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FLATFISHES (PLEURONECTIFORMES)

By

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ABSTRACT

Eighteen flatfish species were collected by trawl and box dredge during Project Hourglass, a 28 month systematic sampling program off southwestern Florida. Species taken, in order of abundance, were *Syacium papillosum, Etropus rimosus, Bothus robinsi, Symphurus diomedianus, Cyclopsetta fimbriata, Citharichthys macrops, Citharichthys gymnorhinus, Etropus crossotus, Gymnachirus melas, Symphurus urospilus, Symphurus minor, Symphurus plagiusa, Achirus lineatus, Gastropsetta frontalis, Symphurus parvus, Paralichthys albigutta, Ancylopsetta quadrocellata* and *Bothus ocellatus.* Keys to the genera and species known to occur on the Florida Shelf are provided. Insofar as possible the following information is presented for each species, based on Hourglass material, various museum collections and published reports: list of recent literature, descriptive data, geographical distribution, environmental correlatives, seasonality, diurnality, food and feeding, reproduction, size, abundance and commercial importance.

An "ecological key" illustrates those attributes allowing the 18 species (plus *Trinectes maculatus*) to coexist along the same shelf segment. Primary differences are recognizable in food and feeding, habitat and behavior.

Zoogeography of Gulf of Mexico flatfishes was examined using a modified analysis of faunal coincidence in which relative species abundance was considered. The flatfish fauna of the Gulf of Mexico (including the Florida Keys) is more closely related to the fauna of the eastern United States than to that of the Caribbean. Three western Atlantic flatfish assemblages are recognized: 1) an arctic-boreal group, 2) a warm-temperate to subtropical group, extending through the Florida Keys and Gulf of Mexico and 3) a Caribbean group, extending to Brazil and including the Bahamas and Bermuda.

Contribution No. 197

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INTRODUCTION

The flatfishes (Heterosomata or Pleuronectiformes) are widespread and important members of the benthos represented in the Gulf of Mexico by 4 families, 17 genera and 45 species. Flatfishes are particularly abundant on the open continental shelf, where they are frequently of commercial importance. Representatives are also found in bathyal depths, on coral reefs, in rivers and estuaries, and in fresh water springs many miles inland.

Modern flounder systematics begins with Norman's (1934) worldwide monographic treatment of the families Psettodidae, Bothidae and Pleuronectidae. Ginsburg (1951) reviewed the western Atlantic tonguefishes (Cynoglossidae). The western Atlantic Soleidae have not been comprehensively treated, but Dawson (1964, 1967a) has reviewed the soleid genus *Gymnachirus*. Nine Gulf of Mexico flatfish species (20% of the known fauna) have been described since 1950.

Most of our information on flatfish life histories applies to boreal species, particularly the large, commercially important pleuronectid flounders of the North Atlantic. By comparison, Gulf of Mexico flatfishes are poorly understood. Except for a few nearshore and commercial species, biology of Gulf stocks is known only from occasional and isolated observations. A notable exception is Dawson's (1968) contribution to the biology of the Mexican flounder, *Cyclopsetta chittendeni*, based on 16 months of systematic sampling in the northern Gulf.

Other recent work on western Atlantic flatfishes (apart from strictly systematic accounts) includes a field guide to western North Atlantic Bothidae by Gutherz (1967), anatomical and developmental descriptions of *Achirus lineatus* by Houde *et al.* (1970) and Futch (1970), studies of larval bothids by Smith and Fahay (1970) and Gutherz (1971), a contribution to the biology and systematics of *Syacium* by Fraser (1971), and studies on the early life history of *Monolene sessilicauda* by Futch (1971) and of *Syacium papillosum* by Futch and Hoff (1971).

Information is presented here on nineteen flatfish species; for most, basic biology has been hitherto unknown. Eighteen were collected during systematic sampling off southwestern Florida on the open shelf shoreward of 73 m. The exception, *Trinectes maculatus*, seldom occurs offshore, but is considered in this account because it is abundant in bays, estuaries and rivers of the Florida west coast.

METHODS AND MATERIALS

This report is based primarily on collections made during Project Hourglass, a systematic sampling program on the continental shelf of southwestern Florida (Figure 1). Flatfishes were sampled at the following stations along east-west transects off Egmont Key and Sanibel Island. Depths are reported to the nearest whole meter:

Fishery Station A, 27°35' N Lat, 82°50' W Long, 6 m
Fishery Station B, 27°37' N Lat, 83°07' W Long, 18 m
Fishery Station C, 27°37' N Lat, 83°28' W Long, 37 m
Fishery Station D, 27°37' N Lat, 83°58' W Long, 55 m
Fishery Station E, 27°37' N Lat, 84°13' W Long, 73 m
Fishery Station I, 26°24' N Lat, 82°06' W Long, 6 m
Fishery Station J, 26°24' N Lat, 82°28' W Long, 18 m
Fishery Station K, 26°24' N Lat, 82°58' W Long, 37 m
Fishery Station L, 26°24' N Lat, 83°22' W Long, 55 m
Fishery Station M, 26°24' N Lat, 83°43' W Long, 73 m

Joyce and Williams (1969) described in detail the rationale, cruise patterns, stations, gear, sampling procedures and methods of specimen handling, plus all physical data accumulated during 28 months of the program (August 1965-November 1967). Briefly, this involved monthly night sampling of all fishery stations (Regular Cruises) and daytime sampling at Stations B, C, and D (Post-cruises), using a 20 ft (6.1 m) trynet and a 36 in. (0.9 m) rectangular box dredge. Supplementary cruises were made in July 1966 and January 1967, using a 45 ft (13.7 m) balloon-type otter trawl. Larval fishes, collected at fishery stations by plankton and nekton nets, will be treated in separate reports.

Specimens were preserved in 10% seawater Formalin and stored in 40% isopropyl alcohol. Representative lots have been catalogued into the Florida Department of Natural Resources (FSBC) fish reference collection. At time of curating, total and standard lengths (mm) of each specimen were taken with a standard fish measuring board, gut contents were cursorily examined for fullness and major inclusions, and gonadal conditions were rated macroscopically as 1) immature, 2) active-developing, 3) active-ripening, 4) ripe, 5) postspawning-spent, or 6) inactive. Criteria for gonadal conditions, plus additional details on handling and processing of specimens and data, are included in the checklist of Hourglass fishes (Hoff and Topp, in press). In the species accounts, standard lengths (mm SL) are used except where otherwise noted. Proportional measurements were recorded with dial calipers. Fecundities were estimated from aliquots and ova diameters were measured by ocular micrometer.

For each species, pertinent literature published since 1950 is emphasized, unless summarized elsewhere in a more recent review. Keys are provided to all flatfish genera known to occur on the Florida Shelf (southern Florida Bay to Cape San Blas, exclusive of the Florida Keys), and to Florida Shelf species of those genera represented in Hourglass collections. A single exception is the bothid genus *Citharichthys*, for which a key to western Atlantic species is provided.

Procedures used in the zoogeographical analysis are outlined in that section.

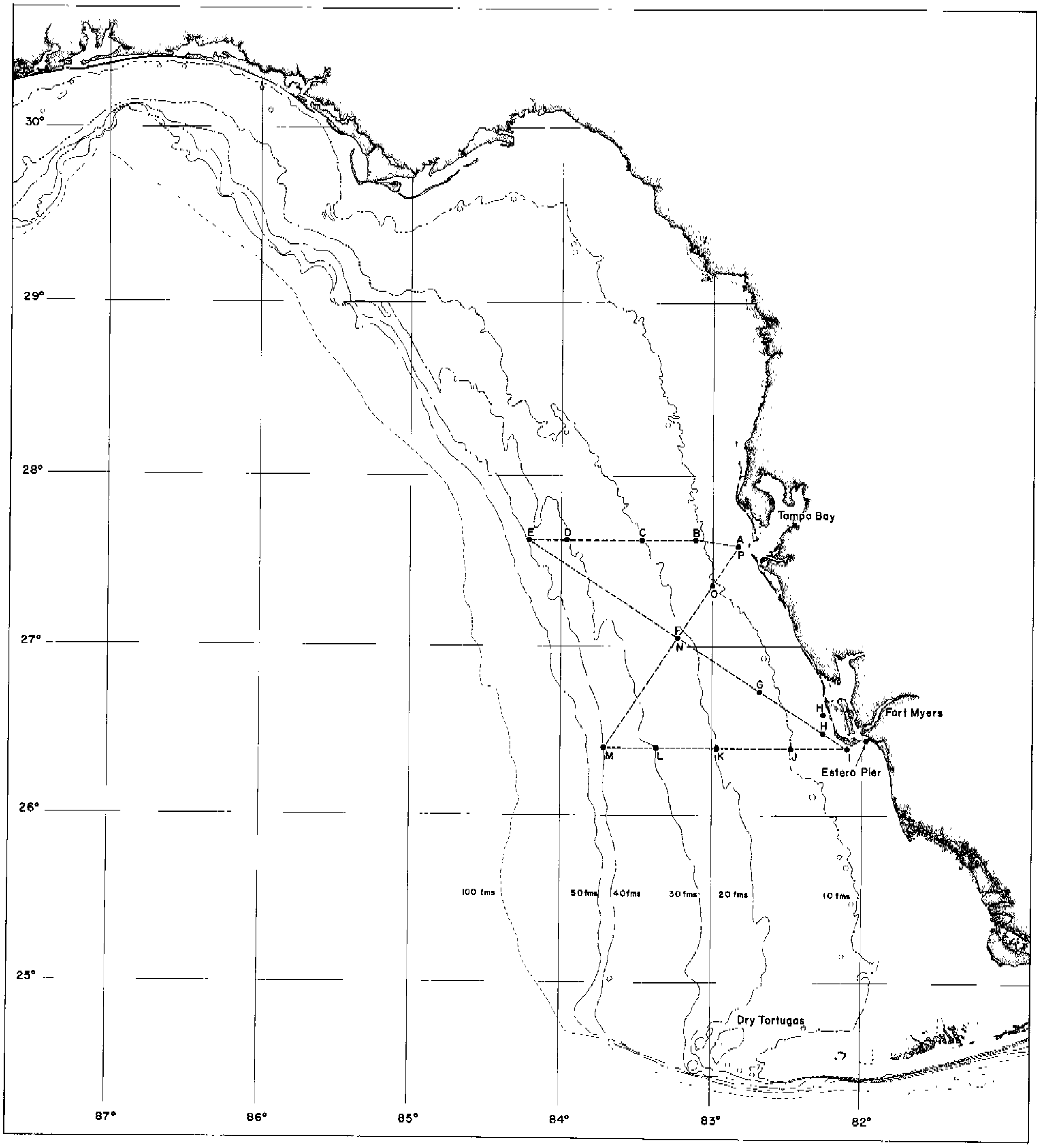

Figure 1. Hourglass cruise pattern and station locations. Flatfishes were collected at Stations A-E and I-M.

SPECIES ACCOUNTS

Four families of Pleuronectiformes occur in the western North Atlantic. In the Gulf of Mexico nearly every coastal and open shelf locality supports representatives of the Bothidae (lefteye flounders), Soleidae (soles) and Cynoglossidae (tonguefishes). The Pleuronectidae (righteye flounders) is represented by a single species, *Poecilopsetta beani*, which ranges from New England to northern Brazil, ordinarily at depths exceeding 300 m. On the Florida Shelf it is known from a single record (R/V *Oregon*, Station 34).

KEY TO THE FLATFISH FAMILIES KNOWN TO OCCUR ON THE FLORIDA SHELF

1. Preopercular margin free, not hidden by skin and scales 2

1. Preopercular margin adnate, hidden by skin and scales 3

2. Eyes and pigment on right side . . . . Pleuronectidae

2. Eyes and pigment on left side . . . . Bothidae

3. Eyes and pigment on right side . . . . .Soleidae

3. Eyes and pigment on left side . . . . Cynoglossidae

FAMILY BOTHIDAE

The Bothidae are diverse in form and habit, with examples ranging from diminutive and weak-jawed species (*Citharichthys gymnorhinus* and *Etropus* spp.) to large, well-toothed piscivores (*Paralichthys* spp.). The family is represented in the Gulf of Mexico by 27 species of 12 genera and on the Florida Shelf by 21 species of 9 genera. Norman (1934:60) recognized three subfamilies, based on position and support of the pelvic fin. Two, the Paralichthinae and Bothinae, are found on the Florida Shelf.

KEY TO THE GENERA OF BOTHIDAE KNOWN TO OCCUR ON THE FLORIDA SHELF

1. Pelvic bases symmetrical, the fin of eyed side not attached along midabdominal ridge (Figure 2a) 2

1. Pelvic bases asymmetrical, the fin of eyed side attached along midabdominal ridge (Figure 2b, c) 4

2. Pelvic fins of equal length; anterior dorsal fin rays not elongate; gill rakers long and slender, one-third length of eye or longer . . . . *Paralichthys*

2. Pelvic fins subequal in length, the left fin produced or elongate; anterior dorsal fin rays elongate; gill rakers short and stout, less than one-third length of eye 3

3. Eyed side with an ocellated spot on lateral line near caudal peduncle; scales of eyed side

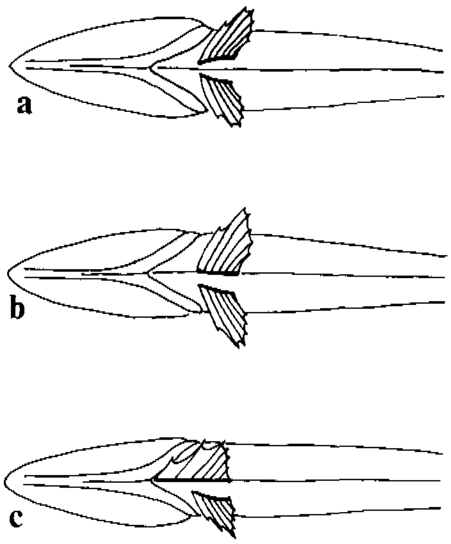

Figure 2. Ventral view of bothid flounders, showing length and relative position of pelvic fin bases.

strongly ctenoid, body rough to the touch; origin of dorsal fin above anterior edge of upper eye . . . . *Ancylopsetta*

3. Eyed side with no ocellated spot on lateral line nor on posterior one-fourth of body; scales of eyed side small, cycloid, embedded, body smooth to the touch; origin of dorsal fin well in advance of upper eye . . . . *Gastropsetta*

4. Pectoral fin of blind side absent . . . . *Monolene*

4. Pectoral fin of blind side present 5

5. Mouth small, maxillary extending to or slightly beyond anterior margin of lower eye; upper jaw length not exceeding 28% HL 6

5. Mouth moderate to large, maxillary extending well beyond anterior margin of lower eye; upper jaw length exceeding 28% HL 7

6. Pelvic fin base of eyed side at least twice as long as that of blind side (Figure 2c); lateral line distinctly arched above pectoral fin . . . . *Bothus*

6. Pelvic fin bases of approximately equal length; lateral line slightly elevated, but not distinctly arched above pectoral fin . . . . *Etropus*

7. Pelvic fin base of blind side not originating anterior to that of eyed side; mouth large, maxillary extending to posterior margin of lower eye; upper jaw length exceeding 45% HL; dorsal and anal fins each marked with two or three prominent spots . . . . *Cyclopsetta*

7. Pelvic fin base of blind side originating well anterior to that of eyed side; mouth moderate, maxillary not extending much beyond middle of lower eye; upper jaw length not exceeding 45% HL; dorsal fin unmarked, or bearing numerous dark spots 8

8. Gill rakers of lower limb with upper margins dentate (Figure 3a) . . . . *Syacium*

8. Gill rakers of lower limb with upper margins smooth or crenulate, but not dentate (Figure 3b, c) . . . . *Citharichthys*

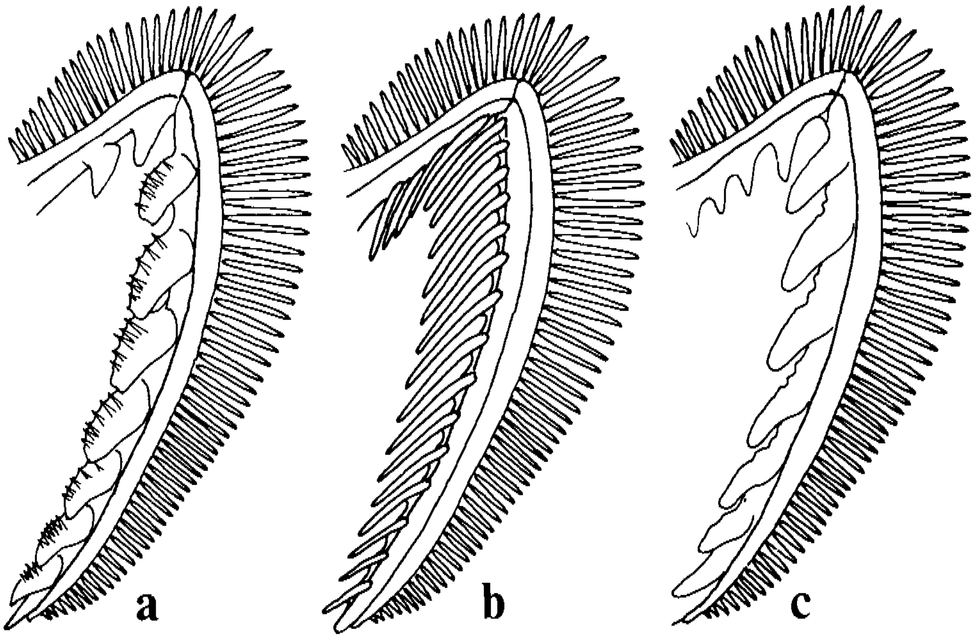

Figure 3. Gill rakers of a) *Syacium* and b,c) *Citharichthys.*

Paralichthys Girard

Paralichthys Girard, 1858:246 (type, *Pleuronectes maculosus* Girard); Norman, 1934:69 (synonymy, diagn.); Ginsburg, 1952a:300 (generic and subgeneric diagnoses).

Ginsburg (1952a), in his review of *Paralichthys* and the closely related *Hippoglossina* and *Pseudorhombus*, distinguished the former by its strong caniniform anterior teeth and presence of accessory scales in adults.

The genus is represented in the western North Atlantic by five species, at least three being of considerable economic importance. Of the three, *Paralichythys albigutta* is the only one regularly found in coastal waters contiguous to the Hourglass sampling area. A single specimen of *P. lethostigma* from Tampa was reported by Henshall (1895:220), but it cannot be located at the U.S. National Museum (the depository of his collection), nor are there other USNM specimens from the Florida west coast south of Apalachee Bay (Robert H. Kanazawa, pers. comm.). Gunter and Hall's (1965:47) specimens from near the Caloosahatchee Estuary are the only verified record of the species along this coast. Specimens of *P. lethostigma* reported by Springer and Bullis (1956:64) from west of St. Petersburg in 9 fm (16 m) and by Tabb and Manning (1961:639) from Florida Bay are likely *P. albigutta.*

KEY TO THE SPECIES OF *PARALICHTHYS* KNOWN TO OCCUR ON THE FLORIDA SHELF

1. Body depth exceeding 47% SL; lateral line scales 104 or more . . . *Paralichthys squamilentus*

1. Body depth not exceeding 47% SL; lateral line scales 100 or fewer 2

2. Interorbital distance (measured between soft margins) generally not exceeding 2.8% SL; anal rays 63 or fewer; lateral line scales 82 or fewer; eyed side of young bearing three distinct ocelli, arranged as in Figure 4, these spots frequently persisting in adults . . . . *Paralichthys albigutta* (Figure 4)

2. Interorbital distance (measured between soft margins) generally exceeding 2.8% SL; anal rays 63 or more; lateral line scales 85 or more; eyed side not bearing ocelli . . . . *Paralichthys lethostigma*

The following list of references dates primarily from Ginsburg's (1952a) revision and is by no means exhaustive.

Paralichthys albigutta Jordan and Gilbert

Gulf flounder, Figure 4

Paralichthys albigutta Jordan and Gilbert, 1883a:302 (Pensacola, Fla., Beaufort, N. Car.); Mast, 1916 (color patterns); Norman, 1934:75 (synonymy, key, distrib.); Osborn, 1939 (color change); Gunter, 1945:86 (Texas); Baughman, 1950:137 (Texas); Behre, 1950:43 (Grand Isle, La.); Ginsburg, 1952a:324, Fig. 13 (key, synonymy, descr., distrib., ecology, comp. with *P. dentatus* and *P. lethostigma*); Hildebrand, 1954:291 (w. Gulf of Mex.); de Sylva, 1954:30 (Edgewater, Fla.); Reid, 1954:64 (Cedar Key, Fla.); Kilby, 1955:230 (Cedar Key, Fla.); Joseph and Yerger, 1956:128 (Alligator Harbor, Fla.); Menzel, 1956:97 (listed, St. George Sound, Fla.); Springer and Bullis, 1956:64 (Gulf of Mex. localities); Boschung, 1957:192 (synonymy, distrib., Ala.); Murdock, 1957:21 (Braden and Manatee Rivers, Fla.); Simmons, 1957:187 (upper Laguna Madre, Texas); Briggs, 1958:297 (listed, Fla.); Deubler, 1958 (postlarvae, N. Car.); Robins, 1958:29 (listed, Fla.); Hoese, 1959:4 (Texas); Simmons and Hoese, 1959:74 (Cedar Bayou, Texas); Deubler, 1960:339 (Bogue Sound, N. Car.); Springer and Woodburn, 1960:86 (ecology, Tampa Bay); Tagatz and Dudley, 1961:10 (Beaufort, N. Car.); Richmond, 1962:94 (Horn Is., Miss.); Schultz, 1962b:10 (Aransas and Copano Bays, Texas); Springer and McErlean, 1962:51 (Matecumbe Key, Fla.); Topp, 1963:47 (tagging, Fla.); Beaumariage, 1964:32 (tagging, Fla.); Anderson and Gehringer, 1965:27 (Cape Canaveral area, Fla.); Bullis and Thompson, 1965:33 (w. N. Atl. localities); Christensen, 1965:222 (Loxahatchee R., Fla.); Gunter and Hall, 1965:51 (Caloosahatchee Estuary, Fla.); Hoese, 1965:57 (Port Aransas, Texas); Miller, 1965:101 (Port Aransas, Texas); Moe and Martin, 1965:137 (off Tampa Bay, Fla.); Parker, 1965:217 (Galveston Bay system, Texas); Roessler, 1965:314 (Biscayne Bay, Fla.); Roithmayr, 1965:22 (industrial fishery, Gulf of Mex.); Beaumariage and Wittich, 1966:43 (tagging, Fla.); Compton, 1966:68 (off Port Aransas and other Texas localities); Gutherz, 1967:12 (key, descr., distrib.); Tagatz, 1967:47 (St. Johns R., Fla.); Böhlke and Chaplin, 1968:213 (Bahamas); Fox and Mock, 1968:47 (Barataria Bay, La.); Beaumariage, 1969:10 (tagging, Fla.); Struhsaker, 1969:298 (se. U.S.); Dahlberg and Odum, 1970:387 (season, Ga. estuary); de Sylva, 1970:52, Pls. 86, 87 (Biscayne Bay, Fla.); Nugent, 1970:53 (Biscayne Bay, Fla.); Roessler, 1970:866, 885 (Everglades Nat. Park); Grimes, 1971:App. II (Crystal R., Fla.); Humm *et al.*, 1971:132 (Anclote R. and anchorage, Fla.); Wang and Raney, 1971:44 (Charlotte Harbor Estuary, Fla.); Cooley, in press (Pensacola, Escambia, and Little Sabine Bays, and Santa Rosa Sound, Fla.).

Paralichthys albiguttus Jordan and Evermann, 1898:2631 (Cedar Key, Fla.); Hildebrand and Cable, 1930 (early life hist., Beaufort, N. Car.); Hutton *et al.*, 1956:60 (listed, Boca Ciega Bay, Fla.); Hoese, 1958:345 (Texas).

Paralichthys albigutulus Pearse *et al.*, 1942:189 (Beaufort, N. Car.).

Paralichthyes albigutta Vick, 1964:51 (St. Andrews Bay, Fla.).

Most early difficulties in distinguishing western Atlantic species of *Paralichthys* were resolved by Ginsburg (1952a), who demonstrated that *P. albigutta, P. lethostigma,* and *P. dentatus* could be separated by combinations of meristic characters (primarily gill raker and anal fin ray counts). Hourglass specimens of *P. albigutta* agree with Ginsburg's scheme, having 13-15 gill rakers on the first arch of the blind side and 59-62 anal rays.

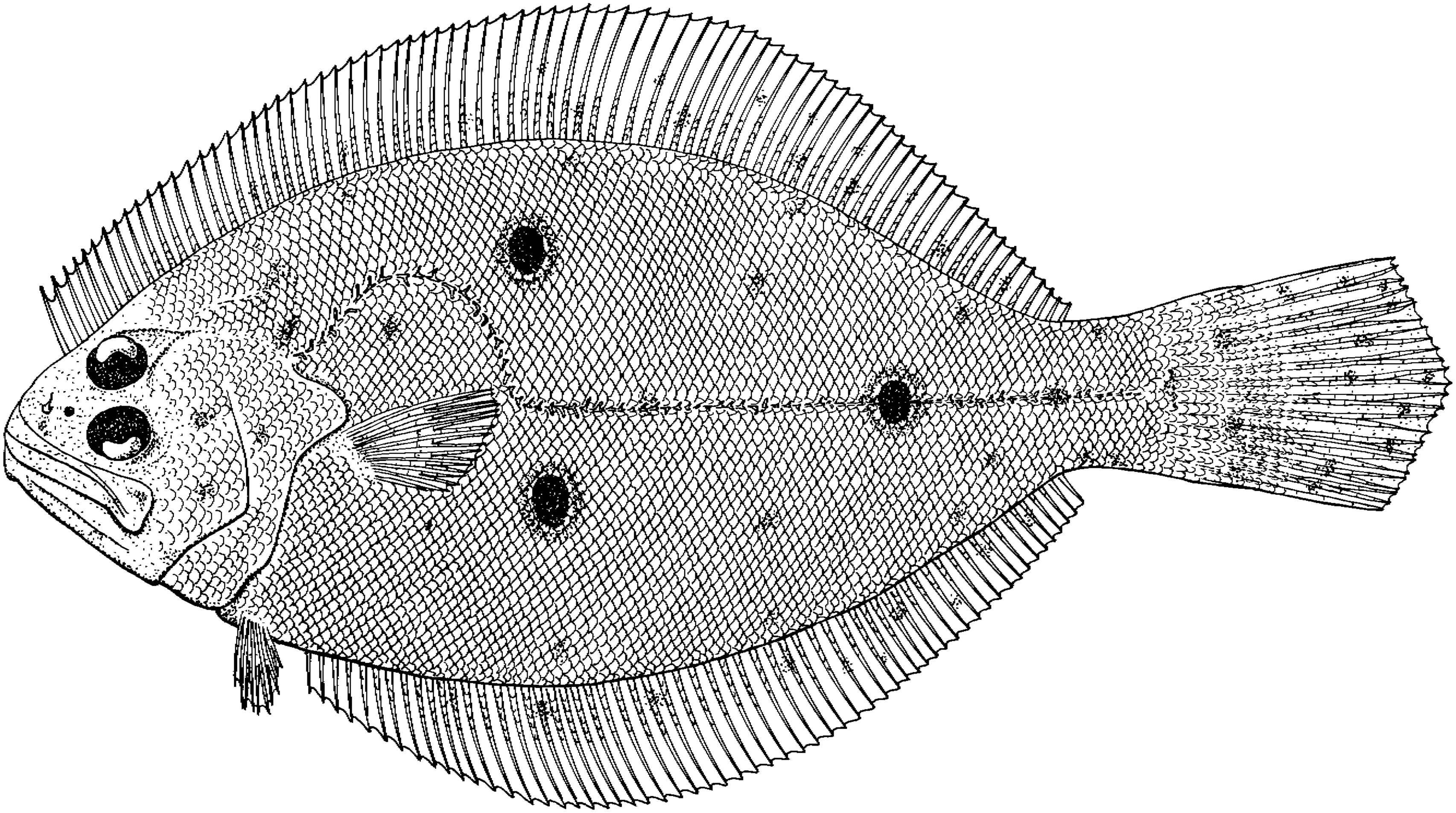

Figure 4. *Paralichthys albigutta* Jordan and Gilbert, FSBC 1073, 152 mm SL, Sarasota Bay, Fla.

Distribution. Ginsburg (1952a:325) reported the range of *Paralichthys albigutta* from Cape Lookout, North Carolina to Corpus Christi Pass, Texas. Subsequent records by Hildebrand (1954:292) from off Padre Island, Texas, and Simmons (1957:187), who found it "fairly common" in the upper Laguna Madre, extend its range in the western Gulf.

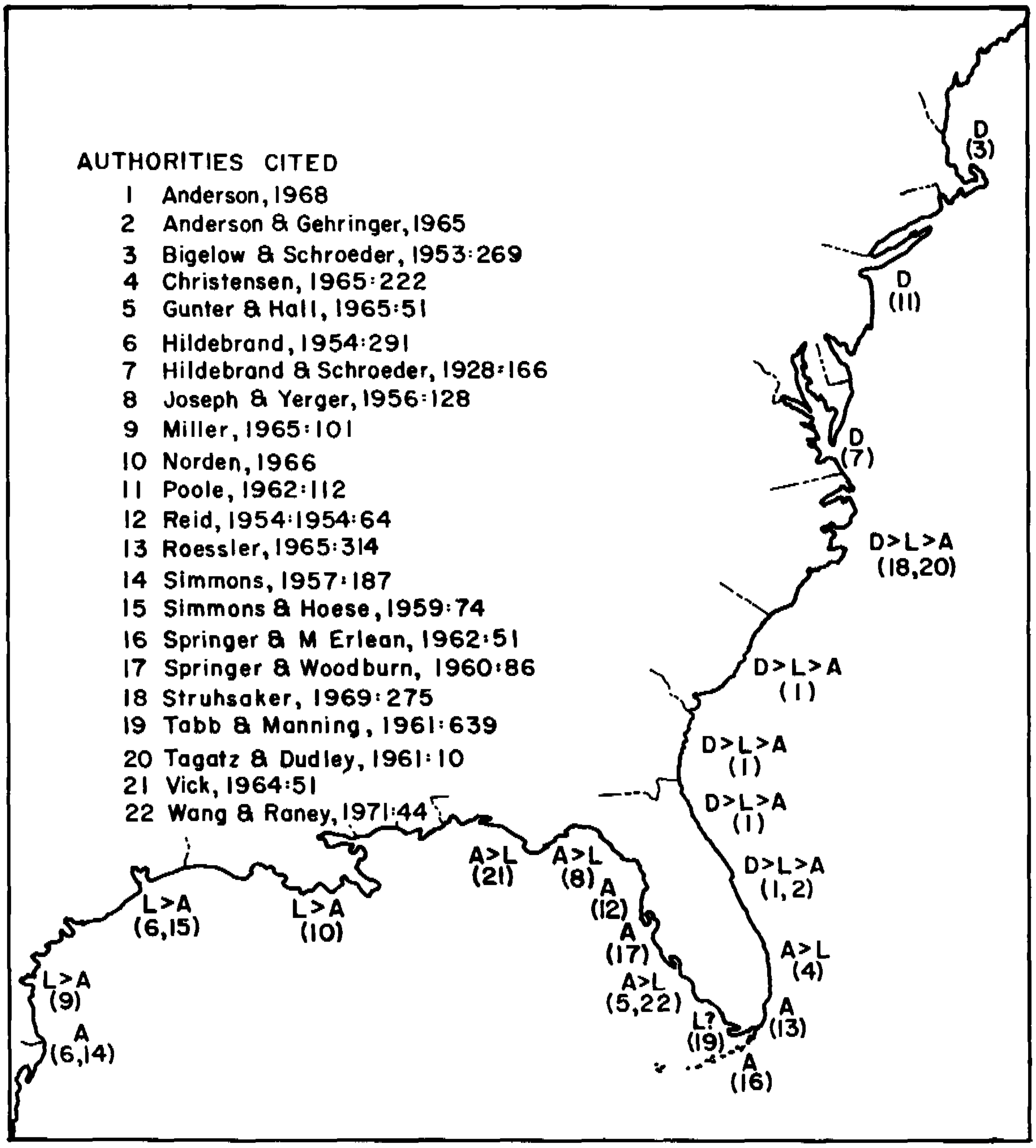

Figure 5. Relative abundance of three commercially important species of *Paralichthys* along the eastern and Gulf coasts of the United States. Numbers in parentheses refer to authorities cited. D = *Paralichthys dentatus*, L = *P. lethostigma*, A = *P. albigutta.*

West of the Mississippi Delta *Paralichthys albigutta* is much less important than *P. lethostigma*, the latter being dominant on the western Gulf shrimp grounds (Hildebrand, 1954:292), in Cedar Bayou, Texas (Simmons and Hoese, 1959:74) and Vermillion Bay, Louisiana (Norden, 1966:131). East of the Delta *P. albigutta* dominates, being more common than *P. lethostigma* at St. Andrews Bay, Florida (Vick 1964:51) and Alligator Harbor, Florida (Joseph and Yerger, 1956:128). Ginsburg (1952a:330) implies that *P. lethostigma* is abundant along the Florida west coast as far south as Tampa, but the species rarely occurs south of Apalachee Bay.

Analysis of published distributional records for the three commercially important species of *Paralichthys* of the eastern and Gulf coasts of the United States shows them to occupy well defined latitudinal ranges (Figure 5). *P. dentatus*, which is not found in the Gulf of Mexico, extends from the Gulf of Maine southward to the Cape Canaveral area, and dominates the landings wherever the three species occur sympatrically. *P. lethostigma* has the most restricted latitudinal range, occurring on the east coast from North Carolina to the Loxahatchee River, Florida, and on the Gulf coast from the Caloosahatchee Estuary, Florida to Corpus Christi Pass, Texas. The range of *P. albigutta* is unbroken from North Carolina around peninsular Florida and along the Gulf coast to the Laguna Madre, Texas. It occurs in greatest numbers along the Florida west coast.

Occurrence in Hourglass Collections. Six specimens were taken during Hourglass sampling, all by trynet at night, as follows:

Sta. B, 4 Oct. 1965, 162 mm
8 Nov. 1965, 307 mm
3 Mar. 1966, 280 mm
1 Dec. 1966, (2) 210-243 mm

Sta. C, 7 Feb. 1966, 430 mm

Bottom temperatures for Hourglass collections of *Paralichthys albigutta* ranged from 15.9-27.0°C; salinities from 33.40-35.74‰. *P. albigutta* has been reported at temperatures from 8.3°C (Reid, 1954:65) to 32.5°C (Springer and Woodburn, 1960:86) and salinities from 7.7‰ (Tagatz, 1967:47) to 60‰ (Simmons, 1957:187). Reports by Gunter (1945:46) and others consistently indicate that *P. albigutta* is not commonly found at salinities below 20‰.

Food Habits. Stomachs of three Hourglass specimens were empty, one contained fish remains, one contained fish and shrimp, and one contained unidentifiable remains. Examination of an additional 32 specimens from FSBC collections, mostly from Tampa Bay, agree with published findings that *Paralichthys albigutta* feeds almost exclusively on fishes and crustaceans. Of the 16 stomachs containing food, penaeid shrimp and portunid crabs were well represented among the crustaceans, and the following fishes were identified: *Anchoa* sp., *Fundulus similis, Syngnathus* sp., *Haemulon* sp., and *Gobiosoma robustum.* These examinations, based on specimens larger than 50 mm, generally agree with observations of Reid (1954:66) and Springer and Woodburn (1960:86), who found that small *P. albigutta* feed primarily on crustaceans, changing to a more piscivorous diet as they grow larger. Judging from studies of Darnell (1958:405) and Poole (1964), feeding habits of *P. albigutta* are similar to those of its two large congeners, *P. lethostigma* and *P. dentatus.*

Maturation and Spawning. Macroscopic examination of gonads from 6 Hourglass and 74 FSBC specimens indicates that *Paralichthys albigutta* spawns in the Gulf of Mexico from November through February. Ripe males (FSBC 2857 and 2942) were collected in the northern Gulf during

January; spent females (FSBC 3835) occurred in the Tampa Bay area during February. Data kindly provided by Charles R. Futch (pers. comm.) show that larvae appear locally between December and early March. Small juveniles occur early in the year throughout their range (Reid, 1954:65; Springer and Woodburn, 1960:86; Tagatz and Dudley, 1961:10). Gonadal examinations indicate that females mature at about 145 mm.

Size and Importance. Ginsburg (1952a:326) concluded, primarily on the basis of museum material, that *Paralichthys albigutta* is a small species, usually under 10 in. (25 cm) and cited a 39 cm specimen from Cedar Key (reported by Jordan and Swain, 1885:233) as the largest known. Specimens taken in the sport fishery, however, frequently exceed this length, as do those caught incidental to live bait shrimp trawling along the Florida west coast. A report by Vick (1964:51) of market specimens at Panama City of 28 in. (71 cm) weighing 11 lb (5 kg) more realistically approximate maximum size.

Ginsburg (1952a:326) reported that *Paralichthys albigutta* is "evidently of minor economic importance in the southern states." Since *P. albigutta* is the only large flounder landed from Jupiter Inlet on the east coast to north of Cedar Key on the Gulf coast, and since it contributes some 75% of the flounder catch along the northwestern Florida coast and a small percentage (perhaps 10%) along the northeastern coast, it is possible to arrive at a reasonable estimate of the commercial value of this species in Florida. Based on 1968 landings (U.S. Fish and Wildlife Service, 1968), 350,626 lb of "flounders" were landed during that year. By the above scheme, *P. albigutta* contributed some 198,400 lb, or about 57% of the Florida catch, valued at about $41,000.

Gastropsetta Bean

Gastropsetta Bean, 1895:633 (type, *Gastropsetta frontalis* Bean); Gutherz, 1966:473 (diagn.).

The monotypic genus *Gastropsetta* closely resembles *Ancylopsetta* in bearing ocelli, but placement of these ocelli, in addition to differences in scale type, anterior profile, dorsal fin origin and urohyal bone, distinguishes the two genera (Gutherz, 1966:474).

Gastropsetta frontalis Bean

Shrimp flounder, Figure 6

Gastropsetta frontalis Bean, 1895:633, figure (Fla. Keys); Norman, 1934:128 (synonymy, key, descr., distrib.); Longley and Hildebrand, 1941:39 (descr., s. of Tortugas); Springer and Bullis, 1956:63 (ne. Fla., Fla. Keys, Gulf of Campeche); Sand, 1956 (e. Fla.); Briggs, 1958:296 (listed, Fla.); Tyler, 1959:146 (diff. from *Ancylopsetta*, key, distrib.); Bearden, 1961:10 (listed, S. Car.); Bullis and Thompson, 1965:33 (e. Fla., Fla. Keys); Gutherz, 1966:472, Fig. 8C (diagn., key, descr., distrib.); 1967:12, Fig. 12 (descr., key, distrib.); Voss, 1967:67 (Carib. coast of Panama); Duke and Rudolph, 1969:63 (Carib. coast of Panama); Struhsaker, 1969:298 (se. U.S.).

Gastropsetta frontalis is nowhere abundant. It occurs along the southeastern coast of the United States from North Carolina to the Florida Keys, along the western Florida coast, and on the Campeche Bank. Gutherz (1966:474) extended its range into the Bahamas (Great Inagua) and south to Panama. It is considered "rare" (occurring in less than 10% of trawling stations) on the continental shelf of the southeastern United States (Struhsaker, 1969:298). In the western Gulf of Mexico it is known from a single collection taken off Tobasco, Mexico in 46 m (Springer and Bullis, 1956:63).

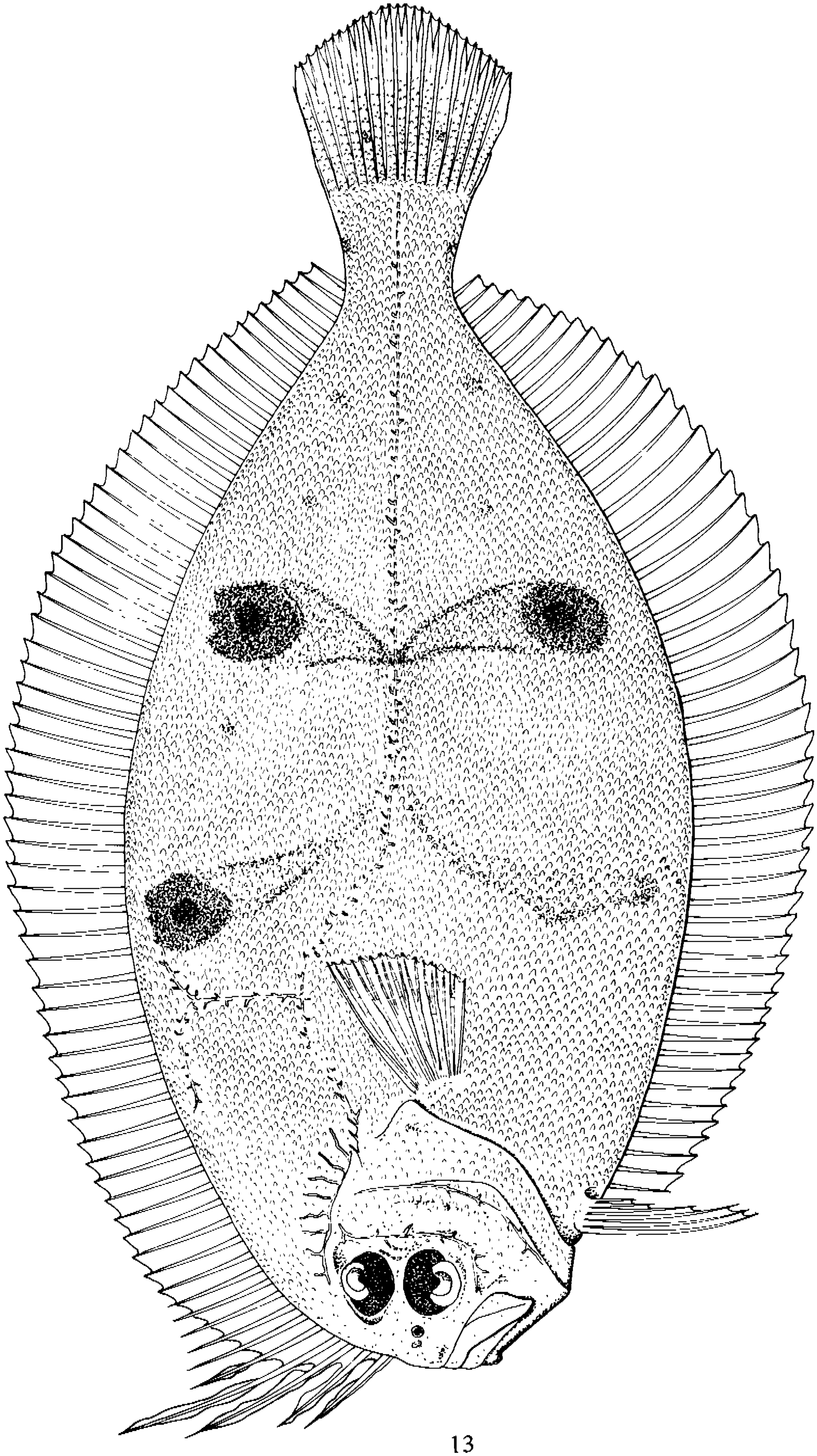

Figure 6. *Gastropsetta frontalis* Bean, FSBC 5313, 185 mm SL, Hourglass Sta. D.

Eleven specimens were taken during Hourglass sampling, as follows:

Sta. C,	12 Apr. 1967,	206 mm, trynet
Sta. D,	2 Dec. 1966,	122 mm, trynet
	2 Aug. 1967,	(2) 66-185 mm, trynet
	1 Sep. 1967,	140 mm, trynet
Sta. K,	12 Jan. 1967,	119 mm, balloon trawl
Sta. L,	4 Sep. 1965,	220 mm, trynet
	13 June 1966,	210 mm, trynet
	22 July 1966,	51 mm, balloon trawl
Sta. M,	13 Oct. 1966,	133 mm, trynet
	6 July 1967,	172 mm, trynet

An additional specimen, 160 mm, was captured in a baited lobster trap during Post-Hourglass sampling at 27°42'N, 84°10'W in 46 m.

All Hourglass specimens were captured at depths between 37 and 73 m. Elsewhere, *Gastropsetta frontalis* has been reported at depths of 35-183 m, with no apparent relationship between capture depth and latitude or size.

Bottom temperatures for Hourglass specimens of *Gastropsetta frontalis* ranged from 18.0-25.4°C; salinities from 35.90-36.65‰. Because the species appears restricted to offshore waters within a rather narrow depth range, it is doubtful that these limits are often exceeded.

Stomachs of four uncatalogued FSBC specimens collected off southwestern Florida were examined; three contained crustacean parts, the fourth contained remains of a synodontid fish.

Gonads in late stages of ripening were found in specimens collected on 30 May 1965, 6 June 1965, 13 June 1966, and 3 July 1965, indicating a spring or early summer spawning season. Our smallest specimens, 51 and 66 mm, collected on 22 July 1966 and 2 August 1967, may represent young of the year from early season natalities.

Ancylopsetta Gill

Ancylopsetta Gill, 1864:224 (type, *Ancylopsetta quadrocellata* Gill); Gutherz, 1966 (synonymy, diagn., revision).

Notosema Goode and Bean, 1883:192 (type, *Notosema dilecta* Goode and Bean).

Ramularia Jordan and Evermann, 1898:2633 (type, *Ancylopsetta dendritica* Gilbert).

The bothid genus *Ancylopsetta*, as revised by Gutherz (1966), is represented in Hourglass collections by a single species, *A. quadrocellata*.

