COMPOSITION, ECOLOGY, AND DYNAMICS OF DEMERSAL FISH COMMUNITIES ON THE NORTHWESTERN GULF OF MEXICO CONTINENTAL SHELF, WITH A SIMILAR SYNOPSIS FOR THE ENTIRE GULF.

by

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ABSTRACT

Two major communities of demersal fishes are found over soft bottom on the continental shelf in the northwestern Gulf of Mexico inshore of the 91-m (50 fm = fathom) contour: 1) a white shrimp grounds community located at about 3.5-22 m (2-12 fm), and 2) a brown shrimp grounds community located at about 22-91 m (12-50 fm). The overall and seasonal compositions of these ichthyofaunas are described and their community ecology is discussed. The faunas of the two shrimp grounds were distinct at the family level except that a zone of faunal overlap occurred at 18-36 m (10-20 fm). Most species that were abundant on one shrimp grounds were absent or virtually absent on the other. The fish communities were structurally similar on the two shrimp grounds in that a single species and family dominated each community. These taxa were Micropogon undulatus and the family Sciaenidae on the white shrimp grounds, and Stenotomus caprinus and the family Sparidae on the brown shrimp grounds. Most species were not abundant. The ichthyofauna was richer on the brown shrimp grounds than on the white shrimp grounds. The fauna was richest in the cold months, especially on the brown shrimp grounds. The fishes of the white shrimp grounds have a strong affinity for estuaries whereas the fishes of the brown shrimp grounds are independent of estuaries.

Relative biomass was much higher on the brown shrimp grounds than on the white shrimp grounds. Relative biomass was much higher in summer than during winter, especially on the white shrimp grounds. Overall, 11.35 volumes of discard were landed to one volume of headed shrimp. We estimate that about 219,050 metric tons (483 million lb) of fish were discarded

annually in the Gulf by Texas-based shrimp trawlers during the period 1962-71.

The Gulf ichthyofauna apparently consists of one faunal assemblage that includes at least four major demersal fish communities whose distribution is largely determined by sediment composition, salinity (and/or associated factors), topographic relief and temperature.

Life histories and population dynamics are described for 15 species each of which made up 3% or more of the catch on a given shrimp grounds: *Arius felis*, *Halieutichthys aculeatus*, *Serranus atrobranchus*, *Stenotomus caprinus*, *Cynoscion arenarius*, *Cynoscion nothus*, *Micropogon undulatus*, *Stellifer lanceolatus*, *Upeneus parvus*, *Polydactylus octonemus*, *Trichiurus lepturus*, *Peprilus burti*, *Bellator militaris*, *Prionotus paralatus*, and *Syacium gunteri*. The demersal fishes of the two shrimp grounds appear to be similar in their population dynamics. This generalization and its implications may hold throughout the Gulf for demersal fish communities of soft bottoms on the continental shelf. Nearly all specimens captured were 200 mm or less in length with the exception of *Trichiurus lepturus*. Typical life spans appear to be only one or two years, so that these fishes must mature rapidly. Their theoretical total annual mortality rates are about 90-100%, so that there must be a rapid turnover of biomass on each shrimp grounds. Fishes with this type of life cycle tend to withstand extensive fishing without danger of overharvesting, so that they apparently have great fisheries potential. The Gulf shrimp fishery at present does not appear to be overharvesting the demersal fishes.

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INTRODUCTION

The most valuable fishery in the Gulf of Mexico depends on three species of shrimp: the brown (*Penaeus aztecus*), white (*P. setiferus*) and pink shrimp (*P. duorarum*). Large quantities of fishes are captured and discarded incidental to shrimping (Bullis and Carpenter 1968). The species composition of the catch in the northwestern Gulf is unknown, however, except for Hildebrand (1954, 1955); and the size compositions and magnitude of the catch are poorly known. Little is known about the life histories or population dynamics of the fishes of the northwestern Gulf, especially those inhabiting water deeper than 27 m (15 fm = fathom) despite numerous studies including Gunter (1938, 1941, 1945), Baughman (1950 a, b), Hildebrand (1954, 1955), Springer and Bullis (1956), Hoese (1958), Copeland (1965), Miller (1965), Hoese et al. (1968), and Moore, Brusher and Trent (1970). Most of the studies cited were qualitative, based on very small samples from the catch, and/or based on sampling at only a few stations off Port Aransas, Tex. (Fig. 1) in water shallower than 27 m.

The purposes of our study were to determine the biomass, species composition, and size distribution of the fishes caught by Texas-based shrimpers in the Gulf. This paper describes the diversity, annual and seasonal compositions, and relative biomasses of the fish communities, provides an estimate of the fish catch off Texas, and describes the size compositions and life histories of the more abundant fishes.

Many of our findings apparently have broad application in the Gulf though our study and all previous studies have been based upon poor experimental design, especially for estimating species abundance. The numbers of a species (abundance) captured in a unit of effort by a trawl can be described by the equation:

$$y_i = \mu + \{sv\} + e_i$$

where the particular observation y is denoted by i, μ is mean abundance in some defined area, e is random variation associated with the i'th observation, and sv represents sources of variation that influence abundance and cause contagion. Important sources of variation affecting catches of demersal fishes include temperature, topography, and substrate composition (Struhsaker 1969), time of day (Miller 1965; Dawson 1967; Moore et al. 1970), salinity (Gunter 1967) and their interactions and depth. If sources of variation are not recognized and included in the model, they are lumped with random variation and may cause serious misinterpretations. Previously published works from the Gulf have not attempted to identify quantitatively the sources of variation affecting catches. They also have not attempted random (or restricted random) sampling either geographically or in time. These shortcomings make "more than general" comparisons among studies hazardous, especially because demersal fishes of the Gulf apparently are short-lived and must undergo great seasonal fluctuations in abundance.

MATERIALS AND METHODS

Collections were made aboard commercial shrimp trawlers during normal operations, so that sampling locations, gear, and times were decided by the shrimpers. We improvised procedures to avoid conflict with their routine.

We spent 33 days in four cruises during the periods 27 Sept.-3 Oct. 1973 (September), 6-15 Jan. 1974, 23 Mar.-1 Apr. 1974 (March), and 25-29

June 1974 trawling from off the Colorado River to High Island (Fig. 1) on the white shrimp grounds (about 3.5-22 m; 2-12 fm) and off Freeport on the brown shrimp grounds (about 22-91 m; 12-50 fm). We made 21 tows in 82.5 hr of fishing time on the white shrimp grounds and made 39 tows in 240.5 hr of trawling on the brown shrimp grounds (Table 1). We worked on both shrimp grounds during the first two cruises; but the March and June cruises were confined to the brown and white shrimp grounds, respectively. Figure 2 indicates the depths sampled. We trawled on the white shrimp grounds during daylight in June and January but round-the-clock in September. We fished from just before dark to just after dawn on the brown shrimp grounds. We towed four 12-m balloon trawls during September, two 18-m balloon trawls during January and March, and one 7.5-m balloon trawl during June. Each trawl had a tickler chain, and tow durations varied from about 1-12 hr.

After the catch was dumped on the deck we helped separate the shrimp from the discard catch (everything but shrimp). We tried to set aside a specimen of each species of fish captured to develop a species list. A sample of the discard (about 18 kg) was obtained by shoveling small portions from various areas of the deck into a 19-liter container. We shoveled the remaining discard into 36-kg fish baskets to measure its quantity, and the shrimpers estimated the weight of the "headed" shrimp catch. All fishes in the 18-kg sample were identified, enumerated and measured. Many were preserved and returned to the laboratory to confirm field identifications.

Relative discard biomass was expressed as catch/tow, because there was no apparent relationship between size of the catch and tow duration on either of the two grounds within seasons. The discard/shrimp ratio was estimated by the ratio of the mean catches, and its confidence limits were estimated by the normal approximation assuming a completely random sample of tows (Cochran 1963). Certain assumptions of these procedures (notably the random sample of tows) were not fulfilled. Cochran discusses the assumptions and consequences of their failure: in general, our estimate of the variance is probably too small and the confidence limits are probably too narrow.

Length frequencies were expressed as moving averages of three using total length (TL) or fork length (FL) depending upon species. Total length was taken to speed field processing of certain abundant fork-tailed fishes. The linear regressions of fork length on total length were calculated using program BMD-05R (Dixon 1967) to convert total length to fork length.

RESULTS

Family and Species Composition

We captured 103 species of fishes representing 43 families in the 18-kg samples (Appendix 1). An additional 58 species from 33 families were culled from the main catch (Appendix 2). Overall, we captured 161 species from 43 families. The bathymetric distributions of families and species in the areas sampled were similar to the defined limits for the two shrimp grounds, although a zone of faunal overlap occurred at about 18-36 m (10-20 fm) (Fig. 2).

Ichthyofaunas of the white and brown shrimp grounds were distinct at the family level (Table 2). Nine families constituted 98% of the catch (by numbers) on the white shrimp grounds. The Sciaenidae (64%), Trichiuridae

(14%), Polynemidae (5%), and Ariidae (5%) made up 88%. Fifteen families made up 99% of the catch on the brown shrimp grounds. The Sparidae (40%), Triglidae (17%), Sciaenidae (8%), Mullidae (6%), Bothidae (6%), and Serranidae (5%) made up 82%. Only the Sciaenidae, Bothidae, Carangidae and Stromateidae made up 1% or more of the catch on each grounds. The Sciaenidae were greatly reduced in abundance on the brown shrimp grounds, and the comparatively few Bothidae on the white shrimp grounds occurred primarily in the faunal overlap zone. The Ariidae, Polynemidae and Pomadasyidae were absent or virtually absent from the brown shrimp grounds. The Sparidae, Synodontidae, Ophidiidae, Serranidae, Mullidae, Triglidae and Tetraodontidae were absent or virtually absent from the white shrimp grounds.

Species composition was distinctly different on the two shrimp grounds (Table 2). On the white shrimp grounds, 15 abundant species constituted 96% of the catch. Together, Micropogon undulatus (30%), Trichiurus lepturus (14%), Cynoscion nothus (13%), Stellifer lanceolatus (10%), Cynoscion arenarius (8%), Polydactylus octonemus (5%) and Arius felis (5%) made up 85%. On the brown shrimp grounds, 23 abundant species constituted 93% of the catch. Together, Stenotomus caprinus (39%), Prionotus paralatus (8%), Bellator militaris (6%), and Upeneus parvus (6%) made up 59%. Each species listed in Table 2 was at least common in frequency of occurrence (Appendix 1) on the grounds where it was abundant except Syacium gunteri and Synodus poeyi. The last two species were uncommon on the white and brown shrimp grounds, respectively.

Only five species--Micropogon undulatus, Leiostomus xanthurus, Cynoscion arenarius, C. nothus and Syacium gunteri--made up 1% or more of the catch on each shrimp grounds. However, C. arenarius, C. nothus and especially M. undulatus were much less abundant on the brown shrimp grounds. Comparatively few Syacium gunteri were captured on the white shrimp grounds, and they occurred primarily in the overlap zone. Most species that were abundant on the white shrimp grounds were either absent from the brown shrimp grounds--Stellifer lanceolatus, Arius felis, Vomer setapinnis, Orthopristis chrysoptera, and Menticirrhus americanus--or were virtually absent--Polydactylus octonemus, Brevoortia patronus and Opisthonema oglinum. Similarly, most species that were abundant on the brown shrimp grounds were either absent from the white shrimp grounds--Prionotus paralatus, Bellator militaris, Synodus foetens, Serranus atrobranchus, Lutjanus campechanus, Pristipomoides aquilonaris, Rhomboplites aurorubens, and Scorpaena calcarata--or were virtually absent--Stenotomus caprinus, Upeneus parvus, Synodus poeyi, Porichthys porosissimus, Halieutichthys aculeatus, Lepophidium sp., Centropristis philadelphica and Prionotus rubio.

Many other species exhibited a high frequency of occurrence on the brown shrimp grounds, although they were not abundant numerically. Species that were at least common (Appendix 1) included Raja texana, Saurida brasiliensis, Ogcocephalus sp. A, Brotula barbata, Mullus auratus, Prionotus stearnsi, Cyclopsetta chittendeni, Engyophrys senta, Gymnachirus texae, Balistes capriscus, Sphoeroides dorsalis, and S. parvus. Except for Ogcocephalus sp. A, these forms were absent or virtually absent from the white shrimp grounds.

Seasonal Changes in Species Composition on the White Shrimp Grounds

The most abundant species on the white shrimp grounds during each cruise

(Table 3) included Micropogon undulatus (41%), Trichiurus lepturus (16%), Stellifer lanceolatus (14%), Cynoscion arenarius (7%), and Polydactylus octonemus (7%) in September and Cynoscion nothus (50%), Peprilus burti (12%), T. lepturus (10%) and M. undulatus (6%) in January. During June M. undulatus (29%), T. lepturus (15%), Arius felis (13%), C. arenarius (13%) and S. lanceolatus (9%) were most important.

There were marked seasonal changes in composition, although inshore sampling was not extensive in the colder months. By winter A. felis, T. lepturus and P. octonemus greatly declined in abundance. Similarly, the Sciaenidae greatly decreased and showed drastic shifts in species composition: M. undulatus, S. lanceolatus, and C. arenarius greatly decreased in abundance, but C. nothus greatly increased. P. burti seemed more abundant by winter. Syacium gunteri, Trachurus lathami and Ogocephalus sp. A are important fishes of the brown shrimp grounds, but they were abundant on the white shrimp grounds (at 18-22 m; 10-12 fm) during winter. Many very large Pogonias cromis, Sciaenops ocellata and Archosargus probatocephalus were caught at 18-22 m during January, but they were too large to appear in our samples.

Seasonal Changes in Species Composition on the Brown Shrimp Grounds

The most abundant species on the brown shrimp grounds during each cruise (Table 4) included Stenotomus caprinus (30%), Micropogon undulatus (16%), Syacium gunteri (14%), Serranus atrobranchus (7%), Leiostomus xanthurus (5%), Upeneus parvus (5%), and Prionotus rubio (5%) in September and S. caprinus (41%), Prionotus paralatus (11%), and Bellator militaris (9%) in January. During March S. caprinus (43%), P. paralatus (9%), U.

parvus (8%) and B. militaris (6%) were important.

Seasonal changes in species composition on the brown shrimp grounds did not seem as great as those on the white shrimp grounds. S. atrobranchus, Leiosotmus xanthurus, M. undulatus and S. gunteri declined in relative abundance by winter. Abundance of P. paralatus, B. militaris, and Halieutichthys aculeatus markedly increased by winter. Other species that seemed more abundant during January or March included Saurida brasiliensis, Synodus poeyi, Porichthys porosissimus, Pristipomoides aquilonaris, Lagodon rhomboides, Scorpaena calcarata, Ogcocephalus sp. A, Rhomboplites aurorubens, and Prionotus stearnsi. Rhizoprionodon terraenovae and Carcharhinus acronotus were abundant in the main catch during January, but they were too large to appear in our samples.

Community Diversities

The ichthyofauna was richer on the brown shrimp grounds than on the white shrimp grounds. The samples contained 103 species of which 82 were collected on the former grounds and 63 on the latter grounds. More time was spent on the brown shrimp grounds than on the white shrimp grounds, and this may explain the difference in numbers of species. However, scatter diagrams of the regressions of number of species/1000 individuals (sp/1000 ind) on number of individuals in a sample (x) show that consistently many more sp/1000 ind were taken at a given x on the brown shrimp grounds in both September and January (Fig. 3).

A richer fauna was present in the colder months, especially on the brown shrimp grounds. Samples from the brown shrimp grounds contained 63 species in January and 65 in March but only 48 in September. On the white shrimp grounds, the samples contained 38 species in September, 42 in January and 38 in June. Scatter diagrams of the regressions of sp/1000 ind similarly indicate greater species richness on both shrimp grounds during the colder months (Fig. 3).

The fish communities of the two shrimp grounds were structurally similar. A single species dominated each community, and that species made up 30-40% of the total number of individuals captured on each grounds (Fig. 4). Most species taken on the two grounds were not abundant.

Diversity expressed as Shannon and Wiener's $\underline{H}'$ and equitability $\underline{E}$ (Krebs 1972) was slightly higher on the brown shrimp grounds than on the white shrimp grounds. Mean $\underline{H}'$ was 1.825 on the white shrimp grounds (range 0.892-2.444) and 2.251 on the brown shrimp grounds (range 1.275-2.586). Mean $\underline{E}$ was 0.616 on the white shrimp grounds (range 0.293-0.937) and 0.673 on the brown shrimp grounds (range 0.396-0.788). The difference in diversity between the two grounds apparently was largely due to species richness rather than equitability.

Seasonal and Bathymetric Distributions of Relative Biomass

Relative discard biomass varied greatly between seasons and grounds. It was much higher on the brown than on the white shrimp grounds and much greater in summer than during winter. Mean discard/tow on the brown shrimp grounds was about two and five times that on the white shrimp grounds during September and January, respectively (Table 1). The decline in biomass by winter was especially great on the white shrimp grounds. Biomass on the white shrimp grounds in June was only about twice that in January, however, one 7.5-m trawl was used during June in contrast to two 18-m trawls in January. Biomass decreased on the brown shrimp grounds during winter, but it was apparently still at least as large as that on the white shrimp grounds during summer.

The discard was predominantly fish, although a miscellany including Callinectes similis, Squilla sp., shells, squid, and rock shrimp made up about 10-30%. The miscellany formed an average of 13.6% of the discard on the white shrimp grounds in June and 30% in January. It made up 21.4% in January on the brown shrimp grounds. Invertebrates were most important during winter, especially on the white shrimp grounds; but, in general, fish biomass closely paralleled discard biomass.

Estimation of the Discard-Shrimp Ratio and Total Catch

The ratios of the mean discard and shrimp catches varied greatly depending on season and grounds. The pooled ratio was 11.35 discard volumes to one of headed shrimp (Table 1) with a variance of 0.68 and lower and upper 95% confidence limits of 9.70 and 13.00. The ratios were highest on both grounds during the warmer months. Overall, the ratio was higher on the white (12.57) than on the brown shrimp grounds (11.03); in contrast, the ratios were higher on the brown than on the white shrimp grounds during September and January, the only periods when collections were made on both grounds. The variance of the ratio was much higher on the white (4.67) than on the brown shrimp grounds (0.76). This suggests that the pooled ratio on the white shrimp grounds may be biased by improper seasonal weighting and/or non-random sampling, because it was greatly increased by comparatively large discard catches in June.

We estimated that the mean annual discard of Texas-based shrimp trawlers in the Gulf was 248,660 metric tons (548.3 million lb) during the ten-year period 1962-1971, because the mean annual shrimp catch (headed shrimp) in that period was 48.3 million lb based on annual shrimp landings reported by Power and Lyles (1964), Lyles (1965, 1966, 1967, 1968, 1969), Anonymous (1971), Wheeland (1972, 1973) and Thompson (undated). The 95% lower and upper confidence limits of the discard were 212,472-284,762 metric tons (468.5-627.9 million lb). Assuming that invertebrates made up about 10-20% of the discard, the overall fish-shrimp ratio was about 10 volumes of fish to 1 volume of shrimp. Therefore, Texas-based shrimp trawlers captured about 219,050 metric tons (483 million lb) of fish in the Gulf annually. Our observations suggest that essentially the entire fish catch is discarded.

