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TILEFISHES OF THE GENUS *CAULOLATILUS* CONSTRUCT BURROWS IN THE SEA FLOOR

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ABSTRACT

Observations from submersibles indicate that blueline tilefish (*Caulolatilus microps*) and possibly blackline tilefish (*C. cyanops*) construct burrows in the seafloor sediments off Florida and South Carolina. Further in situ and sidescan sonar observations in an area northeast of Cape Canaveral found burrows at water depths between 91–150 m. A typical large burrow (up to 3 × 1.5 m) was elliptical to linear in shape at the sediment surface with a shaft at a slight angle into the substrate. Sonograms showed that average density of larger burrows was 1.5 burrows per 1,000 m^2. Small burrows (0.3–0.6 m diameter) were generally circular, and often occurred in clusters that in some locations achieved densities of 0.5–1.0/m^2. The burrows were occupied, and apparently constructed, by up to three individual tilefish. These entered the shaft of the burrow head first and exited tail first. Unidentified juvenile fishes, several species of crabs, and conger eels shared burrows with blueline tilefish. On two occasions blueline tilefish were observed in the same burrows as golden tilefish (*Lopholalitus chamaeleonticeps*).

Accumulating evidence indicates that tilefishes (Branchiostegidae and/or Malacanthidae of some authors) construct their burrows in the sea floor. This has been verified for *Malacanthus* (Clifton and Hunter, 1972; Colin, 1973; Thresher, 1983), *Hoplolatilus* (Randall and Dooley, 1974), and studied extensively in the tilefish, *Lopholatilus chamaeleonticeps*. For the latter species, we have described behavior and ecology and demonstrated that the distribution of the burrow habitat is dependent, in part, on the sediment regime (Able et al., 1982; Grimes et al., 1986), and that this species can significantly reshape the sea floor through its burrowing activity (Twichell et al., 1985).

Prior studies of the blueline tilefish (*Caulolatilus microps*) have determined age, growth and mortality (Ross and Huntsman, 1982), reproductive biology (Ross and Merriner, 1983), and food habits (Ross, 1982). Despite these intensive studies, little is known of its habitat. This demersal branchiostegid is known to occur over the outer continental shelf, shelf break and upper slope (Struhsaker, 1969; Grimes et al., 1982; Chester et al., 1984) in depths of 75–236 m (Ross and Huntsman, 1982), off the southeastern United States and as far south as Campeche, Mexico (Dooley, 1978).

Here we present evidence from a sidescan sonar survey and observations from a submersible that *Caulolatilus microps*, and perhaps other species of *Caulolatilus*, construct burrows in the substrate.

METHODS

Blueline tilefish (and other *Caulolatilus*, see Results) were observed during 15 JOHNSON-SEA-LINK (Busby Associates, 1981; Askew, 1985) submersible dives along the edge of the continental shelf from South Carolina and southern Florida (Table 1). Observations were recorded on audio tapes, video tapes, and 35-mm photographs. Many of these observations were originally made (1975–1977, Table 1) as part of a larger survey off the central east coast of Florida (Avent and Stanton, 1979). The available 35-mm film from these earlier dives was reviewed and combined with our more recent observations.

In 1984 sidescan sonar images (sonographs) were collected in an area northeast of Cape Canaveral (Fig. 1) as part of a study of *L. chamaeleonticeps*. After observing holes or depressions on the sonographs in water depths shallower than those at which tilefish commonly occur, we dove on those sites (JSL

Table 1. Summary of submersible observations of *Caulolatilus* in the South Atlantic Bight. Prefixes (I or II) before dive number indicates JOHNSON-SEA-LINK submersible I or II. See Figure 1 for locations off Florida