KEY TO THE SPECIES OF *ANCYLOPSETTA* KNOWN TO OCCUR ON THE FLORIDA SHELF

1. Ocular side bearing four prominent ocelli, the first located above arch of lateral line . . . . *Ancylopsetta quadrocellata* (Figure 7)

1. Ocular side bearing three prominent ocelli; no ocellus above arch of lateral line . . . . *Ancylopsetta dilecta*

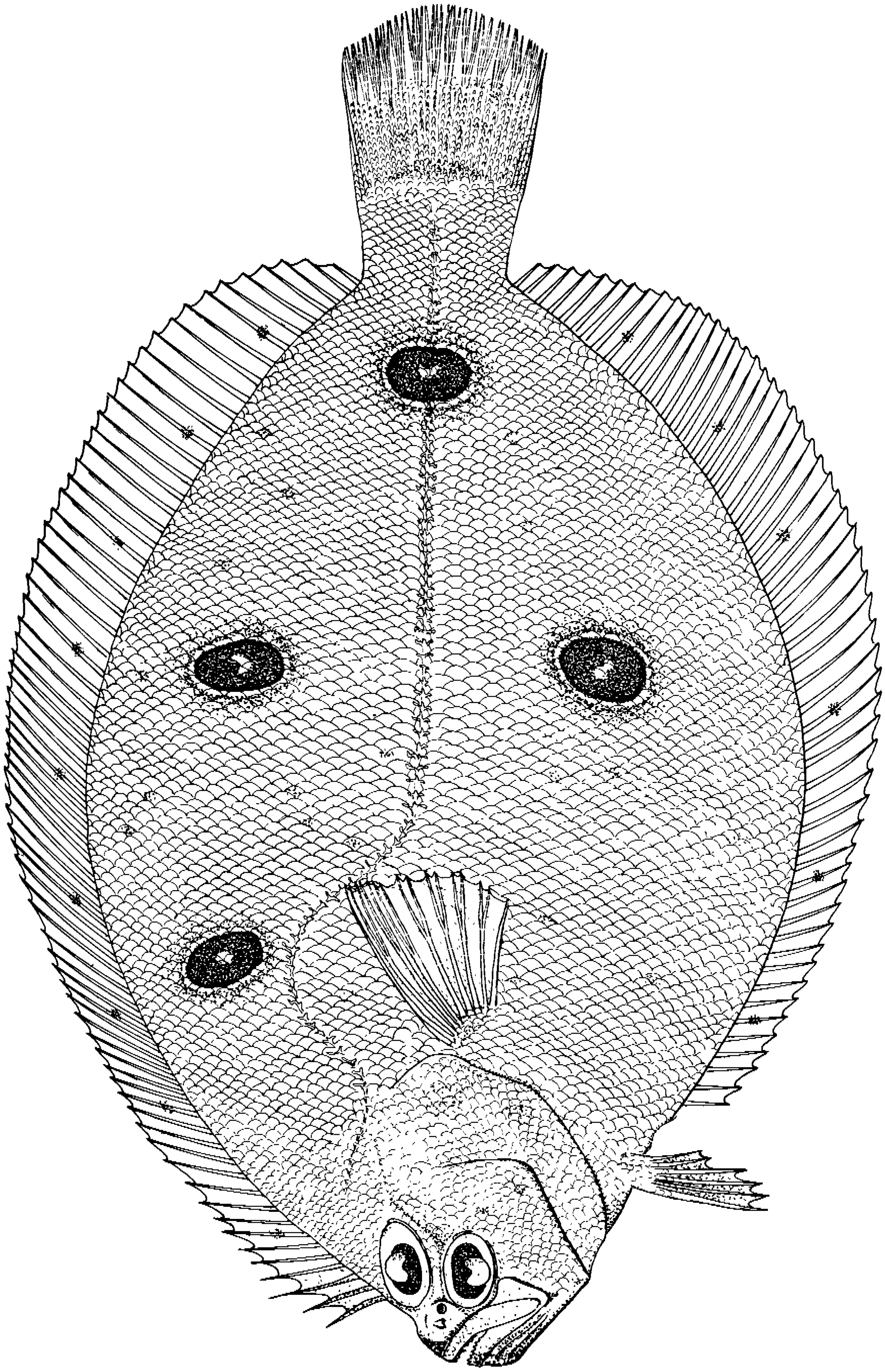

Figure 7. *Ancylopsetta quadrocellata* Gill, FSBC 3898, 122 mm SL, Tampa Bay.

Ancylopsetta quadrocellata Gill

Ocellated flounder, Figure 7

Ancylopsetta quadrocellata Gill, 1864:224 (Pensacola, Fla.); Jordan and Goss, 1889:250 (descr., distrib.); Norman, 1934:127, Fig. 82 (synonymy, key, descr., distrib.); Pearse *et al.*, 1942:189 (Beaufort, N. Car.); Gunter, 1945:86 (ecology, Texas); Baughman, 1950:137 (Corpus Christi, Freeport, Port Aransas, Texas); Behre, 1950:41 (listed, Grand Isle, La.); Gunter and Knapp, 1951:135 (Texas coast); Miles, 1951:19 (Apalachicola Bay, Fla.); Simmons, 1951a:4; 1951b:6 (listed, Texas); Caldwell, 1954:183 (Cedar Keys, Fla.); Hildebrand, 1954:293 (Texas, Miss., La., Gulf of Campeche); Hildebrand, 1955:202 (season, depth, Campeche Banks); Joseph and Yerger, 1956:127 (Alligator Harbor, Fla.); Menzel, 1956:55 (St. George Sound, Apalachee Bay, Fla.); Springer and Bullis, 1956:62 (Gulf of Mex. localities); Boschung, 1957:193 (synonymy, descr., distrib., Mobile Bay, Gulf Shores, Miss. Sound); Simmons, 1957:188 (salinity, Laguna Madre, Texas); Briggs, 1958:296 (listed, Fla.); Hoese, 1958:345 (Texas); Day, 1959:6 (Matagorda Bay, Texas); Hoese, 1959:6 (listed, West Bay, Texas); Tyler, 1959:145 (key, relationships); Christmas *et al.*, 1960:7 (Miss. purse seine fishery); Springer and Woodburn, 1960:86 (ecology, Tampa Bay, Fla.); Bearden, 1961:10 (listed, S. Car.); Tabb and Manning, 1961:639 (Cape Sable, Fla.); Schultz, 1962a:14; 1962b:10 (Texas localities); Compton and Bradley, 1963:7; 1964:421 (depth, Texas); Vick, 1964:51 (St. Andrews Bay, Fla.); Anderson and Gehringer, 1965:23, 27 (season, Cape Canaveral, Fla.); Bullis and Thompson, 1965:32 (N. Car., S. Car., Ga., Fla., La., Texas); Moe and Martin, 1965:136, Table 2 (off Tampa Bay, Fla.); Parker, 1965:217 (Galveston Bay System, Texas); Roithmayr, 1965:22 (Miss. R. to Mobile Bay); Cervigon, 1966:803, Fig. 343 (misident., Venezuela); Compton, 1966 (Texas localities); Gutherz, 1966:469, Fig. 8 (synonymy, descr., distrib.); 1967 (key, descr., distrib.); Tagatz, 1967:46 (St. Johns R., Fla.); Anderson, 1968 (s. Atl. coast of U.S.); Cervigon, 1968:216 (correction of misident. in Cervigon, 1966); Struhsaker, 1969:297, App. D (cont. shelf off se. U.S.); Copeland and Fruh, 1970: App. Table 1 (Galveston Bay, Texas); Dahlberg and Odum 1970:387 (season, Ga. estuary); Grimes, 1971:App. II, III (Crystal R., Fla.); Humm *et al.*, 1971:132 (Anclote R. and anchorage, Fla.); Cooley, in press (Pensacola Bay, Escambia Bay, Santa Rosa Sound, Fla.).

Pseudorhombus quadrocellata Jordan and Gilbert, 1879:370.

Paralichthys ommatus Jordan and Gilbert, 1882b:824; Jordan and Swain, 1885:234 (Cedar Keys, Fla.).

Distribution and Abundance. *Ancylopsetta quadrocellata* is found along the southeastern coast of the United States from North Carolina to the southern tip of Florida, and along the Gulf coast from Cape Sable to the Campeche Banks. The reported occurrence of the species from Venezuela (Cervigon, 1966:803) has more recently been recognized (Cervigon, 1968:216) as *A. kumperae* Tyler.

Pearse *et al.* (1942:189) seined specimens along the beaches in Beaufort, North Carolina, but reported the species to be less common than *Paralichthys dentatus* or *P. albigutta.* Along the southeastern United States *Ancylopsetta quadrocellata* is commonly taken in trawl hauls on the open shelf (Struhsaker, 1969:297). From Cape Sable northward along the Florida west coast it is reportedly less common. Miles (1951:19), in an analysis of the trash fishery of Apalachicola Bay, encountered *A. quadrocellata* in only one Gulf station area, but found juveniles common in the bay proper. In Texas, however, Hoese (1958:345) and Gunter and Knapp (1951:135) found the species more abundant in the shallow Gulf than in the bays.

Occurrence in Hourglass Collections. Five specimens of *Ancylopsetta quadrocellata* were taken during Hourglass sampling, all by trynet at night, as follows:

Sta. A,	2 June 1967,	133 mm
Sta. C,	6 June 1966,	196 mm
	2 Nov. 1967,	200 mm
Sta. I,	12 June 1966,	130 mm
Sta. J,	14 Feb. 1966,	197 mm

Ecology. Bottom temperatures for Hourglass specimens of *Ancylopsetta quadrocellata* ranged from 16.44-28.5°C; salinities from 32.84-36.13‰. The species apparently tolerates a rather wide range of these conditions, having been taken in temperatures ranging from 10.9° to 30.9°C (Schultz, 1962b:10) and in salinities from 1.9‰ (Schultz, 1962a:14) to the high salinities of the Laguna Madre, Texas (Compton and Bradley, 1964:421).

Hourglass specimens were taken at depths of 6, 18, and 37 m. Both adults and juveniles are commonly found in shallow waters throughout their range, often in depths of 1 m or less. The species has been reported during exploratory fishing in the northern Gulf of Mexico in depths exceeding 100 m (Springer and Bullis, 1956:62) and off the east coast of Florida in some 330 m (Bullis and Thompson, 1965:32).

There are indications that *Ancylopsetta quadrocellata* may move to deeper waters during warmer weather. Copeland (1965:19), for example, found tide trap emigrants in Aransas Pass, Texas during summer and fall, and Compton (1965) found peak abundance in deeper waters (20-37 m) during June and July off the Texas coast. Analysis of tabulations by Anderson (1968) shows a sharp decline in Georgia catches from "inside" waters between April and June, coincident with greatly increased catches in "outside" waters. Peak catches in Florida east coast "outside" waters occurred in August.

Food Habits. Examination of gut contents of seven specimens indicates that *Ancylopsetta quadrocellata* feeds primarily on crustaceans and fish. A stomatopod, *Eurysquilla plumata* Bigelow 1901, found in the stomach of a 196 mm specimen from Hourglass Sta. C on 6 June 1966, constitutes the first record for this crustacean in the Gulf of Mexico (David K. Camp, pers. comm.). An ophichthid eel, *Myrophis punctatus*, approximately 240 mm, found in the gut of a 212 mm specimen, was kindly identified by Mrs. Bonnie Eldred. The following food items were recovered from Hourglass and FSBC specimens:

SPECIMEN	FOOD ITEMS
HG Sta. A 2 June 1967 (133 mm)	Decapoda Brachyura *Heterocrypta* sp. (1) *Portunus* sp. (1) *Parthenops* sp. (1 claw) megalops (1)
HG Sta. C 6 June 1966 (196 mm)	Stomatopoda *Eurysquilla plumata* (1)
FSBC 2545 27°37'N, 83°15'W 16 Dec. 1964 (178 mm)	Porifera (spicules) crustacean parts fish scale
FSBC 3732 26°16'N, 82°53'W 5 June 1965 (248 mm)	Stomatopoda *Squilla rugosa* (1)
FSBC 2880 27°24'N, 83°20'W 22 Dec. 1964 (255 mm)	fish vertebrae
FSBC 3811 27°35'N, 82°45'W 25 Jan. 1966 (212 mm)	Pisces: Ophichthidae *Myrophis punctatus*

FSBC 3898
mouth of Tampa Bay
18 May 1966 (125 mm)
	Ostracoda (1)
	Mysidae (12)
	Amphipoda (1)
	Stomatopoda: Lysiosquillidae (1)
	Decapoda
	  Porcellanidae
	    Euceramus sp. (1)
	  Portunidae
	    Portunus sp. (2)
	  Paguridae (2)

Maturation and Spawning. Examination of Hourglass material supplemented by 20 specimens from FSBC collections confirms a late fall or winter spawning season in the Gulf of Mexico, as indicated by Joseph and Yerger (1956:127), Hildebrand (1955:202), and Miller (1965:100). Miller found two distinct size ranges in Texas samples between February and May, one 36-58 mm, the other 170-182 mm, probably representing age groups O and I. Other published records of Gulf of Mexico juveniles less than 100 mm have been reported only from February through May.

Macroscopic appearance of adult gonads agrees with these data. Two males (FSBC 2545, 183-206 mm) collected on 16 December 1964 and one female (FSBC 2880, 255 mm) collected on 22 December 1964, both from off Tampa Bay, contained gonads in late stages of ripening. A female taken on 25 January 1966 from the same approximate location (FSBC 3811, 212 mm) appeared to be in post-spawning condition. Based on our material, *Ancylopsetta quadrocellata* probably matures during its first year.

Size and Importance. A maximum size of 400 mm (presumably SL) has been reported by Compton and Bradley (1964:7) from the Texas coast. In the Tampa Bay area large specimens (over 300 mm) are sometimes caught by sport fishermen, but their value as a sports fish is overshadowed by the more important flatfish, *Paralichthys albigutta.* In the Cape Sable area they are occasionally taken by anglers (Tabb and Manning, 1961:639), and they are no doubt included elsewhere in the sport fishery as well. They form only a small percentage of the various "trash" and "scrap" fisheries in the Gulf of Mexico (Miles, 1951:19; Compton, 1965).

Cyclopsetta Gill

Cyclopsetta Gill, 1889:601 (type, *Hemirhombus fimbriatus* Goode and Bean).

Azevia Jordan and Goss, 1889:271 (type, *Citharichthys panamensis* Steindachner).

The genus *Cyclopsetta,* characterized by uniserial teeth in both jaws and short spinulate gill rakers, contains two western Atlantic representatives, *C. chittendeni,* and *C. fimbriata,* with only the latter known from the Florida Shelf. Dawson's (1968) contribution to the biology of *C. chittendeni* in the northern Gulf of Mexico has been particularly useful in providing related biological data on an important congener.

Cyclopsetta fimbriata (Goode and Bean)

Spotfin flounder, Figure 8

Hemirhombus fimbriatus Goode and Bean, 1886:591 (ne. Gulf of Mex.).

Arnoglossus (?) *fimbriatus* Jordan and Goss, 1889:262.

Cyclopsetta fimbriata Bean, 1895:635, Fig. 2; Norman, 1934:137, Fig. 90 (synonymy, key, descr., distrib.); Longley and Hildebrand,

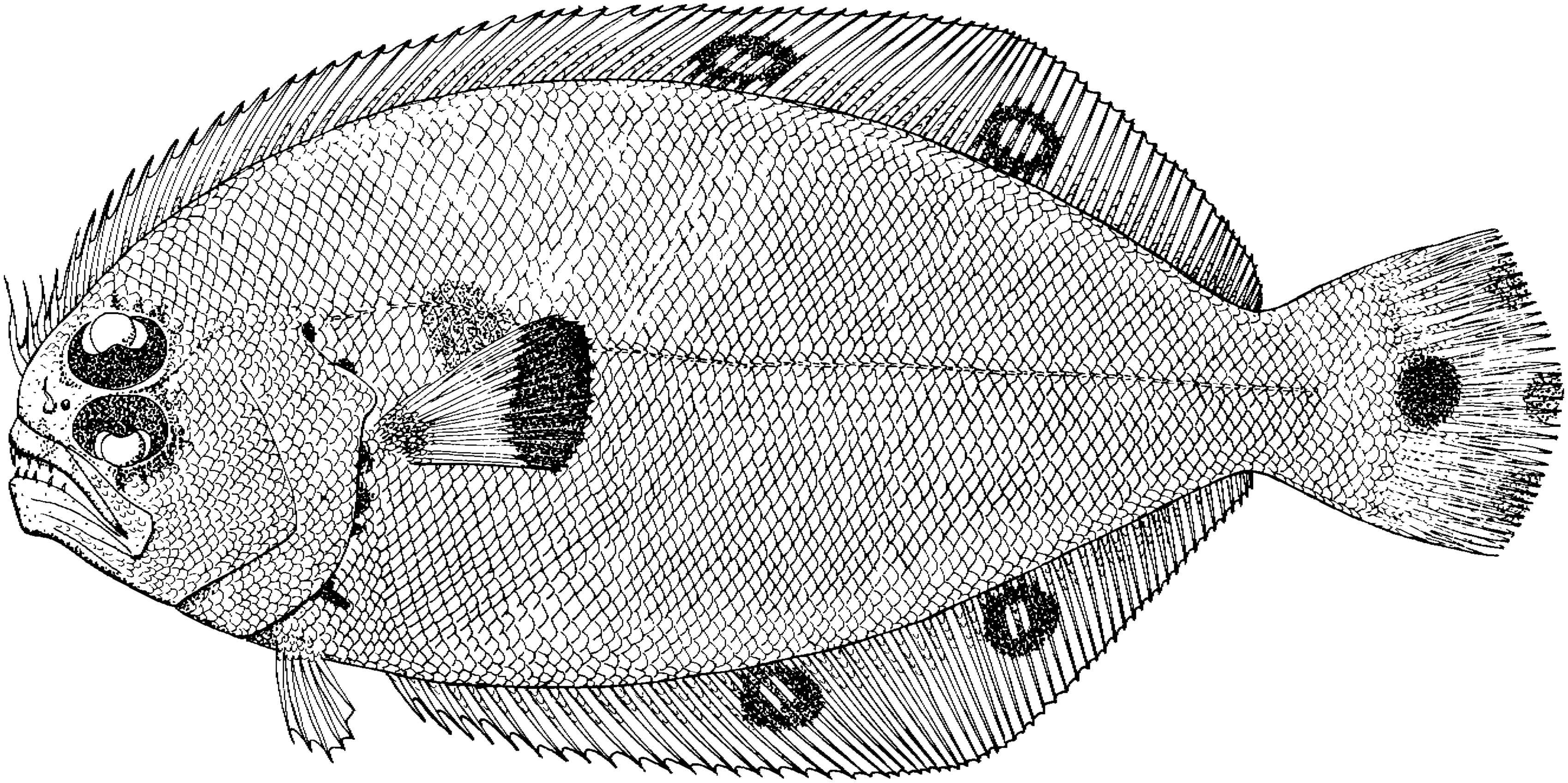

Figure 8. *Cyclopsetta fimbriata* (Goode and Bean), FSBC 5063, 167 mm SL, Hourglass Sta. J. Squamation partially reconstructed.

1941:42 (s. of Tortugas, Fla.); Baughman, 1950:137 (Galveston, Texas); Hildebrand, 1955:203 (Campeche Bank); Springer and Bullis, 1956:63 (Gulf of Mex. localities); Briggs, 1958:296 (listed, Fla.); Hoese, 1958:345 (listed, Texas); Bullis and Thompson, 1965:33 (se. U.S., Gulf of Mex. and Carib. localities); Moe and Martin, 1965:136 (off Tampa Bay); Gutherz, 1967:25, Fig. 26 (key, descr., distrib.); Struhsaker, 1969:298 (se. U.S.); Gutherz, 1971 (larval develop. and distrib.).

Cyclopsetta fimbriata resembles *C. chittendeni* of the northern Gulf of Mexico, but differs from the latter in its pattern of spots on the dorsal, caudal, and pectoral fins. Although *C. chittendeni* is common off Texas, its distribution apparently breaks rather abruptly east of the Mississippi Delta, having been reported in the northern Gulf no further east than 87°45'W (Springer and Bullis, 1956:63). Distributions of the two species overlap in a rather broad area of the northern Gulf, with *C. chittendeni* being most abundant in the northwestern Gulf, and *C. fimbriata* occupying the eastern Gulf and southeastern Atlantic coasts of the United States, the Carribbean coast of Middle and South America, and the Greater Antilles. *C. fimbriata* is commonly trawled on the open shelf of the southeastern United States (Struhsaker, 1969:298), and appears to be fairly common off Tampa Bay. On the Campeche Bank shrimping ground it is considered "very rare" (Hildebrand, 1955:203).

Occurrence in Hourglass Collections. Sixty-one specimens of *Cyclopsetta fimbriata* were taken in 52 separate collections during Hourglass sampling, at all but the two shallow stations, A and I. A maximum catch of four specimens was collected at Station D in March 1967. One specimen was taken during diving collections in July 1967. The specimens ranged from 28-293 mm; no comparative size records are available in the literature. Table 1 shows number of specimens collected by station and month, plus size range (mm) for each collection.

Ecology. A chi-square analysis of all specimens grouped by depth (18, 37, 55, and 73 m) showed no significant deviation (P=0.05) from a random bathymetric distribution (X^2 = 6.51, d.f. = 3), nor was there any apparent relationship between size and capture depth. The species has only once been reported from less than 18 m (Springer and Bullis, 1956:63, northern Gulf of Mexico, 7.3 m), and it is seldom found in depths greater than 90 m. A maximum depth of 125 fm (229 m) has been reported from the Great Bahama Bank (Bullis and Thompson, 1965:33).

Bottom temperatures for Hourglass collections of *Cyclopsetta fimbriata* ranged from 17.0-30.0°C; salinities from 32.54-36.55‰. The species probably experiences extremes of these conditions very infrequently, for it is not known to enter bays or shallow coastal waters. Dawson (1968:507), who found a comparable depth range for the closely related *C. chittendeni* in the northern Gulf of Mexico, did not consider salinity the primary factor limiting inshore distributions.

Annual, seasonal, or diurnal catch patterns were not discernible. Stomach contents of two specimens (FSBC 2159, 130 mm, nw. of Marquesas Keys, 18 m, 1 May 1962; FSBC 3145, 210 mm, w. of Tampa Bay, 119 m, 11 May 1963) consisted entirely of fish remains.

Age, Growth, and Spawning. Gonads of 29 Hourglass females of *Cyclopsetta fimbriata* were macroscopically examined for indications of ripening and spawning. Two specimens collected at Station C on 16 April 1966 and 20 May 1967 contained turgid ovaries extending well forward into the body cavity proper, and were filled with a large proportion of clear ova, indicating a late stage of ripening. Appearance of a 28 mm juvenile on 1 July 1967 agrees with the inferred late spring spawning period. If Dawson's (1968:507) postulated fall or winter spawning season for *C. chittendeni* is correct, the latter may be reproductively separated from the closely related *C. fimbriata*, with spawning seasons a half year out of phase.

TABLE 1. NUMBERS AND SIZE RANGE (mm SL) OF *CYCLOPSETTA FIMBRIATA* COLLECTED DURING PROJECT HOURGLASS BY STATION AND MONTH.

Cyclopsetta fimbriata

STA	1965					1966													1967												TOT
	A	S	O	N	D	J	F	M	A	M	J	J	J sp	A	S	O	N	D	J	J sp	F	M	A	M	J	J	A	S	O	N	
A																															
B₁																		1 220													1
B₂						1 138																									1
C₁	1 93								1 192					1 20				1 196			1 102			1 161		1 28				1 186	8
C₂						1 293			2 108-233	1 211								1 212						1 235				1 150			7
D₁							2 130-270	1 203							1 180	1 190			1 164				1 112				1 161	1 140			9
D₂				1 203								1 162					1 162					4 111-253	1 197	1 192						2 179-200	11
E																	1 246	1 222												1 190	3
I																															
J	1 285					1 285							3 87-167							1 194	1 106								2 162-188	1 74	10
K								1 115	1 120				1 149			2 196-210				1 147	1 95								1 222		8
L											1 124																				1
M												1 224									1 193				1 185				1 180		4
TOT	2			1		3	2	2	4	1	1	2	4	1	1	3	2	4	1	2	4	4	2	3	1	1	1	2	4	5	63

Plotted monthly length frequencies (20 mm classes) suggest that recruitment into the sampling gear occurred during winter, when a standard length of some 80 mm was reached. Modal progressions, although indistinct, indicate lengths of approximately 115 mm and 210 mm by the completion of the first and second years of life, with accelerated growth occurring during summer. If this growth scheme is valid, a small proportion of the population may survive past age 2, with a maximum size of some 300 mm corresponding to a life span of 2½ years.

Importance. Cyclopsetta fimbriata may ultimately form a small component of an industrial or food fishery off southwestern Florida, but among the bothids it is far less important on the inner shelf than *Syacium papillosum.* The importance of *C. fimbriata* does not rival that of the related *C. chittendeni*, which has been considered by Gunter and Knapp (1951) to be the most common large flatfish in offshore waters of the northern Gulf of Mexico.

Etropus Jordan and Gilbert

Etropus Jordan and Gilbert, 1882a:364 (type, *Etropus crossotus* Jordan and Gilbert); Norman, 1934:154 (synonymy, diagn.).

Citharichthys (in part) Parr, 1931:2.

The genus *Etropus* is distinguished from *Citharichthys* by its small mouth and correspondingly weak dentition, but this distinction is not beyond dispute (Parr, 1931:2). Two species, *E. crossotus* Jordan and Gilbert and *E. rimosus* Goode and Bean, are represented in Hourglass collections. A third, *E. microstomus* (Gill) has been reported from the northern Gulf of Mexico (Springer and Bullis, 1956:63), but there remains some confusion as to the distinction of this species from *E. rimosus.* Although Jordan and Evermann (1898:2689) questioned separation of *E. crossotus* from *E. rimosus*, the distinction in Hourglass and FSBC specimens is clear-cut both morphologically and ecologically. According to Gutherz (1967:27), *E. intermedius* Norman is probably a synonym of *E. crossotus.*

KEY TO THE SPECIES OF *ETROPUS* KNOWN TO OCCUR ON THE FLORIDA SHELF

1. Supplementary squamation absent from free portion of primary body scales; pectoral fin of ocular side shorter than 17% SL; orbital diameter small, 21-23% HL; gill rakers on lower limb 7-9 . . . . *Etropus crossotus* (Figure 9)

1. Supplementary squamation present on free portion of primary body scales; pectoral fin of ocular side longer than 18% SL; orbital diameter 22-30% HL; gill rakers on lower limb 4-7 (usually 5) . . . . *Etropus rimosus* (Figure 10)

Etropus crossotus Jordan and Gilbert

Fringed flounder, Figure 9

Etropus crossotus Jordan and Gilbert, 1882a:364 (Mazatlan); Jordan and Gilbert, 1883a:305 (Lake Pontchartrain, Mazatlan, Panama, Galveston); 1883b:618 (Charleston, S. Car.); Jordan and Goss, 1889:278 (key, descr., distrib.); Evermann and Marsh, 1900:329 (descr., distrib., Puerto Rico); Hildebrand and Schroeder, 1928:173, Fig. 88 (descr., Cape Charles City, Va.); Norman, 1934:158 (synonymy, key, descr., distrib.); Gunter, 1938:340 (season, migration, La.); Gunter, 1945:86 (season, ecology, Copano and Aransas Bays, Texas); Gunter, 1950:301, Table 1 (Texas); Miles, 1951:20 (Apalachicola Bay, Fla.); Ingle, 1952:10, Table 5 (Great Point Clear, Ala.); Hildebrand, 1954:295 (depth pref., Miss. Delta to Yucatan); Hildebrand, 1955:203 (color, abundance, depth, Campeche Banks); Joseph and Yerger, 1956:128 (ecology, Alligator Harbor, Fla.); Springer and Bullis, 1956:63 (n. Gulf of Mexico, Campeche); Boschung, 1957:199 (synonymy, distrib., Ala.); Simmons, 1957:188 (season, Laguna Madre, Texas); Hoese, 1958:345 (listed, Texas); Hoese, 1959:4 (lower Galveston, East and West Bays, Texas); Simmons and Hoese, 1959:77, Table 4 (Mesquite Bay and Cedar Bayou, Texas); Harrison and Martin, 1960:4 (listed, Va.); Hoese, 1960:332

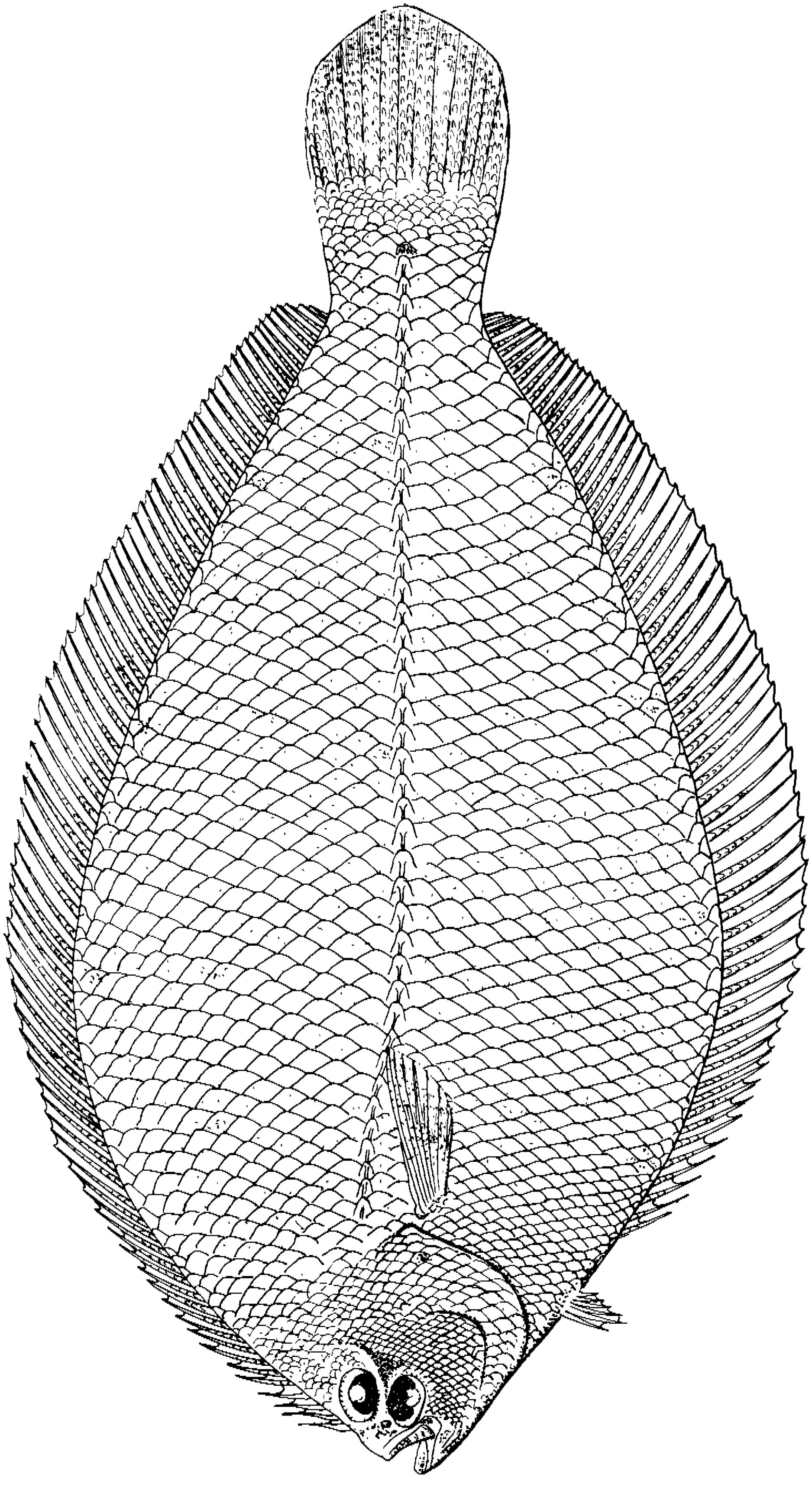

Figure 9. *Etropus crossotus* Jordan and Gilbert, FSBC uncat., 95 mm SL, Tampa Bay.

(Mesquite Bay, Texas); Stevens, 1960:10 (Sabine Lake, Texas); Tagatz and Dudley, 1961:10 (Beaufort, N. Car.); Lyon, 1962:2 (Matagorda Bay, Texas); Schultz, 1962a:13 (ecology, Mesquite Bay and Cedar Bayou, Texas); Schultz, 1962b (ecology, season, Aransas and Copano Bays, Texas); Tabb *et al.*, 1961:62 (season, Florida Bay); Gunter and Hall, 1963 (St. Lucie Estuary, Fla.); Compton and Bradley, 1964:421 (season, Gulf of Mex. off Port Aransas); Rounsefell, 1964:386 (salinity, New Orleans to Breton Sound, La.); Vick, 1964:51 (St. Andrews Bay, Fla.); Anderson and Gehringer, 1965:23, Table 9 (season, depth, Cape Canaveral, Fla.); Bullis and Thompson, 1965:33 (N. Car., e. coast of Fla., Fr. Guiana); Compton, 1965 (season, Gulf of Mex. off Port Aransas and other Texas localities); Gunter and Hall, 1965:46 (Caloosahatchee Estuary, Fla.); Hoese, 1965:56 (Port Aransas, Texas); Miller, 1965:100 (ecology, season, Port Aransas, Texas); Parker, 1965:217 (listed, Galveston Bay, Texas); Roithmayr, 1965:22 (Miss. R. to Mobile Bay); Burleigh, 1966:55 (Lake Borgne, La.); Compton, 1966 (season, Port Aransas and other Texas localities); Gutherz, 1967:28, Fig. 29 (key, descr., distrib.); Anderson, 1968:8 (abundance, season, S. Car., Ga., Fla.); Fox and Mock, 1968:51, Table 5 (season, Barataria Bay, La.); Jorgenson and Miller, 1968:4 (length relationships); Tagatz, 1968:47 (St. Johns R., Fla.); Struhsaker, 1969:298 (listed, se. U.S.); Copeland and Fruh, 1970:App. Table 1 (Galveston Bay, Texas); Dahlberg and Odum, 1970:387 (season, Ga. estuary); Grimes, 1971:App. II, III (Crystal R., Fla.); Cooley, in press (Pensacola Bay, Santa Rosa Sound, Fla.).

Etropus crossotus atlanticus Parr, 1931:16 (descr., distrib., comp. with *E. c. crossotus*); Behre, 1950:43 (listed, Grand Isle, La.); Reid, 1954:64 (ecology, season, Cedar Key, Fla.); Kilby, 1955:230 (Cedar Key, Fla.); Day, 1959 (Matagorda Bay, Texas); Springer and Woodburn, 1960:86 (Tampa Bay, Fla.); Dawson, 1965:279 (length-weight relationships); Moe and Martin, 1965:145 (ecology, off Tampa Bay, Fla.).

Citharichthys crossotus Parr, 1931:13 (descr., distrib.); Gines and Cervigon, 1968:44 (se. of Trinidad to Fr. Guiana).

Citharichthys atlanticus Briggs, 1958:296 (listed, Fla.); Duarte-Bello, 1959:130 (distrib.).

Citharicthys atlanticus Bearden, 1961:11 (listed, S. Car.).

Hourglass specimens agree with Gutherz's (1967:28) synoptic description of *Etropus crossotus* and with Parr's (1931:16) subspecific definition of *E. c. atlanticus.* Norman (1933:203) described *Etropus intermedius* from Trinidad and Brazil, distinguishing it from *E. crossotus* chiefly on the basis of body depth, head profile and pectoral fin length. Gutherz (1967:27), who examined specimens of *E. crossotus* from the south Atlantic region of the United States, found a general overlap in counts and measurements and suggested the two may be conspecific. Cervigon (1966) makes no mention of *E. intermedius* among the Venezuelan ichthyofauna; counts and measurements from his (1966:793) examples of *E. crossotus* agree with those of other published accounts of that species. Inasmuch as *E. intermedius* is known from only three specimens, counts and measurements of which overlap those of *E. crossotus* (a common species near the type locality of *E. intermedius*), the two species are likely synonymous.

Morphometric data (expressed in thousandths of standard length) for seven Hourglass specimens of *Etropus crossotus* are (mean values in parentheses): standard length (mm), 85.6-104.6 (93.0); body depth, 539-577 (562); head length, 218-228 (223); snout length, 031-045 (039); length of orbit, 047-051 (048); length of upper jaw, 044-052 (047); depth of caudal peduncle, 128-137 (134); length of pectoral fin, ocular side 56-169 (160), blind side 117-134 (125). Counts are (number of specimens in parentheses): dorsal fin rays 76(1), 77(1), 80(2), 81(1), 83(2); anal fin rays 61(2), 62(1), 63(1), 64(3); pectoral fin rays, ocular side 8(1), 9(3), 10(3), blind side 8(1), 9(6); gill rakers, lower limb 7(4), 8(1), 9(2), upper limb 3(1), 4(4), 5(2); lateral line scales 40(1), 41(2), 42(2), 43(1).

Occurrence in Hourglass Collections. Eighteen specimens of *Etropus crossotus* were taken during Hourglass sampling, as follows:

Sta. A,	30 Aug. 1965,	75 mm, trynet
	3 Sep. 1965,	72 mm, box dredge
	1 Aug. 1966,	69 mm, box dredge

	31 Aug. 1966,	(2) 55 mm, box dredge
	6 Nov. 1966,	86 mm, box dredge
	5 Feb. 1967,	(2) 91-105 mm, box dredge
	31 Aug. 1967,	80 mm, box dredge
Sta. I,	9 Mar. 1966,	99 mm, trynet
	12 Nov. 1966,	91 mm, box dredge
	12 Jan. 1967,	(2) 72-75 mm, box dredge
	11 Oct. 1967,	89 mm, trynet
	14 Nov. 1967,	91 mm, box dredge
	8 Mar. 1967,	85 mm, box dredge
Sta. J,	15 Feb. 1967,	(2) 100-104 mm, box dredge

Distribution and Abundance. In the western Atlantic, *Etropus crossotus* ranges from Chesapeake Bay south through the West Indies to Trinidad and Venezuela and possibly to southern Brazil as *E. intermedius* Norman. It is common throughout the Gulf of Mexico, and probably occurs along the Caribbean coast of Central America (*Etropus* sp. of Caldwell and Caldwell, 1964:46). Along the eastern United States, coastal Georgia appears to be a center of abundance (Anderson, 1968:8), while in the Gulf of Mexico the species abounds in coastal waters from the Mississippi Delta to Yucatan (Hildebrand, 1954:295). Along northern South America it is considered rare (Gines and Cervigon, 1968:44).

Ecology. In Hourglass collections, *Etropus crossotus* was sharply segregated from *E. rimosus* by its virtual restriction to the shallow stations (6 m); commercial trawl catches confirm that it seldom occurs in waters deeper than 18 fm (33 m). A maximum depth of 35 fm (64 m) has been reported by Gutherz (1967:28), but capture details are not listed. Bullis and Thompson (1965:33) reported a capture depth of 28 fm (51 m) off French Guiana.

Bottom temperatures for Hourglass collections of *Etropus crossotus* ranged from 17.0-30.5°C; salinities from 32.63-35.19‰. The species has been found in temperatures of 11°C in Texas (Schultz, 1962b) and the St. Johns River, Florida (Tagatz, 1967:47), but the upper value of 30.5°C has not been exceeded elsewhere by more than one degree.

Etropus crossotus frequently enters waters of low or fluctuating salinity. Although Gunter (1945:86) and Gunter and Hall (1963:226) have stated that it "does not like brackish water," it has been frequently reported from less than 5‰, including a Texas record from 1.2‰ (Schultz, 1962a:13). An upper value of "45‰ or less" has been reported by Simmons (1957:188) from the Laguna Madre, Texas.

Hourglass specimens were taken from substrate charactized as "quartz sand and crushed shell, with a fine layer of silt" (Joyce and Williams, 1969:18). Reid (1954:64) noted abundance of *Etropus crossotus* where mud and organic detritus was a predominant bottom feature; data from Miles (1951:20) and Springer and Bullis (1956:63) corroborate this apparent preference.

Etropus crossotus was at no time abundant in Hourglass collections, but its absence from April through July in both 1966 and 1967 is consistent with other accounts of seasonal availability. Miller (1965:100), for example, observed a decline in Texas inshore trawl catches of *E. crossotus* in March, and suggested migration from shoal waters during that month. Most other northern and eastern Gulf surveys (Gunter, 1938:340, 1945:86; Reid, 1954:64; Simmons, 1957:188; Schultz, 1962a:13, 1962b; Compton and Bradley, 1964:421; Compton, 1965:67; Miller, 1965:100) also indicate a relative scarcity of shallow water stocks from April through July. Compton and Bradley (1964:421) found an April peak in the Gulf proper, further supporting the notion of spring migration to deeper waters. This implied migration was not substantiated by offshore catches during Hourglass sampling.

Gunter (1938:340) found a peak in the open Gulf in July, but inferred, on the basis of a pronounced inshore peak in September and October, that migration to deeper waters may occur before the approach of winter. Along Florida's east coast and northward, shallow water trawl catches decline sharply from October to December (Anderson and Gehringer, 1965:23; Anderson, 1968:8).

Food Habits. Examination of gut contents of eight specimens from Stations A and I indicates that *Etropus crossotus* is primarily, but not exclusively, a bottom feeder, with a diet similar to that observed by Reid (1954:65) at Cedar Key, Florida. Benthonic polychaetes and crustaceans were most frequent among the following food items:

- Chaetognatha (Sta. I, Nov. 1967)
- Annelida
    - Polychaeta: Onuphidae and unidentified remains
- Crustacea
    - Amphipoda
    - Decapoda: Brachyura (including megalopa, Sta. I, Oct. 1967), Penaeidae, and unidentified remains

Inclusion of crab megalops and chaetognaths among the food of *Etropus crossotus* points to occasional excursions up into the water column, an activity noted in several other primarily benthonic flatfishes. Verheijen and DeGroot (1967), for example, recorded activities of benthonic pleuronectids in aquaria and found there is a feeding period during which activity is restricted to the bottom level, whereas at other times there is much additional swimming at higher levels. MacGintie and MacGintie (1949:422) observed flatfish dashing up from muddy bottoms in pursuit of small fish, a feeding strategy which, according to Miller (1967:2524), "appear[s] to be highly energy conserving, unless the success of capture were very poor." An analogous strategy has been documented for the winter flounder, *Pseudopleuronectes americanus*, by Olla, Wicklund and Wilk (1969:719).

Ingested Polychaeta included examples of Onuphidae, builders of tubes protruding a few millimeters above the substrate (Thomas Savage, pers. comm.). Exclusion of tube material from gut contents demonstrates the ability of *E. crossotus* to selectively crop these worms with its small, finely dentate jaws. Its mode of feeding seems acutely selective, judging from the virtual absence of sand and shell particles among ingested food.

Maturation and Spawning. Ovaries of *Etropus crossotus* are symmetrical or nearly so. In an 89 mm specimen (Sta. I, Oct. 1967) both ovaries were slender, extending posteriad to the 25th anal ray, the ovary of the ocular side measuring 20 mm, with a greatest diameter of 2 mm. In a 99 mm specimen the ovary of the blind side measured 36 mm, reaching the 33rd anal ray. A 103 mm specimen collected in June 1963 (FSBC 2700) had 55 mm ovaries extending to the 45th anal ray. Excised ovaries of this specimen, judged by histological analysis to be in a late stage of ripeness, were expanded and turgid, scalloped ventrally, and imprinted by hemal spines and anal pterygiophores. Egg number, estimated from an aliquot, was 155,000 in a 99 mm female from Sta. I, March 1966. About one-fourth of the ova averaged 0.14 mm, the remainder 0.03 mm. Largest ova in the June 1963 specimen (FSBC 2700) were 0.45 mm. Testes of a 91 mm specimen collected at Sta. A, Feb. 1967, measured 4 mm. No sexual dimorphism in external fish morphometry is apparent.

Gonads of three males and three females were examined histologically after staining with Harris hematoxylin and Eosin Y and sectioning at 6μ, and the condition of each was judged, following criteria of Moe (1969). This examination, supported by analysis of gonads from numerous FSBC specimens, agrees with observations of Moe and Martin (1965:145), who postulated a spawning season from March until at least June, based on appearance of ripe females during that period.

Specimens less than 30 mm SL have been reported from June to October by Reid (1954:64), Springer and Woodburn (1960:86) and Tagatz (1967:47), and no doubt represent young of the year.

Size and Importance. On the Florida Shelf, *Etropus crossotus* grows to about 135 mm SL, based on a maximum reported total length (TL) of 169 mm (Moe and Martin, 1965:145) (SL = 0.80 TL, based on 15 Hourglass specimens). In the northern Gulf, a maximum length of 156 mm TL has been recorded by Gunter (1945:86), who found his largest specimens in waters of high salinity. In the southern part of their range they reach a comparable size, with a maximum of "6 inches" (about 152 mm TL) reported for specimens from Brazil (Jordan and Goss, 1889:279).

Although this little flounder seldom exceeds a weight of 40 g (calculated from Dawson, 1965:279), it often enters commercial catches in numbers sufficient for status in an industrial fishery. On the Yucatan Shelf in depths of 11-18 m it is taken in nearly every drag, and its abundance is exceeded by only one other flatfish (Hildebrand, 1955:203). In the upper Gulf between the Mississippi Delta and Mobile Bay it enters the industrial bottomfish fishery, to be processed as catfood and fish meal. Along the south Atlantic coast of the United States (South Carolina to Florida) the catch during shrimp trawling during the early 1930's averaged 49 per hour, or 3.0% of the total fish catch; during December, Georgia catches reached 420 per hour, or 15.7% of the catch (Anderson, 1968:8, 13). In the Hourglass sampling area it merits little concern commercially.

Etropus rimosus Goode and Bean

Gray flounder, Figure 10

Etropus rimosus Goode and Bean, 1886:593 (*Albatross* Sta. 2408, ne. Gulf of Mex.); 1895:450, Pl. 104, Fig. 360; Norman, 1934:158 (synonymy, key, descr., distrib.); Longley and Hildebrand, 1941:45 ("Gulf of Mexico"); Bullis and Thompson, 1956:33 (N. Car., S. Car., Ga.); Joseph and Yerger, 1956:149 (outside Alligator Harbor, Fla.); Briggs, 1958:296 (listed, Fla.); Tabb and Manning, 1961:639 (ecology, Florida Bay); Moe and Martin 1965:145 (off Tampa Bay, Fla.); Gutherz, 1967:29, Fig. 31 (key, descr., distrib.); Beaumariage, 1968:8 (listed as "trash fish" off Tampa Bay, Fla.); Struhsaker, 1969:298 (se. U.S.); Grimes, 1971:App. III (Crystal R., Fla.); Cooley, in press (Santa Rosa Sound, Fla.).

Etropus microstomus Jordan and Goss (in part) (not Gill, 1864), 1889:278.

Citharichthys rimosus Parr, 1931:9 (descr., distrib.).

Citharicthys rimosus Bearden, 1961:11 (listed, S. Car.).

