
Live bottom and shelf-edge sponge and coral habitats	Bearden and McKenzie 1972; Barans and Burrell 1976; Manooch and Barans (footnote 5)

*Haemulon aurolineatum* may occupy a number of different microhabitats within a fairly restricted geographic area, such as reef tops, forereefs, backreef grass beds, patch reefs, and alcyonarian coral patches in the Florida Keys (Davis 1967).

*Haemulon aurolineatum* occurs from shallow water to offshore reefs, open sandy areas, and shelf live-bottom areas at least as deep as 91 m (Manooch and Barans footnote 5), though not very commonly deeper than 60 m (Fishery Management Plan for the Snapper-Grouper Complex of the South Atlantic Region<sup>6</sup>). Smith (1976) reported that *H. aurolineatum* is one of the most common deep-water reef fish in the eastern Gulf of Mexico at depths >30 m.

### *Haemulon plumieri*

Like the juveniles, adult *H. plumieri* occupy a variety of habitats. Along the southeastern Atlantic coast of the United States they occur primarily over live-bottom shelf areas (Struhsaker 1969; Barans and Burrell 1976).

Bearden and McKenzie (1972) reported *H. plumieri* from 33.4 to 55.6 m (18-30 fathoms) on live bottom off South Carolina, and Anderson and Gehringer (1965) reported them from exploratory cruises off the southeastern United States at 0-37.0 m (0-20 fathoms) in winter, and 37.0-185.3 m (20-100 fathoms) in fall; they were absent from spring and summer samples. *Haemulon plumieri* appears to prefer shelf areas with ridges of hard substrate containing soft materials in between (Fishery Management Plan for the Snapper-Grouper Complex of the South Atlantic Region footnote 6). No *H. plumieri* were taken at MARMAP (Marine Resources, Monitoring, Assessment and Prediction) sand-bottom trawl stations in the South Atlantic Bight (Wenner et al. 1979 a,b,c,d).

In the Gulf of Mexico, *H. plumieri* is much more common in the east than the west, being known in the northwestern Gulf from only a few offshore collections (Hoese and Moore 1977). Courtenay (1961) reported *H. plumieri* abundant on the west coast of Florida north to Pensacola in summer, and Smith (1976) found them at 12-36 m in the eastern Gulf; *H. plumieri* was one of the most common reef fishes in the area, particularly at 12-18 m depths. Wang and Rancy (1971) captured *H. plumieri* off Charlotte Harbor, Fla., in July and September, and Grimes (1971) and Grimes and Mountain (1971) caught them at Crystal River, Fla., from July to December. Hastings (1972) found *H. plumieri* around inshore jetties in St. Andrew Bay, Fla., from April to December and in deeper inshore waters year-round, but more commonly on reefs offshore. Other authors (Springer and Woodburn 1960; Hastings et al. 1976; Smith et al. 1979) also reported *H. plumieri* more common on offshore hard substrates than inshore in the eastern Gulf of Mexico, but usually in depths < 50 m (Konchina 1977).

*Haemulon plumieri* is common among loggerhead sponges on the pink shrimp grounds of Campeche Bank (Hildebrand 1954). Lyubimova and Kapote (1971) found *H. plumieri* on the eastern and central parts of the Bank, and Sauskan and Olacchia (1974) reported them most frequently caught in central nearshore areas. Juárez (1975) found them only on the extreme northeastern tip of the Yucatan Peninsula on Campeche Bank and speculated that their presence there may be due to available coral habitat.

*Haemulon plumieri* is the most common inshore grunt in southern Florida and the Bahamas from shore to the outer reef (Courtenay 1961). Davis (1967) found concentrations typically associated with isolated rubble areas, alcyonarian coral patches, patch reefs, and wrecks near Alligator Reef, Fla., but also on reef tops, near shore, and in *Thalassia* beds. Böhlke and Chaplin (1968) never collected *H. plumieri* in water over 6.1 m (20 ft) deep in the Bahamas but found them commonly along edges of patch reefs during the day.

In the West Indies, Ogden and Ehrlich (1977) reported *H. plumieri* adults residing on patch reefs and in back-reef lagoon areas in St. Croix. Billings and Munro (footnote 3) found them singly or in small groups on the reef crest, reef sill, and near the top of the fore-reef drop-off during the day in Jamaica; schools were found near gorgonians, sponges, and over flat rocky bottoms. At night they were found over grass flats and rubble (Billings and Munro footnote 3).

## 2.3 Determinants of distribution changes

### *Haemulon aurolineatum*

Primary causes of distribution changes in *H. aurolineatum* appear to be temperature, salinity, water clarity, habitat and food availability, nocturnal-diurnal foraging patterns, currents, and substrate type. *Haemulon aurolineatum* is restricted to areas of suitably high temperatures. Manooch and Barans (footnote 5) never found *H. aurolineatum* in water < 10.3°C, even on live bottom where they were common at higher temperatures, and rarely found them at < 13°C. Galloway (1941) reported *H. aurolineatum* killed by 13.9°C water during a cold wave at Key West, Fla. Low water temperatures in winter may cause an offshore displacement in the northern parts of the range and may account for the greater abundance offshore than in shallow water in the northern Gulf of Mexico and along the southeastern United States (Springer and Woodburn 1960; Hastings 1972; Manooch and Barans footnote 5). Southern displacement may also occur in cold winters, such as 1977, when Manooch and Barans (footnote 5) found a shift of abundance from north of lat. 32°30'N to south of it. Miller and

<sup>6</sup>Fishery Management Plan for the Snapper-Grouper Complex of the South Atlantic Region. South Atlantic Fishery Management Council. Charleston, S.C. Draft, March 1980.

Richards (1980) reported *H. aurolineatum* from inshore reefs in the South Atlantic Bight and classified the species as warm-temperate tolerant. Olacchca and Sauskan (1974) also found seasonal differences in distribution on Campeche Bank due to changes in bottom water temperature.

*Haemulon aurolineatum* prefers fairly high salinity and clear water and appears to avoid estuarine areas. Reid (1954), Tabb and Manning (1961), Wang and Raney (1971), and Ogren and Brusher (1977) reported taking *H. aurolineatum* only in deeper, more saline parts of the estuaries they studied. Reid (1954) collected specimens at 17.5‰ at Cedar Key, but most collections reported in the literature were from near or above 30‰.

Food availability also affects distribution. Randall (1963) found *H. aurolineatum* to be much more abundant on artificial patch reefs than on fringing reefs in St. John, U.S. Virgin Islands, and theorized that the difference may have been due to food availability. Individuals undertake nocturnal migrations away from their daytime habitats to forage on nearby grass and sand flats (Randall 1963; Davis 1967; Smith and Tyler 1972; Billings and Munro footnote 3; Hastings et al. 1976).

Eggs and larvae are probably pelagic (Billings and Munro footnote 3) and their distribution is influenced by currents. On Campeche Bank most spawning activity takes place on the eastern part of the Bank and the young are carried to the west by currents (Sauskan and Olacchca 1974). Spawning and feeding areas on Campeche Bank are also occupied seasonally and are influenced by currents and food availability (Sokolova 1965; Sauskan and Olacchca 1974).

Distribution is also influenced by substrate type. Calcareous bottoms, such as areas of shell, limestone, or other broken relief, are preferred. In the Gulf of Mexico, calcareous bottom often is inhabited by the pink shrimp community. On brown shrimp grounds in the northwestern Gulf, *H. aurolineatum* is primarily associated with small patches of broken relief (Chittenden and McEachran 1976). The greater abundance of *H. aurolineatum* offshore in the northern Gulf of Mexico may be due to the scarcity of broken-relief bottom close to shore.

#### *Haemulon plumieri*

There is little information on factors influencing distribution changes in *H. plumieri*. Temperature undoubtedly limits the range of this warm-water species. Miller and Richards (1980) reported *H. plumieri* from intermediate depth reefs in the South Atlantic Bight and classified the species as subtropical tolerant. Seasonality exhibited by *H. plumieri* in shallow water in the northern Gulf of Mexico may be due to temperature, this species generally being absent from shallow water in winter and early spring (Reid 1954; Moe 1963; Grimes 1971; Grimes and Mountain 1971; Wang and Raney 1971; Hastings 1972). *Haemulon plumieri* has been found in water as low as 13°C in the northern Gulf of Mexico (Hastings 1972). Seasonal movements to deeper water could also be due to spawning activity (Reid 1954). On Campeche Bank, *H. plumieri* is influenced by temperature and may seek deeper water in summer (Lyubimova and Kapote 1971); greatest concentrations were found from August to December, with larger fish at greater depths.

Habit and food availability influence local distributions of *H. plumieri*, certain habitats such as hard substrates possibly being preferred (Juárez 1975). Like *H. aurolineatum*, *H. plumieri* is often associated with calcareous substrates and broken relief (Chittenden and McEachran 1976). Diurnal-nocturnal foraging migrations account for diel habitat change (Davis 1967; Randall 1967;

Billings and Munro footnote 3; Ogden 1977; Ogden and Ehrlich 1977).

Currents probably affect egg and larval distribution, though little is known concerning this.

Sec 2.22, 3.16, 3.32, 3.41, and 3.51.

#### 2.4 Hybridization

Hybrids between *H. aurolineatum* and *H. steindachneri*, and *H. aurolineatum* and *H. boschmae*, have been reported (F. Cervigon pers. commun. as cited in Ccquea R. and Pérez 1971).

No hybrids of *H. plumieri* are known.

### 3 BIONOMICS AND LIFE HISTORY

#### 3.1 Reproduction

##### 3.1.1 Sexuality

There is no sexual dimorphism in body shape or color in *H. aurolineatum* or *H. plumieri*, though males grow larger than females (Billings and Munro footnote 3). Sauskan and Olacchca (1974) reported that on Campeche Bank, females predominated in *H. aurolineatum* specimens 11.5-19.4 cm (type of length measurement unspecified), males predominated in specimens 19.5-23.4 cm (measurement unspecified), and all specimens over 23.5 cm were males (Fig. 5).

There is no evidence of sex reversal or hermaphroditism in either species.

See 4.11

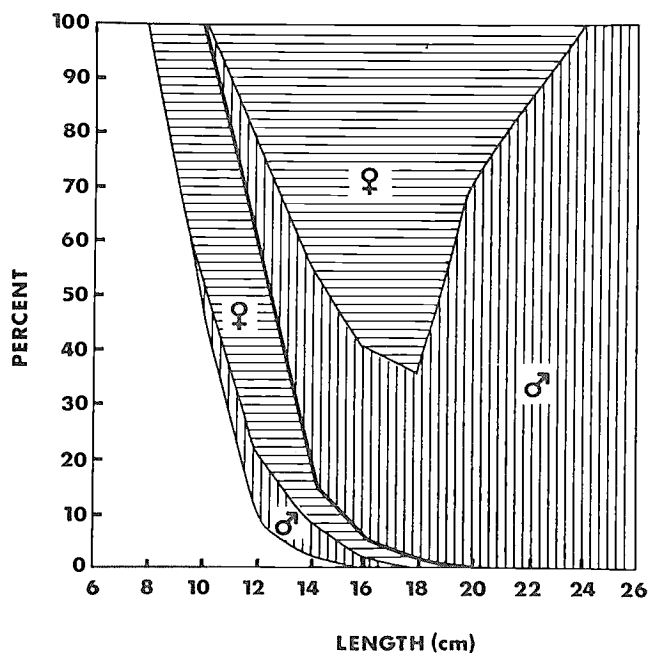


Figure 5.—Sex composition (in percent) of *Haemulon aurolineatum* of increasing body length (cm) on Campeche Bank, 1964-72. Mature individuals appear to the right of the heavy line, and immature individuals to the left. Juveniles are indicated by unpatterned areas. (From Sauskan and Olacchca 1974, fig. 7.)

#### 3.1.2 Maturity

*Haemulon aurolineatum* transforms from juvenile to adult color

pattern and body form at about 5.4 cm SL (Courtenay 1961), though sexual maturity does not occur until fish are about twice that length. Beebe and Tee-Van (1928) reported that an 11.0 cm SL female and two 8.0 cm SL males from Haiti appeared to be in spawning condition. The smallest ripe female caught in Jamaica by Billings and Munro (footnote 3) was 13.0 cm FL and 34 g and the smallest ripe male 14.7 cm FL and 55 g. *Haemulon aurolineatum* on Campeche Bank mature when about 3 yr old, and all of the commercial catch on the Bank is sexually mature (Sokolova 1965). Sauskan and Olacchea (1974) found that *H. aurolineatum* on Campeche Bank from 7.5 to 13.4 cm (measurement unspecified) were up to 3 yr old and mostly immature, and specimens 13.5-19.4 cm (measurement unspecified) were 3-5 yr old and about half were mature. Specimens 19.5-25.4 cm (measurement unspecified) were 5 yr old or older and all were mature. Females mature first, at 11.5-17.4 cm, mainly 11.5-13.4 cm, and males mature at 11.5-15.4 cm, mainly 13.5-15.4 cm (measurement unspecified) (Sauskan and Olacchea 1974). At <9.4 cm (measurement unspecified) and 1 yr old, external sexing is impossible (Sauskan and Olacchea 1974).

*Haemulon plumieri* matures during the third year of life on Campeche Bank, at < 18 cm (measurement unspecified) and 0.30-0.35 kg body weight (Lyubimova and Kapote 1971). Billings and Munro (footnote 3) found males fully mature at 24.0-25.9 cm FL, with a mean size at maturity of 20 cm FL. Females were fully mature at 26.0-27.9 cm FL, with a mean size at maturity of 22 cm FL. The smallest ripe male found was 14.5 cm FL and 60 g, and the smallest ripe female was 14.3 cm FL and 59 g (Table 4).

Table 4.—Percentages of ripe or spent fish and comparison of length-frequency distributions of male and female *Haemulon plumieri* in Jamaican waters. (From Billings and Munro see text footnote 3, table 3.6.1.)

Length (FL, cm)	Males		Females	
	n	% ripe or spent	n	% ripe or spent
12.0-13.9	12	†(0)	27	0
14.0-15.9	85	4	171	4
16.0-17.9	153	8	161	4
18.0-19.9	124	22	136	17
20.0-21.9	100	27	137	34
22.0-23.9	66	28	123	41
24.0-25.9	67	55	140	56
26.0-27.9	50	38	180	82
28.0-29.9	82	32	188	77
30.0-31.9	114	45	61	67
32.0-33.9	30	47	12	†(75)
34.0-35.9	3	(33)	1	(100)
36.0-37.9	2	(50)	2	(100)
38.0-39.9	0	—	0	—
Total	888		1,339	

†Percentages in parentheses are based on samples of fewer than 20 fish.

### 3.13 Mating

No records of mating in *H. aurolineatum* or *H. plumieri* were found. Billings and Munro (footnote 3) stated that pairing probably does not take place. Pairs of *H. plumieri* occasionally face and push each other with open mouths, but whether this is courtship or territoriality is not known (Böhlke and Chaplin 1968). Spawning aggregations may occur (Billings and Munro footnote 3).

See 3.51.

### 3.14 Fertilization

Fertilization is probably external with eggs and sperm being liberated simultaneously (Billings and Munro footnote 3).

### 3.15 Gonads

Haemulid gonads are paired, elongated structures lying along the dorsal wall of the body cavity adjacent to the swim bladder. The ovaries are rounded and translucent, and the testes are angular in cross section and opaque (Billings and Munro footnote 3). At maturity the ovaries are pink-brown and the testes white.

Mean percentage of body weight of ovaries of seven specimens of *H. aurolineatum* (mean body weight 91 g) measured by Billings and Munro (footnote 3) was 4.07%. Beebe and Tee-Van (1928) found the testes of a 12.5 cm SL male to be 1.5 cm long and 0.3 cm wide.

Gonosomatic indices of ripe adult *H. plumieri* from Campeche Bank were found to be 7.0-9.3 for females and 0.7-1.3 for males (Lyubimova and Kapote 1971). Billings and Munro (footnote 3) provided the following information for female *H. plumieri* from Jamaica:

	Mean body weight (g)	Mean ovary weight (g)	Mean percentage body weight
158-250	209	3.96	1.82
251-388	326	10.20	2.88

See 4.31.

### 3.16 Spawning

#### *Haemulon aurolineatum*

Spawning appears to take place over much of the year, with spawning peaks occurring. The time of spawning may vary geographically.

Manooch and Barans (footnote 5) reported that *H. aurolineatum* probably spawns primarily in mid-spring in the South Atlantic Bight. Running-ripe males and partially spent females were taken in April 1979: a considerable decrease in ovary weight followed the April sampling. Juveniles (3.3 cm TL) taken in summer trawl catches probably were spawned the previous year. More than 38% of the females caught in each season were maturing or ripe.

Hastings (1972) felt that the presence of juveniles near jetties in the Florida panhandle indicated summer and fall spawning there. This is later in the year than spawning reported by Longley and Hildebrand (1941) farther south in Florida. Plankton sampling in the eastern Gulf of Mexico by Houde et al. (footnote 4) indicated that the major abundance of haemulid larvae (probably mostly *Haemulon* spp.) in that area was in late winter and spring, probably indicating a winter-spring spawning peak.

On Campeche Bank, Sokolova (1965) reported *H. aurolineatum* spawning over about half the year with main spawning in fall, but beginning as early as July or August. Sauskan and Olacchea (1974) reported the main spawning on Campeche Bank in summer (July and September), with most pronounced spawning offshore on the central Bank at depths > 50 m. A secondary spawning peak occurred in the winter in nearshore and central areas of the eastern and western Bank (Fig. 6). Juárez (1975) reported two main spawning areas on Campeche Bank—one on the northeastern Bank

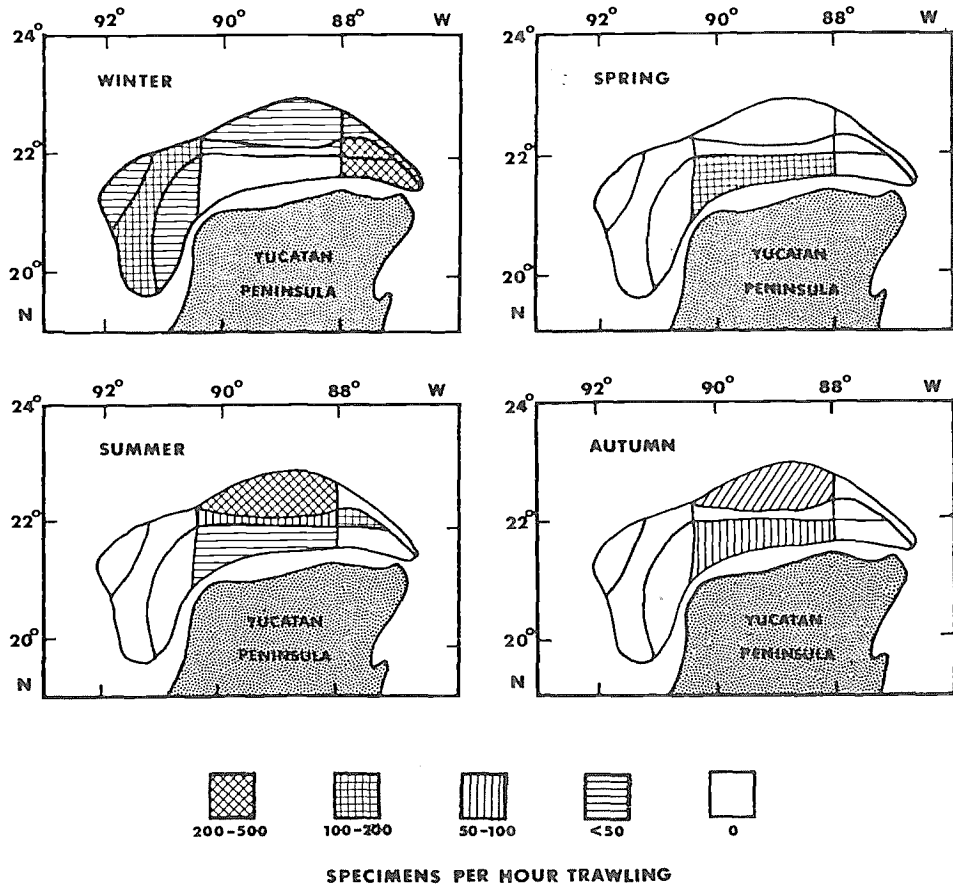


Figure 6.—Average abundance of spawning individuals of *Haemulon aurolineatum* in 1964-72 on Campeche Bank by season. (From Sauskan and Olachea 1974, fig. 8.)

in spring, and another on the central Bank in spring, summer, and fall.