Dive no.	Transect or location	Date	Depth range (m)	Depth range of tilefish occurrence (m)	Temperatures range (°C)	Temperatures at tilefish occurrence (°C)
I-251	Bethel Shoals	19 Jun 1975	79–139	106–110	—	—
I-252	Bethel Shoals	20 Jun 1975	137–183	140–142	16.0–17.2	16.8
I-253	Malabar	24 Jun 1975	81–152	108–119	—	—
I-255	Sebastian	25 Jun 1975	113–177	131–149	—	—
I-349	Ft. Pierce	26 Mar 1976	144–261	166	—	—
II-67	Eau Gallie	10 Jun 1976	107–187	123–156	14.8–16.4	14.8–16.0
II-119	Lake Worth	—	30–132	107–127	15.4–23.4	15.4
II-120	Jupiter Inlet	16 Sep 1976	186–306	198	10.7–14.1	13.9–14.0
II-197	Oslo	16 May 1977	61–104	102–104	14.5–20.0	14.5
II-283	Bethel Shoals	10 Nov 1977	104–107	107	17.9–18.0	18.0
I-1242	off Charleston, South Carolina	2 Aug 1983	—	57–63	15	—
I-1252	off Charleston, South Carolina	7 Aug 1983	189–212	203–211	12	—
I-1543	off Cape Canaveral	15 Apr 1984	150–164	152	14.0–15.0	15.0
II-824	off Cape Canaveral	23 May 1984	130–140	130–140	13.8–14.1	13.8–14.1
I-1566	off Cape Canaveral	2 Oct 1984	98–114	105–113	14.2–15.2	14.3–14.8
Ranges for off Florida			30–306	102–198	10.7–23.4	13.8–18.0

dive II-824 and I-1566). During these dives, discrete replicate surface sediment samples were retrieved with a 19 × 19-cm clam shell grab mounted on the manipulator arm of the submersible (Hoskin et al., in press). Grain-size statistics were computed following methods used by Folk and Ward (1957) and are summarized in Table 2. In one instance a single blueline tilefish was collected with a suction device by the submersible after injecting a rotenone mixture (Gilmore et al., 1981) into the burrow.

RESULTS

It was impossible to identify the species of all *Caulolatilus* observed in the various habitats described below, especially from 35-mm photographs. However, in most instances where positive identification was possible, these were blueline tilefish, *C. microps*. Visual verifications (in situ and from video tapes) of this species were based on the relatively small mouth, presence of a dark spot at the axil of the pectoral fin and a blue line from the eye to the tip of the snout (Dooley, 1978). In addition, a single specimen (40 cm fork length) was positively identified, based on the same characters, after it was collected when rotenone was injected into its burrow (JSL Dive II-824). In one instance, a blackline tilefish *C. cyanops* (Fig. 2) was tentatively identified (J. Dooley, pers. comm.) based on a photograph. A *C. microps* was photographed exiting from the same burrow.

Our submersible, sidescan, and sedimentological data show that *C. microps* constructs burrows in relatively soft, sandy sediments off the central east coast of Florida. Most burrows occurred between 91–150 m (Fig. 1) and some may be constructed as deep as 198 m and at bottom water temperatures of 13.8–18.0°C (Table 1). The shoreward limit of their distribution is not known, but because burrow abundance decreased on the shoreward ends of our sidescan transects, we feel this was close to their minimum depth. Off South Carolina the *C. microps* was also observed in holes under rock ledges and boulders (Table 1).