Hourglass specimens of *Etropus rimosus* agree well with the original description and subsequent figure of Goode and Bean (1886:593; 1895:450, Pl. 104, Fig. 360). Tables 2 and 3 list

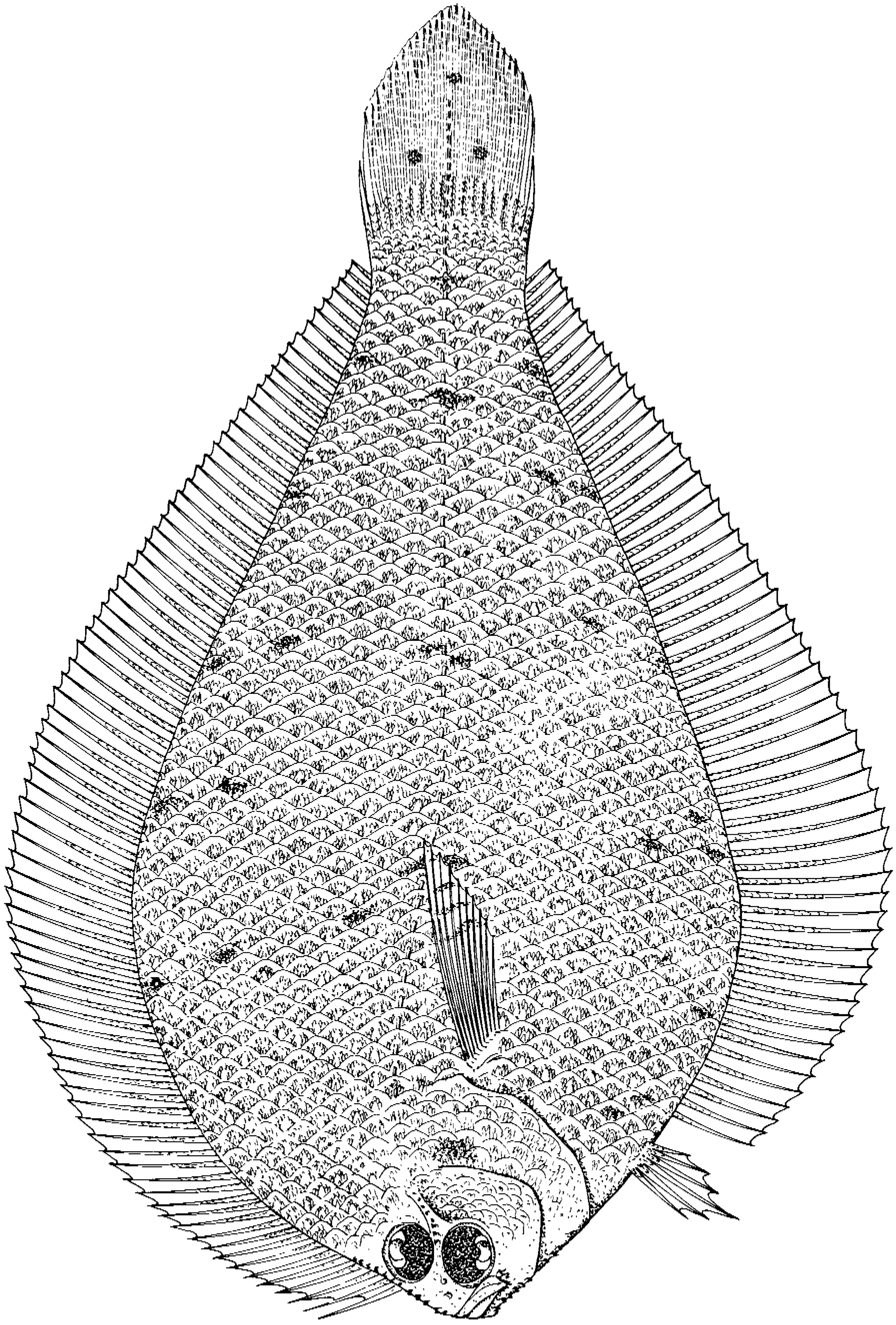

Figure 10. *Etropus rimosus* Goode and Bean, FSBC uncat., 88 mm SL, Hourglass Sta. C.

measurements and counts for 12 males and 12 females of *E. rimosus* from Hourglass Station C, 3 March 1966.

TABLE 2. PROPORTIONAL CHARACTERS, EXPRESSED IN THOUSANDTHS OF STANDARD LENGTH, OF 12 MALES AND 12 FEMALES OF *ETROPUS RIMOSUS* COLLECTED AT HOURGLASS STATION C, 3 MARCH 1966.

Character	Males (12)		Females (12)	
	Range	Mean	Range	Mean
Standard length (mm)	67.2-95.0	77.3	60.8-91.4	73.2
Body depth	518-574	537	470-558	522
Head length	232-257	244	241-260	250
Snout length	036-046	043	038-048	043
Length of orbit	060-075	067	063-076	070
Length of upper jaw	048-067	057	058-067	061
Depth of caudal peduncle	127-147	137	125-146	134
Length of pectoral fin (ocular side)	214-245	225	210-244	227
Length of pectoral fin (blind side)	135-169	148	135-163	149

TABLE 3. DISTRIBUTION OF DORSAL, ANAL AND PECTORAL FIN RAYS, LATERAL LINE SCALES, AND GILL RAKERS OF 24 SPECIMENS OF *ETROPUS RIMOSUS* COLLECTED AT HOURGLASS STATION C, 3 MARCH 1966.

Dorsal fin rays	74	75	76	77	78	79	80	81
	1	2	6	2	8	2	2	1
Anal fin rays	58	59	60	61	62	63		
	3	5	5	7	3	1		
Pectoral fin rays	8	9	10	11				
ocular side		1	22	1				
blind side	12	12						
Lateral line scales[1]	37	38	39	40	41	42	43	
	3	4	5	4	2	1	1	
Gill rakers[2]	4+6	5+6	6+5	6+6	6+7			
(lower and upper)	1	8	2	11	2			

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[1] based on 20 specimens

[2] raker at angle included in count for lower limb

The closely related *Etropus microstomus* (Gill), recorded from the northern Gulf of Mexico and from New Jersey to southern Florida, overlaps broadly in counts and proportions with *E. rimosus*, the chief distinction being a mean body depth of 48% SL for *E. microstomus*, 52% SL for *E. rimosus*. The two have been further distinguished by the relative extent of accessory squamation covering the body scales (Norman, 1934:155, 158; Gutherz, 1967:27), but among our specimens of *E. rimosus* this character is so variable that it embraces the extremes reported for both species. Jordan and Goss (1889:278) and Jordan and Evermann (1898:2689) were unable to distinguish the two.

Through the kindness of Miss Sally Leonard, (Virginia Institute of Marine Science), ten specimens of *Etropus microstomus* (FSBC 6335, 69.4-91.3 mm) from the mouth of Chesapeake Bay, 26 July 1966, were provided. Most were notably more slender than our local *E. rimosus*, their body depth ranging from 44.0-49.4% SL (x = 45.8% SL) (*cf.* Table 2). If the two species are distinct, their ranges overlap broadly, with *E. microstomus* occurring further north.

Extent and strength of cephalic squamation in *Etropus rimosus* varies among males and females, but males are generally better armed. Most large *E. rimosus* males have granular ctenoid scales covering the anterior dorsal and anal fin bases, the interorbital ridge, the underparts of the lower jaw, and the snout, except around the nostrils. Although a few large females are scaled to a similar extent, most bear unmodified ctenoid scales on the head, with the snout and interorbital ridge scaleless. Morphometric differences between sexes are not apparent (Table 2).

Distribution and Abundance. Etropus rimosus ranges from North Carolina to the southern tip of Florida and along the Florida Gulf coast north to Alligator Harbor. It has not been reported elsewhere in the Gulf of Mexico. It is judged "common" (occurring in 10-50% of trawl catches) on the open shelf and shelf-edge of the southeastern United States (Struhsaker, 1969:298), and it abounds off southwestern Florida.

Occurrence in Hourglass Collections. A total of 674 specimens (19-104 mm) were taken in 69 separate collections during Hourglass sampling. A maximum catch of 83 specimens were taken at Station C on 3 March 1966. Table 4 shows number of specimens collected by station and month, plus size range for each collection. No comparative size records are available in the literature.

Ecology. Distribution of *Etropus rimosus* in Hourglass collections was strictly depth-specific, with over 96% of all specimens taken from the 37 m stations (C and K). This depth range ecologically separates the species from its shallow water congener, *E. crossotus.*

Other Gulf of Mexico records of *Etropus rimosus* are from similar depths. Goode and Bean's (1886:593) type specimen was dredged from the northeastern Gulf in 21 fm (38 m), and the 57 specimens collected by Moe and Martin (1965:145) were all taken in about 17 fm (31 m), near Hourglass Station C.

Along the Atlantic coast *Etropus rimosus* has been collected by U.S. Fish and Wildlife Service vessels from North Carolina to northern Florida in 4-22½ fm (7-41 m) (Bullis and Thompson, 1965:33). A specimen described by Parr (1931:9) was taken off Cape Fear, North Carolina in 95 fm (174 m), and Gutherz (1967:29) reported a maximum depth of 100 fm (183 m).

In the Gulf, bathymetric restriction of *Etropus rimosus* may be based on substrate, which at Stations C and K (where most specimens were collected) has been characterized by Joyce and

TABLE 4. NUMBERS AND SIZE RANGE (mm SL) OF *ETROPUS RIMOSUS* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Etropus rimosus																															
STA	1965					1966													1967												TOT
	A	S	O	N	D	J	F	M	A	M	J	J	J sp	A	S	O	N	D	J	J sp	F	M	A	M	J	J	A	S	O	N	
A		1 75																													1
B₁			1 62							1 59								1 88													3
B₂	1 56						1 39																								2
C₁		10 59-72			4 50-89			83 58-96				11 38-87	15 36-94	2 40-89	45 34-98		15 46-90		16 54-83	34 56-98	1 69	2 80					1 52		3 81-95	33 39-96	275
C₂	1 59					1 93		48 53-97	19 59-90		31 65-92				3 73-87	1 93					2 58-78	4 65-84	9 68-91		38 52-104				34 53-95	9 55-88	200
D₁	1 80			1 80	1 75	1 80		1 54				1 19										1 76									7
D₂				1 48				2 55-65														4 55-61									7
E																		1 68													1
I																															
J																													1 68	3 83-91	4
K	8 65-97		4 78-94	7 45-85	1 54	2 81-91		2 65-73	2 54-76			24 46-99	43 50-100	3 40-62	4 57-90	5 59-65	4 50-62		1 77	4 68-80	1 80	1 72				1 93	3 65-92	7 64-96	33 62-95	14 61-86	174
L																															
M																															
TOT	11	11	5	9	6	4	1	136	21	1	31	36	58	5	52	6	19	2	17	38	4	12	9		38	1	4	7	71	59	674

Williams (1969:18) as bearing limestone outcroppings "separated by relatively extensive sections of smooth bottom composed of crushed shell and other organically-derived calcium particles . . . covered with a heavy layer of white calcareous silt." The sharp reduction in catches at the 55 m stations (D and L) may be associated with a proliferation of coralline algae, which at these depths (and beyond) form a continuous blanket over much of the bottom (Gould and Stewart, 1956:9). At the 18 m stations (B and J) the generally large component of Gulf reef biota (sponges, corals, etc.) may be responsible for the scarcity of the species.

Bottom temperatures for Hourglass collections of *Etropus rimosus* ranged from 15.9-30.5°C. Off Georgia and South Carolina *E. rimosus* has been reported from bottom temperatures of 57.2° and 58.55°F (14.2° and 14.7°C) (Bullis and Thompson, 1965). Bottom salinities for Hourglass specimens ranged from 32.63-36.45°/₀₀.

At Station C, catch per unit effort varied considerably from month to month, but in no consistent way (at Station K this statistic was less variable). The absence of seasonal, thermal, or other correlatives with availability at Station C indicates a lack of spatial homogeneity of the stock, in turn suggesting that either 1) aggregates of *Etropus rimosus* move about on an otherwise homogeneous substrate or 2) substrate variation produces localization within the stock, with different subsections being sampled by our gear from month to month. Judging from faunal composition of associated dredge samples at Stations C and K (William G. Lyons, pers. comm.), the second possibility seems the more tenable.

Food Habits. Examination of gut contents of 36 specimens indicates that *E. rimosus* is a selective bottom carnivore. It apparently does not move up into the water column to feed, as *E. crossotus* may occasionally do. Most commonly encountered food items were small crustaceans (chiefly amphipods) and polychaetes. Seasonal or geographical differences in diet were not discernible. The following items, based primarily on samples from Stations C and K, were found in gut samples.

Protozoa: Foraminifera
Porifera (spicules)
Bryozoa (one specimen from Sta. K)
Brachiopoda
Mollusca
    Gastropoda: *Tectonatica, Rhizorous* and others
    Bivalvia: Tellinidae and others
Annelida
    Polychaeta: Aphroditidae, fragments and tubes of others
Crustacea
    Ostracoda (Sta. K only)
    Cumacea (Sta. K only)
    Amphipoda
    Isopoda
    Decapoda: Brachyura, Penaeidae, and unidentified remains
Vertebrate eggs
Sand, shell, and detritus

Age and Growth. Scales were of little use in age determination. Of 14 specimens examined from Station C, March 1966, two of each sex showed scale circuli distinctly cutting across the radii, but with no consistency in position. Plotted length frequencies likewise produced an unclear picture of modal progression and age structure. Bimodality is apparent in some collections, with modal separation of 20-40 mm. Specimens less than 45 mm, present in collections of November 1965, February 1966, July-September 1966 and November 1967, are likely age I fish.

Maturation and Spawning. Ovaries of *Etropus rimosus* are symmetrical, 32-44% SL, extending on either side of the saggital septum to about the 35th anal pterygiophore. Testes are small, 5-6% SL, and wholly contained within the body cavity.

Sexual size dimorphism, observed by Moe and Martin (1965:145), was analyzed for 38 females and 45 males from Hourglass Station C, March, 1967. Mean standard lengths were 75.7 and 69.6 mm. Although this difference is significant (z = 1.98; P = 0.05), it is much less marked than that observed by Moe and Martin for 10 females and 5 males. Prominent size dimorphism was not consistent throughout Hourglass collections, with mean standard lengths for 135 males being 73.7 mm, for 145 females, 70.3 mm. If size dimorphism is a real phenomenon in natural populations of *Etropus rimosus*, it may be based on somatic growth lag in females during periods of gametal accretion. Ordinarily, female bothids grow significantly faster than males, as demonstrated by Poole (1961:12).

Although age composition could not be reliably judged, all females examined from Hourglass collections (40-96 mm) contained a proportion of ripe or ripening eggs; gross appearance of ovaries remained constant year-round. Ova were enumerated from a 72.6 mm specimen from Station C, March 1966. Weight of gonads, blotted dry on filter paper, was 0.301 g. Egg number, estimated from an aliquot, was 158,000, one-tenth of which were noticeably larger than the rest. If all larger eggs reach maturity at spawning, total eggs released annually per female, based on this estimate, would be a multiple of 15,800, depending upon the number of spawnings during the year.

Microscopically, two classes of eggs were observable throughout all ovaries examined: 1) primary oocyces, these being angular, translucent, unpigmented, and averaging 0.04 mm, and 2) developing or resting oocytes, these being angular or ovate, opaque yellow, ranging to 0.41 mm, with the space between yolk and oolema varying from 4.3-10.0% of total egg diameter.

Ova of females from Stations C and K during 1967 were analyzed, in an attempt to establish spawning time. Egg diameters of one female from each of eight collections are plotted in the histograms of Figure 11. In each sample, the prominent mode in small ova (0.09 mm) represents primary oocytes, constituting some 90% of the total. Among the remainder, modality within samples is generally less distinct, the heterogeneity of egg size probably indicating asynchronous maturation. Larger eggs of each sample, however, are generally well represented.

The June sample from Station C contained an additional group of large, spherical, translucent eggs, 0.43-0.53 mm, apparently in late stages of ripening. Although females were absent at Station C during collections of the four subsequent months, two taken at Station K in August contained no enlarged eggs. Spawning therefore may commence about June and perhaps continues through the summer.

Importance. This small flounder is frequently taken during exploratory trawling for offshore demersal fishes along the southeastern United States (Struhsaker, 1969:269), but its small size

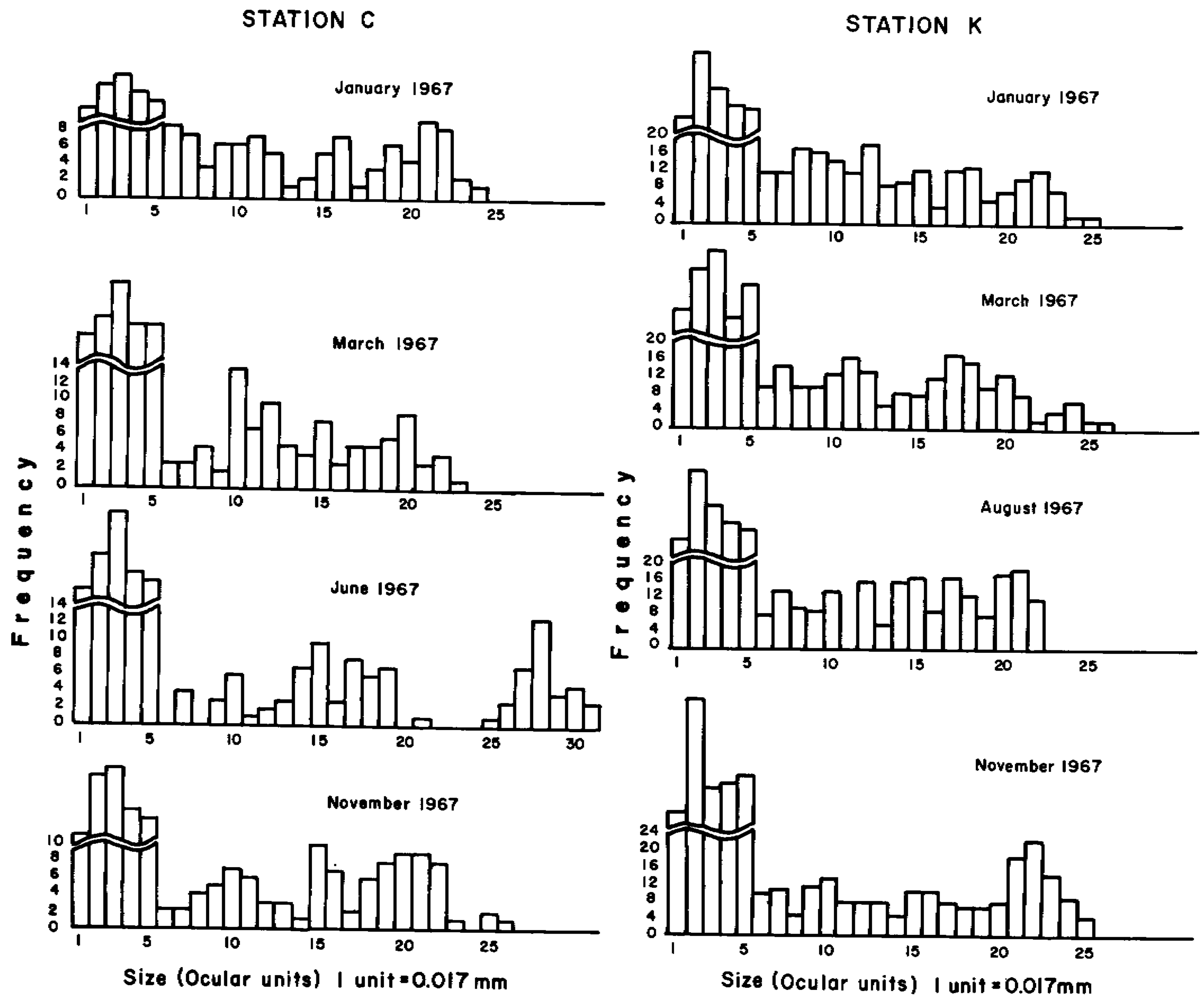

Figure 11. Egg size frequencies of *Etropus rimosus*, Stations C and K, 1967. Station C histograms based on 125 eggs each; Station K histograms, 250 eggs each. Primary oocytes (1-5 ocular units) are represented by broken portion of histogram.

limits potential significance in an industrial fishery. It has been included among "trash fishes" used experimentally in the manufacture of fish meal (Beaumariage, 1968:8).

Citharichthys Bleeker

Citharichthys Bleeker, 1862:429 (type, *Citharichthys cayennensis* Bleeker); Parr, 1931:1 (in part; revision, including *Etropus*); Norman, 1934:139 (synonymy, diagn.).

The genus *Citharichthys*, containing some 17 species, is represented on both coasts of the Americas and in the eastern tropical Atlantic. Parr (1931) denied a distinction between this genus and the weakly-dentate small-mouthed *Etropus*, and provided a lengthy demonstration of the "impracticability of basing a generic subdivision upon this feature alone." His scheme, however, was not incorporated into Norman's (1934) classification, and most recent workers, including ourselves, have preferred to retain both genera.

The following key to western Atlantic species of *Citharichthys* is based on literature and museum specimens. Characters separating *C. uhleri* are based on the single known specimen. According to Dawson (1969b:365), *C. uhleri* may eventually prove to be the senior synonym of *C. arenaceus.* We have drawn heavily upon Dawson's (1969b) comparisons for separating *C. abbotti, C. arenaceus,* and *C. spilopterus.*

KEY TO THE WESTERN ATLANTIC SPECIES OF *CITHARICHTHYS*

(Those known to occur on the Florida Shelf are marked with an asterisk.)

1. Body slender, 34-43% SL (usually less than 40%); mouth small, upper jaw less than 9% SL; snout with an osseous (not spinous) protuberance projecting beyond mouth . . . .*Citharichthys arctifrons**

1. Body depth exceeding 40% SL; mouth large, upper jaw greater than 9% SL; snout without osseous protuberance 2

2. Gill rakers of lower limb long and slender, 18-24; snout completely scaled; cephalic armature present on males, absent on females . . . . *Citharichthys amblybregmatus*

2. Gill rakers of lower limb fewer than 19; snout partially scaled or naked 3

3. Dorsal fin with 90 or more rays; anal fins with 70 oı more rays; caudal peduncle slender, less than 10% SL . . . . *Citharichthys dinoceros**

3. Dorsal fin with 85 or fewer rays; anal fin with 67 or fewer rays; caudal peduncle greater than 10% SL 4

4. Eyes large, orbital diameter exceeding 8% SL; spines or prominences on snout, orbital rim, maxillary, lacrymal margin and symphysis of lower jaw 5

4. Eyes small, orbital diameter less than 8% SL; no spines or prominences on head 8

5. Dorsal fin rays 74-84; anal fin rays 60-67; pectoral fin rays of ocular side usually 11 or 12; pelvic fin rays of ocular side 6; symphyseal spine, when present, directed ventrad 6

5. Dorsal fin rays 70-76; anal fin rays 51-60; pectoral fin rays of ocular side usually 9 or 10; pelvic fin rays of ocular side 5; symphyseal spine, when present, horizontal or nearly so . . . 7

6. Cephalic armature strong, a prominent horizontally directed spine on snout projecting well beyond profile; interorbital diameter exceeding 2% SL in specimens greater than 50 mm SL; upper pectoral ray elongate . . . . *Citharichthys cornutus** male

6. Cephalic armature weak, spine on snout scarcely projecting beyond profile; interorbital diameter not exceeding 2% SL; upper pectoral ray not elongate . . . . *Citharichthys cornutus** female and juvenile

7. Cephalic armature strong, a horizontally directed spine on snout, another at symphysis of lower jaw, both projecting well beyond profile; dorsal and anal fins elevated at midlength (SL) of fish, both fins bearing a prominent black blotch . . . . *Citharichthys gymnorhinus** male (Figure 12)

7. Cephalic armature weak, spines on snout and symphysis scarcely projecting beyond profile; dorsal and anal fin rays not elevated at midlength, and not bearing a prominent black blotch . . . . *Citharichthys gymnorhinus** female and juvenile (Figure 12)

8. Scales in lateral line fewer than 41; margin of operculum of blind side bearing leaflike cirri; ocular side of body profusely covered with dark spots . . *Citharichthys macrops** (Figure 15)

8. Scales in lateral line exceeding 41; margin of operculum not bearing cirri 9

9. Dorsal fin rays fewer than 70; lateral line scales exceeding 50; ocular side of body dark brown with white blotches . . . . *Citharichthys uhleri*

9. Dorsal fin rays 70 or more; lateral line scales 50 or fewer; ocular side of body speckled with tan or brown spots or unspotted 10

10. Caudal vertebrae 24-25, usually 24; first dorsal ray inserted above posterior naris; anterodorsal contour concave . . . . *Citharichthys spilopterus**

10. Caudal vertebrae 21-23, usually 22; first dorsal ray inserted anterior to level of posterior naris; anterodorsal contour convex 11

11. Upper jaw length 39-44% of head length; anterior profile with distinct notch in front of eye; ocular side dark brown, flecked with tan . . . . *Citharichthys arenaceus*

11. Upper jaw length 35-39% of head length; anterior profile with slight notch in front of eye; ocular side light sandy tan, flecked with brown . . . . *Citharichthys abbotti*

Of the six species of *Citharichthys* known to occur on the Florida Shelf, only *C. gymnorhinus* and *C. macrops* were taken during Hourglass sampling. *C. arctifrons, C. cornutus* and *C. dinoceros* are generally found on the outer shelf or shelf edge.

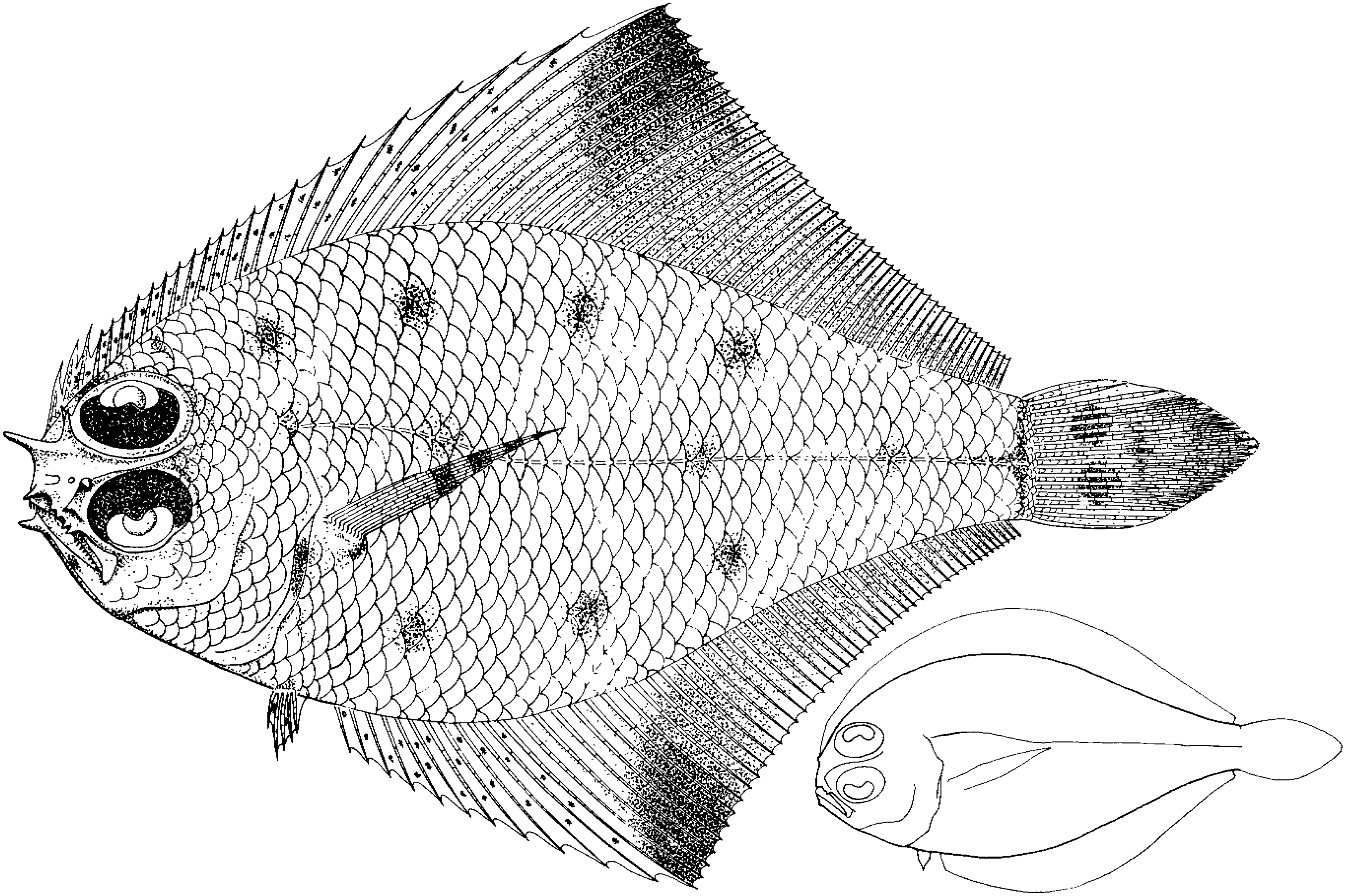

Figure 12. *Citharichthys gymnorhinus* Gutherz and Blackman, male, FSBC 5196, 42 mm SL, Hourglass Sta. D. Line drawing of female inset.

Citharichthys gymnorhinus Gutherz and Blackman

Figure 12

Citharichthys cornutus Bullis and Thompson (in part), 1965:33.

Citharichthys sp. Gutherz, 1967:30, footnote 12; Starck, 1968:31 (Alligator Reef, Fla.).

Citharichthys gymnorhinus Gutherz and Blackman, 1970:345, Figures 5 and 6 (Florida Keys, Caribbean localities).

Possible synonym:

Citharichthys sp. Metzelaar, 1919:132 (Dutch West Indies).

While the original description of *Citharichthys gymnorhinus* Gutherz and Blackman was in preparation, 35 specimens were recognized as an undescribed species among Hourglass collections. These specimens, along with several located at the U.S. National Museum (USNM), were independently incorporated into a new species description, unfortunately duplicating the efforts of Gutherz and Blackman (1970).

The diagnosis and description included herein are based on adults and juveniles not seen by Gutherz and Blackman, primarily from Hourglass collections. Standard length does not include the ethmoid spine.

Material Examined.—*Citharichthys gymnorhinus.* USNM Acc. No. 251937, 11 (8 males, 37.1-50.2 mm and 3 females, 36.1-47.0 mm), off Venezuela, Woods Hole Oceanographic Institution R/V *Atlantis*, Cr. 240, 10°32.5'N, 65°55'W, 40 fm (73 m), trynet, 3 Nov. 1957. USNM 159551, 5 (males, 36.4-53.7 mm), off Guyana, U.S. Fish and Wildlife Service R/V *Oregon*, Sta. 2000, 07°55'N, 57°30'W, 45 fm (82 m), ballerina trawl, 5 Nov. 1957. USNM Acc. No. 261501, 3 (male, 42.8 mm and 2 females, 36.9-37.5 mm), off Panama, R/V *Oregon*, Sta. 5739, 09°43'N, 79°20'W, 52 fm (95 m), shrimp trawl, 19 Oct. 1965. FSBC 1559, 2 (male, 36.7 mm and female, 39.8 mm), off Virgin Is., R/V *Oregon*, Sta. 2622, 18°45'N, 64°40'W, 24 fm (44 m), flat trawl, 28 Sep. 1959. USNM 129946, 2 (males, 42.8-45.6 mm), Florida Keys, U.S. Fish Commission Steamer *Albatross*, Sta. 2316, 24°25'N, 81°47'W, 15 Jan. 1885. USNM 117039 (male, 44.5 mm), south of Tortugas, Fla., 26 June 1932, coll. W. H. Longley. FSBC 4990, 2 (males, 41.4-44.0 mm), Hourglass (HG) Sta. E, trynet, 3 July 1966. FSBC 5244, 2 (males, 42.5-45.0 mm), HG Sta. M, trynet, 16 Feb. 1967. FSBC 5196 (male, 42.0 mm), HG Sta. D, balloon trawl, 26 Jan. 1967. FSBC 5139 (male, 30.4 mm), HG Sta. L, trynet, 15 Nov. 1967. FSBC 5197 (male, cleared and stained), HG Sta. D, trynet, 21 June 1967.

FSBC uncatalogued material: 1 (33.4 mm), HG Sta. D, trynet, 2 Aug. 1967. 6 (13.0-24.7 mm), HG Sta. E, trynet, 2 Aug. 1966. 1 (21.0 mm), HG Sta. D, box dredge, 2 July 1967. 1 (male, 24.9 mm), HG Sta. M, trynet, 6 Aug. 1966. 3 (12.0-31.2 mm), HG Sta. M, trynet, 5 Sep. 1966. 1 (13.6 mm), HG Sta. D, box dredge, 4 Apr. 1967. 2 (10.3-30.2 mm), HG Sta. D, box dredge, 21 May 1967. 1 (12.9 mm), HG Sta. L, box dredge, 16 May 1967.

Citharichthys cornutus. USNM 159431, 5 (3 males, 51.7-62.9 mm and 2 females, 47.5-54.2 mm), off Venezuela, R/V *Oregon*, Sta. 1987, 09°36'N, 59°44'W, 80 fm (146 m), flat trawl, 4 Nov. 1957. USNM 117094, 16 (50.1-66.4 mm), Tortugas, Fla., 11 July 1932, coll. W. H. Longley. USNM Acc. No. 261501 (male, 51.3 mm), off Panama, R/V *Oregon* Sta. 5738, 09°40'N, 79°07'W, 120 fm (219 m), shrimp trawl, 19 Oct. 1965. USNM Acc. No. 272254, 10 (7 males, 48.6-74.1 mm and 3 females, 52.3-67.8 mm), off Cuba, U.S. Fish and Wildlife Service R/V *Silver Bay*, Sta. 2664, 23°34'N, 79°05'W, 150 fm (274 m), balloon trawl, 6 Nov. 1960. USNM 117039 (male, 61.6 mm), s. of Tortugas, Fla., 26 June 1932, coll. W. H. Longley. FSBC 2229, 2 (males, 61.7-66.4 mm), Gulf of Mexico, between 25°50' and 26°15'N, approx. 84°50'W, 200-223 fm (366-408 m), 25-26 July 1962, M/V *Carousel* (private vessel, J. Moore and D. Sherman). FSBC 3073, 3 (2 males, 62.3-64.4 mm and

1 female, 58.6 mm), Gulf of Mexico, between 25°25' and 27°00'N, approx. 84°10'W, 200-223 fm (366-408 m), 24 July 1962, M/V *Carousel.*

Diagnosis. A dwarf, sexually dimorphic *Citharichthys*, reaching a maximum known size of less than 55 mm. Modally with dorsal rays 72-73, anal rays 57, and pectoral rays 10 on ocular side. Pelvic rays 5 on ocular side, 6 on blind side. Cephalic armature well developed: males with a horizontal spine on snout, a nearly horizontal spine at symphysis of lower jaw, several short spines on lower lacrymal border, one on maxillary head on ocular side, and two short subequal spines on each orbital rim; armature of females similarly arranged but not prominent. Dorsal fin of male elevated at about midlength (SL), anal fin similar, each bearing a dark blotch; distal half of pectoral fin with 4-5 dark transverse bars.

Description. A small species, reaching sexual maturity in the Gulf of Mexico by 30 mm, displaying sexual dimorphism (Figure 12) in cephalic armature, color pattern, and dorsal and anal fin shape. Body deep, anterior profiles smoothly rounded, reaching a maximum depth at about midlength (SL); posterior profiles symmetrical, slightly concave. Caudal fin pointed; peduncle short. Pectoral fins similar in both sexes, fin of ocular side with upper rays moderately produced, about 40% longer than on the blind side.

Eyes large, vertically in line, or with lower eye slightly in advance of upper; interorbital narrow, concave. Anterior naris of ocular side covered by a fleshy flap; nares of blind side small, uncovered. Mouth moderate, strongly oblique, curved; maxillary almost reaching middle of eye. Fixed teeth small, close set, somewhat enlarged near front of upper jaw, premaxillary dentate to posterior end. Pseudobranchiae well developed. No cirri on opercular margin or branchiostegal membrane. Scales ovate, deciduous, those on blind side cycloid, on ocular side ctenoid. No accessory squamation evident on primary body scales (most specimens completely denuded).

TABLE 5. DISTRIBUTION OF MERISTIC CHARACTERS OF *CITHARICHTHYS GYMNORHINUS* AND *C. CORNUTUS.*

Dorsal fin rays	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
C. gymnorhinus (36)	5	7	8	8	5	2	1								
C. cornutus (19)					1	1	1	2	3	4	2	3		1	1

Anal fin rays	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
C. gymnorhinus (38)	2		4	3	2	7	10	3	6	1							
C. cornutus (19)										1	1	5	1	6	3	1	1

Pectoral fin rays (ocular side)	8	9	10	11	12
C. gymnorhinus (40)	1	12	26	1	
C. cornutus (16)			1	12	3

Pectoral fin rays (blind side)	5	6	7	8	9	10
C. gymnorhinus (40)	9	29	2			
C. cornutus (19)	3	10	4	1		1

Gill rakers (upper limb)	3	4	5
C. gymnorhinus (18)	2	8	8
C. cornutus (18)		7	11

Gill rakers (lower limb)	9	10	11	12	13	14
C. gymnorhinus (18)	2	13	3			
C. cornutus (20)		1	8	8	2	1

TABLE 6. PROPORTIONAL CHARACTERS, EXPRESSED IN THOUSANDTHS OF STANDARD LENGTH, OF *CITHARICHTHYS GYMNORHINUS* AND *C. CORNUTUS.* POST-METAMORPHOSIS ALLOMETRY MARKED (+) OR (–).

Character	*C. gymnorhinus*			*C. cornutus*		
	No.	Range	Mean	No.	Range	Mean
Standard length (mm)	37	30.4-53.7	43.0	23	47.5-74.1	61.1
Body depth (+)	36	418-499	469	23	426-496	460
Head length (–)	37	249-292	271	23	269-300	282
Snout length	37	046-066	054	23	048-062	055
Length of orbit (–)	35	080-114	096	23	092-111	100
Interorbital width (males)	29	010-021	017	15	008-051	029
Interorbital width (females)	6	010-025	017	6	011-014	013
Length of upper jaw (–)	37	099-126	112	23	118-137	128
Depth of caudal peduncle (–)	37	105-126	115	23	097-114	105
Length of pectoral fin, ocular side (males)	28	223-321	262	10	161-231	205
Length of pectoral fin, ocular side (females)	6	217-313	249	3	192-223	211
Length of pectoral fin, blind side	31	144-211	181	13	136-168	150

Proximal one-fourth of interradial membranes of caudal fin finely scaled; interorbital area, snout and jaws naked. Lateral line nearly straight, slightly elevated above pectoral fin. Dorsal fin commencing on blind side; first three or four rays fleshy and slightly exserted. Successive dorsal rays of male gradually lengthening, reaching maximal length (36% SL) by 21st-25th ray, then shortening posteriorly; anal fin of male similar to dorsal, its rays reaching maximal length (29% SL) by 9th-11th ray; dorsal and anal fins of females not elevated. Gill rakers slender, short, about one-third orbital diameter; 3-5 on upper limb, 9-11 on lower, none at angle. Pelvic fin of ocular side with 5 rays (2 of 19 with 6), of blind side 6. Caudal fin with 17 rays. FSBC 5197 (cleared and stained) with 9 trunk and 24 caudal vertebrae. Scales in lateral line 35-38. Other counts are shown in Table 5. Proportional measurements are summarized in Table 6.

Cephalic armature showing distinct dimorphism by 30 mm, males with a strong dermal spine projecting anteriad from ethmoid region at level of ventral margin of upper eye; two subequal spines on anterior rim of upper orbit, a corresponding pair on dorsoanterior rim of lower orbit; several small spines on lower lacrymal border; an anterolaterally directed spine on articular head of maxillary on ocular side; a symphyseal spine on lower jaw, directed horizontally or slightly downward, slightly weaker than spine on snout. Females with similar arrangement of armature but with spines scarcely projecting, the anterior spines reduced to small bosses.

Ocular side tan to brown in alcohol. Two rows of four indistinct dark blotches on side, one following the dorsal contour, the other following the ventral (Figure 12), the latter row commencing with a dark vertical dash below pectoral base just behind operculum. A third row of four blotches, frequently less distinct, along lateral line; a dusky area at posterior end of lateral line and across hypural plate. A pair of small spots on proximal half of caudal fin, one above and one below midline; several incomplete vertical markings on distal half of fin. Distal three-fifths of pectoral fin of ocular side with four or five dark transverse bars. Dorsal and anal fins speckled with small dark spots, conspicuous on blind side; these fins in mature males each bearing a prominent black blotch at about midlength of fish, posterior halves of these fins dusky; dorsal and anal fins of females not bearing a black blotch, nor dusky posteriorly.

Incipient cephalic armature is present in the smallest specimens examined (11.2-15.3 mm SL), but a more reliable character for identification of small juveniles is the presence of 8-20 distinct melanophores on the posterior flanks of both ocular and blind sides.

Comparisons. Three species of western Atlantic *Citharichthys (C. gymnorhinus, C. cornutus, C. amblybregmatus)* are characterized by strongly developed cephalic armature in males. Gutherz and Blackman (1970:344) have distinguished *C. amblybregmatus* from the other two by its high number of gill rakers on the lower limb of the first arch (18-24 vs. fewer than 16), by the large scales covering the snout, and by a wide interorbital distance and blunt head in the males.

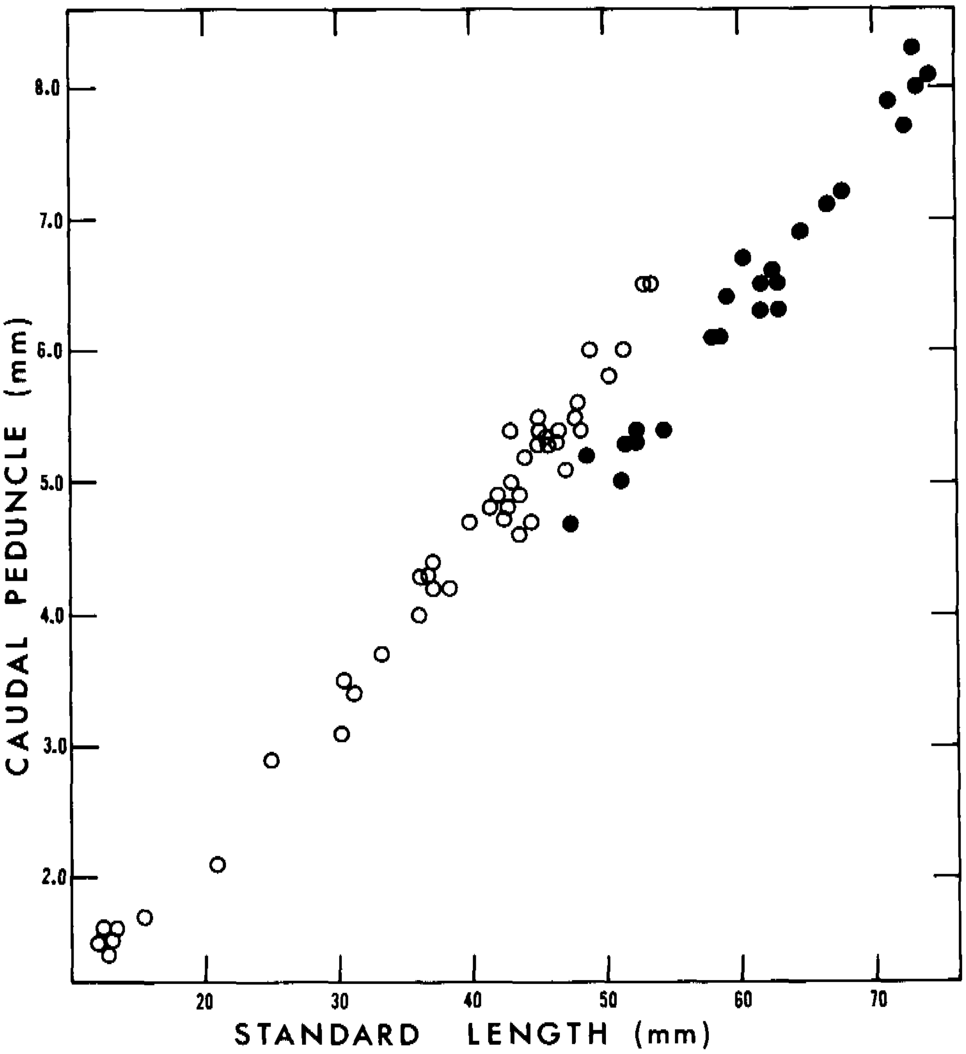

Figure 13. Scatter diagram of caudal peduncle depth plotted against standard length for *Citharichthys gymnorhinus* (open circles) and *C. cornutus* (solid circles).

Arrangement of cephalic armature in males of *Citharichthys gymnorhinus* and *C. cornutus* is similar, but *C. gymnorhinus* males are quickly separated by the symphyseal spine of the lower jaw. In males of *C. cornutus* this spine is directed ventrally or posteroventrally, while in males of *C. gymnorhinus* it projects horizontally or nearly so. *C. gymnorhinus* is further distinguished from *C. cornutus* by its more prominent lacrymal armature, by its pelvic fin formula, and by its significantly fewer dorsal and anal fin rays (Table 5). A scatter diagram of caudal peduncle depth plotted against standard length (Figure 13) distinguishes the two species morphometrically. Separation of the two by relative dimensions of two characters is demonstrated in the triangular graph (Figure 14), where each is expressed as a percentage of the sum of upper jaw length, caudal peduncle depth, and standard length.

Remarks. Although widespread and apparently rather common, *Citharichthys gymnorhinus* has no doubt been accepted in most collections as the young of its larger congener, *C. cornutus*. A possible exception is Metzelaar (1919), who reported on a series of small flounders from the Dutch West Indies as juveniles of an undiagnosed species "apparently distinct from *C. unicornis* [=*C. cornutus*], but not fit for type of a new species, the largest measuring only 55 mm. . . ." Metzelaar's specimens agree with *C. gymnorhinus* in size and meristic data but their reportedly adherent scales and the shallow collection depth (3-8 fm) (5-15 m) leave their identity suspect.

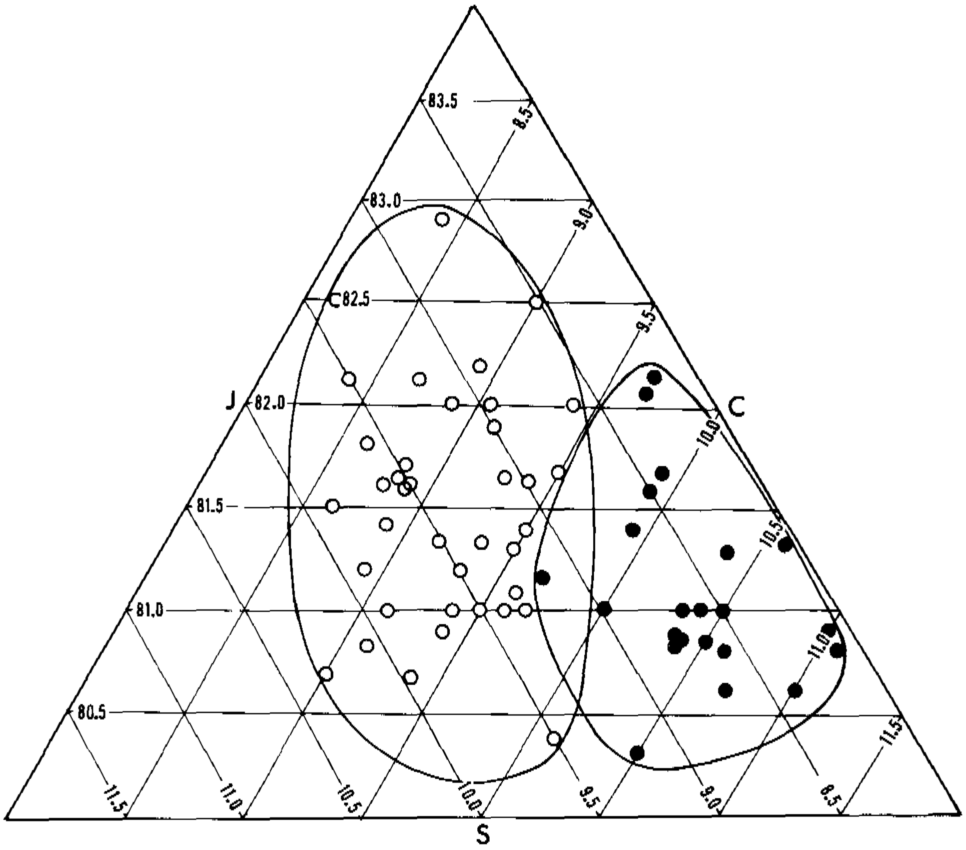

Figure 14. Separation of *Citharichthys gymnorhinus* (open circles) from *C. cornutus* (solid circles) based on percentage contribution of standard length (S), upper jaw length (J) and caudal peduncle depth (C).