Munro et al. (1973) collected ripe females in January, April, May, July, and August in Jamaica and observed juveniles throughout the year. Billings and Munro (footnote 3) also reported spawning year-round in Jamaica, with a peak from January through April. Least spawning activity occurred September through December. Peak spawning occurred at temperatures over 28°C, with little spawning activity at lower temperatures (Billings and Munro footnote 3).

*Haemulon aurolineatum* reportedly spawns from January to May and in July and August in Puerto Rico (Erdman 1977); year-round in Brazil (Cervigon 1966); and throughout the year in Venezuela, with a peak in July (Cervigon 1966).

#### *Haemulon plumieri*

Spawning appears to occur over much of the year, with a peak in spring. Smith (1968) found ripe fish near Miami, Fla., in late March and early April, but not in February. On the west coast of Florida, Reid (1954) reported that the presence of juveniles inshore in fall indicated spring spawning and perhaps an accompanying migration to deeper water. Moe's (1966) studies on the west coast of Florida indicated that large schools may form for spawning. Party boat catches examined by Moe (1966) had large numbers of ripe *H. plumieri* in May, some ripe and some spent fish in June, and no ripe individuals in July. Later tagging studies in the eastern Gulf of

Mexico (Moe 1972) showed that spawning aggregations occurred near home reefs, with little migration. On Campeche Bank, *H. plumieri* spawns in April and May. Evermann and Marsh (1902) found spawning *H. plumieri* off Puerto Rico in schools on shoals and over rocky bottoms in August and September, but Erdman (1956, 1977) found ripe *H. plumieri* in Puerto Rico from February to April, and in September and November, with a peak in March. Munro et al. (1973) found some spawning activity year-round in Jamaica, with a maximum in March and April and a minimum in October (Fig. 7). They noted that spawning on offshore banks was probably less seasonal. Billings and Munro (footnote 3) found the greatest propor-

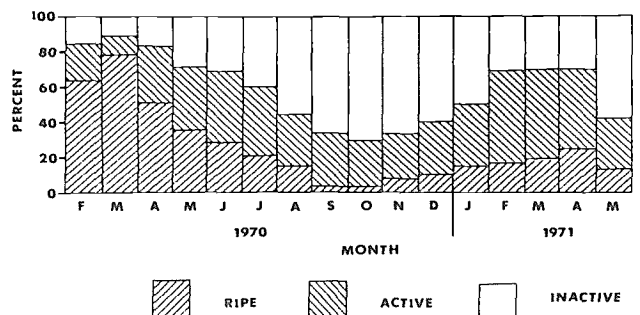


Figure 7.—Seasonal variations in the proportions of ripe, active, and inactive gonads of *Haemulon plumieri* in Jamaica (0-15 m). (From Munro et al. 1973, fig. 4a.)

tion of ripe *H. plumieri* in Jamaica from January through April, with a secondary peak in October and November. Minimum activity occurred in June, July, and December (Table 5). *Haemulon plumieri* appears to shed its eggs in batches over a period of time (Billings and Munro footnote 3).

Table 5.—Monthly percentages of inactive (I), active (A), ripe (R), and spent (S) gonads in samples of mature *Haemulon plumieri* in Jamaican waters. (From Billings and Munro see text footnote 3, table 3.4.1.)

Month	n	Percentage			
		I	A	R	S
January	157	38	18	38	6
February	176	31	29	34	8
March	120	28	38	25	9
April	275	7	8	47	38
May	222	33	35	21	11
June	163	55	34	4	7
July	155	52	32	11	5
August	147	51	27	19	3
September	174	72	13	5	10
October	199	56	11	22	11
November	262	39	22	22	17
December	217	58	26	9	4
Total	2,267				

### 3.17 Spawn

Although no specific information was found on the eggs of *H. aurolineatum*, Billings and Munro (footnote 3) provided general information on haemulid eggs. Prior to being spawned, the eggs are spherical, opaque, negatively buoyant in water, and about 0.5 mm in diameter. Ripe ovaries of most grunts examined had two egg size-classes—large ones ready to be spawned and smaller ones probably to be shed the following season. At ovulation, which probably takes place shortly before spawning, the eggs increase in size and become transparent.

Ripe ovarian eggs of *H. plumieri* are about 0.50 mm in diameter (Billings and Munro footnote 3) and the spawned eggs 0.90-0.97 mm in diameter (Saksena and Richards 1975). The eggs are unsculptured, contain a single oil globule 0.22-0.24 mm in diameter, and have a narrow (0.03 mm) perivitelline space and a transparent chorion (Saksena and Richards 1975).

### 3.2 Preadult phase

#### 3.21 Embryonic phase

Although there is no information available regarding *H. aurolineatum*, the eggs are probably pelagic. Hatching time is unknown.

Eggs of *H. plumieri* are probably pelagic and hatch in the laboratory in < 20 h at 24.2°C (Saksena and Richards 1975).

#### 3.22 Larvae and adolescent phase

##### *Haemulon aurolineatum*

There is little information on larvae of *H. aurolineatum*. Manooch and Barans (footnote 5) reported that identification of *H. aurolineatum* larvae was not possible at that time. Length of planktonic life of the larvae is not known, but may be short. Munro et al.

(1973) did not find haemulid larvae in open-ocean plankton samples taken near Jamaica, though Guitart Manday (1971) reported haemulid larvae (5.0-7.0 mm TL) in plankton hauls taken between 0 and 50 m, at night.

Juveniles are often found in shallow water, though distinguishing species is difficult in small individuals. The smallest juvenile grunts observed by Billings and Munro (footnote 3) in Jamaica were 1-2 cm (measurement unspecified), with small schools of juveniles present year-round, but especially in April, May, and August. Young school on nursery grounds or on reefs near adult schools and over *Thalassia* beds where they congregate at edges of sand patches (Billings and Munro footnote 3).

Courtenay (1961) described and illustrated juveniles from 18.5 to 53.9 mm SL. Head and caudal colorations are of prime importance in separating juvenile *Haemulon* species (Fig. 8): Courtenay's description of *H. aurolineatum* juvenile pigmentation follows: caudal spot and lateral stripe connected by scattered, dark melanophores in young individuals, later becoming separated; as growth proceeds, the oval spot is slightly constricted over the caudal base, spreading onto the caudal.

Juvenile *H. aurolineatum* change to the adult body form and color pattern at lengths over 5.4 cm SL. Transformation also involves a change in feeding strategy from diurnal plankton feeding to nocturnal benthic foraging in most grunts (Billings and Munro footnote 3).

##### *Haemulon plumieri*

Saksena and Richards (1975) reared *H. plumieri* in the laboratory and described larval development. At hatching, larvae were 2.7-2.8 mm SL with a large ellipsoid yolk sac and white pigment scattered over the body and yolk sac. Some yolk and the oil globule remained 24 h after hatching, but were almost completely absorbed after 48 h, when larvae were actively feeding. The following description of larval development is from Saksena and Richards (1975) (Figs. 9-12).

#### Morphology

Body depth at the pectoral fin symphysis 9.4% SL just after yolk absorption, 20% SL in 5.8 mm larvae, and 32.9% SL in 23.4 mm juveniles. Growth in the laboratory was most rapid during the first 30 d after hatching but slowly declined afterwards. Larvae grew from about 2.7 mm SL at hatching to 10.0 mm SL at 20 d, and 12.6 mm SL at 30 d, with an average daily growth rate of 0.32 mm/d. Standard length was about 96% TL for newly hatched larvae, but 82% TL for larvae 6.0-8.0 mm SL, and 80% TL for larvae larger than 12.0 mm SL. The larval gut was relatively short. A detailed table of morphometric data was presented by Saksena and Richards (1975) for larvae of various ages.

#### Pigmentation

Newly hatched larvae had several small melanophores from the snout to above the eyes, a few large stellate melanophores on the anterior edge of the yolk sac, several others along the gut and on the dorsal and ventral edges of the myomeres in the trunk region, and two small melanophores on the ventral edge and one on the dorsal edge of the notochord near its tip. The eyes began to develop pigment 1 d after hatching and were completely pigmented by the following day.

At 3.7 mm SL, melanophores became larger and more numerous, though pigment was absent from the head region. A few large stellate melanophores were on the dorsal edge of the gut and were

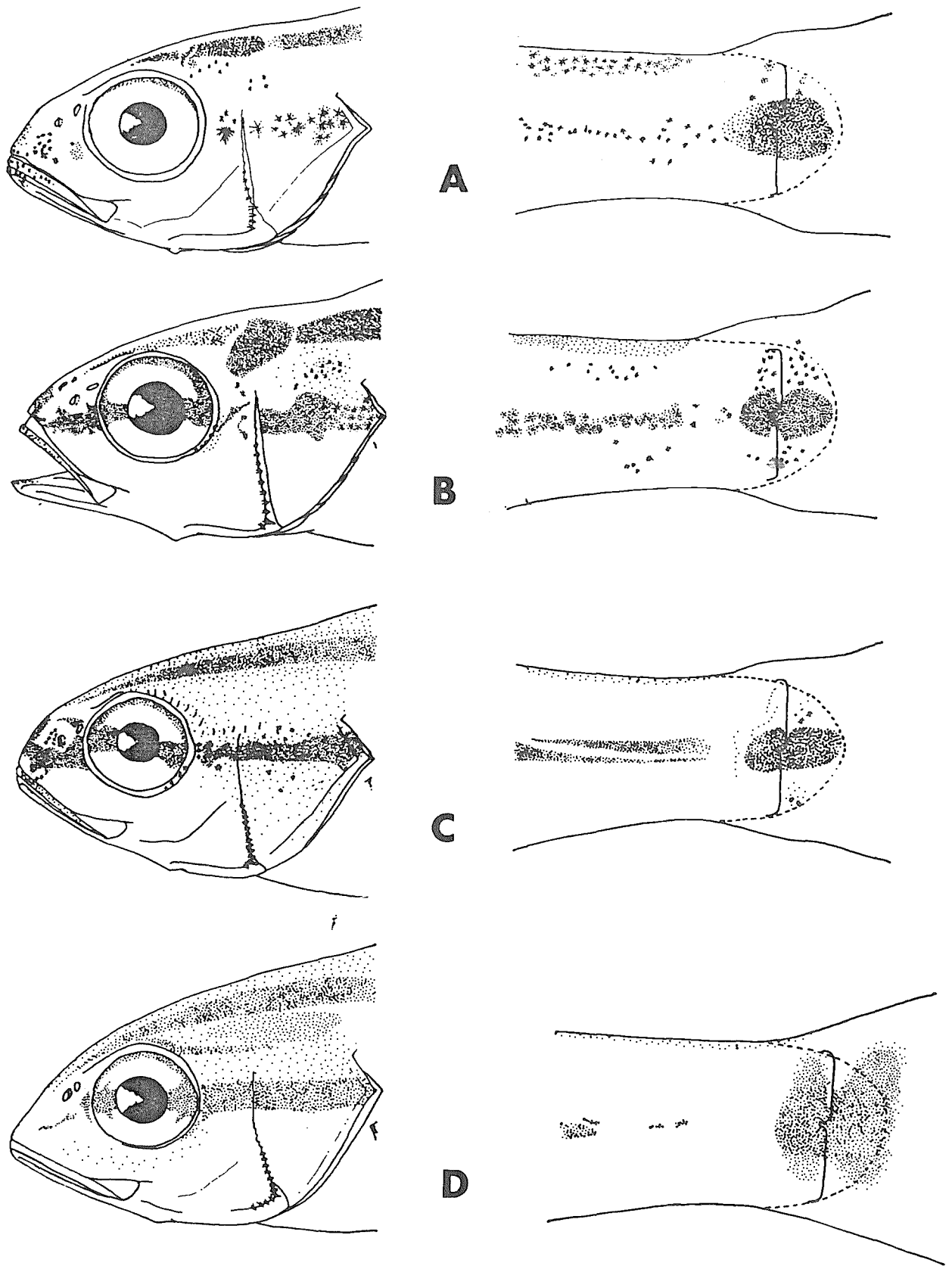


Figure 8.—Head and caudal regions of juvenile *Haemulon aurolineatum*. (From Courtenay 1961, figs. 13b-d, 14a.)



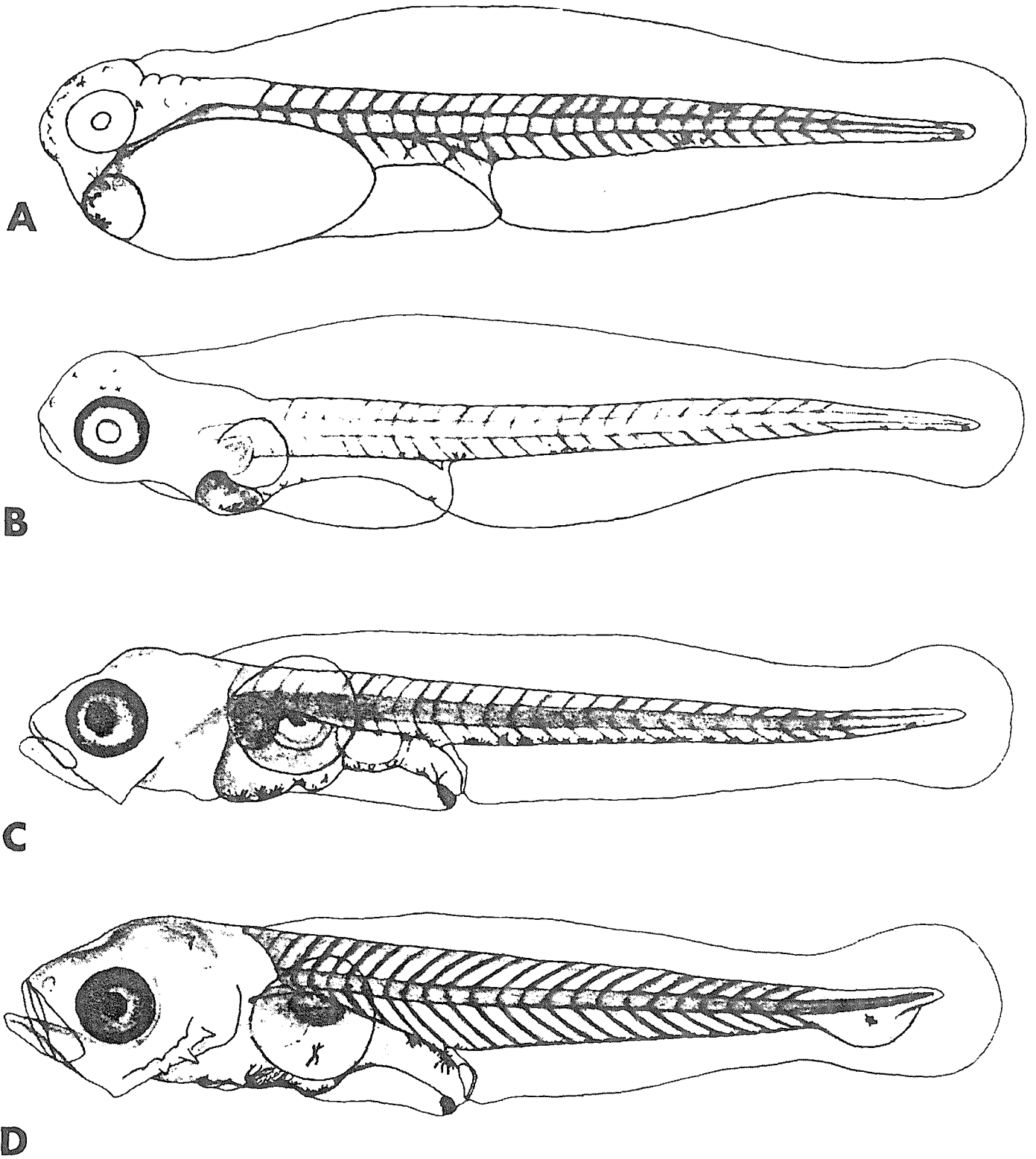


Figure 9.—Larvae of *Haemulon plumieri*: A. newly hatched, 2.7 mm SL; B. 1 d after hatching, 3.2 mm SL; C. 4 d after hatching, 3.7 mm SL; D. 6 d after hatching, 4.6 mm SL. (From Saksena and Richards 1975, figs. 1-4.)

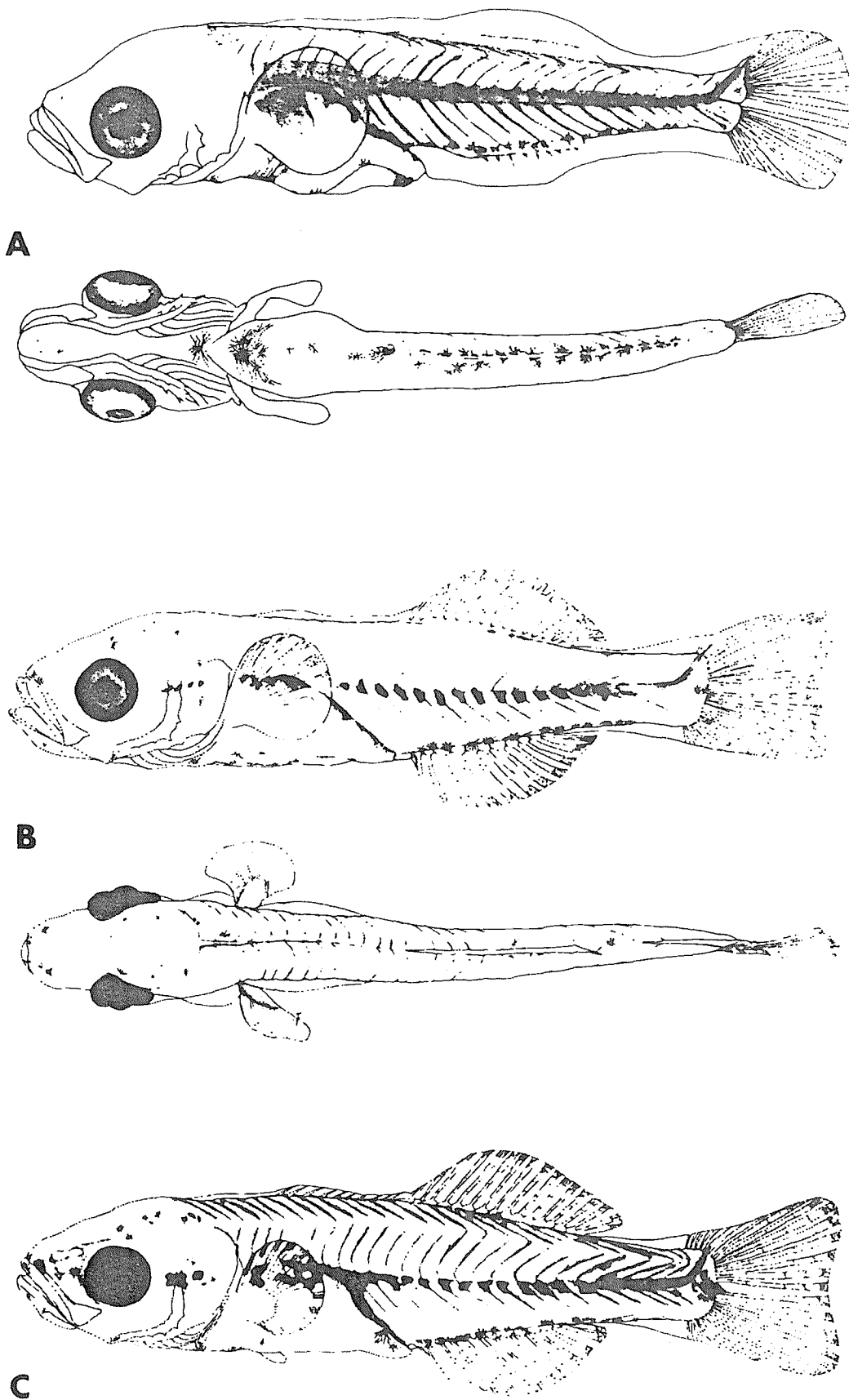


Figure 10.—Larve of *Haemulon plumieri*: A. lateral and ventral views of larva 9 d after hatching, 5.8 mm SL; B. lateral and ventral views of larva 12 d after hatching, 8.2 mm SL; C. 13 d after hatching, 9.1 mm SL. (From Saksena and Richards 1975, figs. 5-7.)

