FOOD HABITS OF GEORGIA ESTUARINE FISHES I. FOUR SPECIES OF FLOUNDERS (PLEURONECTIFORMES: BOTHIDAE)

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ABSTRACT

The food habits of four species of bothid flounders from Georgia coastal waters were examined by means of stomach content analyses. Ocellated flounders, *Ancylopsetta quadrocellata* (Gill); bay whiff, *Citharichthys spilopterus* (Günther); and windowpane, *Scophthalmus aquosus* (Mitchill) fed heavily on the mysid shrimp, *Neomysis americana*, without regard to season of the year or location within the estuary. The food habits of both *A. quadrocellata* and *C. spilopterus* changed to some extent as the fish became larger. Organisms larger than *N. americana* dominated the stomach contents of *A. quadrocellata* larger than 150 mm standard length and *C. spilopterus* larger than 125 mm. *S. aquosus*, in the size range examined, fed almost exclusively on *N. americana*.

Fringed flounder, *Etropus crossotus* (Jordan and Gilbert) primarily consumed the calanoid copepod, *Pseudodiaptomus coronatus*, during the spring, summer, and fall and diversified their food habits during the winter. *P. coronatus* dominated the stomach contents both in the rivers and sounds of Georgia estuarine waters and was the dominant organism in fishes of all sizes up to 100 mm when polychaete annelids became important. The food of *E. crossotus* did not appear to vary with time of day; however, *E. crossotus* did not actively feed at night. The difference in food habits between *E. crossotus* and the other three bothid species appears to be associated with the relative size of the mouth.

Pleuronectiform fishes of the family Bothidae are common in the estuarine waters of the southeastern United States. Otter trawl samples taken within the sounds and rivers of Georgia indicate that fishes of the family Sciaenidae are the most common, with bothids being among the next most common species. Summer flounder, *Paralichthys dentatus* and southern flounder, *P. lethostigma*, are common, but are not present in commercially exploitable quantities. *P. albigutta* has also been reported from Georgia waters, but appears to be relatively rare (Dahlberg and Odum, 1970). Ocellated flounder, *Ancylopsetta quadrocellata*, while not commercially valuable, is occasionally caught by sport fishermen.

Bothid flounders are generally associated with the bottom, either lying on the surface of the substrate or buried to a greater or lesser extent in the sediments. The feeding behavior of flounders under various conditions (both in nature and in culture) has been described (Steven, 1930; Olla, Wicklund, and Wilk, 1969; de Groot, 1970; Olla, Samet, and Studholme, 1972; Stickney, White, and Miller, 1973), but little information on the selective food habits of bothids is presently available. The food habits of *Paralichthys* sp. have been examined by Darnell (1958) in the Gulf of Mexico and by Poole (1964) in New England waters. A limited amount of additional information on *P. albigutta* is also available from samples taken off the southwestern coast of Florida (Topp and Hoff, 1972). Examination of the stomachs from a few specimens of *A. quadrocellata* and *Etropus crossotus*, fringed flounder, demonstrated that both feed on crustaceans in Florida waters (Topp and Hoff, 1972) with *E. crossotus* also utilizing polychaetes and chaetognaths for food (Reid, 1954; Topp and Hoff, 1972). Fourteen species of bothid flounders were examined by de Groot (1971) who found that they divided into three groups by food preference: fish feeders, crustacean feeders, and polychaete-mollusc feeders.

The food habits of bothid flounders along the Georgia coast have not been previously elaborated. For purposes of the present study, four

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species were selected which seasonally account for the majority of bothids captured by otter trawling and were thus judged to be important in the energy flow through the Georgia estuarine ecosystem. The four species chosen were *A. quadrocellata*; bay whiff, *Citharichthys spilopterus*; *E. crossotus*; and windowpane, *Scophthalmus aquosus*. Other important Pleuronectiform fishes of the Georgia coast include *P. dentatus*, *P. lethostigma*, *Trinectes maculatus*, and *Symphurus plagiusa*.

MATERIALS AND METHODS

The coastal region of Georgia consists of a system of barrier islands separated by sounds from which a network of rivers and tidal creeks emanate. The tide range (reaching nearly 3 m on spring tides) coupled with the low relief of the barrier islands and coastal plain results in extensive areas of intertidal marshlands. The marshes are dominated by *Spartina alterniflora*.

Flounders were collected by otter trawl and cast net from Wassaw Sound, Ossabaw Sound, St. Catherines Sound, and Sapelo Sound, and from various locations in rivers above the sound limits (Figure 1). Most of the fish utilized in this study were captured during 1971 and 1972 by personnel from the Savannah Science Museum and Skidaway Institute of Oceanography. Others were donated from collections made by workers at the University of Georgia Marine Institute during 1968. Whole fish were preserved in 10% Formalin[3] after capture.

Location, date of capture, and standard length were recorded for each specimen used in the study. The stomachs were removed, and their contents examined under a dissecting microscope. Organisms found within the stomachs were identified to species when possible and counted. Parasitic nematodes and trematodes were found in many stomachs but were excluded from the food habit data.

In many instances identifications of food organisms were made from pieces of animals found within stomachs. In most cases these pieces provided enough material for specific identification, but in those cases where decomposition made identification to species impossible, the material was identified to the class or family level. Few cases were found in which the stomachs contained completely unidentifiable organic material. Emphasis was placed on correctly enumerating the organisms found in stomachs. Neither biomass nor volumetric displacement data were obtained. Since food items were often identified from parts of an individual (the remainder having been either digested or not actually ingested), it was felt that any estimate of biomass would have little significance.

Many stomachs contained pieces of polychaete annelids which had apparently been nipped off by the fish in their feeding activities. Since it was not possible to reconstruct these fragments into whole animals, heads were counted. Counts based on fragments of organisms cannot be considered completely accurate; however, such food organisms often accounted for a relatively small fraction of the total stomach contents. The organisms which made up the numerical bulk of the food were usually in good condition, facilitating exact counting.