Based on Hourglass collections, exclusion of *Citharichthys gymnorhinus* from depths shallower than 55 m and predominance of specimens (23 of 35) from the deepest stations (73 m) suggest a moderately deep shelf habitat for Gulf of Mexico populations. Caribbean specimens are known from 37-139 m; Gutherz and Blackman (1970:346) reported a maximum depth of 110 fm (201 m) from the Bahamas.

Citharichthys gymnorhinus is apparently separated bathymetrically from *C. cornutus*, the latter being found in depths exceeding 350 m in the Gulf of Mexico, and generally beyond 137 m in the Caribbean. A collection by W. H. Longley containing both species (USNM Acc. No. 144662) from south of the Tortugas was apparently trawled at two separate stations, one in 39 fm (71 m) and one in 60-72 fm (110-132 m). If a similar bathymetric distinction exists in these waters, *C. gymnorhinus* was probably collected at the shallow station.

Annual, seasonal or latitudinal trends in abundance are not apparent in Hourglass material, but juveniles smaller than 14 mm were taken from April to September, thereby indicating extended spring and summer spawning in the Gulf. The gut of a 45.4 mm specimen (FSBC 5197) taken in June 1967 contained crustacean remains almost exclusively, with amphipods dominant. Remains of two *Citharichthys gymnorhinus*, one a female approx. 33 mm, were found in the gut of a stargazer, *Kathetostoma albigutta*, 112 mm, collected by box dredge at Hourglass Sta. D, 21 November 1967.

Citharichthys gymnorhinus reaches maturity at a size well below that of any other known flounder. Ovaries in a 21.0 mm female (Hourglass Sta. D, 2 July 1967) macroscopically appeared active. Ovaries in a 30.2 mm specimen (Hourglass Sta. D, 21 May 1967) were filled with ripe, spherical eggs; males of comparable size had well developed testes, plus the full complement of secondary sexual characters. A sample of eggs from a 39.8 mm fish (FSBC 1559) taken off the Virgin Islands on 28 September 1959 ranged from 0.52-0.65 mm in diameter.

A series of young specimens (less than 15 mm) collected in Hourglass dredge samples were completely metamorphosed. Positive or negative post-metamorphosis allometry is shown by a (+) or (–) in Table 6.

Distribution. *Citharichthys gymnorhinus* has been reported from the Florida Keys, the Bahamas, Hispaniola, Puerto Rico, Tobago, and off Colombia, Panama and Nicaragua (Gutherz and Blackman, 1970:346). It is now known to occur on the Florida Shelf and off Cuba, the Virgin Islands, Venezuela and Guyana.

Citharichthys macrops Dresel

Spotted whiff, Figure 15

Citharichthys macrops Dresel, 1885:539 (Pensacola, Fla.); Parr, 1931:20 (descr., distrib.); Norman, 1934:147, Fig. 100 (synonymy, key, descr., distrib.); Longley and Hildebrand, 1941:43 (Tortugas); Fowler, 1944:441, 460 (Green Turtle Cay, Bahamas; Bonacca Is., Honduras); Gunter, 1945:85 (Aransas Pass, Texas); Baughman, 1950:136 (Freeport, Galveston and Aransas Pass, Texas); Miles, 1951:19 (Apalachicola Bay, Fla.); Hildebrand, 1954:294 (Matagorda, Texas; Louisiana); Hildebrand, 1955:203 (color, Campeche); Joseph and Yerger, 1956:128 (Alligator Harbor, Fla.); Menzel, 1956:55 (St. George Sound and Apalachee Bay, Fla.); Springer and Bullis, 1956:62 (Gulf of Mex. localities); Briggs, 1958:296 (listed, Fla.); Hoese, 1958:345 (listed, Texas); Springer and Woodburn, 1960:86 (off Tampa Bay, Fla.); Bearden, 1961 (listed, S. Car.); Springer and McErlean, 1962:44 (Lower Matecumbe Key, Fla.); Compton and Bradley, 1963:7; 1964:421 (Texas); Gunter and Hall, 1963:280 (St. Lucie Estuary, Fla.); Anderson and Gehringer, 1965:27, Table 12 (Cape Canaveral, Fla.); Bullis and Thompson, 1965:33 (N. Car., S. Car., Ga., Fla.); Christensen, 1965:220 (Jupiter R. and Loxahatchee R., Fla.); Compton, 1965:Table 1, 2 (season, depth, Port Aransas and other Texas localities); Moe and Martin, 1965:147 (off Tampa Bay, Fla.); Compton, 1966 (season, Port Aransas, Port Mansfield and Port Isabel, Texas); Gutherz, 1967:33, Fig. 35 (key, descr., distrib.); Struhsaker, 1969:298, App. B (se. U.S.); deSylva, 1970:52 (Biscayne Bay, Fla.); Grimes, 1971:App II (Crystal R., Fla.); Cooley, in press (Pensacola Bay, Little Sabine Bay, Santa Rosa Sound, Fla.).

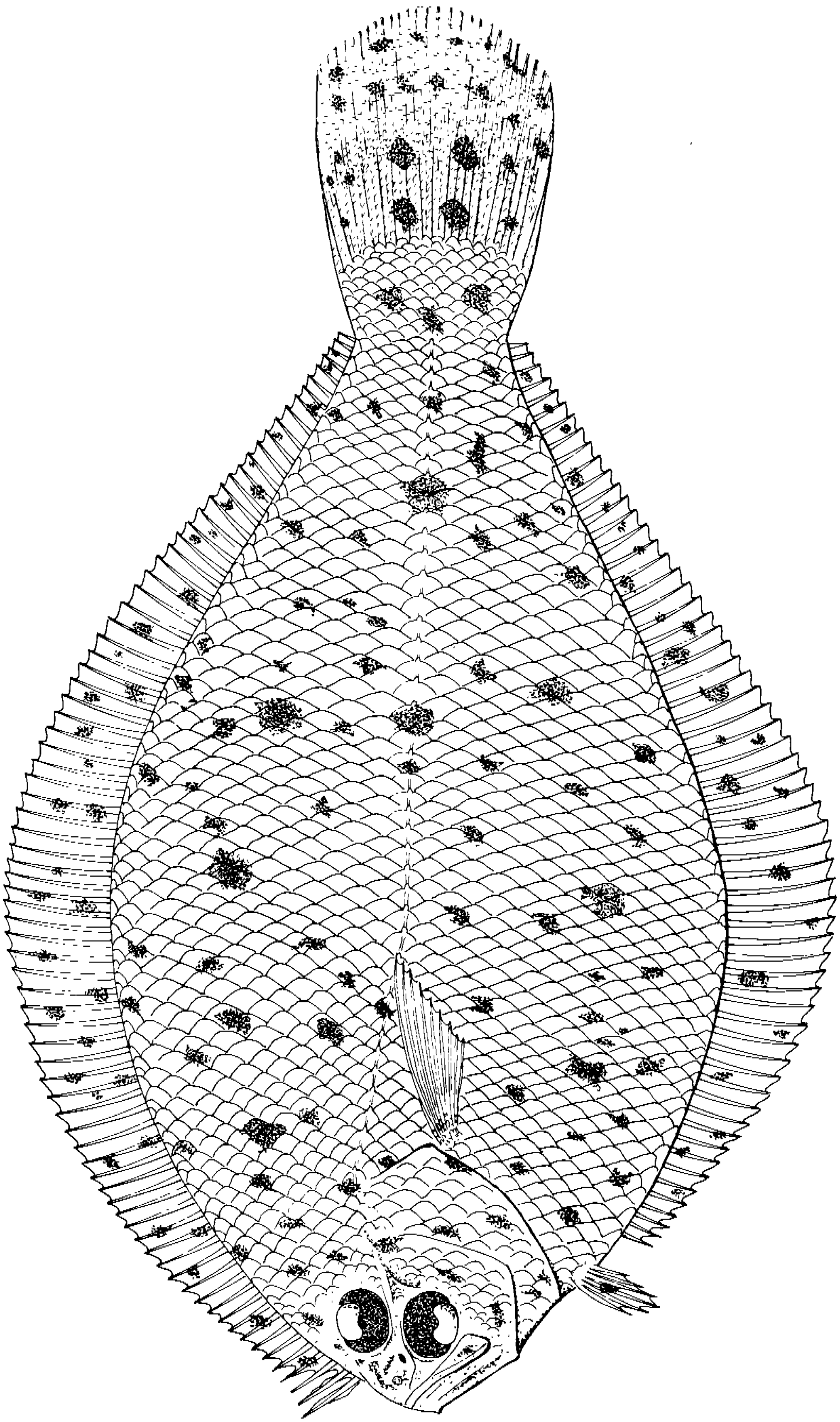

Figure 15. *Citharichthys macrops* Dresel. FSBC 3740, 75 mm SL, Gulf of Mexico west of Pithlachascotee R. in 3-4 m depth.

Citharichthys macrops is a distinctive and easily recognized species, characterized by prominent dark spots and blotches on the ocular side. In Hourglass specimens the opercular margin of the blind side is fringed with leaflike cirri, a character apparently undiagnosed before. Morphometric data for six males, four females and one juvenile are listed in Table 7. Counts for 11 specimens are (number of specimens in parentheses): dorsal fin rays 79(1), 80(2), 81(6), 82(2); anal fin rays 59(1), 61(5), 62(4), 63(1); pectoral fin rays, ocular side 10(9), 11(1), 12(1), blind side 7(1), 8(3), 9(6); gill rakers, lower limb 12(1), 13(3), 14(1), 15(6), upper limb 4(2), 5(5), 6(4); lateral line scales 37(1), 39(2), 40(5).

TABLE 7. PROPORTIONAL CHARACTERS, EXPRESSED IN THOUSANDTHS OF STANDARD LENGTH, OF *CITHARICHTHYS MACROPS.*

Character	Males (6)		Females (4)		Juvenile
	Range	Mean	Range	Mean	
Standard length (mm)	78.3-140.1	120.0	96.4-149.8	130.2	29.9
Body depth	495-528	510	476-511	490	478
Head length	238-266	247	245-253	250	281
Snout length	043-055	048	044-052	047	060
Length of orbit	062-069	066	051-064	059	070
Length of upper jaw	095-102	099	095-106	099	120
Depth of caudal peduncle	135-139	137	117-132	125	100
Length of pectoral fin (ocular side)	148-166	159	142-163	154	134
Length of pectoral fin (blind side)	116-122	119	101-129	117	

Distribution. Citharichthys macrops occurs from North Carolina to the southern tip of Florida, throughout the Gulf of Mexico, and along the Caribbean coast of Central America south to Honduras. Fowler (1944:441) reported it from the Bahamas. Struhsaker (1969:298) characterized it as "very common" along the southeastern United States, where it appeared in over 50% of trawling stations on the open continental shelf. In the Gulf of Mexico it apparently reaches peak abundance on the hard sand bottom off Campeche; farther north *C. spilopterus* largely replaces it (Hildebrand, 1954:294; 1955:203).

Occurrence in Hourglass Collections. Forty-one specimens were taken in 29 collections during Hourglass sampling, with never more than three specimens per collection (Table 8). Struhsaker (1969:298) indicated a similarly diffused distribution for *Citharichthys macrops* along the southeastern United States. Although taken at the majority of his stations, it was most often found in small numbers.

Our specimens ranged from 31-152 mm. A maximum documented size of 162 mm SL (SL = 0.79 TL, based on 10 specimens) has been reported for a ripe female, 205 mm TL, collected off Tampa Bay (Moe and Martin 1965:147). Small size and sparse distribution limit its potential status to that of a minor inclusion in any future industrial fishery.

TABLE 8. NUMBERS AND SIZE RANGE (mm SL) OF *CITHARICHTHYS MACROPS* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Citharichthys macrops																														
STA	1965					1966													1967											TOT
	A	·S	O	N	D	J	F	M	A	M	J	J	J sp	A	S	O	N	D	J	J sp	F	M	A	M	J	J	A	S	O	N	
A						3 49-133			1 74					1 67														1 85	2 75-95		8
B₁																		1 150	3 125-128												4
B₂	1 136						2 39-120				1 116							1 127	1 126		2 130-135										8
C₁								1 137							1 142										1 140						3
C₂																															
D₁																															
D₂																															
E																															
I						1 31		1 77				1 96									1 58					1 98	2 56-104				7
J				1 141	1 133		2 126-136		1 75				3 102-140																	2 128-138	10
K												1 152																			1
L																															
M																															
TOT	1			1	1	4	4	2	2		1	2	3	1	1			2	4		3				1	1	2	1	2	2	41

Ecology. All but four specimens occurred at depths of 18 m or less, and none was collected beyond 37 m. *Citharichthys macrops* is seldom found in waters exceeding 40 m; maximum reported depth is 50 fm (92 m) (Gutherz, 1967:33). Although restricted to shallow waters, it is not often found in bays and estuaries. Joseph and Yerger (1956:128) collected a single specimen in Alligator Harbor, but frequently found specimens in nearby waters outside the harbor. Gunter and Hall (1963:280) reported it "not commonly taken inshore" in the St. Lucie Estuary, presumably implying increased abundance offshore. Although eight Hourglass specimens were collected adjacent to Tampa Bay (Sta. A), none was collected during Springer and Woodburn's (1960) study of the bay proper.

Bottom temperatures for Hourglass collections of *Citharichthys macrops* varied from 15.9-31.0°C, approximating the range of published extremes (15.4°C–Gunter, 1945:85; 32.8°C–Moe and Martin, 1965:145). Bottom salinities ranged from 32.26-36.47°/₀₀. Gunter and Hall's (1963:280) specimen from the St. Lucie Estuary was collected in 25.7°/₀₀, the lowest salinity on record for this species.

Citharichthys macrops is found most frequently on bottoms of sand and/or crushed shell. Hildebrand (1954:294) postulated an ecological separation of *C. macrops* from *C. spilopterus* based on substrate, the former preferring hard sand, the latter preferring mud. Collections of *C. macrops* taken by U.S. Fish and Wildlife Service vessels have been primarily from sand and shell, but catches from mud and coral bottoms have been recorded (Springer and Bullis, 1956:62; Bullis and Thompson, 1965:33). Unconsolidated sediments at Hourglass Stations A, B, I & J are basically of quartz and shell sand.

Seasonal, annual or diurnal patterns were not evident in Hourglass collections of *Citharichthys macrops*. Stomach contents of six adults collected during November 1965, January, February, March and July 1966 and November 1967 were heavily represented by small crustaceans, primarily caridean shrimp of the genera *Processa* and *Synalpheus*. Penaeid shrimp and sponge spicules were also present.

Maturation and Spawning. Based on appearance of small juveniles in Hourglass collections, an extended spawning season from about August through December is inferred. Specimens of 31, 39 and 56 mm were collected during January, February and August, respectively. Lengths of small juveniles from other areas include 20 mm from Texas in March (Compton, 1966), 31 mm from Lower Matecumbe Key, Florida in June (Springer and McErlean, 1962:44) and 52 mm from Jupiter, Florida on 31 December (Christensen, 1965:220).

Moe and Martin (1965:147) postulated a spring spawning season off Tampa Bay, based on appearance of ripe fish in March. Reexamination of their March material shows a condition of active ripening, with the ovaries not yet crowding into the body cavity. Their March specimens would probably have spawned in late autumn.

Examination of additional Florida west coast specimens in FSBC collections indicates a spawning season generally consistent with that suggested by Hourglass material. Three juveniles, 46-52 mm, collected on 27 December 1966 off Keaton Beach (29°55'N) and 13 specimens, 57-76 mm, collected on 3 June 1965 off the Pithlachascotee River (28°20'N) probably represent year class 0.

Syacium Ranzani

Syacium Ranzani, 1840:18 (type, *Syacium micrurum* Ranzani); Norman, 1934:129 (synonymy, key, diagn.); Gutherz, 1971 (larval develop. and distrib.).

Of the three western North Atlantic species of *Syacium*, two (*S. gunteri* and *S. papillosum*) are definitely known to occur in the Gulf of Mexico. Most published records of *S. micrurum* from the Florida Shelf have been examined by Dr. Thomas H. Fraser (J.L.B. Smith Institute of Ichthyology, pers. comm.) and found to be either *S. papillosum* or *Citharichtys* sp. According to Dr. Fraser, *S. micrurum* is widespread in the tropical western Atlantic, but probably does not occur along the Gulf coast of Florida.

In the zoogeographical section of this paper *S. micrurum* is considered present but rare on the Florida Shelf, based on its reported occurrence off Naples, Florida (Springer and Bullis, 1956:63). However, it is not included in the accompanying key.

Norman (1934:62) and Gutherz (1967:5) recognized the presence of uniserial teeth in the lower jaw of *Syacium* and three related genera. Dawson (1969b:369) has shown, however, that this condition in *Syacium* applies only to fixed teeth, and that an additional two or three rows of movable teeth occur in the lower jaw of *S. gunteri*. A similar condition, easily detected in alizarin-stained material, exists in *S. papillosum*.

KEY TO THE SPECIES OF *SYACIUM* KNOWN TO OCCUR ON THE FLORIDA SHELF

1. Body depth exceeding 46% SL; gill rakers of first arch typically 7 on lower limb, 3 on upper; ocular side usually bearing a dark blotch just anterior to caudal peduncle . . *Syacium gunteri*.

1. Body depth less than 46% SL; gill rakers of first arch typically 8 on lower limb, 2 on upper; ocular side usually without prominent spots or blotches . . . . *Syacium papillosum*. (Figures 16 and 17)

Syacium papillosum

Dusky flounder, Figures 16 and 17

Pleuronectes papillosus Linnaeus, 1758:271.

Syacium papillosum Jordan and Goss, 1889:269 (key, descr., distrib.); Beebe and Tee-Van, 1933:72 (Bermuda); Gunter, 1933:34 (off Grand Isle and East Bay, La.); Norman, 1934:130, Fig. 84 (synonymy, key, descr., distrib.); Fowler, 1941:144 (Bahia and Rio de Janero, Brazil); Longley and Hildebrand, 1941:40 (ecology, Tortugas, Fla.); Baughman, 1950:136 (Galveston and Corpus Christi, Texas); Gunter and Knapp, 1951:131 (La. and Texas); Hildebrand, 1954:294 (w. Gulf of Mex.); Hildebrand, 1955:203 (Campeche Banks); Joseph and Yerger, 1956:149 (near Alligator Harbor, Fla.); Menzel, 1956:97 (St. George Sound, Fla.); Springer and Bullis, 1956:64 (Gulf of Mex. localities); Briggs, 1958:297 (listed, Fla.); Hoese, 1958:344 (listed, Texas); Duarte-Bello, 1959:130 (listed, Cuba); Bearden, 1961:10 (listed, S. Car.); Bullis and Thompson, 1965:34 (w. Atlant. localities); Moe and Martin, 1965:145 (off Tampa Bay, Fla.); Roithmayr, 1965:22 (industrial fishery, n. Gulf of Mex.); Beaumariage and Wittich, 1966:49 (tagging, Fla.); Cervigon, 1966:790, Fig. 334 (descr., distrib., Venezuela); Compton, 1966:58 (off Port Aransas, Texas); Juhl, 1966:Table 2 (Fla. w. coast localities); Voss, 1967:68 (Carib. coast of Panama); Gilbert, 1968:75 (Marineland, Fla.); Struhsaker, 1969:298 (se. U.S.); Duke and Rudolph, 1969:128 (Carib. coast of Panama); Bayer *et al.*, 1970:A68 (sw. Carib.); de Sylva, 1970:52 (Biscayne Bay, Fla.).

Longley and Hildebrand (1941:40) distinguished *Syacium papillosum* from *S. gunteri* on the basis of size, body depth, dorsal and anal fin rays and lateral line scales. Dorsal fin ray counts of 30 Hourglass specimens of *S. papillosum* differ significantly from Longley and Hildebrand's (1941:Table 3) counts of 99 Tortugas specimens (t = 3.37), with means of 85.7 and 87.2 rays for the two populations (Table 9). Anal fin ray counts for the two populations agree.

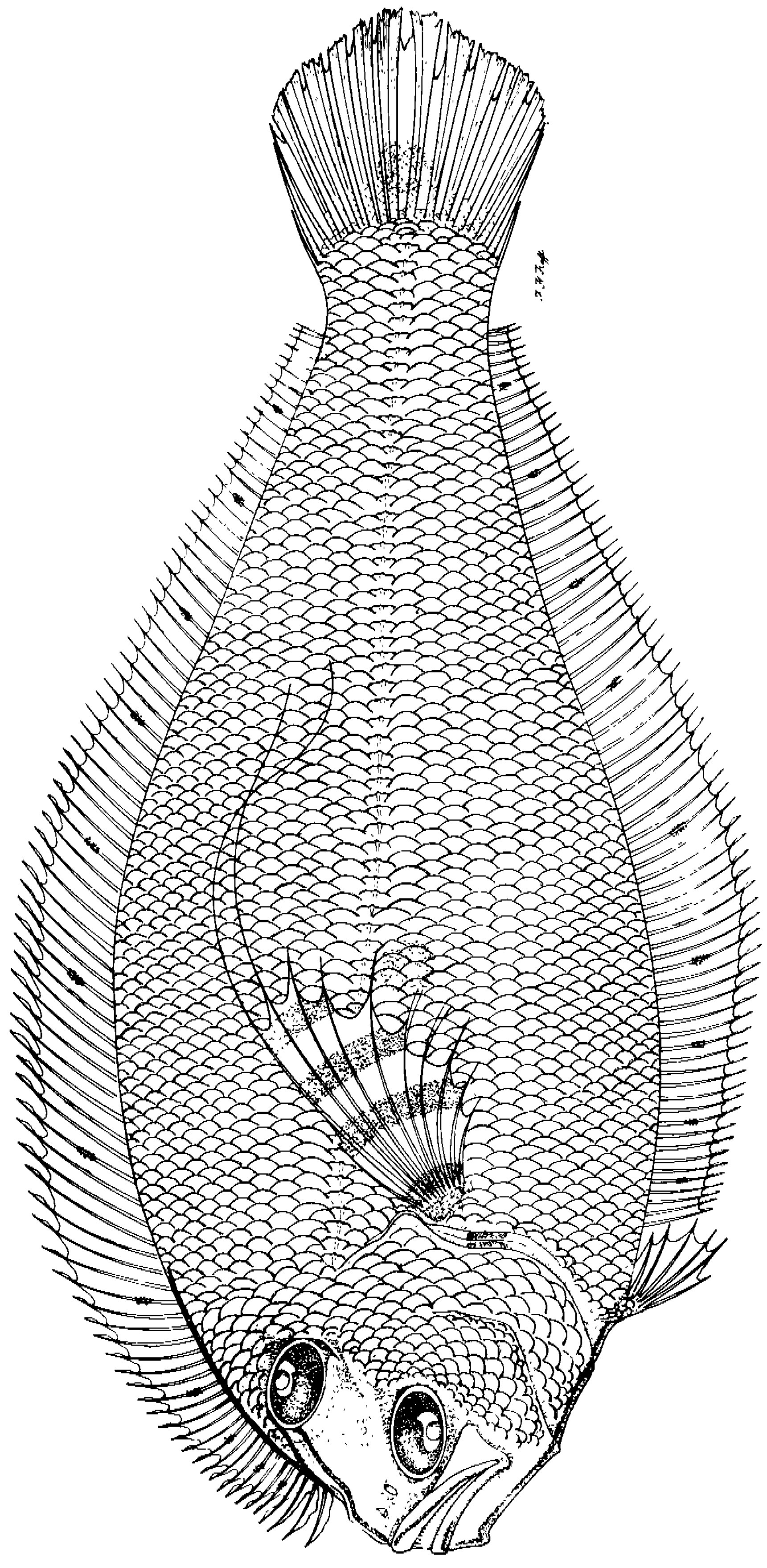

Figure 16. *Syacium papillosum* (Linnaeus), male, FSBC uncat., 150 mm SL, Hourglass Sta. D.

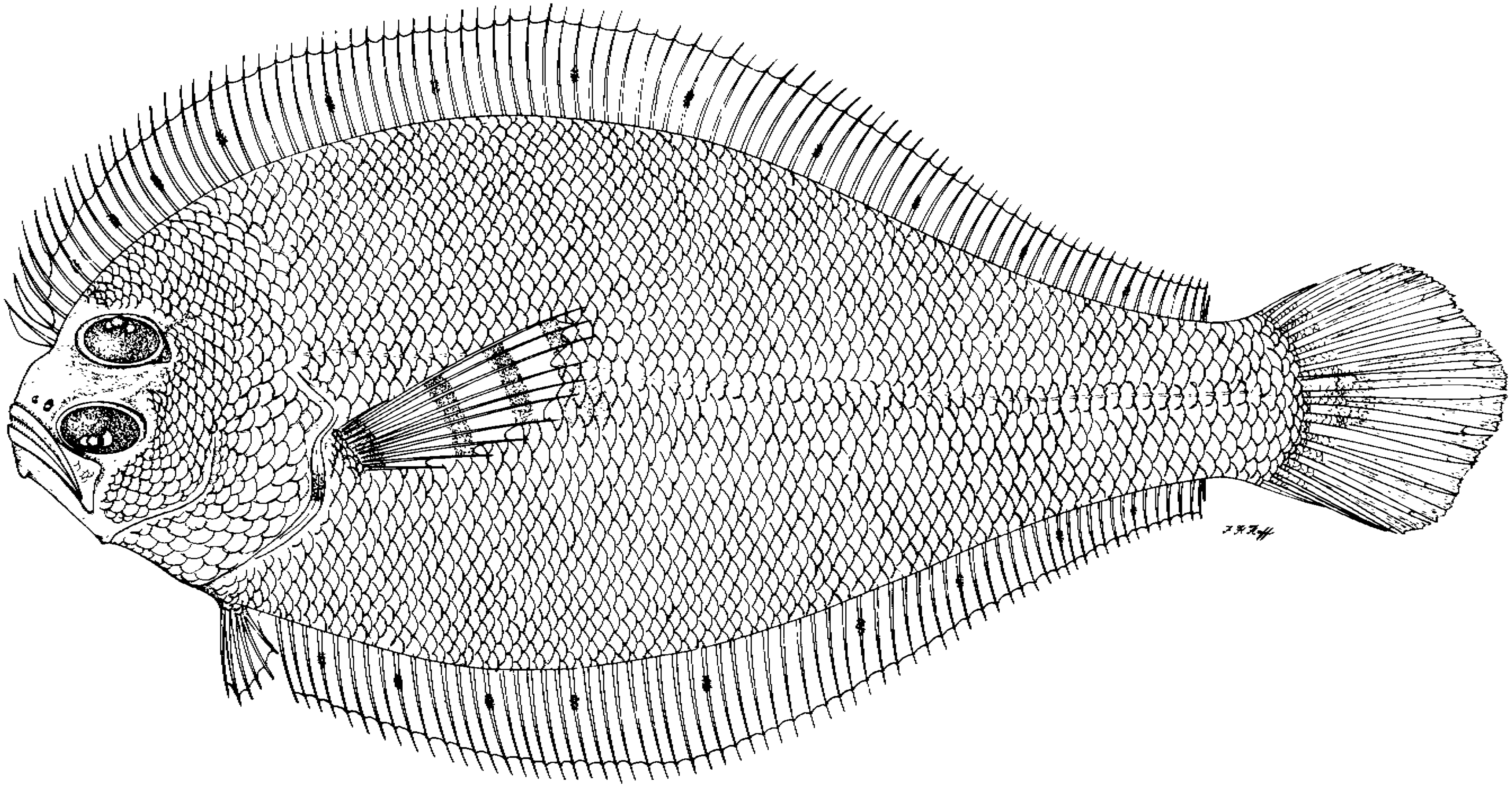

Figure 17. *Syacium papillosum* (Linnaeus), female, FSBC uncat., 150 mm SL, Hourglass Sta. D.

TABLE 9. DORSAL AND ANAL FIN RAY COUNTS FOR 30 HOURGLASS AND 99 TORTUGAS SPECIMENS OF *SYACIUM PAPILLOSUM.* TORTUGAS DATA FROM LONGLEY AND HILDEBRAND (1941: TABLE 3).

Dorsal Rays	81	82	83	84	85	86	87	88	89	90	91	92
Hourglass	1	1	4	2	5	8	3	3	1	2		
Tortugas			1	7	10	19	19	20	14	4	4	1

Anal Rays	62	63	64	65	66	67	68	69	70	71	72
Hourglass	1			1	4	6	6	7	3	2	
Tortugas		1	1	3	7	25	21	19	15	5	2

Early accounts (e.g., Jordan and Evermann, 1898:2671, Fig. 941; Norman, 1934:131) make no mention of the striking sexual dichromism in the anterior parts of *Syacium papillosum.* The following notes on a live 280 mm male taken by hook and line are intended to augment the cursory color descriptions of Longley and Hildebrand (1941:40) and others: turquoise markings on maxillary and mandible, extending posteriad along dorsal outline to about 25th ray and along ventral outline to first pelvic ray; a pair of parallel lines extending from snout to anterior margin of upper orbit. Blind side of dorsal fin tinged with green. Blind side of body dusky.

In a sample of 60 mature fish from Sta. M, mean size of males (175.9 mm) was significantly larger than mean size of females (159.1 mm) (t = 4.1). Among the 130 Hourglass specimens exceeding 200 mm, only two were females.

Distribution. Syacium papillosum occurs from North Carolina southward through the Gulf of Mexico and Caribbean, along the Atlantic coast of South America to Rio de Janeiro, and in the Bahamas and Bermuda.

In the Gulf of Mexico, *Syacium papillosum* and *S. gunteri* are sympatric along much of the shelf. There is good evidence, however, that their distribution is strongly influenced by substrate, with *S. papillosum* preferring a bottom of calcareous material, and *S. gunteri* preferring sand and mud. Along the Florida Shelf, where sediments are mainly calcareous, *S. papillosum* occurs in great numbers, while *S. gunteri* is absent between latitudes of about 25° and 29°. Off Cape San Blas, where clay and silt are deposited by the Apalachicola River, a few *S. gunteri* occur, but *S. papillosum* remains dominant westward to about 88°W Long. Near the Mississippi Delta and westward, where terrigenous sediments dominate, *S. gunteri* replaces *S. papillosum*; along the Texas coast *S. gunteri* is the commonest flatfish in 18-55 m, with *S. papillosum* seldom occurring (Gunter and Knapp, 1951:135). On the Campeche Bank where sediments are again primarily calcareous, *S. papillosum* is dominant, being taken in nearly every drag by shrimp trawlers (Hildebrand, 1955:203).

Occurrence in Hourglass Collections. During Hourglass sampling 3549 specimens (18-253 mm) were taken in 283 separate collections (Table 10). All stations were represented, but only 9 specimens were collected at Stations A and I. A maximum single catch of 85 specimens (46-221 mm) was taken at Sta. D on 15 March 1967 with a 20 ft trynet. Catch per unit effort for the two trawl sizes (20 ft vs. 45 ft) did not differ significantly.

TABLE 10. NUMBERS AND SIZE RANGE (mm SL) OF *SYACIUM PAPILLOSUM* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Syacium papillosum

STA	1965					1966													1967												TOT
	A	S	O	N	D	J	F	M	A	M	J	J	J sp	A	S	O	N	D	J	J sp	F	M	A	M	J	J	A	S	O	N	
A			1 120													1 163															2
B₁	2 102-151		13 62-161	17 60-210	5 137-176	9 52-180	4 100-186	7 56-200	2 60-121	2 85-106		6 90-157	8 83-185		3 107-158	2 89-128	2 61-174	4 59-124	1 75	7 55-205		1 63				1 122				1 135	97
B₂	13 41-137		1 58			11 77-212					4 74-179				1 63			2 73-151			1 92	1 202					1 44			2 182-224	37
C₁	11 97-210	7 83-219	2 82-147	6 87-180	1 66	5 35-173	2 121-143	66 33-215	3 71-175			15 23-218	9 62-199		38 64-159	2 167-187	14 48-180	14 63-225	17 78-211	60 41-204	3 130-175	3 60-114	6 61-214	4 74-197	1 78				11 32-252	43 40-215	343
C₂	3 87-202		22 97-207	4 102-165		1 233	1 202	45 65-197	40 33-228	5 92-172	25 62-221	2 80-120		5 87-195	9 61-174	29 70-172	6 85-198	10 61-229	1 134		9 86-177	26 61-209	12 57-224	1 89	58 69-224	3 65-172		1 70	45 69-182	12 53-147	375
D₁	9 118-171	3 121-146	20 46-192	7 110-180	9 47-173	11 50-187	11 58-190	12 51-158	11 60-223	11 50-253	9 81-214	16 70-190	5 71-136	14 74-205	5 30-200	5 74-195	9 102-225	32 70-206	6 56-200	58 45-195	8 86-173	7 73-209	11 58-212	9 66-198	2 31-197	11 35-168	15 66-194	13 63-175	3 95-137	28 93-189	370
D₂	36 67-200		16 45-208	23 51-202			30 53-237	9 60-211	1 60	9 114-209	24 50-171	57 53-197		29 52-200	22 62-217	27 72-206	49 70-210	63 40-202	2 93-183		10 61-188	85 46-221	5 67-167	2 85-101	6 66-138		1 174	6 42-192	5 94-207	10 90-148	527
E		9 46-185	18 72-181	7 108-173	24 95-182	6 88-190	20 82-167	23 49-188	9 47-185		7 120-177	65 42-202	1 135	30 33-172	11 105-177	25 67-175	17 69-178	12 31-164	7 103-166	36 63-186	14 77-150	3 85-134	10 67-155	6 88-143	9 35-155	10 74-190	2 144-159	10 96-162	1 191	14 77-172	406
I	1 169	1 167			1 168			1 186														1 166	2 72-100								7
J	3 29-102	1 120	3 73-131	4 79-215	16 53-211	3 46-165	7 41-123	13 52-181	11 55-135	3 69-164	2 83-144		18 79-103	2 48-49	1 113	3 92-167	3 78-122	7 80-205	9 74-136	11 70-141	3 74-96	2 48-88	1 55	2 77-85		1 89	3 29-120		27 73-196	38 53-180	197
K	20 29-200	3 139-207	15 77-158	7 40-193	8 65-228	13 55-200	6 76-170	13 75-180	14 48-119	6 102-218	13 67-221	43 71-240	53 70-195	9 30-208	18 28-220	4 42-136	12 54-170	4 55-72	1 167	36 54-180	16 52-155	2 51-52	4 51-145	6 64-200	1 31	1 69	2 46-87	4 102-138	39 20-165	48 71-194	421
L	1 222	12 143-211	15 97-225	13 116-220	14 97-213	11 104 231	22 150-191	8 80-94	7 132-222	4 134-191	15 116-212	17 59-219	66 53-230	14 69-215	8 65-195	8 77-200	8 30-186	6 81-170	10 40-200	21 75-210	1 84	2 161-165	5 132-213	5 61-203	1 62	7 84-192		3 27-102	7 32-185	7 32-187	318
M		3 72-172	7 100-150		19 77-195	21 106-176	3 150-191	19 112-20	4 33-210	12 125-186	3 171-202	68 67-202	9 105-206	12 140-192	27 18-200	11 165-210	9 92-175	3 144-180	6 78-153	81 53-208	27 77-197	33 41-192	3 151-166	6 127-195	12 65-203	4 154-190	6 132-178	7 150-175	12 78-188	22 106-206	449
TOT	99	39	133	88	97	91	106	216	102	52	102	289	169	115	143	117	129	157	60	310	92	166	59	41	90	38	30	44	150	225	3549

Ecology. Published depth records for *Syacium papillosum* range from 6-210 fm (11-384 m) (Bullis and Thompson, 1965:34), but records from depths exceeding 50 fm (92 m) are rare. Catches increased with depth during Hourglass sampling, suggesting greater availability in waters deeper than 73 m.

Mean fish size generally increased with depth, with significant differences between mean standard lengths of samples from 18, 37 and 55 m (Table 11). Bottom temperatures for Hourglass collections of *Syacium papillosum* ranged from 13.9-31.0°C; bottom salinities from 31.22-36.71‰. Relative abundance at the 73 m stations (E and M) was greatest from July through September, corresponding to the period of highest water temperature.

TABLE 11. MEAN STANDARD LENGTH (mm) OF HOURGLASS COLLECTIONS OF *SYACIUM PAPILLOSUM*, BY CAPTURE DEPTH.

Depth (m)	No. of Specimens	Mean Size (mm SL)	t Value
18	197	109	
			2.61**
37	541	126	
			4.45**
55	560	141	
			1.42
73	572	137	

**significant at p=0.01

No differences in catches or size distributions were evident between stations along the northern cruise transect (A-E) versus those along the southern (I-M).

At Stations B, C and D, where replicate daylight collections were made, tests for paired samples showed no significant differences between day and night catches of *Syacium papillosum*. Feeding patterns, however, imply quiescent nocturnal behavior. At night the animals probably lie partially buried in the substrate, as is usual for bothid flatfishes (Mast, 1916:182).

Food Habits. Stomachs of 170 specimens were examined; 134 contained food. The following items were identified:

- Porifera
  - Demospongia
- Echinodermata
- Mollusca
  - *Cyclopecten nanus*
  - *Laevicardium pictum*
  - *Loliguncula brevis*
- Annelida
  - Archiannelida
  - opheliid
  - mycostomid
  - *Neanthes* sp.
- Arthropoda
  - Merostomata
    - *Limulus polyphemus*
  - Mysidacea
    - mysid
  - Isopoda
  - Amphipoda
    - gammarid
- Stomatopoda
  - *Squilla* sp.

    - *Meiosquilla quadridens*
    - *Meiosquilla schmitti*
    - *Eurysquilla plumata*
- Decapoda
    - Penaeidea
        - *Solenocera* sp.
        - *Penaeus* sp.
        - *Metapenaeopsis goodei* (?)
        - *Trachypenaeus constrictus*
        - *Sicyonia brevirostris*
        - *Sicyonia typica*
    - Caridea
        - *Leptochela* sp. 1 and 2
        - *Periclimenaeus* sp.
        - *Alpheus armillatus*
        - *Synalpheus* sp.
        - *Ogyrides* sp.
        - *Processa* sp.
    - Macrura
        - *Scyllarus chacei*
        - *Scyllarus depressus*
        - callianassid
    - Anomura
        - axiid
        - *Munida irassa*
        - *Pachycheles rugosa*
        - *Paguristes* sp.
        - *Pagurus* sp.
    - Brachyura
        - *Raninoides loevis*
        - *Ranilia* sp.
        - *Iliacantha* sp.
        - *Calappa* sp.
        - *Portunus spinicarpus*
        - *Pilumnus* sp.
        - *Micropanope* sp.
        - *Menippe* sp.
        - *Goneplax barbata*
        - *Euryplax* sp.
        - *Speocarcinus* sp.
        - *Pinnixa* sp.
        - *Palicus* sp.
        - *Mithrax* sp.
        - *Parthenope* sp.
        - *Parthenope serrata*
        - *Solenolambrus tenellus*
        - *Heterocrypta granulata*
- Chordata
    - anguilliform
    - synodontid
    - *Syngnathus fuscus*
    - gobiid
    - *Scorpaena calcarata*
    - blenniid
    - ophidiid
    - *Ogcocephalus parvus*

To show relative importance of each type of food organism, the number of fish in which each food item occurred is listed in Table 12 as a percentage of the total number of fish examined (the occurrence method of Hynes, 1950). The tabulation suggests that *Syacium papillosum* is a generalized carnivore, feeding chiefly on crustaceans and to a smaller extent fishes, polychaetes and mollusks.

Few conspicuous differences in feeding habits were found when diets were compared by capture depth, season or fish size (Table 12). In seasonal comparisons, fish caught during warmer months had ingested a larger proportion of decapod crustaceans, especially anomurans and brachyurans. In comparison of feeding habits by fish size, no drastic shifts were encountered, although stomatopods, macrurans and fishes were more frequently found in larger specimens.

To determine time of day of feeding, proportion of empty stomachs among 626 specimens collected at Stations B, C and D during regular Hourglass sampling (primarily between 1800 and 0330 hrs.) were compared with that of 815 specimens collected during Post-Hourglass sampling (primarily between 1015 and 1645 hrs.). Figure 18 shows that proportion of empty stomachs is generally higher at night, indicating decreased nocturnal feeding activity.

TABLE 12. PERCENTAGE OCCURRENCE OF FOOD ITEMS OF *SYACIUM PAPILLOSUM* BY DEPTH, SEASON AND FISH SIZE.

	Depth (m)		Season				Fish Size (mm)				
	6-37	55-73	May thru Oct.	Nov. thru Apr.	July 1966	Jan. 1967	⟨100	101-150	151-200	⟩200	Total
Porifera	–	1.2	–	1.0	–	–	–	–	1.6	–	0.6
Echinodermata	–	1.2	–	1.0	–	–	–	–	–	5.3	0.7
Mollusca	6.7	3.7	5.7	5.0	3.0	–	2.6	8.0	4.9	5.3	5.3
Bivalvia	5.6	1.2	4.3	3.0	3.0	–	2.6	6.0	1.6	5.3	3.5
Cephalopoda	1.1	2.5	1.4	2.0	–	–	–	2.0	3.3	–	1.8
Annelida	15.7	4.9	8.6	12.0	6.0	–	–	12.0	8.2	21.1	10.6
Archiannelida	1.1	–	1.4	–	–	–	–	–	–	5.3	0.6
Polychaeta	14.6	4.9	7.1	12.0	6.0	–	7.9	12.0	8.2	15.8	10.0
Arthropoda	53.9	56.8	62.9	49.0	48.5	35.6	34.2	50.0	72.1	47.4	54.7
Merostomata	1.1	–	–	1.0	–	–	–	2.0	–	–	0.6
Mysidacea	4.5	1.2	1.4	4.0	–	–	2.6	4.0	3.3	–	2.9
Isopoda	2.2	–	–	2.0	–	4.4	2.6	–	–	–	1.2
Amphipoda	5.6	2.5	–	7.0	–	11.1	7.9	4.0	3.3	–	4.1
Stomatopoda	6.7	6.2	8.6	5.0	3.0	–	2.6	4.0	8.2	10.5	6.5
Decapoda	50.6	53.1	60.0	45.0	48.5	28.9	28.9	48.0	67.2	47.4	51.2
Shrimp	38.2	22.2	31.4	30.0	15.2	20.0	26.3	34.0	29.5	31.6	30.6
Macrura	–	3.7	4.3	–	3.0	–	–	–	1.6	5.3	1.8
Anomura	2.2	18.5	14.3	7.0	30.3	4.4	7.9	6.0	14.8	–	10.0
Brachyura	21.3	23.5	30.0	17.0	27.3	4.4	5.3	14.0	39.3	21.1	22.3
Chordata (Pisces)	13.5	16.0	17.1	13.0	9.1	4.4	13.2	20.0	9.8	26.3	14.7
Total Fish Examined	89	81	70	100	33	45	38	50	61	19	170

Maturation and Spawning. Gonads of 1750 males and 1400 females from Hourglass and FSBC collections were examined macroscopically to delimit spawning season. By plotting gonadal stages on fish length and month of capture for each Hourglass station, a diagrammatic picture of reproductive activity emerges (Figure 19), from which the following inferences can be made:

1. Spawning occurs over a protracted period, beginning in February and continuing as late as November, with peak activity from May through June. An extended spawning period has been suggested for *Syacium papillosum* by Moe and Martin (1965:34) and for *S. gunteri* by Miller (1965:101).
2. Sexual maturity occurs at about 100-130 mm.
3. Spawning occurs at depths greater than 18 m, as indicated by absence of active females at Stations B and J.

Gunter (1933:34) reported ripe females, 82.2-109.6 mm, from 5 fm (9 m) in East Bay, Louisiana. Both water depth and fish size differ from our data for spawning females; thus it is likely that Gunter based his observations on the smaller, more prevalent *Syacium gunteri*.

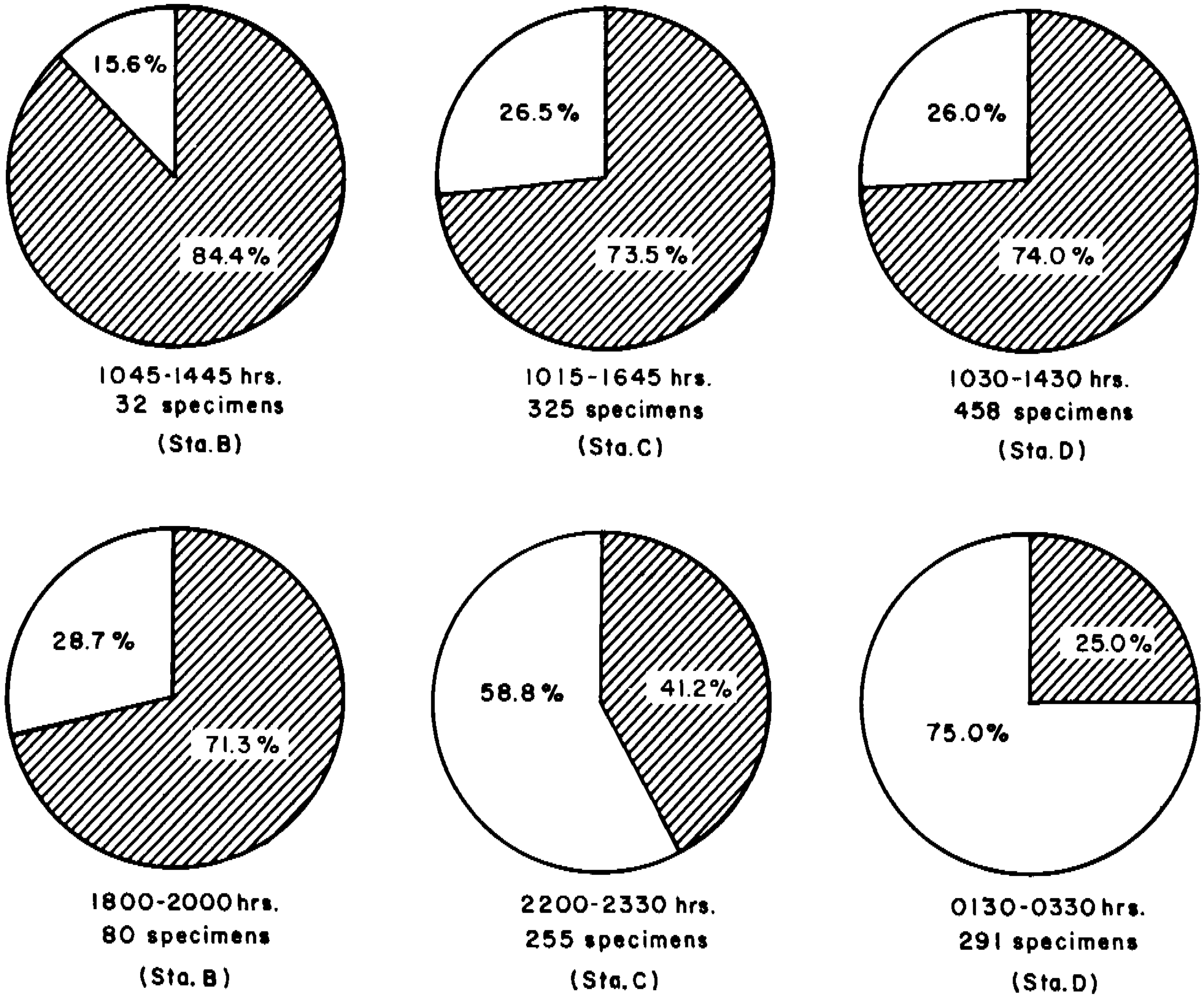

Figure 18. Proportion of *Syacium papillosum* stomachs containing food (shaded) at various hours, illustrating decreased nocturnal feeding activity.