SYSTEMATIC ACCOUNT

Length frequencies and aspects of the life histories of each species that made up 3% or more of the total catch on a given grounds are discussed herein in phylogenetic order following Bailey et al. (1970).

Arius felis

Arius felis was abundant on the white shrimp grounds but was absent on the brown shrimp grounds, in agreement with Gunter (1938, 1945), Hildebrand (1954), and Moore et al. (1970). Similarly, this is an abundant coastal species along the southeast U.S. (Anderson 1968; Struhsaker 1969). *A. felis* does appear in deep water at times, because Franks et al. (1972) recorded it at 91 m (50 fm). *A. felis* was most abundant during the warmer months as found by Gunter (1945), Bearden (1961), Anderson (1968), Moore et al. (1970), Swingle (1971), Christmas and Waller (1973), and Gallaway and Strawn (1974).

Most of our specimens were about 100-160 mm FL (Fig. 5), although the extreme lengths were 75 to 291 mm. Except for a 610-mm giant (Smith 1907 cited by Mansueti and Hardy 1967), reported maximum sizes are about 430 mm TL (Gunter 1945; Gunter and Hall 1963; Christmas and Waller 1973) or much smaller (Reid 1955b; Springer and Woodburn 1960; Miller 1965; Franks et al. 1972; and Gàllaway and Strawn 1974). Therefore, our largest specimen was similar in size to the largest fish typically observed.

Spawning occurs in estuaries about early-May to mid-August (Lee 1937; Gunter 1938, 1945; Ward 1957; Christmas and Waller 1973; Gallaway and Strawn 1974). Modal length during June was about 100-130 mm. These fish were probably age I, because Gunter (1945), Gunter and Hall (1963), and Gallaway and Strawn (1974) reported similar lengths for age I fish in June. We collected at least two year classes during June and September, but age I fish dominated the catch. Gunter and Hall (1963) and Swingle (1971) also found at least two year classes. However, the typical life span of *A. felis* is apparently about one or two years.

Halieutichthys aculeatus

Halieutichthys aculeatus was abundant only on the brown shrimp grounds. Although this species has been reported from 16 to at least 182 m (9-100 fm) (Miller 1965; Bullis and Struhsaker 1970), our findings agree with Longley and Hildebrand (1941) and Franks et al. (1972) who captured it primarily at 73-109 m (40-60 fm). This species was most abundant during the colder months. A few specimens appeared at the outer edge of the white shrimp grounds during that period.

Most of our specimens were 60-85 mm TL (Fig. 6), and extreme lengths were 51 and 92 mm. These lengths agree with those reported by Miller (1965), Moe and Martin (1965), and Franks et al. (1972). Our length frequencies show only one year class, so that the life span of this species is apparently one year.

Serranus atrobranchus

Serranus atrobranchus was one of the most abundant fishes on the brown shrimp grounds in agreement with the bathymetric distribution found by Hildebrand (1954) and Franks et al. (1972). We captured no specimens on the white shrimp grounds, although Robins and Starck (1961) note records from 11 m (6 fm). We found *S. atrobranchus* most abundant during September, and Franks et al. (1972) found it most abundant from September to March.

Most of our specimens were 60-130 mm FL (Fig. 7), and the extreme lengths were 35 and 174 mm. The latter length is apparently the largest recorded. We captured one 35-mm specimen during January, and Hildebrand (1954) captured fish of that size in January and March. Therefore, spawning apparently occurs in the fall and early winter. Our length frequencies indicate that two year classes were present in September. Fish presumably approaching age I were about 60-90 mm in September and remained that size through March. Fish presumably approaching age II were about 110-130 mm in September and disappeared by January. Therefore, the typical life span of this species is apparently about two years.

Stenotomus caprinus

Stenotomus caprinus was the most abundant species on the brown shrimp grounds where it made up 30-43% of the catch on each cruise. Gunter and Knapp (1951), Hildebrand (1954), Caldwell (1955), Roithmayr (1965), Moore et al. (1970), and Franks et al. (1972) also found it very abundant at depths corresponding to the brown shrimp grounds, and Chittenden and Moore (unpublished manuscript) reported that it made up 30% of the catch at 110 m (60 fm). Few S. caprinus enter shallower water. We collected only one specimen on the white shrimp grounds, and Franks et al. (1972, Fig. 10) found an inshore bathymetric distribution similar to our observations.

Most of our specimens were 85-140 mm FL (Fig. 8), and the extreme lengths were 67 and 156 mm. Our largest specimen is similar in size to the maximum sizes reported by Hildebrand (1954) and Caldwell (1955), although Franks et al. (1972) collected a 221-mm FL fish. Spawning apparently occurs in the spring; because Hildebrand (1954) captured 95-139 mm fish with well-developed gonads in February, and Caldwell (1955) and Miller (1965) found 26-37 mm fish in early May and June. Presumably young-of-the-year grow to 80-110 mm by late September, because only one year class appears in our length frequency data from September. These fish apparently spawn during their first winter. Our length frequencies indicate that only one, possibly two, year classes were present in winter. Most fish approached age I during winter. Therefore, the typical life span of this species is apparently one or two years.

Cynoscion arenarius

Cynoscion arenarius was abundant on both the white and brown shrimp grounds in agreement with Hildebrand (1954), Roithmayr (1965), Moore et al. (1970), and Franks et al. (1972). However, we found it much more abundant on the white shrimp grounds. We found C. arenarius most abundant from June to September on the white shrimp grounds, but it was most abundant on the brown shrimp grounds from January to March. It was abundant only as deep as 20 m (11 fm) during September, but it was abundant to 58 m (32 fm) in January and March (Fig. 2). Gunter (1945) suggested that this species migrates from estuaries to the Gulf in cool weather. Our data suggest this movement penetrates deeply into the brown shrimp grounds.

Most of our specimens were about 70-250 mm TL (Fig. 9), and the extreme lengths were 54 and 374 mm. The size of our largest fish is similar to the maximum sizes reported by Hildebrand (1954) and Guest and Gunter (1958), and is much larger than those reported by Reid (1955b), Miller (1965), Perret (1966), and Christmas and Waller (1973). Although Franks et al. (1972) and Vick (1964) captured specimens as large as 453 and 590 mm, respectively, individuals larger than 300 mm appear to be comparatively rare.

Spawning apparently occurs from early spring to late summer. Gunter (1945), Springer and Woodburn (1960) and Franks et al. (1972) captured ripe or nearly ripe fish in February and March, and fish about 25-35 mm have been captured from April to October (Gunter 1945; Reid 1955b; Swingle 1971; Christmas and Waller 1973; Gallaway and Strawn 1974). Our length frequencies suggest one age group occurred during June. These fish were about 70-150 mm which is similar to the sizes that Reid (1955b) observed at the same time of year. This age group was about 120-180 mm in September and dominated the catch. These fish were probably young-of-the-year. We found only one specimen smaller than 50 mm during the warm months and only three less than 130 mm during winter. Therefore, the young-of-the year apparently remain in estuaries until they are at least 50-60 mm. They leave the estuaries with the onset of cool weather, but our length frequencies show no evidence of them entering the Gulf unless they were the dominant age group in June and September. Gunter (1945) captured a ripe 157-mm long male in March, so that C. arenarius apparently spawns at age I. Our length frequencies and the comparative paucity of fish larger than about 250 mm indicate that the typical life span of this species is only one or two years.

Cynoscion nothus

Cynoscion nothus was abundant on both the white and brown shrimp grounds in agreement with Gunter (1945), Hildebrand (1954), Haskell (1961), Miller (1965), Roithmayr (1965), and Moore et al. (1970). However, we found it much more abundant on the white shrimp grounds. C. nothus was most abundant during winter and constituted half the catch on the white shrimp grounds during January.

Most of our specimens were 60-200 mm TL (Fig. 10), and the extreme lengths were 50 and 230 mm. Our largest specimen is comparable in length to those reported by Hildebrand and Cable (1934), Gunter (1945), Hildebrand (1954), Miller (1965), and Christmas and Waller (1973). Although Franks et al. (1972) captured a 380-mm fish, specimens larger than 200-230 mm appear to be uncommon.

Spawning occurs from late spring through early fall according to the literature. Fish smaller than 28 mm have been captured from June to late-October (Hildebrand and Cable 1934; Christmas and Waller 1973), and Miller (1965) captured several running ripe females in May. We captured no specimens smaller than 130 mm in June or September, although they were abundant during January. Few C. nothus are captured in estuaries (Ginsburg 1931; Gunter 1938, 1945; Miller 1965; Swingle 1971; Christmas and Waller 1973).

Therefore, our findings indicate that spawning occurs primarily during fall, as Gunter's (1945) observations suggest, and that little spawning occurs before late summer. Although spawning of _C. arenarius_ and _C. nothus_ may overlap, our findings suggest temporal separation of their peak spawning periods.

Our length frequencies show that one age class, about 150-185 mm in length, predominated during September in agreement with Gunter (1945). These fish apparently were approaching or had just reached age I. Gunter (1945) suggested that nearly all _C. nothus_ disappeared in their second winter which is slightly after the time when this species becomes age I. Similarly, our data suggests the typical life span of _C. nothus_ is little more than one year.

Micropogon undulatus

Micropogon undulatus was the most abundant species on the white shrimp grounds and was abundant on the brown shrimp grounds in agreement with Moore et al. (1970) and Franks et al. (1972). It was most abundant during the summer and was greatly reduced in numbers by January as Gunter (1938, 1945) and Anderson (1968) reported.

Most of our specimens were about 100-210 mm TL (Fig. 11), and the extreme lengths were 79 and 270 mm. Our largest specimen is comparable to the maximum sizes that White and Chittenden (1976) concluded were typical of the Carolinean Province. Our length frequencies indicate that one age group was dominant at a given time. This age group was about 120-190 mm in September which corresponds to the size of fish then approaching age I (White and Chittenden, 1976). Our data indicate that this species typically lives only one or two years as White and Chittenden (1976) concluded was the case throughout the Carolinean Province.

Stellifer lanceolatus

Stellifer lanceolatus was abundant on the white shrimp grounds but absent on the brown shrimp grounds in agreement with Gunter (1938, 1945), Hildebrand (1954), and Miller (1965). Abundance declined greatly by winter as Hildebrand and Cable (1934) and Anderson (1968) reported. We captured only two specimens during January, although our collections on the white shrimp grounds were at 16-22 m (9-12 fm) in January.

Most of our specimens were about 40-130 mm TL (Fig. 12), although the extreme lengths were 29 and 153 mm. Our largest specimen is similar to other reported maxima which are typically about 160 mm (Welsh and Breder 1924; Hildebrand and Cable 1934; Miller 1965). A 170-mm specimen (Gunter 1945) is apparently the largest recorded.

Spawning occurs from about April to mid-summer (Welsh and Breder 1924; Hildebrand and Cable 1934; Gunter 1938, 1945; Hoese 1973). Some spawning occurs in the fall, because Hoese (1965) and Christmas and Waller (1973) collected larvae about 4-13 mm in September and October. Maturity begins at age I (Welsh and Breder 1924; Hildebrand and Cable 1934).

Our length frequencies, which are similar to those reported by Welsh and Breder (1924), Gunter (1945), and Reid (1956), suggest that several year classes (including the young-of-the-year) were present in June and September. Presumably age I fish were about 80-125 mm and dominated the catch. Therefore, the typical life span of this species is apparently only about a year, as Welsh and Breder (1924) and Gunter (1938) suggested.

Upeneus parvus

Upeneus parvus was abundant on the brown shrimp grounds, as Hildebrand (1954) observed. We captured only one specimen on the white shrimp grounds, and Miller (1965) captured none.

Most of our specimens were 90-145 mm FL (Fig. 13), and the extreme lengths were 60 and 157 mm. The young are planktonic or pelagic until they reach about 48-61 mm standard length and assume a benthic existence (Caldwell, 1962). Transformation from the pelagic habit apparently occurs during much of the year. We captured 60-mm specimens in January and 78-mm fish in March, and Hildebrand (1954) captured 69-mm specimens in March and 75-mm fish in July. However, transformation from the pelagic habit seems to occur primarily during spring. Our length frequencies indicate that one year class dominates at a given time, and size increases from about 80-110 mm in September to about 100-145 mm in March. Therefore, the typical life span of this species apparently is about one year.

Polydactylus octonemus

Polydactylus octonemus was much more abundant on the white shrimp grounds than on the brown shrimp grounds, in agreement with Gunter (1938, 1945), Hildebrand (1954, 1955), and Miller (1965). It was abundant at stations as deep as 36 m (20 fm) only during September (Fig. 2). We found P. octonemus most abundant during the warm months in agreement with Gunter (1938, 1945), McFarland (1963), Miller (1965), and Gallaway and Strawn (1974). Some individuals apparently overwinter in the shallow northern Gulf, although Hildebrand (1955) frequently captured this species during February off Campeche Bank, Mexico. We captured 33 specimens on the white shrimp grounds in January, and McFarland (1963) captured many in the surf during late March. Neither we nor Hildebrand (1954) captured any specimens on the brown shrimp grounds during winter.

Most of our specimens were about 100-155 mm FL (Fig. 14), and the extreme lengths were 84 and 171 mm. Our largest specimen is comparable to a 204-mm specimen that Gunter (1945) observed and is larger than other reported maximum sizes (Hildebrand 1954; Miller 1965). Spawning apparently occurs offshore in late winter or early spring (Gunter 1938, 1945), and fish reach about 100 mm by the end of summer (Gunter 1938). Gunter (1945) found young and at least one other year class during summer, and Gallaway and Strawn (1974) found only one year class. Our length frequencies suggest that one year class, probably the young-of-the-year, dominated the catch in September when they were about 105-145 mm. Therefore, the typical life span of this species is apparently about one year.

Trichiurus lepturus

Trichiurus lepturus was much more abundant on the white shrimp grounds than on the brown shrimp grounds and was most abundant during the warmer months. This species rises off the bottom at night (Dawson 1967) and would be less vulnerable to the brown shrimp fishery. Moore et al. (1970) collected around-the-clock, however, and their findings agree with ours. This species was abundant at stations as deep as 75 m (41 fm) during winter but only as deep as 35 m (19 fm) during September (Fig. 2) in agreement with Miller (1965) and Dawson (1967). They concluded that spawning occurs during winter or early spring in water deeper than 36 m (20 fm) and that the young recruit to inshore waters during summer.

Most of our specimens were about 140-660 mm TL (Fig. 15), and the extreme lengths were 115 and 730 mm. This species grows to about 1525 mm

(Dawson 1967), but few specimens larger than 850 mm have been reported from the Gulf (Gunter 1945; Springer and Woodburn 1960; Miller 1965; Swingle 1971; Franks et al. 1972; Christmas and Waller 1973). We captured no small fish on the white shrimp grounds during June when apparently one year class dominated the catch, so that the young-of-the-year apparently were still offshore. Young-of-the-year apparently were at least 120 mm in September. They grew to at least 180-250 mm in January when they approached age I, as Dawson (1967) found for late maturing fish. Age I fish were apparently about 220-500 mm by late June but predominantly about 300-450 mm. Although Dawson (1967) reported age classes 0, I, and II during June, his length frequencies suggest virtually no age II fish. Therefore, the typical life span of this species is apparently about one or two years.

Peprilus burti

Early references to *Poronotus triacanthus* in the Gulf are herein considered *Peprilus burti* following Caldwell (1961), Collette (1963), and Haedrich (1967). *P. burti* was much more abundant on the white shrimp grounds than on the brown shrimp grounds suggesting that it is primarily a coastal species in the Gulf, although Horn (1970) reported records from 2-245 m (1-135 fm). We did not find this species abundant at depths greater than 29 m (16 fm), although Moore et al. (1970) and Franks et al. (1972) did at times. We found the relative abundance of *P. burti* greatest during winter. However, the fauna on the white shrimp grounds was greatly reduced in winter and our findings might reflect that. Other workers have found *P. burti* more abundant in the warmer months (Moore et al. 1970; Swingle 1971; Franks et al. 1972; Christmas and Waller 1973). This is a pelagic schooling species. Therefore, data on its abundance are difficult to interpret.

Most of our specimens were 85-120 mm FL (Fig. 16), and the extreme lengths were 58 and 169 mm. Our largest specimen is comparable to the maximum sizes (150-180 mm FL) reported by Gunter (1945) and Franks et al. (1972), the largest recorded lengths that we are aware of. Spawning apparently occurs throughout the year but is probably centered on the cold months, because fish 20-35 mm FL have been reported from January to June and in August, November and December (Gunter 1945; Hoese 1965; Miller 1965; Swingle 1971; and Christmas and Waller 1973). Hildebrand (1954) found that young-of-the-year, about 64-85 mm FL, were very abundant in May. Our length composition indicates that one year class, probably the young-of-the-year, dominated the catch in September. These fish were about 80-120 mm FL then and were about 95-120 mm at age I in January. The few fish as small as 60 mm in January might represent a younger age class. Miller (1965) and Christmas and Waller (1973) also found two age groups in January or February: one age group was composed of recently spawned young, and the other was similar in size to the dominant age group that we observed in January. Therefore, the typical life span of this species is apparently about one year.

Bellator militaris

Bellator militaris was captured only on the brown shrimp grounds, and it was most abundant during the cold months. Its bathymetric distribution is about 35-182 m (19-100 fm) (Hildebrand 1954; Bullis and Struhsaker 1970), although a few specimens have been reported in water as shallow as 3.5 m (2 fm) (Hildebrand 1955; Moe and Martin 1965).

Most of our specimens were 65-110 mm TL (Fig. 17), and the extreme lengths were 20 and 110 mm. A size of 120 mm is apparently the largest recorded (Longley and Hildebrand 1941; Ginsburg 1950). We collected a 20-mm fish in March and a 44-mm specimen in September, so that spawning apparently begins in winter and may extend into spring or early summer. Our length frequencies suggest only one year class. Therefore, the typical life span of this species is apparently about one year.

Prionotus paralatus

Prionotus paralatus was captured only on the brown shrimp grounds in agreement with its reported bathymetric range of about 22-164 m (12-90 fm) (Ginsburg 1950; Hildebrand 1954). Moore et al. (1970) found this species abundant at 64-109 m (35-60 fm) throughout the year; although we found it most abundant during the cold months, and Franks et al. (1972) collected it only during January and March.

Most of our specimens were 80-180 mm TL (Fig. 18). The extreme lengths were 70 and 198 mm, the latter being the largest specimen we are aware of. Other reported maxima have been 128-184 mm (Ginsburg 1950; Hildebrand 1954; and Franks et al. 1972). Spawning apparently occurs during late winter; because Hildebrand (1954) captured fish 49-79 mm in May, and we captured no smaller fish in January or March. Our length frequencies indicate that two year classes dominated during the cold months. Presumably age I fish were about 80-125 mm and presumably age II fish were about 135-160 mm. Therefore, the typical life span of this species is apparently about two years.

