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TEMPORAL AND SPATIAL VARIATION IN HABITAT CHARACTERISTICS OF TILEFISH (*LOPHOLATILUS CHAMAELEONTICEPS*) OFF THE EAST COAST OF FLORIDA

Kenneth W. Able, Churchill B. Grimes, Robert S. Jones and David C. Twichell

ABSTRACT

The tilefish, *Lopholatilus chamaeleonticeps*, constructs burrows in carbonate sediments off the central east coast of Florida at similar temperatures (8.6–15.4°C) and in similar sediment textures (high proportion of silts and clays) to conspecifics in the Mid-Atlantic Bight. The depths at which we observed tilefish off Florida (150–290 m), based on submersible observations and sidescan sonar operations during 1983 and 1984, were similar to those recorded in 1975–1977 (137–266 m) before the inception of the directed fishery. Both are similar to the range observed in the Mid-Atlantic Bight although tilefish there can be found at shallower and slightly deeper depths (80–305 m). The largest burrows off Florida (1.5-m diameter) were smaller than those observed in the Mid-Atlantic Bight (up to 5 m). The behavior of tilefish around the burrow and the invertebrates and fishes co-inhabiting the burrows off Florida are nearly identical to those in the Mid-Atlantic Bight. Despite the relatively narrow annual temperature range observed off Florida, abrupt changes in temperatures (+6°C) occurred over a 48-h period based on thermograph records. Our observations, and those of others from several areas along the U.S. east coast, suggest that this species probably constructs burrows throughout its geographic range, and that temperature and sediment composition largely determine its distribution. Exclusion experiments off Florida, along with prior removal experiments in the Mid-Atlantic Bight, indicate that tilefish construct and maintain the burrows.

The tilefish, *Lopholatilus chamaeleonticeps,* occurs along the outer continental shelf and upper slope from Nova Scotia, Canada (Markle et al., 1980) to Surinam, South America, but is apparently excluded from the Caribbean (Dooley, 1978). Two stocks have been identified (Katz et al., 1983). The northern stock is limited to the Middle Atlantic Bight, southern New England and presumably occurs north to Nova Scotia. The southern stock occurs south of Cape Hatteras and into the Gulf of Mexico, at least as far as the Yucatan Peninsula. Of these, the northern stock has been studied extensively, including aspects of the fishery (Grimes et al., 1980, 1982; Turner, 1986), life history (Turner et al., 1983; Grimes et al., 1986, 1988), population dynamics (Turner, 1986) and habitat (Able et al., 1982; Grimes et al., 1986; Twichell et al., 1985). The southern stock has also received considerable attention. Several studies have provided estimates of potential catch rates off North Carolina and South Carolina (Low et al., 1983) as well as aspects of the reproductive biology (Erickson and Grossman, 1986; Erickson et al., 1985), growth, mortality and age composition (Harris and Grossman, 1985) and sediment-habitat relationships (Grossman et al., 1985) off Georgia. Recently, the distribution of tilefish, based in part on sidescan sonar observations of their burrows, has been determined off South Carolina and Georgia (Barans and Stender, in review).[1] Also, the occurrence of tilefish in burrows in the northern Gulf of Mexico has been confirmed with submersible observations (Jones et al., 1989) and abundance has been estimated from longline experiments and submersible observations (Matlock et al., 1991).

[1] Barans, C.A. and B. W. Stender. Tilefish distribution and trends in relative abundance off South Carolina and Georgia. N. Amer. J. Fish. Mgt. In review.

In the mid 1980s, the increased value of the fishery, especially off Florida, prompted further studies. Our prior research efforts on the northern stock, especially with regard to the habitat ecology, led us to investigate the spatial and temporal patterns of distribution for the southern stock during 1983 and 1984. More specifically, we chose to examine habitat relative to sediment and thermal regimes. This study was undertaken with the rationale that if these patterns were consistent with those for the northern stock, then we might effectively predict the distribution of tilefish in other areas. Our prior experience also allowed us to compare tilefish behavior, and that of the burrow associates, of the Florida population with that for the northern stock.

Materials and Methods

Submersible Operations.—During 1983 and 1984, we conducted four cruises to tilefish habitats off the central east coast of Florida (Table 1, Fig. 1). Initial in situ observations were made in 1983 along transects using the U.S. Navy's 41.8-m, nuclear-powered research submarine NR-1 (Ballard, 1985). Navigation for these transects was by dead reckoning using ship's heading and ground speed from a Doppler sonar. During transects over the bottom, this vessel traveled on two retractable wheels. Visual observations were made from three 10-cm diameter viewing ports. Observations of the bottom were continuously recorded on videotape along with the audio comments of the observers. Shipboard computers automatically logged bottom temperature and salinity.

More intensive in situ observations were made from the JOHNSON-SEA-LINK (JSL) I and II submersibles in 1984 (Askew, 1985). Typically, JSL dives were approximately 3-h in duration. Simultaneous observations were made from the sphere and the dive chamber. Photographic and video documentation were recorded while moving over the bottom (Grimes et al., 1986; Twichell et al., 1985). Temperature and conductivity profiles through the water column and on the bottom were recorded with a conductivity-temperature-depth recorder with visual readout in the submersible sphere. Tilefish lengths were estimated relative to objects of known length (i.e., fish traps and submersible manipulator arm).

Because we intended to revisit individual tilefish burrows frequently during 1984, we deployed an acoustic pinger from the JSL submersible at a Long Term Study Site (LTSS) established northeast of Cape Canaveral (Fig. 2) at a depth of 237 m in April 1984 (Fig. 3). The location of this site was based on initial observations during 1983 with NR-1. The exact location was chosen after reconnaissance dives with JSL. A thermograph (Eiseman and Holt, 1979) was deployed with the pinger. It recorded temperature every hour. The pinger-thermograph package was recovered and replaced during May and recovered in October 1984.