Moe and Martin (1965:145) reported eight ripe females among some 30 specimens of *Syacium papillosum* collected off Tampa Bay in 16-18 fm (29-33 m) in June, and postulated an early summer spawning period. Re-examination of their material shows the females to be actively developing and ripening, but not ripe.

The extended spawning period obscures modal length progressions in even our smallest size classes. Although juveniles less than 30 mm SL (6 specimens) occurred only from July through October, we collected 30-40 mm fish in all months except February and May.

Fecundity. Five large females (150-185 mm) collected on 5 and 6 July 1967 at Stations K and L were used to estimate fecundity. Estimates ranged from 22,200 to 68,800, with an average of 55,200 eggs. For two specimens, ova density in a cross section aliquot near the posterior end of

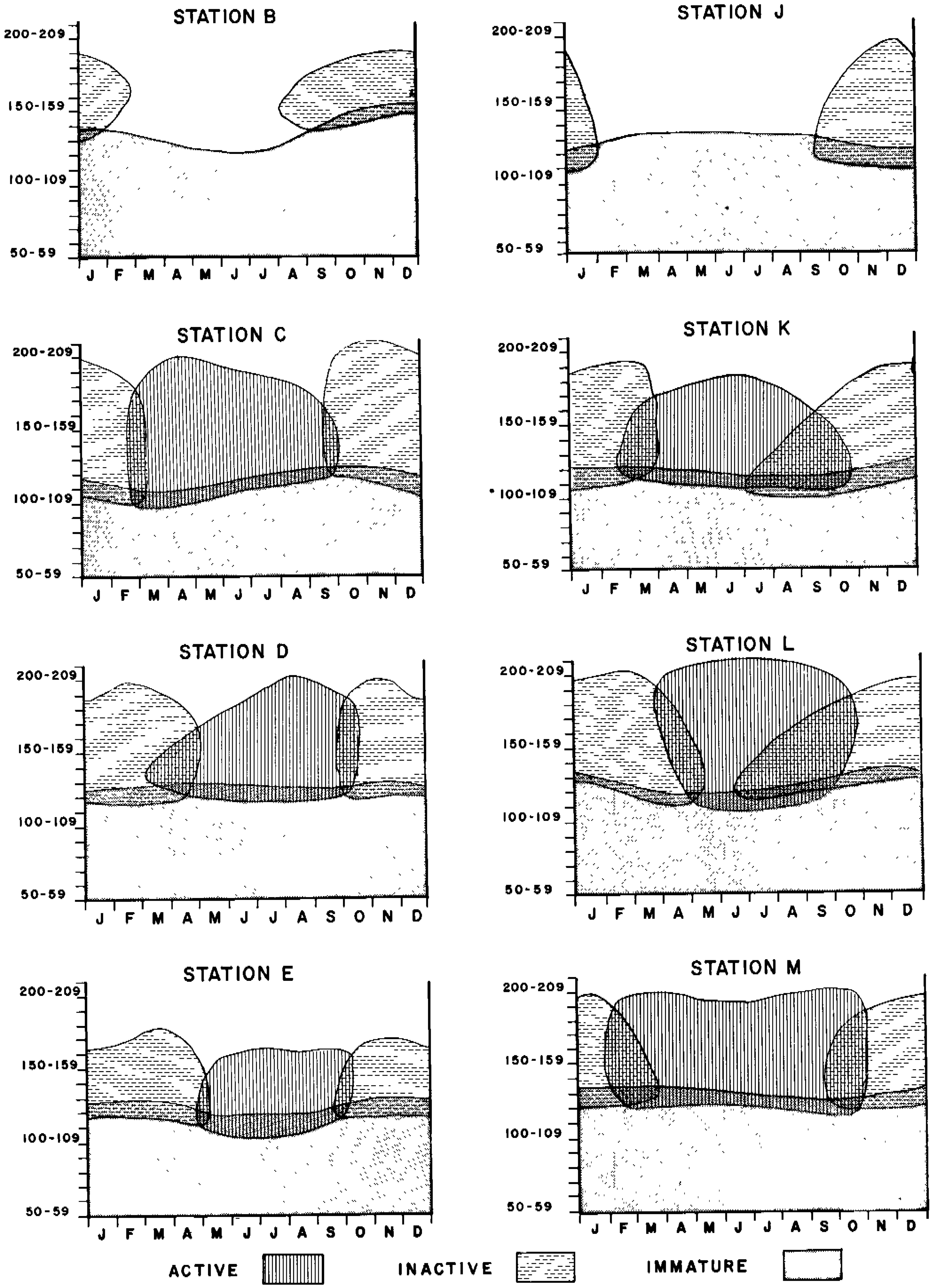

Figure 19. Gonadal stages of *Syacium papillosum* by station, fish size and month of capture.

each ovary was compared to density in the anteroventral end (near the oviduct). The following values were obtained:

185 mm specimen, Sta. L
  Blind side, posterior section 40,700 ova/g
  Blind side, anteroventral section 27,900 ova/g
  Ocular side, posterior section 45,700 ova/g
  Ocular side, anteroventral section 43,600 ova/g

150 mm specimen, Sta. K
  Blind side, posterior section 89,000 ova/g
  Blind side, anteroventral section 111,400 ova/g
  Ocular side, posterior section 284,200 ova/g
  Ocular side, anteroventral section 150,200 ova/g

Differences in ova density within individual fish were due primarily to variations in amount of ovarian tissue included in the aliquots; ova diameters were similar throughout each ovary. Distribution of 250 diameters from the 185 mm specimen was unimodal, ranging from 0.05 to 0.50 mm, with a mean diameter of 0.26 mm.

Commercial potential. Although small, *Syacium papillosum* occurs in great numbers and represents a valuable potential resource along the southwestern Florida coast.

Length-weight relationship, based on a random sample of 23 preserved specimens, is expressed by the formula

$$\log W = -4.885 + 3.044 \log L,$$

where W is weight (g) and L is standard length (mm). Our largest Hourglass specimens, therefore, would weigh scarcely more than one-half pound, and by current marketing standards only a small proportion of the catch could be processed for table use. However, the species would be an important inclusion in any industrial fishing operation in this area.

Juhl (1966:Table 3) reported substantial landings of the species (335 lbs in seven 45 min drags) north of Tampa Bay during exploratory fishing in 21-30 fm (38-55 m), but did not include it among the 16 species of commercial interest.

Bothus Rafinesque

Bothus Rafinesque, 1810:23 (type, *Bothus rumula* Rafinesque).

Some confusion still exists concerning distribution and systematic status of western Atlantic species of *Bothus*. Gutherz (1967) recognized five species, *B. ocellatus, B. lunatus, B. ellipticus* (which may be conspecific with *B. maculiferus*) and *Bothus* sp. [= *B. robinsi* Jutare (MS name)], the latter being dominant on the Florida Shelf. Most reports of *B. ocellatus* from Gulf of Mexico localities will likely prove to be *B. robinsi*.

Although other species of *Bothus* have not been documented with certainty from the Gulf, they may well enter from the Caribbean during their long pelagic postlarval existence. Kyle

(1913:5) first noted that species of *Bothus* may have an indefinitely prolonged postlarval stage, and that even juveniles and adults may exist pelagically as an adaptation for living contiguous to deep water. In the western Atlantic, 42 mm TL *B. ocellatus* postlarvae have been carried by the Gulf Stream as far north as Georges Bank (Colton, 1961:275).

We have examined juvenile specimens of *Bothus ocellatus* (FSBC uncat., VGS 60-97) from the Florida Keys, the smallest of which (14.0 mm SL) is completely metamorphosed. Thus if identification of Colton's 42 mm *B. ocellatus* larva is correct, there must be either a considerable reduction in size at metamorphosis, or a wide size range over which metamorphosis occurs. Retardation of metamorphosis seems the most likely explanation for the unusually large expatriate larvae on Georges Bank. Kyle (1913:49) has ascribed proximity of deep water as a governing factor in length at metamorphosis among the flatfish genera *Arnoglossus* and *Pleuronectes*.

Among Hourglass and FSBC collections of larval and juvenile *Bothus* are a 35.5 mm SL (41.7 mm TL) postlarva (FSBC uncat., PF 470), probably *B. lunatus*, collected in the Yucatan Straits (22°30'N 85°44'W) on 12 May 1969, and an 18.7 mm SL (22.7 mm TL) metamorphosing specimen (FSBC uncat., PF 496), probably *B. ocellatus*, from the same approximate location and time (C. Futch, pers. comm.). Such records imply recruitment of bothine flounders into the Gulf of Mexico from the Caribbean, and suggest that at least a component of our Gulf of Mexico stocks may be derived by much the same mechanism as phyllosoma larvae of the spiny lobster, *Panulirus argus*, are delivered to Florida in the plankton (Ingle *et al.*, 1963; Sims and Ingle, 1967).

KEY TO THE SPECIES OF *BOTHUS* KNOWN TO OCCUR ON THE FLORIDA SHELF

1. Caudal fin either lacking distinct spots, or more frequently with two distinct spots arranged vertically on caudal fin; caudal vertebrae generally 25 or 26 . . . *Bothus ocellatus* (Figure 20)

1. Caudal fin with two distinct spots arranged longitudinally along middle of fin; caudal vertebrae generally 27 or 28 . . . . *Bothus robinsi* (Figure 21)

Bothus ocellatus (Agassiz)

Eyed flounder, Figure 20

Rhombus ocellatus Agassiz, in Spix and Agassiz, 1829:85, Pl. 46 (Brazil).

Platophrys ocellatus Evermann and Marsh, 1900:321, Fig. 105 (Puerto Rico).

Bothus ocellatus Norman, 1934:222, Fig. 168 (synonymy, key, descrip., distrib.); Jutare, 1962:10 (synonymy, diagn., descrip., larval distrib.); Gutherz, 1967:41, Fig. 43 (key, descrip., distrib.); Cervigon, 1966:800, Fig. 341 (Venezuela); Böhlke and Chaplin, 1968:215, figure (Bahamas); Randall, 1968:163, Figs. 186, 187 (Greater Antilles); de Sylva, 1970:51 (Biscayne Bay, Fla.).

In most of the existing literature *Bothus ocellatus* has not been distinguished from the closely related *B. robinsi*. Without reference to the specimens on which these records were based, validation is generally impossible. In the above references identification has been verified through adequate descriptions or figures. Norman (1934:222) acknowledged that more than one species may have been confused in his description, but his figure is unmistakably that of *B. ocellatus*.

A single specimen, a 63 mm immature male, was collected during Hourglass sampling at Sta. K, 30 January 1967, in a 45 ft. balloon-type otter trawl. Bottom temperature was 18.0°C, bottom salinity 36.21‰. The specimen, FSBC 5501, has 84 dorsal rays, 60 anal rays and 26 caudal

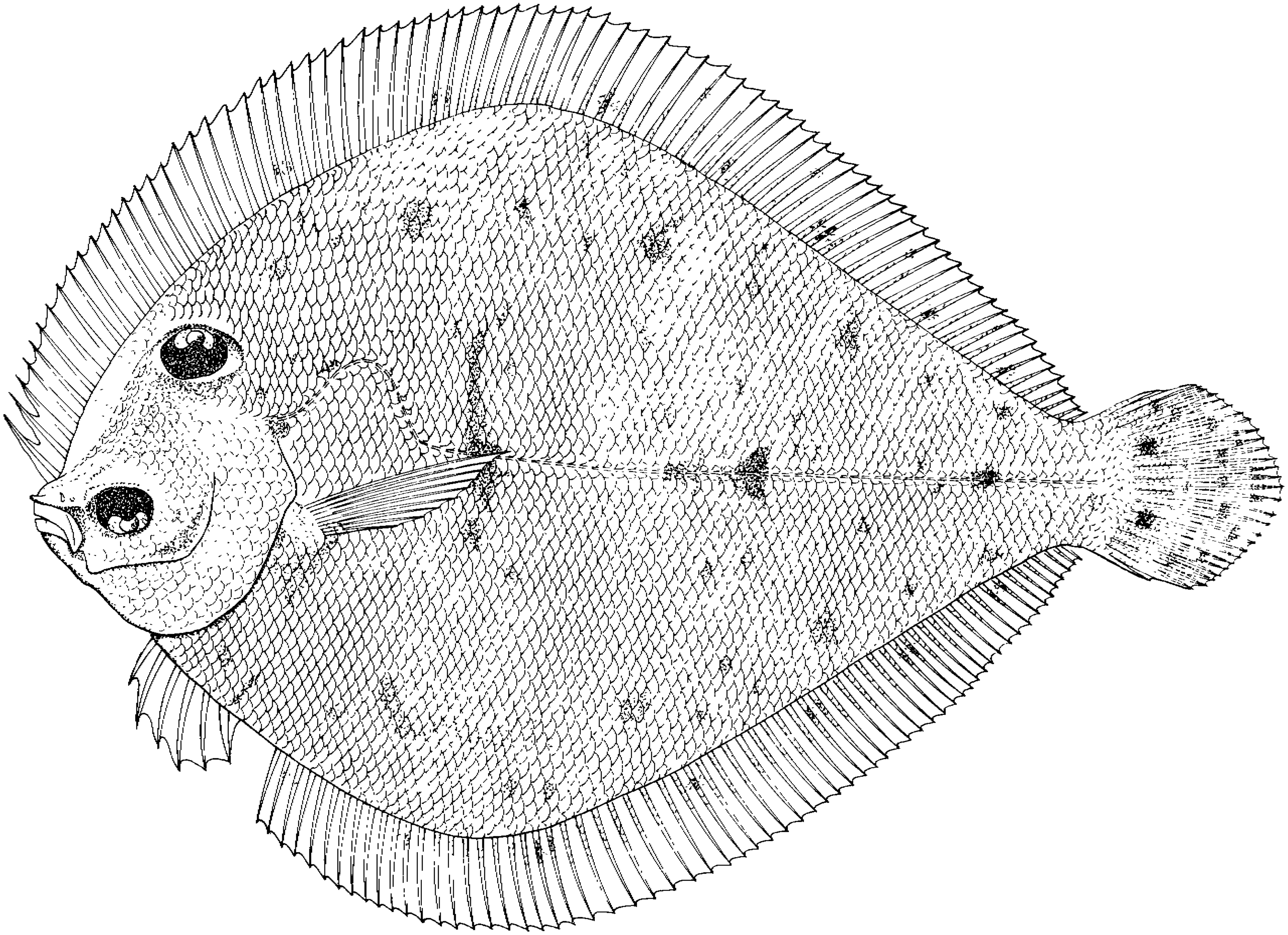

Figure 20. *Bothus ocellatus* (Agassiz), male, FSBC uncat., 99 mm SL, Tortugas shrimp grounds.

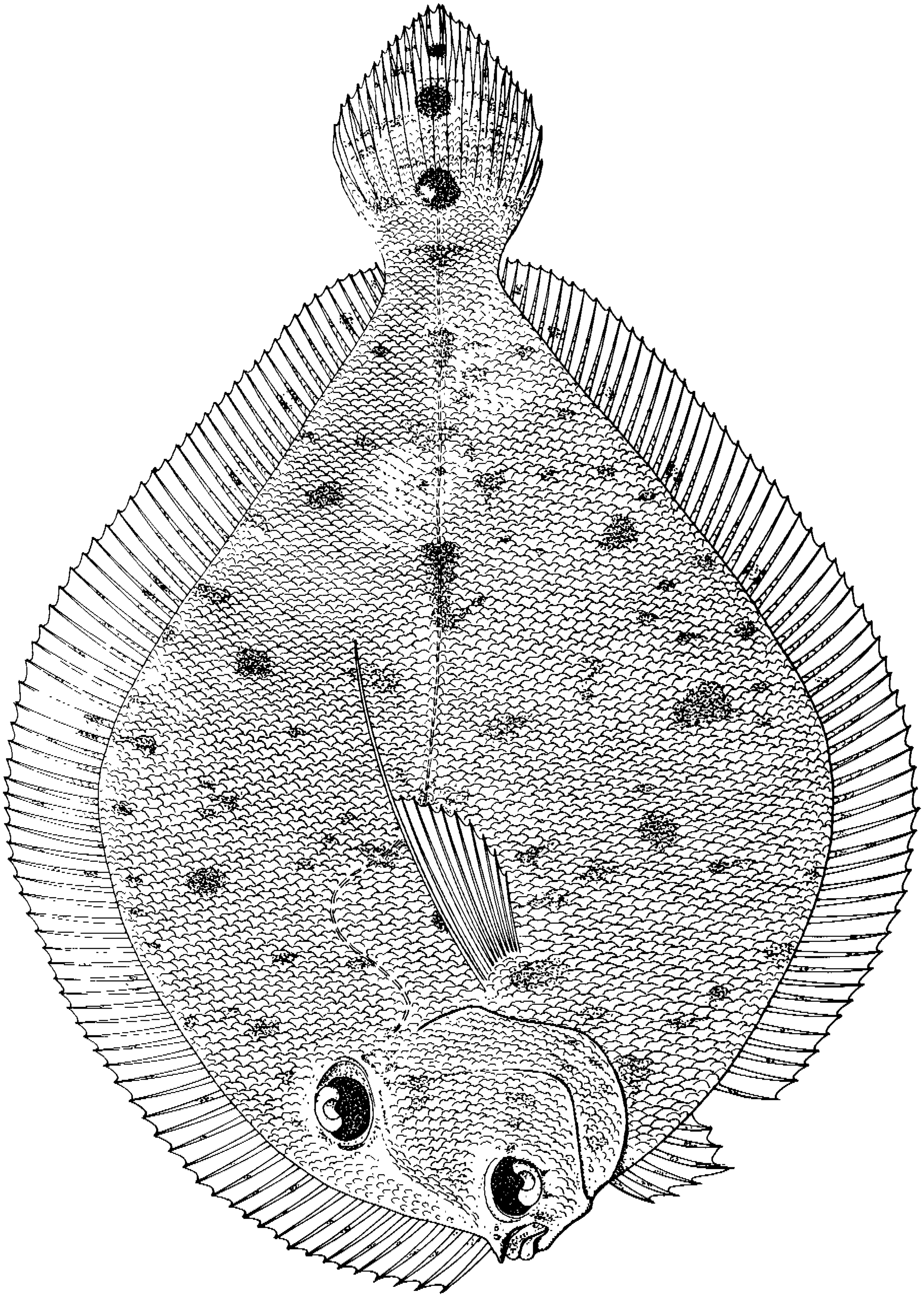

Figure 21. *Bothus robinsi* Jutare (MS name), male, FSBC 3898, 122 mm SL, Tampa Bay.

vertebrae. The gut was packed with parts of small crustaceans, polychaetes and calcareous shell fragments.

Bothus robinsi Jutare[1]

Figure 21

Bothus robinsi Jutare (MS name), 1962.

Bothus ocellatus Norman, 1934:222 (in part); Springer and Bullis, 1956:62 (in part); Moe and Martin, 1965:149 (off Tampa Bay).

Bothus sp. Christensen, 1965:218 (intracoastal waterway n. of Jupiter Inlet, Fla.); Moe and Martin, 1965:149 (off Tampa Bay, Fla.); Cervigon, 1966:798, Fig. 340 (Venezuela); Gutherz, 1967:40, Fig. 42 (key, descrip., distrib.); Böhlke and Chaplin, 1968:216 (Bahamas).

Bothus robinsi is not readily distinguishable from the closely related *B. ocellatus* by external meristic characters, and the two differ but slightly in morphometry. Juveniles and adults are best separated by the arrangement of caudal fin spots, which in *B. robinsi* are placed one behind the other, while in *B. ocellatus* the spots are absent or arranged one above the other. Jutare (1962:41) found the two separable with 83% correctness by caudal vertebrae, *B. ocellatus* generally having 25 or 26, *B. robinsi* 27 or 28.

Adults of *Bothus robinsi* are sexually dimorphic in interorbital distance, which remains small (less than 10% SL) in females and juveniles, but reaches 14% SL in large males. Figure 22, in which interorbital width is plotted against standard length for 20 males, 14 females and 2 juveniles of undetermined sex, shows divergence of regression lines for this character at about 85 mm, a length roughly corresponding to that at which sexual maturity is attained. Sexual dimorphism is also displayed in snout armature and, according to Jutare (1962:20), in pectoral fin length.

Proportional measurements for interorbital width, body depth and caudal peduncle depth for 36 specimens from FSBC collections are shown in Table 13.

Occurrence in Hourglass Collections. During Hourglass sampling, 416 specimens of *Bothus robinsi* were taken in 128 separate collections, at all stations except A and E. Table 14 shows catch distribution by month and station.

Only one specimen in Hourglass collections of *Bothus robinsi* exceeded 150 mm SL. This fish, a 222 mm SL (252 mm TL) ripe female, was collected at Sta. L on 13 June 1966.

Catches during Supplementary Cruises (July 1966 and January 1967) using a 45 ft balloon-type otter trawl were unexpectedly light. An average of 8 fish were caught during each Supplementary Cruise, as compared to an average of 14.1 per cruise with the 20 ft trawl, with catch per unit effort averaging nearly four times greater for the latter.

Ecology. Annual, seasonal or diurnal catch variations were not evident. Bottom temperatures for Hourglass collections of *Bothus robinsi* ranged from 13.9-30.0°C; bottom salinities from 31.22-36.49‰. A temperature of 12°C recorded for the collection of a 41 mm specimen off St. Petersburg Beach on 19 December 1962 is the minimum known for the species (FSBC collections). A minimum salinity of 23.9‰ has been recorded by Christensen (1965:218).

A strong year-round correlation exists between fish size and water depth. The following size ranges and means (SL) were observed for collections of *Bothus robinsi* at stations along the 18, 37 and 55 m contours:

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[1] This name is based on a Master's thesis (1962) and manuscript currently in preparation by Thelma Jutare, who shall be responsible for the name and the conditions making it available.

18 m Sta. B: 24-140 mm; mean, 76 mm
Sta. J: 54-119 mm; mean, 90 mm

37 m Sta. C: 51-150 mm; mean, 113 mm
Sta. K: 51-145 mm; mean, 111 mm

55 m Sta. D: 53-143 mm; mean, 121 mm
Sta. L: 49-138 mm; mean, 125 mm

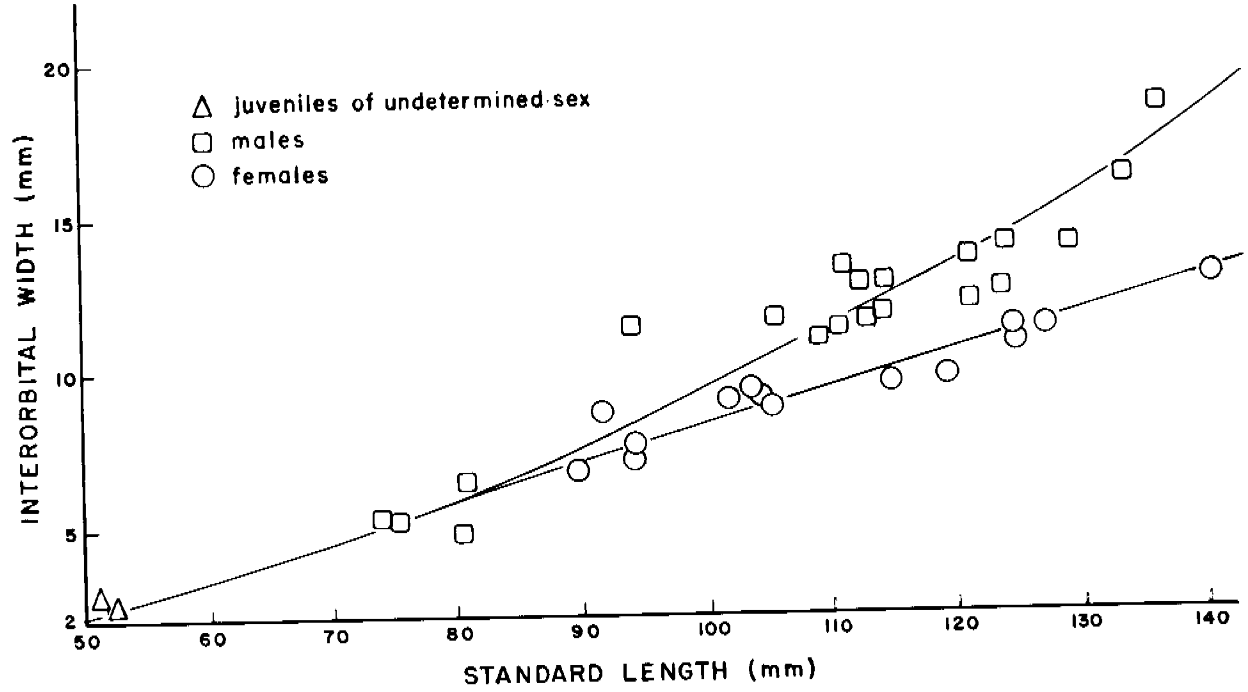

Figure 22. Interorbital width plotted against standard length for 20 males, 14 females and 2 juveniles of *Bothus robinsi*.

TABLE 13. PROPORTIONAL CHARACTERS, EXPRESSED IN THOUSANDTHS OF STANDARD LENGTH, OF 20 MALES, 14 FEMALES AND 2 JUVENILES OF *BOTHUS ROBINSI.*

Character	Males (20)		Females (14)		Juveniles (2)	
	Range	Mean	Range	Mean	Range	Mean
Standard length (mm)	73.5-136.6	108.8	89.9-141.3	109.3	50.8-52.7	51.8
Body depth	652-756	685	666-744	713	653-677	665
Caudal peduncle depth	099-118	109	103-119	109	102-110	106
Interorbital width	060-136	103	075-095	085	046-053	050

The tendency for larger individuals of a species to occupy greater depths has been ascribed to a number of factors, (e.g., see Gunter, 1945, 1950, 1961; Moe and Martin, 1965), but exceptions are common, and no single factor uniformly accounts for the tendency. In general, decreasing physiological plasticity of larger individuals is probably related to greater environmental stability in deeper waters.

It is difficult to account for the striking bathymetric restriction of *Bothus robinsi* to depths of 55 m or less. At Stations D and L (55 m) 163 specimens were collected during regular Hourglass sampling, while at Stations E and M (73 m), scarcely 35 km distant, only one specimen was taken. While extremes of temperature and salinity may play a part in excluding the species from shallow coastal waters (where it is likewise virtually absent), it is doubtful that these variables could exert so strong an influence in deeper waters where relatively stable oceanic conditions prevail. Rather, the exclusion of *B. robinsi* from our 73 m stations is probably related to differences in substrate and associated biota. Further speculation must await analyses of benthic communities at these depths.

Gut contents of 10 specimens from Hourglass (Sta. D) and FSBC collections were examined. The following items were found (number in parentheses indicates frequency of food items):

- Bryozoa (2)
- Brachiopoda (1)
- Echinodermata
    - Ophiuroidea (1) from 124 mm specimen
- Chaetognatha
    - *Sagitta* (1) from 140 mm specimen
- Mollusca
    - Scaphopoda
        - *Cadulus mayori* (5)
    - Gastropoda
        - *Tectonatica pusilla* (16)
        - *Psarostola minor* (2)
        - *Marginella aureocincta* (1)
        - *Parvoturbodes francesae* (1)
        - *Nassarius* sp. (2)
        - *Murex* sp. (1)

TABLE 14. NUMBERS AND SIZE RANGE (mm SL) OF *BOTHUS ROBINSI* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Bothus robinsi

STA	1965					1966													1967												TOT
	A	S	O	N	D	J	F	M	A	M	J	J	J sp	A	S	O	N	D	J	J sp	F	M	A	M	J	J	A	S	O	N	
A																															
B₁	2 82-93		2 97-102	2 85-105	1 91		2 42-73	1 55				5 46-74			1 49			3 51-94	1 69	1 65		1 75				2 24-66		1 72			25
B₂	1 82					1 105					2 45-49	1 74				2 107-120			1 32		1 66						2 69-104			5 99-140	16
C₁	2 126-145			3 125-128				5 80-108				1 126	2 118-120		1 118			6 70-118	1 73				1 115	1 122			1 122			9 116-150	33
C₂			4 97-140					5 94-130			5 93-125					7 51-131						3 112-142	1 107								25
D₁	3 127-136	1 116	2 122-132	7 110-131	5 110-137	2 101-126		30 53-143	1 133	1 125		12 112-132	2 128-130	3 120-138	6 118-138	7 108-136	5 115-132	7 109-132	6 115-134	2 127-138	4 125-139	4 115-130	2 120-122			3 118-128				7 106-125	122
D₂	1 131		9 112-133	15 106-137			9 115-131	9 113-125			7 112-131			8 113-128	3 115-125			4 109-135	4 111-131		5 116-124	1 116-134	1 131		2 121-124			2 110-133	2 127-134	5 103-130	87
E																															
I						1 68																									1
J		1 56		2 63-100	2 77-109	2 66-70	2 54-57					1 84										3 89-104						1 73	3 98-116	8 84-119	25
K		3 125-143	2 93-113	4 61-128		1 123		3 51-130	1 123		2 113-121	3 105-120	4 112-140		4 118-130	3 118-123	1 65			1 119	1 131			1 83				2 117-128	1 118	3 122-127	40
L	4 49-138			3 111-131	5 111-134	2 115-122	3 118-126	2 123-127	3 116-135	1 118	1 222	5 122-126	4 110-123	1 124				1 126	1 136		3 133-135			1 131						1 126	41
M																			1 51												1
TOT	13	5	19	36	13	9	16	55	5	2	17	28	12	12	15	19	6	21	15	4	14	12	5	3	2	5	3	6	6	38	416

        Turridae (4)
        Eulimidae
    Bivalvia
        Cyclopecten nana (1)
        Laevicardium pictum (1)
        Tellina sybaritica (1)
        Poromya rostrata (1)
        Nuculana sp. (5)
        Unidentified bivalves and shell remains
Annelida
    Polychaeta (5) from 3 specimens
    Polychaeta tube (1)
Crustacea
    Isopoda (1)
    Amphipoda (2)
    Decapoda
        Caridea: *Leptochela* (1)
        Penaeidae (2)
        Brachyura: Majidae (1)
        Anomura
            Galatheidae: *Munida* sp. (approx. 40)
            Paguridae (9)
        Unidentified crustacean remains
Pisces: clupeoid fish remains, 24 mm, in gut of 140 mm specimen

Nearly all mollusks listed above were removed from the gut of a single 126 mm specimen. Only two others contained mollusks as food items, these in insignificant quantities. Some of the gastropod shells may have been harboring pagurid crabs. Fishes are probably an infrequent inclusion in the diet of *Bothus robinsi*, judging from the latter's small, weakly dentate jaws. The presence of *Sagitta* and the semi-pelagic caridean shrimp, *Leptachela*, suggests that *B. robinsi* may make occasional feeding excursions off the bottom.

Cursory examination of stomach contents of 378 additional specimens shows that crustaceans, polychaetes and mollusks make up the bulk of the diet. A similar diet was reported by Jutare (1962:37) for 27 adults of *Bothus* (presumably *B. ocellatus*). Most feeding occurs during the day, with 108 of 127 stomachs (85.3%) from day samples containing food as compared with only 53 of 251 stomachs (21.1%) for night samples. Starck and Davis (1966:344), in their studies of night habits of reef fishes, observed *B. ocellatus* "resting, uncovered, on the sand."

Length frequency analyses demonstrate virtually no change in monthly modal sizes, indicating either an extended breeding season or a variable growth rate. About sixty percent of the catch ranged from 110 to 130 mm (Figure 23). Scarcity of 50-110 mm fish suggests that stocks were not uniformly sampled by our gear; possible explanations include:

1. Recruitment from shallower or deeper areas, such as has been demonstrated by Powles and Kohler (1970:2060) for the witch flounder, *Glyptocephalus cynoglossus*. However, only one Hourglass specimen was taken on either side of the 18-55 m range. Moreover, *Bothus robinsi* has not been reported from contiguous inshore areas (Tampa Bay: Springer and Woodburn, 1960; Caloosahatchee Estuary: Gunter and Hall, 1965), nor from depths greater than 50 fm (92 m) (Gutherz, 1967:40).

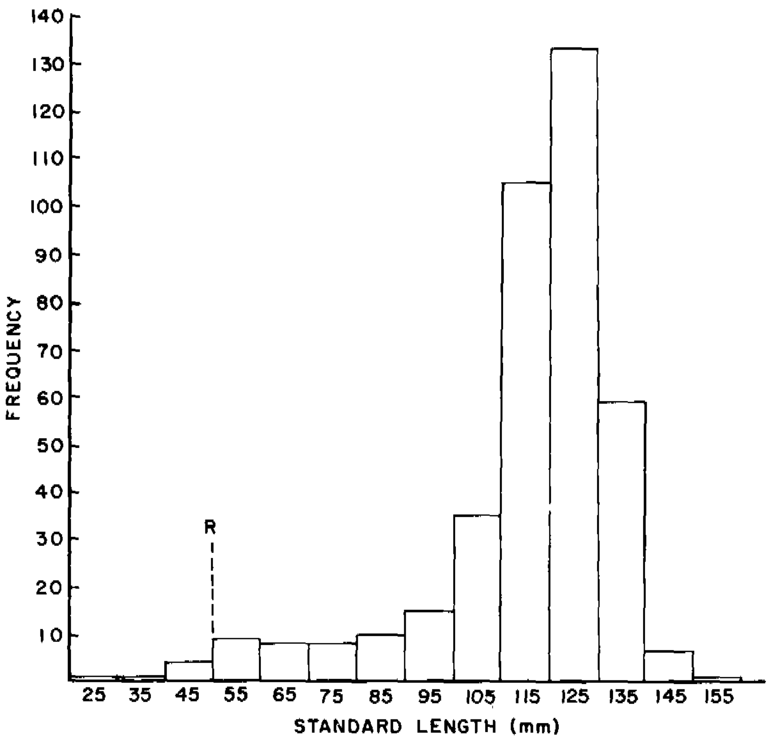

Figure 23. Length frequency distribution of *Bothus robinsi* taken during Hourglass collecting. R = probable size at recruitment.

2. Recruitment from epipelagic waters. Kyle's (1913:112) inference of pelagic stocks of oceanic bothids leads to the possibility that adult bottom stocks of *Bothus robinsi* in the area of Hourglass sampling may be recruited at least in part from pelagic stocks.

3. Ontogenetic behavioral differences. Juveniles or small adults, if foraging well above the bottom or if buried in the substrate, may be less vulnerable than large adults to trawling gear.

4. Microdifferences in habitat. Habitat differences within the demonstrated bathymetric range of *B. robinsi* may result in clumping of smaller individuals outside sampled areas.

The above explanations for the observed size frequencies (Figure 23) presuppose a constant growth rate in which the relationship between age and fish length is linear. An alternate explanation for the shape of the catch curve is based on the possibility that linear growth of larger fish may decrease at a moderate rate, while the corresponding mortality rate is small and fairly steady. Ricker (1958:72, Fig. 2.11) has constructed a model using these assumptions, to show that the number of fish at certain intermediate sizes in the catch theoretically exceed the number of smaller sizes nearby. Hart (1932:Fig. 4) demonstrated this phenomenon for actual populations of whitefish, *Coregonus clupeaformis*, in Ontario. However, without a good picture of the age structure of our populations of *Bothus robinsi*, this possibility remains highly tenuous.

Maturation and Spawning. Macroscopic examination of gonads in Hourglass and FSBC collections of *Bothus robinsi* suggest an extended summer and fall breeding season, with ripe females occurring in collections from June to November. Jutare (1962:43) postulated an "unrestricted kind of spawning" for *Bothus*, based on presence of females with ovaries in various stages of development, different types of eggs in ripe ovaries, and larvae of all sizes in the plankton at all times of the year.

Importance. Although *Bothus robinsi* is plentiful along Florida's west coast, it seldom exceeds 150 mm SL, and cannot be regarded as a potentially important commercial species.

FAMILY SOLEIDAE

The family Soleidae is represented by six species in the western North Atlantic. Of the four known from the Florida Shelf, *Gymnachirus texae* and *Trinectes maculatus* were not taken during Hourglass sampling. The latter is widespread and abundant but almost exclusively confined to shallow coastal and estuarine waters. Recent literature and pertinent comments on this species are included in this account.

Gymnachirus texae is known on the Florida Shelf from a single record off Cape San Blas. It apparently replaces *G. melas* in the northern and western Gulf. *G. nudus* is known from the Yucatan Shelf and the Caribbean; *Trinectes inscriptus* is known from the Florida Keys and Greater Antilles.

In separating the species of *Gymnachirus*, the following criteria defined by Dawson (1964:647) are included:

Number of stripes: Total number of primary and secondary stripes, or portions thereof, terminating or originating at dorsal margin on right side, from tip of snout to caudal extremity, inclusively. In occasional specimens having a complete peripheral stripe along dorsal and anal margins, this count is modified to include those stripes reaching or approximating this marginal band.

Number of accessory sensory lines: Number of accessory sensory lines crossing right lateral line between pectoral base and base of caudal fin.

KEY TO THE SOLES (SOLEIDAE) KNOWN TO OCCUR ON THE FLORIDA SHELF

1. Scales present; gill openings confluent below; eyed side of adults mottled or patterned, but not striped with prominent vertical bands 2

1. Scales absent; gill openings reduced to small slits; eyed side of adults striped with prominent vertical bands 3

2. Pectoral fins absent; interbranchial septum entire, not pierced by a foramen (Figure 24a) . . . . *Trinectes maculatus*

2. Right pectoral fin present; interbranchial septum pierced by a foramen (Figure 24b) . . . . *Achirus lineatus* (Figure 26)

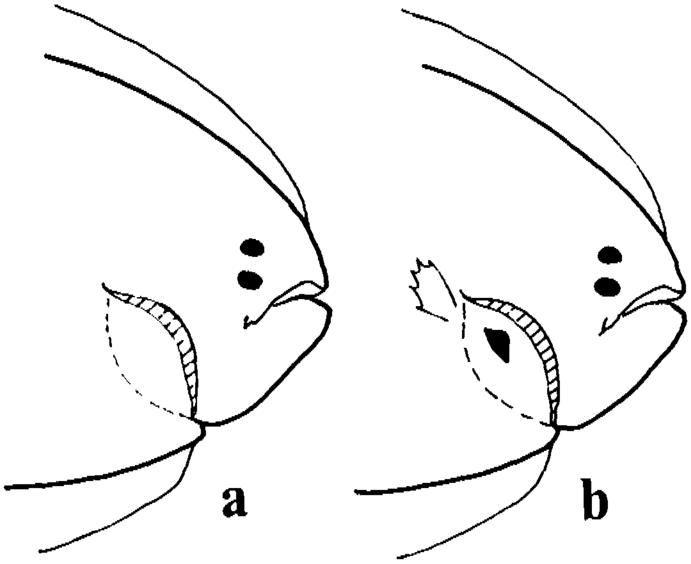

Figure 24. Exposed view of opercular region, gill arches excised, of a) *Trinectes maculatus* (interbranchial foramen absent) and b) *Achirus lineatus* (interbranchial foramen present).

3. Adults normally with long (to 6.0 mm) dermal cirri on interspaces or stripe-interface margins; accessory sensory lines of right side 5-9; primary stripes 25-49; caudal stripes normally interrupted; dorsal rays 57-66; anal rays 41-48 . . . . *Gymnachirus texae* (Figure 25)

3. Adults lacking dermal cirri, or with short (less than 2.0 mm) cirri on interspaces or stripe-interface margins; accessory sensory lines of right side 7-10; primary stripes 15-32; caudal stripes normally complete; dorsal rays 62-70; anal rays 44-52 . . . . *Gymnachirus melas* (Figure 27)

Achirus Lacépède

Achirus Lacépède, 1803:658 (type, *Pleuronectes achirus* Linnaeus).

Achirus closely resembles *Trinectes* in having well developed gill openings meeting below (in contrast to the small slits of *Gymnachirus*), well developed ctenoid scales, and fringes on the blind side of the head. *Achirus* differs from *Trinectes* in retaining a pectoral fin on the right side, and in having an unperforated interbranchial septum.

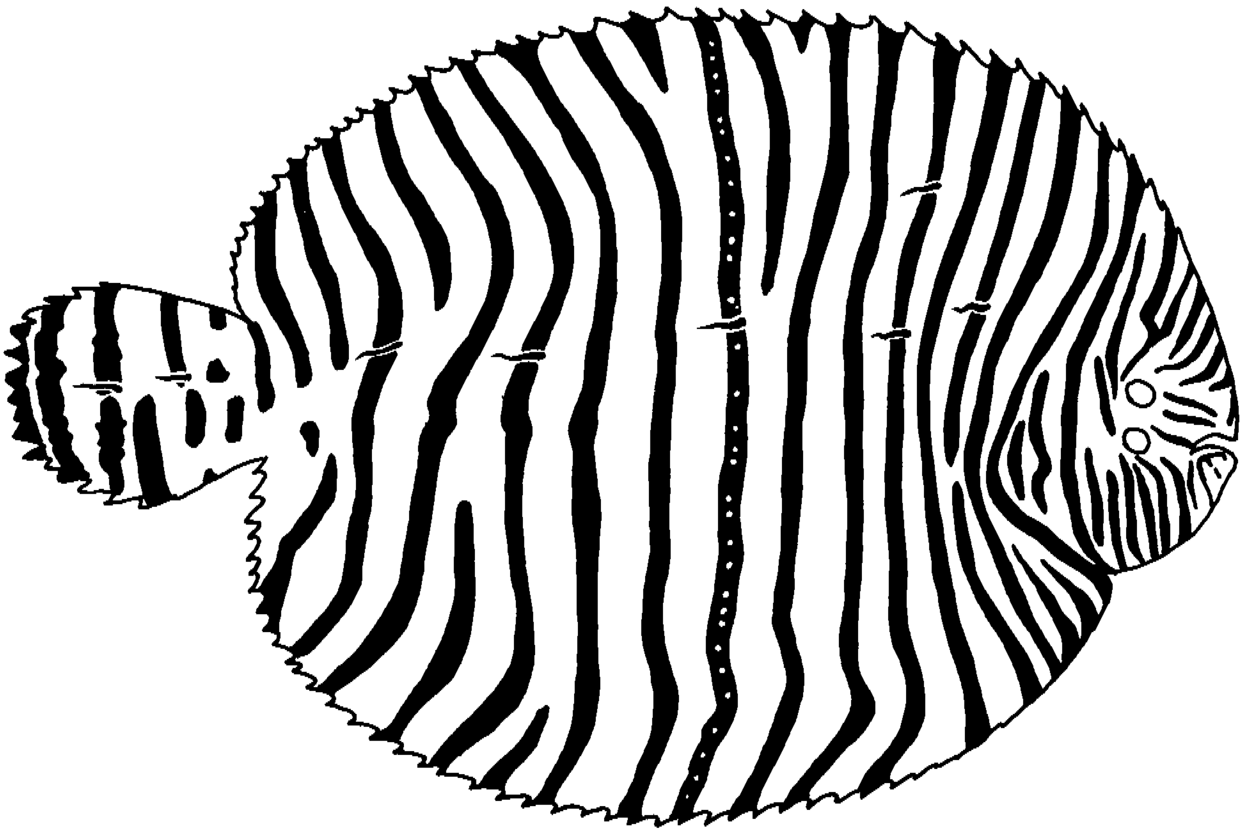

Figure 25. *Gymnachirus texae* Gunter, redrawn in part from Dawson (1964:Fig. 5); details from a 42 mm SL specimen (FSBC 6336) collected south of Grand Isle, Louisiana. Pore arrangement shown on third accessory line only.

Achirus lineatus Linnaeus

Lined sole, Figure 26

Pleuronectes lineatus Linnaeus, 1758:268 (Jamaica).

Achirus lineatus Jordan and Goss, 1889:309, 312 (synonymy, descr.); Nichols, 1930:390, Fig. 304 (diagn., descr., habits, Puerto Rico); Gunter, 1938:341 (Barataria Bay, La.); Gunter, 1945:88 (Texas localities); Baughman, 1950:137 (Texas records); Behre, 1950:43 (Grand Isle, La.); Simmons, 1951a:4; 1951b:6 (Cedar Bayou Pass, Texas); Hildebrand, 1954:296 (off St. Joseph and Matagorda Islands, Texas); Reid, 1954:67 (ecology, Cedar Key, Fla.); Hildebrand, 1955:204 (Campeche Bank); Kilby, 1955:231 (Cedar Key and Bayport, Fla.); Reid, 1955:448 (East Bay, Texas); Hutton *et al.*, 1956:60 (Boca Ciega Bay, Fla.); Joseph and Yerger, 1956:129 (Alligator Harbor, Fla.); Menzel, 1956:97 (St. George Sound, Fla.); Reid, 1956:317 (East Bay, Texas); Boschung, 1957:204 (synonymy, distrib., Ala.); Woodburn *et al.*, 1957:21, 24 (Tampa Bay and Anclote Key, Fla.); Briggs, 1958:297 (listed, Fla.); Hoese, 1958:346 (listed, Texas); Caldwell *et al.*, 1959:18 (Tortuguero, Costa Rica); Day, 1959:6 (Matagorda Bay, Texas); Duarte-Bello, 1959:131 (Cienfuegos, Cuba); Renfro, 1959:27 (Galveston and Trinity Bays, Texas); Springer, 1960:24 (Lower St. Lucie and Indian Rivers, Fla.); Springer and Woodburn, 1960:86 (Tampa Bay, Fla.); Tabb and Manning, 1961:639 (n. Fla. Bay); Pullen, 1962:13 (Upper Galveston Bay, Texas); Schultz, 1962a:14 (Mesquite Bay and Cedar Bayou, Texas); 1962b:10 (Aransas and Copano Bays, Texas); Springer and McErlean, 1962:42 (Matecumbe Key, Fla.); Tabb *et al.*, 1962:51, 61 (Coot Bay and Coot Bay Pond, Fla. Bay); Gunter and Hall, 1963:282 (St. Lucie Estuary, Fla.); Compton and

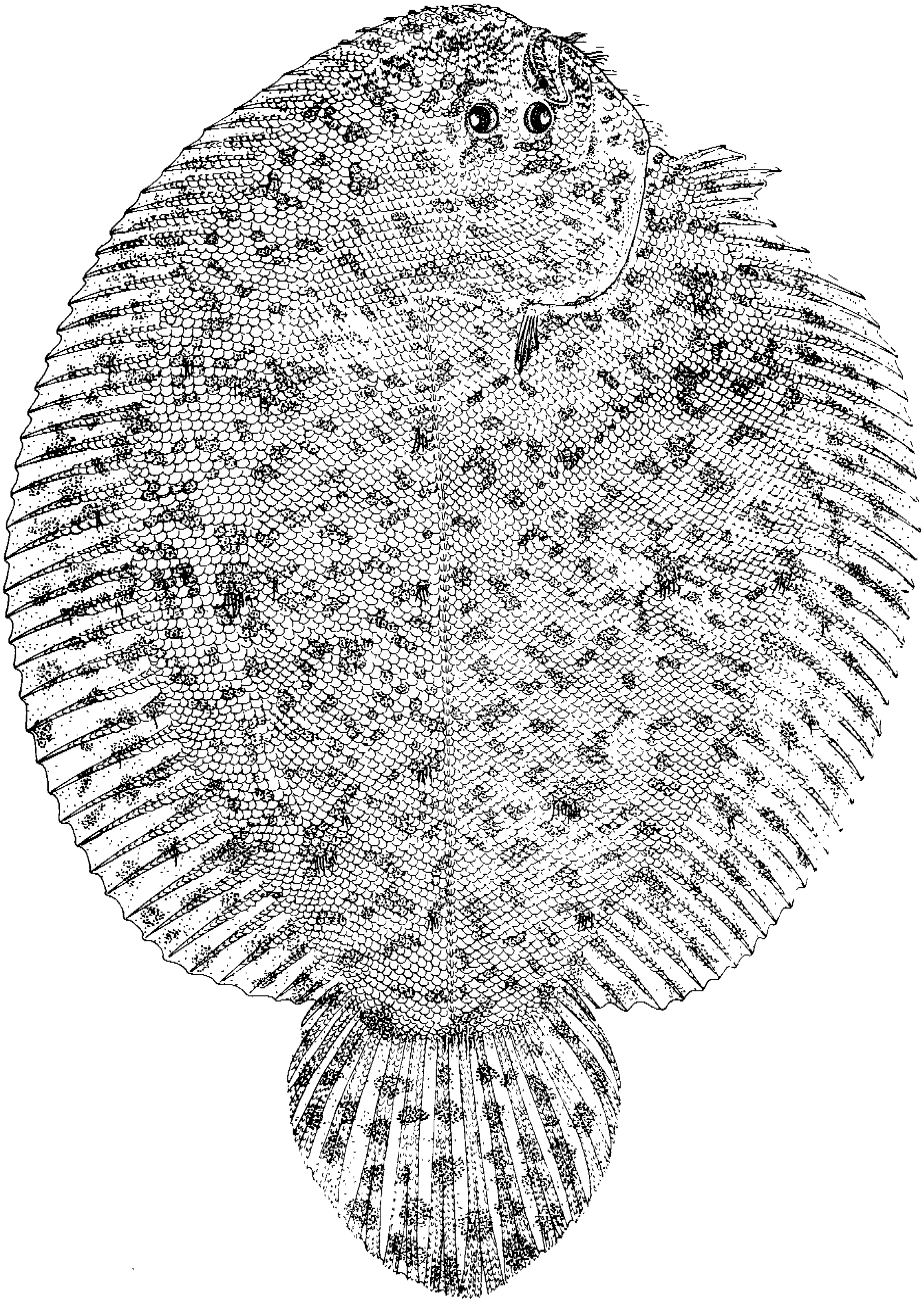

Figure 26. *Achirus lineatus* Linnaeus, FSBC 5333, 92 mm SL, Hourglass Sta. A.

