A Preliminary Analysis of the Tilefish, *Lopholatilus chamaeleonticeps*, Fishery in the Mid-Atlantic Bight

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The tilefish, *Lopholatilus chamaeleonticeps*, a large demersal species of the outer continental shelf, presently supports a valuable fishery in the Mid-Atlantic Bight (Cape Cod to Cape Hatteras). In 1978 over 3,000 t (7 million pounds) worth about $4 million were landed in this area.

Tilefish and the fishery for them have an interesting and varied history. This species was first discovered in 1879 (Goode and Bean, 1880) but suffered a mass mortality, estimated conservatively at 1.5 billion fish, in 1882 (Collins, 1884) and was feared extinct just as interest was developing in a fishery for it. It was theorized that the warmer water of the continental shelf edge in which they resided was displaced by cold continental shelf water (Verrill, 1882) thus causing the mortality. Then in 1892 eight specimens were caught in several locations between south of Martha's Vineyard and the Delaware Capes (Rathbun, 1895), and they apparently increased in abundance thereafter (Bumpus, 1899).

Little is known of the biology of tilefish. Large adults may attain a maximum size of about 60 pounds, however, most fish average 5 to 20 pounds. They are known to occupy burrows in "pueblo village communities" in the vicinity of submarine canyons (Cooper and Uzman, 1977; Warme et al., 1977), where they feed primarily on crustaceans, fish, squid, and polychaete worms.[1] The remaining information on tilefish biology is summarized in Freeman and Turner,[2] and it is apparent that there is inadequate data on the life history and population dynamics to manage this species.

The purpose of this paper is to describe the commercial longline fishery in the Mid-Atlantic Bight and report preliminary results of catch and fishing effort studies.

Methods

Data on the commercial fishery was obtained in cooperation with longline fishermen from Barnegat Light, N.J. (Fig. 1). Since the spring of 1978, cooperating fishermen have maintained logs providing necessary catch information (e.g., catch, catch location, amount of gear fished, configuration of gear, and time fished). Information for earlier years was obtained from fishermen's logs and occasional notes of Steve Turner. Together these represent 86 commercial fishing trips between 1974 and the spring of 1979. It is important to note that these data provide only limited coverage of the fishery, especially for earlier years. We do not know total annual efforts nor can we extrapolate them, because we lack adequate information before 1978. However, we feel these data are sufficient to describe the fishery operating from Barnegat Light and provide useful indices to variations in effort and abundance by seasons, fishing areas, and depths. A hook

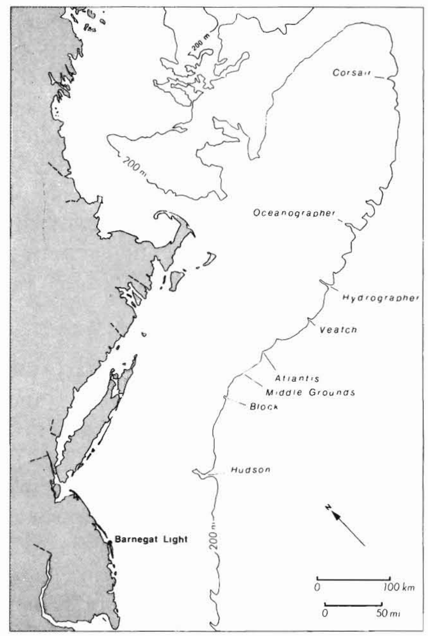

Figure 1.—A portion of the Mid-Atlantic Bight and Georges Bank showing major submarine canyon fishing areas.

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[1]Turner, S. C., and B. L. Freeman. 1978 Food habits of tilefish, *Lopholatilus chamaeleonticeps*, in the Mid-Atlantic Bight. Unpubl. manuscr., 18 p. Northeast Fisheries Center Sandy Hook Laboratory, National Marine Fisheries Service, NOAA, Highlands, NJ 07732.