The JSL submersibles were navigated during mapping and transect dives (Fig. 2) with a Honeywell short-baseline acoustic tracking system from the support ships. Orientation while on the bottom was aided by position relative to the transponder and NR-1 tracks that were still visible from the November 1983 dive. Marked beer cans filled with cement were also deployed to provide navigation aids. Distance over the bottom was determined with a Doppler sonar system.

Sample Collection.—Lengths of tilefish from the general study area were obtained from fishing vessel catches. We attempted to collect invertebrates and fishes from tilefish burrows and over the adjacent bottom with conical fish traps (6-mm mesh) that were deployed and retrieved with the submersible. Location specific and replicate surface sediment samples were collected with a 19 × 19 cm grab-sampler attached to the manipulator arm of the submersible. Grain size statistics were computed based on Folk and Ward (1957).

Tilefish Distribution and Behavior.—Prior records of tilefish occurrence off the central east coast of Florida (1975–1977, Table 2) were originally recorded as part of a larger survey (Avent and Stanton, 1979). The available 35-mm film from these earlier dives was reviewed, compared to available dive logs, and incorporated into our more recent observations.

To determine the role of tilefish in maintenance of the burrow and the associated community, we excluded them by deploying a 1.2-m steel ring, with 7-cm mesh monofilament net sewn into the ring, over two intact but unoccupied burrows during April 1983. These "exclusion lids" effectively prevented large juvenile and adult tilefish from entering the burrows, but allowed potential burrow associates easy exit and entrance through the meshes of the lid. In fact, on subsequent dives we observed some burrow associates moving through the meshes.

Sidescan Sonar.—Sonographs of the bottom can easily detect tilefish burrows (Twichell et al., 1985; Able et al., 1987b). These sidescan sonar images of the seafloor were made directly from NR-1 during

Table 1. Cruise dates and locations for *Lopholatilus chamaeleonticeps* observations off the central east coast of Florida during 1983 and 1984. See Figure 1 for general locations. JSL refers to JOHNSON-SEA-LINK. Prefix I or II refers to either JSL submersible I or II

Submarine or submersible	Location	Dates	Duration or number of dives	Dive depth (mm)	Bottom temperatures (°C)	Temperature range of tilefish observations	Number of tilefish observed	Number of tilefish burrows	Visibility (m)	Current speed (cm^2 sec^{-1})
NR-1	off Ft. Pierce	18–19 Nov. 1983	22 h 55 min	168–295	9.8–15.5	9.8–15.4	15	103	3.0–6.1	0.8–4.3
NR-1	northeast of Cape Canaveral	19–20 Nov. 1983	7 h 3 min	198–258	12.7–15.2	12.7–15.2	12	106	1.1–3.7	1.0–1.5
JSL-I	northeast of Cape Canaveral	9–18 Apr. 1984	7	149–286	9.5–15.0	10–11	7	50	2–12	0.1–3.3
JSL-II	northeast of Cape Canaveral	19–25 May 1984	7	129–291	8.6–13.9	8.6–8.7	0	4	3–9	0.1–0.25
JSL-I	northeast of Cape Canaveral	1–5 Oct. 1984	5	99–238	9.7–18.5	9.7–11.3	3	45	1.5–9	0.1–0.5

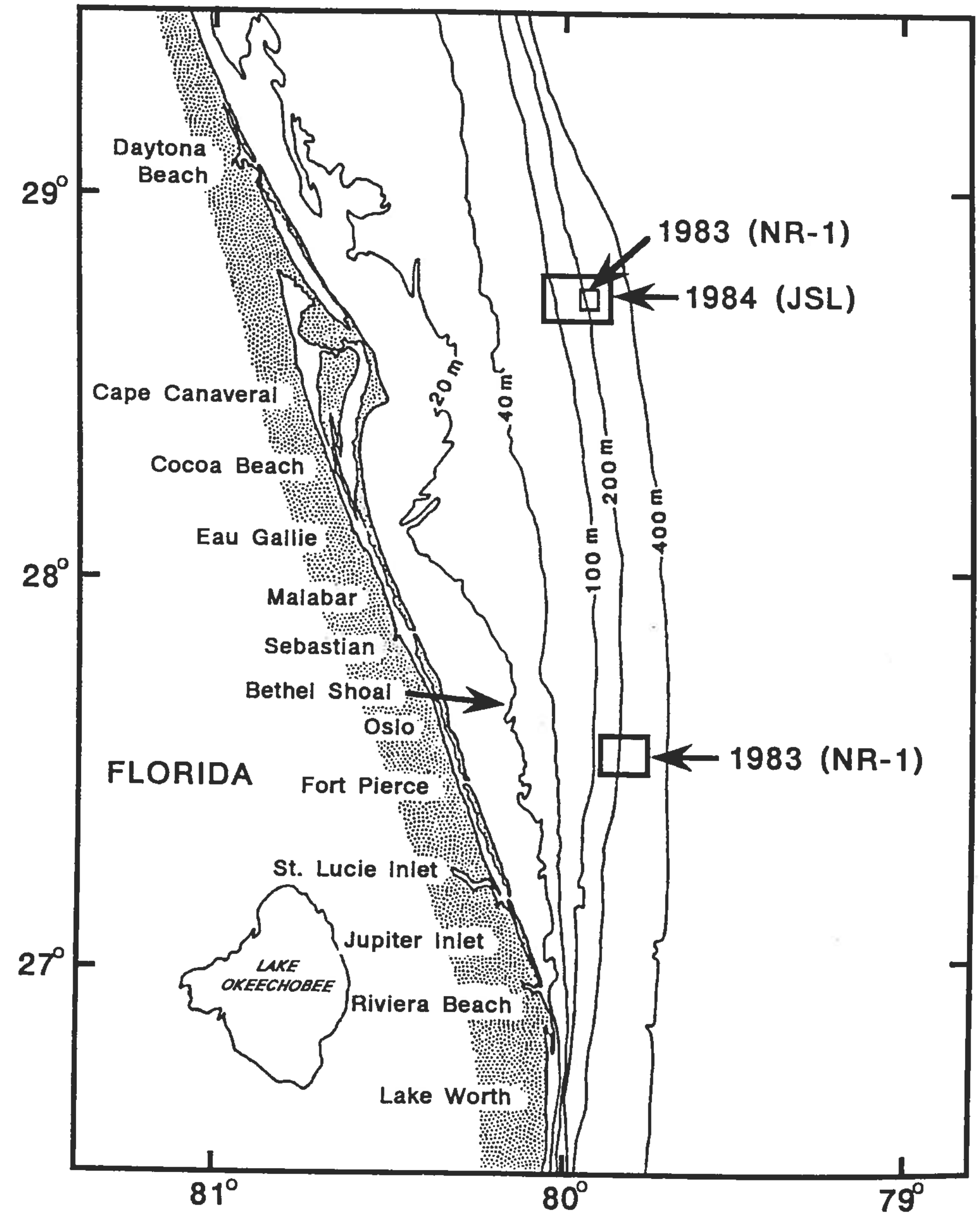
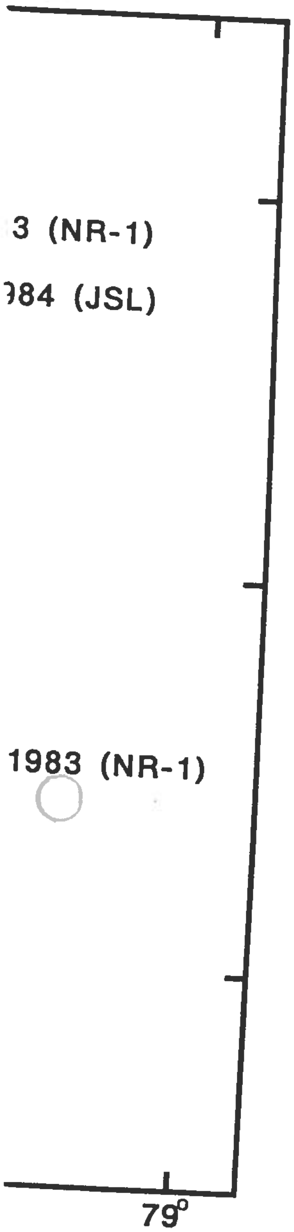