One of the more important organisms found, *Neomysis americana*, has not been reported from as far south as Georgia by many previous authors, although it has been reported from the stomachs of two species of Gadidae, *Urophycis regius* and *U. floridanus* (Sikora, Heard, and Dahlberg, 1972). The reported range of *N. americana* is from the Gulf of St. Lawrence to Virginia (Tattersall, 1951; Wigley and Burns, 1971). This range was extended to near the northern South Carolina border by Williams (1972) who also reported that *N. americana* was common in North Carolina. The range is presently again being extended by A. B. Williams (pers. commun.) who has examined and verified examples of *N. americana* from our collections.

RESULTS AND DISCUSSION

Overall Evaluation

Data summarizing the food of each of the four bothid species are presented in Table 1. Organisms are excluded which were not present in at least 1% of the stomachs examined in any of the four species of fish or which did not account for 1% or more of the total food organisms found in the stomachs of one or more of the species of fish. A complete list of food organisms recovered is presented in the Appendix.

[3] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

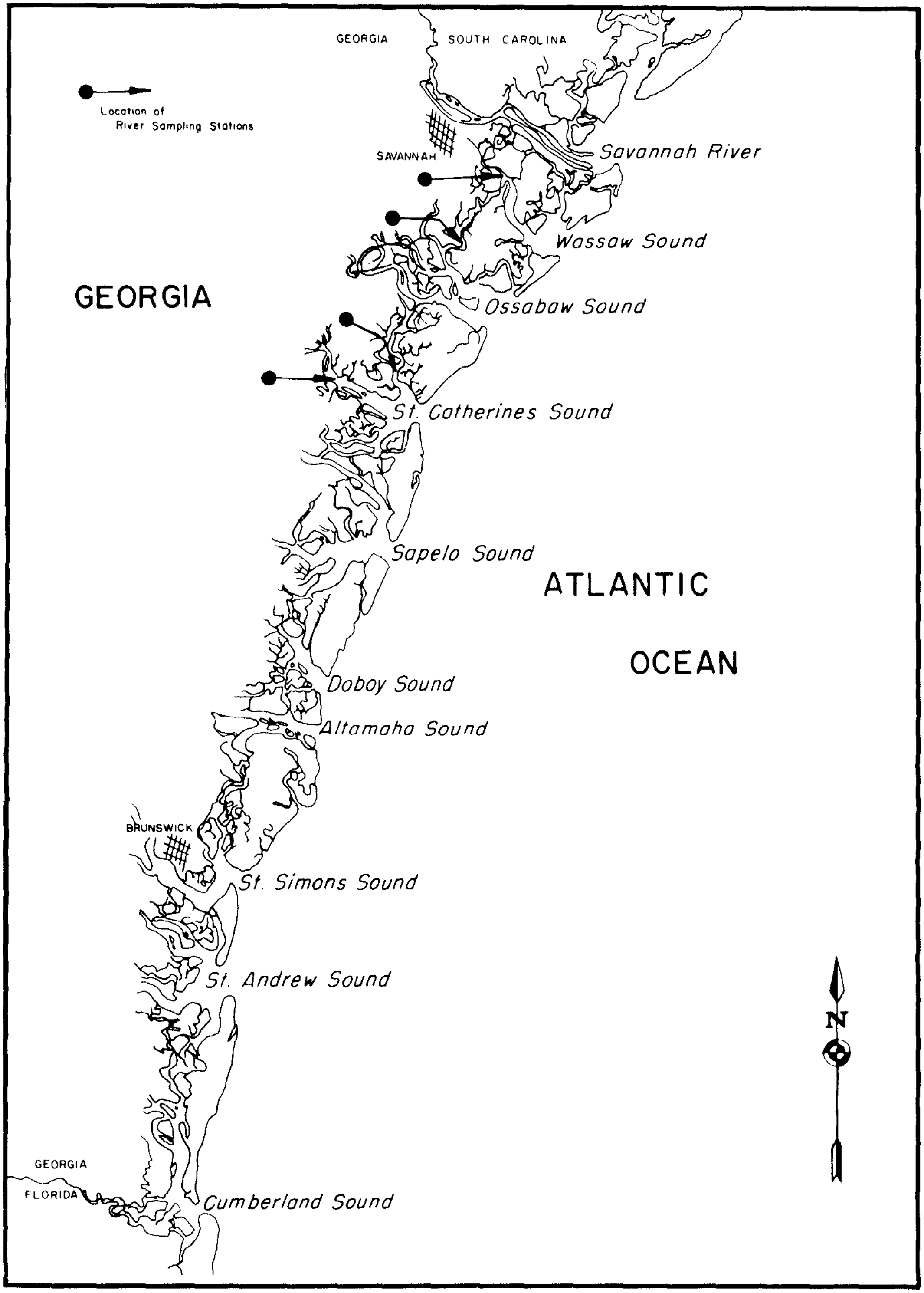

FIGURE 1.—Sampling area along the coast of Georgia indicating the sounds and river locations from which fish samples were obtained.

The food habits of *E. crossotus* are distinct from those of the other three species (Table 1). *Pseudodiaptomus coronatus* dominated the stomach contents of *E. crossotus* but accounted for only an insignificant fraction of the stomach contents of *A. quadrocellata*, *C. spilopterus*, and *S. aquosus*. The stomach contents of each of the latter three species were dominated by *Neomysis americana*.

Of secondary importance in the stomachs of *E. crossotus* were polychaete annelids, especially the spionid, *Paraprionospio pinnata*. The importance of *Pa. pinnata* is extended if the assumption is made that most of the animals listed under Spionidae (Table 1) were, in fact, *Pa. pinnata* in a state of decomposition, making specific identification impossible.