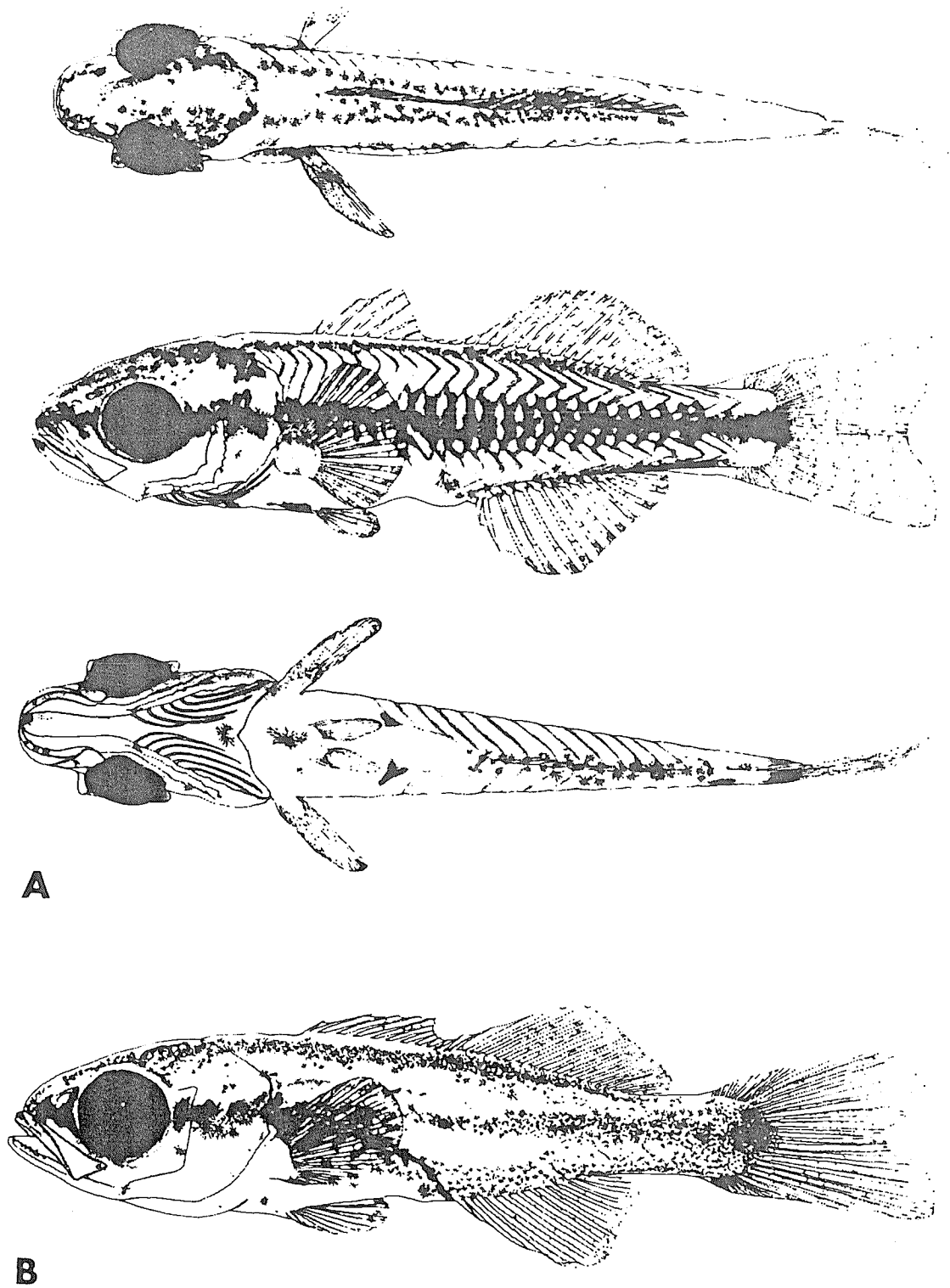
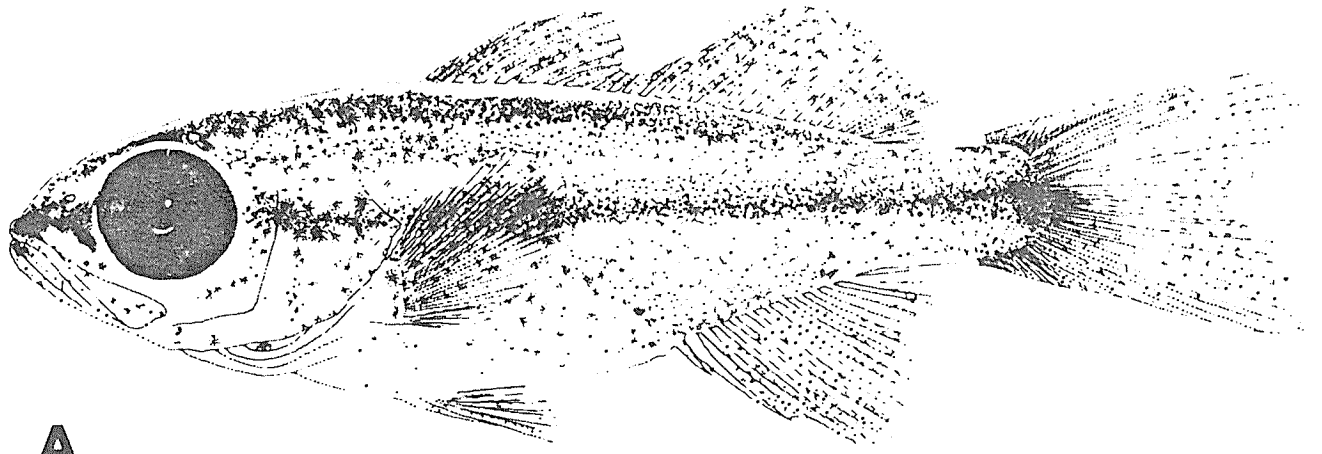
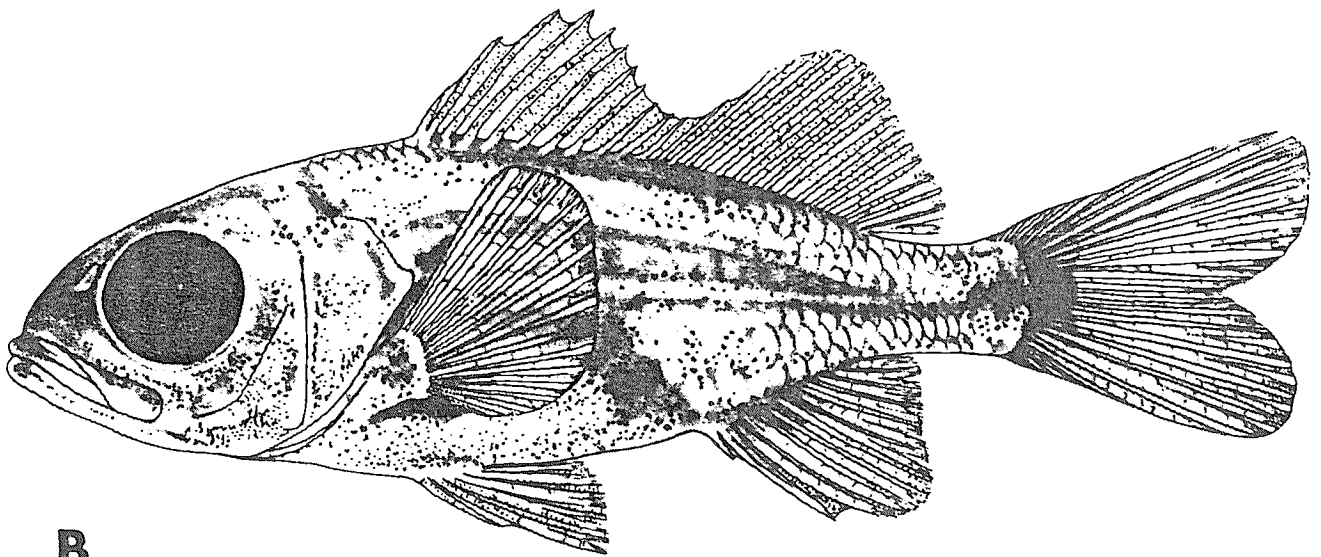


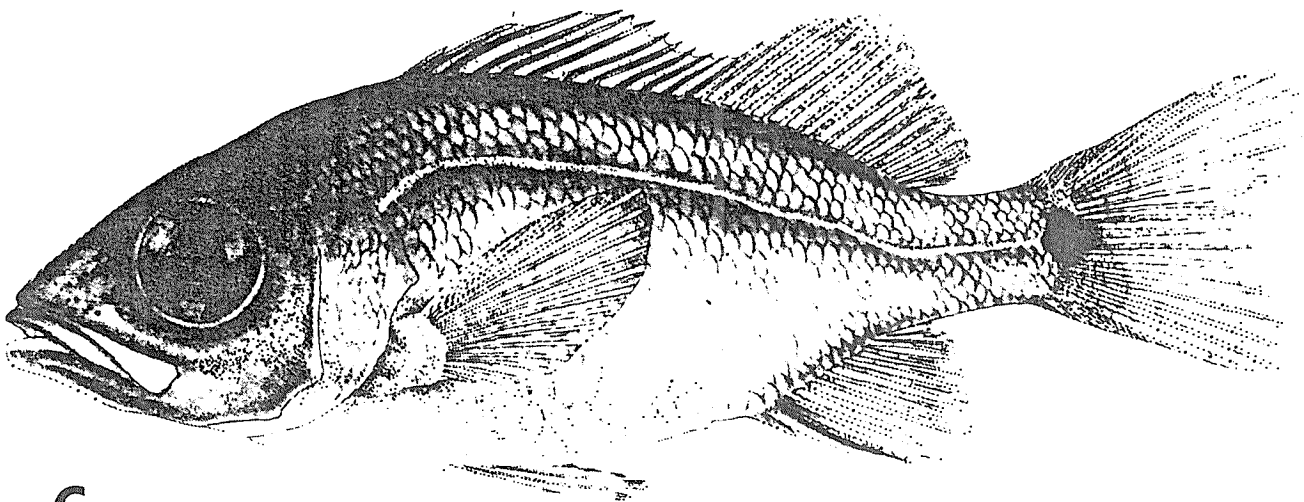
Figure 11.—Larvae of *Haemulon plumieri*: A. dorsal, lateral, and ventral views of larva 18 d after hatching, 9.8 mm SL; B. 30 d after hatching, 12.5 mm SL. (From Saksena and Richards 1975, figs. 8, 9.)



A



B



C

Figure 12.—Juveniles of *Haemulon plumieri*: A. 40 d after hatching, 13.6 mm SL; B. 102 d after hatching, 23.4 mm SL; C. 107 d after hatching, 38.5 mm SL. (From Saksena and Richards 1975, figs. 10-12.)

almost continuous with a series of melanophores arranged along the ventral edge of the myomeres. A small melanophore was present on the ventral edge of the notochord near its tip. Several large stellate melanophores were scattered on the ventral edge of the gut and a large melanophore was present on the anterior edge of the anus.

Pigmentation changed little from 3.7 to 8.2 mm SL, but melanophores became more numerous between 8.2 and 9.1 mm SL, with concentrations of pigment developing on the snout, premaxillaries, and lower jaw, and a midlateral stripe of melanophores ending in a dark spot on the caudal peduncle and fin. A series of large stellate melanophores was present posterior to the anus on the ventral edge of the body and at the base of the second dorsal fin.

At 9.8-12.5 mm SL, additional stellate melanophores formed on the dorsal part of the body and completed a dorsal body stripe. The midlateral stripe darkened and the caudal spot grew larger.

At 13.6 mm SL, the pigmentation had increased in the form of scattered melanophores over the entire body surface, including the fins. The dorsal and midlateral body stripes and the caudal spot were more pronounced, and a third body stripe developed between the first two stripes, extending from the eye to posterior of the first dorsal fin.

Between 23.4 and 38.5 mm SL, pigment was less intense and no definite stripes were present. Except for the caudal spot there was no definite body pattern.

## Fins

Newly hatched larvae had a prominent finfold which persisted, in part, until 5.7 mm SL. Fin ray development was completed between 9.5 and 10.0 mm SL. Fan-shaped pectoral fins without rays developed 1 d after hatching, at 3.2 mm SL. Rayed fins developed in the sequence: caudal, anal and second dorsal, first dorsal and pelvics, and pectorals. The full complement of principal caudal rays (9 + 8) was present at 7.8 mm SL, with secondary rays starting to develop at 7.9 mm SL. The anal fin began to form at 5.7 mm SL, with the first fin elements arising at 5.8 mm SL. Although the full complement of 12 anal fin elements (II, 10) was present at 6.9 mm SL, the normal adult arrangement (III, 9) was not present until 38.5 mm SL. The third anal spine developed first as a segmented ray.

Elements of the second dorsal fin began to develop at 5.8 mm SL, reaching their full complement (I, 15) at 7.9 mm SL. Pelvic fins appeared as buds at 7.9 mm SL, with the spine developing at 8.3 mm SL, and all elements (I, 5) formed by 9.5 mm SL. Spine development in the first dorsal fin began at 7.9 mm SL and reached the full complement (XI) by 9.5 mm SL. The first pectoral rays were discernible at 7.9 mm SL, with the full complement (16 or 17) reached by 9.8 mm SL. Pectoral fin development was dependent more on age than length of the larvae.

Saksena and Richards (1975) also described osteological development of the cranium, fin supports, and vertebral column, and squamation.

Courtenay (1961) described and figured juvenile pigmentation of *H. plumieri* (Fig. 13). Above about 40 mm the young have essentially the adult color pattern. Unlike most *Haemulon* species, *H. plumieri* juveniles lack lateral stripes.

See 2.21.

## 3.3 Adult phase

### 3.31 Longevity

Courtenay (1961) reported that mature adult *H. aurolineatum* average 12.5-17.5 cm SL, the largest specimen he examined being

18.5 cm SL. Much larger adults have since been reported. Sokolova (1965) found that *H. aurolineatum* reach 30 cm (measurement unspecified) and live more than 5 yr on Campeche Bank; Sauskan and Olacchca (1974) found that *H. aurolineatum* may reach 7 yr old on Campeche Bank. The largest specimen collected by Billings and Munro (footnote 3) in Jamaica was 19.5 cm SL; asymptotic fork length estimated for Jamaican *H. aurolineatum* was 23.0 cm. The largest individual sampled by Manooch and Barans (1979) off the southeastern United States was 28.9 cm TL and 9 yr old. Hildebrand and Schroeder (1928) reported a maximum weight of about 0.45 kg (1 lb) for *H. aurolineatum* in the Chesapeake Bay region, and Konchina (1977) gave a maximum weight of about 0.5 kg.

*Haemulon plumieri* reaches about 45.0 cm and 2.5 kg (Konchina 1977), though most specimens are much smaller. The largest reported taken on Campeche Bank (Kapote 1971) was a 31.5 cm male that was more than 6 yr old. Manooch (1976) reported that males off the Carolina coast of the United States reach 12 yr, and females 9 yr, and calculated a theoretical maximum length ( $L^\infty$ ) of 64.0 cm TL. The largest *H. plumieri* taken in Jamaica by Billings and Munro (footnote 3) was 40.6 cm FL, the calculated asymptotic fork length for Jamaican specimens being 42.0 cm.

See 3.43 and 4.13.

### 3.32 Hardiness

*Haemulon aurolineatum*, though basically a warm-water species, is more tolerant of low temperatures and ranges farther north on the east coast of the United States than any other haemulid, except possibly *H. plumieri* (Billings and Munro footnote 3). *Haemulon aurolineatum* and *H. plumieri* were the only grunts to remain in shallow water off Florida in the cold winter of 1957 (Courtenay 1961), though *H. aurolineatum* has been reported killed during cold waves at temperatures below about 14°C (Galloway 1941). Manooch and Barans (footnote 5) reported them absent at temperatures below about 10°C and rare below 13°C off the southeastern United States. Young may be somewhat more tolerant of temperature and salinity extremes than adults (Billings and Munro footnote 3), though Manooch and Barans (footnote 5) noted that juveniles were found at more moderate temperatures than adults off the coast of the southeastern United States. *Haemulon aurolineatum* was one of the few grunts observed by Billings and Munro (footnote 3) in polluted Kingston Harbor, Jamaica.

*Haemulon plumieri* has been collected in water as cold as 13°C (Hastings 1972) and as warm as 35°C (Wang and Raney 1971). Cold deaths of *H. plumieri* were reported at Sanibel Island, Fla. (Storey 1937); Key West, at a water temperature of 14°C (Galloway 1941); and Indian River lagoon, Fla., at a water temperature of 11.1°C (Gilmore et al. 1978).

*Haemulon plumieri* is fairly tolerant of salinity, being found from relatively low salinities (18‰) to over 37‰ (Roessler 1970). Juveniles may have greater tolerance of salinity and temperature than adults (Billings and Munro footnote 3).

Although Springer and Woodburn (1960) listed *H. plumieri* as one of the species killed by a red tide off Pinellas County, Fla., in 1957, Smith (1976) reported that it was one of the fishes in shallow water in the eastern Gulf of Mexico that withstood the red tide of 1971. Smith (1976) speculated that the success of *H. plumieri* during and after the red tide may have been due to its nonspecific habitat needs and relative lack of strict ties to the substrate.

Billings and Munro (footnote 3) found that over 4% of *H. plumieri* entering traps in Jamaica died within 2 wk of entering the traps.

See 2.23.

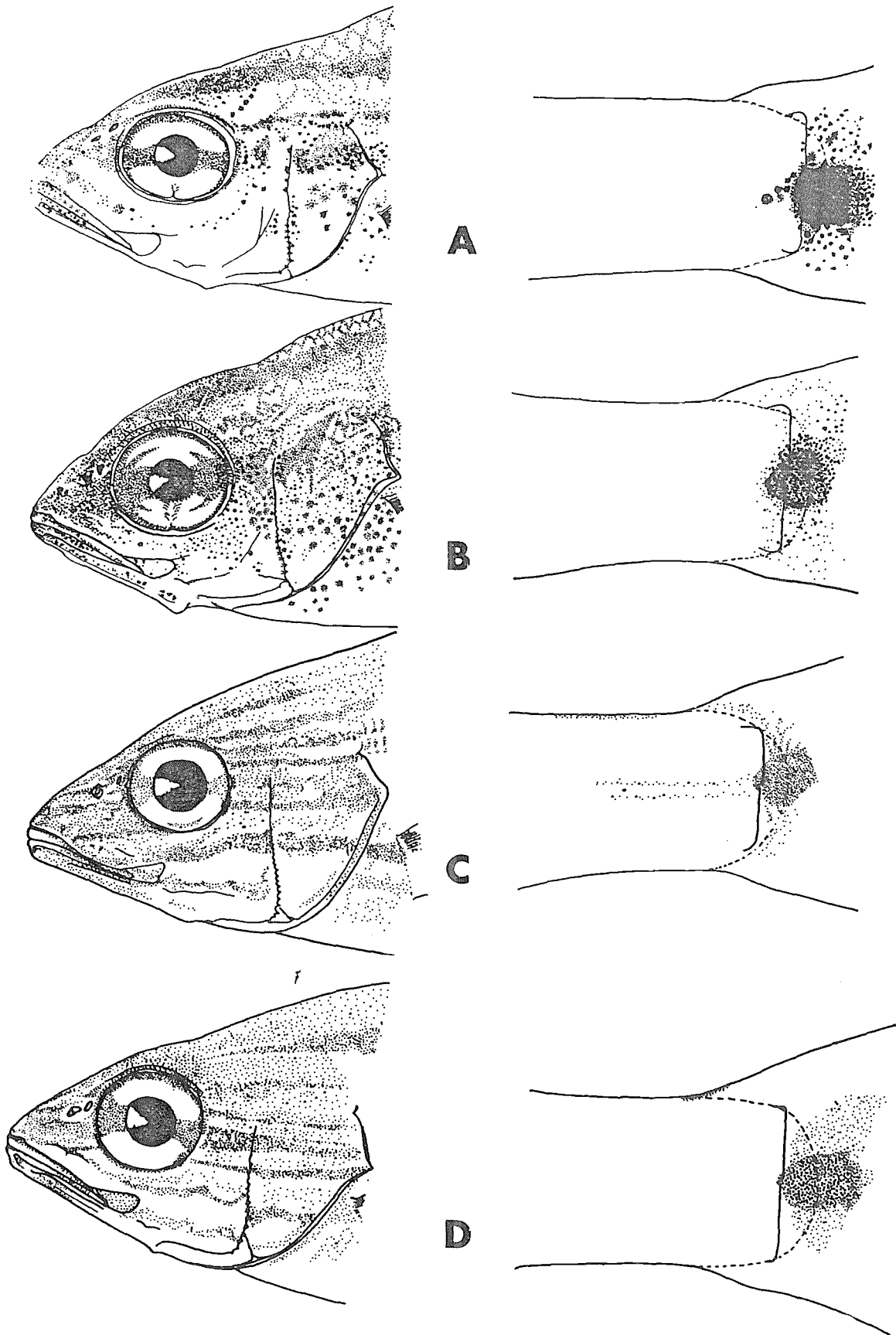


Figure 13.—Details of head and caudal base pigmentation in young *Haemulon plumieri*: A. 19.8 mm SL; B. 23.2 mm SL; C. 35.6 mm SL; D. 42.5 mm SL. (From Courtenay 1961, figs. 12b-d, 13a.)