Figure 1. General study area off the central east coast of Florida including Long Term Study Site. See Figure 2 for additional details.

November 1983 and with a towed transducer from the R.V. Johnson during May 1984. The NR-1 sidescan sonar had a 177.5-kHz frequency and a range of 90 m. The sidescan sonar deployed from the R.V. Johnson was a 100-kHz system with a range of 150 m to each side. The identification of tilefish burrows from sonographs was verified by in situ groundtruthing from NR-1 and JSL submersibles. Navigation during sidescan sonar transects was accomplished with Loran C from the support vessel (for the towed transducer). For the NR-1 sidescan transects (Fort Pierce area), we were able to follow the NR-1 tracks that had just been created prior to sidescanning. These same tracks were often visible on the sonographs collected from the R.V. Johnson in 1984 (Cape Canaveral area).



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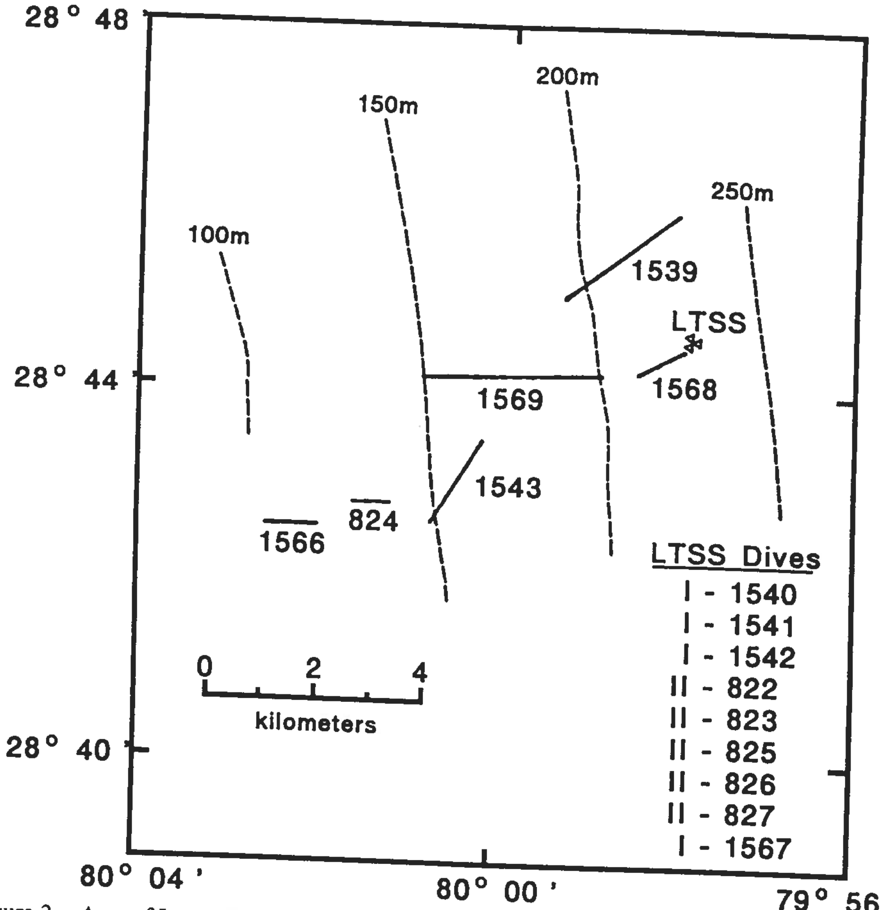


Figure 2. Area of Long Term Study Site (LTSS) with solid lines indicating the track of selected JSL dives. Other dives at the LTSS indicated in lower right corner.