No fish remains were found in any of the stomachs of *E. crossotus* examined, although they were found in *A. quadrocellata, C. spilopterus*, and *S. aquosus*. The difference in primary feeding habits between *E. crossotus* and the other three species of bothids appears to be a reflection of relative mouth size (Figure 2). *E. crossotus* has a very small mouth relative to head length (mouth averages about 6 into head), whereas, *A. quadrocellata, C. spilopterus,* and *S. aquosus* all have relatively larger mouths in proportion to head length (mouth averages 3 to 4 into head). The small mouth of *E. crossotus* correlates with its selectivity for small organisms (such as *Ps. coronatus*, which range from 1 to 1.5 mm in length) and those of small diameter (such as *Pa. pinnata*). While the remaining three fish species appear to favor *N. americana* as a primary food organism, the diversity of sizes or organisms available to them appears greater. *N. americana* ranged from 6 to 12 mm in length in our collections. This organism was not completely excluded from the food of *E. crossotus* (Figure 3) but was fed upon only to a limited extent.

Table 1 presents the food habit data collected for each species without regard to season of the year, location in the estuary, or size of the fish under investigation. In order to more critically evaluate the data collected on each species, a

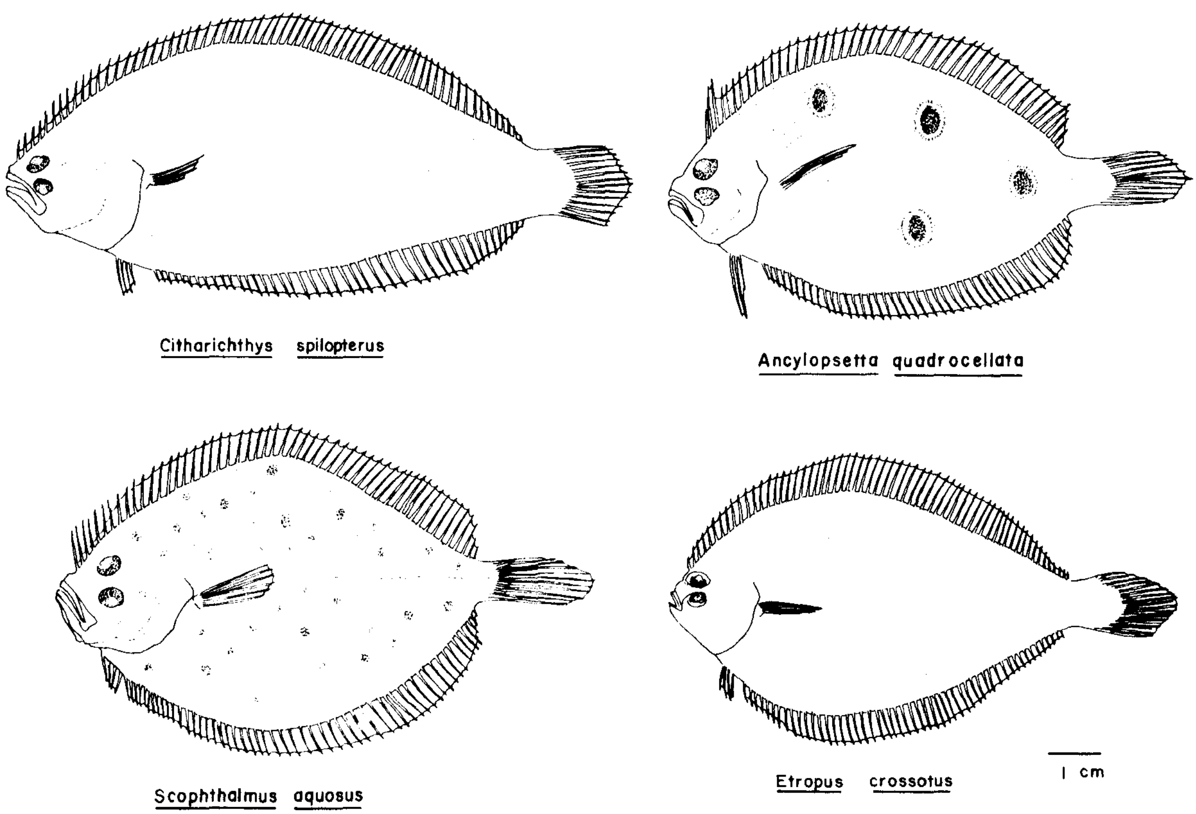

FIGURE 2.—Line drawings of the four species of Bothidae discussed depicting the differences in mouth size relative to body length.

TABLE 1.—Occurrence of organisms appearing in 1% or more of the stomachs examined, or representing 1% or more of the total number of food organisms recovered from the stomachs of one or more of the four species of Bothidae under investigation.[1]