[2]Freeman, B. L., and S. C. Turner. 1977. Biological and fisheries data on tilefish, *Lopholatilus chamaeleonticeps*, Goode and Bean. U.S. Dep. Commer., NOAA, Natl Mar. Fish. Serv., Sandy Hook Lab. Tech. Ser. Rep. 5, 41 p.

was chosen as the most accurate and comparable unit of effort. Differences in catch per unit of effort (CPUE) between years, seasons, fishing areas, depth zones, and vessels were conducted using analysis of variance (ANOVA). The year-seasons and all vessel interactions were not testable due to insufficient data. All other interactions, except area-season, were deemed unimportant by ANOVA. Due to insufficient samples, data for ANOVA were grouped as follows: Seasons—spring-March through May, summer-June through August, fall and winter-September through February; depths—73-145 m (40-79 fathoms), 146-182 m (80-99 fathoms), and deeper than 183 m (100 fathoms); years—1974, 1975 and 1976, 1977 and 1978; and fishing areas—west Hudson, east Hudson, Block to Atlantis, including Middle Grounds, and Veatch Canyons. The data set for this analysis is, of necessity, based on 41 commercial fishing trips, due to the incomplete nature of some of the fishermen's logs.

History of the Fishery

A fishery has existed for tilefish in the Mid-Atlantic Bight since 1915, and 4,500 t (10 million pounds) were landed in 10 months in 1916 (Smith, 1917). Since that time landings have fluctuated between a few hundred kilograms (thousands of pounds) and 3,300 t (7.2 million pounds) (U.S. Department of Commerce, 1979a-d). An important commerical longline fishery has developed in recent years. Since 1972 there has been a dramatic increase in commercial landings and value (Fig. 2, 3). In 1978 over 3,300 t (7.2 million pounds) worth $3.7 million were landed in the Mid-Atlantic Bight. The catch is landed in Massachusetts, Rhode Island, New York, and New Jersey, but the latter has recently accounted for the bulk of the landings (Fig. 2, 3). This trend appears to be continuing, because New Jersey landed 1,906 t (4.2 million pounds), or 54 percent of the Mid-Atlantic total, worth $2.3 million in 1978 (U.S. Department of Commerce, 1979b). The vast majority of this catch is landed at Barnegat Light, N.J., which is the home port for

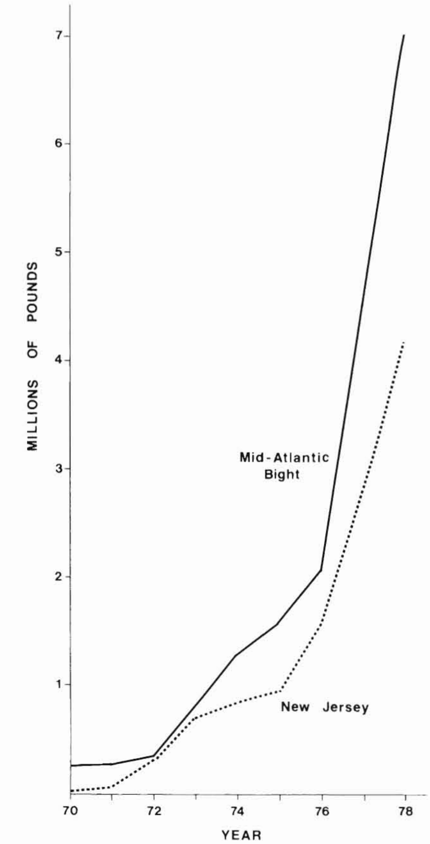

Figure 2.—Annual landings of tilefish in the Mid-Atlantic Bight and New Jersey.

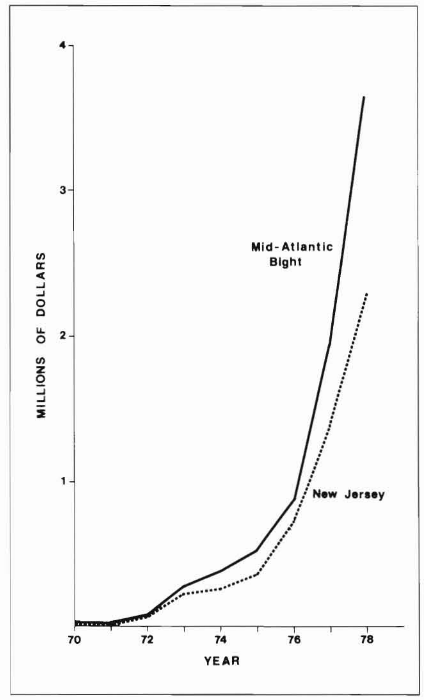

Figure 3.—Annual ex-vessel value of tilefish in the Mid-Atlantic Bight and New Jersey.

15 of the 17 total New Jersey longline vessels (more than half of all vessels fishing for tilefish in the Mid-Atlantic Bight). By comparison, New York landed 953 t (2.1 million pounds), or 29 percent of the Mid-Atlantic total, worth $1.1 million. Most New York landings are at Montauk, N.Y.; several of the New Jersey vessels moved there from Barnegat Light in 1978.