Results and Discussion

Tilefish Burrow Habitat.—*Lopholatilus chamaeleonticeps* construct large burrows in the sediments off the central east coast of Florida that are similar to those observed previously in the Mid-Atlantic Bight (Able et al., 1982; Grimes et al., 1986). Hundreds of burrows were observed at two locations north and south of Cape Canaveral, Florida during 1983 and 1984 (Table 1, Fig. 1), and frequently reported from earlier studies during 1975–1977 from Lake Worth (26°40′N) to Cape Canaveral (28°30′N) in the same general area (Table 2). The tilefish burrows we observed during 1983 and 1984 were funnel-shaped holes that ranged up to 1.5 m diameter at the sediment surface and narrowed to a vertical shaft at the bottom. The upper portion of the funnel occasionally had smaller burrows of associated crustaceans and fishes, but these small burrows appeared much less numerous than those associated with tilefish burrows in the Mid-Atlantic Bight. There were relatively few tilefish observed (Table 1) but their presence was otherwise indicated by sediment plumes from burrows; i.e., smoking burrows (Fig. 3), caused by quick entry into the burrow (Able et al., 1982).

Most tilefish observed from the submersibles were less than 75 cm in length.

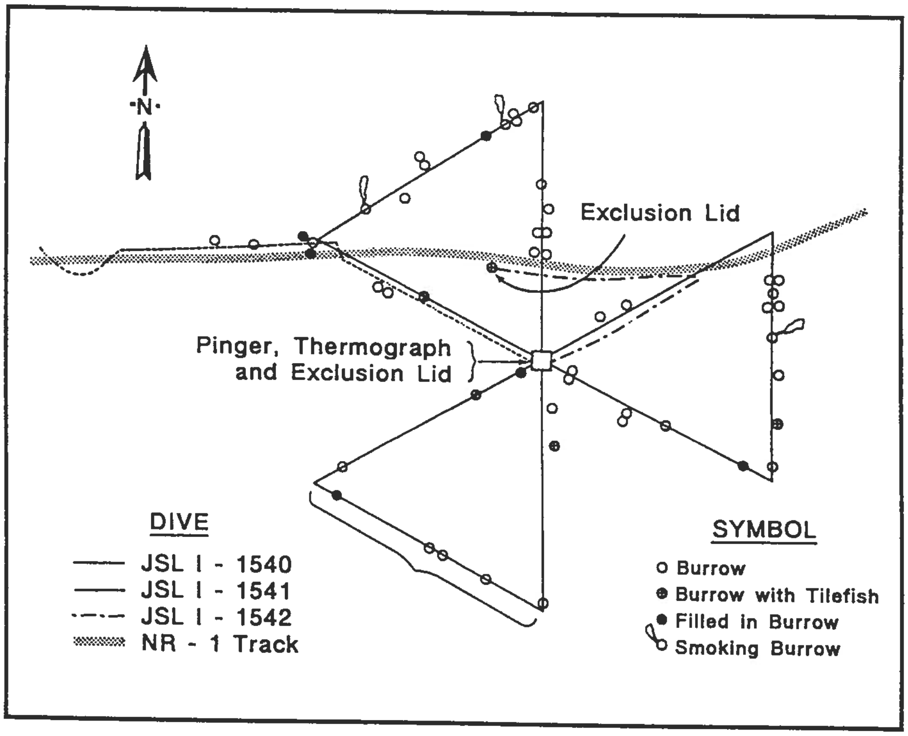
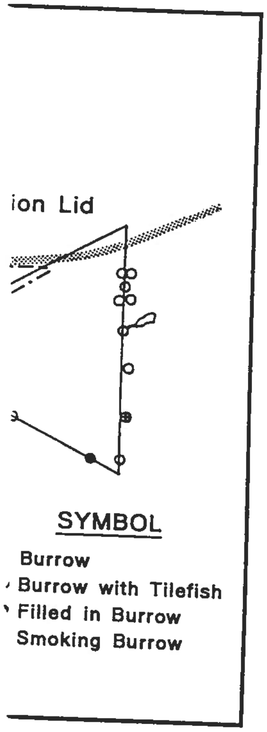


Figure 3. Distribution of tilefish burrows in the immediate vicinity of the Long Term Study Site based on submersible observations.

Tilefish collected on commercial longlines in the LTSS area were from 35–100 cm (Fig. 4) and similar in length to those observed from the submersible. Many of the tilefish burrows were filled in with sediment to varying degrees. In some, the shaft was filled. In others, even the upper funnel-shaped portion was partially filled, while still others were filled almost completely and appeared as subdued depressions in the substrate. In the first two types there were often some associates

Table 2. Past records of JOHNSON-SEA-LINK (JSL) submersible observations of *Lopholatilus chamaeleonticeps* and their burrows off the east coast of Florida. See Figure 1 for locations

JSL Dive number	Date	Location	Total depth Range (m)	Depth range of tilefish	Total temperature range (°C)	Temperature range of tilefish observations (°C)
I-252	20 June 1975	off Bethel Shoal	137–182	137–141	—	—
I-348	25 March 1976	off Bethel Shoal	186–306	195–266	—	—
I-349	26 March 1976	off Ft. Pierce	144–260	219–231	—	—
I-350	5 April 1976	off Sebastian Inlet	179–305	245–266	10.1–12.4	12.2
I-351	6 April 1976	off Cape Canaveral	177–304	182–236	—	—
I-352	7 April 1976	off Cocoa Beach	167–304	228	—	—
I-353	7 April 1976	off Malabar	167–176	181–228	—	—
II-117	15 Sept. 1976	off Lake Worth	197–262	213–220	10.7–13.9	13.1
II-277	26 Oct. 1977	off Bethel Shoal	197–213	201–213	9.9	9.9
Total ranges			137–306	137–266	9.9–13.9	9.9–13.1