	Etropus crossotus		*Citharichthys spilopterus*		*Ancylopsetta quadrocellata*		*Scophthalmus aquosus*	
Food organisms	Percentage occurrence in stomachs	Percentage of total number of organisms	Percentage occurrence in stomachs	Percentage of total number of organisms	Percentage occurrence in stomachs	Percentage of total number of organisms	Percentage occurrence in stomachs	Percentage of total number of organisms
Ectoprocta:								
Bugula neritina	0.2	<0.1	0.0	0.0	0.0	0.0	1.0	0.1
Polychaeta:								
Diopatra cuprea	1.7	0.3	0.0	0.0	0.0	0.0	1.0	0.1
Nereis succinea	4.0	0.2	0.0	0.0	0.5	0.1	1.0	0.1
Nereidae	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Paraprionospio pinnata	29.5	2.9	0.5	0.2	0.0	0.0	0.0	0.0
Spionidae	15.9	2.6	0.5	<0.1	0.9	0.2	0.0	0.0
Asabellides oculata	3.3	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Sabella microphthalma	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Unidentified remains	1.7	0.1	0.0	0.0	0.5	0.1	0.0	0.0
Mollusca:								
Pelecypod siphons	1.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Decapoda—Reptantia								
Pinnixa sp.	2.4	0.1	0.0	0.0	3.2	0.5	0.0	0.0
Portunid megalops and zoea	2.6	0.2	7.1	0.9	0.0	0.0	0.0	0.0
Portunus spinimanus	0.0	0.0	0.5	<0.1	1.4	0.3	0.0	0.0
Portunus gibbesii	0.0	0.0	0.0	0.0	1.4	0.4	0.0	0.0
Neopanope sayi	0.0	0.0	0.0	0.0	3.7	1.0	0.0	0.0
Hexapanopeus angustifrons	0.0	0.0	0.0	0.0	1.8	0.5	0.0	0.0
Cancer irroratus	0.0	0.0	0.0	0.0	1.4	0.4	0.0	0.0
Portunid postlarvae	0.2	<0.1	1.4	0.1	2.8	0.8	0.0	0.0
Callinectes sapidus	0.0	0.0	4.3	0.6	0.5	0.1	0.0	0.0
Decapoda—Natantia:								
Acetes americanus carolinae	0.2	<0.1	0.0	0.0	0.0	0.0	1.0	0.1
Palaemonetes pugio	1.4	0.1	16.2	2.8	0.9	0.5	1.0	0.1
Trachypenaeus constrictus	1.0	0.1	35.7	10.4	7.8	5.3	0.0	0.0
Periclimenes longicaudatus	0.0	0.0	1.4	0.1	0.0	0.0	0.0	0.0
Ogyrides limicola	5.2	0.3	10.5	3.3	0.0	0.0	0.0	0.0
Stomatopoda:								
Squilla empusa	0.0	0.0	15.2	2.0	5.5	1.0	1.0	0.1
Amphipoda:								
Ampelisca vadorum	3.8	0.6	1.0	0.1	1.4	0.3	1.0	0.1
Corophium tuberculatum	2.6	0.2	0.0	0.0	0.9	0.1	1.0	0.1
Unciola serrata	0.2	<0.1	0.0	0.0	3.7	4.6	1.9	0.1
Batea catharinensis	0.5	<0.1	0.0	0.0	0.5	0.1	2.9	0.2
Monoculodes edwardsi	7.4	0.6	1.0	0.1	0.5	0.1	1.0	0.1
Erichthonius brasiliensis	0.2	0.1	0.0	0.0	0.5	0.1	2.9	0.1
Caprella equilibra	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1
Gammarus palustris	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1
Microprotopus ranei	0.2	<0.1	0.0	0.0	0.0	0.0	1.0	0.1
Listriella barnardi	2.1	0.1	1.0	0.1	0.9	0.1	0.0	0.0
Copepoda:								
Pseudodiaptomus coronatus	34.2	84.6	1.4	0.8	0.5	0.8	1.9	0.5
calanoid copepod remains	0.5	0.1	1.0	0.2	0.9	0.1	3.8	1.0
Cumacea:								
Leucon americanus	6.9	0.5	0.5	<0.1	0.0	0.0	0.0	0.0
Mancocuma altera	2.1	0.2	0.0	0.0	0.0	0.0	4.8	0.2
Oxyurostylis smithi	7.4	1.4	0.0	0.0	0.5	0.1	3.8	0.3
Mysidacea:								
Neomysis americana	19.0	3.1	65.7	72.1	51.6	81.0	59.0	96.3
Isopoda:								
Edotea montosa	5.7	0.4	0.0	0.0	0.5	0.1	0.0	0.0
Osteichthyes:								
Symphurus plagiusa	0.0	0.0	4.8	0.5	1.4	0.2	0.0	0.0
Anchoa mitchilli	0.0	0.0	1.0	0.1	0.9	0.3	0.0	0.0
Cynoscion sp.	0.0	0.0	1.9	0.2	0.0	0.0	0.0	0.0
Sciaenidae remains	0.0	0.0	16.7	2.8	0.0	0.0	0.0	0.0
Gobiidae remains	0.0	0.0	4.3	0.5	0.0	0.0	0.0	0.0
Unidentified remains	0.0	0.0	11.4	1.1	1.8	0.3	1.0	0.1
Others	0.0	0.0	0.0	0.7	0.0	0.5	0.0	0.0
Empty stomachs	26.5	—	7.6	—	30.9	—	35.2	—

[1]The total number of stomachs analyzed for each species were: *E. crossotus*, 421; *C. spilopterus*, 210; *A. quadrocellata*, 217; and *S. aquosus*, 105. The total number of organisms obtained from the stomachs of fishes examined were: *E. crossotus*, 8,734; *C. spilopterus*, 2,442; *A. quadrocellata*, 1,490; *S. aquosus*, 2,209.

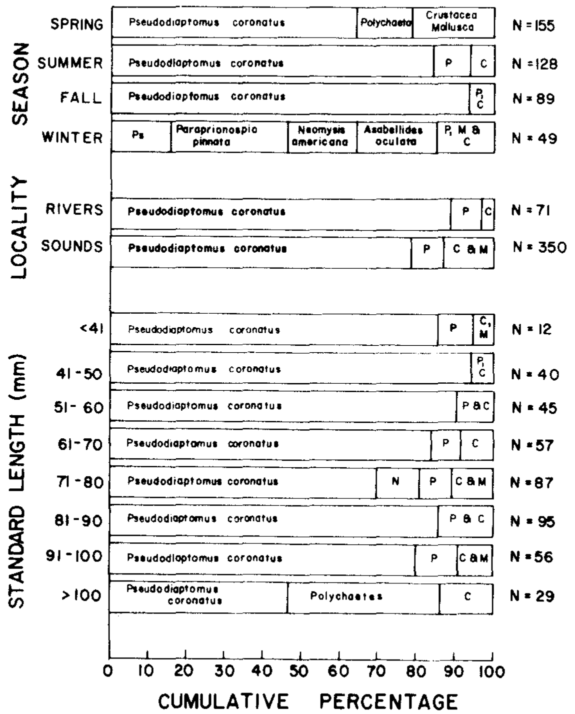

FIGURE 3.—Histogram illustrating the feeding habits of *Etropus crossotus* by season of the year, locality, and standard length. (N = number of stomachs analyzed for each bar, P = Polychaetes, C = Crustacea other than those specifically identified in the bar, Ps = *Pseudodiaptomus coronatus*, M = mollusca, and N = *Neomysis americana.*)

series of figures was prepared which take these parameters into consideration (Figures 3-8).