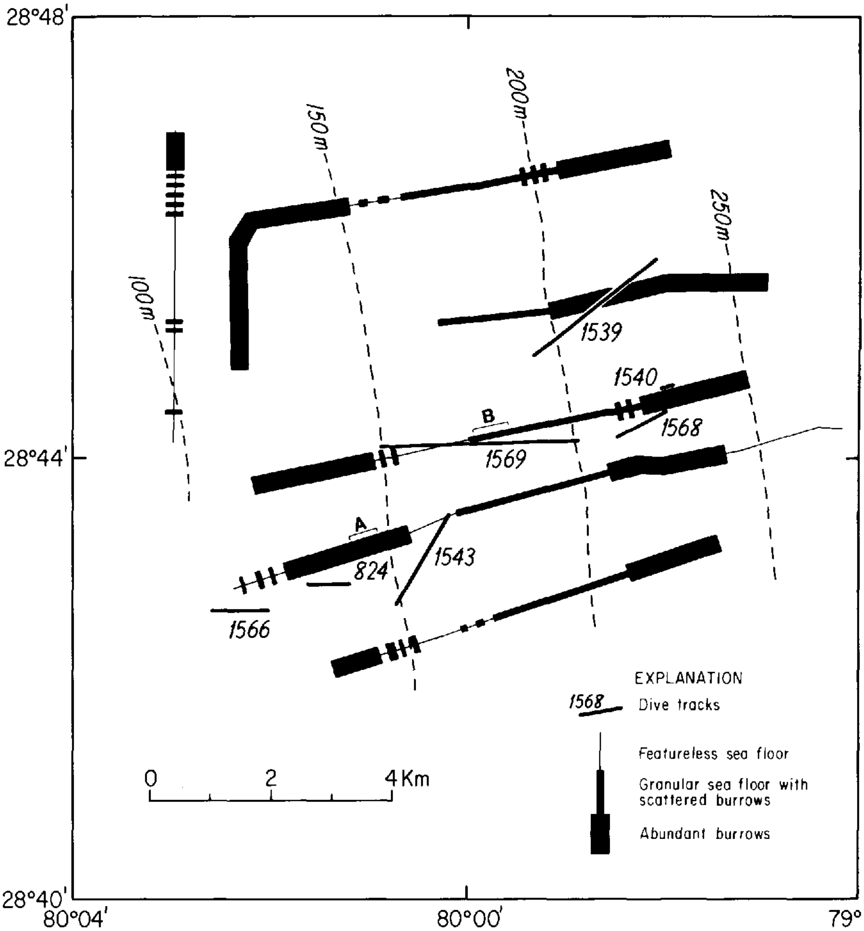

Figure 1. Distribution of *Caulolatilus* (approximately 100–150 m) and *L. chamaeleonticeps* (approximately 200–250 m, Able et al., in prep.) burrows as detected by sidescan sonar. Locations of Figures 4A and B and marked by letters along tracklines.

Burrow Distribution and Organization.—Sidescan sonographs taken off Cape Canaveral in depths of 100–270 m indicated tilefish burrows were located at two relatively distinct depths (Fig. 1). Observations from submersibles confirmed that the burrows in deeper water (>200 m) were those of *L. chamaeleonticeps* and those in shallow water (91–150 m) were the burrows of *Caulolatilus*. The larger *Caulolatilus* burrows, which were linear on the sonographs (Fig. 3), achieved maximum densities of 13 burrows/1,000 m^2. The average density was 1.5/1,000 m^2. Tilefish burrow density dropped sharply to 0.1–0.3/1,000 m^2 in water deeper than 150 m (Fig. 1). Of the burrows shallower than 150 m, 50% of the burrows were less than 20 m from the neighboring burrow (Fig. 4).

The burrows were variable in shape, but typical large burrows (Fig. 2) were elliptical to linear or trench-like with one end deeper than the other. The shaft was at the deeper end. Often a mound of sediment rimmed the shallow margin of many burrows. The largest burrow observed from the submersible was approximately 1.5 × 0.5 m, but larger ones (3 × 1.5 m) were identified on sidescan

Table 2. Sediment grain size descriptors for replicate samples taken at *Caulolatilus* and *L. chamaeleonticeps* habitats during submersible dives northeast of Cape Canaveral. Replicate samples were taken at each of the four sample locations. Sampling occurred at the beginning and end of dive 824, the shallow end of dive 1543 and the middle of dive 1540. See Figure 1 for approximate location

Dive no.	Depth (m)	Weight percent*				Mean size (µm)	Species present
		Gravel	Sand	Silt	Clay		
II-824	130	4.7	76.0	14.4	5.0	202	*Caulolatilus*
II-824		4.4	82.2	10.3	3.1	281	
II-824	140	1.4	70.9	21.2	6.6	102	*Caulolatilus*
II-824		2.0	69.6	21.6	6.8	105	
I-1543	150	0.4	55.5	34.1	9.9	63	both
I-1543		0.2	51.3	36.9	11.7	51	
I-1540	238	0.1	23.8	48.3	27.8	11	*L. chamaeleonticeps*
I-1540		0.0	24.0	47.7	28.3	9	

* Gravel, >2.00 mm; sand, 2.00–0.0625 mm; silt, 0.0625–0.0039 mm; clay, <0.0039 mm.

sonographs. However, the images measured from the sidescan sonographs may include the mound around the burrow as well as the burrow itself. Smaller secondary burrows, made by other organisms, were distributed along the sides of these elongate burrows and were most abundant at the end with the burrow shaft. The opening to the shaft of the burrow was round to elliptical. The size of the shaft opening was larger in larger burrows. Shaft length was greater than the fish length (up to 45–60 cm for the largest fish observed) because the fish disappeared completely into the shaft.

Most smaller burrows (0.3–0.6 m diameter), presumably those of smaller fish, were more circular, distributed in clusters of 3–5, and in some instances, densities were estimated to be as high as 0.5–1.0/m^2. In both large and small burrows the shaft appeared to be dug at a slight angle relative to the surface of the substrate.