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)	10.7–13.9	13.1
3	9.9	9.9
	9.9–13.9	9.9–13.1

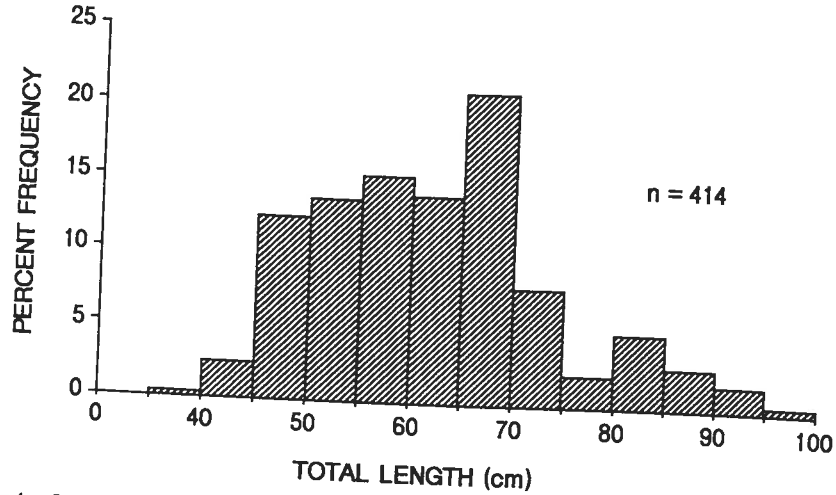


Figure 4. Length frequency distribution of tilefish from commercial longline fishing in the study area.

still present in the burrow. The burrow associates included the decapod crustaceans *Munida forceps* and *Cancer* sp. and the fishes *Anthias woodsi* and *Laemonema barbatulum*. These decapods have also been reported from the burrows of *Caulolatilus* spp. in shallower waters but the fish species were not present there (Able et al., 1987a). All of these species have been previously reported from tilefish burrows in the Mid-Atlantic Bight (Able et al., 1982; Grimes et al., 1986). Where the occupant could be observed, each burrow contained a single tilefish, and fish behavior was similar to that previously described, i.e., head-first entry and tail-first exit (Able et al., 1982; Grimes et al., 1986).

In an attempt to test the role of tilefish in maintaining the burrow and burrow community and to determine the temporal stability of these habitats, we excluded tilefish from two burrows (1.5 and 0.7 m diameter) at the LTSS (Fig. 3) and revisited them over a period of several months (April–October 1984). Burrow "exclusion lids" were deployed, and the size and shape of the burrows were documented with 35-mm photographs and video imagery. From 14 April to 22–24 May, the burrows changed little, although some added sediment was visible in the shaft of each burrow. The smaller burrows of associates in the upper portion of each tilefish burrow were still visible. By 30 October (173 days after deploying lids), one burrow was completely filled with sediment and may not have been identified as a tilefish burrow had it not been for the presence of the exclusion lid. All of the associated species were absent. A second tilefish burrow, the largest, was not completely filled in by this date and the burrows of some galatheid crabs were still visible in the uppermost margin of the tilefish burrow. This burrow appeared identical to earlier observations of burrows (Able et al., 1982) that we had characterized as abandoned. Thus, these experiments with exclusion lids led to observations that were similar to those in the Mid-Atlantic Bight (Grimes et al., 1986), i.e., the burrows had filled in and the typical burrow associates were less abundant or absent. Thus removal of tilefish, either through natural or fishing mortality, would result in the filling in of the burrow. The study area was subjected to intensive fishing pressure, and we observed two boats fishing for tilefish in the study area during our May cruise. Much of the central east coast of Florida was also subjected to the same intensive fishing pressure for tilefish, and resulted in precipitous decline in landing rates during the early 1980's (Fig. 5). Given our

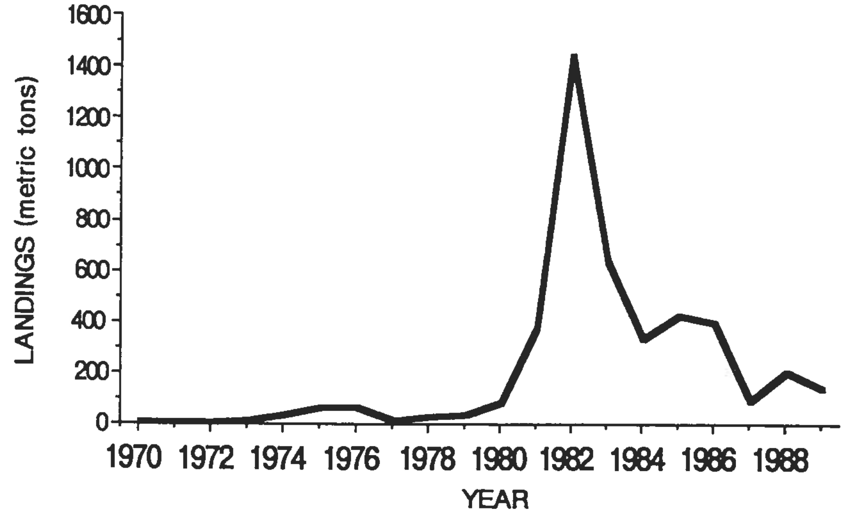


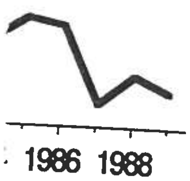
Figure 5. Commercial landings of tilefish off the east coast of Florida from 1970–1989.

observations that tilefish burrows fill in rather quickly, it is clear that intensive fishing in the study area probably accounted for the larger number of filled-in burrows observed during numerous dives in 1984. Further, it seems clear that tilefish are necessary for maintenance of the burrow and the burrow associates as we discussed earlier (Grimes et al., 1986).