Bradley, 1964:421 (off Port Aransas, Texas); Rounsefell, 1964:386 (Miss. R.–Gulf Outlet Channel); Vick, 1964:64 (St. Andrews Bay, Fla.); Christensen, 1965:224 (Jupiter Inlet and Loxahatchee R., Fla.); Compton, 1965:Tables 1, 2 (off Port Aransas, Port Mansfield and Port Isabel, Texas); Dawson, 1965:279 (length-weight relationships, Miss. and La. coasts); Gunter and Hall, 1965:47 (Caloosahatchee Estuary, Fla.); Hoese, 1965:60 (Port Aransas, Texas); Miller, 1965:101 (Port Aransas, Texas); Moe and Martin, 1965:137 (off Tampa Bay, Fla.); Parker, 1965:217 (listed, Texas); Roithmayr, 1965:22 (Gulf of Mex. industrial fishery); Burleigh, 1966:28 (Lake Borgne, La.); Caldwell, 1966:83 (Jamaica); Cervigon, 1966:809 (Venezuela); Compton, 1966 (off Port Aransas, Texas); Tagatz, 1967:47 (St. Johns R., Fla.); Voss, 1967:68 (Carib. coast of Panama); Copeland and Fruh, 1970:App. Table 1 (Galveston Bay, Texas); de Sylva, 1970:61 (Biscayne Bay, Fla.); Futch, 1970 (larval and juvenile ecology, Tampa Bay, Fla.); Houde *et al.*, 1970 (early development, Biscayne and Tampa Bays, Fla.); Hudson *et al.*, 1970:12 (Fla. Bay); Roessler, 1970:966, 885 (Everglades Nat. Park); Humm *et al.*, 1971:132 (Anclote R. and anchorage, Fla.); Cooley, in press (Santa Rosa Sound, Little Sabine Bay, Fla.); Futch *et al.*, in press (osteology).

Achirus lineatus occurs in the western Atlantic from Florida to Uruguay, and is reportedly common throughout most of its range. It is seldom found in salinities lower than 15‰, while the closely related *Trinectes maculatus* commonly occurs in brackish or fresh waters. In published reports, relative abundance of the two at Gulf of Mexico localities therefore varies according to the salinities of the study areas. For example, Springer and Woodburn (1960:86) sampled Tampa Bay stations at salinities usually exceeding 15‰ and collected 91 *A. lineatus* and 5 *T. maculatus*, while Gunter and Hall (1965:47) sampled less saline areas in the Caloosahatchee Estuary and collected 413 *T. maculatus* and only one *A. lineatus.*

Thirteen specimens of *Achirus lineatus* were collected during Hourglass sampling, as follows:

Sta. A, 3 Aug. 1965, 71 mm, box dredge
8 Nov. 1965, 95 mm, box dredge
3 Mar. 1966, 70 mm, box dredge
6 Apr. 1966, 71 mm, trynet
2 July 1966, (2) 75-92 mm, box dredge
Sta. I, 6 Aug. 1965, 73 mm, box dredge
14 Feb. 1966, 76 mm, box dredge
11 Apr. 1966, 68 mm, box dredge
5 July 1966, (2) 81-83 mm, box dredge
12 Nov. 1966, 88 mm, box dredge
15 May 1967, 77 mm, box dredge

All but one specimen were taken by box dredge, indicating that the species spends a substantial part of its time buried in the substrate. However, we have observed Tampa Bay specimens floating, leaflike, on the surface, a posture also reported by Nichols (1930:390). Stomachs of all dredge-caught specimens were empty; the lower gut of one specimen contained shell fragments and crustacean parts.

Specimens collected in April, July and November had gonads in late stages of ripening. Egg diameters in aliquots removed from mid-length of left ovaries were as follows:

Collection date	SL (mm)	No. of eggs examined	Range (mm)	Mean (mm)
8 November 1965	85	184	0.2-0.5	0.35
11 April 1966	78	90	0.2-0.6	0.43
5 July 1966	81	153	0.2-0.5	0.31

Occurrence of ripe or ripening females from April to November agrees with the occurrence of larvae from May through November in Tampa Bay (Futch, 1970:1). Spawning of *A. lineatus*, according to Futch (1970:1), occurs in Tampa Bay from April to November, when day length exceeds 12 hours and water temperatures exceed 20°C.

Trinectes Rafinesque

Trinectes Rafinesque, 1832:142 (type, *Pleuronectes achirus* Linnaeus); Hubbs, 1932 (generic nomenclature).

Trinectes maculatus (Bloch and Schneider)

Hogchoker

Dovel, Mihursky and McErlean (1969) have listed most of the important recent contributions to the life history of *Trinectes maculatus*. These are omitted from the following compilation.

Pleuronecte maculatus Bloch and Schneider, 1801:157.

Trinectes maculatus Hubbs, 1932 (nomenclature); Chabanaud, 1935:16 (synonymy); Bailey *et al.*, 1954:146 (Escambia R., Fla.); Joseph and Yerger, 1956:128 (Alligator Harbor, Fla.); Menzel, 1956:97 (St. George Sound, Fla.); Springer and Bullis, 1956:65 (Gulf of Mex. localities); Woodburn *et al.*, 1959:24 (Anclote Key, Fla.); Gunter and Shell, 1958:16, 19, 23, Tables 2, 5 (Grand Lake and White Lake, La.); Hoese, 1958:345 (Texas); Hoese, 1959:4 (lower Galveston, East and West Bays, Texas); Christmas *et al.*, 1960:7 (Miss. purse seine fishery); Springer, 1960:27 (lower St. Lucie and Indian Rivers, Fla.); Tabb and Manning, 1961:640 (n. Fla. Bay); Tagatz and Dudley, 1961:11 (Beaufort, N. Car.); Dawson, 1962a:89 (length-weight relationships, S. Car.); 1962b (teratology); de Sylva *et al.*, 1962:44 (Delaware R. Estuary); Tabb *et al.*, 1962:51 (Coot Bay and Coot Bay Pond, Fla. Bay); Gunter and Hall, 1963:282 (St. Lucie Estuary, Fla.); Anderson, 1964:50 (S. Car. coastal streams); Rounsefell, 1964:386 (Miss. R. Gulf Outlet Channel); Anderson and Gehringer, 1965:23 (Cape Canaveral area, Fla.); Bullis and Thompson, 1965:34 (Gulf of Mex. and other localities); Dawson, 1965:279 (length-weight relationships, Miss. and La. coasts); Gunter and Hall, 1965:47 (Caloosahatchee Estuary, Fla.); Hoese, 1965:59 (Port Aransas, Texas); Roessler, 1965:314 (Biscayne Bay, Fla.); Roithmayr, 1965:22 (Gulf of Mex. industrial fishery); Burleigh, 1966:28 (Lake Borgne, La.); Norden, 1966:128, 131 (Vermillion Bay, La.); Zilberberg, 1966:129 (nw. Fla. marsh); Dawson, 1967b (teratology); Tagatz, 1967:48 (St. Johns R., Fla.); Anderson, 1968:28 (s. Atlant. coast of U.S.); Fox and Mock 1968:47, 52 (Barataria Bay, La.); Jorgensen and Miller, 1968:9 (length-weight relationships, Ga.); Clark *et al.*, 1969:60 (New Jersey); Dawson, 1969a:106 (color); Dovel *et al.*, 1969 (life hist., Patuxent R. Estuary, Md.); Duke and Rudolph, 1969:133 (Carib. coast of Panama); Struhsaker, 1969:298, App. B (se. U.S.); Copeland and Fruh, 1970:App. Table 1 (Galveston Bay, Texas); Dahlberg and Odum, 1970:387 (season, Ga. estuaries); de Sylva, 1970:61 (Biscayne Bay, Fla.); Richards and Castagna, 1970:247 (e. shore of Va.); Roessler, 1970:866, 885 (Everglades Nat. Park); Grimes, 1971: App. II and III (Crystal R., Fla.); Cooley, in press (w. Fla. localities).

Achirus fasciatus Hubbs, 1932 (synonym of *Trinectes maculatus*); Gunter *et al.*, 1948:314 (red tide mortality, Fla. w. coast); Baughman, 1950:137 (Texas records); Gunter, 1950:301, Table 1 (Chesapeake Bay and Texas coast); Miles, 1951:20 (Apalachicola Bay, Fla.); Pearse and Williams, 1951:146 (N. Car. and S. Car. reefs); Hildebrand, 1954:295 (w. Gulf of Mex. localities); Springer and Bullis, 1956:65 (Gulf of Mex. localities); Boschung, 1957:207 (diagn., descr., synonymy, Mobile Bay, Ala., and Miss. Sound); Duarte-Bello, 1959:131 (listed, Cuba); Bullis and Thompson, 1965:34 (Gulf of Mex. and other localities); Voss, 1967:68 (Carib. coast of Panama); Duke and Rudolph, 1969:28 (fresh waters of Panama).

Trinectes maculatus fasciatus Hubbs and Allen, 1943:128 (Silver Springs, Fla.); Reid, 1954:66 (Cedar Key, Fla.); Kilby, 1955:231 (Cedar Key, Fla.); Simmons, 1957:188 (Laguna Madre, Texas); Briggs, 1958:297 (listed, Fla.); Darnell, 1958:406 (Lake Pontchartrain, La.); Hoese and Berglund, 1958:55 (color, Texas); Caldwell *et al.*, 1959:18 (Tortuguero, Costa Rica); Springer and Woodburn, 1960:87 (Tampa Bay, Fla.).

Trinectes maculatus browni Schultz, 1949:191 (Venezuela); Cervigon, 1966:831 (Venezuela).

Hubbs (1932) treated generic and specific nomenclature of the hogchoker, *Trinectes maculatus*, and demonstrated that this name should stand rather than *Achirus fasciatus* Lacépède.

Both names, however, continue to appear in current literature. Hubbs and Allen (1943:128) distinguished a southern (Gulf of Mexico) subspecies, *T. m. fasciatus* (called *T. m. browni* by some authors) from the northern *T. m. maculatus*, based on the conspicuous spotting on the blind side of the southern form.

Trinectes maculatus is typically restricted to shallow inshore waters throughout its range. Gunter and Hall (1965:47), for example, collected 413 specimens in the Caloosahatchee Estuary, and only eight outside the estuary. Similarly, it is fairly common in Tampa Bay, but has not been reported from outside the bay proper.

A maximum depth of 28-33 fm (51-60 m) has been reported for *T. maculatus* off the Mississippi Delta (Bullis and Thompson 1965:34). Reports of the species from the edge of the Bahama Bank in 125 fm (229 m) (R/V *Oregon* Stations 2467, 2470 and 2480–Bullis and Thompson, 1965:34) are probably in error.

Judging from widespread reports, spawning season of *T. maculatus* is protracted over several months, with peak activity in Gulf of Mexico populations in late spring and summer. Gunter and Hall (1965:47) encountered specimens less than 30 mm in January, February and September; Hoese (1965:59) found larvae in May, June and July in Texas; Reid (1954:66) found "nearly ripe" gonads in a 120 mm specimen in January at Cedar Key. In the St. Johns River, Tagatz (1967:48) collected specimens less than 30 mm during every month except May.

Gymnachirus Kaup

Gymnachirus Kaup, 1858:101 (type, *Gymnachirus nudus* Kaup); Dawson, 1964 (revision of w. Atlantic species).

Gymnachirus, as diagnosed by Dawson (1964:648), is a genus of scaleless dextral soles, adults vertically striped on the eyed side with light tan to nearly black bands. Dawson recognized three species, *G. texae, G. melas* and *G. nudus*, based on differences in morphology, right-side color and ornamentation, and geographical distribution. Only one, *G. melas*, is represented in Hourglass collections.

Gymnachirus melas Nichols

Naked sole, Figure 27

Descriptive and distributional literature has been compiled by Dawson (1964:657). The following references are furnished primarily to update his list:

Gymnachirus melas Nichols, 1916:71, figure (Cape Lookout, N. Car.); Bearden, 1961:11 (listed, S. Car.); Dawson, 1964 (synonymy, diagn., descr., habitat, range); Dawson, 1967a:679 (egg number and size); Struhsaker, 1969:298 (se. U.S.); Bayer *et al.*, 1970:A68 (sw. Carib.); Cooley, in press (Santa Rosa Sound, Fla.).

Gymnachirus williamsoni Bullis and Thompson, 1965:34 (Tortugas, Fla.).

Meristic and morphometric data, tabulated according to Dawson's (1964:Table 3) scheme, is listed in Table 15 for 10 specimens in Hourglass and FSBC collections from southwestern Florida. Table 16 summarizes dorsal and anal fin ray counts of 31 specimens from this area; all but one count fall within the ranges of Dawson's counts for 93 specimens. Identity of our material was very kindly confirmed by Professor Dawson.

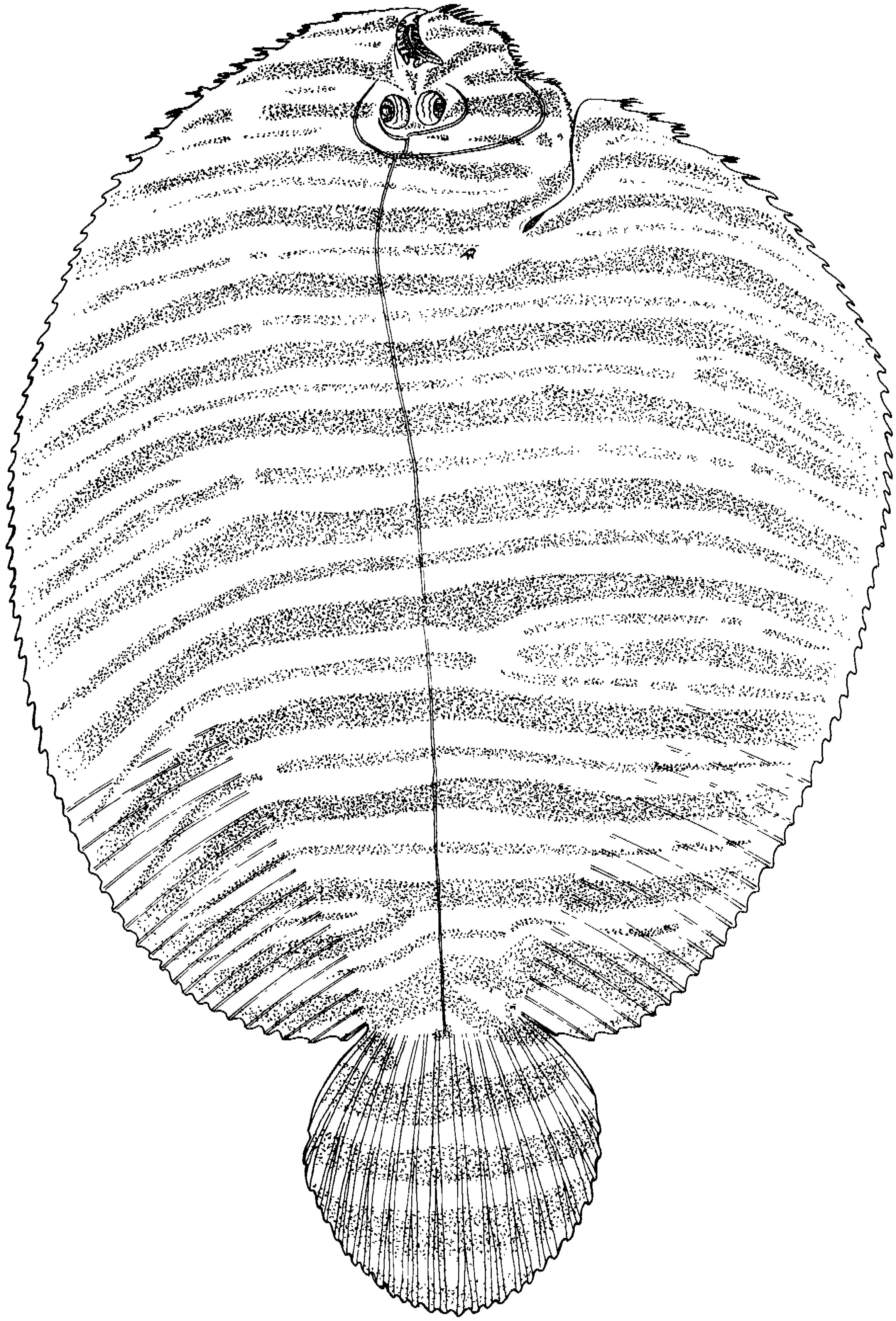

Figure 27. *Gymnachirus melas* Nichols, FSBC 5124, 138 mm SL, Hourglass Sta. E.

TABLE 15. MERISTIC AND MORPHOMETRIC DATA FOR 10 SPECIMENS OF *GYMNACHIRUS MELAS* FROM SOUTHWESTERN FLORIDA (HOURGLASS AND FSBC COLLECTIONS).

Character	Range	Mean
Number of accessory sensory lines	7-10	8.5
Number of pores in third accessory sensory line	32-61	42.0
Number of stripes plus partial stripes originating on dorsal margin	16-33	24.2
Stripe width, mm	1.26-3.24	1.94
Interspace width, mm	1.04-2.22	1.80
Stripe: interspace ratio	0.72-1.32	0.96

TABLE 16. DORSAL AND ANAL FIN RAY COUNTS OF 31 SPECIMENS OF *GYMNACHIRUS MELAS* FROM SOUTHWESTERN FLORIDA (HOURGLASS AND FSBC COLLECTIONS).

	Anal rays							
Dorsal rays	45	46	47	48	49	50	51	Total dorsals
60		1						1
61		1						1
62		2	1					3
63	2	1	1	1	1			6
64			4					4
65		1	1	1				3
66		1	3		1			5
67	1				1	1		3
68		1		1				2
69					1	1		2
70								0
71							1	1
Total anals	3	8	10	3	4	2	1	31

Sixteen specimens (54-147 mm) were taken in 13 collections during Hourglass sampling, as follows:

Sta. E,	3 Mar. 1967,	138 mm, box dredge
	12 May 1967,	130 mm, box dredge
	2 July 1967,	119 mm, box dredge
Sta. J,	12 Nov. 1965,	74 mm, box dredge
	6 Dec. 1965,	100 mm, trynet
Sta. K,	4 Sep. 1965,	143 mm, trynet
Sta. L,	7 Dec. 1965,	145 mm, trynet
	13 June 1966,	(2) 101-120 mm, box dredge
	6 July 1966,	(3) 133-147 mm, box dredge
	16 May 1967,	132 mm, box dredge
Sta. M,	12 May 1966,	102 mm, box dredge
	13 Jan. 1967,	54 mm, trynet
	15 Nov. 1967,	124 mm, box dredge

Bottom temperatures for Hourglass collections of *Gymnachirus melas* ranged from 19.0 to 29.0°; bottom salinities from 35.14 to 36.45‰. On the northern Hourglass transect *G. melas* was taken only at Sta. E; it is taken regularly, however, by bait shrimp trawlers during the summer on the shallow shelf (<6 m) north of Tampa Bay. Trends in diurnality, seasonality or annuality are not evident from Hourglass data.

Dawson's (1964:661) observation that *Gymnachirus melas* may be taken more frequently by dredge than by trawl is supported by Hourglass collections, in which 12 of the 16 specimens were found in dredge samples, pointing to a habit of burying in the substrate.

Stomachs of five specimens were examined. Ingested items included poriferans, bivalve mollusks, onuphid polychaetes, ostracods, amphipods, cumaceans, brachyurans, stomatopods and lancelets. Small crustaceans were dominant.

Gonads of 43 specimens from Hourglass and FSBC collections were examined. Ripe females were present in May and females with active gonads were found until October, indicating a spawning season from May to about November. Presence in our collections of 32-85 mm specimens in March and 45-64 mm specimens in September supports gonadal evidence that the species spawns over an extended period. Based on our material, *Gymnachirus melas* reaches maturity at about 80-100 mm. Dawson (1964:660) reported that most specimens of *G. melas* mature during February, March and April, with smallest specimens occurring in June and July.

Fecundity of a 116 mm specimen (no collection data) was estimated at 15,500 eggs (4200 eggs in left ovary, 11,300 in right). Ovaries were judged to be in an active stage of ripening; diameters of 250 eggs from the right ovary ranged from 0.2 to 0.9 mm, with a mode of 59 eggs at 0.4 mm.

FAMILY CYNOGLOSSIDAE

The family Cynoglossidae is represented in the western Atlantic by a single genus, *Symphurus*, containing some eighteen structurally similar species. Nine (possibly 10) occur in the Gulf of Mexico.

Western Atlantic species of *Symphurus* were thoroughly reviewed by Ginsburg (1951:185), who described six new species in his account. More recently, Böhlke (1961) described two new Bahaman species, *S. ommaspilus* and *S. rhytisma*, and Robins and Randall (1965) described a dwarf species, *S. arawak*, from peripheral areas of the Caribbean.

The following key considers those six species of *Symphurus* known from verified records to occur on the Florida Shelf. Five were taken during Hourglass collecting. The sixth, *S. civitatus*, occurs primarily in the northern Gulf from Alabama to Texas, being known on the Florida Shelf from a single record at St. Joseph Bay (Ginsburg, 1951:198).

KEY TO THE SPECIES OF *SYMPHURUS* KNOWN TO OCCUR ON THE FLORIDA SHELF

1. Dorsal, anal or caudal fins marked with one or more prominent spots 2

1. Dorsal, anal and caudal fins lacking prominent spots 3

2. Posterior one-third of dorsal and anal fins with one to five prominent dark spots (Figure 28); caudal fin without a spot; dorsal rays 88 or more; anal rays 72 or more; caudal rays typically 10 . . . . *Symphurus diomedianus* (Figure 29)

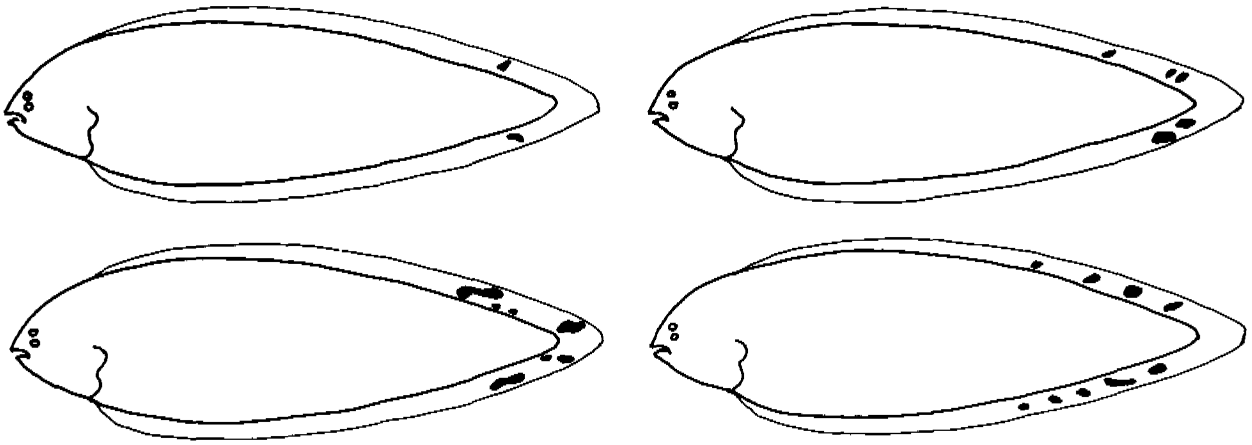

Figure 28. Polymorphism in *Symphurus diomedianus*, showing four variations in spotting of dorsal and anal fins.

2. Posterior half of caudal fin with a prominent black spot; dorsal and anal fins without prominent spots; dorsal rays fewer than 88; anal rays fewer than 72; caudal rays typically 11 . . . . *Symphurus urospilus* (Figure 33)

3. Dorsal rays 85 or fewer; anal rays 68 or fewer; maximum size not exceeding 80 mm SL . . . 4

3. Dorsal rays 85 or more; anal rays 69 or more; maximum size exceeding 80 mm SL 5

4. Dorsal rays 76 or fewer; anal rays 63 or fewer . . . . *Symphurus minor* (Figure 30)

4. Dorsal rays 77 or more; anal rays 63 or more . . . . *Symphurus parvus* (Figure 31)

5. Caudal rays typically 12; operculum without a black spot; living at depths of 4 fm (7 m) or more . . . . *Symphurus civitatus*

5. Caudal rays typically 10; operculum usually bearing a black spot; usually found in depths of less than 4 fm (7 m) . . . . *Symphurus plagiusa* (Figure 32)

Symphurus Rafinesque

Symphurus Rafinesque, 1810:52 (type, *Symphurus nigrescens* Raf., by subsequent designation); Jordan and Goss, 1889:321 (*Symphurus nigrescens* Raf. designated as type species); Ginsburg, 1951:185 (review of western Atlantic species).

Symphurus diomedianus (Goode and Bean)

Spottedfin tonguefish, Figure 29

Aphoristia diomediana Goode and Bean, 1886:589 (type, off Tortugas, Fla.).

Symphurus diomedianus Jordan and Evermann, 1898:2711 (off Tortugas, Fla.); Longley and Hildebrand, 1941:49 (Tortugas, Fla.); Ginsburg, 1951:194, Fig. F (synonymy, descr.); Springer and Bullis, 1956:65 (Gulf of Mex. localities); Briggs, 1958:297 (listed, Fla.); Hoese, 1958:346 (listed, Texas); Duarte-Bello, 1959:65 (listed, Cuba); Bullis and Thompson, 1965:34 (N. Car. and Fla. localities); Moe and Martin, 1965:149 (off Tampa Bay, Fla.); Caldwell, 1966:84 (Jamaica); Cervigon, 1966:817 (Venezuela); Struhsaker, 1969:298, App. B (se. U.S.).

Symphurus diomedianus is the largest, most abundant and most distinctive tonguefish in Hourglass collections. It is easily recognized, even when preserved for long periods, by the one or more prominent spots near the posterior end of both dorsal and anal fins (Figure 28).

It is probably the most widely distributed western Atlantic tonguefish, occurring from North Carolina to Brazil. In the Gulf of Mexico it has been reported from the Tortugas around to southern Texas, and on the Yucatan Shelf. It is by far the most common tonguefish between 20-40 fm (37-73 m) on the southern Florida Shelf, probably rivaling *Symphurus plagiusa* in overall abundance. It is ranked "very common" (present in more than 50% of trawl stations) on the open shelf and shelf edge of the southeastern United States (Struhsaker, 1969:298, App. B).

Occurrence in Hourglass Collections. During Hourglass sampling 148 specimens of *Symphurus diomedianus* were taken in 78 collections (Table 17). Seventeen specimens (11.5%) were collected by box dredge, 99 (66.9%) by 20 ft trynet, and 32 (21.6%) during supplementary sampling in July 1966 and January 1967 by 45 ft balloon trawl. An average of 16 specimens per cruise were taken by balloon trawl, as compared to an average of four per cruise (exclusive of Post-cruises) using the trynet.

Most specimens of *Symphurus diomedianus* were measured in total length when curated. A sample of 42 specimens (120-185 mm TL) was later used to estimate a conversion factor of 0.916 for total to standard length. This relationship appears linear for the sample. Using this value, Hourglass specimens ranged from 48-174 mm SL, with all but one specimen exceeding 100 mm. Maximum reported size is 207 mm SL, from "the coast of North Carolina" (Ginsburg, 1951:195).

Ecology. Hourglass specimens of *Symphurus diomedianus* were collected at and beyond the 37 m stations. Along both transects collections declined at the deepest stations (Table 17), suggesting a rather narrow depth range. Deepest known occurrence is from 80-100 fm (146-183 m), reported by Longley and Hildebrand (1941:49) from the Tortugas. The report of three specimens by Moe and

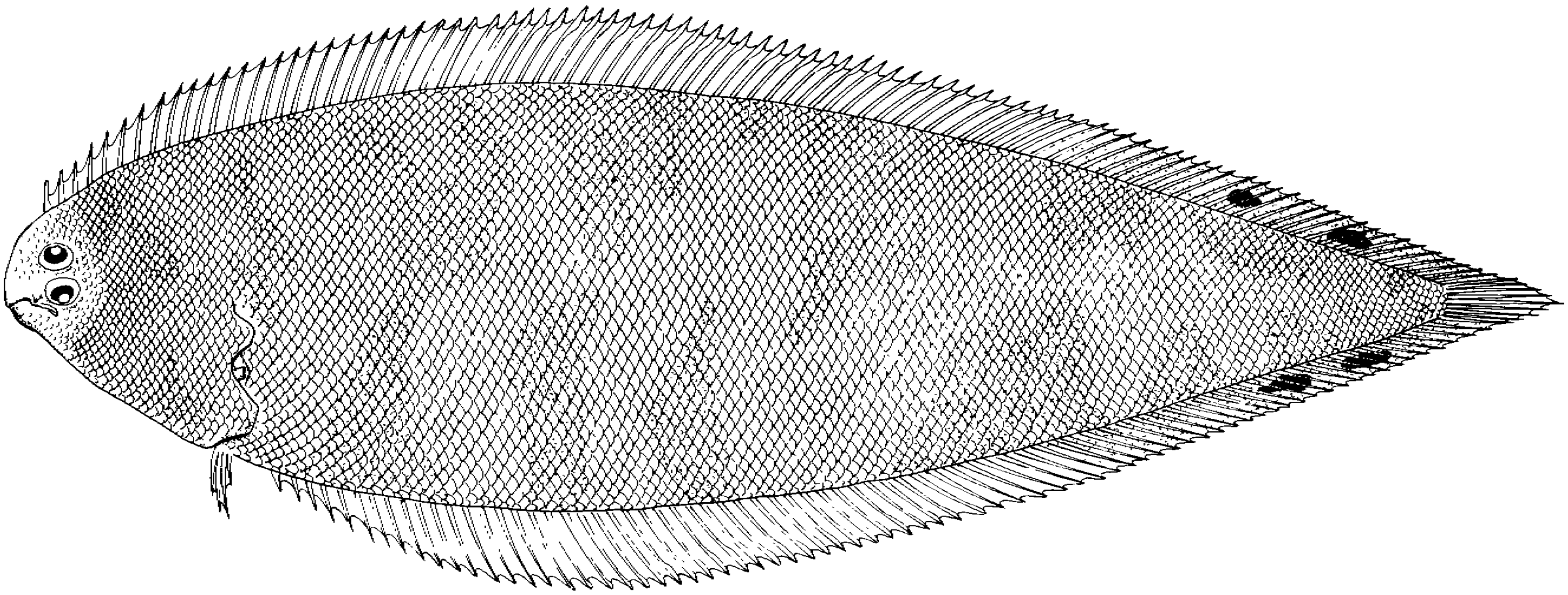

Figure 29. *Symphurus diomedianus* (Goode and Bean), FSBC 3437, 175 mm SL, 27°37'N, 83°43'W.

TABLE 17. NUMBERS AND SIZE RANGE (mm SL) OF *SYMPHURUS DIOMEDIANUS* COLLECTED DURING PROJECT HOURGLASS, BY STATION AND MONTH.

Symphurus diomedianus																															
STA	1965					1966													1967												TOT
	A	S	O	N	D	J	F	M	A	M	J	J	J sp	A	S	O	N	D	J	J sp	F	M	A	M	J	J	A	S	O	N	
A																															
B_1																															
B_2																															
C_1						1 155		6 127-150				1 101	6 101-174		3 130 146		4 119-135		1 153				1 48							1 168	24
C_2			1 170						2 150													1 138			2 135-141				1 151		7
D_1		1 160	1 165	2 153-155		1 142		4 151-171	2 162-165			2 160-171	3 152-159			1 153		2 133-145				1 157	3 126-156		1 158	1 162				2 148-152	27
D_2	1 153											1 160		1 159															1 160	1 154	5
E								2 128 151					3 157-168	1 127	1 165				1 166		1 154		3 118-146				1 142	1 120			14
I																															
J																															
K				1 111		1 150	1 127	6 120-156	2 113-150		1 157	4 112-142	10 126-159			1 117		1 138	1 140	6 117-165	1 139								3 120-137		39
L						1 125	4 125-164	1 151				1 153	2 128-169	1 145		1 165		2 157-161	2 168-173	2 124-140		1 145					1 152	1 160	1 156		21
M												1 119		1 146			2 163-167		3 135-155			1 122						1 148		2 144-149	11
TOT	1	1	2	3		4	5	19	6		1	10	24	4	4	3	6	5	8	8	2	4	7		3	1	2	3	6	6	148

Martin (1965:149) in 10-15 ft (3-5 m) off Tampa Bay is the only documented occurrence of the species in Gulf of Mexico waters shallower than 10 fm (18 m). Cervigon (1966:817) reported an occasional occurrence off Venezuela in depths less than 30 m, but referred to a greater abundance in deeper waters.

To assess differences in mean fish length between stations, between depths and between latitudes, the following means were compared (one specimen, 48 mm SL, was excluded from the analysis):

$$\left.\begin{array}{l}\text{Sta. C: } 140.6\text{ mm}, n = 30\\ \text{Sta. D: } 155.1\text{ mm}, n = 32\\ \text{Sta. E: } 145.8\text{ mm}, n = 14\end{array}\right\} \quad 147.7\text{ mm}, n = 76$$

$$\left.\begin{array}{l}\text{Sta. K: } 137.8\text{ mm}, n = 39\\ \text{Sta. L: } 149.7\text{ mm}, n = 21\\ \text{Sta. M: } 144.2\text{ mm}, n = 11\end{array}\right\} \quad 142.3\text{ mm}, n = 71$$

Although no significant differences were obtained between stations at any given depth, overall means along the northern and southern transects differed significantly ($t = 2.04$, $n = 147$).

Along either transect, mean fish length at the 55 m station (D or L) exceeded mean lengths at 37 and 73 m. These small but consistent differences counter the general notion that fish size increases with depth (e.g., Moe and Martin, 1965:147). It is tempting to speculate that southwestern Florida stocks of *Symphurus diomedianus* are homogeneous with respect to age-group composition, but that growth is optimal within a certain narrow bathymetric zone. The corollary, that *S. diomedianus* fares less well in waters both deeper and shallower, may involve limitations imposed by substrate, biotic associates, or related factors.

Bottom temperatures for Hourglass collections of *Symphurus diomedianus* ranged from 17.5-27.96°C. These values approximate the documented extremes of 63°F (17.2°C) off Pensacola (Springer and Bullis, 1956:65) and 28.5°C off Tampa Bay (Moe and Martin, 1965:149). Bottom salinities for Hourglass collections ranged from 32.26-36.71‰.

Gulf of Mexico collections of *Symphurus diomedianus* by the R/V *Oregon* (Springer and Bullis, 1956:65) were frequently from substrate having a mud component. Hourglass collections were from calcareous substrate; the species was not collected at stations where appreciable proportions of quartz sand were present.

Annual or seasonal trends in abundance were not evident. Diurnal differences (Regular vs. Post-cruises at Stations C and D) were pronounced, with 51 of 63 specimens (81.0%) collected at night. Proportion of fish caught by trynet vs. dredge, however, did not differ with time of day; a chi-square test showed no significant differences between collections made between midnight and dawn, between dawn and dusk, and between dusk and midnight ($X^2 = 0.583$, 2 d.f.).

Food Habits. Stomachs of 140 Hourglass specimens were examined. Of the 49 containing food, 37 were checked cursorily for major inclusions and 12 were examined in detail. The following food items were found:

Polychaeta: Errantia and Sedentaria
Mollusca: Bivalvia, Gastropoda and gastropod eggs

Crustacea
    Amphipoda: Gammaridae
    Isopoda
    Stomatopoda
    Decapoda
        Natantia
        Reptantia: Brachyura
            Xanthidae, Paguridae, Albuneidae: *Albunea*
Brachiopoda
Echinodermata: Ophiuroidea

Crustaceans, particularly crabs, were the most frequently encountered food items, followed by polychaetes and gastropod mollusks.

Reproduction. Gonads of 22 Hourglass and FSBC specimens collected between mid-February and mid-October were macroscopically examined. Five females collected between mid-February and early June had well developed ovaries, those of the blind side extending beyond the 25th anal pterygiophore and containing spherical yellow-orange eggs in late stages of active development. Mean ova diameters (excluding primary oocytes) among the five ranged from 0.35-0.43 mm. Testes of a 169 mm specimen collected on 20 October 1965 were small and inactive. Based on these samples, spawning probably extends from early spring to at least mid-summer. Absence of modal length progressions in Hourglass collections supports this indication of an extended spawning period.

Among 118 specimens (112-182 mm), 70 were males and 48 were females, a ratio differing from 1:1 (X^2 = 4.10). In this sample males averaged 146.8 mm, females 149.1 mm, an insignificant difference (t = 0.836).

Importance. Numerically, *Symphurus diomedianus* is the most important tonguefish along the southwestern Florida coast in depths beyond 10 fm (18 m), but its small size limits its potential as a significant commercial species.

Symphurus minor Ginsburg

Largescale tonguefish, Figure 30

Symphurus minor Ginsburg, 1951:192, Fig. A (off St. George Island, Fla.); Briggs, 1958:298 (listed, Fla.); Moe and Martin, 1965:149 (off Tampa Bay, Fla.); Robins and Randall, 1965:336 (relationship to *S. arawak*); Struhsaker, 1969:298, App. B (se. U.S.).

Symphurus minor, one of the smallest western Atlantic tonguefishes, is dintinguished by its low number of dorsal and anal fin rays. Dorsal rays of nine Hourglass specimens ranged from 69-76 ($\overline{x}$ = 72.4); anal fin rays ranged from 54-63 ($\overline{x}$ = 59.0). Ranges for both characters exceed those listed by Ginsburg (1951:Tables 2 and 3), but means are similar. All Hourglass specimens had ten caudal rays.

Robins and Randall (1965) have suggested that *Symphurus minor* may form the northern component of a north-south species pair, represented in the Caribbean by the closely related *S. arawak*.

Symphurus minor has been reported from Halifax, Nova Scotia southward to West Palm Beach, Florida, and it occurs in the Gulf of Mexico from the southern Hourglass transect (off Fort Myers) to Cape San Blas, Florida. Struhsaker (1969:298, App. B) reports it as "common" (present

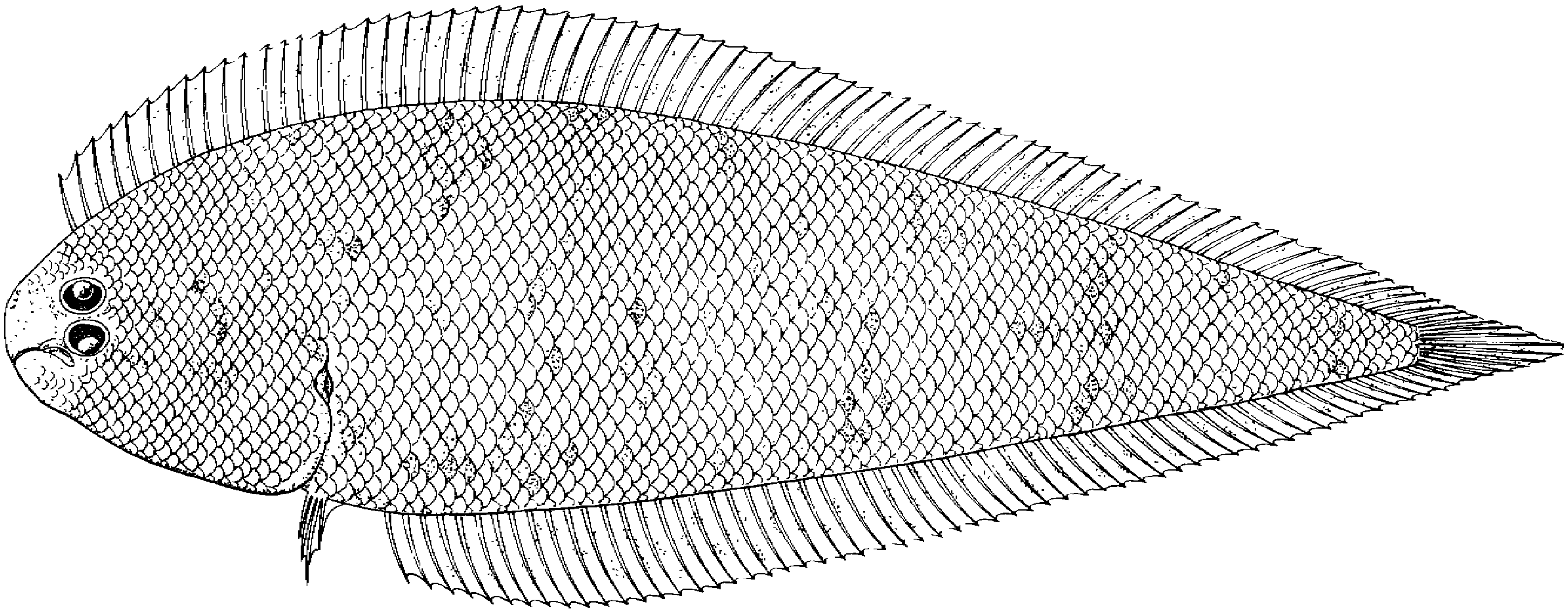

Figure 30. *Symphurus minor* Ginsburg, FSBC 2977, 44 mm SL, west of Egmont Key in 25 m depth.

in 10-50% of trawling stations) on the open shelf of the southeastern United States.

Fourteen specimens were taken in 12 collections during Hourglass sampling, as follows:

Sta. B,	8 Nov. 1965,	70 mm
	2 Nov. 1967,	(2) 31-45 mm
Sta. C,	6 Apr. 1966,	58 mm
	20 May 1967,	40 mm
	1 July 1967,	(2) 11-13 mm
Sta. D,	2 Aug. 1966,	11 mm
	12 May 1967,	33 mm
	6 Oct. 1967,	18 mm
Sta. K,	12 June 1966,	32 mm
	7 Apr. 1967,	45 mm
	14 Nov. 1967,	12 mm
Sta. L,	15 Nov. 1967,	13 mm

Size range of this series approximates that for 16 specimens (26-78 mm) examined by Ginsburg (1951:192), supporting his observation that *Symphurus minor* is a diminutive species.

A single 58 mm Hourglass specimen (6 Apr. 1966, Sta. C) was collected by trynet; the remainder were taken by box dredge. Small size probably limits vulnerability of this species to trawling gear.

Hourglass specimens of *Symphurus minor* were collected from depths of 18-55 m. All but one of Ginsburg's (1951:192) specimens were from 20-49 m; the exception, taken from 93 fm (170 m) off Halifax, Nova Scotia, is also the only specimen known from north of the Carolinas. Bottom temperatures for Hourglass collections of *S. minor* ranged from 18.5-23.3°C; bottom salinities from 35.00-36.49‰. No annual, seasonal or diurnal trends were evident. Remains of a polychaete were found in the stomach of a 58 mm specimen taken at Sta. C on 6 April 1966.

Specimens with ripening gonads were found in April collections. A female collected at Sta. C on 6 April 1966 had ovaries extending on the blind side to the 25th anal pterygiophore; diameters of 39 ripening ova averaged 0.34 mm. Smallest Hourglass specimens (11-13 mm) were collected in July, August, and November.

Symphurus parvus Ginsburg

Pigmy tonguefish, Figure 31

Aphoristia pigra Goode and Bean, 1886:154 (in part).

Symphurus parvus Ginsburg, 1951:192, Fig. B (off Boca Chica, Fla.); Springer and Bullis, 1956:65 (Gulf of Mex. localities); Briggs, 1958:298 (listed, Fla.); Hoese, 1958:246 (listed, Texas); Robins and Randall, 1965:336 (relationship to *S. pelicanus*).

Symphurus parvus closely resembles *S. minor*, but Ginsburg (1951) has demonstrated good separation between the two based on dorsal and anal fin ray counts. For seven Hourglass specimens of *S. parvus* these counts were D. 77-85, $\bar{x} = 80.0$; A. 63-68, $\bar{x} = 64.6$.

Robins and Randall (1965:336) have suggested that *Symphurus parvus* and *S. pelicanus* may represent a north-south species pair generated by repeated latitudinal fluctuations in the fish fauna during glacial and interglacial periods. Inasmuch as the two occur sympatrically throughout much of their range (Florida Shelf, Yucatan Shelf, northern Gulf of Mexico), this interpretation bears further scrutiny.