Behavior of Burrow Occupants.—In every instance, the *Caulolatilus* entered the burrow head first and disappeared completely from sight. On occasion, as many as three fish entered the same burrow simultaneously without touching each other or the sides of the burrow shaft. On several other occasions, two fish entered the same burrow. In one instance, a rotenoned burrow was occupied simultaneously by a 40 cm long (fork length, actual measurement) *Caulolatilus* and by another estimated to be 25 cm long. Exiting the burrow shaft invariably occurred tail first (Fig. 2).

In two instances, *C. microps* shared their burrow with *L. chamaeleonticeps.* In a single observation off Charleston, South Carolina (JSL Dive I-1252), a *C. microps* approached a hole under a rock slab that had been partially occupied by a *L. chamaeleonticeps* seconds earlier. Initial attempts to find another opening under the ledge were unsuccessful, and the *C. microps* found its way into the hole that was occupied by the same *Lopholatilus.* Eventually, the *C. microps* disappeared head first into the opening and was followed by the *Lopholatilus.* Shortly thereafter a hammerhead shark passed by the immediate area. The hiding behavior of both fish appeared to be in response to the presence of the shark.

In a single instance off Florida (JSL Dive I-1543) we observed an unidentified tilefish enter a burrow. Closer inspection revealed two vertical burrows adjacent to each other. After we injected rotenone into one of the burrows, a small (approximately 35–40 cm) *L. chamaeleonticeps* came out and moved out of sight. After several minutes a larger *C. microps* (approximately 50 cm) exited from the