Syacium gunteri

Syacium gunteri was abundant on both the white and brown shrimp grounds, but especially the latter, in agreement with Gunter and Knapp (1951), Hildebrand (1954), Miller (1965), Moore et al. (1970), and Franks et al. (1972). This species may move shoreward during winter, because we captured it on the white shrimp grounds only during January.

Most of our specimens were 80-130 mm TL (Fig. 19), and the extreme lengths were 55 and 159 mm. Our largest specimen is comparable to maximum sizes (146-178 mm) reported by Gunter (1945), Hildebrand (1954), and Miller (1965), although Franks et al. (1972) captured several 200-270 mm specimens. Our length frequencies suggest a constant size composition from September to April and that only one year class was abundant during winter. Therefore, the typical life span of this species apparently is about one year.

DISCUSSION

Ecology of the White and Brown Shrimp Grounds

The fish faunas of the two shrimp grounds have distinctly different relationships to estuaries. The fishes of Galveston Bay, a large estuary adjacent to our study area, include 162 species from 66 families (Parker 1965). Only 27% of the species present in our 18-kg samples from the white shrimp grounds have not been reported from Galveston Bay in contrast to 58% of the fishes from the brown shrimp grounds (Table 5). In addition, only 27% of 15 other species captured on the white shrimp grounds have not been reported from Galveston Bay in contrast to 73% of 48 other species collected on the brown shrimp grounds (Appendix 2).

Fishes of the brown shrimp grounds are independent of estuaries. The characteristic species of the brown shrimp grounds have not been reported from Galveston Bay. The brown shrimp grounds species reported from Galveston Bay are primarily white shrimp grounds taxa that appeared in, but were not abundant in, deeper water.

The white shrimp grounds fishes have a strong affinity for estuaries. Those species not reported from Galveston Bay were typical of the brown shrimp grounds and were very uncommon inshore. The major qualitative difference between the ichthyofauna of Galveston Bay and that of the white shrimp grounds is the occurrence in Galveston Bay of many freshwater families (Polyodontidae, Lepisosteidae, Cyprinidae, Ictaluridae, Catostomidae, Percidae, Centrarchidae), families common to estuarine flats or marshes (Cyprinodontidae, Syngnathidae, Gobiidae, and Atherinidae), and *Cynoscion nebulosus*.

Numerous studies have shown similar dominant fishes on the white shrimp grounds (Gunter 1936, 1938, 1941, 1945; Hildebrand 1954; Haskell 1961; Miller 1965; Roithmayr 1965; Moore et al. 1970; Franks et al. 1972; our study). Although percentage compositions vary, Sciaenidae is the dominant family in the shallow northern Gulf and constitutes about 40-70% or more of the fishes. *Micropogon undulatus*, the dominant species, makes up about 25-60%. Important supporting fauna includes members of the families Trichiuridae, Polynemidae, Ariidae, Clupeidae, Carangidae, Stromateidae, Pomadasyidae, and Bothidae. The Sparidae are unimportant on the white shrimp grounds, although *Lagodon rhomboides* and *Archosargus probatocephalus* are abundant in estuaries (Gunter 1945; Reid 1955 a, b).

The brown shrimp grounds support a distinct ichthyofauna. The dominant family is Sparidae, and *Stenotomus caprinus* is by far the dominant species in agreement with Springer and Bullis (pers. communication cited by Caldwell 1955), Moore et al. (1970), and Franks et al. (1972). Hildebrand (1954, Table 25) found S. caprinus to be only the third most abundant species. However, he collected primarily in water only 18-44 m (10-24 fm) deep. This is in the area of faunal overlap and is shallower than the main bathymetric range of S. caprinus (see Franks et al., 1972, Fig. 10) and probably that of the other fishes of the brown shrimp grounds. This probably accounts, in part, for differences between Hildebrand's findings and ours; because Hildebrand (Table 25) reported many fishes abundant on the brown shrimp grounds that our data indicate to be primarily species of the white shrimp grounds. Important supporting fauna on the brown shrimp grounds includes a rich variety of species from the families Sciaenidae, Triglidae, Serranidae, Bothidae, Synodontidae, Lutjanidae, Carangidae, Stromateidae, Ophidiidae and Batrachoididae as Hildebrand (1954) and Moore et al. (1970) reported. We found that the families Ogocephalidae, Scorpaenidae, Mullidae and Tetraodontidae were also important, in contrast to Hildebrand.

The ichthyofauna was most speciose on the brown shrimp grounds as Hildebrand (1954) noted in comparing his and Gunter's (1945) work. In accordance with theories of environmental stability and spatial heterogeneity (Krebs 1972), the greater faunal diversity on the brown shrimp grounds is probably due to a more stable environment and more diverse habitat on the brown shrimp grounds. The annual range of bottom temperature varies inversely with depth on the continental shelf of the northwestern Gulf, the range being about 20 C at 10 m (5 fm) and about 4 C at 182 m (100 fm) (Abbott and Bright 1975). During the winter bottom temperatures increase and then decrease with depth, the temperatures being about 13 C inshore, about 19 C at 55-73 m (30-40 fm), and 16 C at 182 m (Abbott and Bright 1975; Etter and Cochrane 1975). The brown shrimp grounds, therefore, have a less severe and more stable temperature regime than the white shrimp grounds. The brown shrimp grounds also include or are near areas of broken relief which are extensive along the outer shelf (Springer and Bullis 1954; Bright et al. 1974; Sonnier, Teerling, and Hoese 1976). The broken relief and the warm stable temperatures near the brown shrimp grounds permit the existence of a fauna distinct from and superimposed on the surrounding soft bottom community (Struhsaker 1969; Bright and Cashman 1974). This superimposed fauna includes many tropical fishes (Bright and Cashman 1974) and contributes to the greater species diversity on the brown shrimp grounds.

Species composition was richer during winter than summer, especially on the brown shrimp grounds. The warmer bottom temperatures of the brown shrimp grounds may encourage inshore fishes to move to deeper water during winter. Conversely, winter temperatures on the brown shrimp grounds are cold enough that fishes of the outer shelf or upper continental slope may move inshore as has been observed (Gunter 1938, 1945; Rounsefell 1964; Miller 1965; Franks et al. 1972; Christmas and Waller 1973; our studies) for the gadiforms Urophycis cirratus, U. floridanus, U. regius, Lepophidium sp., and Brotula barbata.

Biomass was much lower in winter than in summer, especially on the white shrimp grounds. Biomass was much higher on the brown shrimp grounds than on the white shrimp grounds. The seasonal trend in biomass that we observed on the white shrimp grounds has been repeatedly found in estuaries and coastal waters throughout the Carolinean Province (Gunter 1936, 1945, 1958; Springer and Woodburn 1960; Tagatz and Dudley 1961; Haskell 1961; McFarland 1963; Roithmayr 1965; Anderson 1968). Moore et al. (1970) found that biomass changed with depth off Texas as we observed. Hildebrand (1954) observed greatest catches on the white shrimp grounds. However, his inshore collections were off Louisiana, and Moore et al. found that biomass was much larger off Louisiana than off Texas. The apparently higher biomass in the northcentral Gulf may be due to penetration of estuarine conditions into the Gulf off Louisiana and Mississippi as Gunter (1967) suggested.

Major Demersal Fish Communities in the Gulf of Mexico

There has long been disagreement over the relationships of fish fauna within the Gulf. Baughman (1950a), Ginsburg (1952), and Briggs (1958) considered the fauna of the eastern and western Gulf distinct, and they divided the fauna at the Mississippi River or at about Cape San Blas, Fla. In contrast, Hildebrand (1954, 1955) and Hoese (1958) considered the fauna of the eastern and western Gulf to be the same except for differences in percentage compositions; they considered north-south differences to be more important.

The Gulf seemingly includes but one faunal assemblage except, possibly, at debatable locations of transition between tropical and Carolinean faunas that Briggs (1974) placed near the southern Gulf. However, at least four more or less distinct major demersal fish communities can be recognized on the continental shelf of the Gulf: white, brown, and pink shrimp communities, and a superimposed broken-relief fauna that includes a large element of tropical reef fishes. Species percentage compositions within the Gulf vary greatly depending upon more or less disjunct environmental conditions. Separation of the communities is apparently based upon sources of variation in demersal fish abundance listed previously (see Introduction).

Sediments change greatly in the Gulf and are a major factor determining the community present. Springer and Bullis (1954) divided the shelf into two major sediment zones: the western Gulf zone, with terrigenous mud bottom, approximately bounded by Pensacola, Fla., and Campeche, Mexico; and the eastern Gulf zone, with biogenic calcareous sediments, along Florida east of Pensacola and Yucatan northeast of Campeche. Shrimp distribution closely matches sediment distribution. White and brown shrimp occupy the terrigenous muds while pink shrimp occur on calcareous sediments (Springer and Bullis 1954; Hildebrand 1954, 1955; Osborne, Maghan and Drummond 1969). Williams (1958) showed that the shrimp actively select these substrates. Similar sediment-associated distribution has been observed for many demersal fishes including Stenotomus caprinus Caldwell 1955), Gymnachirus spp. (Dawson 1964), Syacium gunteri and S. papillosum (Hildebrand 1955; Topp and Hoff 1972), and Centropristis ocyurus and C. philadelphica (Miller 1959).

The dominant fishes are distinctly different on the three shrimp grounds. The predominant fishes of the white shrimp community are in the family Sciaendiae, and Micropogon undulatus is the dominant species. The dominant fishes of the brown shrimp grounds are Stenotomus caprinus of the family Sparidae. We have separated these respective communities into bathymetric ranges of about 3.5-22 m (2-12 fm) and 22-91 m (12-50 fm) following shrimp distribution (Hildebrand 1954; Osborne et al. 1969). The brown shrimp is not abundant at depths greater than 91 m (Osborne et al. 1969). However, Chittenden and Moore (unpublished manuscript) reported that *S. caprinus* made up about 30% of the fishes inhabiting the 110 m (60 fm) contour from the Mississippi River delta to the Rio Grande in close agreement with our findings for the brown shrimp grounds. They concluded that the typical brown shrimp grounds fish community extended to a depth of at least 110 m. The fish fauna inhabiting soft bottom at depths greater than 110 m has not been described. Only a narrow portion of the shelf lies between 110-182 m (60-100 fm), however, and this area may simply be a transition zone for the faunas of the brown shrimp grounds and of the continental slope.

Faunal percentage compositions change greatly inshore associated with salinity change in the northern and western Gulf. The bathymetric distribution of the white and brown shrimp communities is not constant throughout the Gulf, but is apparently affected by salinity and/or associated factors. Continental climate in the northern and western Gulf forms a gradient changing from a humid north-central area to a semi-arid area between the Rio Grande and Corpus Christi, Tex., (Thornthwaite 1948), and these arid conditions extend down along the Mexican coast. The Mississippi River discharge creates estuarine conditions in the Gulf near the delta (Gunter 1967). The average annual salinity increases from about 4 $^{o}/oo$ at Eugene Island, La., to 23 $^{o}/oo$ at Galveston, Tex., 34 $^{o}/oo$ at Port Isabel, Tex., and becomes more stable along this gradient (Hedgpeth 1953). The estuarine-related white shrimp grounds ichthyofauna is apparently most developed in the northcentral Gulf where the continental shelf is narrow and an estuary extends into the Gulf. The white shrimp grounds apparently penetrate into deep water in that area; because *Penaeus setiferus* is captured in commercial quantities at 55 m (30 fm) there (Hildebrand 1954; Osborne et al. 1969), and *Micropogon undulatus* is abundant at 64-109 m (35-60 fm) (Moore et al. 1970; Franks et al. 1972). In contrast, we found *M. undulatus* uncommon deeper than 58 m (32 fm) off Texas; and the white shrimp becomes much less abundant west of the central Texas coast (Gunter 1962, Osborne et al. 1969). Similarly, the families Sciaenidae and Trichiuridae are much less abundant off central Texas than off Louisiana (Gunter 1945; Moore et al. 1970). Species percentage compositions of the white shrimp community probably continue to change gradually along the south Texas and Mexican coast as Hildebrand (1955) recognized. In addition to gradually increasing temperature, the estuaries there differ from those in the northcentral Gulf; because the Laguna Madre of Texas and the Laguna Madre Tamaulipas are hypersaline (Gunter 1967). Hildebrand (1969) described extreme fluctuations in abundance and absences from Laguna Madre Tamaulipas for the larger sciaenids *Cynoscion nebulosus*, *Pogonias cromis*, and *Sciaenops ocellata*. He related their fluctuations to intermittent freshwater dilution of brine conditions. These estuarine species are not characteristically abundant on the white shrimp grounds. However, the impact of salinity conditions along the south Texas and Mexican coasts probably affects the abundance of white shrimp grounds species most dependent on the hyposaline nurseries characteristic of the northcentral Gulf. The only sizeable hyposaline estuaries along Mexico are Laguna de Terminos at Yucatan and Laguna de Tamiahua south of Tampico (Gunter 1967). The latter location is where Hildebrand (1955) suggested that the main faunal change in the western Gulf occurred.

The pink shrimp grounds apparently support a distinct fish community, and its dominant species include *Chloroscombrus chrysurus*, *Eucinostomus gula*, *Diplectrum formosum*, *Prionotus scitulus*, *Etropus crossotus*, *Orthopristis chysoptera* and *Syacium papillosum* (Hildebrand 1955; Moe and Martin 1965). Hildebrand recognized *Haemulon aurolineatum* as the most abundant fish off Campeche, although Moe and Martin did not capture this species off Florida. The pink shrimp grounds community has a strong admixture of species present on the white and brown shrimp grounds. We collected more than 60% of the species that Hildebrand (1955) and Moe and Martin (1965) listed. Several of the species that they found dominant were not uncommon on the other shrimp grounds. The bathymetric distribution of pink shrimp in the Gulf extends only to about 45-64 m (25-35 fm) (Hildebrand 1954; Osborne et al. 1969), but the fish community on the continental shelf seaward of the pink shrimp grounds has not been described.

Temperature regimes and topographic relief greatly influence species compositions in the Gulf, and these factors are entwined ecologically in terms of the presence of tropical reef fishes. Broken relief including coral is extensively but disjunctly distributed throughout the Gulf (Springer and Bullis 1954; Bright et al. 1974). Recent investigators (Bright and Cashman 1974; Smith et al. 1975; Sonnier et al. 1976) agree that intra-Gulf homogeneity exists for the tropical reef fishes. The tropical reef-fish fauna tends to be found further out on the shelf in the northern Gulf. Species least tolerant of lowered winter temperatures may be absent from the northern Gulf. Moore (1975) suggested that the Texas coast is probably a near-marginal environment for many species.

Debate about east-west differences in the Gulf ichthyofauna is occasioned primarily because of differences in sediment composition and distribution. Springer and Bullis (1954) considered the sediments homogeneous within their east and west Gulf zones, but that is not the case. White, brown, and pink shrimp communities are found near Yucatan (Hildebrand 1955), and a white shrimp community occurs off Apalachicola Bay, Fla. (Miles 1950; Hildebrand 1955). Pink shrimp occur in disjunct areas throughout the northern Gulf except off portions of Louisiana (Hildebrand 1955; Osborne et al. 1969), suggesting that suitable sediments and the fishes of that community are scattered throughout the Gulf. We encountered some shell bottom during a few tows on the brown shrimp grounds and captured Haemulon aurolineatum, Eucinostomus gula, Syacium papillosum, Bothus sp. Jutare (Gutherz 1967), Paralichthys albigutta and Centropristis ocyurus. The first three of these species are dominant forms of the pink shrimp grounds, and the latter three are characteristic on the calcareous bottom off the west coast of Florida (Topp and Hoff 1972). Other dominant species of the pink shrimp grounds, including Prionotus scitulus (Hildebrand 1954; Swingle 1971; Christmas and Waller 1973), Chloroscombrus chrysurus, Orthopristis chrysoptera, and Etropus crossotus, also appear in the northern Gulf.

Briggs (1974) placed the southern portions of the Gulf in his Caribbean Province. However, this might be debatable and based primarily on shallow-water fauna. Bright and Cashman (1974) and Smith et al. (1975) agree that one tropical reef-fish fauna exists in the Gulf. Topp and Hoff (1972) concluded that the Gulf, including the Florida keys, supported one flatfish assemblage. We have reviewed evidence that the major known demersal fish communities are more or less dispersed throughout the Gulf. Therefore, the entire Gulf might conveniently be placed in the Carolinean

Province. The junction of Carolinean and tropical faunas in the Gulf may largely involve a gradual displacement of the tropical fauna in the direction of the outer shelf as one proceeds towards the northern Gulf. This treatment, in effect, agrees with Robins (1971) and Gilbert (1973) who, however, label the entire Gulf fauna as tropical. The tropical reef-fish fauna of the present paper corresponds, in part, to Robins' tropical insular fauna which is found over a broad geographical range that includes the Gulf. The demersal fish communities referred to herein correspond, in part, to Robins' northern tropical continental fauna.

Population Dynamics and Harvest Potentials

The 15 most abundant species, which made up about 84% and 75% of the fishes on the white and brown shrimp grounds, respectively, appear very similar in certain aspects of their life histories. They are small: with the exception of *Trichiurus lepturus*, nearly all the fishes captured on both grounds were less than 200 mm in length. Their life spans appear to be only one or two years, in general, so that they must mature rapidly and have high annual mortality rates. Haskell (1961) and Gunter (1938, 1945) made observations similar to ours on the size composition of the white shrimp grounds fauna and the life spans of certain of its species, respectively. These observations on the demersal fishes and their implications may hold throughout the Gulf; because Hildebrand (1955) observed few fish larger than 200 mm TL on the pink shrimp grounds off Mexico which has a species composition similar to that found off western Florida.

The total annual mortality rates of the demersal fishes can be estimated by assuming negative exponential survivorship (Gulland 1969) in which the equation:

$$N_t = N_o e^{-Zt}$$

describes the numbers (N) of fish present at time t where Z is the instantaneous total mortality rate. Following the reasoning of Royce (1972, p. 238), this equation can be solved and the theoretical average annual instantaneous total mortality rate can be expressed as:

$$Z = {}^{4.6}/\text{life span (years)}$$

Converting instantaneous rates to actual mortality rates by using Ricker's (1975) Appendix Table I, we can estimate average total annual mortality rates for different life spans as: 1 yr (95%), 2 yr (90%), and 3 yr (78%).

In general, it appears that the most abundant fishes on the white and brown shrimp grounds have average total annual mortality rates of about 90% or more. Therefore, there must be a rapid turnover of biomass on each shrimp grounds and large seasonal changes in the numbers of each species. Fishes having this type of life cycle tend to withstand very high fishing mortalities without danger of over-harvesting, so that the Gulf demersal fishes apparently represent an enormous potential protein resource as our estimate for the discard off Texas suggests. The population dynamics of Gulf demersal fishes contrast with the larger sizes, longer life spans, apparently lower mortality rates etc. suggested by Bigelow and Schroeder's (1953) descriptions for fishes in northern waters. This apparent geographical difference in population dynamics may mean that the Gulf demersal fishes are not very susceptible to overfishing and that they may have a higher harvest potential than northern fishes do.