The recognition of tilefish in the marketplace as a high quality product is increasing as well. During the spring of 1979, ex-vessel value of tilefish reached $1.35/pound, the highest price yet attained. Not only are the majority of fish landed in New Jersey, but the highest ex-vessel prices are available there as well. For example, Rhode Island, Massachusetts, and New York fishermen received an average price of $0.25, $0.30, and $0.39/pound, respectively, in 1977, while New Jersey longliners were paid an average of $0.49/pound (U.S. Department of Commerce, 1978a-d). This disparity was reduced in 1978 (New Jersey fishermen were paid an average $0.55/pound, and New York and Massachusetts fishermen received $0.51 and $0.41), except in Rhode Island where fishermen received only $0.21/pound for their catch (U.S. Department of Commerce, 1979a-d).

There is a small recreational headboat fishery for tilefish in New York and New Jersey. In 1978, four New Jersey vessels made approximately 12 recreational fishing trips, landing an estimated 4,500 kg (9,900 pounds). These sport fishing trips occur in late fall and early spring, between more lucrative summer fishing for nearshore species (bluefish, flounder, scup, etc.) and totally unsuitable recreational fishing conditions in winter.

Table 1.—Annual variation in the amount of longline fished per trip and catch per hook data available for 1974-78 (*N* = number of fishing trips, $\bar{X}$ = mean, and S = standard deviation).

Item	1974			1975			1976			1977			1978		
	N	$\bar{X}$	S	*N*	$\bar{X}$	S	*N*	$\bar{X}$	S	*N*	$\bar{X}$	S	*N*	$\bar{X}$	S
Amount of longline gear fished per trip in miles (km)	20	11.5 (7.15)		6	8.7 (5.41)		21	20.9 (12.99)		25	23.2 (14.42)		14	28.7 (17.83)	
Catch per hook in pounds (kg)	15	1.3 (0.60)	0.25 (0.11)	3	2.1 (0.99)	1.2 (0.55)	7	1.4 (0.64)	1.5 (0.68)	13	1.5 (0.68)	0.6 (0.27)	14	0.7 (0.32)	0.2 (0.09)

Gear and Operations

Bottom longlines used to catch tilefish are baited with mackerel, herring, or squid and refrozen prior to departure. However, at least two or three vessels are equipped with onboard automatic baiting gear which uses fresher (thawed once) bait. Each tub contains about 0.9 km (0.5 mile) of groundline, and about every 3.7 m (12 feet) branchlines, called snoods (0.4 m or 18 inches long), are attached to the groundline. The longlines, which use 8/0 hooks, are set over the stern and retrieved by hydraulic line haulers. The longline gear is fished in sets, a set consisting of a length of gear anchored and buoyed at either end. Several sets may be made during a single fishing trip.

From 1974 to the spring of 1979, an average trip lasted 4 days, but only 2.4 days were devoted to fishing. Sets averaged 11.1 km (6.9 miles) of gear with 3.2 sets/trip which accounted for an average 30.6 km (19 miles) of gear fished per trip. During these years the average catch per mile of gear was 263 kg (580 pounds), and the average catch per trip was 4,070 kg (8,970 pounds). The average catch rate for all years, weighted equally, was 0.64 kg (1.4 pounds)/hook.

The amount of longline fished each trip has increased markedly since 1974 (Table 1), the 1978 average being 149 percent higher than the 1974 figure. This trend dramatically demonstrates the developmental nature of the fishery during these years. Seasonally, most longline (per trip) was set in summer (41 percent more than in the winter) and fall (19 percent more than winter) (Table 2). These seasonal variations may reflect that catch rates are lowest in summer and fall (see subsequent discussion), and fishermen are setting more longline in an attempt to make a good catch. No doubt generally superior weather conditions in summer and fall are also partially responsible for these seasonal trends.

Table 2.—Seasonal variation in amount of longline fished per trip, number of days fished per trip, total amount of longline fished and catch per hook data available for 1974-78 (*N* = number of fishing trips, $\bar{X}$ = mean, and S = standard deviation).