Etropus crossotus

The food habits of *E. crossotus* related to season of the year, locality within the estuary (rivers as opposed to sounds), and standard length are presented in Figure 3 indicating the percentage of total numbers of food organisms contributed by each taxa. *E. crossotus* was most abundant during the spring and summer months (March through August). *Ps. coronatus* was the dominant organism in the stomachs of *E. crossotus* during the spring, summer, and fall. During the winter, *Ps. coronatus* was displaced to a large extent by the spionid polychaete *Pa. pinnata* and by *N. americana.* Whereas Table 1 indicated that *Pa. pinnata* was of general importance especially in terms of frequency of occurrence in the stomachs, Figure 3 indicates that this organism was more important during the winter (December through February) than during any other season of the year. This change in food habits does not appear to reflect a reduction in the availability of *Ps. coronatus.* Plankton samples taken in conjunction with this and other studies have demonstrated that *Ps. coronatus* is present during the winter in numbers often exceeding those of other seasons of the year. The change in food habits may reflect an increased availability of *Pa. pinnata* rather than a decrease in the availability of *Ps. coronatus.* The increased availability of *Pa. pinnata* may have been a function of an increase in absolute numbers of the polychaetes or may have been due to a change in the behavior patterns of the predator, prey or both. Studies of benthos associated with stations in Ossabaw Sound, from which many of the fishes were collected, indicate that *Pa. pinnata* is the dominant benthic infaunal form throughout the year on mud substrates and exhibits widely fluctuating standing crop levels (Stickney and Perlmutter, unpubl. data).

The possibility that the shift in food habits in winter may have been a function of the size of the fishes occurring in the estuaries during that season was considered. Animals in the larger size ranges did not dominate the winter samples but were generally present during the spring (Figure 4). Fish in the smallest groups were present most often in the summer when *Ps. coronatus* were highly dominant in the stomachs. Suitable numbers of *E. crossotus* were present throughout

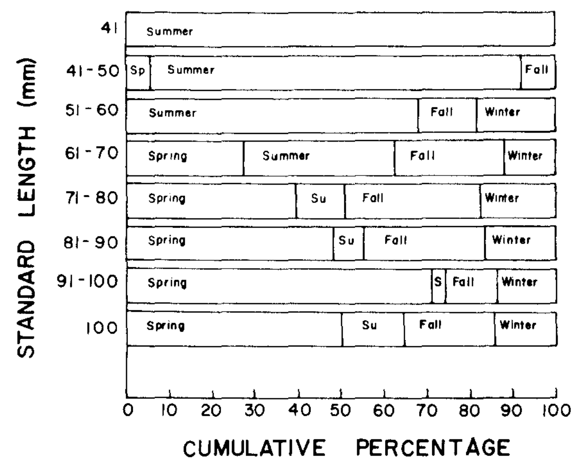

FIGURE 4.—Histogram of percentage of stomachs examined during spring (March through May), summer (June through August), fall (September through November), and winter (December through February) for *Etropus crossotus* of various standard length groups.

each season of the year to provide reliability to the data (Figure 4).

The food habits of *E. crossotus* were similar in both the rivers and sounds of Georgia. There were some alterations in food habits associated with increased standard length, however. While *Ps. coronatus* was present in a greater percentage in the stomachs of *E. crossotus* of all sizes than any other food organism, polychaetes increased in importance in fishes longer than 100 mm. The appearance of polychaetes in stomachs of larger *E. crossotus* may be a function of the increase in mouth size during growth.

Virtually all of the copepods found in the stomachs of *E. crossotus* were *Ps. coronatus*. Plankton samples taken by us during the course of this study verified that the copepod population in Georgia coastal waters is dominated by *Ps. coronatus*.

During October 1972, a series of bihourly trawls over a 24-h period was obtained in Ossabaw Sound. Each trawl was of 10-min duration and covered the same bottom. A total of 121 *E. crossotus* were captured in the 12 samples, and their stomachs were analyzed. Data from these fish were excluded from Figure 3 but are included in Figure 5.

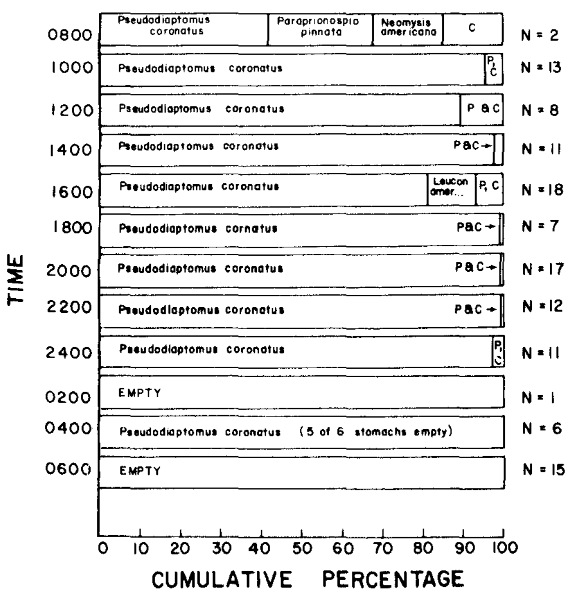

FIGURE 5.—Histogram illustrating the feeding habits of *Etropus crossotus* at 2-h intervals for 24 h. (N = number of stomachs analyzed for each bar, C = Crustacea other than those specifically identified in the bar, P = polychaetes, and Leucon amer. . . = *Leucon americanus*.)