The Penaeid shrimp fishery is the dominant fishery now affecting demersal fishes in the Gulf. Penaeid shrimp apparently also have typical life spans of about 1.5-2 years (see Cook and Lindner 1970; Costello and Allen 1970; Lindner and Cook 1970), so that the population dynamics of the dominant demersal fish and Penaeid shrimp appear very similar. Fishes with life spans and mortality rates similar to those of shrimp can probably be fished at rates similar to those on shrimp without danger of the overfishing which occurs when the point of maximum sustainable yield is passed. If and when shrimp are fished at maximum sustainable yield, those fishes which have longer life spans and lower mortality rates must have refuge areas (such as Lutjanus campechanus and snapper banks) or they will probably be overfished. The Gulf shrimp fishery at present does not appear to be overharvesting the dominant demersal fishes, because the species and size compositions that we found are very similar to those reported by Gunter (1938, 1945) and Hildebrand (1954) early in the history of the white and brown shrimp fisheries.

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FIGURE 1. The Gulf of Mexico.

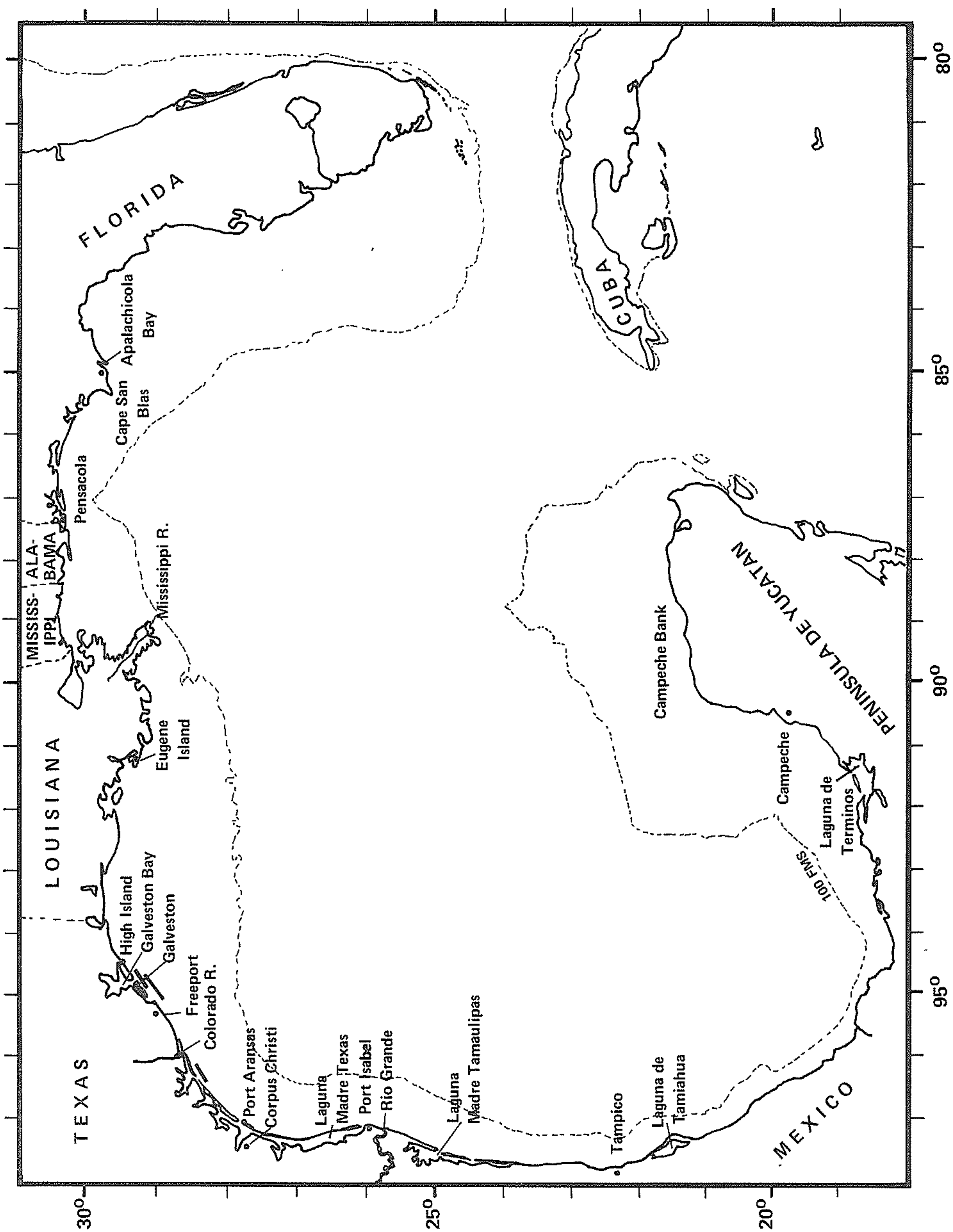

TEXAS
LOUISIANA
MISSISS-IPPI
ALA-BAMA
FLORIDA
CUBA
PENINSULA DE YUCATAN
MEXICO
High Island
Galveston Bay
Galveston
Freeport
Colorado R.
Port Aransas
Corpus Christi
Laguna Madre Texas
Port Isabel
Rio Grande
Laguna Madre Tamaulipas
Tampico
Laguna de Tamiahua
Eugene Island
Mississippi R.
Pensacola
Cape San Blas
Apalachicola Bay
Campeche Bank
Campeche
Laguna de Terminos
100 FMS
30°
25°
20°
95°
90°
85°
80°

FIGURE 2. Depths sampled and bathymetric distributions of abundant species.

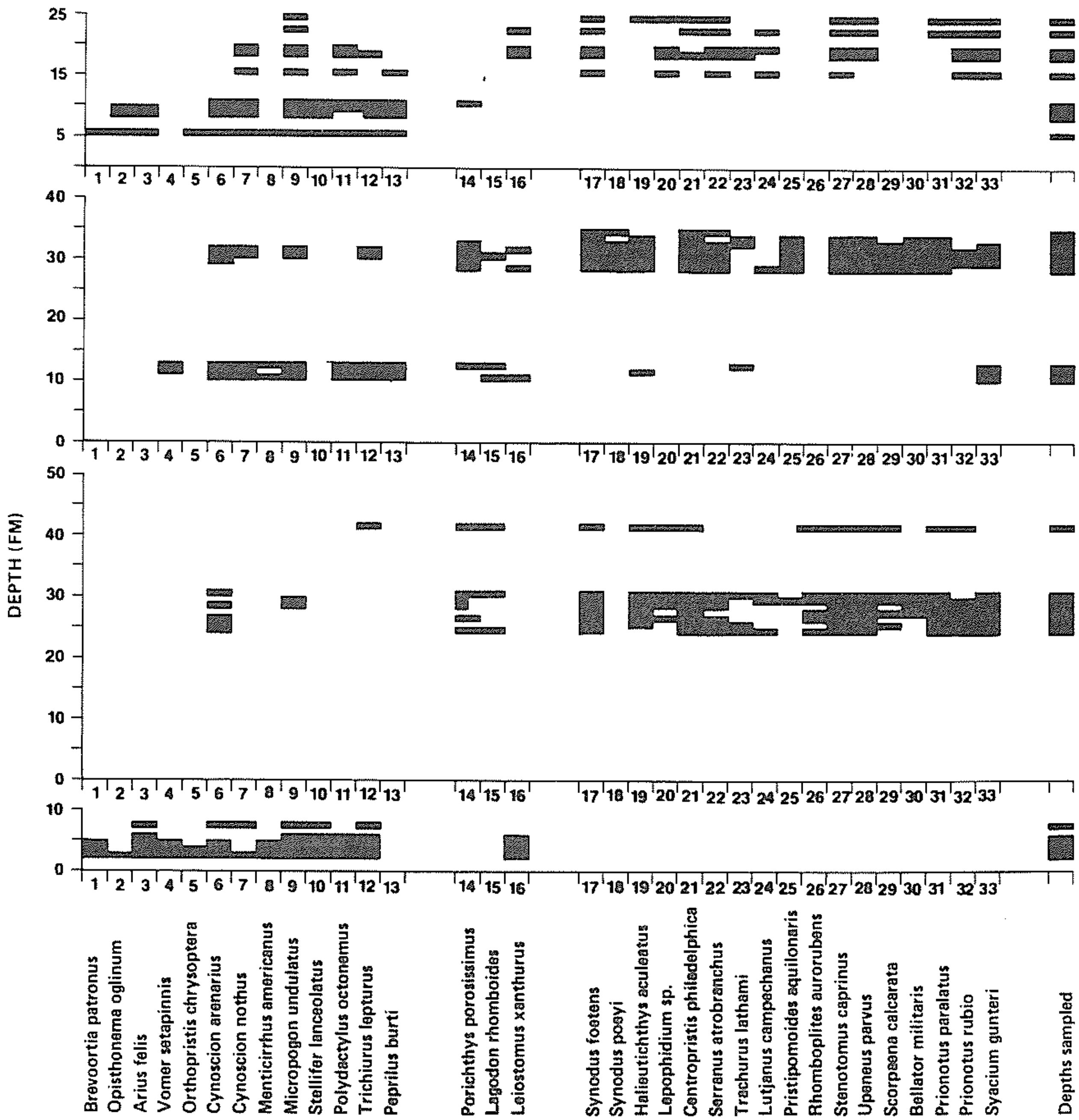
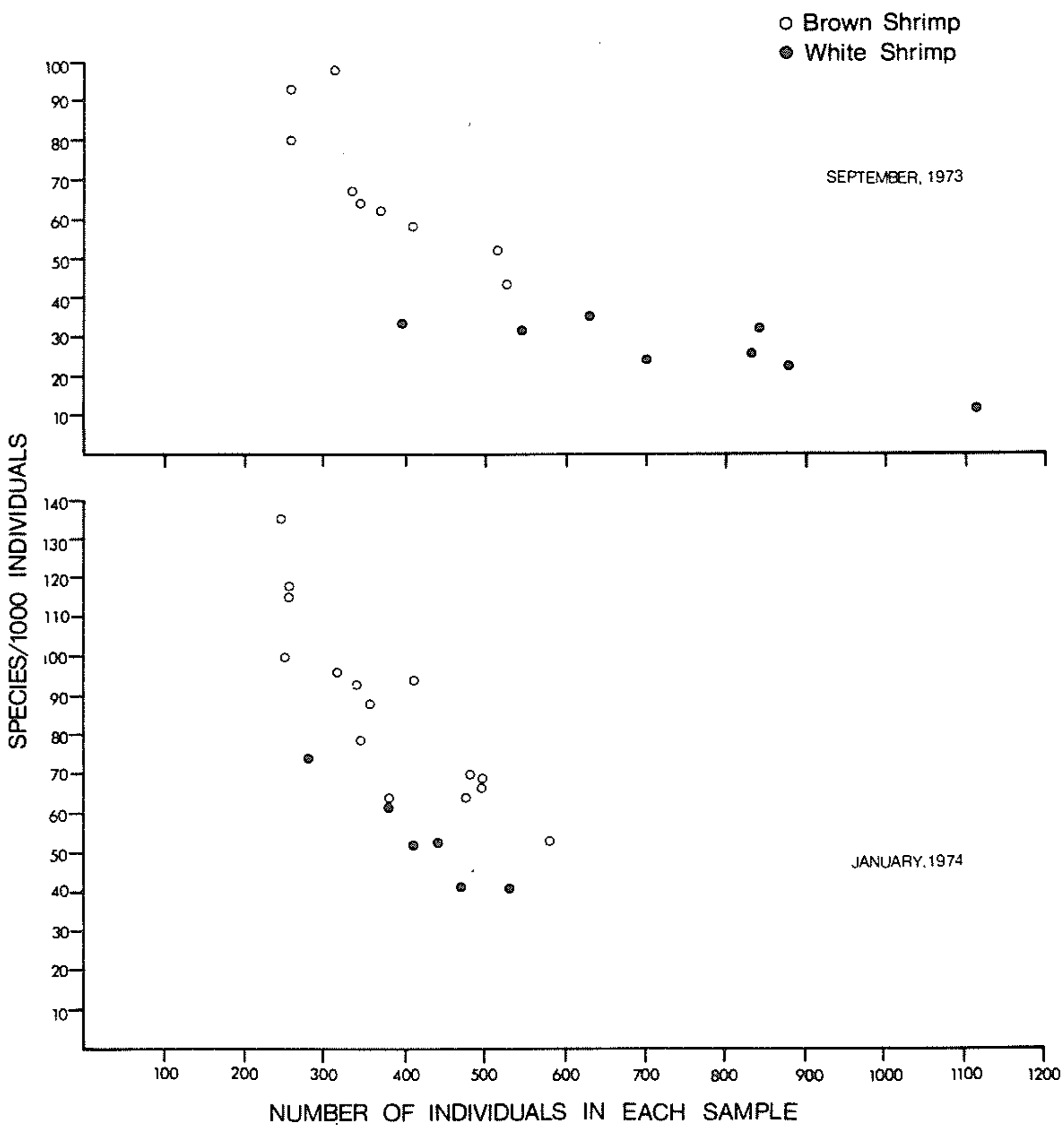

DEPTH (FM)
Brevoortia patronus
Opisthonema oglinum
Arius felis
Vomer setapinnis
Orthopristis chrysoptera
Cynoscion arenarius
Cynoscion nothus
Menticirrhus americanus
Micropogon undulatus
Stellifer lanceolatus
Polydactylus octonemus
Trichiurus lepturus
Peprilus burti
Porichthys porosissimus
Lagodon rhomboides
Leiostomus xanthurus
Synodus foetens
Synodus poeyi
Halieutichthys aculeatus
Lepophidium sp.
Centropristis philadelphica
Serranus atrobranchus
Trachurus lathami
Lutjanus campechanus
Pristipomoides aquilonaris
Rhomboplites aurorubens
Stenotomus caprinus
Upeneus parvus
Scorpaena calcarata
Bellator militaris
Prionotus paralatus
Prionotus rubio
Syacium gunteri
Depths sampled

FIGURE 3. Diversity on the white and brown shrimp grounds during summer and winter. Diversity is expressed as species/1000 individuals.



o Brown Shrimp
● White Shrimp
SEPTEMBER, 1973
JANUARY, 1974
SPECIES/1000 INDIVIDUALS
NUMBER OF INDIVIDUALS IN EACH SAMPLE

FIGURE 4. Community structures on the white and brown shrimp grounds.

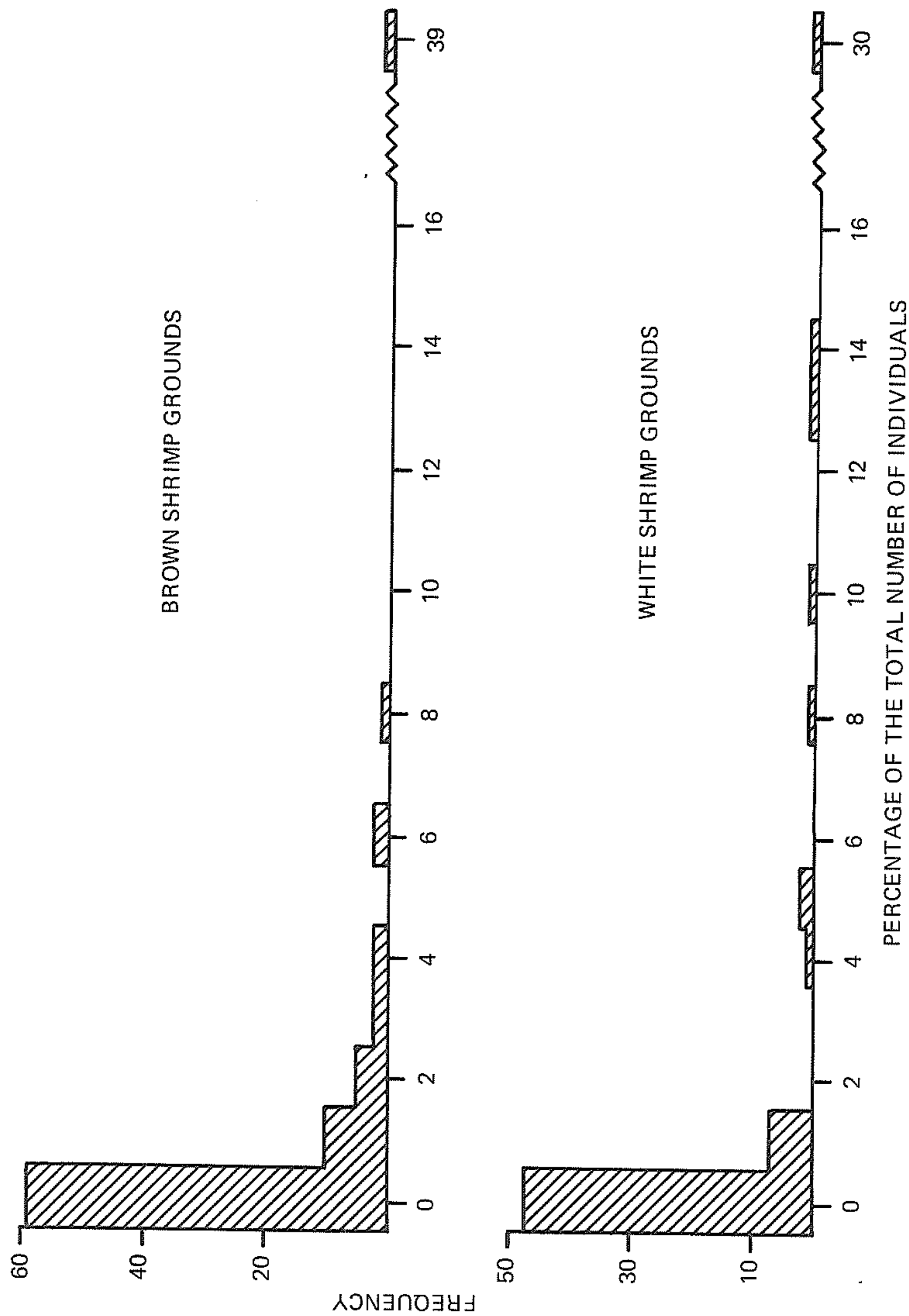
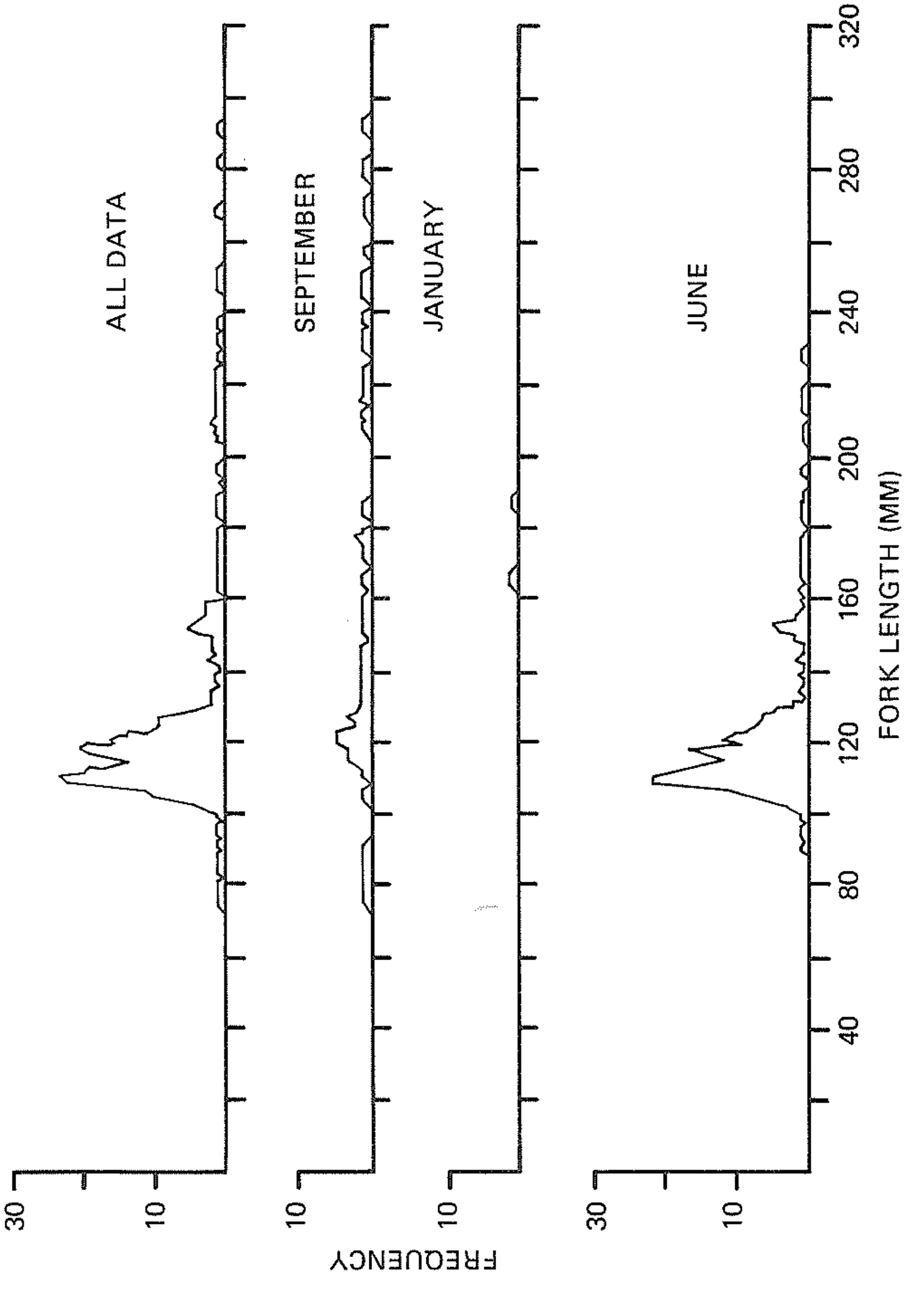