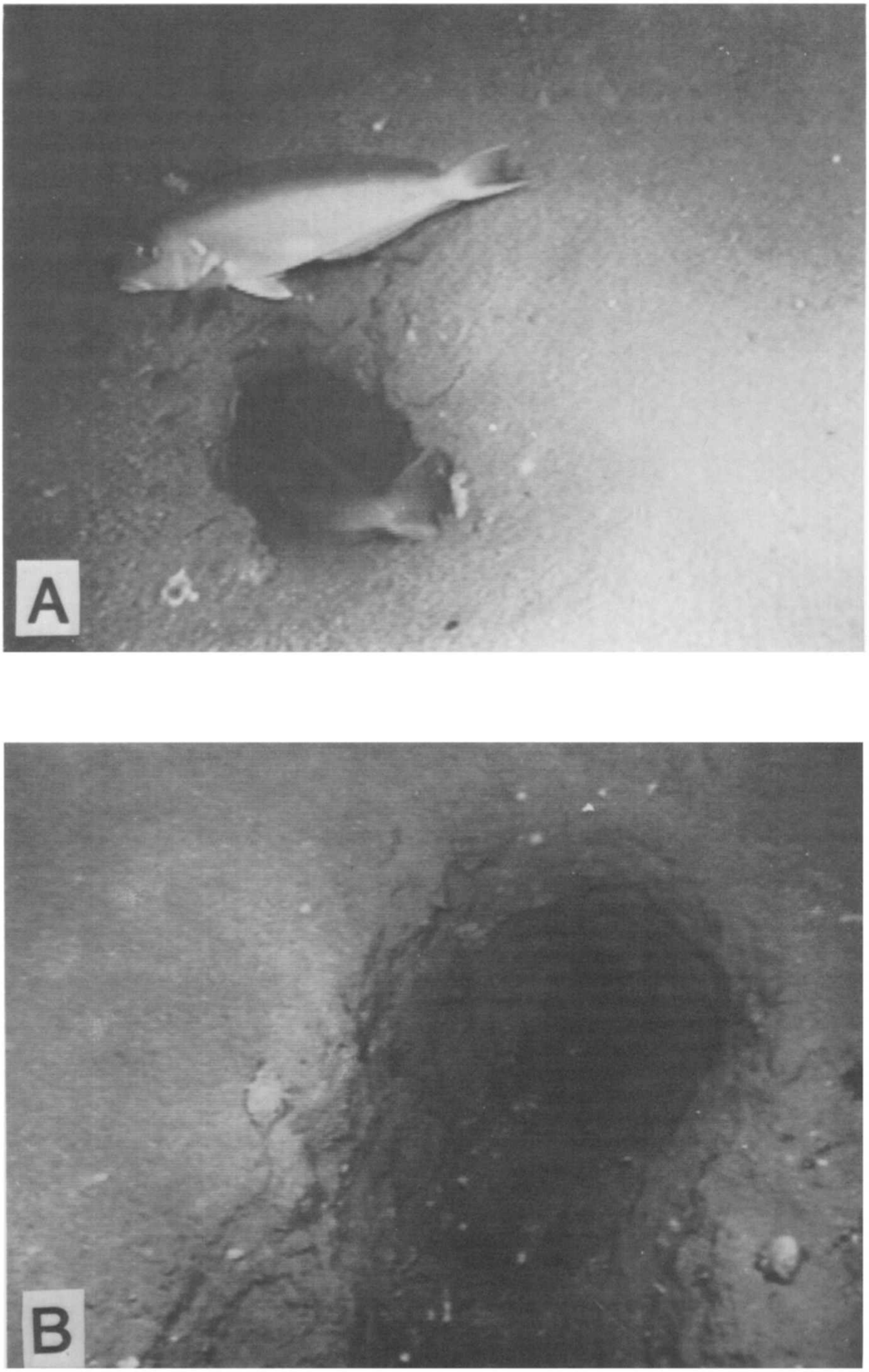

Figure 2. Photographs (JSL dive 1566) of *Caulolatilus* and their burrows. A) Fish still in burrow is backing out after rotenone was injected into burrow; B) larger burrow showing shaft at end of trench.