P. coronatus was the numerically dominant organism in the stomachs with the exceptions of samples taken at 0200, 0600, and 0800 h. At 0200 and 0600 h none of the stomachs examined (16) contained food. At 0800 h only two *E. crossotus* were obtained, and a variety of food organisms were identified, with *Ps. coronatus* most abundant. The 0400 h sample contained six *E. crossotus* of which only one contained food (100% *Ps. coronatus*).

Based on this limited information, it appears that *E. crossotus* feeds mainly during the daylight hours with unchanging food habits throughout the day. This observation correlates with the findings of de Groot (1971) which indicate that bothids are visual feeders.

Ancylopsetta quadrocellata

The food habits of *A. quadrocellata* at different seasons of the year, location within the estuary, and standard length are presented in Figure 6. The preponderance of the animals were captured during the spring, reflecting the seasonal availability of this fish in Georgia estuarine waters.

N. americana was the dominant food organism throughout the year. *Trachypenaeus constrictus* became important during the summer and fall. *Neopanope sayi* was present in significant quantities during the winter.

While the food habits of *A. quadrocellata* captured in rivers were nearly identical to those captured in sounds, there were some differences in food habits with size of the fish. *N. americana* exceeded 50% of the total number of organisms found in the stomachs of fishes of less than 150 mm. Fish remains were found in the stomachs of fishes longer than 75 mm, although fish were never the dominant food organism. *T. constrictus* first became important as food in *A. quadrocellata* longer than 100 mm and was the dominant organism in fishes from 150 to 174 mm. Fishes longer than 175 mm fed on a variety of organisms. These data indicate that the diversity of foods increases with the size of the predator. The relatively large mouth of *A. quadrocellata* compared to that of *E. crossotus* may account for some of this variability in food habits with size (Figure 2).

Ps. coronatus, the dominant organism in the stomachs of *E. crossotus*, was virtually absent from the stomachs of *A. quadrocellata* longer than

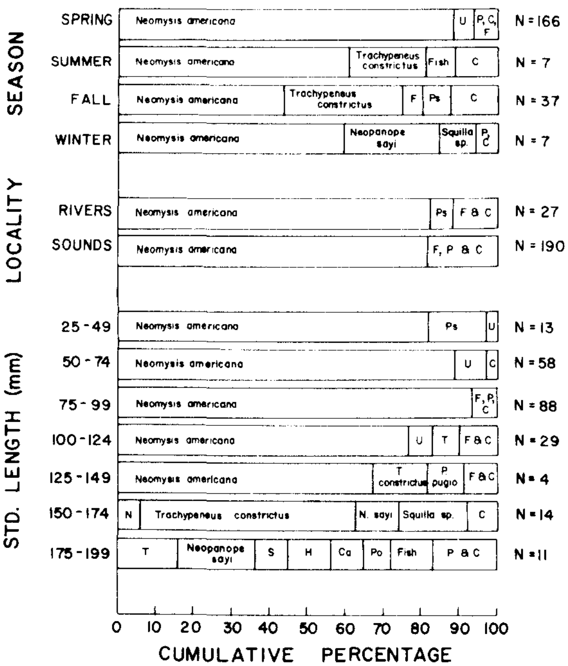

FIGURE 6.—Histogram illustrating the feeding habits of *Ancylopsetta quadrocellata* by season of the year, locality, and standard length. (N = number of stomachs analyzed for each bar, U = *Unciola serrata*, P = polychaetes, C = Crustacea other than those specifically identified in the bar, F = fish remains, Ps = *Pseudodiaptomus coronatus*, and T. constrictus = *Trachypenaeus constrictus*, P. pugio = *Palaemonetes pugio*, N = *Neomysis americana*, S = *Squilla* sp., H = *Hexapanopeus augustifrons*, Ca = *Cancer irroratus*, and Po = *Portunus gibbesii*.

50 mm. This may also relate to mouth size differences between the species. Studies with *Paralichthys lethostigma* and *P. dentatus* reared in the laboratory on brine shrimp, *Artemia salina*, indicate that once the flounders reach sufficient size (in this case about 25 mm), they have difficulty retaining ingested *A. salina* nauplii (Stickney and White, unpubl. data). The nauplii tend to be flushed through the gills and out the operculums. While the fish are still able to hunt the *A. salina* by sight, they do not seem to ingest a great number of nauplii. The relative mouth sizes of *P. lethostigma* and *P. dentatus* are similar to those of *A. quadrocellata, C. spilopterus,* and *S. aquosus.*

Citharichthys spilopterus

The food habits of *C. spilopterus* in relation to season of the year, location, and size are documented in Figure 7. The majority of the fish examined were captured during the summer (June through August). No fish were captured during the winter months (December through February). *N. americana* was the dominant species occurring in the stomachs of *C. spilopterus* during each of the three seasons for which data are available. A greater proportion of *T. constrictus* occurred in fishes captured in sounds than in those taken from rivers. The percentage of *N. americana* and fish remains in the stomachs of *C. spilopterus* from the two localities were nearly identical.

Food habit patterns relative to standard length of *C. spilopterus* were similar to those observed in *A. quadrocellata. N. americana* became less important as food with increasing size in *C. spilopterus. T. constrictus* became the dominant organism in *C. spilopterus* of 125 mm and above. *N. americana* was absent in the stomachs of fishes longer than 125 mm.

Fish less than 50 mm were not obtained in the trawls. It is possible that all sizes of *C. spilopterus* do not occur in Georgia estuarine waters but merely that they migrate through the southeastern Atlantic coast during certain seasons of the year. Specimens longer than 140 mm were not taken. The seasonal distribution observed agrees with that determined by Dahlberg and Odum (1970).