BROWN SHRIMP GROUNDS
WHITE SHRIMP GROUNDS
FREQUENCY
PERCENTAGE OF THE TOTAL NUMBER OF INDIVIDUALS
60
40
20
50
30
10
0
2
4
6
8
10
12
14
16
39
30

FIGURE 5. Length frequency compositions of *Arius felis*. Frequencies are expressed as moving averages of three.



ALL DATA
SEPTEMBER
JANUARY
JUNE
FREQUENCY
FORK LENGTH (MM)
30
10
10
10
30
10
40
80
120
160
200
240
280
320

FIGURE 6. Length frequency compositions of _Halieutichthys aculeatus_. Frequencies are expressed as moving averages of three.

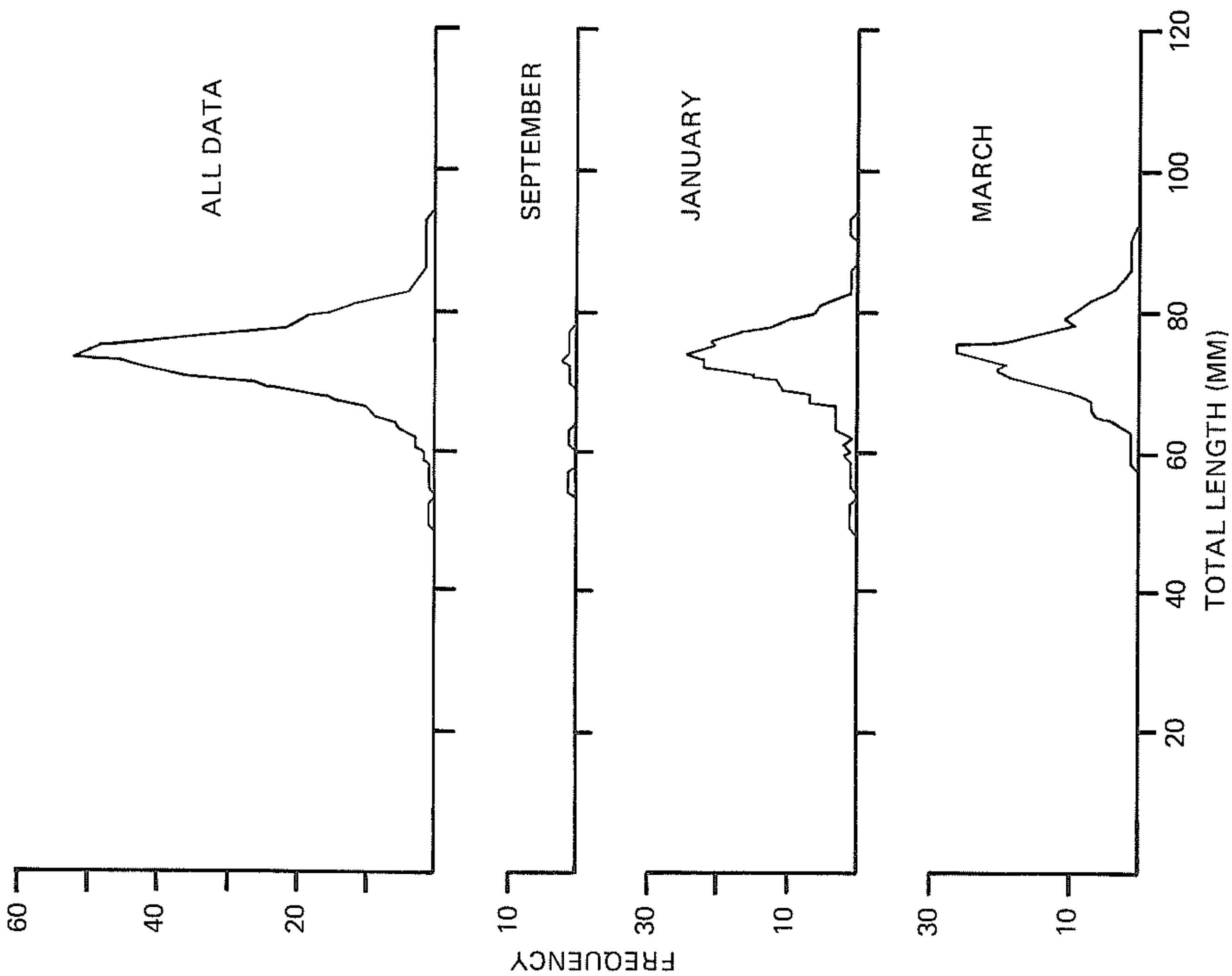

ALL DATA
SEPTEMBER
JANUARY
MARCH
FREQUENCY
60
40
20
10
30
10
30
10
TOTAL LENGTH (MM)
20
40
60
80
100
120

FIGURE 7. Length frequency compositions of *Serranus atrobranchus*. Frequencies are expressed as moving averages of three.

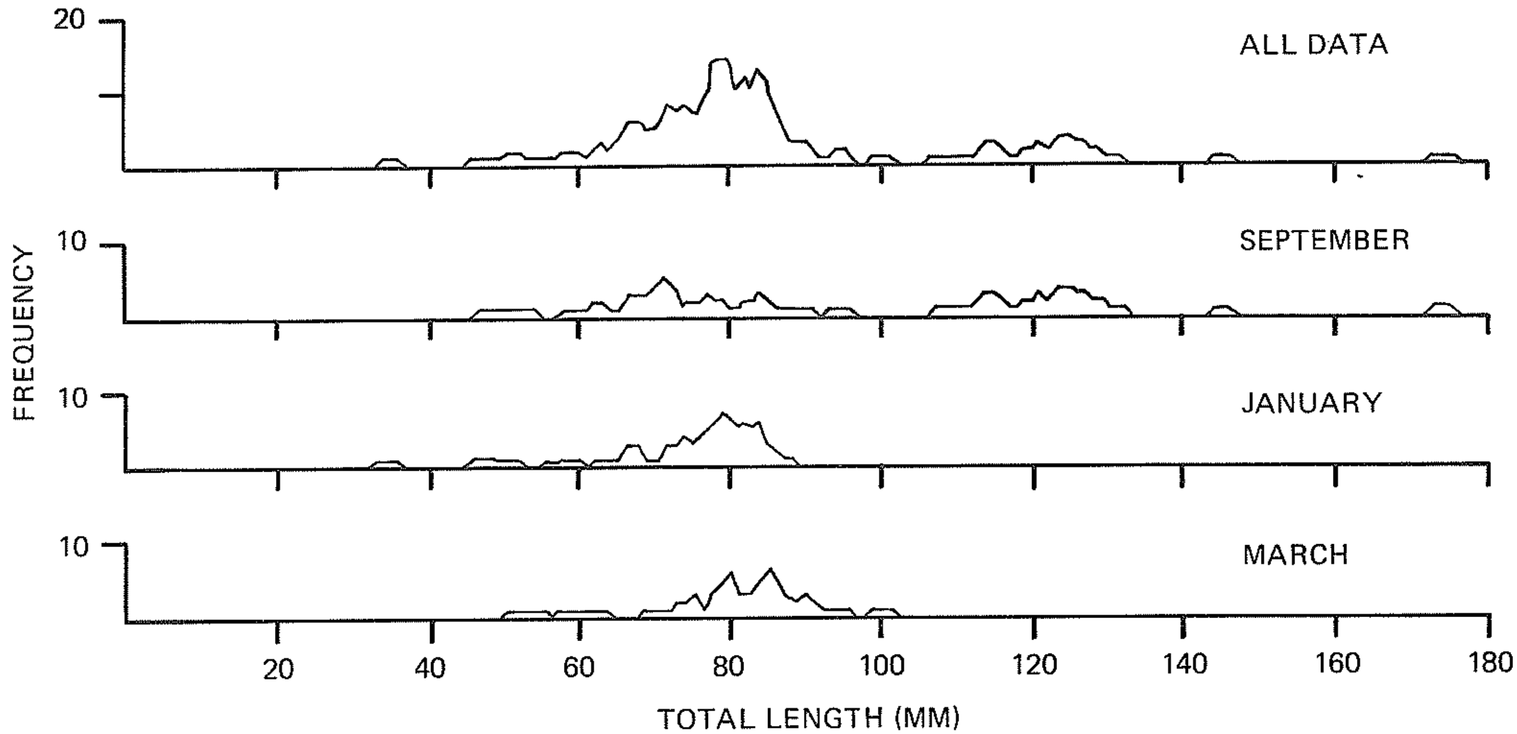

ALL DATA
SEPTEMBER
JANUARY
MARCH
FREQUENCY
20
10
10
10
20
40
60
80
100
120
140
160
180
TOTAL LENGTH (MM)

FIGURE 8. Length frequency compositions of *Stenotomus caprinus*. Frequencies are expressed as moving averages of three.

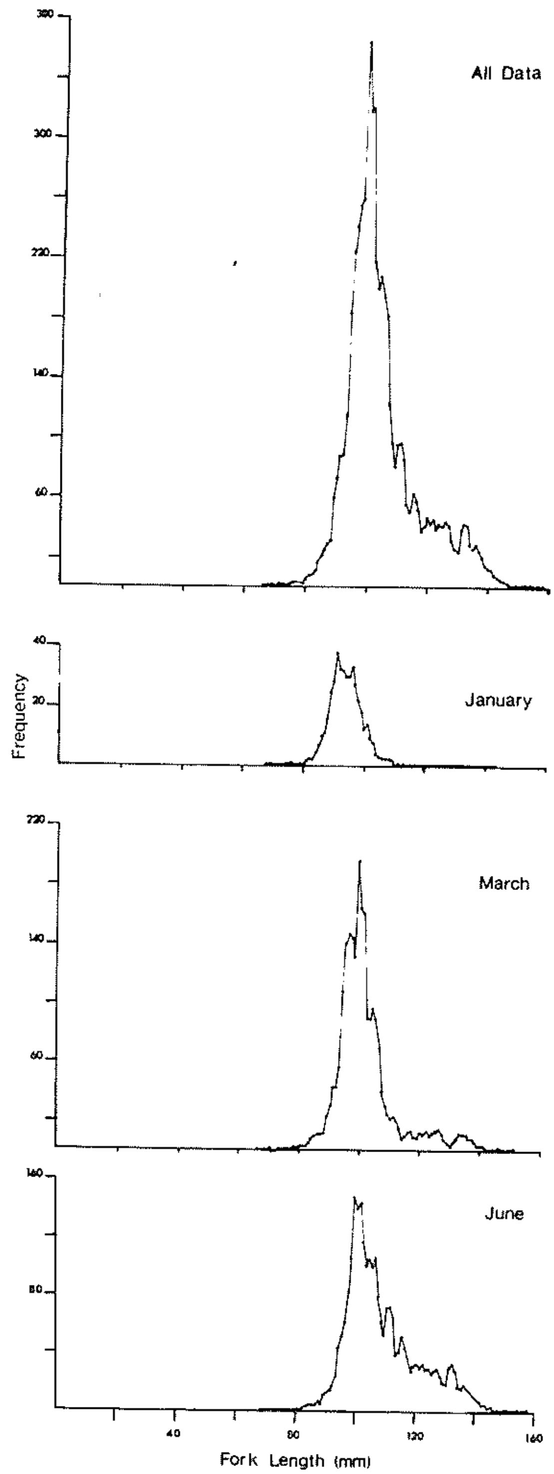

All Data
January
March
June
Frequency
Fork Length (mm)

FIGURE 9. Length frequency compositions of *Cynoscion arenarius*. Frequencies are expressed as moving averages of three.

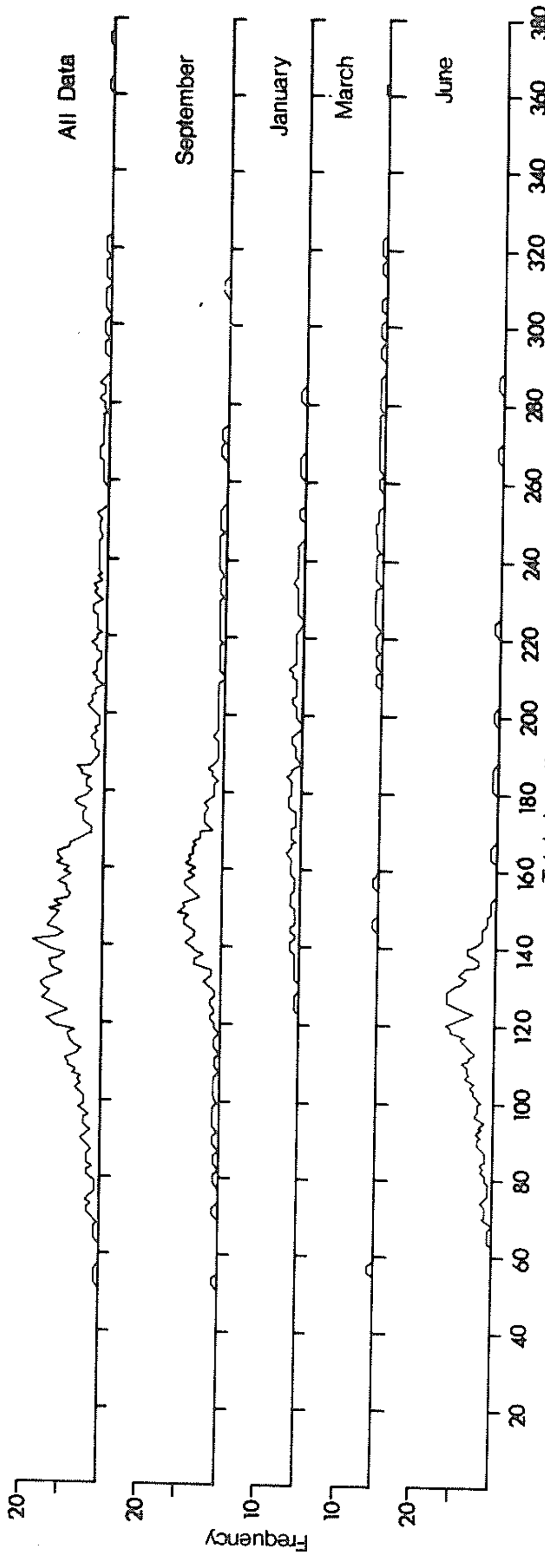

All Data
September
January
March
June
Frequency
Total Length (mm)
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
380
20
20
10
10
20

FIGURE 10. Length frequency compositions of *Cynoscion nothus*. Frequencies are expressed as moving averages of three.