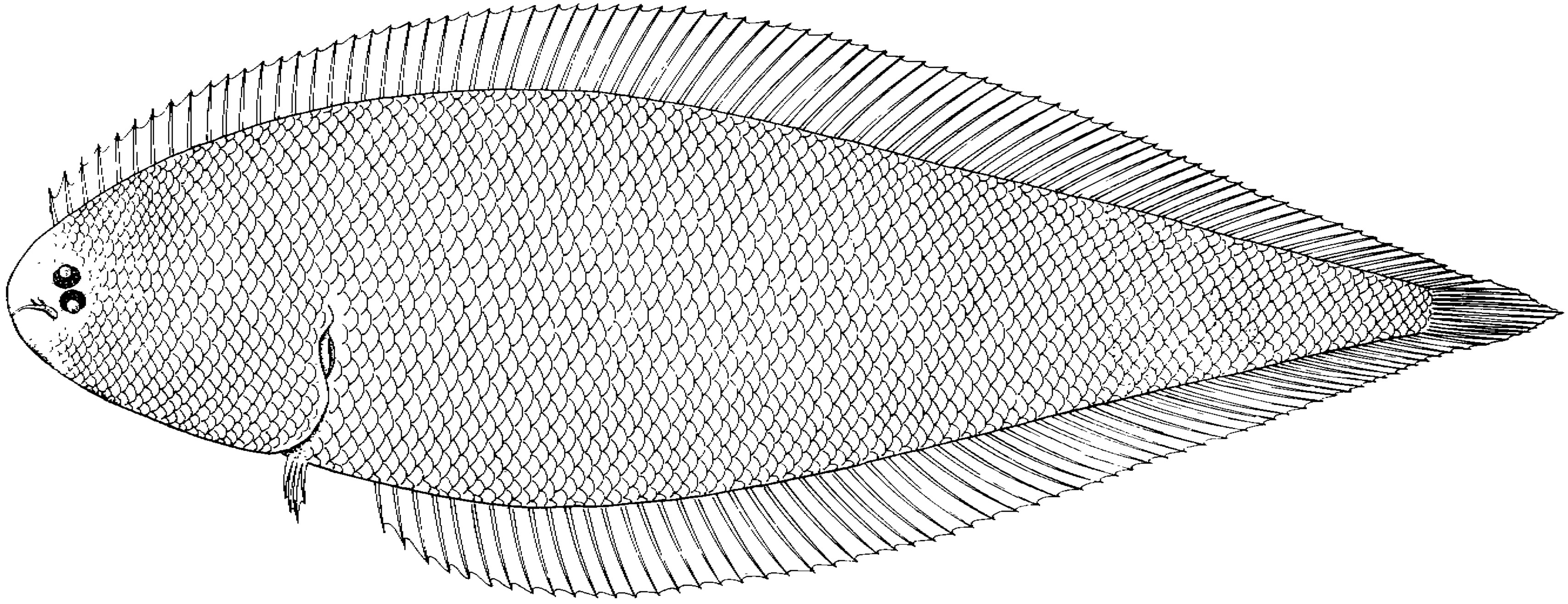

Figure 31. *Symphurus parvus* Ginsburg, FSBC 6543, 30 mm SL, Hourglass Sta. C.

Symphurus parvus is known from the east coast of Florida (West Palm Beach), the Florida Keys, the Gulf of Mexico, and probably (Ginsburg, 1951:193) the West Indies. In the Gulf of Mexico it is known from R/V *Oregon* collections off Texas and on the Yucatan Shelf (Springer and Bullis, 1956:65), and from the Florida west coast. It is nowhere abundant.

Seven specimens were taken in Hourglass collections, as follows:

Sta. C, 11 Aug. 1967, 30 mm, trynet
Sta. D, 8 Feb. 1966, 37 mm, trynet
12 May 1967, 57 mm, box dredge
Sta. E, 3 July 1966, 51 mm, trynet
2 Aug. 1966, 43 mm, box dredge
Sta. L, 5 Sep. 1966, 62 mm, box dredge
7 Dec. 1966, 23 mm, box dredge

Maximum size of *Symphurus parvus* probably approximates that of *S. minor*. The largest known specimen (78 mm) was taken from 45 fm (72 m) off Boca Chica, Florida (Ginsburg, 1951:192).

Although *Symphurus parvus* and *S. minor* both occurred at Hourglass Stations C, D, and L, the former may range to deeper waters. Known depth range is from 37 to about 109 m. Bottom temperatures for Hourglass collections of *S. parvus* ranged from 18.75-24.0°C; bottom salinities from 33.82-36.31‰. Stomachs of two specimens (Sta. E, 2 Aug. 1966; Sta. L, 5 Sep. 1966) contained crushed shell and detritus.

Gonads of three Hourglass females were examined. A 43 mm specimen (Sta. E, 2 Aug. 1966) was immature, and a 37 mm specimen (Sta. D, 8 Feb. 1966) was maturing, with ovaries beginning their posterior elongation. A 62 mm specimen (Sta. L, 5 Sep. 1966) contained actively developing ovaries measuring 17 mm on the blind side and 22 mm on the eyed side. Oocytes smaller than 0.17 were numerous; 895 ova (0.17-0.50 mm, $\bar{x} = 0.35$ mm) were enumerated for the two gonads.

Symphurus plaguisa Linnaeus

Blackcheek tonguefish, Figure 32

Pleuronectes plagiusa Linnaeus, 1766:455.

Symphurus plagiusa Jordan and Goss, 1889:325 (Beaufort, Charleston, Pensacola, Key West); Hildebrand and Schroeder, 1928:177, Fig. 91 (synonymy, descr., distrib., Chesapeake Bay); Nichols, 1930:391, Fig. 305 (diagn., descr., Puerto Rico); Gunter, 1938:342 (Barataria Bay, La.); Fowler, 1941:146 (Brazil); Pearse *et al.*, 1942:189 (Beaufort, N. Car.); Gunter, 1945:88 (Texas localities); Miles, 1949:Table 4 (predation, Texas); Baughman, 1950:137 (Texas records); Ginsburg, 1951:195, Fig. G (synonymy, descr.); Miles, 1951:20 (Apalachicola Bay, Fla.); Pearse and Williams, 1951:146 (N. Car. and S. Car. reefs); Simmons, 1951a:4; 1951b:7 (Cedar Bayou Pass, Texas); Siebenaler, 1953:14 (Biscayne Bay, Fla. shrimp fishery); Reid, 1954:67 (Cedar Key, Fla.); Kilby, 1955:232 (Cedar Key, Fla.); Reid, 1955:448 (East Bay, Texas); Joseph and Yerger, 1956:129 (Alligator Harbor, Fla.); Menzel, 1956:97 (St. George Sound, Fla.); Springer and Bullis, 1956:65 (Gulf of Mex. localities); Boschung, 1957:210 (synonymy, distrib., Ala.); Simmons, 1957:188 (Laguna Madre, Texas); Woodburn *et al.*, 1957:21, 22 (Tampa Bay, Fla.); Briggs, 1958:298 (listed, Fla.); Hoese, 1958:346 (listed, Texas); Day, 1959:6 (Matagorda Bay, Texas); Duarte-Bello, 1959:132 (listed, Cuba); Hoese, 1959:4 (lower Galveston Bay, East and West Bays, Texas); Renfro, 1959:27 (Galveston and Trinity Bays, Texas); Christmas *et al.*, 1960:7 (Miss. purse seine fishery); Harrison and Martin, 1960:4 (listed, Va.); Springer, 1960:27 (lower St. Lucie and Indian Rivers, Fla.); Springer and Woodburn, 1960:87 (ecology, Tampa Bay, Fla.); Bearden, 1961:11 (listed, S. Car.); Massman *et al.*, 1961:Table 2 (Chesapeake Bay); Tabb and Manning, 1961:640 (n. Fla. Bay); Tagatz and Dudley, 1961:11, Tables 3 and 4 (Beaufort, N. Car.); Martinez, 1962:3 (Corpus Christi Bay systems, Texas); Massman *et al.*, 1962:Tables 3 and 4 (Chesapeake Bay); Pullen, 1962:13 (upper Galveston Bay, Texas); Richmond, 1962:94 (Horn Is., Miss.); Schultz, 1962a:14 (Mesquite Bay and Cedar Bayou, Texas); 1962b:10 (Aransas and Copano Bays, Texas); Springer and McErlean, 1962:54 (Matecumbe Key, Fla.); Tabb *et al.*, 1962:51, 61 (n. Fla. Bay); Compton and Bradley, 1963:7 (off Port Aransas, Texas); Gunter and Hall, 1963:282 (St. Lucie Estuary, Fla.); Compton and Bradley, 1964:421 (off

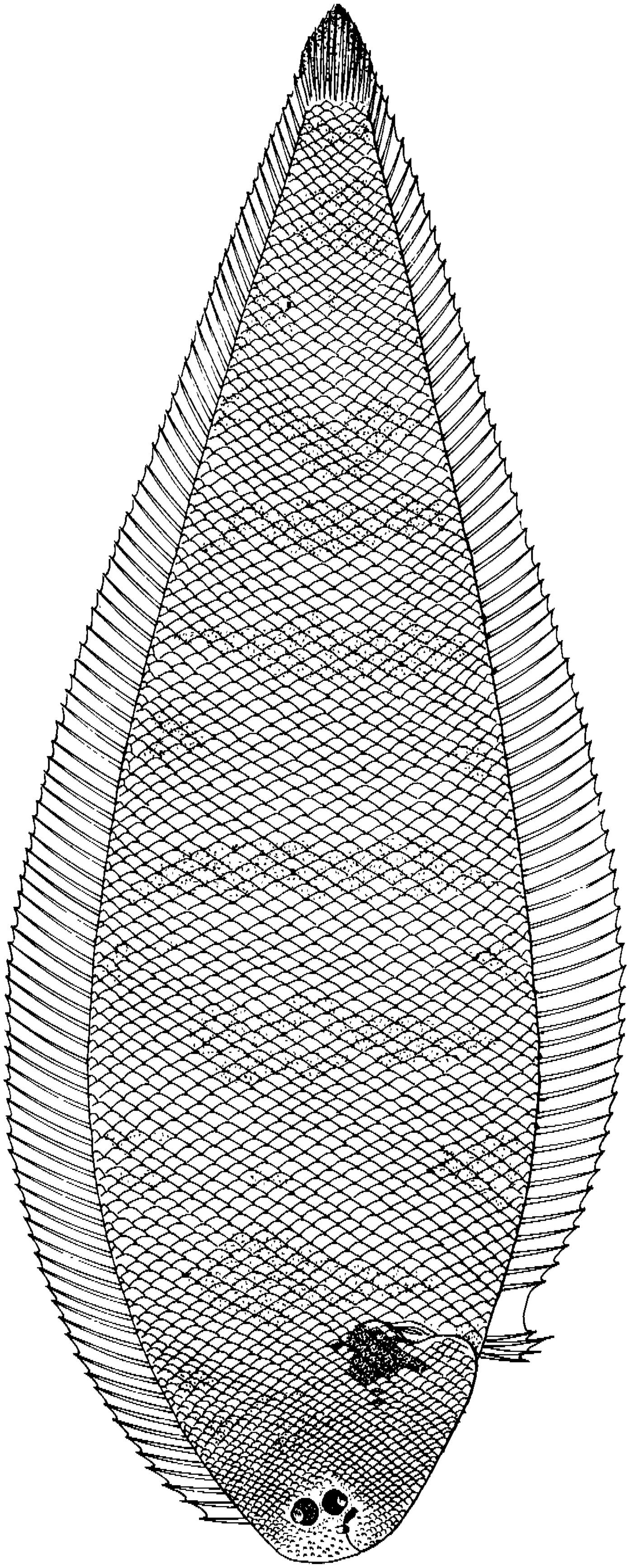

Figure 32. *Symphurus plagiusa* Linnaeus, FSBC 2812, 129 mm SL, Tampa Bay.

Port Aransas, Texas); Rounsefell, 1964:386 (Miss. R.–Gulf Outlet Channel); Anderson and Gehringer, 1965:23 (Cape Canaveral area, Fla.); Bullis and Thompson, 1965:34 (w. Atlant. localities); Compton, 1965:Tables 1 and 2 (off Port Aransas Inlet, Port Isabel and Port Mansfield, Texas); Christensen, 1965:225 (Jupiter Inlet and Loxahatchee R., Fla.); Copeland, 1965:19 (Aransas Pass Inlet, Texas); Dawson, 1965:279 (length-weight relationships, Miss. and La. coasts); Gunter and Hall, 1965:47 (Caloosahatchee R. estuary, Fla.); Hoese, 1965:60 (Port Aransas, Texas); Miller, 1965:102 (Port Aransas, Texas); Moe and Martin, 1965:146 (off Tampa Bay, Fla.); Parker, 1965:218 (listed, Texas); Roessler, 1965:314 (Biscayne Bay, Fla.); Roithmayr, 1965:22 (Gulf of Mex. industrial fishery); Burleigh, 1966:29 (Lake Borgne, La.); Compton, 1966 (off Port Aransas, Texas); Norden, 1966:128, 131 (Vermillion Bay, La.); Zilberberg, 1966:129 (nw. Fla. marsh); Tagatz, 1967:48 (St. Johns R., Fla.); Anderson, 1968:20 (s. Atlant. coast of U.S.); Böhlke and Chaplin, 1968:226, figure (Eleuthera Is., Great Bahama Bank); Fox and Mock, 1968:47 (Barataria Bay, La.); Jorgenson and Miller, 1968:6 (length relationships, Ga.); Clark *et al.*, 1969:60 (Cape Hatteras, N. Car.); Duke and Rudolph, 1969:28 (Carib. coast of Panama); Struhsaker, 1969:298, App. B (se. U.S.); Bayer *et al*, 1970: A68 (sw. Carib.); Copeland and Fruh, 1970: App.Table 1 (Galveston Bay, Texas); Dahlberg and Odum, 1970: 387 (season, Ga. estuary); de Sylva, 1970:54 (Biscayne Bay, Fla.); Richards and Castagna, 1970:247 (e. shore of Va.); Roessler, 1970:866, 885 (Everglades Nat. Park); Dahlberg, 1971:260 (reversed specimen); Grimes, 1971: App.II (Crystal R., Fla.); Humm *et al.*, 1971:132 (Anclote R. and anchorage, Fla.).

Symphurus plagiura Hutton *et al.*, 1956:60 (Boca Ciega Bay, Fla.).

Symphurus plagiosa Vick, 1964:64 (St. Andrews Bay, Fla.).

Hourglass specimens of *Symphurus plagiusa* and FSBC specimens from nearby areas generally agree with Ginsburg's (1951:196) description. Anal fin ray count (67) of one specimen (Sta. A, 6 Jan. 1967, 148 mm) falls below the range reported for this character by Ginsburg.

Symphurus plagiusa is an extremely abundant shallow water tonguefish; no important inventory of coastal southeastern United States omits it. Trawler operators often regard it as a nuisance, for specimens frequently become enmeshed in the webbing in such numbers as to interfere with effectiveness of the gear.

The species occurs from New York to the Bahamas and Greater Antilles (Ginsburg, 1951:196; Böhlke and Chaplin, 1968:226). In the Gulf of Mexico it occurs from Cape Sable, Florida to the Laguna Madre, Texas, and on the Yucatan Shelf. The range reported by Briggs (1958:298) obviously includes that of *Symphurus plagusia*, an unfortunate anagram of *S. plagiusa.*

Occurrence in Hourglass Collections. Fourteen specimens were taken in eight collections during Hourglass sampling, as follows:

Sta. A,	3 Aug. 1965,	150 mm, box dredge
	4 Oct. 1965,	145 mm, box dredge
	7 Feb. 1966,	138 mm, box dredge
	6 June 1966,	130 mm, box dredge
	1 Aug. 1966,	124 mm, box dredge
	6 Jan. 1967,	148 mm, box dredge
Sta. I,	21 Mar. 1966,	(7) 109-162 mm, trynet
	8 Mar. 1967,	166 mm, box dredge

Ecology. Size range (109-166 mm) greatly exceeds that of Springer and Woodburn's (1960:87) Tampa Bay specimens (18.7-118.5 mm) and suggests, among other possibilities, recruitment from the bay to the open shelf.

Along the southwestern Florida coast *Symphurus plagiusa* is predominantly a near-shore species, occurring in great numbers in the bays and shallow coastal waters. In Tampa Bay it is a common resident, present at all seasons (Springer and Woodburn, 1960:87). Moe and Martin (1965:146), in their sampling off Tampa Bay, collected more than half their specimens in depths less than 20 ft (6 m). Hourglass collection depth (6 m) probably approaches the usual bathymetric limit for the species. Deepest known occurrence is from 50 fm (92 m), taken at R/V *Oregon* Sta. 944 off Pensacola, Florida (Bullis and Thompson, 1965:34). Judging from published accounts (e.g., Reid, 1954:67; Kilby, 1955:232; Hoese, 1965:60), *S. plagiusa* has a decided preference for soft, muddy bottoms. In the vicinity of Hourglass sampling the generally calcareous substrate of the outer shelf thus may have an effect in confining the species to inshore areas.

Hourglass collections of *Symphurus plagiusa* were taken at bottom temperatures of 11.3-30.0°C and bottom salinities of 29.8-36.06°/₀₀. The species has reportedly been found at a minimum temperature of 5°C (Roessler, 1970:883) and is known from the St. Johns River at 34.1°C (Tagatz, 1967:48). It is the most euryhaline of the western Atlantic cynoglossids, having been reported from fresh water in the St. Johns River (Tagatz, 1967:48) and not infrequently from salinities of 3°/₀₀ or less (Renfro, 1957:27; Schultz, 1962a:14; 1962b:10; Gunter and Hall, 1963:282). According to Simmons (1957:188), it does not tolerate salinities much above 35°/₀₀, maximum reported salinity for the species is 42.9°/₀₀ (Roessler, 1970:885).

Food Habits. Stomachs of 13 Hourglass specimens of *Symphurus plagiusa* were examined. Four were empty, three contained unidentifiable animal remains, and the remaining six (FSBC 4791, HG Sta. I, 9 March 1966) contained crab and other crustacean remains, polychaetes, amphipods, cumaceans and brachiopods. Springer and Woodburn (1960:87) found food of Tampa Bay specimens to consist almost entirely of copepods and polychaetes. Reid (1954:67) found copepods, amphipods, ostracods, and occasionally polychaetes and bivalves in Cedar Key specimens.

Reproduction. Judging from numerous reports of gonadal conditions and of occurrences of larvae and small juveniles, Gulf of Mexico populations of *Symphurus plagiusa* spawn during spring and summer, commencing about March. Developing ova were found in Hourglass specimens from Station I on 21 March 1966.

Importance. Although the tonguefishes are characteristically small, *Symphurus plagiusa* occurs in sufficient numbers throughout much of its range to rate as a minor inclusion in several "industrial" or "scrap" fisheries. Along the continental shelf of the southeastern United States it is ranked by Struhsaker as "very common" (occurring in more than half the trawling stations); on a yearly basis *Symphurus* spp. make up about 1% of the catch in the Cape Canaveral area (Anderson, 1968:20). In the Gulf of Mexico, *S. plagiusa* is taken in the industrial bottomfish fishery (Roithmayr, 1965:22) and in the Mississippi purse seine fishery (Christmas *et al.*, 1960:7).

Symphurus urospilus Ginsburg

Spottail tonguefish, Figure 33

Symphurus urospilus Ginsburg, 1951:193, Fig. D (off Savannah, Ga.); Springer and Bullis, 1956:65 (Gulf of Mex. localities); Briggs, 1958:298 (listed, Fla.); Bullis and Thompson, 1965:35 (ne. Fla. and Fla. Keys); Moe and Martin, 1965:149 (off Tampa Bay, Fla.); Beaumariage, 1968:8 (off St. Petersburg, Fla.); Struhsaker, 1969:298, App. B (se. U.S.).

Symphurus urospilus is easily distinguished from all other western Atlantic tonguefishes by a distinctive black caudal spot that persists even in long-preserved material. Ginsburg (1951:193) expressed probability, on the basis of two specimens, that the normal caudal fin ray count would prove to be eleven; among four Hourglass specimens, three have 11, the other 10.

The species has been reported from Savannah, Georgia to southern Florida, and in the Gulf of Mexico from the Florida Keys to Apalachee Bay and from west of Yucatan. Struhsaker (1969:298,

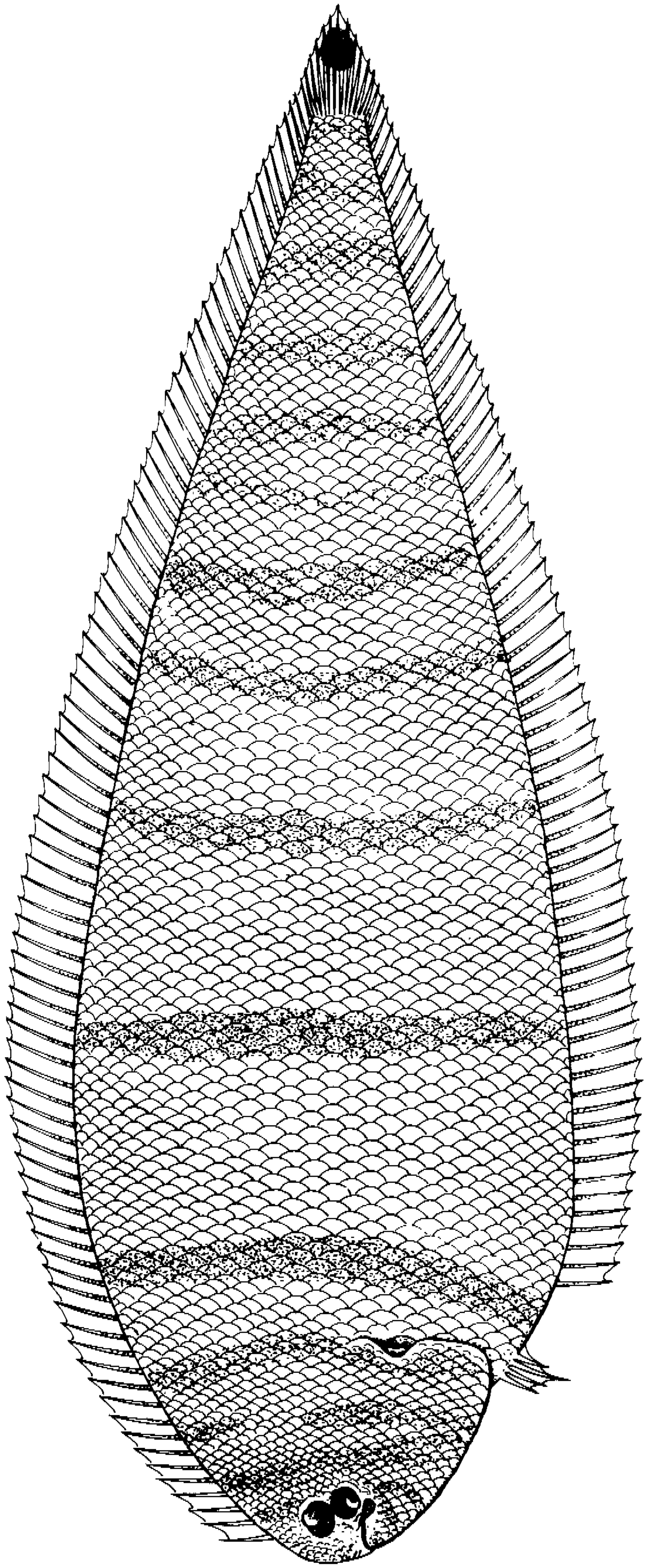

Figure 33. *Symphurus urospilus* Ginsburg, FSBC 2460, 143 mm SL, 60 mi w. of Tarpon Springs, Fla.

App. B) ranked it as "rare" (occurring in less than 10% of trawling stations) along the continental shelf of the southeastern United States.

Fifteen specimens were taken in ten collections during Hourglass sampling, as follows:

Sta. A, 8 Oct. 1966, 148 mm, box dredge
Sta. B, 1 Dec. 1966, (2) 115-126 mm, trynet
2 Nov. 1967, 27 mm, box dredge
Sta. I, 7 Apr. 1967, 136 mm, box dredge
Sta. J, 3 Sep. 1965, (2) 106-130 mm, trynet
6 Dec. 1965, 140 mm, trynet
14 Feb. 1966, 137 mm, trynet
21 July 1966, (4) 135-152 mm, balloon trawl
4 Sep. 1966, 108 mm, trynet
15 Feb. 1967, 55 mm, box dredge

Bottom temperatures of 16.44-30.0°C and bottom salinities of 32.84-36.19‰ were recorded for Hourglass collections of *Symphurus urospilus*. Hourglass specimens occurred only at depths of 6 and 18 m; published records indicate that the depth range probably does not much exceed these limits. Deepest known record is from 15-17 fm (27-31 m), reported for the Florida Keys by Bullis and Thompson (1965:35).

Stomachs of three specimens from Sta. J contained crustacean parts. A specimen from Sta. B (1 Dec. 1966) contained a small gastropod.

Ripe and ripening gonads were found in specimens from September collections of 1965 and 1966. A specimen collected on 26 August 1958 near the Tortugas (FSBC 800, 88 mm) contained developing ova averaging 0.325 mm in diameter. The smallest Hourglass specimen (27 mm) was collected in November.

Symphurus urospilus has no commercial potential. Beaumariage (1968:8, Table 2), however, included the species in experimental reduction of "trash fish" into fish meal.

SPAWNING SEASONS

Probable spawning seasons of Hourglass flatfishes are summarized in Figure 34. Most extend over several months, making modal length progressions of offspring difficult to follow and age groups difficult to define from length frequency data. Among species considered here, *Syacium papillosum* has the longest spawning season–probably a period of some ten months. Although this species was represented in Hourglass collections by more than 3500 specimens, it showed no recognizable modal progressions, even when plotted by water depth, latitude and sex.

Duration of spawning season is frequently related to amount of seasonal fluctuation in an animal's environment. Where fluctuations are pronounced, such as in northern latitudes, breeding seasons are generally timed to produce offspring coincident with ample food supply (Russell-Hunter, 1970:82). In an environment where physical conditions and food supply are comparatively constant, such as in tropical or deep bottom waters, protracted breeding seasons are often advantageous in allowing sustained production of offspring, thus ameliorating density dependent mortality.

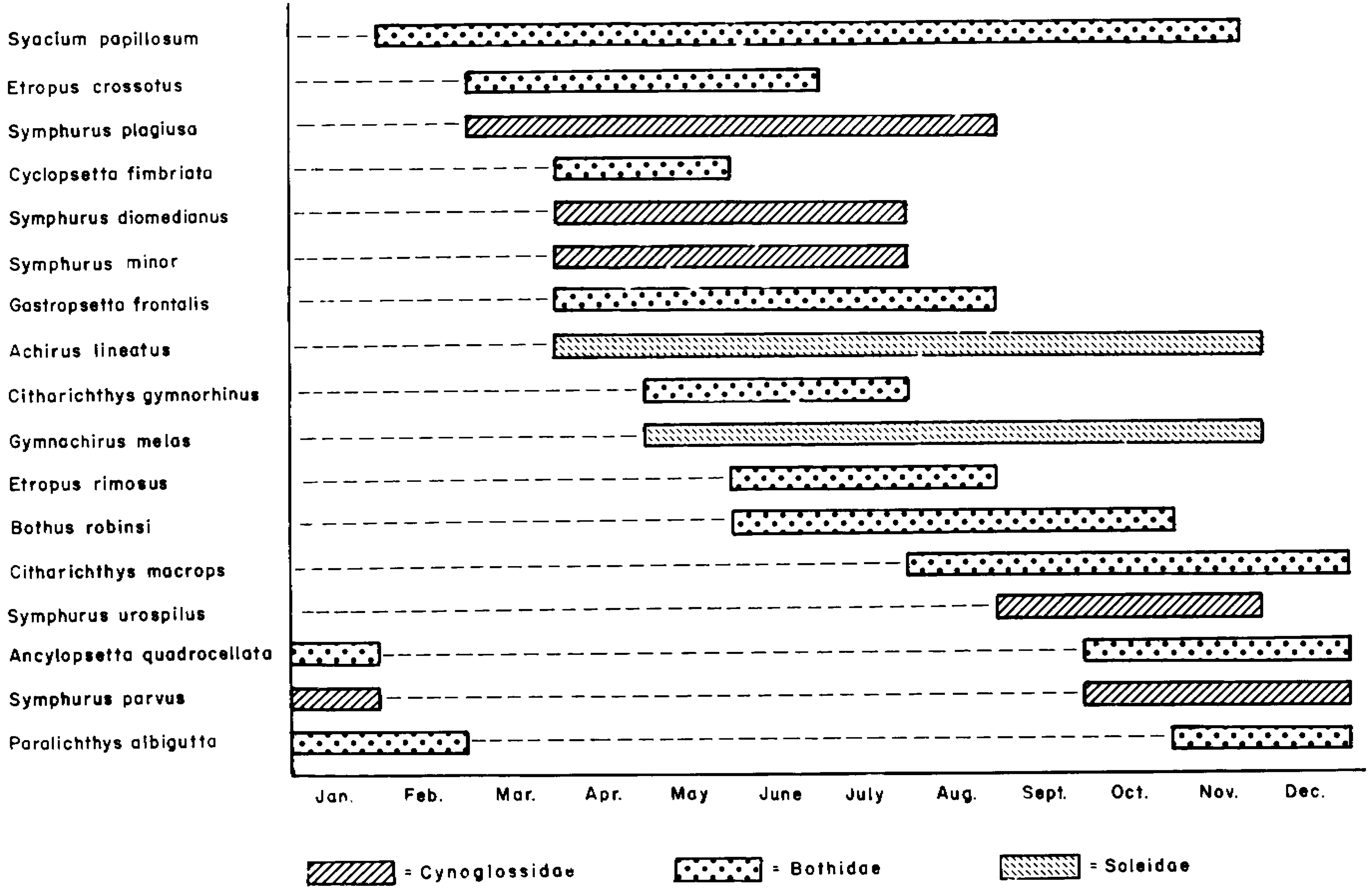

Figure 34. Probable spawning seasons of Hourglass flatfishes.

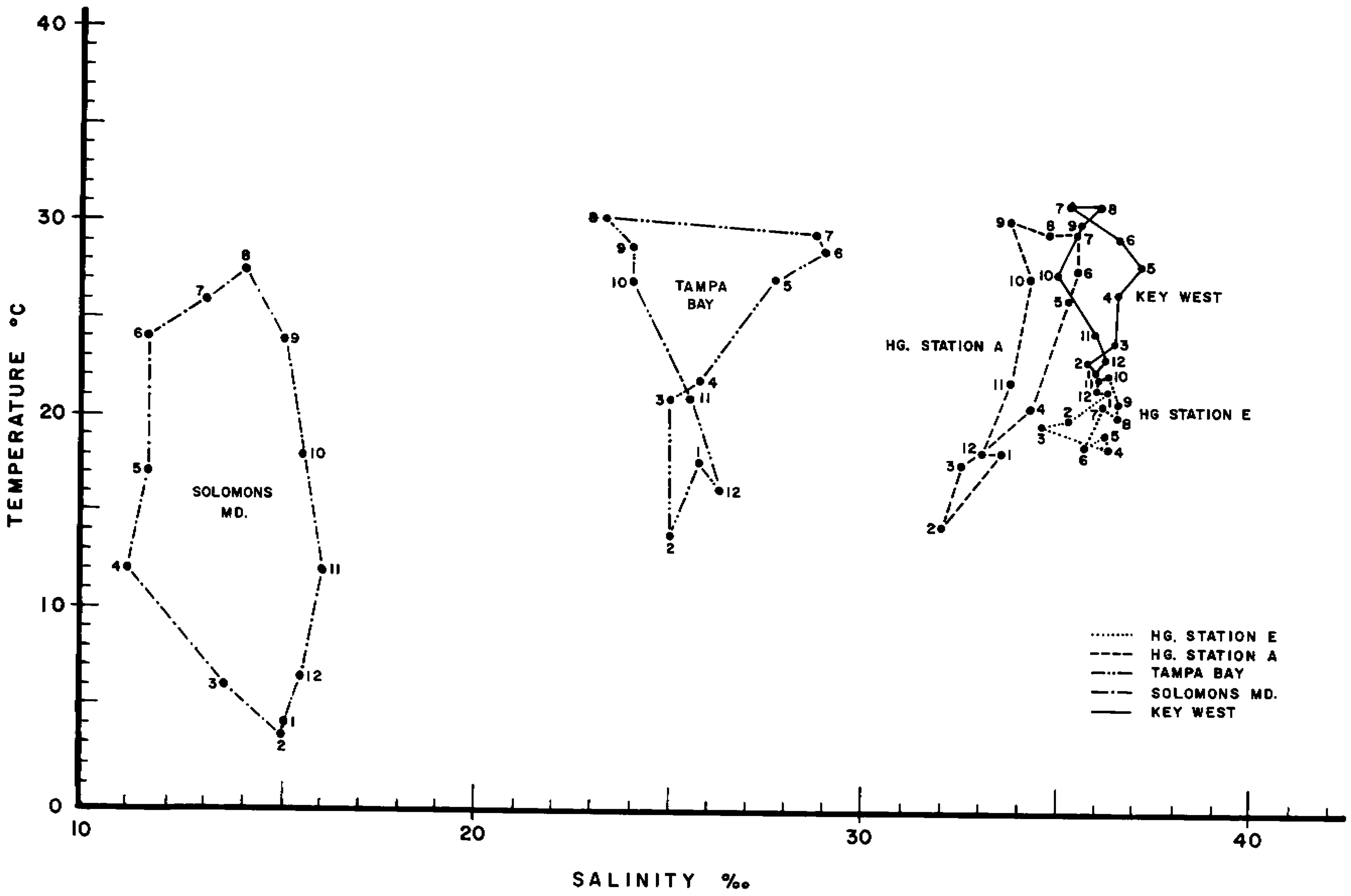

Figure 35. Mean hydrographic climates, shown by temperature-salinity polygons, for Hourglass Stations A and E, Tampa Bay, Key West and Solomons, Maryland.

Temperature-salinity polygons, devised by Hedgpeth (1953:142) to demonstrate "hydrographic climate," are useful here in comparing relative environmental fluctuation at various localities. Figure 35 presents polygons constructed from 1) average monthly bottom temperatures and salinities at Hourglass Stations A and E (6 and 73 m) (data from Joyce and Williams, 1969), 2) average monthly data in Tampa Bay (Areas I-IV of Saloman and Taylor, 1968), and 3) average data at Solomons, Maryland and Key West, Florida (from Hedgpeth, 1953:145). Among the five localities, hydrographic climate at Hourglass Station E fluctuates least, having lower temperatures than Key West, but about the same salinities. At Hourglass Station A the temperature range approximates that of Tampa Bay, but salinities are higher and less variable. At Solomons, Maryland (Chesapeake Bay) average salinities are lower than in Tampa Bay but vary about the same amount, while average temperatures are lower and much more variable.

ECOLOGICAL DIFFERENTIATION AMONG HOURGLASS FLATFISHES

Flatfishes collected during Project Hourglass provide an exceptional opportunity to examine ecological differentiation among a unified phyletic group on a limited segment of continental shelf.

Eighteen flatfish species were taken during Hourglass sampling. These, plus the hogchoker, *Trinectes maculatus*, comprise the flatfish fauna from 40 fm (73 m) shoreward. Several subunits of morphologically similar species can be distinguished within the group. The five Hourglass tonguefishes, for example, are scarcely distinguishable in the museum, differing by little more than a few dorsal and anal fin rays. An analogous circumstance in crayfish species has been phrased by Bovbjerg (1970:227), and applies aptly here: "Such closely related species must have a preponderance of traits in common, yet their [ecological] isolation implies some important differences."

The purpose here is to investigate these habits, mechanisms, strategies, preferences and other attributes that allow the 19 flatfish species to coexist on the same shelf segment without simultaneously competing for the same resources. Mayr (1963:69) has emphasized that this ecological compatability with potential competitors is one of the most important of species characters.

The most revealing studies of niche diversity have been carried out on animals that may be directly observed in their natural environment. MacArthur's (1958) study of warblers of northern coniferous forests is an outstanding example. Fewer such investigations have been undertaken in the marine environment, and these have usually been limited to intertidal and shallow subtidal animals. Kohn's (1959) study of intertidal gastropods of the genus *Conus* is a frequently cited example. More recently, studies of intertidal amphipods (Croker, 1967) and shallow water blenniid fishes (Stephens *et al.*, 1970) have expanded our understanding of niche diversity among marine animals.

For open shelf animals, direct information is ordinarily more difficult to obtain, and ecological distinctions are often less expressive. Moreover, animals with protracted breeding seasons and indeterminate growth have ontogenetic continua in which a given life stage of one species may be in transient competition with an earlier or later stage of another. In this study, direct and continuing observations of the flatfishes and their surroundings were not possible, and it was necessary to rely almost exclusively on such implied evidence as size, structure, stomach contents, associated biota, and physical data.

Habitat. Hourglass flatfishes are arranged in well defined depth zones associated with unique sets of physical and biological conditions. Particularly important correlatives are substrate and biotic communities (the "biotope" and "biocoenosis" of Thorson, 1957:473).

In the Hourglass area, both lithified and unconsolidated sediments are arranged in bands paralleling the coast. Their composition and distribution have been examined by Gould and Steward (1956); bottom characteristics at Hourglass stations have been briefly described by Joyce and Williams (1969). Both studies indicate that the bottom is similar at corresponding depths along the two transects, but that it differs considerably at successive depths. In addition, microdifferences in habitat (which allow greater niche diversity) may produce non-random distributions at a given station. This has been suggested (p. 67) to explain an apparent non-uniformity of sampling by our gear. Characterization of bottom communities along Hourglass transects must await completion of investigations currently under way.

Probable bathymetric distributions of flatfishes, based primarily on Hourglass collections, are shown in Figure 36. The curve for each species was constructed by plotting proportion of Hourglass specimens occuring at each depth. Some of the curves were then extended to indicate known or probable distributions in waters shallower or deeper than Hourglass stations. Bathymetric separation of similar species is demonstrated by the following examples:

1) *Etropus crossotus* closely resembles *E. rimosus* in size and morphology. Collections of the former were restricted to depths of 18 m or less, while over 96% of the latter were from 37 m.

2) Among the large tonguefishes, *Symphurus plagiusa* abounds in the bays and shallow coastal waters, but does not occur beyond 6 m; *S. urospilus* was collected primarily at 18 m, while *S. diomedianus* occurred only at 37 m and beyond.

3) *Gymnachirus melas* was collected only at 18 m and beyond while the two other soleid species are restricted to bays and shallow coastal waters of less than 6 m.

4) Partial bathymetric separation exists among the large paralichthine predators, with *Gastropsetta frontalis* typically occurring at depths beyond those occupied by *Paralichthys albigutta* and *Ancylopsetta quadrocellata.*

Size. A general correlation exists, by way of the trophic apparatus, between fish size and food habits. The smallest Hourglass flatfish, *Citharichthys gymnorhinus*, reaches sexual maturity at about 30 mm and attains a maximum size of about 55 mm. It is separated from the two other small flatfishes, *Symphurus minor* and *S. parvus*, by depth and method of feeding.

The only Hourglass flatfish regularly exceeding 300 mm is *Paralichthys albigutta*, a common resident of the bays and shallow coastal areas. It reaches sexual maturity at about 145 mm, and attains a maximum size of some 700 mm. Its nearest potential competitor, *Ancylopsetta quadrocellata*, has less well armed jaws and seldom exceeds 300 mm.

Sexual size dimorphism may enable a species to broaden its utilization of the environment and expand into subniches (Mayr, 1970:146). Among Hourglass flatfishes this phenomenon is exemplified by *Syacium papillosum*, in which adult males are significantly larger than females.

Finally, larvae of *Bothus* may remain planktonic until reaching a fairly large size (over 40 mm for *B. ocellatus*), thus resisting competition with demersal young of other flatfishes.

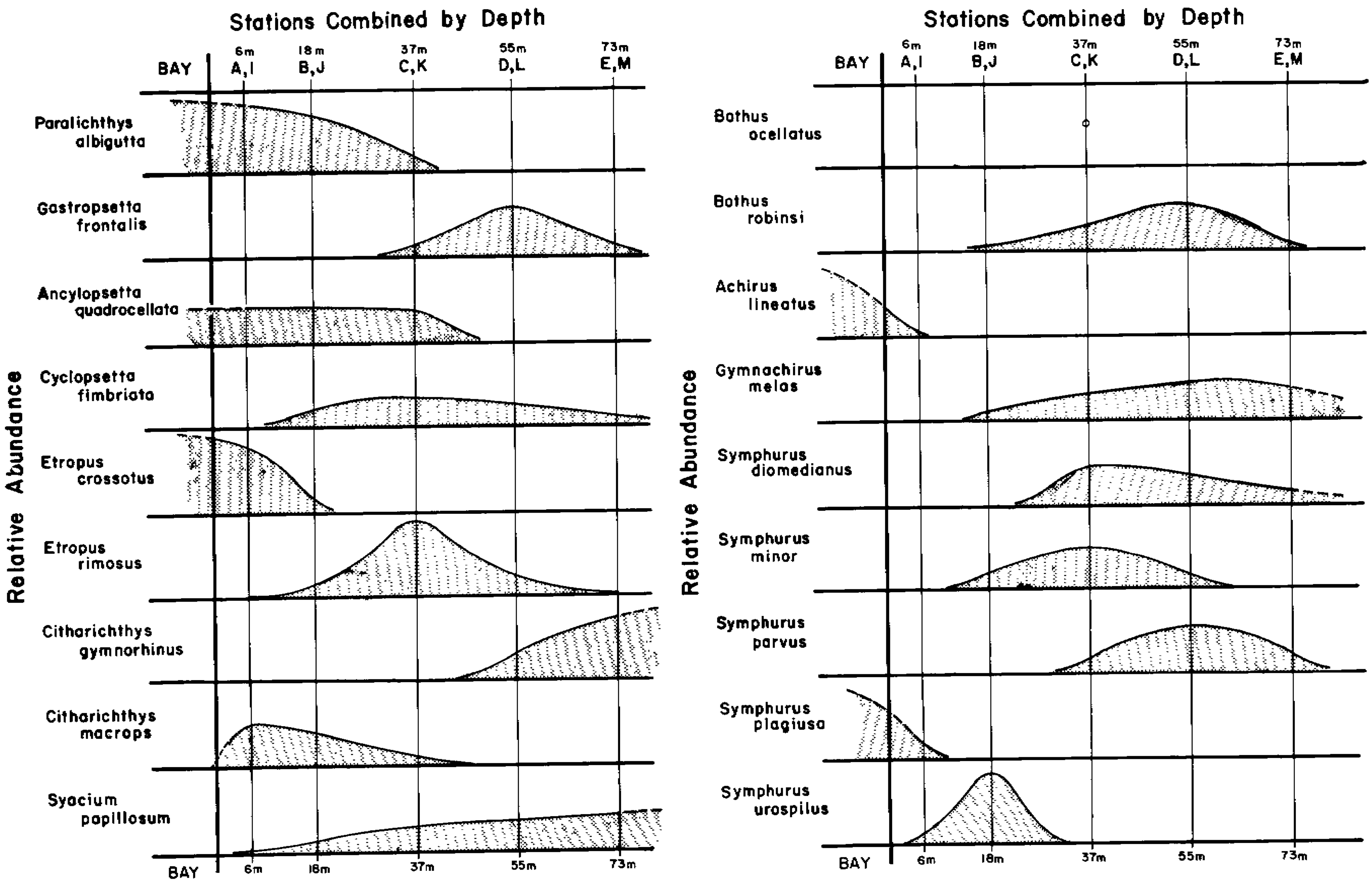

Figure 36. Bathymetric distribution of 19 flatfish species, based primarily on Hourglass collections.

Reproduction. Staggering of reproductive seasons, a mechanism promoting temporal isolation of the young, may reduce competition among certain Hourglass species. *Symphurus minor* and *S. parvus*, for example, are distinguishable only by fin ray count. They occupy the same depths, reach the same maximum size and apparently exploit the same type of food in much the same way. However, *S. minor* spawns from April through July, while *S. parvus* spawns from October through January.

Food and Feeding. Food relations are of fundamental importance in any study of evolutionary ecology (Hutchinson, 1959:147). When considering ecological differentiation it is important to emphasize differences in 1) structure and function of the feeding apparatus, 2) size and composition of food items and 3) feeding time and behavior.

Yazdani (1969) examined jaw adaptations in representatives of major flatfish families and arranged the species into four groups by their known food and feeding behavior. A similar scheme was devised by de Groot (1969, 1971), based on differences in sensory factors (olfaction and feeding) and morphology of digestive tract and gill rakers.

With slight modification these distinctions can be applied to Hourglass flatfishes. Among the Bothidae, *Paralichthys albigutta* and *Cyclopsetta fimbriata* are large visual feeders generally preying upon free swimming food such as other fish. Both have large mouths with strong canine teeth useful for seizing large motile prey. Large individuals of both species are piscivorous. Species of *Etropus* and *Bothus* represent the other extreme, having tiny mouths and feeding mainly on small sedentary or slow moving prey. *E. crossotus* is able to selectively crop tube-dwelling polychaetes with its finely dentate jaws.

The remaining bothids are intermediate in terms of jaw structure and diet. *Syacium papillosum* typifies this group, having sharp, slender teeth with some small canines, and feeding on crustaceans, fishes, polychaetes and mollusks.

According to Yazdani (1969:185), the feeding apparatus of soles and tonguefishes is adapted for taking strictly bottom living food such as polychaetes. Hourglass species fed primarily on small crustaceans, polychaetes and mollusks.

Inferred behavior of Hourglass flatfishes suggests exploitation of different resources or of a given resource at different times or in different ways. For example, gear selectivity (trynet vs. dredge) and proportion of empty stomachs at various collection times indicate that Hourglass flounders are primarily daylight feeders while soles and tonguefishes are night feeders. *Etropus rimosus* and *Bothus robinsi* may occasionally forage well up into the water column, judging from such ingested items as crab megalops, chaetognaths, and semipelagic caridean shrimp.

Key. The following key is not intended as a functional aid to identification, although it may be helpful as such. Rather, it has been prepared to illustrate the more obvious characters allowing the 19 species to coexist along the same small segment of shelf, and to demonstrate ecological diversity among Hourglass flatfishes. Key characters such as habitat preference and spawning season are based upon observations and collections of specimens along the southwestern Florida coast, particularly during Project Hourglass.