Item	Fall			Winter			Spring			Summer		
	N	$\bar{X}$	S	*N*	$\bar{X}$	S	*N*	$\bar{X}$	S	*N*	$\bar{X}$	S
Amount of longline gear fished per trip in miles (km)	17	20.1 (32.2)		10	16.9 (27)		37	17.9 (28.6)		22	23.9 (38.2)	
Number of days fished per trip	14	2.1		5	2.2		21	2.9		22	2.5	
Catch per hook in pounds (kg)	14	0.99 (0.45)	0.4 (0.18)	3	1.4 (0.64)	0.9 (0.41)	26	1.6 (0.73)	0.8 (0.36)	9	0.7 (0.32)	0.2 (0.09)
Total amount of longline fished in miles (km)		341 (546)			169 (270)			662 (1,059)			526 (842)	

Relative to fishing area, the amount of gear fished per trip increased with distance from Barnegat Light (Table 3). For example, the average amount of longline set on a trip to Atlantis Canyon (one of the more distant fishing areas from Barnegat Light) was 122 percent of that fished at west Hudson Canyon. This trend may indicate that many long distance trips were of an exploratory nature, so fishermen set large amounts of gear in search of new productive fishing grounds, or they fished more gear to make a longer trip profitable.

The length of fishing trips also varied seasonally, the longest trips occurring in spring and the shortest in the winter (Table 2). These differences perhaps reflect that more time is involved in fishing successful gear in the spring when catch rates are highest (see subsequent discussion) and trips are shorter in winter due to generally unfavorable weather conditions.

Fishing Effort, Catch, Catch Rates, and Size of Fish

Total fishing effort has undoubtedly increased since 1974. The number of vessels engaged in fishing in the Mid-Atlantic Bight has increased from 4 or 5 in 1974 to approximately 25 in 1978. Also, the fishing power of a unit of effort has probably increased since 1974 because of factors related to locating concentrations of fish. This includes such things as improved vessels, better navigation, and increased experience. In contrast to many fisheries, there have been few changes in the fishing gear itself that would affect the fishing power of a unit of effort. While the recent addition of automatic baiting machines

Table 3.—Variation in amount of longline fished per trip, number of days fished per trip, total amount of longline fished, and catch per hook at different fishing areas that are identified by their proximity to the major submarine canyons (N = number of fishing trips, $\bar{X}$ = mean, and S = standard deviation).

Item	West Hudson Canyon			Hudson Canyon			East Hudson Canyon			Middle Grounds			Block Canyon			Atlantis Canyon			Veatch Canyon		
	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
Number days fished per trip	23	1.8		7	2.4		13	2.5		1	1.0		2	2.5		3	3.3		8	2.8	
Amount of longline gear fished per trip in miles (km)	33	17.1 (27.4)		14	17.0 (27.2)		5	22.0 (35.2)		1	9.0 (14.4)		2	27.5 (44.0)		3	38.1 (60.9)		9	24.4 (39.0)	
Catch per hook in pounds (kg)	24	1.1 (0.49)	0.4 (0.18)	6	1.4 (0.64)	0.3 (0.14)	8	1.7 (0.77)	0.4 (0.18)		(44.0)		1	1.4 (0.47)		3	0.8 (0.36)	0.05 (0.02)	6	2.04 (0.93)	1.7 (0.77)
Total amount of longline fished in miles (km)		564 (903)			238 (381)			110 (176)			9 (14)			55 (88)			114 (183)			220 (351)	

aboard two or three vessels has reportedly produced higher catch rates due to superior bait quality, CPUE data needed to verify this is presently lacking.

Using total amount of longline fished by sampled vessels as an index to total effort, there are variations in effort by season, fishing area, and depth. Seasonally, greatest effort was in the spring (39 percent), when catch rates were highest (see subsequent discussion), and lowest in winter (10 percent) (Table 2). Low effort in winter probably reflects generally poor weather conditions. Those fishing areas nearest to the home port of Barnegat Light received the greatest effort (Table 3), the west Hudson Canyon area having 43 percent of the total. Concerning the distribution of effort relative to depth, most fishing (85 percent of total effort) occurred between 110 and 183 m (60 and 100 fathoms) (Table 4).

Some trends in CPUE are apparent, and they may reflect changes in abundance of tilefish. Seasonally, CPUE was high in spring and winter and low in summer and fall (Table 2), and these differences are statistically significant (Table 5). These fluctuations in catch rate and perhaps abundance are recognized by the fishermen (i.e., they speak of spring blitz and summer drought), are reflected in prices (i.e., highest annual ex-vessel price is always in summer when supplies are low), and are also reflected in the operation of the fishery as previously mentioned. Tilefish at or near spawning condition have been observed mid-March through mid-September (Collins, 1884; Bigelow and Schroeder, 1953; Dooley, 1978; Freeman and Turner, footnote 2). Possibly low summer and fall catch rates reflect changes in feeding behavior during spawning.