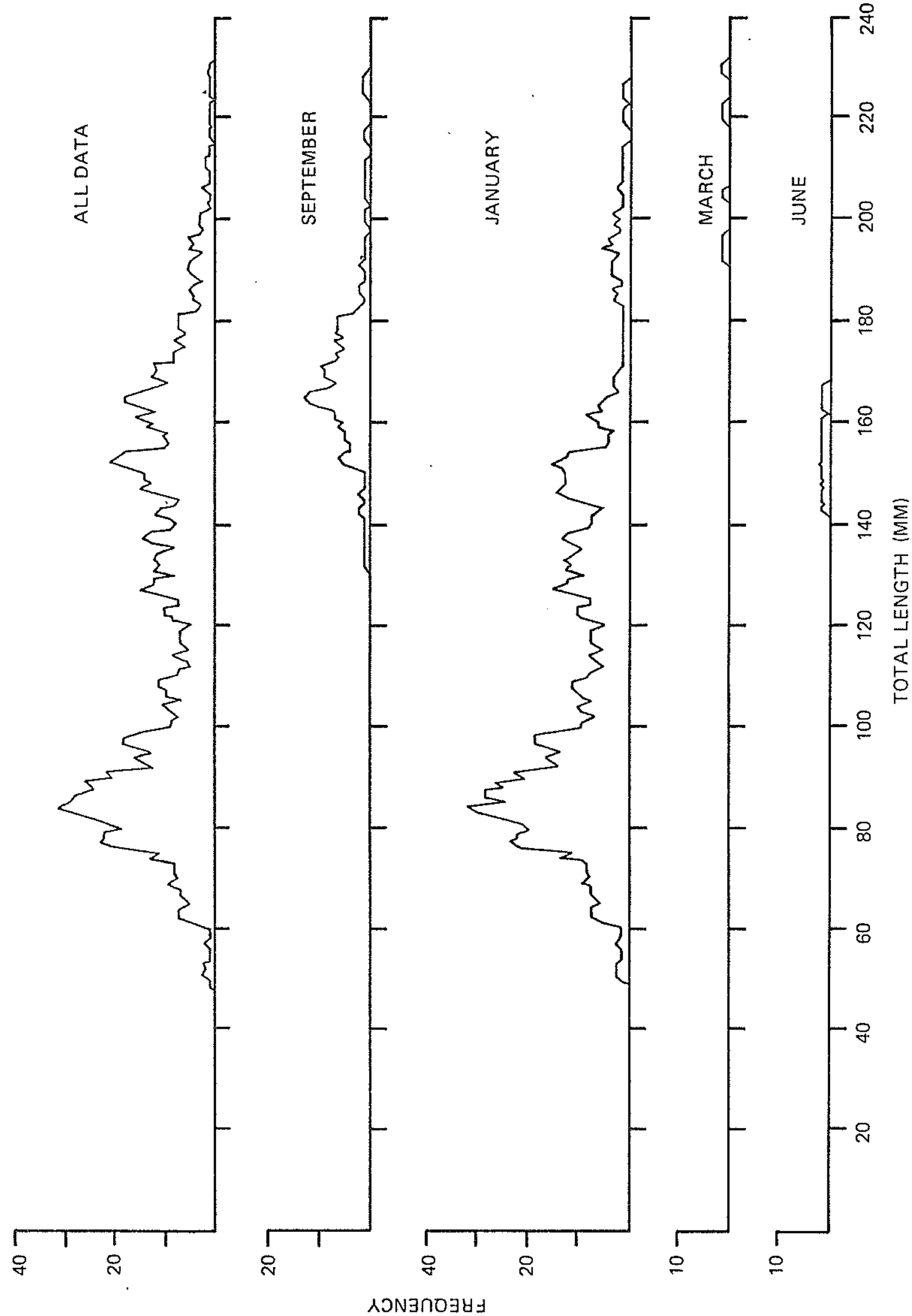

ALL DATA
SEPTEMBER
JANUARY
MARCH
JUNE
FREQUENCY
40
20
20
40
20
10
10
20
40
60
80
100
120
140
160
180
200
220
240
TOTAL LENGTH (MM)

FIGURE 11. Length frequency compositions of *Micropogon undulatus*. Frequencies are expressed as moving averages of three.

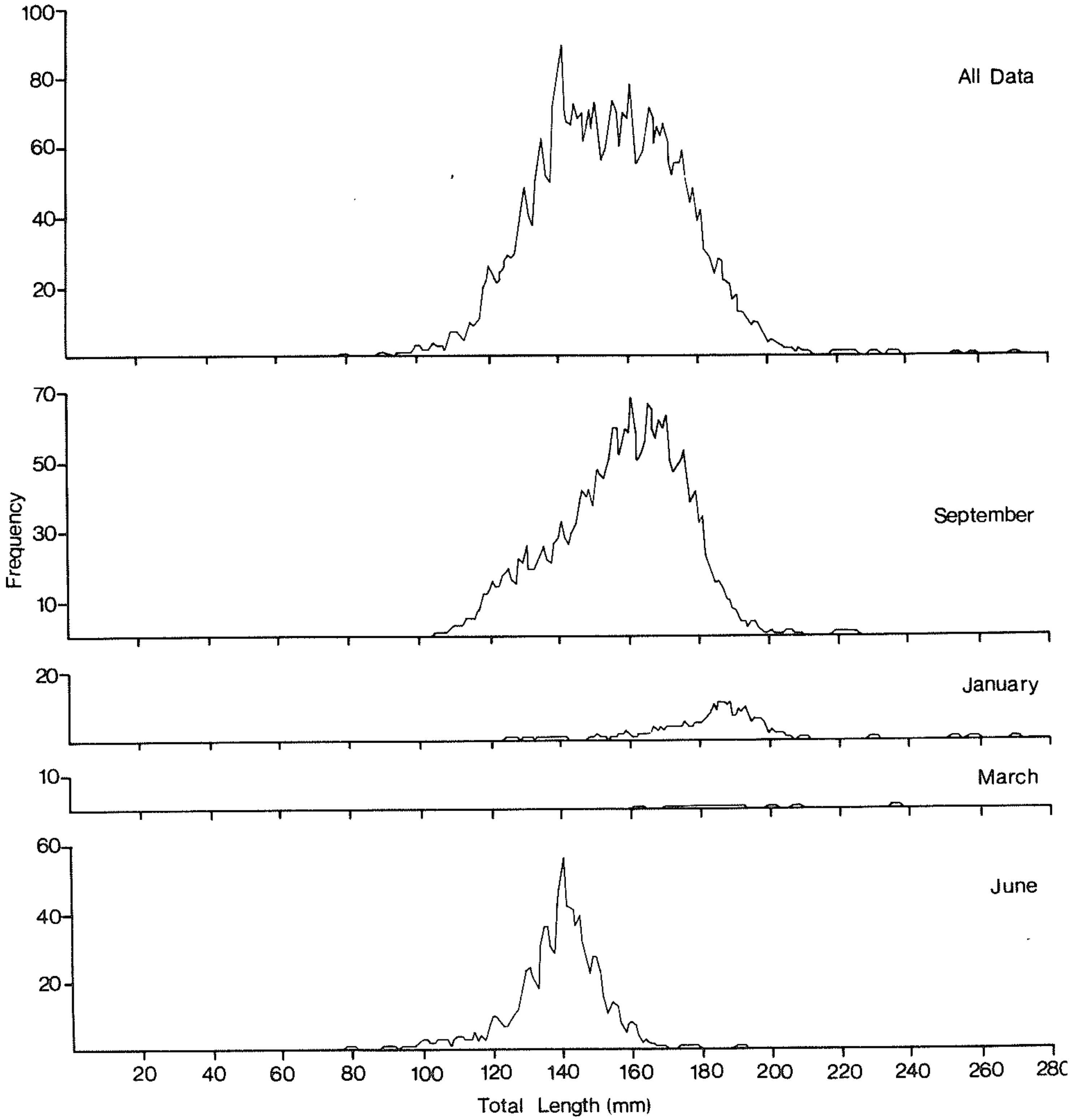

All Data
September
January
March
June
Frequency
Total Length (mm)
100
80
60
40
20
70
50
30
10
20
10
60
40
20
20
40
60
80
100
120
140
160
180
200
220
240
260
280

FIGURE 12. Length frequency compositions of *Stellifer lanceolatus*. Frequencies are expressed as moving averages of three.

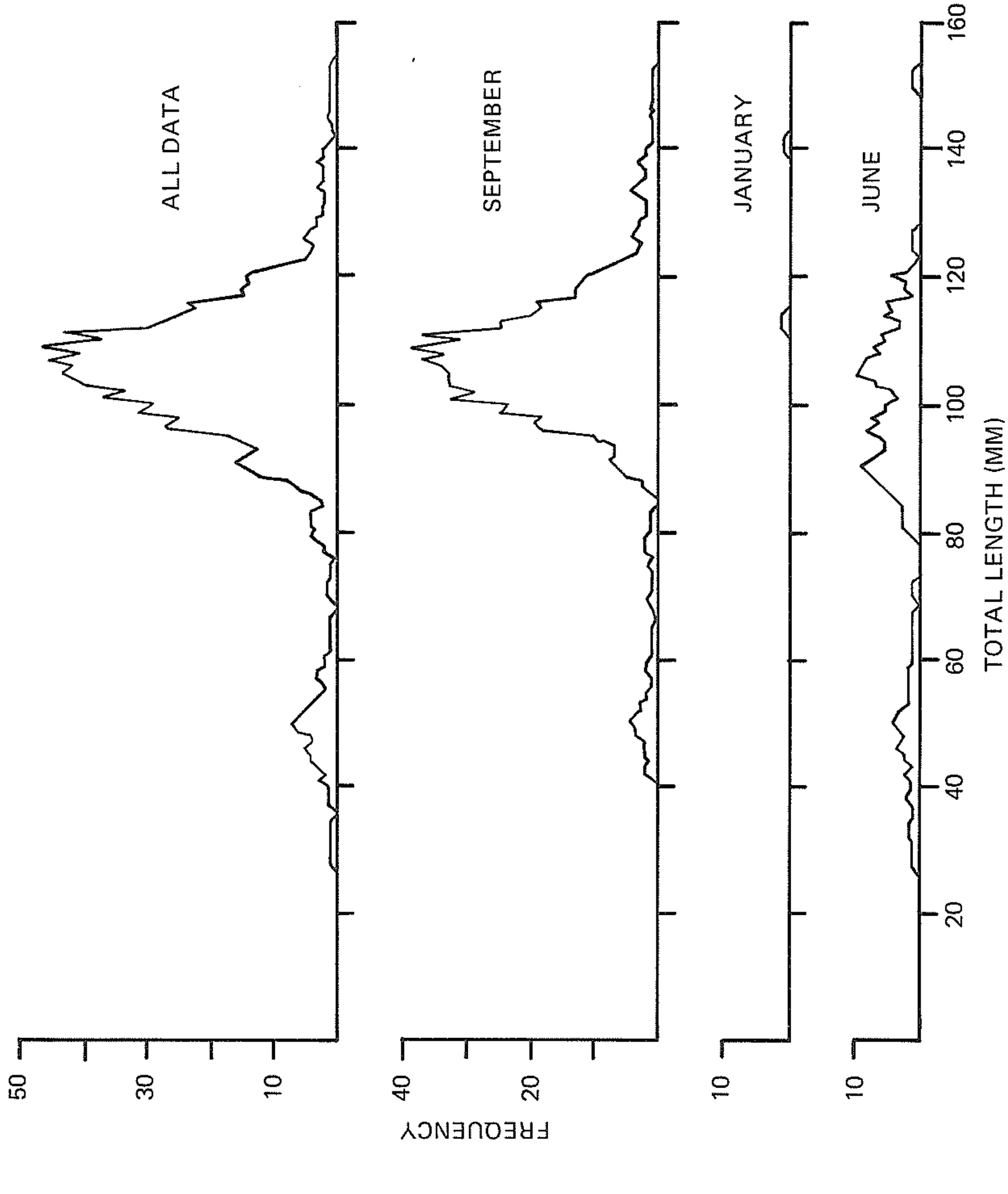

ALL DATA
SEPTEMBER
JANUARY
JUNE
FREQUENCY
TOTAL LENGTH (MM)
50
30
10
40
20
10
10
20
40
60
80
100
120
140
160

FIGURE 13. Length frequency compositions of *Upeneus parvus*. Frequencies are expressed as moving averages of three.

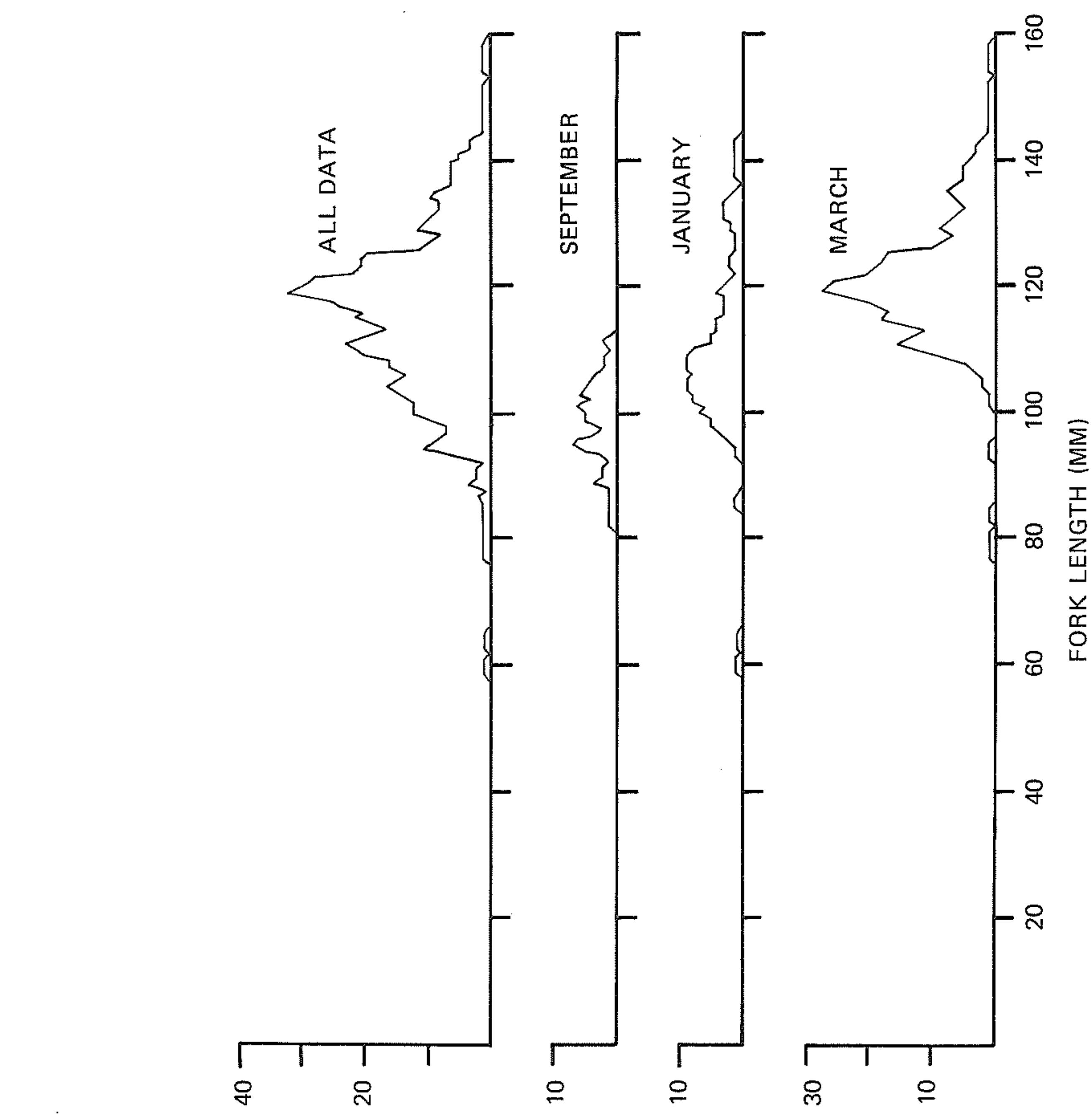

ALL DATA
SEPTEMBER
JANUARY
MARCH
FREQUENCY
40
20
10
10
30
10
20
40
60
80
100
120
140
160
FORK LENGTH (MM)

FIGURE 14. Length frequency compositions of *Polydactylus octonemus*. Frequencies are expressed as moving averages of three.

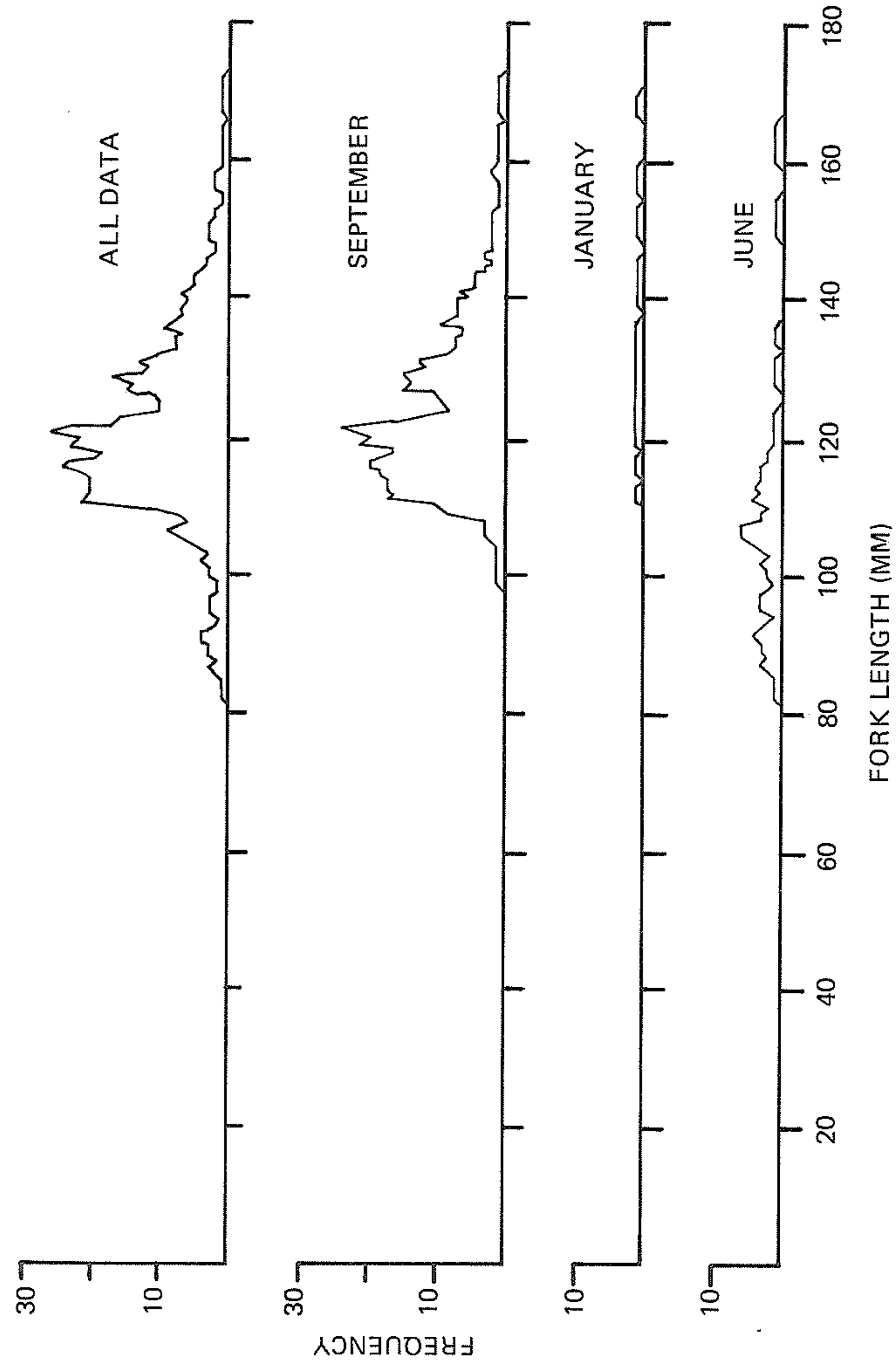

ALL DATA
SEPTEMBER
JANUARY
JUNE
FREQUENCY
30
10
FORK LENGTH (MM)
20
40
60
80
100
120
140
160
180

FIGURE 15. Length frequency compositions of *Trichiurus lepturus*. Frequencies are expressed as moving averages of three.