ECOLOGICAL KEY TO THE FLATFISHES COLLECTED DURING PROJECT HOURGLASS (plus *Trinectes maculatus*)

1. Mouth nearly symmetrical, jaws and dentition of eyed side similar to those of blind side; mouth suited for seizing prey between jaws. Gut in form of a simple loop. Feeds during daytime, primarily by sight 2

1. Mouth strongly twisted toward blind side, dentition of eyed side poorly if at all developed; mouth suited for cropping food from the bottom with blind side of mouth. Gut in form of a complicated loop. Feeds at night, primarily by olfaction 12

2. Large flounders, attaining a maximum size of 290 mm or more. Mouth armed with strong canine teeth. Adults piscivorous 3

2. Small flounders, not exceeding 280 mm. Mouth without strongly differentiated teeth. Feeds primarily on foods other than fish 4

3. Attains a maximum size of about 700 mm. Abounds in bays and shallow coastal waters; seldom occurs beyond 18 m. Spawns from November through February . . . . *Paralichthys albigutta*

3. Does not exceed 300 mm. Absent from bays and coastal waters of 6 m or less, reaching maximum density at 37 m. Spawns during April and May . . . . *Cyclopsetta fimbriata*

4. Mouth small, upper jaw about 25% head length, reaching to anterior edge of lower eye. Diet probably includes substantial proportion of polychaete worms 5

4. Mouth large, upper jaw usually exceeding 35% head length, reaching beyond anterior edge of lower eye. Diet probably seldom includes polychaete worms 8

5. Characteristically associated with coral reefs (Starck, 1969) (and thus occurring on the Florida Shelf only as a stray) . . . . *Bothus ocellatus*

5. Not associated with coral reefs 6

6. Attains a maximum size of about 150 mm. Teeth well developed on jaws of eyed side. Gill rakers short and stubby . . . . *Bothus robinsi*

6. Seldom exceeds 100 mm. Teeth scarcely if at all developed on upper jaw of eyed side. Gill rakers short and slender 7

7. Makes occasional excursions off bottom to take pelagic food. Limited to nearshore waters of 18 m or less, with maximum density at 6 m. Typically associated with sediments containing quartz sand. Spawns from March through May or June . . . . *Etropus crossotus*

7. Not known to feed pelagically. Seldom found in depths less than 37 m. Typically associated with sediments of shell sand. Spawns from June through August . . . . *Etropus rimosus*

8. Occurs primarily in bays or shallow coastal waters out to 37 m 9

8. Occurs primarily at depths of 37 m and beyond 10

9. Reaches a maximum size of 400 mm. Gill rakers short and broad; diet probably includes a substantial proportion of fish. Commonly found in bays and estuaries, at depths of 1 m or less, and in salinities less than 5°/₀₀ . . . . *Ancylopsetta quadrocellata*

9. Does not exceed a length of 165 mm. Gill rakers long and slender; diet probably seldom includes fish. Seldom found in bays and estuaries; not known from salinities less than 25 °/₀₀ . . . . *Citharichthys macrops*

10. Reaches a maximum size of about 55 mm. Diet includes a substantial proportion of small crustaceans (chiefly amphipods) and probably seldom includes fish. Limited to depths greater than 37 m . . . . *Citharichthys gymnorhinus*

10. Reaches a maximum size of 225 mm or more. Adult diet includes crustaceans (usually larger than amphipods) and fish. Not limited to depths of 37 m or more 11

11. Adults sexually dimorphic, males attaining a maximum size of over 250 mm, females seldom exceeding 200 mm. Gill rakers stout but of moderate length. Bathymetrically widespread, from 6 - 73 m and probably beyond, with no sharp peaks of maximum population density . . . . *Syacium papillosum*

11. Adults not sexually dimorphic, males and females probably reaching a maximum size of some 225 mm. Gill rakers broad and very short. Bathymetrically restricted to a rather narrow depth range (37 - 73 m), with maximum population density at 55 m . . . . . . *Gastropsetta frontalis*

12. Virtually restricted to bays and shallow inshore waters; infrequently occurring on the open shelf to a depth of 6 m 13

12. Restricted to open shelf waters, almost exclusively in depths exceeding 6 m 15

13. Attains a maximum size of about 125 mm. Broadly euryhaline, frequently entering brackish or fresh waters. Rarely occurs on the open shelf . . . . *Trinectes maculatus*

13. Attains a maximum size of over 150 mm. Seldom found in salinities less than 15 °/₀₀. Occasionally occurs on the open shelf 14

14. Anterior parts fringed with dermal cirri, probably sensory in function. Juveniles and adults occasionally feed on surface plankton. Large adults not known to leave the bays. Spawns from April through November . . . . *Achirus lineatus*

14. Anterior parts not fringed with dermal cirri. Juveniles and adults not known to feed on surface plankton. Large adults (over 120 mm) occurring on the shallow open shelf, but not in the bays. Spawns from March through August . . . . *Symphurus plagiusa*

15. Attains a maximum size of about 80 mm 16

15. Attains a maximum size of about 150 mm or more 17

16. Spawns from October through January . . . . *Symphurus parvus*

16. Spawns from April through July . . . . *Symphurus minor*

17. Occurs in depths of less than 37 m, typically associated with sediments containing quartz sand . . . . *Symphurus urospilus*

17. Occurs primarily in depths of 37 m and beyond, typically associated with sediments of shell, algal and oolite sand 18

18. Attains a maximum size of over 200 mm. Body scaled; dermal cirri absent . . . . *Symphurus diomedianus*

18. Attains a maximum size of about 150 mm. Scales absent; anterior parts bearing dermal cirri, probably sensory . . . . *Gymnachirus melas*

ZOOGEOGRAPHY OF THE GULF OF MEXICO FLATFISHES

The flatfishes are a well defined group, their asymmetry uniquely adapting them to close association with the substrate. Many are but a single trophic level from their suspension and deposit-feeding prey. Despite limitations imposed by their basic design, they differ considerably in size, color, food habits and behavior, and they occupy a variety of niches. Gulf of Mexico flatfishes demonstrate this variety but still form a unified group well-suited for zoogeographical analysis.

Zoogeographers typically define their regions through comparisons of faunal lists. The most comprehensive and revealing use of this technique was made by Ekman (1953), who ascertained major zoogeographical provinces of the world's seas. Such comparisons ordinarily show fauna to be variously endemic, circumglobal, disjunct, or coincident with that of other regions. Percentages of "faunal coincidence" are often used to quantify relationships leading to the proposal of faunal "barriers" such as land masses, oceanic deeps or thermal boundaries. This approach is of course reliable only within the bounds of taxonomic certainty, and its scope extends only to the limits of reliable lists.

For subdividing a major region (having by definition a somewhat homogeneous biota), analyses must proceed at the species level. Barriers are less pronounced, and the precise extent of a given sub-region is frequently disputed. Hedgpeth (1953:201) noted that delineation of biotic provinces usually varies with the author's judgment. However, one may more precisely say that distributions differ from group to group according to a variety of physical and biological factors.

For example, the typically West Indian gorgonians of the Tortugas and lower Florida Keys, which are likely limited by temperature, are replaced north of Tampa Bay by a fauna "clearly identical with but discontinuous from that of the Carolina coast" (Bayer, 1954:282). Distribution of algae is likewise influenced by temperature, that of the eastern Gulf being primarily tropical (Taylor, 1954:177; Earle, 1969:232; Dawes and Van Breedveld, 1969:13), with the northern Gulf supporting a considerably varied tropical flora supplemented seasonally with a temperate element related to the east coast of the United States but not present in southern Florida (Humm and Taylor, 1957:231). The penaeid shrimp, many of which range from temperate to tropical waters, are sensitive to substrate as a distributional agent (Williams, 1958; Pérez Farfante, 1969). In the eastern

Gulf, commercial penaeids are distributed according to bottom type and inshore nursery areas, a break in species composition occurring in the northeastern corner (Hildebrand, 1954:326, 350). Substrate is also of primary importance in determining the occurrence of marine plants; substrate differences along the eastern Gulf provide the principal basis for regions there recognized by Earle (1969:77).

Along the Florida west coast alone, faunal boundaries have been variously proposed for Apalachicola, Cedar Keys, Anclote Keys, Tampa Bay, Charlotte Harbor, Cape Romano and Cape Sable, in each case with some justification. Lack of agreement has thus been generated more by distributional factors among benthic groups than by varying whims of their investigators. Despite his criticism, Hedgpeth (1953:210) acknowledges that "the object of interpreting faunal relationships is not to stress differences or to point out resemblances but to indicate the processes resulting in both faunal composition and mass."

Most Gulf of Mexico groups are characterized by certain recognizable and recurring patterns. These were recognized for the fishes by Evermann and Kendall (1900) and have since been reaffirmed by most authors:

1. A small endemic component. According to Hedgpeth (1953:210), the small number may reflect prevailing environmental extremes, enabling development of large populations of wide-ranging adaptable species at the expense of development of indigenous forms.

2. A West Indian component. Some authors, including Ekman (1953), regard the entire Gulf as part of the West Indian (Caribbean) province.

3. A temperate component, related to the fauna of the east coast of the United States. This component is frequently discontinuous, being shared by the Atlantic and northern Gulf coasts, but absent from southern Florida and the Caribbean. The disjunct pattern is generally thought to have been generated either following periods of Pleistocene submergence of the Florida peninsula or following warmer interglacial periods when southerly displaced faunas retreated northward along either coast.

Procedures

Flatfish assemblages from various parts of the Gulf of Mexico were compared to corresponding assemblages both within the Gulf and elsewhere. Areas within the Gulf were chosen on the basis of known or suspected distributional patterns. Degrees of correspondence were determined by a modified analysis of faunal coincidence in which relative species abundance was considered.

Most species occur on the open shelf, within fairly well-defined bathymetric zones. Rationale for using the 100 fm (183 m) isobath as a zonal boundary has been developed by Thompson (1963:20). The Gulf of Mexico shelf, extending from the northeastern tip of Yucatan (Cabo Catoche) around to and including the Florida Keys, was divided into seven parts (Figure 37), and the flatfish fauna tabulated for each:

1. *Florida Keys.* Geographically the Florida Keys are a 200 mile island chain along the northern edge of the Florida Straits from the Tortugas Keys to Biscayne Bay. Their biota is strongly influenced by the Gulf Stream, and is typified by nearshore reefs of living coral. Similar reefs extend, at increasing depths, northward along the Florida east coast to

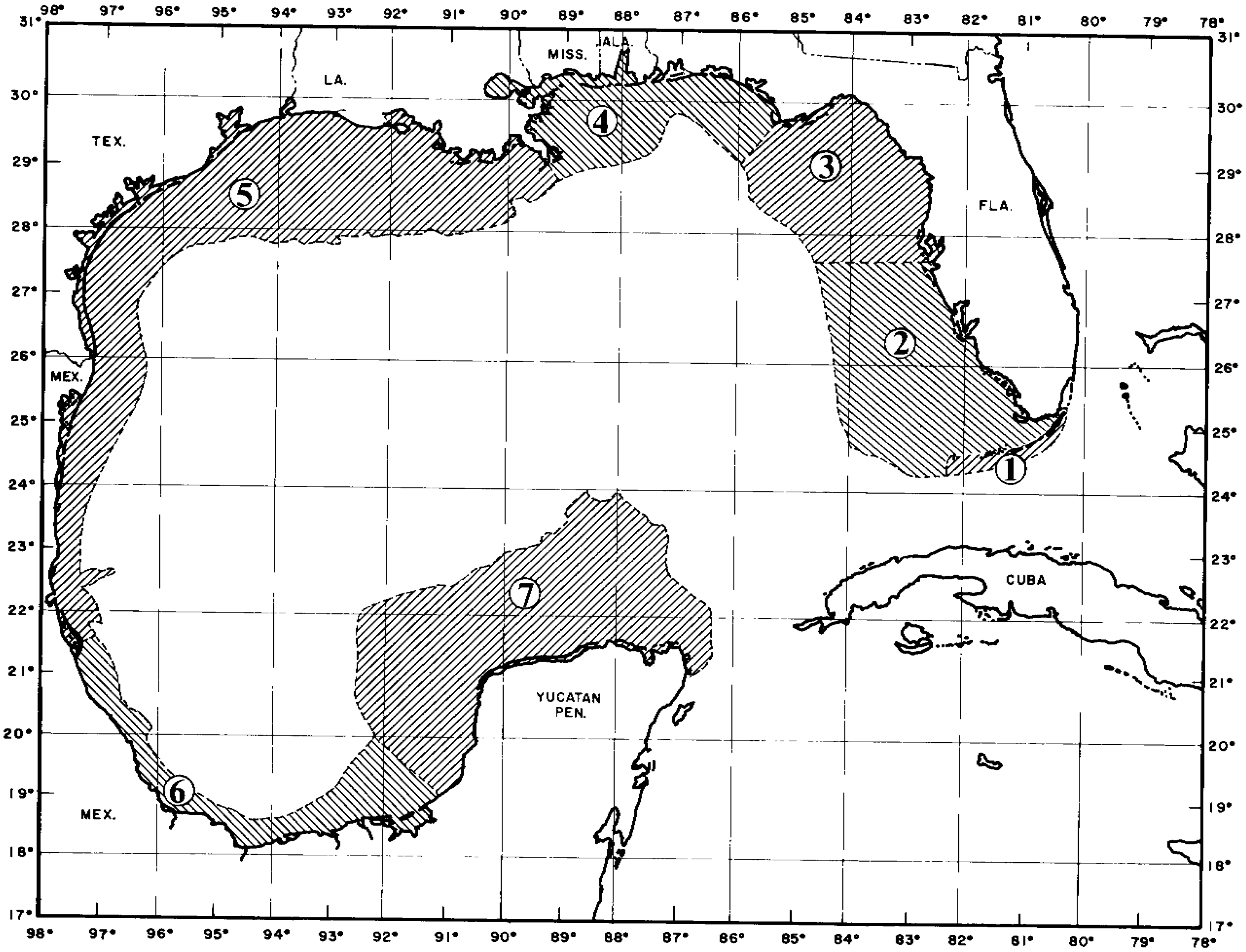

Figure 37. Gulf of Mexico shelf (shore to 100 fm isobath), showing divisions used in zoogeographical analysis of the flatfishes.

about Jupiter, a point thought by some authors (e.g., Clench, 1945) to mark the southern extent of the so called Transatlantic Province. Reef biota of this northward extension is essentially that of the Florida Keys proper, but the inshore area, including Biscayne Bay, supports a substantial number of temperate continental species.

The Florida Keys are herein defined as the continental shelf along the northern edge of the Florida Straits from Key Largo to the Tortugas. Principal ichthyofaunal surveys are those of Longley and Hildebrand (1941) for the Tortugas and Starck (1968) for Alligator Reef. Certain collection localities in the former are vague, and more properly refer to the Florida Shelf.

2. and 3. *Florida Shelf.* This is a broad oceanic shoal, physiographically similar to the adjacent plain. In a representative shelf segment off central Florida, Gould and Stewart (1956) found lithified sediments of cemented lime, including 1) nearshore deposits of cemented shell beachrock, 2) limestone, ranging from soft marl to conglomeritic and foraminiferal limestone, 3) small patches of living and dead coral, and 4) calcareous algae, primarily in 30-50 fm (55-92 m). These sediments are covered in places by a thin veneer of unconsolidated sediments arranged in zones paralleling the coast. Proceeding seaward these are quartz sand, broken shell, algal sand, white sand, and foraminiferal sand and silt. According to van Andel (1960:51), sediments from the northeastern Gulf Shelf extend well onto the Florida Shelf.

For this analysis, and for the accompanying flatfish keys, the Florida Shelf extends from southern Florida Bay northward to Cape San Blas. The area so defined corresponds in a general way to the "sponge grounds," proposed by Hedgpeth (1954:206) as one of four major bottom communities of the Gulf of Mexico; the continuity of this biotope has been emphasized by Briggs (1958:244). Most systematic sampling programs other than Hourglass collections have been confined to bays and inshore areas (e.g., Reid, 1954; Joseph and Yerger, 1956; Springer and Woodburn, 1960). For offshore areas both here and elsewhere, collections by U.S. Fish and Wildlife Service vessels (Springer and Bullis, 1956; Bullis and Thompson, 1965) have been used, but cautiously. At the level of Tampa Bay, the area is arbitrarily divided into a South Florida Shelf (2) and North Florida Shelf (3).

4. *Northeastern Gulf Shelf.* (Cape San Blas to Mississippi Delta). Dominant shelf sediments in this area are extensive reaches of quartz sand; at the outer shelf margin are extensions of the algal and foraminiferal sand zones recognized off central Florida (Gould and Stewart, 1956:16). Deltaic sediments (sand, silt and mud) occur immediately east of the Delta (Shepard, 1958:158), while some silt and clay are deposited locally by the Apalachicola River (Lynch, 1954:78). Ichthyofaunal lists are available for Alabama (Boschung, 1957), St. Andrews Bay, Florida (Vick, 1964), and Pensacola Bay, Florida (Cooley, in press).

5. *Northwestern Gulf Shelf.* (Mississippi Delta to Cabo Rojo, Veracruz). This area corresponds to two Gulf provinces of Pulley (1952), his "northwestern Gulf" and "Texas transitional." Deposits are characterized by sands, silts and clays, delivered primarily by the Mississippi River and the Rio Grande. Sand-size particles are found only in bays and inshore areas along most of the coast, while fine silt occurs across the entire shelf (van Andel, 1960:40). Much of the material, particularly in the northern Gulf between 92° and

95°, was deposited during older cycles of sedimentation (Ballard and Uchupi, 1970:550). Details of surface deposits between the Mississippi Delta and the Rio Grande are given by Curray (1960) and Krawiec (1966). Little is known about the sediments south of the Rio Grande (Yanez, 1968:3).

Results of numerous faunal surveys are available for Louisiana and Texas waters. These include the comprehensive survey of Texas marine fishes by Gunter (1945) and the more recent annotated list by Hoese (1958). Much of our knowledge of shelf fishes south of the Rio Grande is from analyses of fauna associated with commercial shrimps, particularly Hildebrand's (1954) collections from the "24-10 grounds."

At the outer edge of the northern Gulf shelf are areas of high relief supporting typical coral reef assemblages which, according to Hildebrand *et al.* (1964:132), are the source of tropical forms occasionally found along the coast.

6. *East Mexican Shelf* (Cabo Rojo, Veracruz to Sabuncuy, Campeche). Sedimentology and oceanography of the narrow continental shelf off the Mexican states of Veracruz and Tabasco are essentially unknown (Yanez, 1968:3). Lynch (1954:79, Fig. 16), using data compiled from several sources, has shown the sediments to be primarily mud, with a narrow band of sand inshore. On the inner shelf west of Laguna de Terminos in the southern Campeche Gulf are deltaic sediments of quartz sand and of alluvial material rich in organics; east of the Laguna are biogenous sediments, chiefly mollusk shells broken down to all sizes (Yanez, 1968). This transition, recognized by Springer and Bullis (1954:4) as occurring roughly off Sabuncuy, fairly well divides the brown and pink shrimp fisheries (Hildebrand, 1955:225).

7. *Yucatan Shelf* (Sabuncuy, Campeche to Cabo Catoche, Yucatan). This area resembles the Florida Shelf in being a broad limestone plateau with a minimum of land-derived detrital sediments. The shelf is of limestone overlain by a thin blanket of unconsolidated sediment, much of which is associated with earlier sea levels. According to Harding (1964:24), these sediments consist of skeletal remains of various planktonic and benthonic organisms, ooids, calcareous pellets, lithic fragments and grapestone aggregates. Logan *et al.* (1969) divided the shelf sediments into four lithologic units (Sigsbee Blanket, Progresso Blanket, Sisal Blanket, Yucatan reef unit), and described the composition of each.

   Fishes of Alacranes Reef have been studies by Hildebrand *et al.* (1964), of Triángulos Oeste Reef and Cayo Arenas by Chavez (1966). Fishes associated with commercial shrimp catches west of the peninsula have been documented by Hildebrand (1955).

Flatfishes were tabulated from the following areas outside the Gulf of Mexico:

1. *Antilles.* Few differences are apparent between the Antillean ichthyofauna and that of coastal Central and South America. Distinctions are here made solely for convenience. Recent checklists are available for Cuba (Duarte-Bello, 1959), Jamaica (Caldwell, 1966) and elsewhere. Randall (1968) lists only those flatfishes found near coral reefs.

2. *Central and South America.* This includes shelf areas along the coast from the

northeastern tip of Yucatan to eastern Brazil. Helpful sources of information are Lowe (1962), Caldwell (1963), Cervigon (1966), and Bayer *et al.* (1970).

3. *Bahamas.* Although geographically extra-limital, its fauna is distinctly West Indian. Major reference: Böhlke and Chaplin (1968).

4. *Southeastern Florida to Cape Canaveral.* Surprisingly little has been published on the shelf fishes of this area. A list of Biscayne Bay fishes compiled by Voss *et al.* (1969) has been included in de Sylva's (1970) recent report. Lists are available from the Jupiter and Loxahatchee Rivers (Christensen, 1965) and the St. Lucie River (Springer, 1960; Gunter and Hall, 1963). Landings at Cape Canaveral have not been considered, since trawlers frequently forage well afield both north and south of the Cape.

5. *Cape Canaveral to Cape Hatteras.* Checklists are available for several local areas. A major recent source of shelf records is Struhsaker (1969).

6. *Cape Hatteras to Cape Cod.* In addition to local lists, primary references are Hildebrand and Schroeder (1928) and Bigelow and Schroeder (1953).

Analysis

All flatfishes known to occur in the Gulf of Mexico are listed by area in Table 18. Those designated "deeper than 100 fm" typically inhabit depths beyond the continental shelf. Only one, *Symphurus marginatus*, is yet unknown from less than 100 fm (183 m). Swingle (1971:335) has recently shown that *Cyclopsetta decussata* (known only from the type, collected 40 mi south of Port Aransas, Texas) is a synonym of *C. chittendeni.*

Percentage of faunal coincidence between any two given areas was generally an unreliable (or at least unrevealing) indication of actual relationship between their flatfish faunas. This percentage, initially defined as the ratio of shared (coincident) flatfish species to the total for the two areas, was therefore modified by weighing each species according to its abundance in each area.

For example, *Syacium papillosum* and *Paralichthys albigutta* abound on the Florida Shelf, while *S. gunteri* and *P. lethostigma* are scarce. In the western Gulf the opposite situation prevails, with *S. gunteri* and *P. lethostigma* abundant and the other two scarce. Faunal differences are not apparent when based on the mere presence of these species, whereas a comparison weighted for abundance allows a certain amount of discrimination.

A modified index was therefore devised in which each species was rated (within the limits of available data) according to its abundance in each area as "unreported," "rare" (known only from one or a very few records), "common" (regularly reported), or "abundant." Each species may then contribute an increment to the rate of faunal coincidence according to the observed difference in its abundance between two given areas. Increments range from 0 for a species abundant in one area but absent in the other, to 1 for a species abundant in both areas.

In comparing the faunas of two areas the sum of these increments, expressed as percentage of the total number of species, may be expressed by

$$F = \frac{100 \sum_{i=1}^{n} d_i}{n}$$

TABLE 18. DISTRIBUTION OF GULF OF MEXICO FLATFISHES, WITHIN AND OUTSIDE THE GULF.

	Florida Keys	S. Florida Shelf	N. Florida Shelf	Northeastern Gulf Shelf	Northwestern Gulf Shelf	East Mexican Shelf	Yucatan Shelf	Caribbean Antilles	Central and South America	Bahamas	Bermuda	S. Florida to C. Canaveral	C. Canaveral to C. Hatteras	North of Cape Hatteras	Deeper than 100 fm.
Ancylopsetta dilecta	+	+	+	+	+		+	+	+				+		
Ancylopsetta quadrocellata		+	+	+	+	+	+					+	+		
Bothus ocellatus	+	+						+	+	+	+	+	+	+	
Bothus robinsi		+					+	+	+	+		+	+		
Citharichthys abbotti						+									
Citharichthys arctifrons	+		+				+					+	+	+	+
Citharichthys cornutus	+		+		+		+	+	+	+			+	+	+
Citharichthys dinoceros	+	+													+
Citharichthys gymnorhinus		+						+	+	+					
Citharichthys macrops	+	+	+	+	+		+		+			+	+		
Citharichthys spilopterus	+	+		+	+	+		+	+			+	+	+	
Cyclopsetta chittendeni				+	+	+	+	+	+						
Cyclopsetta fimbriata	+	+	+	+	+		+	+	+				+		
Engyophrys sentus	+				+	+			+	+					
Etropus crossotus		+	+	+	+		+	+	+			+	+	+	
Etropus microstomus				+	+								+	+	
Etropus rimosus		+	+										+		
Gastropsetta frontalis	+	+	+		+		+		+	+			+		
Monolene sessilicauda	+		+	+				+	+			+	+	+	+
Paralichthys albigutta		+	+	+	+					+		+	+		
Paralichthys lethostigma		+	+	+	+							+	+		
Paralichthys squamilentus	+	+	+	+	+							+	+		
Scophthalmus aquosus					+								+	+	
Syacium gunteri	+		+	+	+	+	+	+	+						
Syacium micrurum	+	+		+		+		+	+	+	+	+	+		
Syacium papillosum	+	+	+	+	+		+	+	+		+	+	+		
Trichopsetta ventralis	+		+	+		+					+	+			
Poecilopsetta beani		+		+	+			+	+				+	+	+
Achirus inscriptus	+							+	+	+					
Achirus lineatus	+	+	+	+	+		+	+	+			+	+		
Gymnachirus melas	+	+	+	+					+	+		+	+	+	
Gymnachirus nudus							+	+	+			+			
Gymnachirus texae			+	+	+	+	+								
Trinectes maculatus	+	+	+	+	+				+			+	+	+	
Symphurus arawak	+							+	+	+					
Symphurus civitatus			+	+	+	+	+						+	+	
Symphurus diomedianus	+	+	+	+	+	+	+		+			+	+		
Symphurus marginatus															+

TABLE 18, CONTINUED. DISTRIBUTION OF GULF OF MEXICO FLATFISHES, WITHIN AND OUTSIDE THE GULF.

	Florida Keys	S. Florida Shelf	N. Florida Shelf	Northeastern Gulf Shelf	Northwestern Gulf Shelf	East Mexican Shelf	Yucatan Shelf	Caribbean Antilles	Central and South America	Bahamas	Bermuda	S. Florida to C. Canaveral	C. Canaveral to C. Hatteras	North of Cape Hatteras	Deeper than 100 fm.
Symphurus minor		+	+									+	+	+	
Symphurus parvus	+	+			+		+					+			
Symphurus pelicanus					+		+	+							
Symphurus piger	+				+							+			+
Symphurus plagiusa	+	+	+	+	+		+	+	+	+		+	+	+	
Symphurus pusillus					+									+	
Symphurus urospilus	+	+	+				+					+	+		
BOTHIDAE (27)	16	17	15	16	18	7	13	13	16	8	3	14	21	8	4
PLEURONECTIDAE (1)	0	1	0	1	1	0	0	1	1	0	0	0	1	1	1
SOLEIDAE (6)	4	3	4	4	3	1	3	3	5	2	0	4	3	2	0
CYNOGLOSSIDAE (11)	6	5	5	3	7	2	6	3	3	2	0	6	5	4	2
TOTAL (45)	26	26	24	24	29	10	22	20	25	12	3	24	30	15	7

where F = weighted percentage of faunal coincidence
n = total number of species in both areas, and
d = contributing increment, according to the difference in abundance of a species between the two areas.

A matrix of values so derived is presented in Table 19. Despite a number of obvious shortcomings in this method, ability to discriminate between the various faunas is substantially improved when quantitative differences in species abundance are considered. Reid (1954:74), in his zoogeographical comments on the fishes of Cedar Keys, apparently recognized, but did not attempt to quantify, the increased significance of this type of analysis when he stated, "Although the total number of species making up a given fauna may be of some zoogeographical interest as an expression of the highways and barriers operating, it is of far more ecological significance to know the relative population densities of the more abundant forms constituting the fauna. The genera represented by many species and the species represented by many individuals are potent biotic factors in the environment, while the forms represented by the occasional or sporadic straggler obviously contribute little to the community." Similarly, Hildebrand (1954:345; 1955:225) recognized that most differences between various Gulf faunas are quantitative rather than specific.

TABLE 19. WEIGHTED PERCENTAGES OF COINCIDENCE FOR FLATFISH FAUNAS WITHIN AND OUTSIDE THE GULF OF MEXICO.

	S. Florida Shelf	N. Florida Shelf	Northeastern Gulf Shelf	Northwestern Gulf Shelf	East Mexican Shelf	Yucatan Shelf	Caribbean Antilles	Central and South America	Bahamas	S. Florida to C. Canaveral	C. Canaveral to C. Hatteras	North of C. Hatteras
Florida Keys	48	49	43	40	21	44	29	35	26	50	45	23
S. Florida Shelf		64	46	41	14	43	25	29	24	52	57	21
N. Florida Shelf			60	43	16	49	20	25	15	48	60	23
Northeastern Gulf Shelf				62	28	44	26	28	14	51	53	23
Northwestern Gulf Shelf					29	47	25	23	12	36	41	24
East Mexican Shelf						33	14	14	14	14	14	13
Yucatan Shelf							27	23	18	37	39	19

Discussion

Highest percentage of flatfish coincidence among the areas compared in Table 19 is between the North Florida Shelf and South Florida Shelf, likely reflecting the similar biogenous sediments of the two areas.

Florida Shelf flatfishes differ from the majority of faunal groups, including the fishes generally (see Gunter *et al.*, 1948:314), in that the usual case involves an observable transition from temperate to tropical species. Several authors have attempted to locate the faunal "break" between the two. Ginsburg (1952b:99), for example, proposed Cape Romano for the fishes, while Coomans (1962:100) designated Cedar Key as the northern boundary of the tropical Caribbean molluscan province based on the annual surface isotherm of 25°. Parenthetically, scarcity of hermatypic corals north of the Florida Keys, supposedly the result of temperature limitation (Smith, 1954:291), is probably associated with other environmental parameters as well (e.g., water clarity and currents). Reefs of living coral have been encountered in the northern Gulf (Hildebrand *et al.*, 1964:132), and reef corals have recently been documented along the North Carolina coast where temperatures may remain below the generally accepted 16° minimum tolerance temperature for about three months of the year (Macintyre and Pilkey, 1969:374).

For most Florida Shelf groups the transition from temperate to tropical is probably gradual. Reid (1954:89) has shown that among the fishes, southern forms begin to appear somewhat irregularly and seasonally while species density of northern fishes decreases.

Work (1969:624) has shown, by way of several examples, that the coastline from about Clearwater to the Aucilla River (roughly corresponding to the North Florida Shelf) has, by "some peculiar hydrographic anomaly," a much more tropical molluscan fauna than does southwestern Florida. Work has further shown (p. 625) that the number of Carolinian species (Cape Hatteras to

Florida) also increases as one moves from southwestern Florida toward the Apalachee Bay region of the northeastern Gulf of Mexico. Neither pattern is apparent as such among North Florida Shelf flatfishes. They sustain a strong relationship not only to adjacent areas (64 and 60%) but to the Yucatan Shelf (49%), the Florida Keys (49%) and the east coast of the United States (23-60%).

The northern limit of the Florida Shelf (as herein defined) marks the approximate eastern limit of the ranges of several flatfishes abounding in the northwestern Gulf, namely, *Paralichthys lethostigma, Trichopsetta ventralis, Ancylopsetta dilecta, Cyclopsetta chittendeni, Syacium gunteri,* and *Gymnachirus texae.* Their abundance declines sharply at the Mississippi Delta, but they are occasionally encountered off Cape San Blas, where they occur in association with substrates locally similar to those at the Delta and westward. This same phenomenon has been reported for commercial shrimp, the Apalachicola white shrimp fishery being considered extra-limital from that of the western Gulf (Hildebrand, 1955:225). This zoogeographic extension for certain northwestern Gulf animals may derive its influence from terrigenous materials delivered by the Apalachicola River. Ginsburg (1952b:101) recognized similar distributional peculiarities among certain benthic fish species, but failed to consider substrate as a significant distributional factor. Instead, he postulated an "unrecognized past barrier somewhere between what is now Cape San Blas and Mobile Bay."

The importance of the Mississippi Delta has been disputed as to its zoogeographic influence on faunal distributions. Baughman (1950) considered the "vast silt-laden flood of the Mississippi" a major barrier, while other authors (e.g., Hildebrand, 1954:342) have minimized its influence. For the flatfishes, the 62% coincidence rate between the Northeastern and Northwestern Gulf Shelves implies little significance for the Delta as a distributional barrier. A much lower rate (43%) occurs between faunas of the North Florida Shelf and Northwestern Gulf Shelf, where the distinction between biogenous and terrigenous sediments is clear-cut.

The western Gulf of Mexico shows a temperate to tropical transition parallel to that of the eastern Gulf, but collections along the Mexican coast have been less than adequate for most groups, and few opinions have been ventured on the location of a faunal break. For the commercial fishes, Hildebrand (1955:225) recognized a change from a fishery relying primarily on sciaenids in the north to one producing many centropomids and gerreids, the main break probably occurring in the vicinity of Tampico. The offshore Texas banks, bearing living reef coral and a tropical biota including "at least 50 species of fishes which have not been reported from Texas" (Hildebrand *et al.*, 1964:132), when thoroughly documented may alter many existing notions of Gulf of Mexico zoogeography.

Patterns of flatfish distribution and abundance in the western Gulf south of Texas are far from clear. Estimates here based on meager and restrictive data are in need of additional support, and emphasize the insufficiency of systematic sampling in this area. For the East Mexican Shelf, calculated rates of coincidence with other Gulf areas (Table 19) are probably deceptively low, although the area may well prove to be faunistically the most remote of the Gulf. The single endemic Gulf flatfish, *Citharichthys abbotti,* is known only from collections in this area.

The Yucatan Shelf (Sabuncuy to Cabo Catoche) has been extensively sampled by fishing vessels of the U.S. Fish and Wildlife Service, but these efforts have been directed primarily toward documenting potential fishery resources. In one of two recent systematic sampling efforts, Hildebrand *et al.* (1964) found the fauna of Alacranes Reef similar to that of the Florida Keys, with more than 90% of Alacranes fishes having been reported from the Tortugas. However, only one flatfish species was represented in these collections. The remaining 21 are found on the open shelf, and are more closely related to those of other Gulf of Mexico areas (including the Florida Keys) than to those of the Caribbean.

The Florida Keys reef fauna is unquestionably West Indian. At Alligator Reef only seven of the 389 "reef associated fishes" have not been reported elsewhere in the West Indies (Starck, 1968:10). Flatfishes, however, are seldom coralophilic; among 13 species collected by Starck (1968), only two, *Bothus ocellatus* and *Symphurus arawak*, are typically associated with coral reefs. The remainder, though normal residents of the area, are more characteristically associated with other biotopes.

As such, the Florida Keys flatfishes are related to the warm-temperate fauna of the Florida Shelf and east coast of the United States, while their West Indian affinities are less pronounced (Table 19). Thus the zoogeographical relationship of the Florida Keys to the Gulf of Mexico is strong insofar as the flatfishes are concerned, while the coral reef fauna is more closely allied to that of the West Indies.

Latitudinal distributions of Gulf of Mexico flatfishes are arranged in Figure 38 according to the northern limits of their ranges. By this approach major geographical breaks in northward distribution can be seen, stepwise, these being the northern Gulf coast, Cape Hatteras, and Cape Cod. Only two Gulf of Mexico species, *Symphurus minor* and *Scophthalmus aquosus*, occur north of Cape Cod, and neither reaches the southern tip of Florida. *S. aquosus* and *Etropus microstomus* are examples of species with a classically "disjunct" distribution, both occurring only in the extreme northern Gulf and along the east coast of the United States north of Cape Canaveral. Five Gulf of Mexico species are distributed transequatorially; another six reach nearly to the equator. Of these eleven, nine range northward along the east coast of the United States beyond 30°.

Table 20 lists the numbers of flatfish species known from areas outside the Gulf of Mexico, plus proportions of these faunas occurring in the Gulf. The values vary in about the same way as those in Table 19. From these tables it is quickly apparent that the Gulf of Mexico flatfish fauna is decidedly similar to that of the east coast of the United States. We may thus regard it as a well unified warm-temperate to subtropical fauna, closely resembling that of the so-called Carolinian sub-province (Cape Hatteras to south Florida), and rather distinct from that of the Caribbean.

The western North Atlantic flatfishes may be divided into three major shelf assemblages (Figure 39): 1) an arctic-boreal group, characterized by large pleuronectids whose centers of abundance are typically north of Cape Cod and whose southern limits seldom reach Cape Hatteras; 2) a warm-temperate to subtropical fauna with many bothids and few pleuronectids, overlapping the arctic-boreal fauna in the Mid-Atlantic Bight between Cape Cod and Cape Hatteras, extending southward through the Florida Keys and including the entire Gulf of Mexico; and 3) a Caribbean fauna, again dominated by bothids, extending along the coasts of Central and South America to Brazil, and including the Caribbean Antilles, the Bahamas and Bermuda.

SUMMARY

Flatfishes were sampled on the open shelf off southwestern Florida during Project Hourglass–28 months of systematic sampling (August 1965-November 1967) along two east-west transects off Egmont Key and Sanibel Island. Five stations (6, 18, 37, 55, and 73 m) were sampled monthly along each transect, using trawls and box dredge.

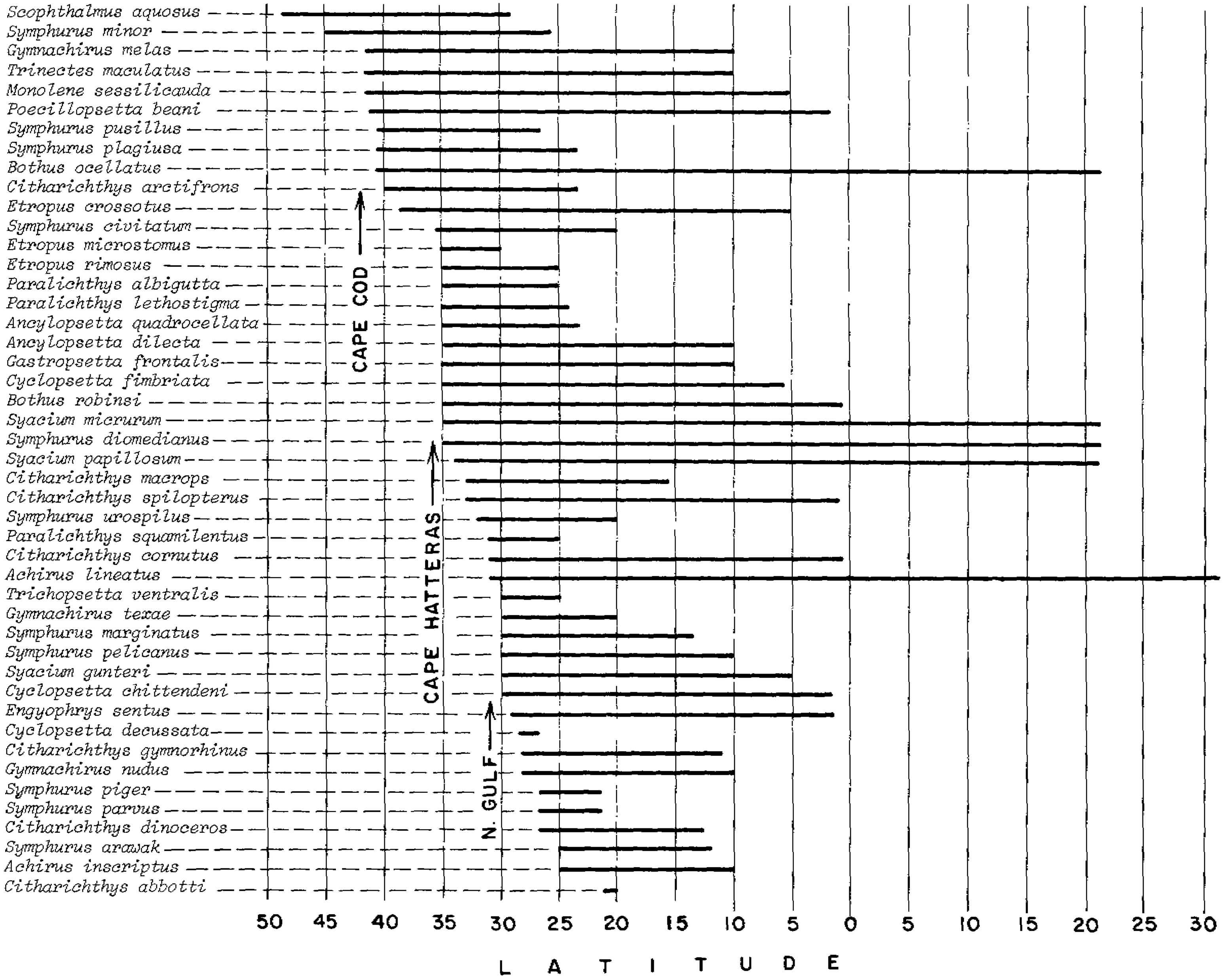

Figure 38. Latitudinal distribution of Gulf of Mexico flatfishes, arranged according to the northern limits of their ranges.

TABLE 20. NUMBERS OF FLATFISH SPECIES KNOWN TO OCCUR IN AREAS OUTSIDE THE GULF OF MEXICO, AND PROPORTIONS OF THESE FAUNAS OCCURRING IN THE GULF.

	Number of flatfish species	Number occurring in Gulf of Mexico	Percentage occurring in Gulf of Mexico
Southern tip of Florida to C. Canaveral	26	24	92.3
Cape Canaveral to Cape Hatteras	34	30	88.2
North of Cape Hatteras	25	15	60.0
Caribbean (Antilles and coastal)	43	25	58.1
Bahamas	18	11	61.1
Bermuda	4	3	75.0

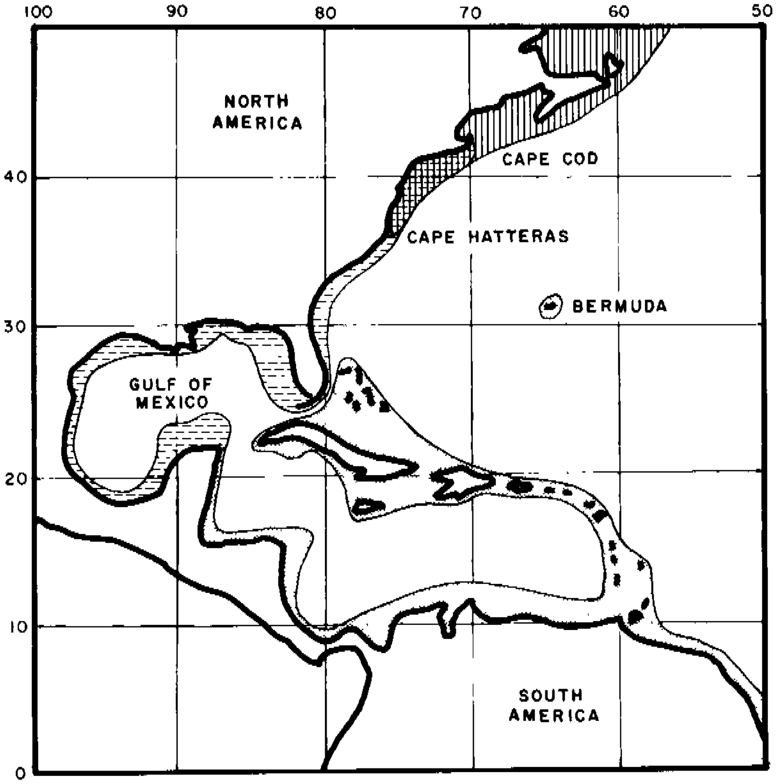

Figure 39. Major shelf assemblages of western North Atlantic flatfishes: 1) arctic-boreal, 2) warm-temperate to subtropical, 3) Caribbean.

Three families, 11 genera and 18 species were collected: *Paralichthys albigutta, Gastropsetta frontalis, Ancylopsetta quadrocellata, Cyclopsetta fimbriata, Etropus crossotus, E. rimosus, Citharichthys gymnorhinus, C. macrops, Syacium papillosum, Bothus ocellatus, B. robinsi, Achirus lineatus, Gymnachirus melas, Symphurus diomedianus, S. minor, S. parvus, S. plagiusa,* and *S. urospilus.* Insofar as possible the following information is presented for each species, based on

Hourglass material, various museum collections, and published reports: review of recent literature, descriptive notes, distribution, depth, substrate, hydrographic data, seasonality, diurnality, food and feeding habits, reproduction and commercial importance. Keys are presented for families, genera and species known to occur on the Florida Shelf, and for the western Atlantic species of *Citharichthys*. Among the species accounts, emphasized points include:

1. Among the three commercially important species of *Paralichthys*, only *P. albigutta* occurs regularly along the Florida west coast south of Apalachee Bay. It is the most important commercial flatfish landed in Florida, constituting about 57% of the catch.

2. *Cyclopsetta fimbriata* replaces its large northern Gulf congener, *C. chittendeni*, on the Florida Shelf. Spawning seasons of the two may be a half year out of phase.

3. *Etropus crossotus* is well separated from *E. rimosus* both morphologically and ecologically. The former is virtually restricted to depths of 18 m or less, while the latter seldom occurs in depths less than 37 m.

4. Inclusion of crab megalops and chaetognaths among the food of *Etropus crossotus* suggests occasional feeding excursions up into the water column. Similar feeding habits are implied for *Bothus robinsi*.

5. Extent and strength of cephalic squamation in *Etropus rimosus* varies, but males are generally better armed.

6. The diminutive *Citharichthys gymnorhinus* reaches maturity at 30 mm SL and attains a maximum size of some 55 mm. Its range is extended to include the Florida Shelf, Cuba, Virgin Islands, Venezuela and Guyana.

7. *Syacium papillosum* is the most abundant flatfish on the Florida Shelf. Food consists primarily of crustaceans, fishes, polychaetes and mollusks; feeding activity implies quiescent nocturnal behavior. Spawning occurs from February to as late as November, in depths greater than 18 m. Sexual maturity is reached at about 100-130 mm SL.

8. *Bothus robinsi* is sharply limited to depths less than 73 m; this restriction probably relates to differences in substrate and associated biota. Scarcity of 50-100 mm fish in Hourglass collections suggests that stocks were not uniformly sampled; possible explanations are given.

9. Diurnal differences were pronounced in catches of *Symphurus diomedianus*, with 81% collected at night. Crustaceans, particularly crabs, were the most frequently encountered food items, followed by polychaetes and gastropods.

10. Hourglass specimens of *Symphurus plagiusa* were significantly larger than those reported from contiguous bay waters, suggesting, among other possibilities, recruitment from the bays to the open shelf.

Spawning seasons of most Hourglass flatfishes are protracted, making modal size progressions of offspring difficult to follow. In general, duration of spawning is related to amount of seasonal fluctuation in the environment. "Hydrographic climates" are demonstrated for Hourglass stations, Tampa Bay and elsewhere.

Ecological diversity among Hourglass flatfishes is discussed. An "ecological key" is presented to illustrate the habits, mechanisms and other attributes allowing the 18 Hourglass flatfishes (plus *Trinectes maculatus*) to coexist along the same shelf segment without simultaneously competing for the same resources. The more obvious ecological distinctions involve fish size, depth, substrate, biotic communities, food, feeding mechanisms, and behavior.

Zoogeography of the Gulf of Mexico shelf flatfishes was investigated using a modified analysis of faunal coincidence in which relative species abundance was considered:

1. Seven subregions of the Gulf of Mexico shelf were considered: Florida Keys, South Florida Shelf, North Florida Shelf, Northeastern Gulf Shelf, Northwestern Gulf Shelf, East Mexican Shelf, and Yucatan Shelf. Six areas outside the Gulf were considered.

2. Highest percentage of coincidence within the Gulf is between the North Florida Shelf and South Florida Shelf, likely reflecting the similar calcareous sediments of the two areas.

3. Several species abounding on the Northwestern Gulf Shelf decline sharply in abundance at the Mississippi Delta but are encountered off Cape San Blas, where they are associated with substrates locally similar to those at the Delta and westward.

4. Based on percentage of faunal coincidence, the Mississippi Delta does not constitute a pronounced zoogeographical barrier for the flatfishes.

5. The East Mexico Shelf may well prove to be faunistically the most remote of the Gulf. The single endemic Gulf flatfish, *Citharichthys abbotti*, is known only from this area.

6. Although the Florida Keys reef fauna is unquestionably West Indian, its flatfish fauna is related to the warm-temperate fauna of the Florida Shelf and east coast of the United States. Thus the zoogeographical inclusion of the Florida Keys within the Gulf of Mexico is valid for the flatfishes but not for the Florida Keys ichthyofauna generally, nor for other predominantly coralophilic groups.

7. The western North Atlantic flatfishes can be divided into three basic zoogeographical assemblages, 1) an arctic-boreal fauna, characterized by large pleuronectids, overlapping in the mid-Atlantic Bight with 2) a warm-temperate to subtropical fauna, dominated by bothids, extending through the Florida Keys and including the entire Gulf of Mexico and 3) a Caribbean fauna, dominated by bothids, extending to Brazil and including the Bahamas and Bermuda.

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