### 3.33 Competitors

The most important food competitors of grunts are porgies, goatfishes, wrasses, hogfishes, and mojarras (Randall 1967; Billings and Munro footnote 3). Interspecific competition for food is probably not great due to the variety of food items consumed and because each species favors a particular food type (Billings and Munro footnote 3). Some competition may exist for schooling sites on reefs, though competition for both food and space resources may be reduced through diurnal-nocturnal migrations, and habitat differences between juveniles and adults. Although small grunts are usually not territorial, large individuals may vigorously defend territories up to 2 m in diameter, intraspecifically (Motchek and Silva Lee 1975).

*Haemulon plumieri* often associates with other species and may school heterotypically. Davis (1967) found *H. plumieri* with *H. album*, *H. melanurum*, and *H. parrai* near hard substrates and with *H. aurolineatum* over grass patches near Alligator Reef. Ogden and Ehrlich (1977) reported young *H. plumieri* schooling with *H. flavolineatum* and *Mulloidichthys martinicus* in the Virgin Islands. See 3.51.

### 3.34 Predators

*Haemulon aurolineatum* is preyed upon by a wide variety of predators. Randall (1967) listed *H. aurolineatum* from the stomachs of several other reef species: *Gymnothorax moringa*, *Aulostomus maculatus*, *Lutjanus analis*, *L. cyanopterus*, *L. joco*, *Ophichthys oplis*, *Epinephelus striatus*, and *Seriola dumerili*. *Haemulon aurolineatum* has been found in stomachs of *Scomberomorus maculatus* off Ceará, Brazil, (Ferreira de Menezes 1970) and in adult *Pagrus pagrus* off the Carolinas (Manooch 1977). In Jamaica, grunts are preyed upon by serranids, lutjanids, and carangids (Billings and Munro footnote 3) and in Cuba by serranids and sphyraenids (Valdés Muñoz and Silva Lee 1977).

*Haemulon aurolineatum* may be important in diets of other commercially valuable fishes. Springer and Woodburn (1960) reported that a specimen of *Epinephelus morio* taken on a reef off Tampa Bay, regurgitated hundreds of small *H. aurolineatum*. Packer (pers. commun. as cited in Manooch and Barans footnote 5) found young specimens approximately 33 mm long (TL) in stomachs of black sea basses, *Centropristis striata*, off North Carolina near ridges on the shelf.

Predators of *H. plumieri* include groupers (*Epinephelus* spp.) and lizardfish (*Synodus* spp.) (Ogden and Ehrlich 1977); Spanish mackerel, *Scomberomorus maculatus* (Ferreira de Menezes 1970); dog snapper, *Lutjanus joco* (Randall 1967); and sharks (Billings and Munro footnote 3). Other suitably large piscivores probably also prey on *H. plumieri*.

No information regarding predators on eggs or larvae is available.

### 3.35 Parasites, diseases, injuries, and abnormalities

Trematodes have been found in the caecum and intestine of *H. aurolineatum*: *Genolopa ampullacea* from Gulf of Mexico specimens (Manter 1954) and *Hamacreadium oscitans*, *Lasiotocus longicaecum*, and *L. longovatus* from Jamaican specimens (Nahhas and Cable 1964).

Overstreet (pers. commun. as cited in Smith 1968) reported that *H. plumieri* in Biscayne Bay, Fla., contained monogean, digean, acanthocephalan, nematode, and cestode parasites. Billings and

Munro (footnote 3) found cestode larvae (c.f. *Otobolurium dipsacum*) in bladders of *H. plumieri* from Jamaica, as well as nematodes in gut mesenteries and ovaries.

Billings and Munro (footnote 3) mentioned haemulid injuries which probably were the result of predatory attacks. Gudger (1933) reported a pug-headed specimen of *H. plumieri*.

### 3.36 Chemical composition

Korzhova (1965) analyzed the composition of *H. aurolineatum* from the Gulf of Mexico and Caribbean Sea and found that 34.5% of the total fish weight was skin and flesh and 41.5% of the total weight was head. Flesh contained 20.6% protein and had a caloric content of 97 calories/100 g wet weight. Composition of the whole fish was 72.4% water, 17.2% protein, 4.5% fat, and 4.9% ash. Edwards (1973) found the content of homogenized *H. aurolineatum* from Venezuela to be 67.51% protein, 22.73% ash, 9.36% lipids, and 0.59% carbohydrates. Total caloric content was 4.762 kcal/g dry weight.

Detailed studies on protein digestion, absorption, and peptidase activity in *H. plumieri* were conducted by Smith (1967, 1968, 1970). Earlier studies by Pierce (1936) found digestion time in *H. plumieri* to be 25-33 h. Composition of *H. plumieri* is 77.3% water, 19.4% protein, 0.7% lipids, and 1.6% ash (Gutiérrez B. 1976).

Cequea R. and Pérez (1971) studied plasma proteins and hemoglobins of *H. aurolineatum* and *H. plumieri*, using electrophoresis.

### 3.4 Nutrition and growth

#### 3.41 Feeding

*Haemulon aurolineatum* and *H. plumieri* are primarily benthic feeders, although their larval and early juvenile stages may feed higher in the water column.

Foraging of *H. aurolineatum* is usually on sand or grass flats near reefs, primarily at night (Randall 1963; Davis 1967; Collette and Talbot 1972; Smith and Tyler 1972; Ogden and Ehrlich 1977; Parrish and Zimmerman 1977). Hastings et al. (1976) reported similar nocturnal foraging near offshore platforms in the Gulf of Mexico and noted the significance of this behavior in importing biomass to reef or platform communities. Sauskan and Olaechea (1974) reported that feeding of *H. aurolineatum* on Campeche Bank was most intense in winter and spring and low during spawning.

*Haemulon plumieri* also feeds primarily at night, migrating off reefs to forage in seagrass beds and over alcyonarian patches (Randall 1963, 1967; Davis 1967; Motchek and Silva Lee 1975; Ogden 1977; Ogden and Ehrlich 1977). Hastings et al. (1976) found that *H. plumieri* feeds on attached material on pilings around offshore platforms in the northern Gulf of Mexico. Very small juveniles pick plankton from the water column during the day (Ogden and Ehrlich 1977).

See 3.51.

#### 3.42 Food

##### *Haemulon aurolineatum*

*Haemulon aurolineatum* is a generalized carnivore, preying primarily on benthic invertebrates of moderate to very small size; small juveniles feed primarily on zooplankton (Randall 1967). Beebe and Tee-Van (1928) reported that *H. aurolineatum* is omnivorous, their specimens from Port-au-Prince Bay containing sand,

mud and bottom detritus, algae, worms, mollusks, copepods, isopods, shrimps, small crabs, and plankton, but Randall (1967) felt that the algal and detrital material they reported was probably ingested incidentally along with invertebrates. Longley and Hildebrand (1941) noted that *H. aurolineatum* is less intimately associated with coral habitats than some other grunts and found 1,000 planktonic copepods in the stomach of a single 50 mm SL specimen.

Davis (1967) found alpheid shrimps, stomatopods, ostracods, amphipods, isopods, hermit crabs, copepods, fish, polychaetes, gastropods, and sand in *H. aurolineatum* collected in the Florida Keys. Randall (1967) examined guts from Puerto Rico and Virgin Islands specimens (Table 6). Edwards (1973) reported polychaetes, amphipods, and mollusks as the main foods of *H. aurolineatum* in Venezuela. Sauskan and Olacchia (1974) reported the diet of *H. aurolineatum* on Campeche Bank as about 70% crustaceans (squillids, brachyurans, penaeids), 18% polychaetes, 7% blue-green algae, and 5% small fish. Valdés Muñoz and Silva Lee (1977) found *H. aurolineatum* feeding on polychaetes, unidentified eggs, amphipods, and mollusks on artificial reefs off the southwest coast of Cuba.

Table 6.—Stomach contents of *Haemulon aurolineatum* from Puerto Rico and the U.S. Virgin Islands. (From Randall 1967.)

Food	Volume (%)
Shrimps and shrimp larvae	33.6
Polychaetes ( <i>Chlacia</i> sp.)	31.0
Unidentified crustaceans	8.8
Unidentified eggs	6.2
Hermit crabs and larvae	4.4
Crabs and crab larvae	3.7
Amphipods ( <i>Ampelisca</i> sp., <i>Elasmopus</i> sp., <i>Euryxtheus</i> sp., <i>Megamphopus</i> sp., <i>Plutis</i> sp.)	3.4
Copepods ( <i>Uca</i> sp.)	2.5
Gastropods ( <i>Alvania auberiana</i> , <i>Caecum pulchellum</i> , <i>Retusa</i> sp.)	2.1
Pelecypods ( <i>Salenya occidentalis</i> )	1.6
Barnacle larvae	0.9
Scaphopods ( <i>Cadulus acus</i> , <i>Dentalium</i> sp.)	0.4
Isopods	0.2

About 44% of the specimens from Puerto Rico examined by Parrish and Zimmerman (1977) contained crabs, primarily the xanthid sandflat crab *Micropanope lobifrons*, but also *Portunus spinicarpus*, *Portunus* sp., and *Pinnixa*. Also frequently abundant in the guts were shrimp, such as the carideans *Leptochela serratorbita*, *Sicyonia*, and *Latreutes*, and alpheids. The squillid *Pseudosquilla ciliata*; ascidians (mostly *Microcosmus helleri*); the bivalve mollusks *Musculus lateralis*, *Tellina consobrina*, and *Pitar* sp.; amphipods (mostly *Chevalia aviculae*); polychaetes; tanaids; and isopods were also found.

#### *Haemulon plumieri*

*Haemulon plumieri* is also a generalized carnivore, adults feeding particularly on benthic invertebrates (Manooch 1976). Beebe and Tee-Van (1928) reported *H. plumieri* collected in Haiti contained echinoderms, polychaetes, mollusks, shrimp, crabs, and fish (including *Diodon hystrix*). *Haemulon plumieri* from Alligator Reef contained polychaetes, majid crabs, alpheid shrimps, isopods, fish, and sand (Davis 1967). Parrish and Zimmerman (1977) found crabs and amphipods in specimens of *H. plumieri* from Puerto Rico. Randall (1967) and Valdés Muñoz and Silva Lee (1977) presented detailed accounts of food items of *H. plumieri* in Puerto Rico and the Virgin Islands, and Cuba, respectively (Tables 7, 8).

Table 7.—Stomach contents of *Haemulon plumieri* from Puerto Rico and the U.S. Virgin Islands. (From Randall 1967.)

Food	Volume (%)
Crabs ( <i>Mithrax</i> sp.)	26.0
Polychaetes	14.5
Echinoids ( <i>Diadema anillarum</i> , <i>Eucidaris tribuloides</i> , spatangoid)	12.4
Sipunculids ( <i>Aspidosiphon</i> sp.)	8.3
Gastropods ( <i>Acmaca antillarum</i> , <i>Strombus gigas</i> )	6.9
Shrimps (alpheids)	5.8
Ophiuroids ( <i>Ophiotrix</i> )	5.7
Unidentified crustaceans	5.3
Fishes	3.3
Hemichordates	3.3
Unidentified animal matter	3.0
Holothurians ( <i>Thyane pseudofusus</i> )	2.7

Table 8.—Food of *Haemulon plumieri* in Cuba. (From Valdés Muñoz and Silva Lee 1977, tables 8, 9.)

Food	Volume (%)
From mangrove areas	
Polychaetes	25.7
Crustaceans (carida, ostracoda, amphipoda, tanaidacea, portunids, pagurids, copepods, isopods, mysids, cumaceans, nebaliceans)	8.8
Tunicates	3.5
Echinoderms (holothurians, ophiuroids)	1.9
Mollusks (scaphopods, chitons, fissurellid limpets)	1.1
Fish (ophichthyids)	0.3
Unidentified	58.8
From natural reefs, Cayo Diego Pérez	
Crustaceans	52.2
Polychaetes	3.6
Nemertean	0.5
Mollusks	0.5
Echinoderms	0.5
Unidentified	42.5

Carr and Adams (1973) found that juveniles (21–40 mm SL) from Crystal River were mainly planktivorous. Copepods were the main food item in specimens 21–35 mm SL, followed by a transition to mysids and postlarval shrimp (60% of stomach contents of 36–40 mm fish). Sand grains and detritus were also found in the stomachs examined. Reid (1954) reported similar results from juveniles collected at Cedar Key.

#### 3.43 Growth rate

##### *Haemulon aurolineatum*

Several workers have published information on growth of *H. aurolineatum*, most indicating that they grow fairly rapidly before maturity and quite slowly after maturity. Sokolova (1965) back-calculated sizes at age from scales and reported rapid growth in the first 2 yr of life of Campeche Bank fish. Sauskan and Olacchia (1974) also found that *H. aurolineatum* on Campeche Bank grew more rapidly prior to maturity than after. Olacchia and Hernández (1976) calculated a von Bertalanffy relationship for Campeche Bank *H. aurolineatum*, with considerably different parameters. Manooch and Barans (footnote 5) aged specimens from the South Atlantic Bight, using otoliths and scales, and found that the first annulus of the otolith usually formed in late winter or early spring. Growth increments of *H. aurolineatum* aged by scales were:



Age increment (yr)	Length increase (mm, TL)
I-II	46.5
II-III	21.1
III-IV	17.0
IV-V	14.5

$$TL = 1.7489 SR^{0.9572} \quad (r = 0.93, n = 103).$$

*Haemulon aurolineatum* grows faster than most other previously studied reef fishes from the South Atlantic Bight (Manooch and Barans 1979). Size-at-age data based on the work of several investigators appear in Table 9, and von Bertalanffy growth parameters are listed in Table 10.

where total lengths (TL) and scale radii (SR) are related by the function:

Length-weight relationships of *H. aurolineatum* were derived by several workers (Table 11). Other growth data were provided by

Table 9.—Size-at-age data for *Haemulon aurolineatum*.

Measurement and source	Age (yr)								
	1	2	3	4	5	6	7	8	9
Mean length (cm)									
Sokolova 1965 <sup>1</sup>	8.94	12.40	15.21	17.22	18.94	20.20	— <sup>2</sup>	—	—
Sauskan and Olacchea 1974 <sup>3</sup>	10.7	14.7	17.2	18.0	18.5	19.3	20.0	—	—
Manooch and Barans (text footnote 5) <sup>4</sup>	13.54	18.19	20.30	22.00	23.45	25.57	26.58	27.70	28.67
Manooch and Barans (text footnote 5) <sup>5</sup>	10.30	16.93	19.93	21.60	23.04	24.62	25.80	26.62	28.05
Manooch and Barans (text footnote 5) <sup>6</sup>	12.24	15.94	18.92	21.31	23.22	24.76	25.99	26.98	27.78
Mean weight (g)									
Sauskan and Olacchea 1974 <sup>7</sup>	46.1	92.3	125.7	136.6	144.6	156.0	166.8	—	—
Sauskan and Olacchea 1974 <sup>8</sup>	33.6	80.8	116.8	138.3	150.5	157.3	160.1	—	—

<sup>1</sup>Campeche Bank, 1964: lengths back-calculated from scales; type of length measurement unspecified.

<sup>2</sup>Not given.

<sup>3</sup>Campeche Bank: observed lengths; type of length measurement unspecified.

<sup>4</sup>South Atlantic Bight: observed total lengths.

<sup>5</sup>South Atlantic Bight: back-calculated total lengths.

<sup>6</sup>South Atlantic Bight: theoretical total lengths based on von Bertalanffy equation:

$$l_t = 310 (1 - \exp[-0.22017(t + 1.28)]).$$

<sup>7</sup>Campeche Bank: observed weights.

<sup>8</sup>Campeche Bank: theoretical weights based on von Bertalanffy equation:

$$W_t = 1.645.5 (1 - \exp[-0.664(t + 0.34)]).$$

Table 10.—Von Bertalanffy growth equation parameters for *Haemulon aurolineatum* and *H. plumieri*. Standard equation for length at age is:  $l_t = L_\infty(1 - e^{-k(t-t_0)})$ , and for weight at age:  $w_t = W_\infty(1 - e^{-k(t-t_0)})^b$ .

Species and source	Locality	Parameter					
		$L_\infty$ (cm)	$W_\infty$ (g)	$t_0$ (yr)	$K$	$b$	
<i>H. aurolineatum</i>	Sauskan and Olacchea 1974	— <sup>1</sup>	164.5	-0.34	0.664	3	
	Olacchea and Hernández 1976	Campeche Bank	27.13	—	-1.7511	0.1839	—
	Manooch and Barans 1979	South Atlantic Bight	31.0	—	-1.28	0.22017	—
<i>H. plumieri</i>	Billings and Munro (text footnote 3)	Jamaica	42.0	—	—	0.34	—
	Manooch 1976	Carolinas	64.0	—	-1.007	0.1084	—

<sup>1</sup>Not given.

Billings and Munro (footnote 3) from Jamaica:  $SL = 0.88 FL + 0.3$ , where SL is standard length and FL is fork length, both in centimeters; and  $d = 0.300 l - 0.20$ , where  $l$  is fork length and  $d$  is body depth, both in centimeters.

#### *Haemulon plumieri*

Several studies have been conducted to evaluate growth of *H. plumieri*. Moc (1966, 1967) provided growth data based on tag-recapture studies on the west coast of Florida (Table 12). Length-at-age data were collected by Kapote (1971) and Manooch (1976) for *H. plumieri* from Campeche Bank and the Carolina coast, respectively (Table 13). Growth rate appears to be higher along the coast of the southeastern United States than on Campeche Bank. Billings and Munro (footnote 3) studying Jamaican populations, found that offshore populations grew faster than inshore populations. Growth rates in Jamaica were higher than those reported by Moc (1966, 1967) and Manooch (1976); von Bertalanffy growth equation parameters are presented in Table 10. Growth curves prepared by Billings and Munro (footnote 3) and Manooch (1976) appear in Figures 14 and 15.

Table 11.—Length-weight parameters for *Haemulon aurolineatum* and *H. plumieri*. The length-weight relationship is defined as:  $L = aW^b$ , where  $L$  is length in centimeters and  $W$  is body weight in grams.