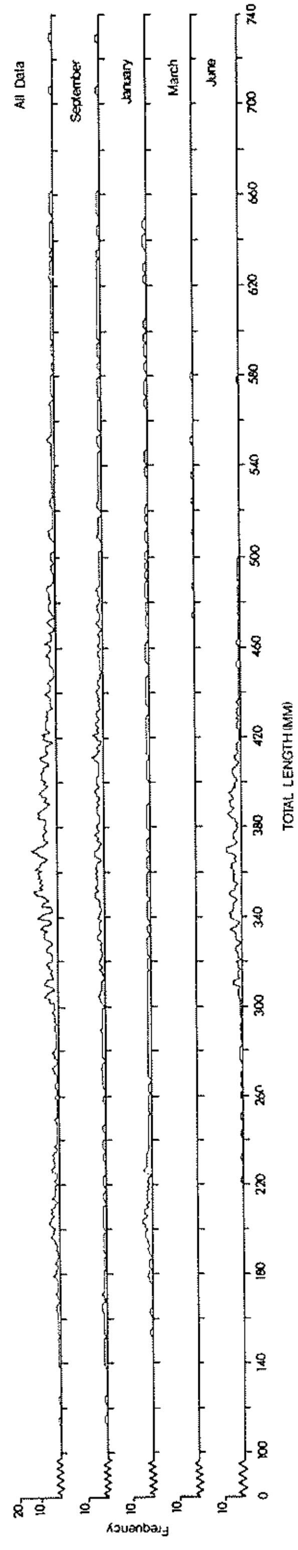

All Data
September
January
March
June
Frequency
20
10
0
100
140
180
220
260
300
340
380
420
460
500
540
580
620
660
700
740
TOTAL LENGTH (MM)

FIGURE 16. Length frequency compositions of *Peprilus burti*. Frequencies are expressed as moving averages of three.

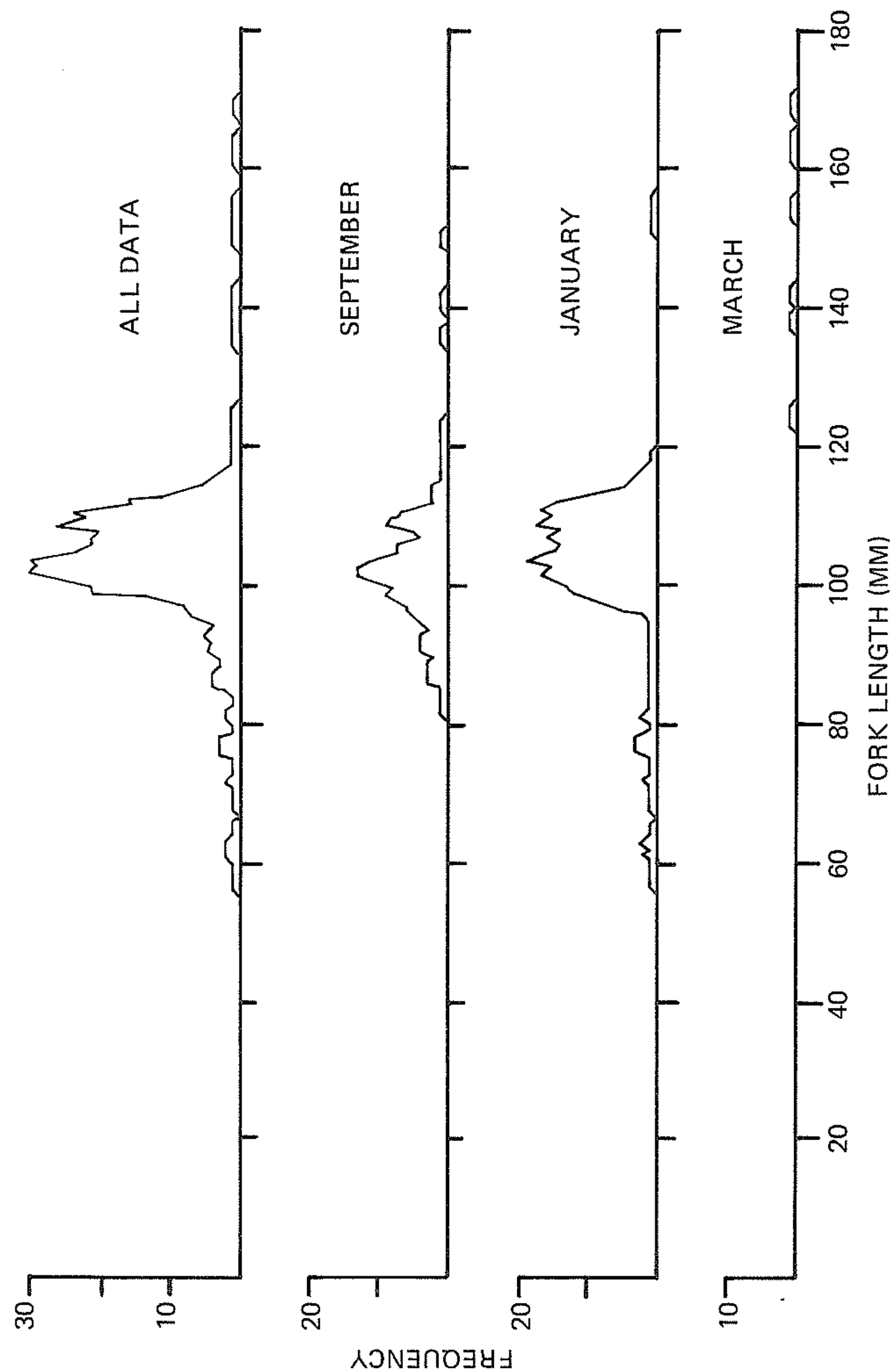
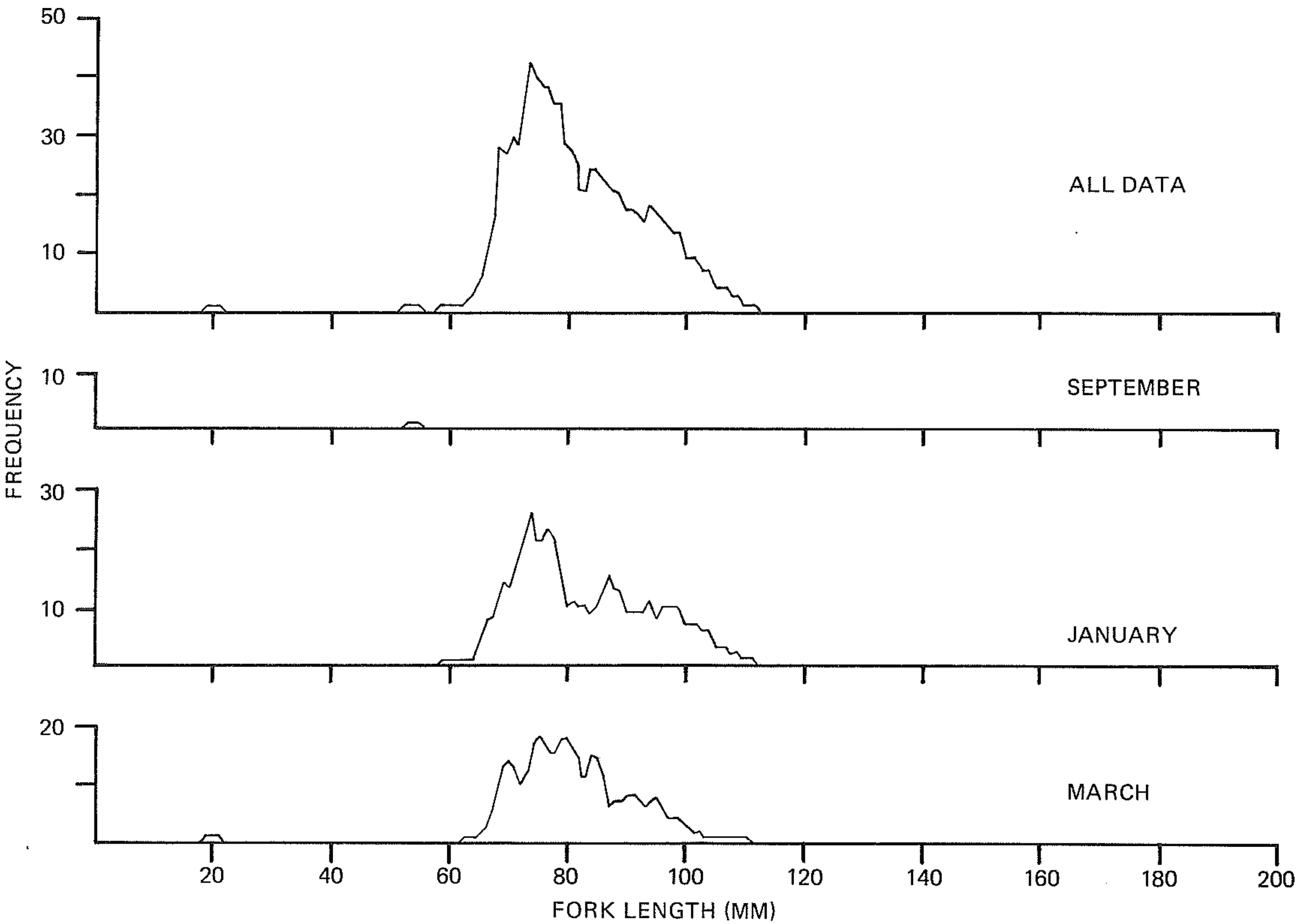

ALL DATA
SEPTEMBER
JANUARY
MARCH
FREQUENCY
30
10
20
20
10
FORK LENGTH (MM)
20
40
60
80
100
120
140
160
180

FIGURE 17. Length frequency compositions of Bellator militaris. Frequencies are expressed as moving averages of three.



50
30
10
ALL DATA
FREQUENCY
10
SEPTEMBER
30
10
JANUARY
20
MARCH
20
40
60
80
100
120
140
160
180
200
FORK LENGTH (MM)

FIGURE 18. Length frequency compositions of *Prionotus paralatus*. Frequencies are expressed as moving averages of three.

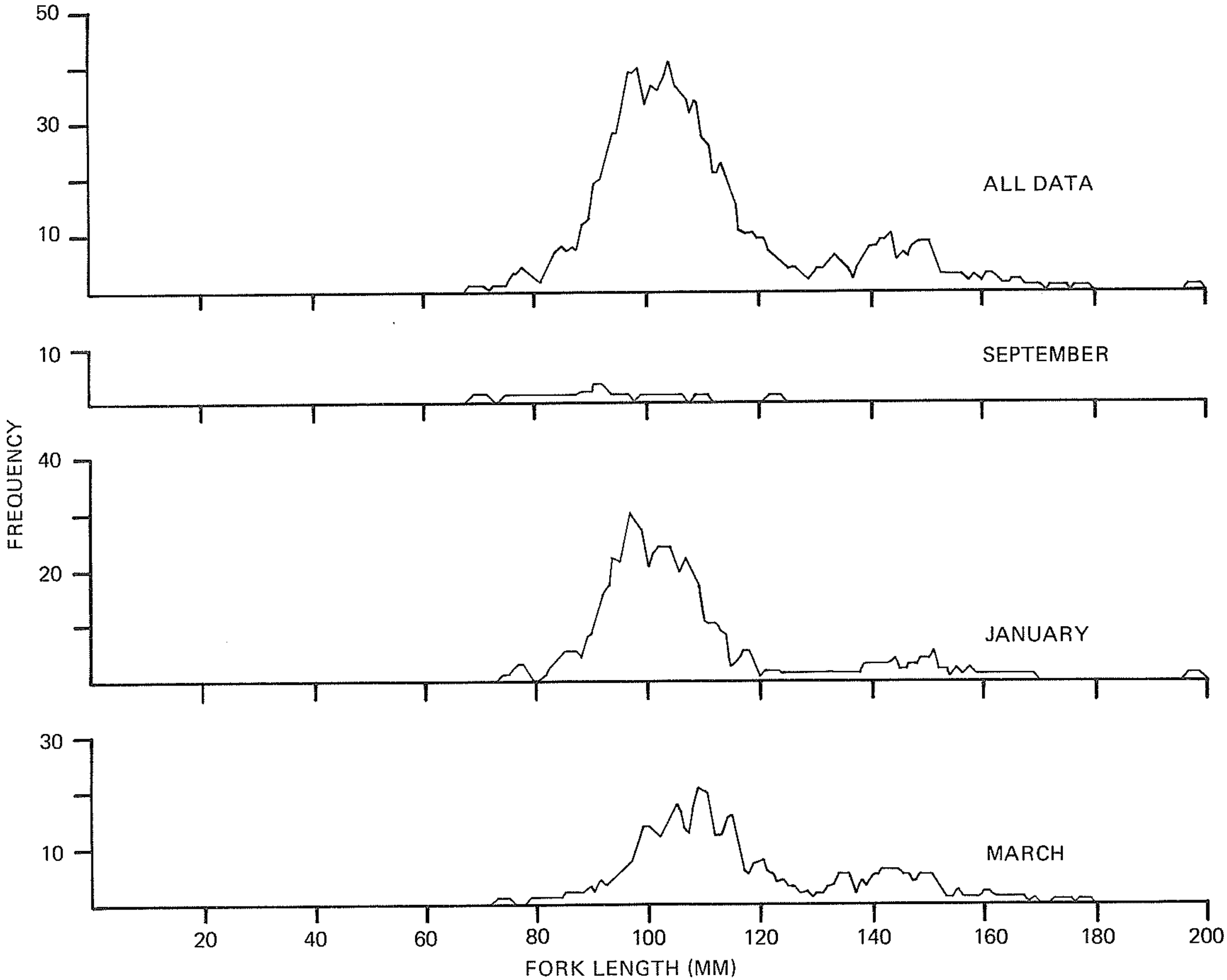

ALL DATA
SEPTEMBER
JANUARY
MARCH
FREQUENCY
50
30
10
10
40
20
30
10
20
40
60
80
100
120
140
160
180
200
FORK LENGTH (MM)

FIGURE 19. Length frequency compositions of *Syacium gunteri*. Frequencies are expressed as moving averages of three.

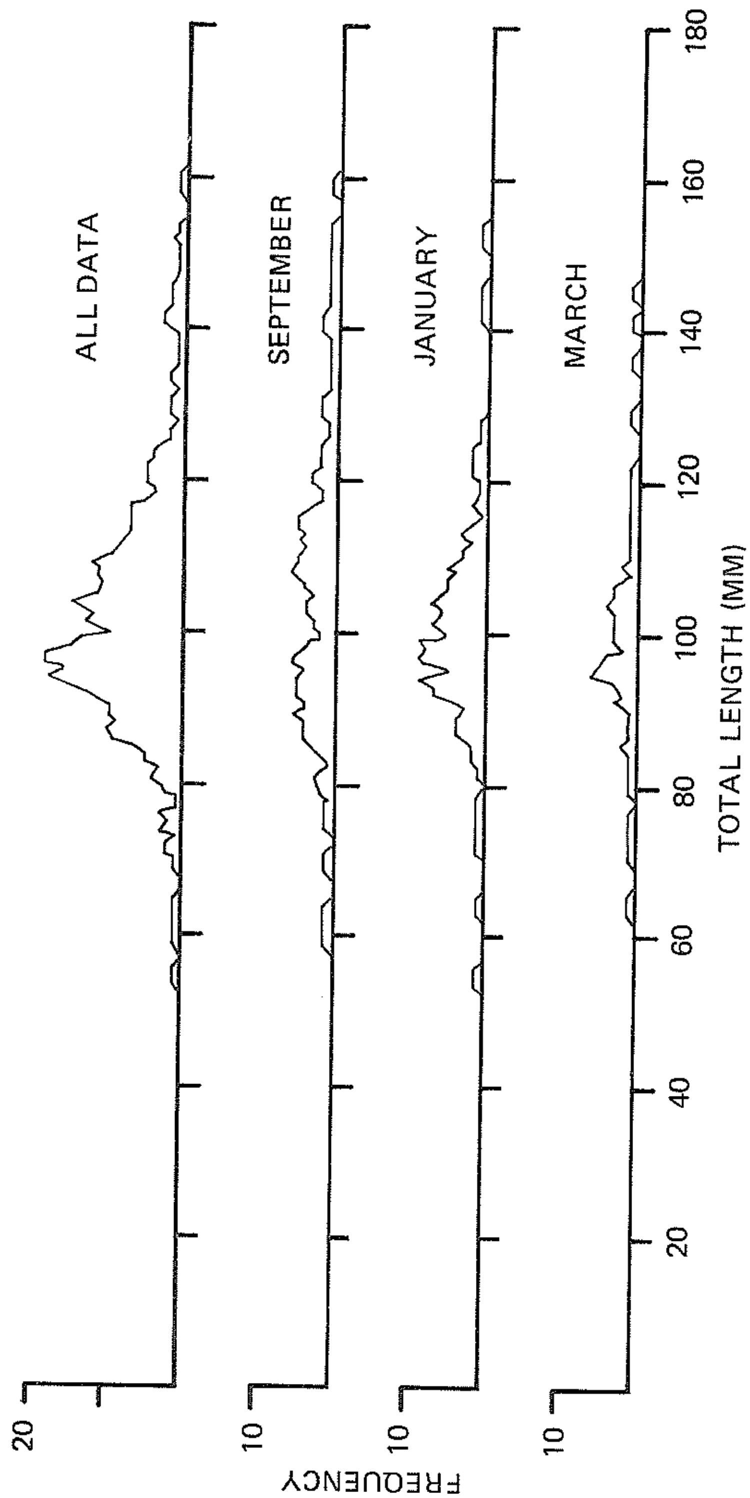

ALL DATA
SEPTEMBER
JANUARY
MARCH
FREQUENCY
20
10
10
10
TOTAL LENGTH (MM)
20
40
60
80
100
120
140
160
180

Table 1. Summary of sample sizes (n), total hours trawled, total discard catch, mean discard/tow, mean shrimp/tow, and ratios of the means (D/S). Shrimp and discard are expressed as volumes, one volume being a 36-kg fish basket.

Period	n	Total Hours Trawled	Total Discard Caught	Discard/Tow	Shrimp/Tow	D/S
WHITE SHRIMP GROUNDS						
September	8	28.25	118.5	14.81	.99	14.91
January	6	38.50	23.5	3.92	1.02	3.83
March	–	–	–	–	–	–
June	7	15.75	64.0	9.14	.33	27.71
Overall	21	82.50	206.0	9.81	.78	12.57
BROWN SHRIMP GROUNDS						
September	8	31.25	207.0	25.88	1.50	17.31
January	15	99.25	312.0	20.80	2.22	9.38
March	16	110.00	158.5	9.91	1.02	9.80
June	–	–	–	–	–	–
Overall	39	240.50	677.5	17.37	1.58	11.03
OVERALL						
September	16	59.50	325.5	20.34	1.24	16.35
January	21	137.75	335.5	15.98	1.88	8.51
March	16	110.00	158.5	9.91	1.02	9.80
June	7	15.75	64.0	9.14	.33	27.71
Overall	60	323.00	883.5	14.73	1.30	11.35

Table 2. Abundant families and species of fishes on the white and brown shrimp grounds. An abundant taxon represented 1% or more (rounded to the nearest "whole number") of the total catch on a given grounds. ABS means absent.