Spatial Distribution of Tilefish Burrows.—Burrows of tilefish (both *Lopholatilus* and *Caulolatilus*), based on sidescan sonar records, were distributed in two distinct zones, one shallower than approximately 150 m and one deeper than 200 m (Fig. 6). The former are those of *Caulolatilus* spp. (Able et al., 1987a), while the latter are those of *Lopholatilus chamaeleonticeps* as determined by submersible observations. The maximum depth limits of *Lopholatilus* burrows could not be determined because the towing cable for the sidescan was too short to operate in water deeper than approximately 250 m. In situ observations in 1983 determined the depth range to be 175–294 m, while in 1984 it was 150–290 m. These depths are similar to those recorded from previous in situ observations off Florida (Table 2), but ranged somewhat deeper than off South Carolina and Georgia (137–222 m; Barans and Stender, in review) and most records in the Mid-Atlantic Bight (80–305 m; Grimes et al., 1986).

Burrow density of *L. chamaeleonticeps* varied within the study area. Densities were greatest in the center (Line 3), where they ranged from 2.91–8.10 burrows·1,000 m^{-2}. Densities were lower to the north (Line 2: 1.24–2.59, Line 1: 1.97–2.05 burrows·1,000 m^{-2}) and lower still to the south (Line 4: 0.99–2.05 burrows·1,000 m^2) and lowest at the southernmost end (Line 5: 0.44–0.52 burrows·1,000 m^{-2}). On a smaller scale, it appears that the burrows at the LTSS were distributed in patches or as individuals (Fig. 3).

Bottom temperatures over the depth distribution of *Lopholatilus* ranged from 8.6–15.4°C based on submersible observation (Tables 1, 2), which is similar to temperatures recorded from the Mid-Atlantic Bight (9–14°C, Grimes et al., 1986) and cooler, on the average, than *Caulolatilus* spp. (13.8–18.0°C) in nearby shallower waters (Able et al., 1987a). Gulf Stream temperatures in the water column



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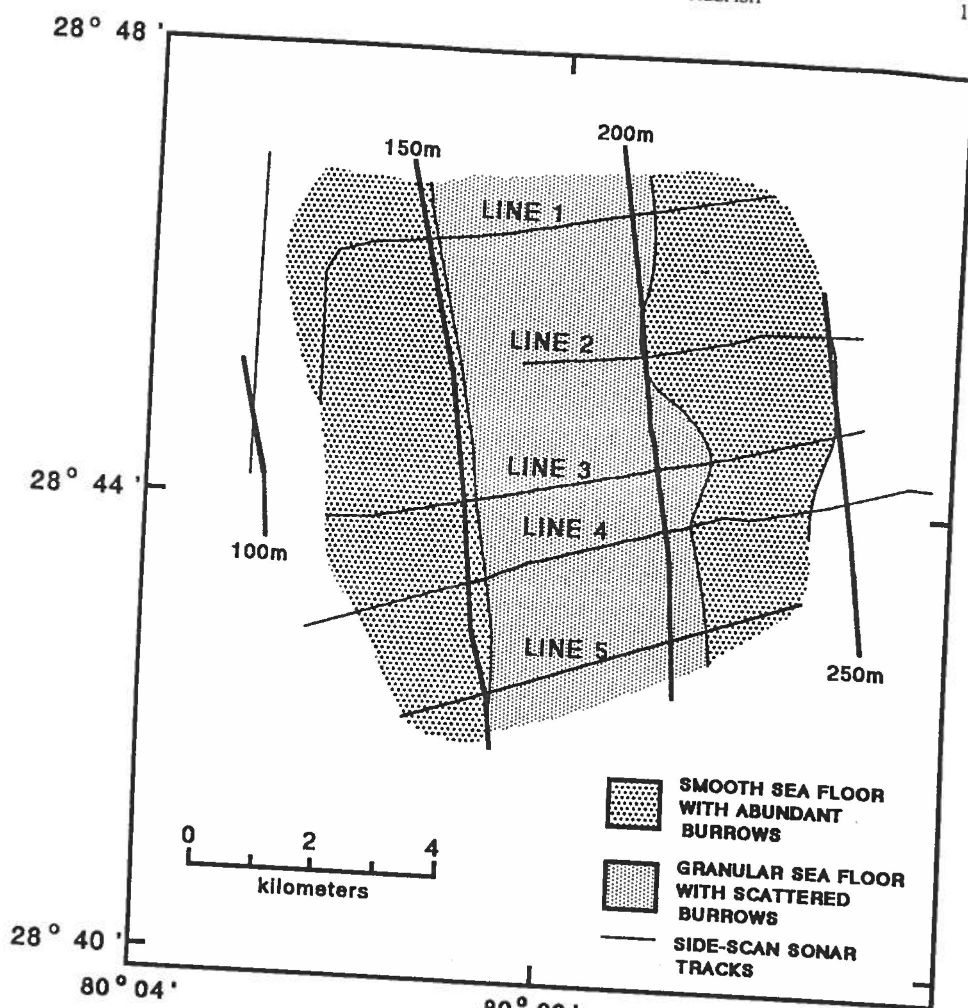

Figure 6. Distribution of tilefish burrows in the study area based on five sidescan sonar track lines. Burrows shallower than 150 m are those of *Caulolatilus* spp., and those deeper than 200 m are occupied by *Lopholatilus chamaeleonticeps*.

above tilefish habitats can be much warmer (up to 27°C) during most seasons (Fig. 7). The relatively narrow temperature ranges that have been recorded where tilefish occur do not necessarily reflect a stable environment. A long temperature record (Fig. 8) at the study site indicates that while temperatures can be stable for long periods (17 July–11 Aug), they can also vary as much as +6°C in a 48-h period (13–15 Aug). Such abrupt temperature changes may cause tilefish to cease feeding and thus account for the abrupt changes in catch rates reported by fishermen in the area (Able, pers. observ.) because movement away from burrows is not likely for tilefish over the same time scale (Grimes et al., 1986). These long-term records also indicated that temperatures lower than 8°C, which is lower than usually reported, can persist for days.