Species	Locality	Restrictions	Parameter		Source
			$a$	$b$	
<i>H. aurolineatum</i>	South Atlantic Bight		0.0099	3.0905	Manooch and Barans (text footnote 5) <sup>1</sup>
	Jamaica	Specimens 7.2-11.6 cm FL	0.0094	3.25	Billings and Munro (text footnote 3) <sup>2</sup>
	Jamaica	Specimens 12.1-18.0 cm FL	0.0298	2.79	Billings and Munro (text footnote 3) <sup>2</sup>
	Venezuela		0.0023	3.4396	Edwards 1973 <sup>3</sup>
<i>H. plumieri</i>	N. and S. Carolina	Males and females	0.0150	3.0229	Manooch 1976 <sup>4</sup>
	N. and S. Carolina	Males only	0.0135	3.0503	Manooch 1976 <sup>4</sup>
	N. and S. Carolina	Females only	0.0153	3.0214	Manooch 1976 <sup>4</sup>
	Jamaica		0.0238	2.93	Billings and Munro (text footnote 3) <sup>2</sup>

<sup>1</sup>Used total length, wet body weight;  $r = 0.996$ ,  $n = 70$ .

<sup>2</sup>Used fork length, wet body weight.

<sup>3</sup>Used standard length, dry body weight.

<sup>4</sup>Used total length, wet body weight;  $r = 0.97$ .

Table 12.—Growth of tagged-recaptured *Haemulon plumieri* in the eastern Gulf of Mexico. (From Moe 1966, table 7; 1967.)

TL at tagging (mm)	TL at recapture (mm)	Growth rate (mm/mo)
225	234	3.6
262	338	2.0
264	280	1.9
280	286	2.4
287	307	1.4

Length-weight relationship parameters of *H. plumieri* are presented in Table 11. Females weigh somewhat less than males of a comparable length (Manooch 1976). Billings and Munro (footnote 3) calculated other body relationships of *H. plumieri*:

$SL = 0.92 FL - 0.5$ , where  $SL$  is standard length and  $FL$  is fork length;

$TL = 1.15 FL$ , where  $TL$  is total length;

body depth (cm) =  $0.366 FL$  (cm) - 0.50; and

scale radius (mm) =  $0.366 FL$  (cm) + 1.35.

Manooch (1976) related scale radius ( $SR$ ) to total length as follows:

$$TL = 0.5180 (SR)^{1.1824} \quad (r = 0.93).$$

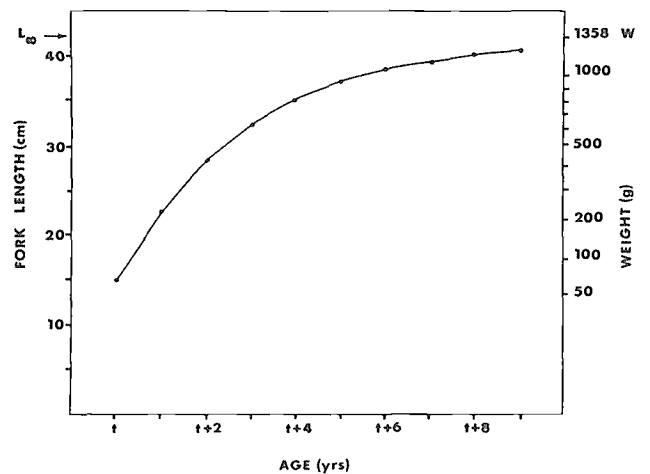


Figure 14.—Growth curve for *Haemulon plumieri* in Jamaica estimated using the growth equation:  $l_{(t+1)} = L_{\infty}(1 - k) + kl_t$  derived from von Bertalanffy, where  $L_{\infty} = 42$  cm,  $k = 0.71$ , and  $t = 1$  yr. The instantaneous growth rate ( $K$ ) is 0.34. (From Billings and Munro see text footnote 3, fig. 3.7.)

Table 13.—Size-at-age data for *Haemulon plumieri*. All lengths are in centimeters.

Source	Age (yr)											
	1	2	3	4	5	6	7	8	9	10	11	12
Kapote 1971 <sup>1</sup>	— <sup>2</sup>	—	23.8	26.5	29.1	30.7	—	—	—	—	—	—
Kapote 1971 <sup>3</sup>	—	—	23.6	25.8	28.3	—	—	—	—	—	—	—
Kapote 1971 <sup>4</sup>	—	—	23.6	26.0	28.0	30.7	—	—	—	—	—	—
Manooch 1976 <sup>5</sup>	17.7	22.7	26.7	29.6	32.9	35.6	39.0	41.2	43.0	45.0	46.8	48.2
Manooch 1976 <sup>6</sup>	—	20.9	26.3	30.5	32.8	35.8	39.1	40.0	42.8	44.9	45.6	48.1
Manooch 1976 <sup>7</sup>	9.7	18.5	24.4	28.3	31.4	34.1	36.7	38.9	41.4	43.9	46.6	49.2

<sup>1</sup>Campeche Bank; males only; total lengths.

<sup>2</sup>Not given.

<sup>3</sup>Campeche Bank; females only; total lengths.

<sup>4</sup>Campeche Bank; males and females combined; total lengths.

<sup>5</sup>North and South Carolina; empirical total lengths based on scale readings.

<sup>6</sup>North and South Carolina; empirical total lengths based on otolith readings.

<sup>7</sup>North and South Carolina; calculated total lengths based on scale readings.

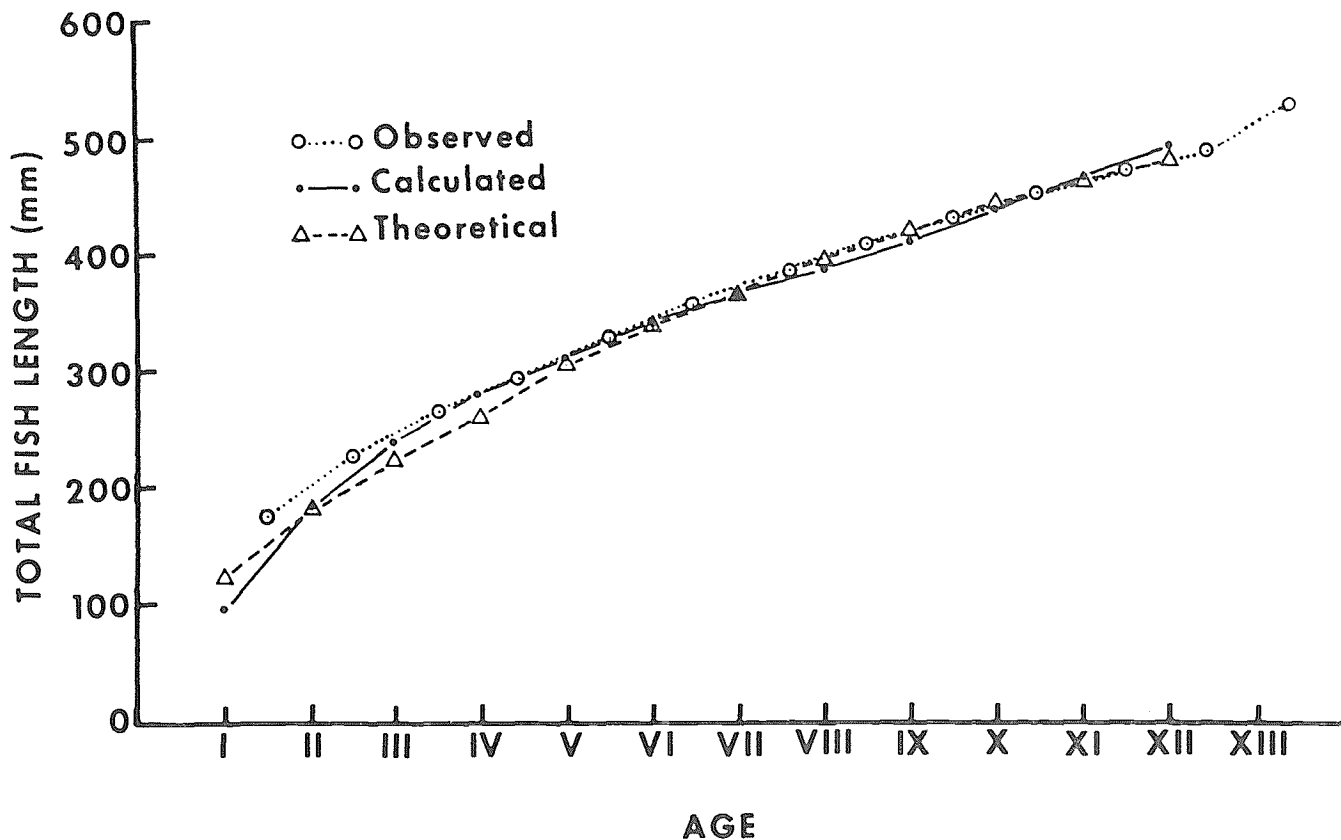


Figure 15.—Comparison of absolute, back-calculated, and theoretical growth curves for *Haemulon plumieri* from the southeastern Atlantic coast of the United States, obtained from scale readings. (From Manooch 1976, fig. 6.)

### 3.5 Behavior

#### 3.51 Migrations and local movements

##### *Haemulon aurolineatum*

Movements of *H. aurolineatum* are of three types: seasonal inshore-offshore migrations, size-dependent habitat changes, and nocturnal foraging migrations. Seasonal inshore-offshore migrations have been noted on Campeche Bank by several authors. Individuals apparently gather in fall on eastern Campeche Bank to spawn (Sokolova 1965). Lyubimova and Kapote (1971) similarly reported *H. aurolineatum* most dense on the eastern and central Bank in fall and winter. Offshore migrations in spring-summer and inshore migrations in fall-winter were mentioned by Olacchia and Sauskan (1974) and Sauskan and Olacchia (1974) (Fig. 16). Billings and Munro (footnote 3) noted migrations of young grunts from nursery areas to adult grounds in Jamaica. Stone et al. (1979) observed that size plays a role in movement of subadult *H. aurolineatum* in reef areas of southern Florida. Different size-groups inhabit different patch reefs, and apparently move away when they reach a certain size. Manooch and Barans (footnote 5) noted a minor offshore migration of adults and juveniles in the South Atlantic Bight in winter. *Haemulon aurolineatum* appears to avoid water shallower than about 20 m during winter north of Florida (Manooch and Barans footnote 5).

Nocturnal foraging migrations of grunts, including *H. aurolineatum*, are well known. Such migrations have been noted in the Virgin Islands (Randall 1963; Collette and Talbot 1972; Smith

and Tyler 1972; Ogden and Ehrlich 1977), Puerto Rico (Parrish and Zimmerman 1977), Jamaica (Billings and Munro footnote 3), the Florida Keys (Davis 1967), and on offshore platforms in the northern Gulf of Mexico (Hastings et al. 1976). These migrations usually begin at dusk, with the dense diurnal schools becoming less organized and finally dispersing over grass and sand flats. Fish return to their diurnal resting schools at dawn. Such migrations may reduce predation on the adults, increase available foraging areas, and play an important role in energy input to reef communi-

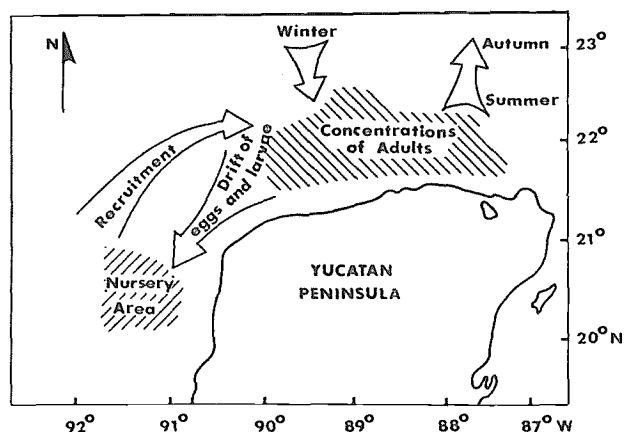


Figure 16.—Main zones of concentration of *Haemulon aurolineatum* on Campeche Bank and probable seasonal movements. (From Olacchia and Sauskan 1974, fig. 2.)

tics. No information exists on foraging migrations of grunts in deeper water.

### *Haemulon plumieri*

Although some short-range migrations of *H. plumieri* may occur, most evidence indicates that movements are slight and confined primarily to foraging. Tagging studies by Moc (1966) on the west coast of Florida showed that only 2 of 39 recaptures moved more than 8.0 km (5 mi) from the tagging site, and only 26% moved more than 4.8 km (3 mi). Moc (1966) felt that these were probably casual wanderings rather than true migrations, and that individuals spent most of their lives in the same general area. The greatest movement probably occurred during or before spawning, when large schools formed. Beaumariage (1969) reported that three tagged *H. plumieri* were recovered 4 yr later at the tagging site. Springer and McErlean (1962) found little migration of tagged *H. plumieri* on patch reefs off Upper Matecumbe Key, Fla.; even during a hurricane most of them maintained home reefs. McLean and Herrnkind (1971) reported two dense schools of grunts, primarily *H. plumieri*, migrating along the shore of North Bimini, Bahamas, over open sand. These schools of 4,500-10,000 individuals may have been moving to avoid turbid water created by a storm.

Juveniles may change habitats or reef resting sites during their growth, not selecting adult territories for some time (Ogden 1977; McFarland 1980). Billings and Munro (footnote 3) reported that juveniles may migrate away from reefs at Port Royal, Jamaica, at about 25 cm FL, but their migration routes are unknown.

Most documented movements of *H. plumieri* are diurnal-nocturnal foraging migrations. Ogden (1977) and Ogden and Ehrlich (1977) studied these migrations extensively in St. Croix, using tagging and diver observation. Heterotypic grunt schools, including *H. plumieri*, moved off reefs to feed beginning about 10 min after sunset and returned to the reef 20-30 min before sunrise. Largest fish left the reef first and returned last. Schools remained together until they were off the reef, possibly to reduce predation. Migration routes distributed fish evenly over nocturnal foraging grounds, such as grass beds. These routes remained constant over the short term, and more or less so over the long term.

### 3.52 Schooling

*Haemulon aurolineatum* and *H. plumieri*, like most grunts, are schooling fishes. Both adults and juveniles form schools on reefs or over other hard substrate during the day. These schools are usually composed of one size-class but may be heterotypic with other similar-sized species. Daytime resting schools may be quite dense and occur in a variety of habitats. Billings and Munro (footnote 3) reported adult schools among corals on Jamaican reefs, with juvenile schools over *Thalassia* beds, near edges of sand patches, or on reefs near adults. The density of schools may depend on light intensity (Billings and Munro footnote 3) and schooling may defend against diurnal predation (Davis 1967). Conspecific attraction has been noted in some grunts (e.g., *H. plumieri*) and may account for large trap catches (Billings and Munro footnote 3).

*Haemulon aurolineatum* has been observed in mixed schools with *H. striatum* and *Eumelichthys atlanticus* on deep reef ledges of Alligator Reef with 200 to 300 mm SL individuals of *Lutjanus griseus* and *H. parrai* off Windley Key, Fla. (Davis 1967) and with *H. striatum* in Biscayne National Monument, Fla. (Stone et al. 1979). Juveniles of *H. aurolineatum* school with juvenile *H.*

*flavolineatum* in St. John (Smith and Tyler 1972). Ogden (1977) and Ogden and Ehrlich (1977) reported heterotypic resting schools of grunts, including *H. aurolineatum* and *H. plumieri*, on patch reefs in St. Croix. Starck and Davis (1966) found *H. aurolineatum* in small resting schools among the coral *Acropora cervicornis* in the Florida Keys.

*Haemulon plumieri* has been observed schooling with *H. sciurus*, *H. flavolineatum*, *Acanthurus chirurgus*, *Mulloidichthys martinicus*, and other species (Collette and Talbot 1972; Motchek and Silva Lee 1975; Ogden and Ehrlich 1977). Schools are common in reef areas during the day, particularly near patch reefs (Böhlke and Chaplin 1968; Ogden 1977; Ogden and Ehrlich 1977). Collette and Talbot (1972) reported *H. plumieri* common in small resting schools of 5-20 individuals on Virgin Island reefs. Ogden (1977) found that small juvenile *H. plumieri* school with juvenile *H. flavolineatum* on patch reefs at St. Croix, while larger juveniles (15-25 cm, measurement unspecified) roam the reefs and adjacent flats. Heterotypic schools of young grunts are often associated with the corals *Porites porites* and *Acropora palmata* on St. Croix patch reefs (Ogden and Ehrlich 1977), whereas larger subadults (12-15 cm, measurement unspecified) in schools of up to several hundred individuals are no longer associated with any particular coral formations. Schools remain intact during the day and break down at night when the fish leave the reef to forage.

Conspecific attraction tends to draw *H. plumieri* into fish traps, though some are known to escape (Billings and Munro footnote 3). Billings and Munro (footnote 3) found that if more than four *H. plumieri* were in a Jamaican fish trap, catches thereafter increased considerably.

## 4 POPULATION

### 4.1 Structure

#### 4.11 Sex ratio

Sex ratio of *H. aurolineatum* is close to 1:1 (Sokolova 1965). Billings and Munro (footnote 3) reported 53% females and 47% males from fish-trap catches at Port Royal.

Sex ratios of *H. plumieri* from trap catches in Jamaica generally favor females (Billings and Munro footnote 3) (Table 14). Trap catches from Port Royal reefs vary around the 50% female level, with no apparent seasonal pattern (Fig. 17).

See 3.11.

Table 14.—Sex composition (in percent) of *Haemulon plumieri* from Jamaican trap catches. (From Billings and Munro see text footnote 3, table 4.1.)

Sex	Locality		
	Port Royal reefs	Pedro Cays	Pedro Bank
Females	57	59	69
Males	43	41	31

#### 4.12 Age composition

Sokolova (1965), Sauskan and Olacchea (1974), and Olacchea and Hernández (1976) studied age composition of *H. aurolineatum* on Campeche Bank (Tables 15, 16). Only fish 3 yr old and older enter the commercial fishery on Campeche Bank, with 4-yr-olds dominating catches.

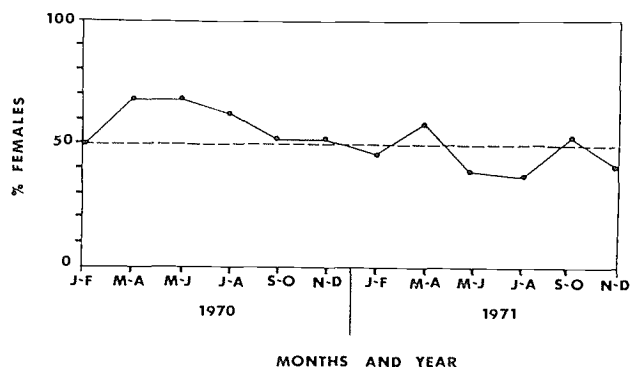


Figure 17.—Variations of sex ratio in bimonthly trap catches of *Haemulon plumieri* from Port Royal, Jamaica, reefs over a 2-yr period. (From Billings and Munro see text footnote 3, fig. 4.1.)

Table 15.—Age composition (in percent) of *Haemulon aurolineatum* on Campeche Bank in 1964. (From Sokolova 1965, table 6.)

Time of catch	Age (yr)		
	3+	4+	5+
January, February	9.0	68.0	23.0
March-May	19.6	65.2	15.2
June-August	18.1	63.8	18.1
September-December	23.4	62.0	14.6
Total	18.7	64.4	16.9

Table 16.—Age composition (in percent) of *Haemulon aurolineatum* on Campeche Bank, and total fishing effort in thousands of hours of trawling of an SRT-M-type vessel. (From Olaechea and Hernandez 1976, table 1.)

Year	Age groups							Total effort
	1	2	3	4	5	6	7	
1969	0.20	7.70	28.50	30.50	26.10	6.30	0.70	18.689
1970	0.10	6.30	26.00	34.40	27.60	8.50	1.10	16.125
1971	—	4.40	24.20	29.90	29.70	10.20	1.60	20.431
1972	0.10	9.20	28.90	30.30	25.00	5.80	0.70	12.680
1973	1.40	9.47	26.47	38.34	25.44	7.91	1.64	14.187
1974	0.78	12.47	30.15	28.53	22.59	4.77	0.81	7.109

<sup>1</sup>Estimated effort.