Catch rates also varied significantly with fishing area (Table 5). The catch rates were lowest and fishing effort highest (amount of longline fished) (Table 3) in fishing areas most accessible to Barnegat Light (west Hudson, Hudson, and east Hudson areas), while the Veatch Canyon area had the highest CPUE. Catch rates were also low in Block and Atlantis Canyon areas, but sample sizes (number of trips for which data is available) were also small. The ANOVA showed a significant interaction between area and season (Table 5). Examination of the data revealed that

Table 4.—Variation in amount of longline fished per trip, total amount of longline fished and catch per hook by depth in meters (fathoms) for 1974-78 (N = number of fishing trips, $\bar{X}$ = mean, and S = standard deviation).

Item	73-108 (40-59)			100-145 (60-79)			146-182 (80-99)			183-218 (100-119)			219-254 (120-139)		
	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S	N	$\bar{X}$	S
Amount of longline gear fished per trip in miles (km)	1	10 (16)		12	22.3 (35.7)		22	17.8 (28.5)		3	20.0 (32.0)		3	15.7 (25.1)	
Catch per hook in pounds (kg)	1	1.9 (0.86)		15	1.2 (0.55)	1.1 (0.49)	21	1.1 (0.49)	0.5 (0.23)	3	1.3 (0.59)	0.7 (0.32)	3	2.1 (0.59)	1.01 (0.46)
Total amount of longline fished in miles (km)		10 (16)			268 (428)			392 (626)			60 (96)			47 (75)	

Table 5.—Analysis of variance of catch-per-hook data from the longline fishery for tilefish.

Source	df	SS	MS	P
Fishing area	3	4.561	1.520	0.0001
Depth zone	2	0.606	0.303	0.549
Season	2	5.143	2.572	0.0001
Year	2	0.222	0.111	0.3179
Vessel	4	0.707	0.177	0.1406
Area-Season	2	6.513	3.257	0.0001

this interaction was due to consistently high catches at Veatch Canyon in the spring.

Catch rates are similar for most depth zones. Highest CPUE occurred at depths that received the least effort (amount of longline fished per trip) (Table 4). The deeper zone may receive less effort because fishing conditions are more difficult there (e.g., more anchor line required, increased currents, closer to shipping lanes, and more gear lost by fouling on lobster pots).

The annual CPUE has decreased over the period spanned by our data (Table 1). Highest annual CPUE was in 1975 (0.99 kg or 2.1 pounds/hook), while the lowest was 1978 at 0.32 kg (0.7 pound/hook). The ANOVA did not indicate significant differences in CPUE betwen years (Table 5). This is probably due to the unequal distribution of data for seasons and fishing area within years.

Recent decreases in size also may be the result of fishing. Length frequency distributions of tilefish from two fishing regions (Hudson Canyon and all areas north and east of Hudson Canyon to Veatch Canyon) show a decrease in modal length since 1974 for the former and 1976 for the latter (Fig. 4). Presumably the decline in modal length is the effect of fishing on lightly exploited stocks, since it has occurred concurrently with increased catches (Fig. 2) and decreased CPUE (Table 1). Interestingly, the modal length of fish collected in 1898, 16 years after the mass mortality (Bumpus 1899), is less than that for Hudson Canyon in 1974 and similar to that for both regions in 1978 (Fig. 4). Assuming that the fish collected in 1898 are representative, the smaller modal length may reflect that they had not yet recovered completely from the mass mortality of 1882.

A comparison of early catch and fishing effort data on unexploited stocks of tilefish with our limited data may offer additional insights into the present status of the stocks in the Mid-Atlantic Bight. The earliest cruise, in May 1879, had an estimated catch of 909 kg (2,000 pounds) on 1,000 hooks (0.9 kg; 2 pounds/hook) (Bumpus, 1899). In August and September 1898, large numbers of tilefish were taken by longline for the first time since the mass mortality in 1882 (Bumpus, 1899). Catch and effort data are not available for all sets made during this cruise, and some sets were deliberately made on marginal tilefish grounds. However, nine sets which landed 1,437 kg (3,162 pounds) on 4,366 hooks (0.32 kg; 0.7 pound/hook) were made under conditions we judged comparable to present conditions. Present CPUE (0.32 kg; 0.7 pound/hook in 1978) is similar to that available for 1898. However, this similarity in CPUE is hard to interpret, because in 1898 tilefish stocks may have been still recovering from the 1882 mass mortality.