TAXON	PERCENTAGE OF THE TOTAL CATCH ON THE WHITE SHRIMP GROUNDS	PERCENTAGE OF THE TOTAL CATCH ON THE BROWN SHRIMP GROUNDS
Clupeidae	2	0
Brevoortia patronus	2	0
Opisthonema oglinum	1	0
Synodontidae	0	3
Synodus foetens	ABS	2
S. poeyi	0	1
Ariidae	5	ABS
Arius felis	5	ABS
Batrachoididae	0	2
Porichthys porosissimus	0	2
Ogcocephalidae	0	4
Halieutichthys aculeatus	0	3
Ophidiidae	0	1
Lepophidium sp.	0	1
Serranidae	0	5
Centropristis philadelphica	0	2
Serranus atrobranchus	ABS	3
Carangidae	2	1
Trachurus lathami	0	1
Vomer setapinnis	1	ABS
Lutjanidae	ABS	3
Lutjanus campechanus	ABS	1
Pristipomoides aquilonaris	ABS	1
Rhomboplites aurorubens	ABS	1
Pomadasyidae	1	0
Orthopristis chrysoptera	1	ABS
Sparidae	0	40
Lagodon rhomboides	0	1
Stenotomus caprinus	0	39
Sciaenidae	64	8
Cynoscion arenarius	8	1
C. nothus	13	1
Leiostomus xanthurus	1	2
Menticirrhus americanus	1	ABS
Micropogon undulatus	30	4
Stellifer lanceolatus	10	ABS

Table 2., Cont.

TAXON	WHITE SHRIMP GROUNDS	BROWN SHRIMP GROUNDS
Mullidae	0	6
Upeneus parvus	0	6
Polynemidae	5	0
Polydactylus octonemus	5	0
Trichiuridae	14	0
Trichiurus lepturus	14	0
Stromateidae	4	1
Peprilus burti	4	0
Scorpaenidae	ABS	1
Scorpaena calcarata	ABS	1
Triglidae	0	17
Bellator militaris	ABS	6
Prionotus paralatus	ABS	8
P. rubio	0	2
Bothidae	1	6
Syacium gunteri	1	4
Tetraodontidae	0	1

Table 3. Abundant taxa on the white shrimp grounds by cruise. An abundant taxon represented 1% or more of the total catch on the cruise. ABS means absent.

TAXON	PERCENTAGE OF THE TOTAL CATCH DURING SEPTEMBER	JANUARY	JUNE
Clupeidae			
Brevoortia patronus	0	0	1
Opisthonema oglinum	1	0	1
Ariidae			
Arius felis	2	0	13
Ogcocephalidae			
Ogcocephalus sp. A.	ABS	1	ABS
Carangidae			
Trachurus lathami	ABS	2	ABS
Vomer setapinnis	0	1	4
Pomadasyidae			
Orthopristis chrysoptera	0	0	2
Sciaenidae			
Cynoscion arenarius	7	4	13
C. nothus	4	50	0
Larimus fasciatus	0	ABS	1
Leiostomus xanthurus	0	1	3
Menticirrhus americanus	1	1	2
Micropogon undulatus	41	6	29
Stellifer lanceolatus	14	0	9
Polynemidae			
Polydactylus octonemus	7	1	3
Trichiuridae			
Trichiurus lepturus	16	10	15
Stromateidae			
Peprilus paru	0	1	0
P. burti	4	12	ABS
Bothidae			
Syacium gunteri	ABS	4	ABS

Table 4. Abundant taxa on the brown shrimp grounds by cruise. An abundant taxon represented 1% or more of the total catch on the cruise. ABS means absent.

TAXON	PERCENTAGE OF THE TOTAL CATCH DURING SEPTEMBER	JANUARY	MARCH
Synodontidae			
Saurida brasiliensis	0	1	0
Synodus foetens	2	2	3
S. poeyi	ABS	2	ABS
Batrachoididae			
Porichthys porosissimus	0	2	2
Ogcocephalidae			
Halieutichthys aculeatus	1	4	4
Ogcocephalus sp. A.	0	0	1
Ophidiidae			
Lepophidium sp.	2	0	1
Serranidae			
Centropristis philadelphica	2	3	3
Serranus atrobranchus	7	2	1
Carangidae			
Trachurus lathami	1	1	0
Lutjanidae			
Lutjanus campechanus	1	0	1
Pristipomoides aquilonaris	0	3	ABS
Rhomboplites aurorubens	ABS	0	3
Sparidae			
Lagodon rhomboides	0	2	1
Stenotomus caprinus	30	41	43
Sciaenidae			
Cynoscion arenarius	0	1	1
C. nothus	1	2	0
Leiostomus xanthurus	5	1	0
Micropogon undulatus	16	2	0
Mullidae			
Upeneus parvus	5	3	8
Polynemidae			
Polydactylus octonemus	2	ABS	ABS
Stromateidae			
Peprilus burti	1	0	0

Table 4., Cont.

TAXON	SEPTEMBER	JANUARY	MARCH
Scorpaenidae			
Scorpaena calcarata	0	1	1
Triglidae			
Bellator militaris	0	9	6
Prionotus paralatus	2	11	9
P. rubio	5	1	3
P. stearnsi	0	1	0
Bothidae			
Engyophrys senta	1	0	0
Syacium gunteri	14	2	2
Tetraodontidae			
Sphoeroides parvus	ABS	0	1

Table 5. Summary of the species collected in our 18-kg samples but not reported by Parker (1965) from Galveston Bay.

SPECIES	COLLECTED ON THE WHITE SHRIMP GROUNDS	COLLECTED ON THE BROWN SHRIMP GROUNDS
Hoplunnis macrurus		X
H. tenuis		X
Uroconger syringinus		X
Saurida brasiliensis	X	X
Synodus poeyi	X	X
Antennarius radiosus		X
Halieutichthys aculeatus	X	X
Ogcocephalus sp. A.	X	X
O. sp. B.	X	
Brotula barbata		X
Lepophidium sp.	X	X
Centropristis ocyurus		X
Serranus atrobranchus		X
Priacanthus arenatus		X
Caulolatilus cyanops		X
Decapterus punctatus		X
Trachurus lathami	X	X
Lutjanus campechanus		X
Pristipomoides aquilonaris		X
Rhomboplites aurorubens		X
Haemulon aurolineatum		X
Conodon nobilis	X	
Stenotomus caprinus	X	X
Equetus acuminatus		X

Table 5., Cont.

SPECIES	WHITE SHRIMP GROUNDS	BROWN SHRIMP GROUNDS
Mullus auratus		X
Upeneus parvus	X	X
Chaetodon sedentarius		X
Sphyraena guachancho		X
Scomberomorus cavalla	X	X
Bellator militaris		X
Prionotus ophryas		X
P. paralatus		X
P. roseus		X
P. rubio	X	X
P. salmonicolor		X
P. stearnsi	X	X
Ancylopsetta dilecta		X
Bothus sp.		X
Cyclopsetta chittendeni		X
Engyophrys senta	X	X
Syacium gunteri	X	X
S. papillosum		X
Trichopsetta ventralis		X
Gymnachirus texae		X
Symphurus civitatus	X	

Table 5., Cont.

SPECIES	WHITE SHRIMP GROUNDS	BROWN SHRIMP GROUNDS
S. diomedianus		X
S. parvus		X
Balistes capriscus	X	X
Lactophrys quadricornis		X
Sphoeroides dorsalis		X
S. spengleri		X

Appendix 1. Overall composition and frequency of occurrence of taxa captured in the 18 kg samples from each shrimp ground. Frequency of occurrence represents the percentage of samples a given taxon appeared in. ABS means absent.

Taxon	WHITE SHRIMP GROUNDS Number	Percentage of Total	Frequency of Occurrence	BROWN SHRIMP GROUNDS Number	Percentage of Total	Frequency of Occurrence
Carcharhinidae	6	0		2	0	
Rhizoprionodon terraenovae	6	0	14	2	0	5
Sphyrnidae	1	0				
Sphyrna lewini	1	0	4			ABS
Rajidae				17	0	
Raja texana			ABS	17	0	32
Dasyatidae	2	0				
Dasyatis sabina	2	0	2			ABS
Elopidae	2	0				
Elops saurus	2	0	9			ABS
Muraenesocidae				11	0	
Hoplunnis macrurus			ABS	5	0	12
H. tenuis			ABS	1	0	2
H. sp.				5	0	-
Congridae						
Uroconger syringinus			ABS	1	0	2
Clupeidae	189	2		37	0	
Brevoortia patronus	67	1	42	19	0	5
Dorosoma cepedianum	1	0	4	1	0	2
Harengula pensacolae	24	0	38	16	0	7
Opisthonema oglinum	97	1	57	1	0	7

Taxon	Number	Percentage of Total	Frequency of Occurrence	Number	Percentage of Total	Frequency of Occurrence
Engraulidae	58	0		1	0	
Anchoa hepsetus	28	0	23	1	0	2
A. mitchilli	30	0	19			ABS
Synodontidae	4	0		513	3	
Saurida brasiliensis	1	0	14	71	0	45
Synodus foetens			ABS	303	2	77
S. poeyi	3	0	9	139	1	25
Ariidae	554	5				
Arius felis	547	5	85			ABS
Bagre marinus	7	0	19			ABS
Batrachoididae	15	0		243	2	
Porichthys porosissimus	15	0	28	243	2	82
Antennariidae				9	0	
Antennarius nuttingi			ABS	1	0	2
A. radiosus			ABS	8	0	15
Ogcocephalidae	40	0		538	4	
Halieutichthys aculeatus	12	0	23	479	3	85
Ogcocephalus sp. A.	26	0	14	59	0	65
O. sp. B.	2	0	9			ABS
Gadidae	2	0		22	0	
Urophysis floridanus	2	0	9	22	0	25
Ophidiidae	1	0		125	1	
Brotula barbata			ABS	13	0	32
Lepophidium sp.	1	0	4	112	1	70
Serranidae	6	0		753	5	
Centropristis ocyurus			ABS	2	0	5
C. philadelphica	6	0	14	359	2	97
Serranus atrobranchus			ABS	392	3	85

Taxon	Number	Percentage of Total	Frequency of Occurrence	Number	Percentage of Total	Frequency of Occurrence
Priacanthidae				1	0	
Priacanthus arenatus			ABS	1	0	2
Branchiostegidae				9	0	
Caulolatilus cyanops			ABS	9	0	20
Carangidae	253	2		110	1	
Caranx hippos	18	0	28			ABS
Chloroscombrus chrysurus	10	0	28	8	0	12
Decapterus punctatus			ABS	1	0	2
Trachinotus carolinus	2	0	9			ABS
Trachurus lathami	56	0	9	101	1	52
Vomer setapinnis	167	1	66			ABS
Lutjanidae				408	3	
Lutjanus campechanus			ABS	78	1	85
Pristipomoides aquilonaris			ABS	149	1	37
Rhomboplites aurorubens			ABS	181	1	65
Gerreidae				15	0	
Eucinostomus gula			ABS	15	0	30
Pomadasyidae	73	1		8	0	
Conodon nobilis	1	0	4			ABS
Haemulon aurolineatum			ABS	8	0	12
Orthopristis chrysoptera	72	1	61			ABS
Sparidae	20	0		5995	40	
Lagodon rhomboides	19	0	28	179	1	55
Stenotomus caprinus	1	0	4	5816	39	100
Sciaenidae	7481	63		1147	8	
Bairdiella chrysura	15	0	23			ABS
Cynoscion arenarius	933	8	100	100	1	65
C. nothus	1545	13	85	136	1	55
Equetus acuminatus			ABS	12	0	15
Larimus fasciatus	57	0	52	12	0	10
Leiostomus xanthurus	130	1	85	224	2	45

Taxon	Number	Percentage of Total	Frequency of Occurrence	Number	Percentage of Total	Frequency of Occurrence
Menticirrhus americanus	118	1	85			ABS
M. littoralis	15	0	14			ABS
Micropogon undulatus	3522	30	100	663	4	62
Pogonias cromis	15	0	9			ABS
Stellifer lanceolatus	1131	10	76			ABS
Mullidae	1	0		850	6	
Mullus auratus			ABS	24	0	32
Upeneus parvus	1	0	4	826	6	97
Ephippidae	17	0		23	0	
Chaetodipterus faber	17	0	38	23	0	27
Chaetodontidae				1	0	
Chaetodon sedentarius			ABS	1	0	2
Mugilidae	4	0				
Mugil cephalus	4	0	9			ABS
Sphyraenidae				1	0	
Sphyraena guachancho			ABS	1	0	2
Polynemidae	581	5		9	0	
Polydactylus octonemus	581	5	95	9	0	22
Trichiuridae	1657	14		36	0	
Trichiurus lepturus	1657	14	100	36	0	37
Scombridae	10	0		3	0	
Scomberomorus cavalla	6	0	4	3	0	2
S. maculatus	4	0	9			ABS
Stromateidae	521	4		78	1	
Peprilus paru	34	0	57	41	0	17
P. burti	487	4	66	37	0	27
Scorpaenidae				103	1	
Scorpaena calcarata			ABS	103	1	75

Taxon	Number	Percentage of Total	Frequency of Occurrence	Number	Percentage of Total	Frequency of Occurrence
Triglidae	14	0		2580	17	
Bellator militaris			ABS	891	6	67
Prionotus ophryas			ABS	15	0	22
P. paralatus			ABS	1206	8	85
P. roseus			ABS	17	0	12
P. rubio	7	0	19	363	2	77
P. salmonicolor			ABS	14	0	25
P. stearnsi	2	0	9	70	0	40
P. tribulus	5	0	19	4	0	5
Bothidae	143	1		823	6	
Ancylopsetta dilecta			ABS	7	0	15
A. quadrocellata			ABS	3	0	7
Bothus sp.			ABS	2	0	5
Citharichthys spilopterus	20	0	38			ABS
Cyclopsetta chittendeni			ABS	55	0	67
Engyophrys senta	1	0	4	59	0	55
Etropus crossotus	20	0	28	15	0	17
Paralichthys lethostigma	5	0	19	2	0	5
Syacium gunteri	97	1	28	661	4	90
S. papillosum			ABS	1	0	2
Trichopsetta ventralis			ABS	18	0	15
Soleidae	6	0		59	0	
Achirus lineatus	6	0	28			ABS
Gymnachirus texae			ABS	59	0	62
Cynoglossidae	9	0		39	0	
Symphurus civitatus	9	0	19			ABS
S. diomedianus			ABS	18	0	25
S. parvus			ABS	1	0	2
S. plagiusa			ABS	20	0	15
Balistidae	2	0		33	0	
Balistes capriscus	1	0	4	24	0	42
Monacanthus hispidus	1	0	4	9	0	17
Ostraciidae				12	0	
Lactophrys quadricornis			ABS	12	0	22

Taxon	Number	Percentage of Total	Frequency of Occurrence	Number	Percentage of Total	Frequency of Occurrence
Tetraodontidae	2	0		123	1	
Lagocephalus laevigatus	2	0	9	13	0	27
Sphoeroides dorsalis			ABS	40	0	47
S. parvus			ABS	69	0	35
S. spengleri			ABS	1	0	2
Diodontidae	3	0		1	0	
Chilomycterus schoepfi	3	0	14	1	0	2
Totals	11,703			14,895		

Appendix 2. Listing of taxa, by cruise, that appeared in the main catch but not in the 18-kg samples.

Taxon	WHITE SHRIMP GROUNDS		BROWN SHRIMP GROUNDS		
	September	January	September	January	March
Carcharhinidae					
Carcharhinus acronotus				X	X
C. falciformis					X
C. leucas					X
C. maculipinnis					X
C. porosus					X
Galeocerdo cuvieri				X	X
Mustelus canis				X	X
Sphyrnidae					
Sphyrna tiburo	X	X			X
Squatinidae					
Squatina dumerili				X	X
Torpedinidae					
Narcine brasiliensis	X				
Dasyatidae					
Dasyatis centroura				X	
Myliobatidae					
Aetobatus narinari	X				
Rhinoptera bonasus	X				
Muraenidae					
Gymnothorax nigromarginatus			X	X	X

Taxon	September	January	September	January	March
Congridae					
Ariosoma bulearicum				X	
Congrina flava					X
Paraconger caudilimbatus				X	
Ophichthidae					
Mystriophis punctifer					X
Ophichthus gomesi	X			X	X
Ophichthus sp.					X
Clupeidae					
Sardinella anchovia			X		X
Batrachoididae					
Opsanus sp.					X
Gadidae					
Physiculus fulvus					X
Ophidiidae					
Lepophidium jeannae				X	
Ophidion welshi	X				
Zeidae					
Zenopsis ocellata	X				
Syngnathidae					
Syngnathus louisianae	X				
Serranidae					
Epinephelus flavolimbatus				X	X
Grammistidae					
Rypticus maculatus				X	X
Priacanthidae					
Pseudopriacanthus altus				X	X
Apogonidae					
Apogon pseudomaculatus				X	

Taxon	September	January	September	January	March
Pomatomidae					
<u>Pomatomus saltatrix</u>			X		
Rachycentridae					
<u>Rachycentron canadum</u>				X	X
Echeneidae					
<u>Echeneis naucrates</u>			X	X	X
Carangidae					
<u>Alectis crinitis</u>			X	X	X
<u>Caranx crysos</u>				X	
<u>Hemicaranx amblyrhynchus</u>		X		X	
<u>Selar crumenophthalmus</u>			X		
<u>Selene vomer</u>	X		X	X	
<u>Seriola dumerili</u>			X		
<u>S. rivoliana</u>				X	
Lutjanidae					
<u>Lutjanus synagris</u>				X	X
Sparidae					
<u>Archosargus probatocephalus</u>		X			
<u>Calamus leucosteus</u>				X	X
Sciaenidae					
<u>Sciaenops ocellata</u>		X			
Uranoscopidae					
<u>Kathetostoma albigutta</u>				X	X
Gobiidae					
<u>Bollmannia communis</u>			X		X
Scombridae					
<u>Euthynnus alletteratus</u>			X		
<u>Scomber japonicus</u>				X	X

Taxon	September	January	September	January	March
Scorpaenidae					
Scorpaena brasiliensis				X	
S. dispar				X	X
S. plumieri		X			
Bothidae					
Cyclopsetta fimbriata				X	X
Paralichthys albigutta		X		X	
P. squamilentus					X
Balistidae					
Aluterus heudeloti				X	
A. schoepfi			X		
Monacanthus ciliatus				X	X