In addition to temperature being a strong contributor to *Lopholatilus* distribution, sediment texture may also be a controlling factor. On the outer continental

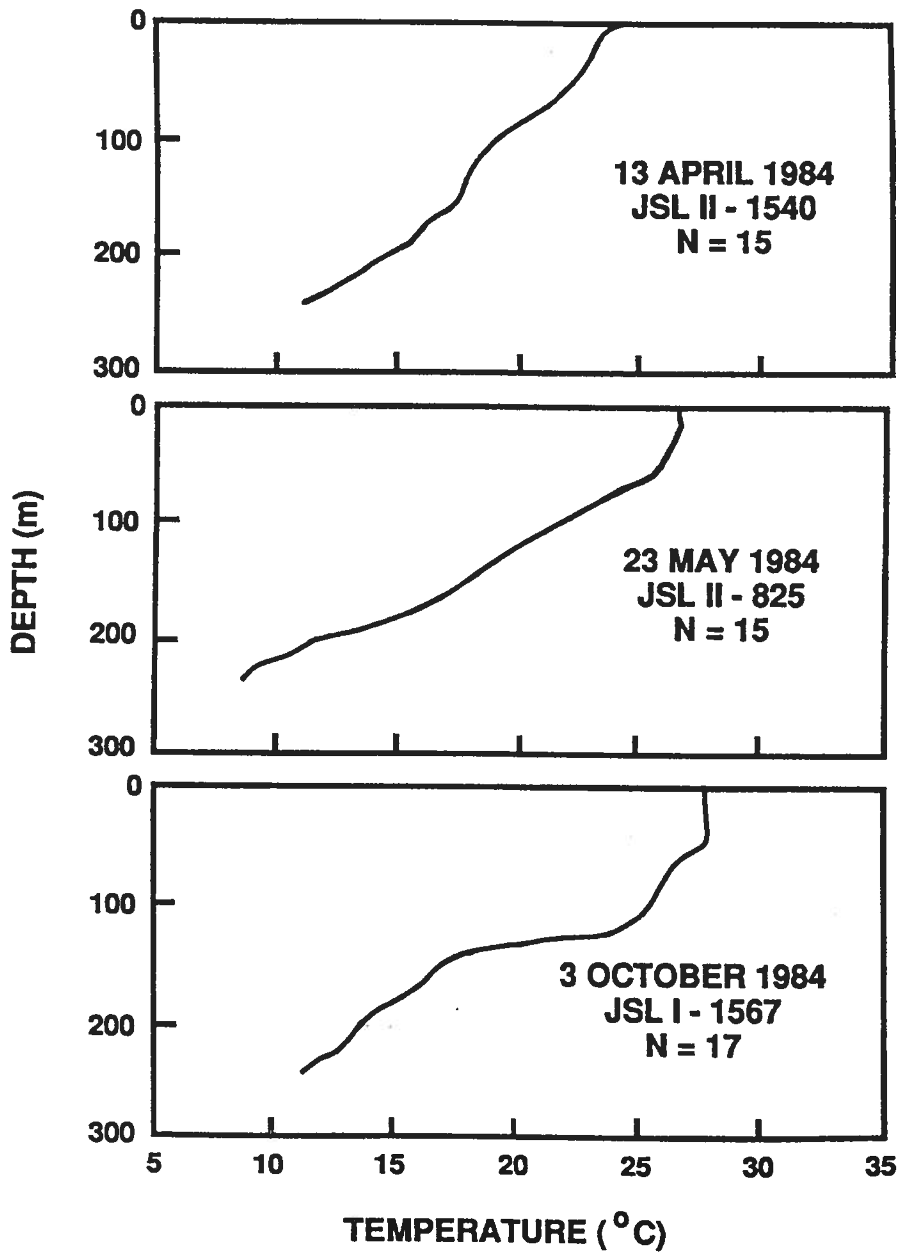

Figure 7. Temperature profiles of the water column collected during ascents on three dives in the study area. See Figure 2 for dive locations.

shelf around the head of Hudson Canyon there is a strong correlation between burrow distribution and the extent of clay deposits (Twichell et al., 1985; Grimes et al., 1986). A similar relationship between sediment grain size and *Lopholatilus* distribution, based on catch rates, has been demonstrated off Georgia (Grossman

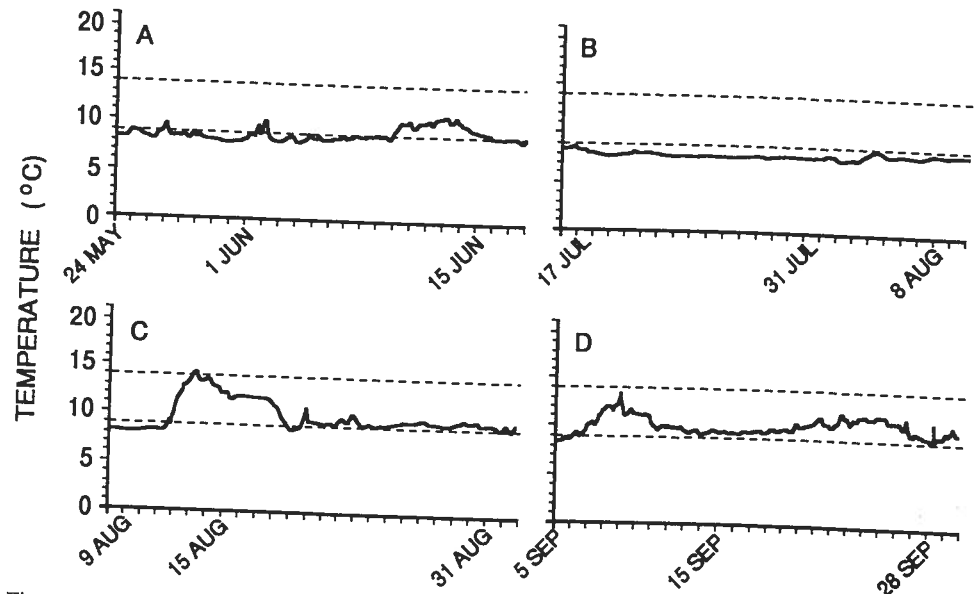

Figure 8. Partial temperature record at Long Term Study Site. Dashed lines indicate 9 and 14°C temperatures as a basis for comparison with Mid-Atlantic Bight temperatures at which *Lopholatilus* commonly occurs.