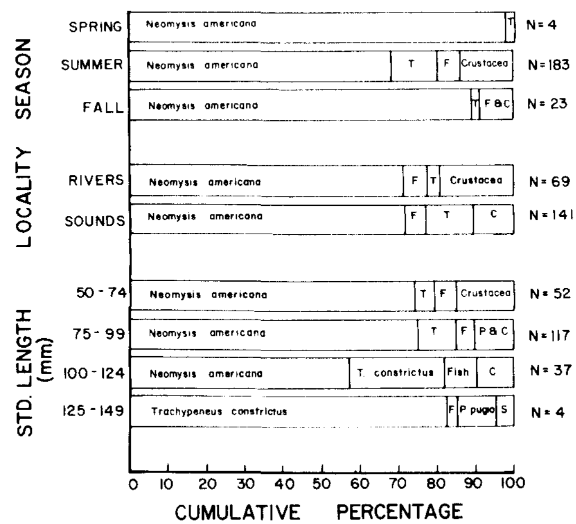

FIGURE 7.—Histogram illustrating the feeding habits of *Citharichthys spilopterus* by season of the year, locality, and standard length. (N = number of stomachs analyzed for each bar, T = *Trachypeneus constrictus*, F = fish remains, C = Crustacea other than those specifically identified in the bar, P = *Palaemonetes pugio*, and S = *Squilla empusa*.)

Scophthalmus aquosus

S. aquosus were present in Georiga coastal waters primarily during the spring (March through May). Few specimens were captured during the remainder of the year (Figure 8). *S. aquosus* fed nearly exclusively on *N. americana* during all seasons and in all locations. Several species of crustacea, fish remains, and an ectoproct made up the remainder of the food organisms found in the stomachs of *S. aquosus* (Table 1).

There was no change in food habits with size as found in *A. quadrocellata* and *C. spilopterus*, even though *S. aquosus* longer than 150 mm were captured. There were few animals in the size ranges above 74 mm, however, and the presumed food habits may reflect a lack of samples. Most of the fish captured were rather small. The relative abundance of small fish compared with the larger sizes is probably a good indication of their relative abundance in nature.

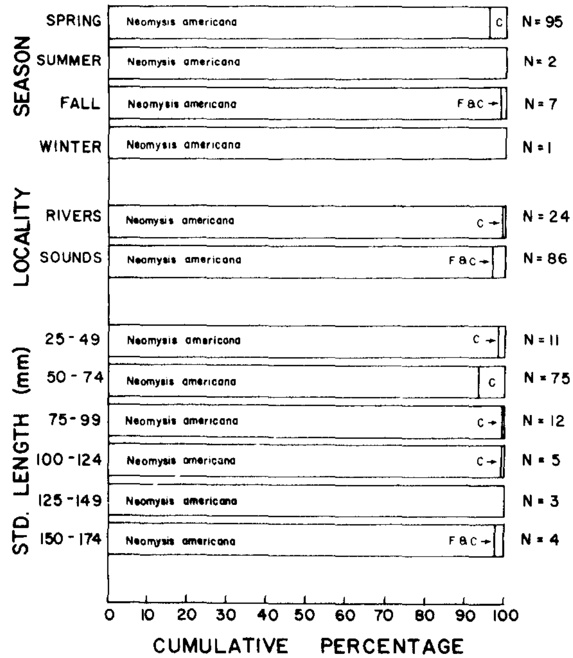

FIGURE 8.—Histogram illustrating the feeding habits of *Scophthalmus aquosus* by season of the year, locality, and standard length. (N = number of stomachs analyzed for each bar, F = fish remains, and C = Crustacea other than *Neomysis americana*.)

CONCLUSIONS

The four bothid fish species examined during this study are all relatively small fishes which feed on a variety of organisms. All appear to be totally carnivorous, since no plant material was recovered from the stomachs. Because of the predominance of certain organisms within the stomachs and the lack of detritus and sand so common in animals which indiscriminately browse off the sediments, they appear to be selective feeders. This selectivity apparently relates to the ability of bothids to feed by sight (de Groot, 1971).

E. crossotus was found to feed heavily on *Ps. coronatus*, and secondarily on spionid polychaetes, especially *Pa. pinnata*. The small mouth relative to body size of *E. crossotus* may play an important role in the food habits of this species. By the same token, the larger mouths of the other species may prohibit them from feeding on small food items.

A. quadrocellata, C. spilopterus, and *S. aquosus* fed heavily on *N. americana*, however, *A. quadrocellata* and *C. spilopterus* adjusted their food habits, becoming more diversified and utilizing *T. constrictus* as a primary food organism as they grew larger. The food habits of *S. aquosus* did not change with increasing size within the range of sizes examined. The relatively larger mouths of these three species seem important in allowing them to consume food organisms of larger sizes than those eaten by *E. crossotus*. The three fishes with the larger mouths fed to some extent on other species of fishes, whereas no fish remains were found in the stomachs of *E. crossotus*.

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LITERATURE CITED

DAHLBERG, M. D., AND E. P. ODUM.
1970. Annual cycles of species occurrence, abundance, and

diversity in Georgia estuarine fish populations. Am. Midl. Nat. 83:382-392.

DARNELL, R. M.
1958. Food habits of fishes and larger invertebrates of Lake Pontchartrain, Louisiana, an estuarine community. Publ. Inst. Mar. Sci., Univ. Tex. 5:343-416.

DE GROOT, S. J.
1970. Some notes on an ambivalent behaviour of the Greenland halibut *Reinhardtius hippoglossoides* (Walb.) Pisces: Pleuronectiformes. J. Fish Biol. 2:275-279.
1971. On the interrelationships between morphology of the alimentary tract, food and feeding behaviour in flatfishes (Pisces: Pleuronectiformes). Neth. J. Sea Res. 5:121-196.