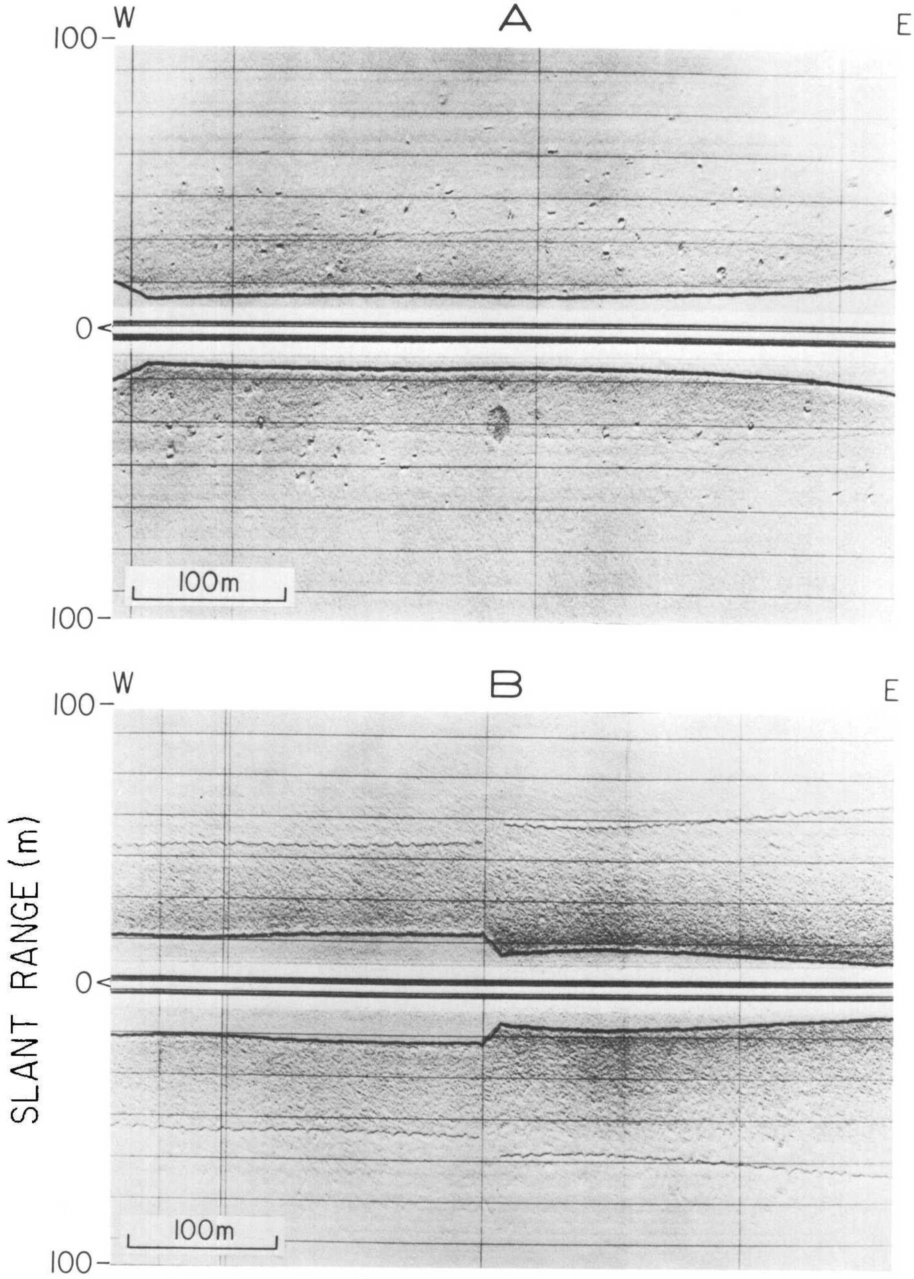

Figure 3. Sidescan sonographs of (A) typical *Caulolatilus* burrows in depths of approximately 100–150 m and (B) deeper area with few, scattered burrows. Burrows in A are linear after correction for difference in horizontal and vertical scales on sonograph. Sonograph locations shown in Figure 2.

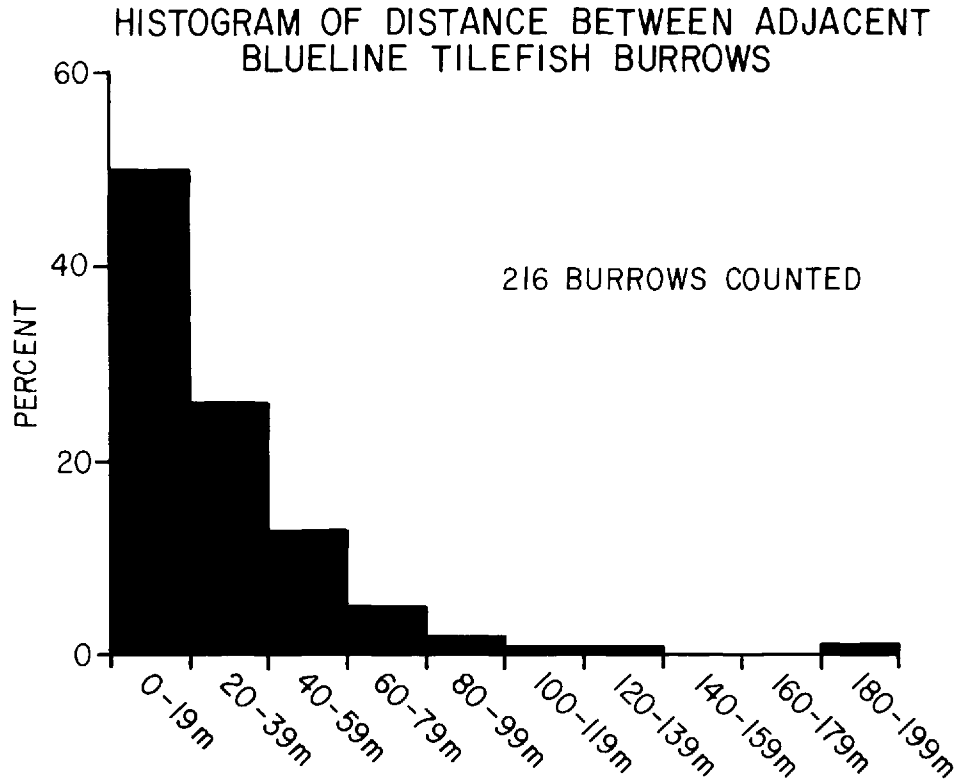

Figure 4. Frequency distribution of distances between adjacent *Caulolatilus* burrows as detected by sidescan sonar.

adjacent burrow. It was obviously affected by the rotenone as indicated by the exaggerated respiratory movements and upside-down swimming. The two burrows must have been interconnected in order for the rotenone to have affected both fish. Contamination of the adjacent burrow by the spreading across the sea floor was impossible because the rotenone mixture floats rather than sinks.

The *Caulolatilus* also shared their burrows with several other species. A large (30–50) school of small (approximately 2–4 cm) unidentified juvenile fish occupied the trench of one burrow and refused to leave even after a *C. microps* was chased from the burrow (JSL Dive I-1566). A spider crab (*Libinia*?) and arrow crab were filmed in the same burrow. A galatheid crab (*Munida forceps*) was collected near the burrow shaft where smaller burrows were visible. After we injected rotenone, a conger eel (*Conger oceanicus*) swam out of the burrow shaft.