et al., 1985). Off the east coast of Florida, although our sediment samples are somewhat limited in number and extent, *Lopholatilus* burrows occur where the silt plus clay content of the sediment is high (>74%) and the sand and gravel content low (<26%) (Fig. 9). *Caulolatilus* spp. burrows, however, occur inshore where the sand and gravel content of surficial sediments exceeds 75% (Able et al., 1987a). These two fishes construct different types of burrows (Grimes et al., 1986; Able et al., 1987a); the vertical shafts of the *Lopholatilus* burrows appear to require the finer-grained, more cohesive sediments in order to be maintained.

In summary, observations in the Mid-Atlantic Bight (Grimes et al., 1986), off South Carolina and Georgia (Barans and Stender, in review), off Texas (Jones et al., 1989), and now off the east coast of Florida indicate that *Lopholatilus chamaeleonticeps* constructs burrows in silty-clay sediments at depths that overlap a general temperature range of 9–14°C. In this study, however, it has been demonstrated that short-term temperature fluctuations, perhaps associated with Gulf Stream meanders, can be abrupt and relatively large. The consistency with which tilefish have been observed in burrows suggests that they are likely to occupy burrows throughout their distribution. One possible exception is in areas where boulders occur (Grimes et al., 1986). The close relationship of *L. chamaeleonticeps* to *L. villari* (Dooley, 1978) from off the east coast of Brazil prompts us to predict that this form constructs burrows as well, as do most members of the family Malacanthidae (or Branchiostegidae of some authors) (Able et al., 1987a).

Additionally, we have provided evidence that *L. chamaeleonticeps* maintain the burrow habitat, and if they are excluded from a burrow it fills in and the members of the associated community disappear. This has probably happened commonly along the east coast of the United States as fisheries for tilefish (Turner, 1986; Harris and Grossman, 1985; Low et al., 1983) developed and expanded.

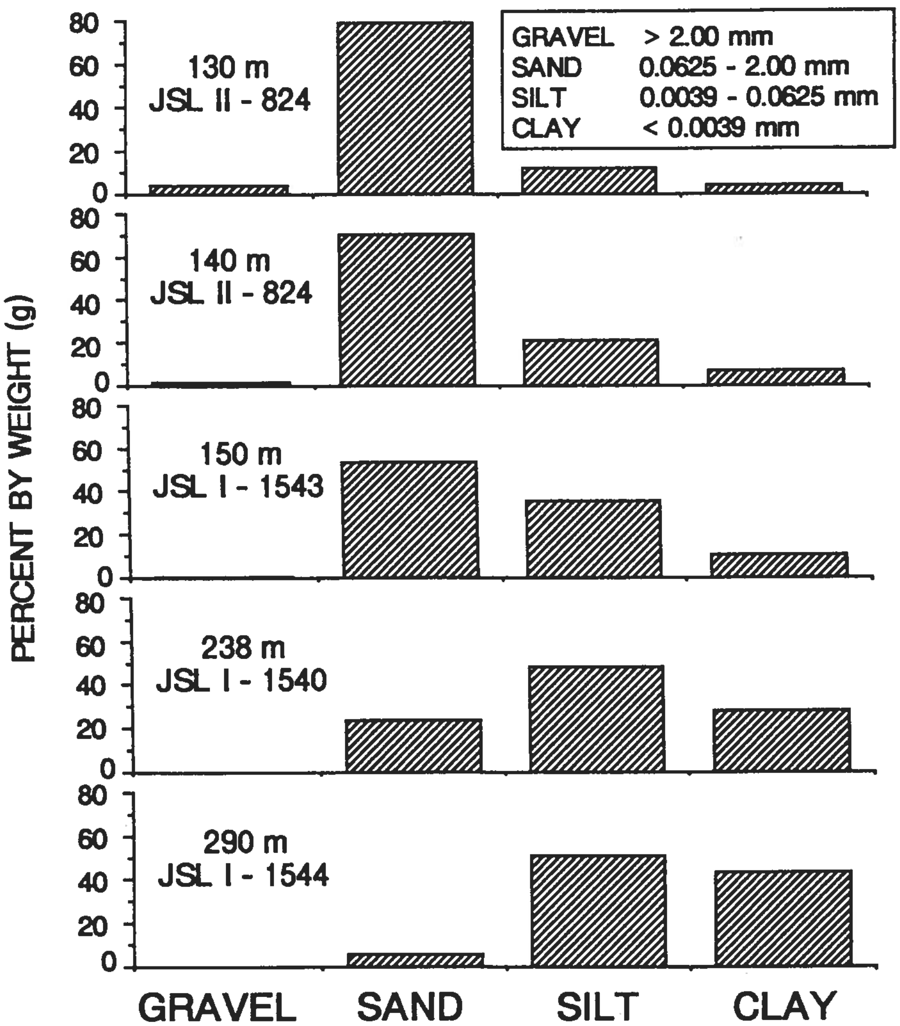

Figure 9. Sediment grain size distribution in the study area. See Figure 2 for dive locations.

Acknowledgments

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Marine Science Institute Contribution No. 824 and Rutgers University's Institute of Marine and Coastal Sciences Contribution 92-36.

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