OLLA, B. L., C. E. SAMET, AND A. L. STUDHOLME.
1972. Activity and feeding behavior of the summer flounder (*Paralichthys dentatus*) under controlled laboratory conditions. Fish. Bull., U.S. 70:1127-1136.

OLLA, B. L., R. WICKLUND, AND S. WILK.
1969. Behavior of winter flounder in a natural habitat. Trans. Am. Fish. Soc. 98:717-720.

POOLE, J. C.
1964. Feeding habits of the summer flounder in Great South Bay. N.Y. Fish Game J. 11:28-34.

REID, G. K., JR.
1954. An ecological study of the Gulf of Mexico fishes, in the vicinity of Cedar Key, Florida. Bull. Mar. Sci. Gulf Caribb. 4:1-94.

SIKORA, W. B., R. W. HEARD, AND M. D. DAHLBERG.
1972. The occurrence and food habits of two species of hake, *Urophycis regius* and *U. floridanus* in Georgia estuaries. Trans. Am. Fish. Soc. 101:513-525.

STEVEN, G. A.
1930. Bottom fauna and the food of fishes. J. Mar. Biol. Assoc. U.K. 16:677-698.

STICKNEY, R. R., D. B. WHITE, AND D. MILLER.
1973. Observations of fin use in relation to feeding and resting behavior in flatfishes (Pleuronectiformes). Copeia 1973:154-156.

TATTERSALL, W. M.
1951. A review of the Mysidacea of the United States National Museum. Bull. U.S. Natl. Mus. 201, 292 p.

TOPP, R. W., AND F. H. HOFF, JR.
1972. Memoirs of the Hourglass Cruises. Flatfishes (Pleuronectiformes). Fla. Dep. Nat. Resour., Mar. Res. Lab. 4(2):1-135.

WIGLEY, R. L., AND B. R. BURNS.
1971. Distribution and biology of mysids (Crustacea, Mysidacea) from the Atlantic coast of the United States in the NMFS Woods Hole collection. Fish. Bull., U.S. 69:717-746.

WILLIAMS, A. B.
1972. A ten-year study of meroplankton in North Carolina estuaries: mysid shrimps. Chesapeake Sci. 13:254-262.

APPENDIX

List of organisms found in stomachs of Bothidae from Georgia estuarine waters

Rhynchocoela
- *Cerebratulus* sp.

Ectoprocta
- *Bugula neritina* (Linnaeus)

Polychaeta
- *Diopatra cuprea* (Bosc)
- *Paraprionospio pinnata* (Ehlers)
- *Nereis succinea* (Frey and Leuckart)
- *Sabellaria vulgaris* Verrill
- *Sabella microphthalma* Verrill
- *Asabellides oculata* Webster
- *Clymenella torquata* Leidy
- Spionidae
- Nereidae

Mollusca
- Gastropod remains
- Pelecypod siphons
- Pelecypod postlarvae

Crustacea
- Amphipoda
  - *Ampelisca vadorum* Mills
  - *Ampelisca* sp.
  - *Listriella barnardi* (Wigley)
  - *Corophium tuberculatum* Shoemaker
  - *Unciola serrata* Shoemaker
  - *Batea catharinensis* Muller
  - *Melita appendiculata* (Say)
  - *Melita nitida* Smith
  - *Monoculodes edwardsi* Holmes
  - *Erichthonius brasiliensis* Dana
  - *Paracaprella tenuis* Mayer
  - *Microprotopus ranei* Wigley
  - *Corophium simile* Shoemaker
  - *Cerapus tubularis* Say
  - *Lembos websteri* Bate
  - *Gammarus palustris* Bousfield
  - *Caprella equilibra* Say
  - *Corophium lacustre* Vanhoffen
- Copepoda
  - *Pseudodiaptomus coronatus* Williams
  - *Labidocera aestiva* Wheeler
  - Calanoid copepoda
- Cumacea
  - *Leucon americanus* Zimmer
  - *Oxyurostylis smithi* Calman
  - *Mancocuma altera* Zimmer

Mysidacea
- *Neomysis americana* (S. I. Smith)

Ostracoda (unidentified)

Isopoda
- *Edotea montosa* Stimpson

Stomatopoda
- *Squilla empusa* Say
- *Squilla neglecta* Gibbes

Decapoda (Natantia)
- *Acetes americanus carolinae* Hansen
- *Penaeus setiferus* (Linnaeus)
- *Trachypenaeus constrictus* (Stimpson)
- *Palaemonetes pugio* Holthuis
- *Palaemonetes vulgaris* (Say)
- *Ogyrides limicola* Williams
- *Periclimenes longicaudatus* (Stimpson)
- *Latreutes parvulus* (Stimpson)
- *Alpheus normanni* Kingsley
- Caridean larvae

Decapoda (Reptantia)
- *Pagurus pollicaris* Say
- *Pagurus* sp.
- *Callinectes sapidus* Rathbun
- *Portunus spinimanus* Latreille
- *Portunus gibbesii* (Stimpson)
- *Callinectes similis* Williams
- *Cancer irroratus* Say
- *Hexapanopeus angustifrons* (Benedict and Rathbun)
- *Neopanope sayi* (Smith)
- *Pinnixa* sp.
- *Persephona punctata aquilonaris* Rathbun
- Megalops and zoea
- Portunid postlarvae

Osteichthyes
- *Prionotus* sp.
- *Symphurus plagiusa* (Linnaeus)
- *Synodus foetens* (Linnaeus)
- *Bairdiella chrysura* (Lacépède)
- *Anchoa mitchilli* (Valenciennes)
- *Etropus crossotus* Jordan and Gilbert
- *Fundulus heteroclitus* (Linnaeus)
- *Menidia* sp.
- *Cynoscion* sp.
- Bothid postlarvae
- Fish remains