Manooch (1976) reported that older *H. plumieri* from off the Carolinas were always males. Males up to 12 yr old were collected, but females reached only 9 yr.

See 3.43 and 4.4.

#### 4.13 Size composition

Experimental trawling for *H. aurolineatum* on Campeche Bank (Sokolova 1965) produced a frequency mode of 17-19 cm (measurement unspecified). This changed only slightly with season and was similar to the size composition of commercial catches, except that the mode of commercial catches was 19-20 cm (measurement unspecified) (Fig. 18). Length and weight distributions for three year-classes on Campeche Bank are shown in Figure 19. Weight of *H. aurolineatum* in commercial catches varied from 60 to 190 g, with 30% of the fish weighing 110-130 g (Fig. 20). Wenner et al. (1979a, b) developed length-frequency plots based on MARMAP trawl surveys off the South Atlantic Bight in 1973 and 1974 (Fig. 21).

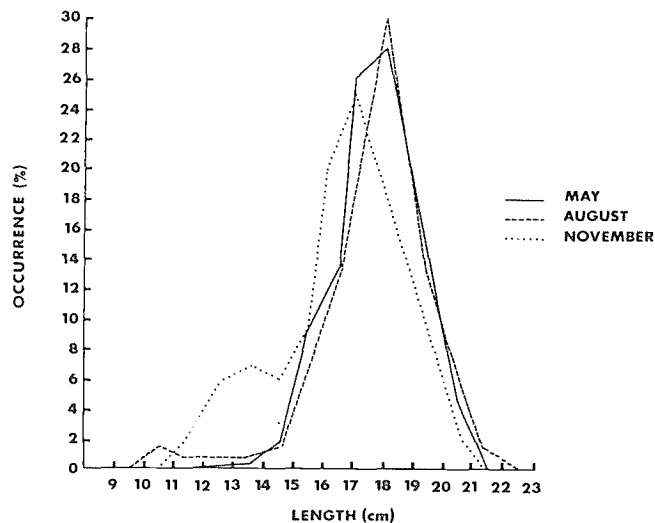


Figure 18.—Size composition of *Haemulon aurolineatum* from Campeche Bank in 1964, caught by experimental trawling. (From Sokolova 1965, fig. 7.)

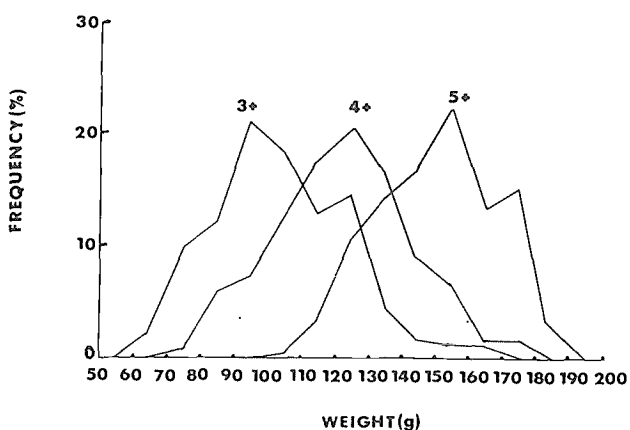
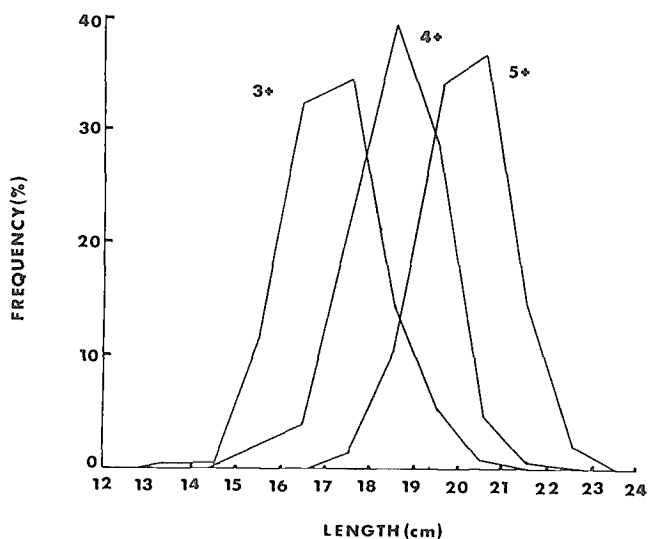


Figure 19.—Length and weight distributions of three year-classes of *Haemulon aurolineatum* on Campeche Bank in 1964. Ages are expressed in years. (From Sokolova 1965 data, tables 8, 9.)

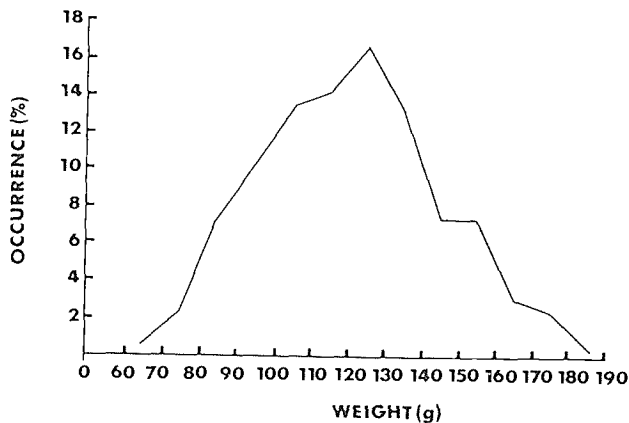


Figure 20.—Weight of *Haemulon aurolineatum* in commercial catches from Campeche Bank in 1964. (From Sokolova 1965, fig. 8.)

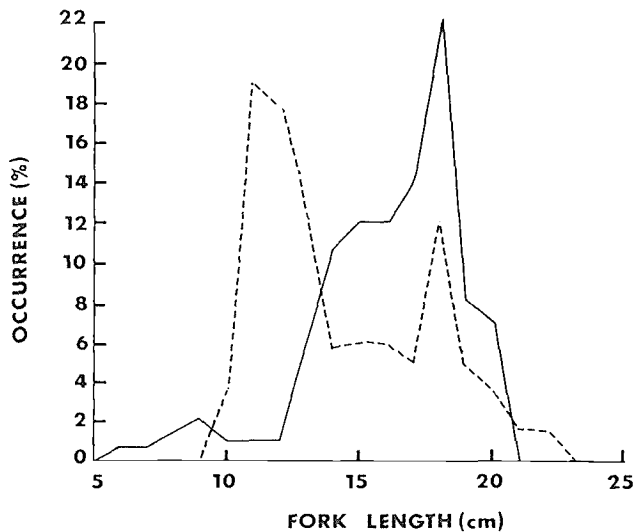


Figure 21.—Length-frequency distribution of *Haemulon aurolineatum* caught in the South Atlantic Bight during fall 1973 (solid line), and spring 1974 (broken line), by MARMAP trawl investigations. (From Wegner et al. 1979a, fig. 5F; 1979b, fig. 16F.)

Billings and Munro (footnote 3) provided length-frequency distributions of *H. plumieri* from Jamaica and compared these data from different areas and for different gear types (Figs. 22-24).

See 3.4.3 and 4.4.

#### 4.14 Subpopulations

See 1.2.3.

#### 4.2 Abundance and density

##### *Haemulon aurolineatum*

*Haemulon aurolineatum* has frequently been reported as an abundant or dominant species where it occurs. Beebe and Tec-Van (1928) reported *H. aurolineatum* very common in Port-au-Prince Bay; Hildebrand (1954) found them extremely abundant over shell bottom on pink shrimp grounds off Campeche, Mexico; Cummins

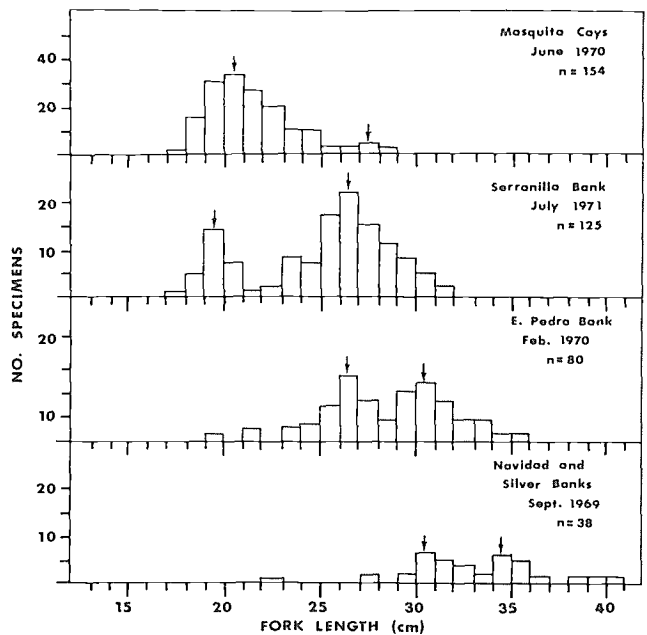


Figure 22.—Length-frequency distributions of *Haemulon plumieri* from trap catches (probable mesh size 4.13 cm maximum dimension) from four areas near Jamaica. Peaks marked with arrows are probable year classes. (From Billings and Munro see text footnote 3, fig. 3.3.)

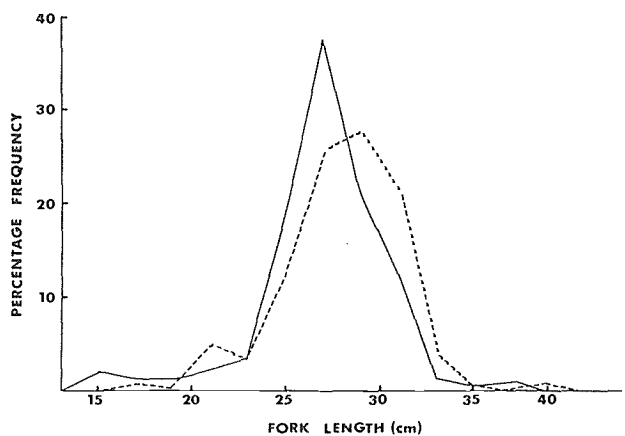


Figure 23.—Length-frequency distributions of line catches (broken line) and trap catches (solid line) of *Haemulon plumieri* from Jamaica stations where both gears were used. (From Billings and Munro see text footnote 3, fig. 4.2.)

et al. (1962) caught *H. aurolineatum* in potential commercial quantities off the southeastern United States on the *Silver Bay*; and Parrish and Zimmerman (1977) reported that *H. aurolineatum* dominated grunt catches in Puerto Rico.

Randall (1963) found that juvenile *H. aurolineatum* were the dominant inhabitants of artificial patch reefs in St. John. Five hundred seventy-seven individuals, weighing a total of 7.38 kg, occupied a reef of about 125 m<sup>2</sup>, with a habitat area of about 50 m<sup>2</sup>. Ogden (1977) and Ogden and Ehrlich (1977) found up to 1,400 individuals on patch reefs in St. Croix. Stone et al. (1979) found that juvenile *H. aurolineatum* were by far the dominant inhabitants of patch reefs in Biscayne National Monument, with over 800 individuals on a single patch reef. Hastings et al. (1976) and Smith et al. (1979) reported them common on artificial reefs and platforms in the northeastern Gulf of Mexico.

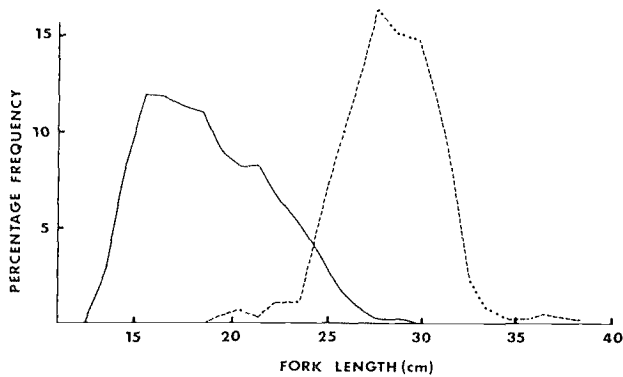


Figure 24.—Estimated mean annual percentage frequency distributions of trap catches of *Haemulon plumieri* at Port Royal, Jamaica, reefs (solid line;  $n = 1,376$ ,  $t = 2$  mo) and at unexploited parts of Pedro Bank (broken line;  $n = 910$ ,  $t = 4$  mo). (From Billings and Munro see text footnote 3, fig. 4.3.)

*Haemulon aurolineatum* is a dominant commercial species on Campeche Bank, making up 65-68% of catches in spring at depths of 30-35 m and 56.3% in summer at 25 m (Sokolova 1965). Lyubimova and Kapote (1971) reported that the densest concentrations of grunts on Campeche Bank were in fall and winter on the eastern and central parts of the Bank. Olaechea and Sauskan (1974) estimated *H. aurolineatum* density on Campeche Bank at 0.0156 t/ha (53.62 t/10 nmi<sup>2</sup>), with greatest densities on the eastern and central parts of the Bank in winter and spring at 20-60 m depths. Sauskan and Olaechea (1974) reported that *H. aurolineatum* made up 24.5% of the total catch on Campeche Bank and almost three-quarters of the catch on the eastern Bank in 15-30 m of water. They estimated the total possible annual catch of *H. aurolineatum* on Campeche Bank at 37,000-40,000 t, with a total estimated stock of 200,000 t.

On Campeche Bank, overall *H. aurolineatum* abundance is greatest in summer and least in winter (Sauskan and Olaechea 1974). On the central and western parts of the Bank, maximum abundance is in shallow water in fall, winter, and spring, but at 50-80 m in summer. On the eastern Bank, abundance is greatest in shallow water in summer. The total biomass of *H. aurolineatum* was estimated at more than 25% of the total demersal ichthyofauna of Campeche Bank. During MEXUS-GOLFO<sup>7</sup> investigations, *H. aurolineatum* made up 36.8% of total night trawl catches and 26.3% of day trawl catches on Campeche Bank.

Investigations off the southeastern United States have shown *H. aurolineatum* to be a common member of the live-bottom community of the shelf. Anderson (1968) reported small catches from shrimp grounds off Georgia. Struhsaker (1969) found *H. aurolineatum* made up 7.1% of the fish catch, by weight, taken by the *Silver Bay* off South Carolina on live bottom in 1960-63, and 6.1% of the catch off northeast Florida. Barans and Burrell (1976) reported that *H. aurolineatum* and *H. plumieri* made up 0.2% (24.1-37.1 m, 13-20 fathoms) and 2.2% (41.7-77.8 m, 22.5-42 fathoms) of the total weight of commercial fishes trawled off South Carolina. *Haemulon aurolineatum* ranked third in total number and fifth in total weight of demersal bony fishes trawled during the MARMAP cruise in fall 1973 (7.0% of total catch by number, 4.5% by weight) (Wenner et al. 1979a) (Fig. 25). Manooch and Barans (footnote 5) stated that it was difficult to assess biomass of

*H. aurolineatum* in the South Atlantic Bight because the species occurred over both sand and live bottoms.

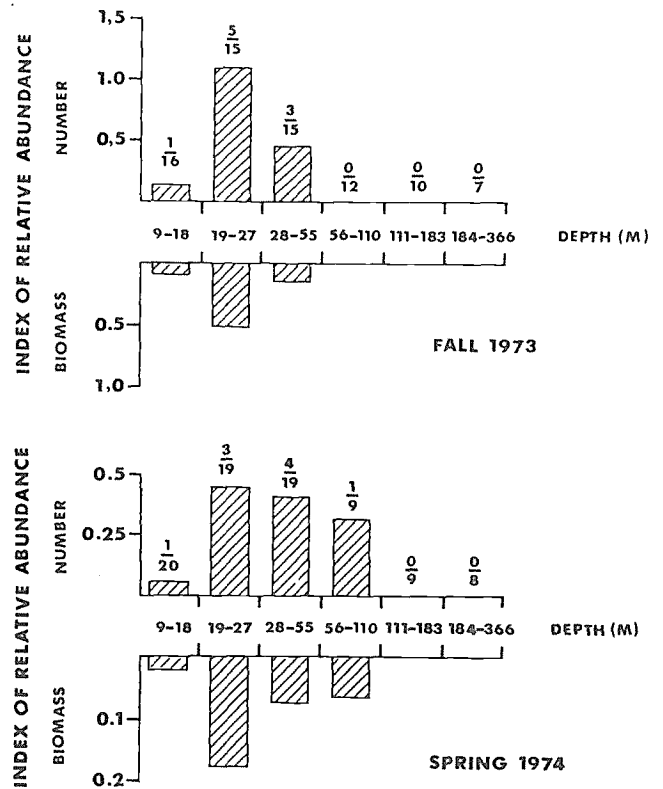


Figure 25.—Index of relative abundance for *Haemulon aurolineatum* in the South Atlantic Bight during fall 1973, and spring 1974, MARMAP groundfish surveys. (From Wenner et al. 1979a, fig. 5E; 1979b, fig. 16E.)

### *Haemulon plumieri*

*Haemulon plumieri* is frequently abundant where it occurs. Jordan and Fesler (1893) reported that it was "not rare in West Florida and on the Carolina coast, while at Key West it is the most abundant food-fish, the amount taken during the year exceeding that of all other shore species combined." Beebe and Tee-Van (1928) found *H. plumieri* to be the commonest grunt in Port-au-Prince Bay. Courtenay (1961) reported that it was the most abundant *Haemulon* species in inshore waters of Florida and the Bahamas. Cummins et al. (1962) trawled *H. plumieri* commonly at *Silver Bay* stations off the southeastern United States. Randall (1963) found it to be the dominant species in number and weight on artificial reefs at St. John, with an estimated density of juveniles of 25.3 fish/m<sup>2</sup>. Smith et al. (1979) similarly found *H. plumieri* to be one of the most abundant fishes on natural and artificial reefs off Clearwater. Stone et al. (1979) found *H. plumieri* on both natural and artificial reefs in Biscayne National Monument, though they were not as common as *H. aurolineatum* and *H. flavolineatum*. *Haemulon plumieri* and *H. flavolineatum* are the dominant species on patch reefs near St. Croix, though their numbers vary throughout the year (Ogden 1977; Ogden and Ehrlich 1977).

*Haemulon plumieri* has been taken during trawl surveys off the southeastern United States, but generally has not been taken abundantly (Struhsaker 1969; Bearden and McKenzie 1972; Barans and Burrell 1976). These surveys probably did not sample the rough bottom which *H. plumieri* prefers and may not accurately represent

<sup>7</sup>MEXUS-GOLFO 1979. Report on MEXUS-GOLFO research activities. Miscogr., 11 p. Southeast Fisheries Center Miami Laboratory, National Marine Fisheries Service, NOAA, 75 Virginia Beach Drive, Miami, FL 33149.

the abundance of *H. plumieri* on the shelf; party boat catches on the Carolina continental shelf include large numbers of *H. plumieri* (Sekavec and Huntsman 1972):

	Percentage of total catch	
	No.	Wt.
Offshore	12%	6%
Inshore	43%	42%

*Haemulon plumieri* is second only to black sea bass in inshore catches on the Carolina shelf.

On Campeche Bank, *H. plumieri* is caught in trawls at depths of 23-36 m. but is not a major component of the catch (Sokolova 1965). Sauskan and Olaechea (1974) and Olaechea and Sauskan (1974) reported that the mean total annual abundance of *H. plumieri* on Campeche Bank is about 10,000 t (compared with 200,000 t for *H. aurolineatum*), with a mean density of 0.0018 t/ha (4.04 t/10 nmi<sup>2</sup>) in the sampled area. Lyubimova and Kapote (1971) found greatest densities of *H. plumieri* on the central and eastern parts of Campeche Bank in fall and winter.

Relative abundance of grunt species may vary considerably from reef to reef in certain areas (Billings and Munro footnote 3). On Pedro Bank reefs in Jamaica, *H. plumieri* and *H. flavolineatum* are numerically dominant (Billings and Munro footnote 3).