Substrate Characteristics.—In most locations where the *Caulolatilus* were observed and photographed, the substrate was smooth and appeared rather stiff. The sediments in which the *Caulolatilus* construct their burrows were much sandier than those where *L. chamaeleonticeps* occurred (Table 2). At a site off Cape Canaveral (JSL Dive I-1543), where *C. microps* and *L. chamaeleonticeps* were found together the values for particle size were intermediate. Bottom current speed at *Caulolatilus* burrows varied from 10.3 to 25.7 cm/sec.

DISCUSSION

Burrow construction may be characteristic of all branchiostegid and malacanthid tilefishes. Our observations for the *Caulolatilus* represent the fourth of the five tilefish genera (Dooley, 1978) in which burrow construction has been demonstrated. The others are *Malacanthus* (Clifton and Hunter, 1972; Colin, 1973; Thresher, 1983), *Hoplolatilus* (Randall and Dooley, 1974), and *Lopholatilus* (Able et al., 1982; Grimes et al., 1986).

As we have discussed previously it is likely that the burrows of *Caulolatilus* serve in predator avoidance, as do those of *Lopholatilus* (Able et al., 1982; Grimes et al., 1986). The head first entry and tail first exit from the burrows, a behavior also common to *Hoplolatilus* (Randall and Dooley, 1974) and *Malacanthus* (Colin, 1973), makes it unlikely that the burrows are used to ambush prey. Also, both juvenile and adult *Caulolatilus* inhabit burrows, in keeping with a predator avoidance hypothesis, rather than for reproduction. Predators, particularly hammerhead and other sharks, have been observed from submersibles in the immediate vicinity of *C. microps* burrows, off South Carolina and Florida.

The burrows of *Caulolatilus* are similar to those of *L. chamaeleonticeps* in many respects. The burrows are constructed in areas of malleable, relatively soft sediments. The burrows of both species possess a wide opening at the substrate surface that narrows to a single shaft. Smaller secondary burrows of associated crustaceans and fish are common to both. Off Florida, the burrows of these two tilefishes differed in some relatively minor but potentially important characteristics. The burrows of *Caulolatilus* are constructed in sandier sediments (Table 2) than are those of *L. chamaeleonticeps* and the larger burrows of *Caulolatilus* are more elongate or elliptical. This shape may be attained as the burrow shaft, which is dug at a slightly oblique angle, is enlarged, thus causing sediment from above the shaft to cave in. As the shaft is dug deeper and becomes more elongate the burrow is lengthened over time. Collapse of the burrows may be more common in these sandier sediments than in sediments burrowed by *L. chamaeleonticeps.* This difference in sediments may make construction of an oblique shaft necessary for the *Caulolatilus* while *L. chamaeleonticeps* can construct vertical burrows in the more cohesive muddy sediments (Twichell et al., 1985) where the latter species is common.

The behavior of the *Caulolatilus* and *L. chamaeleonticeps* is similar in that both enter the burrow head first and exit tail first. They differ in that more than one *Caulolatilus* commonly occupies the same burrow, a behavior pattern that has been observed for some *Hoplolatilus* (Randall and Dooley, 1974) and *Malacanthus* (R. Winterbottom, pers. comm.) as well. In this study, off the east coast of Florida, *Caulolatilus* burrows were found in areas of warmer temperatures (13.9–16.8°C) than the tilefish (approximately 8–14°C) and at shallower depths (generally 90–150 m) for blueline tilefish than for tilefish (149–244 m).

The burrows of the *Caulolatilus* are striking physical features of the otherwise flat sea floor observed from the submersible. Their physical dominance of the bottom topography is confirmed by sidescan sonographs over a much larger area as well (Fig. 1). We suggest that *Caulolatilus,* like *L. chamaeleonticeps* (Twichell et al., 1985), accomplish considerable reworking of the sediments in localized areas although *Caulolatilus* probably do not disturb and redistribute the sediments as much as *L. chamaeleonticeps* do because they are smaller and their burrows are smaller. Nevertheless, their apparent contagious distribution is likely to have pronounced effects on sediment composition in the depths and areas where they are concentrated. The side effects of burrow construction by *Caulolatilus, Lopholatilus* (Twichell et al., 1985), and *Malacanthus* (Clifton and Hunter, 1972) suggest that tilefishes as a group may produce significant changes in substrate composition and stability and may contribute to long-term erosion and transport of sediments wherever they occur.

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