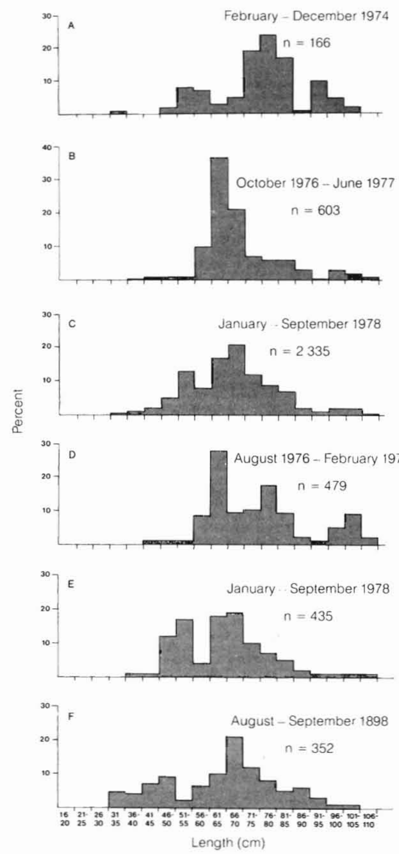

Figure 4.—Length frequencies of tilefish from Hudson Canyon (A,B,C), other fishing areas north and east of Hudson Canyon to Veatch Canyon (D,E) and from off southern New England from Bumpus (1899) (F).

Comparing the catch rates for the unexploited stocks from the May 1879 cruise (Bumpus, 1899) with data for the present fishery may be more productive. Catch rates from the 1879 cruise (0.91 kg; 2.0 pounds/hook) are similar to our spring (all years) CPUE (0.73 kg; 1.6 pounds/hook) (Table 2). If 0.91 kg/hook (2.0 pounds/hook) represents relative abundance of the unexploited stock and logistic growth is assumed for tilefish populations, then maximum sustainable yield (MSY) is at about one-half of the unexploited catch rate (Schaefer, 1954) or about 0.45 kg/hook (1.0 pound/hook). The fishery in 1978 for the same season had a catch rate of 0.31 kg/hook (0.7 pound/hook). The 1978 catch rate is lower than that at the theoretical MSY. However, because the 1898 data might not be truly representative, and the 1978 estimate is based on very preliminary data, no reliable conclusion can be drawn at this time. Additionally, analysis of catch rates may be confounded by changes in fishing power of a unit of effort. Also, this analysis treats the Mid-Atlantic Bight as a single unit, when in fact we have shown that there are significant differences between fishing areas (Table 5). Continued study may demonstrate that there are discrete populations in several areas, and planned future analyses of CPUE by these subareas may show different catch rates.

There is some evidence of a shift in fishing areas that may be related to changing catch rates. In recent years the prime fishing areas have changed from Hudson Canyon to areas farther from Barnegat Light. Exploratory fishing has extended to Georges Bank (Hydrographer, Oceanographer, and Corsair Canyons) (J. Larsen, commercial tilefish fisherman, Barnegate Light, N.J., pers. commun. 1978). These shifts may be in response to lower catch rates in more southern areas. If the fishery has moved to unexploited areas, this may maintain relatively high CPUE for the entire area but may mask local decreases in CPUE.

Catch rates for the present fishery in the Mid-Atlantic Bight are higher than those from the Gulf of Mexico. The latter populations range from lightly exploited to unexploited, since total Gulf of Mexico landings amount to less than 80 tons (176,000 pounds) over the last 5 years (U.S. Department of Commerce 1974-79). Nelson and Carpenter (1968) reported catch rates off the Texas coast of 0.23 kg (0.5 pound/hook) and 0.11 kg (0.23 pound/hook) off Louisiana and the northern Gulf. More recent longlining off Texas yielded an overall average CPUE of 0.07 kg (0.15 pound/hook), but the catch rate was 0.36 kg (0.8 pound/hook) at the best fishing locations.[3] Comparison of these catch rates with those in the Mid-Atlantic Bight is difficult, since numerous factors other than actual abundance (fishing ability, small sampling effort, etc.) may affect the estimates.

Studies in Progress

Researchers at Rutgers University are attempting to determine if different stocks of tilefish occur along the east coast of the United States and in the Gulf of Mexico. Studies of age, growth, mortality, and reproduction of Mid-Atlantic Bight populations are being conducted as well.

Acknowledgments

We began our studies of tilefish and their fishery largely through the urgings and assistance of our friend, the late Lionel A. Walford.

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