#### 4.3 Natality and recruitment

##### 4.31 Reproduction rates

Mean fecundity of 13 ripe female *H. aurolineatum* from Jamaica (mean length 15.4 cm FL, mean weight 69 g) was 30,000 eggs/female (435 eggs/g). The greatest observed fecundity was 83,000 eggs in a 13.1 cm FL, 135 g female (615 eggs/g) whose ovary weight was 7.5 g (Billings and Munro footnote 3). Number of spawns per year is not known.

Billings and Munro (footnote 3) calculated a fecundity-weight relationship for *H. plumieri* from Jamaica of  $e = 607w - 93,000$ , where  $e$  is fecundity and  $w$  is body weight in grams (Fig. 26). Mean calculated fecundity for *H. plumieri* from Port Royal reefs was about 42,000 eggs/female per spawning season (average fish weight 220 g). For unexploited parts of Pedro Bank, Jamaica, 150,000 eggs were found per female per spawning season (average fish weight 400 g).

##### 4.32 Factors affecting reproduction

Little is known about factors affecting reproduction in *H. aurolineatum* and *H. plumieri*, though Munro et al. (1973) suggested that spawning of grunts in Jamaica is initiated when water temperature drops below 28°C. Peak spawning in Jamaica occurs during periods of low water temperature.

##### 4.33 Recruitment

###### *Haemulon aurolineatum*

Sokolova (1965) reported that lack of fluctuations in catches or age distributions of *H. aurolineatum* from Campeche Bank (1962-65) indicated a steady recruitment to the commercial populations there. Olaechea and Hernández (1976) calculated a yield per recruit curve (Fig. 27) and an age of first recruit on Campeche Bank of

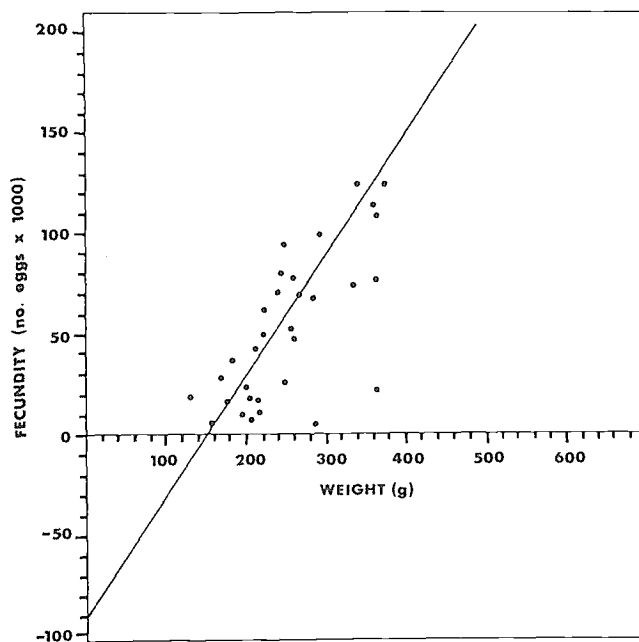


Figure 26.—Relationship of fecundity to weight in *Haemulon plumieri* from Jamaica. Slope of the line is 607 eggs/g and the y-intercept -93,000 eggs. (From Billings and Munro see text footnote 3, fig. 3.1.)

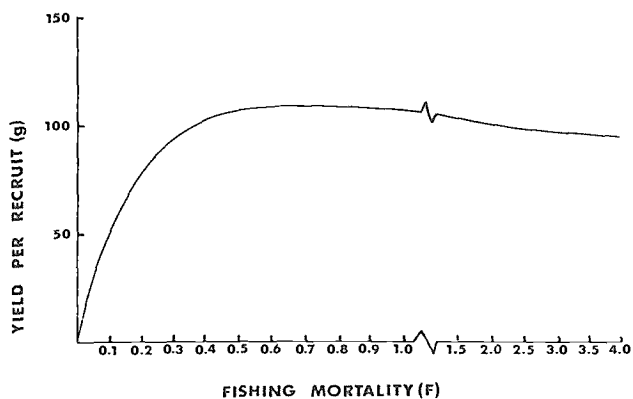


Figure 27.—Yield per recruit curve of *Haemulon aurolineatum* on Campeche Bank for different values of fishing mortality (F). (From Olaechea and Hernández 1976, fig. 1.)

3.32 yr. Recruitment of *H. aurolineatum* to fish traps on Pedro Bank was studied by Billings and Munro (footnote 3), who calculated that the minimum recruitment size to the traps is 13.5 cm FL, the mean recruitment size is 15.9 cm FL, and the size at full recruitment is 16.5 cm FL. The minimum length of *H. aurolineatum* retained by 4.13 cm mesh traps is 14.4 cm FL.

###### *Haemulon plumieri*

Recruitment of *H. plumieri* to patch reefs in St. Croix may vary throughout the year (Ogden and Ehrlich 1977). At Port Royal *H. plumieri* is fully recruited to the fishery at 15.5 cm FL, with a mean recruitment length of 14.9 cm (Billings and Munro footnote 3). At unexploited parts of Pedro Bank, mean recruitment length is 26.2 cm FL. At Port Royal reefs, main recruitment takes place from May to October.

See 4.5.



#### 4.4 Mortality and morbidity

##### *Haemulon aurolineatum*

Natural mortality of *H. aurolineatum* is caused by predation, disease, and senility (Billings and Munro footnote 3). A mortality rate calculated from Pedro Bank trap catches is given in Table 17. Sauskan and Olacchea (1974) calculated a mean total annual mor-

Table 17.—Mortality rate of *Haemulon aurolineatum* from the relative abundances of successive length groups captured in traps (4.13 cm mesh) on Pedro Bank, Jamaica. Because Pedro Bank is essentially unexploited, the total mortality rate ( $Z$ ) is equal to the natural rate ( $M$ ). The instantaneous annual growth rate ( $K$ ) is not known. Method is that of Beverton and Holt (1956). (From Billings and Munro see text footnote 3, table 4.7.)

Length group (FL, cm)	% Frequency	Relative frequency
12.0-12.9		
13.0-13.9	1.7	0.04
14.0-14.9	5.5	0.13
15.0-15.9	28.9	0.67
16.0-16.9	43.0	1.00
17.0-17.9	17.9	0.42
18.0-18.9	2.6	0.06
19.0-19.9	0.4	0.01
20.0-21.9		

$L_{\infty} = 23$  cm

$K = ?$

$l_r$  (length at full recruitment) = 16.0 cm

$l$  (mean length above full recruitment) = 16.9 cm

$$Z = \frac{K(L_{\infty} - \bar{l})}{(\bar{l} - l_r)} = ?$$

$$Z/K = \frac{L_{\infty} - \bar{l}}{\bar{l} - l_r} = 6.78 (= M/K)$$

tality rate for 5-7 yr old *H. aurolineatum* on Campeche Bank of  $Z = 1.65$ . Olacchea and Hernandez (1976) calculated a total annual mortality rate of  $Z = 0.6766$  for *H. aurolineatum* on Campeche Bank and derived the relationship:

$$Z = M + qf = 0.1332 + 0.0356(f)$$

where  $Z$  is total mortality,  $M$  is the instantaneous rate of natural mortality,  $q$  is the catchability coefficient, and  $f$  is fishing effort in thousands of hours of trawling of an SRT-M-type vessel. This equation appears as  $Z = 0.1332 - 0.0356(f)$  in Olacchea and Sauskan's paper, with the mean value of  $Z$  given as  $-0.6766$ . This may have been an error: the equation and  $Z$  value presented above seem more reasonable. Although not enough information is given to evaluate their mortality estimates, Olacchea and Sauskan's figure for natural mortality seems remarkably low and suggests heavy fishing pressure.

Manooch and Barans (1979), working with fish aged by scales and otoliths, stated that *H. aurolineatum* does not live as long and has a higher natural mortality rate than most other reef fishes previously studied in the South Atlantic Bight. The mean total annual mortality rate from catch curves for 1972-78 was 59% ( $Z = 0.887$ ) based on fish age IV and older (Manooch and Barans footnote 5).

##### *Haemulon plumieri*

Mean total annual mortality rates of *H. plumieri* in Jamaica were calculated by Billings and Munro (footnote 3) (Table 18). Manooch (1976) reported that *H. plumieri* was fully recruited to the hook-and-line fishery off the Carolinas by age VII, with a mean total annual mortality of 37-51% (Table 19, Fig. 28).

#### 4.5 Dynamics of population

##### *Haemulon aurolineatum*

Manooch and Barans (1979) derived a yield per recruit model for *H. aurolineatum* entering the hook-and-line and trawl fisheries off the southeastern United States that indicated the maximum yield per recruit at natural mortality ( $M$ ) of 0.3 is 50 g with fishing mortality ( $F$ ) as low as 0.8 and recruitment age of 2.75 yr. Eighty percent (40 g) of the maximum potential yield per recruit is available when  $F = 0.25$  and recruitment age is 1.5-2.5 yr. Sixty-seven percent of the yield per recruit is available at  $F = 0.2$ ,  $M = 0.5$ , and recruitment age 0-1 yr (Manooch and Barans footnote 5).

Olacchea and Hernandez (1976) calculated that maximum yield per recruit of *H. aurolineatum* on Campeche Bank is approximately 110 g

Table 18.—Derivation of annual mortality rates from the relative abundances of successive length groups of *Haemulon plumieri* beyond full recruitment to traps (4.13 cm mesh) at Port Royal, Jamaica, reefs, and at unexploited parts of Pedro Bank (for  $L_{\infty} = 42$  cm,  $K = 0.345$ ). Because Pedro Bank is essentially unexploited, fishing mortality ( $F$ ) is 0, and total annual mortality rate ( $Z$ ) is equal to the natural mortality rate ( $M$ ). (From Billings and Munro see text footnote 3, table 4.3.)

Length group (FL, cm)	Unexploited Pedro Bank		Port Royal Reefs		Adjusted frequency
	% Frequency	Relative frequency	% Frequency	Relative frequency	
12.0-12.9			0.08	0.01	
13.0-13.9			2.83	0.24	
14.0-14.9			7.82	0.66	
15.0-15.9			11.78	1.00	
16.0-16.9			16.65	0.99	
17.0-17.9			11.27	0.96	
18.0-18.9			11.02	0.94	
19.0-19.9	0.27	0.02	8.97	0.76	
20.0-20.9	0.57	0.03	8.08	0.69	
21.0-21.9	0.33	0.02	8.18	0.69	34.5
22.0-22.9	1.07	0.07	6.42	0.54	7.7
23.0-23.9	1.13	0.07	5.17	0.44	6.3
24.0-24.9	4.20	0.26	3.80	0.32	1.2
25.0-25.9	9.00	0.55	1.92	0.16	0.3
26.0-26.9	11.80	0.72	0.85	0.07	0.1
27.0-27.9	16.43	1.00	0.07	0.01	+
28.0-28.9	15.30	0.93	0.07	0.01	+
29.0-29.9	14.83	0.90	0	0	0
30.0-30.9	12.60	0.77	0	0	0
31.0-31.9	8.03	0.49	0	0	0
32.0-32.9	2.40	0.15	0	0	0
33.0-33.9	0.83	0.05	0	0	0
34.0-34.9	0.37	0.02	0	0	0
35.0-35.9	0.07	+	0	0	0
36.0-36.9	0.27	0.02	0	0	0
37.0-37.9	0.20	0.01	0	0	0

$l_r$ (length at full recruitment)	27.0 cm	21.0 cm
Mean FL	29.45 cm	22.0 cm
$Z/K$	5.12 (= $M/K$ )	20.0
$Z$	1.77 (= $M$ )	6.90
$F$	0	5.13
$E (= F/Z)$	0	0.74

Table 19.—Total annual mortality estimates for *Haemulon plumieri* from North Carolina and South Carolina, 1972 to 1975. (From Manooch 1976, table 3.)

Year	Area(s)	Sample size (VII-oldest)	No. of age classes	Method				Mean mortality <sup>1</sup>
				Robson and Chapman	Jackson	Heinke	Beverton and Holt	
1972	all	1,126	7	0.52	0.46	0.46	0.55	0.51
1973	all	954	7	0.49	0.42	0.42	0.53	0.48
1974	all	398	7	0.48	0.40	0.40	0.53	0.47
1975	all	399	7	0.44	0.36	0.36	0.46	0.42
1972-75	all	2,877	7	0.49	0.43	0.43	0.52	0.48
1974-75	Cape Lookout	2237	8	0.38	0.29	0.29	0.43	0.37
1974-75	Cape Fear	368	7	0.48	0.40	0.40	0.47	0.45
1974-75	Cape Romain	332	7	0.42	0.33	0.33	0.42	0.39

<sup>1</sup>Mean of Robson and Chapman, Jackson, and Beverton and Holt method values. Heinke estimate was not used in obtaining mean mortalities since method was almost identical to Jackson.

<sup>2</sup>Sample size was age V-XII.

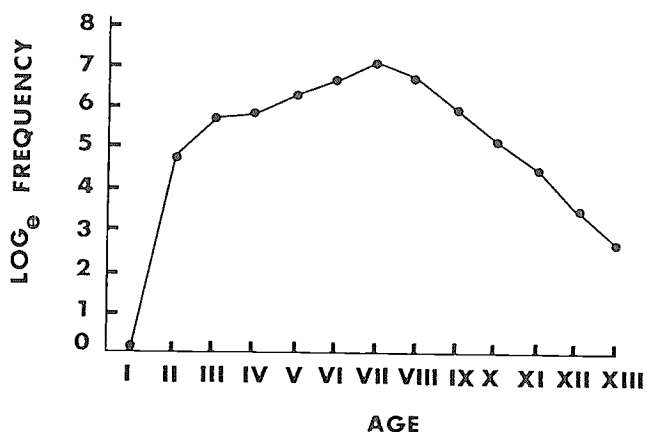


Figure 28.—Catch curves for 5,135 *Haemulon plumieri* sampled from the head-boat fishery off North and South Carolina, 1972 to 1975, where b, the slope of the right descending limb of the curve, equals the instantaneous rate of mortality. (From Manooch 1976, fig. 7.)

at  $F = 0.7$ . Sauskan and Olaechea (1974) constructed a yield-per-recruit curve that differs considerably from that of Olaechea and Hernández, leveling off at higher values of fishing mortality (Fig. 29).

#### *Haemulon plumieri*

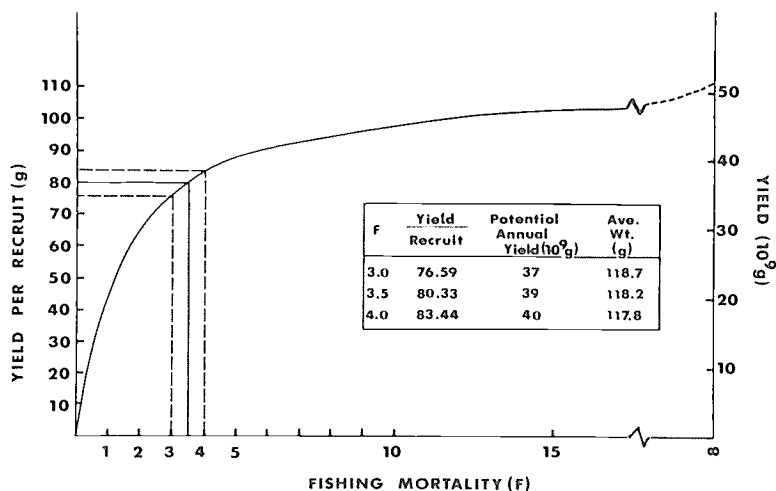
Billings and Munro (footnote 3) estimated recruitment indices for *H. plumieri* from Jamaica are shown in Table 20.

Huntsman and Manooch (1978) determined that the minimum size limit that would maximize yield per recruit of *H. plumieri* is 31.4 cm TL, based on growth data of Manooch (1976).

Table 20.—Estimated recruitment indices for *Haemulon plumieri* from Jamaica. (From Billings and Munro see text footnote 3.)

Location	$I_1$ (cm) FL	No. per 1,000 trap-days $C/f$	Mortality rate $Z$	Recruitment index $R'$
E. Pedro Bank	26.2	262	1.77	463
S. Pedro Bank	26.2	481	1.77	851
W. Pedro Bank	26.2	83	1.77	147
Port Royal reefs	14.9	265-278	6.9	1,828-1,918

Figure 29.—Dependency of potential yield per recruit (in grams) and of potential annual yield for  $R = 0.48 \times 10^9$  individuals on coefficient of fishing mortality ( $F$ ), where  $M = 1.65$ ,  $t_r = 2.88$ ,  $t_{max} = 7$ ,  $t_0 = -0.34$  yr.  $W_\infty = 164.5$  g. Average weight refers to the predicted mean weight of individuals caught at each  $F$ . (From Sauskan and Olaechea 1974, fig. 10.)



#### 4.6 The population in the community and the ecosystem

*Haemulon aurolineatum* and *H. plumieri*, because of their abundance in various areas, probably serve as important forage fishes for larger carnivores. Because of their acceptance of a wide variety of habitats, they may be members of several different communities, such as reef, rocky shore, sand or grass flat, or live-bottom offshore communities.

Associates of *H. aurolineatum* from sand bottom MARMAP stations in the South Atlantic Bight are listed in Table 21. Indices of similarity, however, indicate that these species, with the possible exception of *Centrapristis striata* and *Rhomboplites aurorubens*, are not closely associated with *H. aurolineatum*. Many of the species listed in Table 21 may actually be more commonly associated with hard-bottom communities (Miller<sup>8</sup>).

Table 21.—Similarity indices for species found associated with *Haemulon aurolineatum* during MARMAP investigations in the South Atlantic Bight, 1974-75, sand bottom stations. Method is inverse analysis species cluster, Canberra-metric correlation (Boesch 1971). (From Wenner et al. 1979 a, b, c, d.)

Species	Cruise			
	Spring 1974	Summer 1974	Fall 1974	Winter-early spring 1975
<i>Calanus leucostens</i>	0.2			
<i>Hemipteronotus navacula</i>	0	0		
<i>Paralichthys dentans</i>	- 0.2			
<i>Prionotus scitulus</i>	- 0.2			
<i>Sphaeroides maculatus</i>	- 0.2			
<i>Saurida brasiliensis</i>	- 0.2			
<i>Centrapristis striata</i>	- 0.2	0.3	0.05	- 0.1
<i>Orthopristis chrysoptera</i>	- 0.2			
<i>Lagodon rhomboides</i>	- 0.2			
<i>Chaetodipterus faher</i>	- 0.2			
<i>Menticirrhus americanus</i>	- 0.2			
<i>Mullus auratus</i>	- 0.2		0.05	
<i>Rachycentron canadum</i>	- 0.2			
<i>Dasyatis centroura</i>	- 0.2			
<i>Chilmyxterus schaeppi</i>		0		
<i>Eqetes lanceolatus</i>		0		
<i>Rhomboplites aurorubens</i>		0	0.3	0.3
<i>Otophidiim amastigium</i>			0.1	
<i>Stenotomus aculeatus</i>			0.05	
<i>Ophidian beani</i>				0.5
<i>Priamatus caralinus</i>				0.1
<i>Priamatus ophryas</i>				0
<i>Scarpaena brasiliensis</i>				0
<i>Cyclapsetta finhriata</i>				0
<i>Bathus ocellatus</i>				0
<i>Priamatus rasens</i>				- 0.1
<i>Sphaeroides spengleri</i>				- 0.1
<i>Encinastamus argenteus</i>				- 0.1

Billings and Munro (footnote 3) diagrammed the role of grunts in the shallow-water Caribbean ecosystem (Fig. 30). The variety of habitats occupied by these species and the diurnal-nocturnal habitat changes play an important role in bringing nutrients into reef ecosystems (Billings and Munro footnote 3). Extensive sand and grass flats are essential for providing food, while coral reefs or other hard substrates provide diurnal shelter. Abundance of haemulids is probably proportional to the amount of surrounding feeding grounds (Billings and Munro footnote

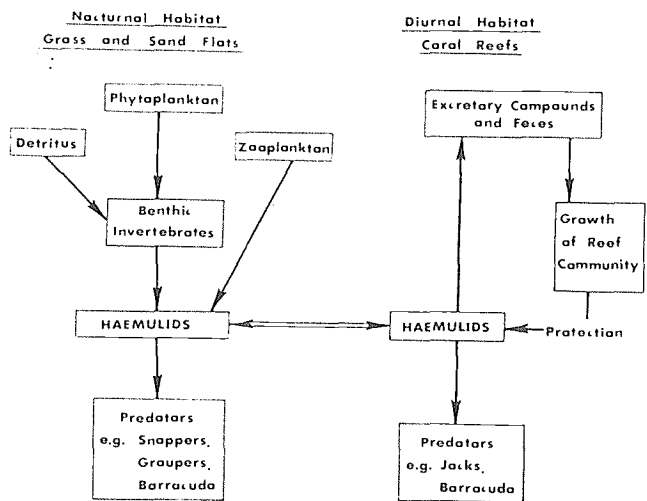


Figure 30.—Diagram to illustrate the position of the haemulids in the food chain and their possible importance in the energy flow between grass or sand flats and areas of coral growth. (From Billings and Munro see text footnote 3, fig. 4.8.)

3). Haemulids are carnivores of the third or fourth trophic level.

See 3.33 and 3.34.

## 5 EXPLOITATION

### 5.1 Fishing equipment

*Haemulon aurolineatum* is caught primarily by hook and line off the southeastern United States (Manooch and Barans footnote 5) but is frequently taken in traps off southeastern Florida, often entering traps in large numbers (Craig 1976). It is also taken throughout its range in trawls and haul seines (Courtenay and Sahlman 1978) and is a common catch of recreational anglers fishing from shore, bridges, jetties, and small boats near shore.

*Haemulon plumieri* is caught primarily by hook and line off the southeastern United States (Manooch 1976) and is a common recreational catch throughout much of its range. It is also harvested by hand-line, seine, and fish traps (Tyler 1964; Courtenay and Sahlman 1978). Beebe and Tee-Van (1928) also mentioned the use of dynamite to harvest *H. plumieri* in Haiti. *Haemulon plumieri* is frequently taken in bottom trawls.

### 5.2 Fishing areas

*Haemulon aurolineatum* is fished throughout its range and is abundant locally, such as on the Tortugas shrimp grounds, in the Gulf of Mexico, and off Venezuela (Courtenay and Sahlman 1978). In most areas, however, with the exception of Campeche Bank, catches are very low in relation to abundance. Sokolova (1965) reported that it is the major commercial fish on Campeche Bank year-round, averaging 60% of the total catch there but most abundant on the eastern Bank. Bearden and McKenzie (1972) found commercial concentrations on live bottom on the open shelf and shelf edge off South Carolina at 18.5-55.6 m (10-30 fathoms).

Recreational catches of *H. aurolineatum* also occur throughout its range. Manooch and Barans (footnote 5) reported that it is the main grunt in recreational catches between North Carolina and Cape Canaveral, Fla.

<sup>8</sup>George C. Miller, Fishery Biologist, Southeast Fisheries Center Miami Laboratory, National Marine Fisheries Service, NOAA, 75 Virginia Beach Drive, Miami, FL 33149, pers. commun. September 1980.

*Haemulon plumieri* is fished throughout its range, both commercially and recreationally (Manooch 1976). Lyubimova and Kapote (1971) reported that *H. plumieri* is one of the most valuable fishes caught on Campeche Bank and produces the best catches in fairly shallow areas (20-30 m) on the central and eastern Bank. Moe (1963) reported that *H. plumieri* are commonly caught by recreational fishermen on the upper west coast of Florida, often with black sea bass and black grouper, and are the basic catch of party boats in Brevard, Monroe, Sarasota, Pinellas, Levy, Taylor, and Wakulla Counties, Fla. *Haemulon plumieri* is abundant in recreational catches along the southeastern Atlantic coast of the United States, especially north of Cape Canaveral (Fishery Management Plan for the Snapper-Grouper Complex of the South Atlantic Region footnote 6).

*Haemulon plumieri* also forms large portions of trap catches in the West Indies and is the species of greatest abundance (10.74% of the total catch) caught in traps on Port Royal reefs (Billings and Munro footnote 3).

Sec 5.43.

### 5.3 Fishing seasons

On Campeche Bank, *H. aurolineatum* commercial catches are highest in fall when density is high due to spawning, but occur year-round (Sokolova 1965). Olacchea and Sauskan (1974), however, reported that *H. aurolineatum* is most concentrated on Campeche Bank in winter and spring at 20-60 m, especially on the eastern and central Bank. In Jamaica, Billings and Munro (footnote 3) reported that grunt abundance was at a minimum between September and November. Recreational catches in the northern Gulf of Mexico appear to be greatest in winter; St. Andrew Bay anglers surveyed by Sutherland (1977) caught *H. aurolineatum* only from October to March.

*Haemulon plumieri* is fished throughout the year, though abundance may vary somewhat locally and seasonally. Lyubimova and Kapote (1971) reported best catches on Campeche Bank in fall and winter; Olacchea and Sauskan (1974) reported *H. plumieri* most common in winter catches on Campeche Bank. Juárez (1975) found *H. plumieri* on eastern Campeche Bank only in spring. Anderson and Gehring (1965) collected *H. plumieri* off the southeastern United States only in winter and fall, during exploratory cruises.

Sec 2.22 and 2.23.

### 5.4 Fishing operations and results

#### 5.41 Effort and intensity

Catch per effort of *H. aurolineatum* by recreational anglers in St. Andrew Bay was reported by Sutherland (1977) as 0.03 fish/angling hour using squid bait and 0.16 fish/angling hour using live shrimp bait.

Manooch and Barans' (footnote 5) studies of *H. aurolineatum* in the South Atlantic Bight indicated that most (67-80%) of the total yield could be attained at low values of  $F$  (0.2-0.25), whereas three times the effort would be required to catch the remaining 20-30%. From an economic and biological viewpoint, Manooch and Barans (footnote 5) recommended that effort in the fishery should be kept low.

Catch of grunts per unit of effort in the trap and handline fisheries of Puerto Rico appears in Table 22; grunt catches in Puerto Rico include *H. plumieri*, *H. aurolineatum*, *H. flavolineatum*, and *H. sciurus* (Fishery Management Plan for Shallow Water Reef Fish, Puerto Rico and U.S. Virgin Islands<sup>9</sup>).

Sec 4.12.

Table 22.—Landings per fish trap and per handline for grunts, Puerto Rico, 1971-75. (Data from Fishery Management Plan for Shallow Water Reef Fish, Puerto Rico and the U.S. Virgin Islands text footnote 9, table 4-2.)

Year	Pounds per unit of effort	
	Trap	Handline
1975	76	4
1974	74	0
1973	48	1
1972	44	3
1971	36	9

#### 5.42 Selectivity

Selectivity of *H. aurolineatum* catches is probably limited to hook- and mesh-size considerations. Billings and Munro (footnote 3) provided some information on fish trap mesh-size selectivity in Jamaica.

Sec 4.13.4.33, and Figure 23.

#### 5.43 Catches

Catch statistics for *H. aurolineatum* and *H. plumieri* are scanty, because separate statistics are not usually reported for this species (Courtney and Sahlman 1978). Grunt landings on the South Atlantic coast of the United States (primarily *H. plumieri* and *H. aurolineatum*) appear in Table 23. In the Gulf of Mexico, commercial grunt catches averaged 89,600 kg (240,000 lb) from

Table 23.—Landings of grunts on the South Atlantic coast of the United States, 1971-75. (Data from Fishery Statistics of the United States, 1971-75, U.S. Department of Commerce, NOAA, NMFS, Statistical Digests 65-69.)

Year	Landings		Value (\$1,000)
	(1,000 kg)	(1,000 lb)	
1975	13.6	30	5
1974	130.3	287	57
1973	31.8	70	15
1972	19.5	43	4
1971	13.6	30	3

1972 to 1976, with a value of \$45,000 (Environmental Impact Statement and Fishery Management Plan for Reef Fish Resources of the Gulf of Mexico<sup>10</sup>). Grunt landings in Puerto Rico (*H. plumieri*, *H. aurolineatum*, *H. flavolineatum*, and *H. sciurus*) are presented in Tables 24 and 25.

<sup>9</sup>Fishery Management Plan for Shallow Water Reef Fish, Puerto Rico and the U.S. Virgin Islands. Caribbean Fishery Management Council, San Juan, Puerto Rico, Draft, July 1979.

<sup>10</sup>Environmental Impact Statement and Fishery Management Plan for Reef Fish Resources of the Gulf of Mexico. Gulf of Mexico Fishery Management Council, Tampa, Fla. Draft, February 1980.

Table 24.—Quantity and value of grunts landed in Puerto Rico, 1971-75. Values in parentheses are percentages of total inshore fish landings of Puerto Rico. (Data from Status of Fisheries of Puerto Rico, Puerto Rico Department of Agriculture, as appears in Fishery Management Plan for Shallow Water Reef Fish, Puerto Rico and U.S. Virgin Islands text footnote 9, tables 3-3, 3-4.)

Year	Landings		Value		
	(1,000 kg)	(1,000 lb)	(\$1,000)	\$/kg	\$/lb
1975	316.4	697 (17)	244 (15)	0.77	0.35
1974	271.5	598 (19)	186 (15)	0.68	0.32
1973	185.2	408 (14)	125 (12)	0.67	0.31
1972	161.2	355 (17)	99 (14)	0.61	0.28
1971	187.5	413 (12)	103 (10)	0.54	0.25
1971-75 Average	222.5	490	151	0.67	0.30

Table 25.—Distribution of catch of grunts by region of Puerto Rico, 1975. (Data from Status of Fisheries in Puerto Rico, Puerto Rico Department of Agriculture, as appears in Fishery Management Plan for Shallow Water Reef Fish, Puerto Rico and U.S. Virgin Islands text footnote 9, table 3-5.)

Region	Landings		Percent total
	(1,000 kg)	(1,000 lb)	
North	1.8	4	1
South	98.5	217	31
East	39.5	87	12
West	176.6	389	56
Total	316.4	697	100

Table 26.—Recreational and commercial fishery catches of grunts in the Cape Canaveral, Fla., area. (From Anderson and Gehringer 1965.)

Location	Recreational catch (1963)													
	Spring			Summer			Fall			Total				
	No.	kg	lb	No.	kg	lb	No.	kg	lb	No.	kg	lb		
Cape Canaveral, southern bridges and causeways	— <sup>1</sup>	—	—	1,350	306	674	892	203	446	2,242	508	1,120		
Cape Canaveral, southern ocean piers	—	—	—	231	52	115	—	—	—	231	52	115		
Port Canaveral, inside	72	16	36	2,840	644	1,419	387	88	194	3,299	749	1,649		
Port Canaveral, outside	86	20	43	—	—	—	412	94	206	498	113	249		
Cape Canaveral, northern banks	—	—	—	489	110	243	357	80	177	846	191	420		
Cape Canaveral, northern bridges	672	153	336	424	94	208	3,424	774	1,704	4,520	1,021	2,248		
Cape Canaveral, northern surf	—	—	—	46	11	24	—	—	—	46	11	24		
Cape Canaveral, northern boat	—	—	—	—	—	—	3,406	774	1,704	3,406	774	1,704		
Commercial catch (1959-62)														
1959		1960			1961			1962			Avg.			
kg	lb	\$	kg	lb	\$	kg	lb	\$	kg	lb	\$	kg	lb	\$
5,493	12,100	908	2,270	5,000	400	—	—	—	—	—	—	1,941	4,275	327

<sup>1</sup>No catch reported.

### *Haemulon aurolineatum*

On Campeche Bank, *H. aurolineatum* is the main commercial fish species, making up about 60% of the total annual catch (Sokolova 1965). Sauskan and Olaccheca (1974) noted a great potential for *H. aurolineatum* in the form of whole fish, canned fish, and fish meal and reported experimental catches by research trawlers of 12-16 t/h trawling on the eastern Bank at 30 m from July to December. Based on a theoretical model, Sauskan and Olaccheca (1974) recommended a maximum annual harvest of 37,000-40,000 t on Campeche Bank. Harvesting much above this level would not be economically feasible, and harvesting over 53,000 t/yr might damage the stock.

In the United States, all grunts landed are combined under one category (Manooch and Barans footnote 5). *Haemulon aurolineatum* is known to enter the industrial groundfish catch in the north-central Gulf of Mexico (Roithmayr 1965) and the shrimp trawl by-catch. Bearden and McKenzie (1972) reported that 0.2% (at 24.1-37.1 m, 13-20 fathoms) and 2.2% (at 41.7-77.8 m, 22.5-42 fathoms) of the total weight of commercial fish trawled in a survey off South Carolina were grunts (*H. aurolineatum* and *H. plumieri*), with an average weight of 0.15 kg (0.32 lb) (range 0.05-0.23 kg, 0.1-0.5 lb).

*Haemulon aurolineatum* enters the recreational fishery throughout its range. Headboats from North Carolina to Cape Canaveral caught an average of 23.2 t of *H. aurolineatum* in 1976 and 1977 (R. L. Dixon pers. commun. as cited in Manooch and Barans footnote 5). *Haemulon aurolineatum* was the most commonly caught grunt by these boats.

### *Haemulon plumieri*

Catches of *H. plumieri* may be fairly high in local areas; Beebe and Tee-Van (1928) reported that *H. plumieri* were almost always seen in markets in Port-au-Prince. Motchek and Silva Lee (1975) reported *H. plumieri* and *H. sciurus* as the most common grunts in Cuban commercial catches.

More quantitative data are available for certain areas. Anderson and Gehringer (1965) reported grunt landings from the Cape Canaveral area (Table 26). Although these landings were not bro-

ken down to species. *H. plumieri* was probably included. Huntsman (pers. commun. as cited in Manooch 1976) reported that over 475,000 *H. plumieri*, weighing about 329 t and comprising 22% of all fish caught in North and South Carolina recreational catches from headboats, were caught from 1972 to 1975. Ulrich et al. (1977) found that small catches of *H. plumieri* were made in the handline fishery directed at snappers and groupers off South Carolina. *Haemulon plumieri* catches were 90.8 kg (200 lb) in 1972 and 272.4 kg (600 lb) in 1973, with no catch reported in 1970, 1971, or 1974. Average ex-vessel price for *H. plumieri* taken by these vessels was \$0.55/kg (\$0.25/lb) in 1976.

Mean catch rates of *H. plumieri* caught in unbaited traps (4.13 cm mesh) at Port Royal were 265 fish in 1970 and 278 in 1971, expressed as corrected numerical catch from 1,000 traps, each soaked for 1 d (Billings and Munro footnote 3). Seasonality, catch and ingress, and conspecific attraction affects on trap catches are examined in Figures 31-33.

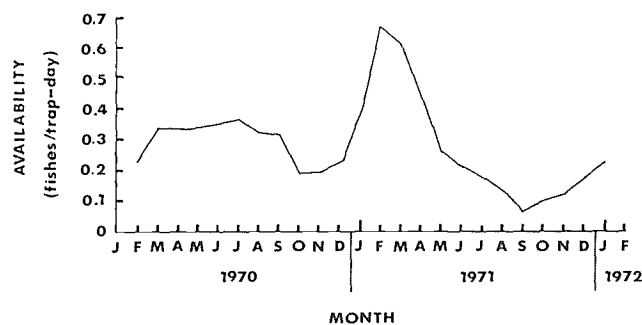


Figure 31.—Variations in monthly mean availability of *Haemulon plumieri* from trap catches at Port Royal, Jamaica, reefs. (From Billings and Munro see text footnote 3, fig. 4.7.)

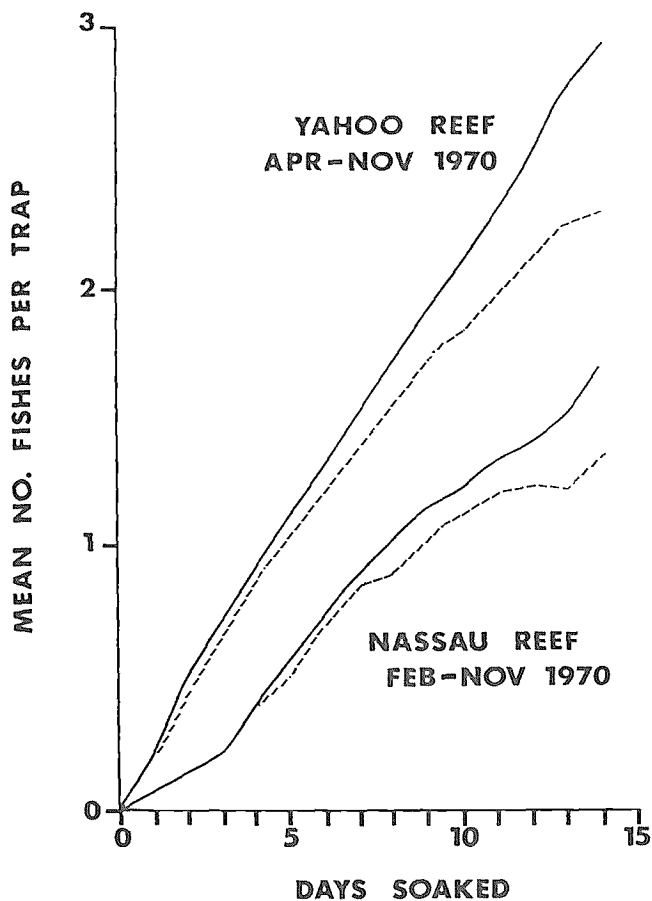


Figure 32.—Mean cumulative trap catch and ingress of *Haemulon plumieri* into traps on Nassau and Yahoo Reefs, Port Royal, Jamaica. Solid lines represent cumulative ingress, broken lines cumulative catch. The difference between the two lines for each reef represents escapement or death in the traps. (From Billings and Munro see text footnote 3, fig. 3.19.)

## 6 PROTECTION AND MANAGEMENT

### 6.1 Regulatory measures

*Haemulon aurolineatum* and *H. plumieri* are subject to regulation under the Fishery Management Plan for the Snapper-Grouper Complex of the South Atlantic Region (footnote 6) and the Fishery Management Plan for Shallow Water Reef Fish, Puerto Rico and the U.S. Virgin Islands (footnote 9). Neither species is covered by management measures in the Environmental Impact Statement and Fishery Management Plan for Reef Fish Resources of the Gulf of Mexico (footnote 10).

## ACKNOWLEDGMENTS

I thank Donald M. Allen, Joan A. Browder, and Albert C. Jones of the National Marine Fisheries Service, Southeast Fisheries Center; George C. Miller and Barbara J. Palko, NMFS, SEFC, Miami Laboratory; Elmer J. Guthertz, NMFS, SEFC, Mississippi Laboratories; Gene R. Huntsman, NMFS, SEFC, Beaufort Laboratory; and Eugene Nakamura, NMFS, SEFC, Panama City Laboratory, for critically reviewing the manuscript.

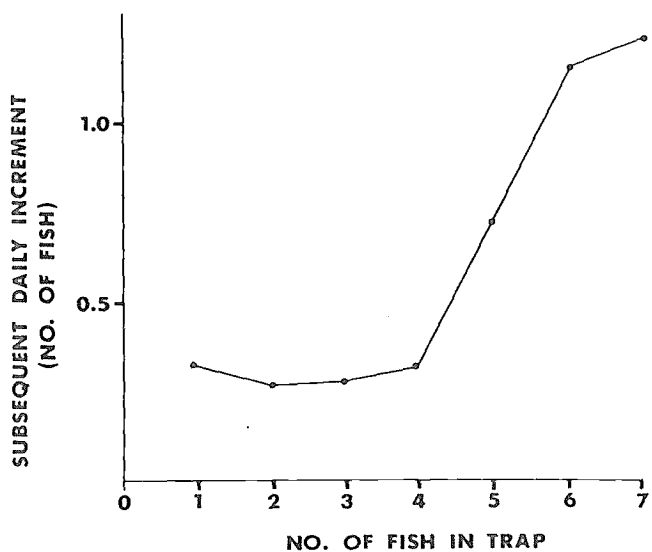


Figure 33.—Effect of conspecific attraction on trap catches of *Haemulon plumieri*. If there are more than four individuals of *H. plumieri* in a trap, the subsequent daily increment of the species increases sharply. (From Billings and Munro see text footnote 3, fig. 3.18.)

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