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Douglas M. Martin

National Oceanic and Atmospheric Administration

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DISTRIBUTION AND ECOLOGY OF THE SYNAPHOBANCHIDAE OF THE GULF OF MEXICO

DOUGLAS M. MARTIN

National Oceanic and Atmospheric Administration, National Ocean Service,
Office of Oceanography and Marine Services, Rockville, Maryland 20852

ABSTRACT Synphobranchid eels of the Gulf of Mexico are an important part of the upper continental slope ichthyofauna, occurring most frequently between 500 and 1,500 m. Two of the four known genera (*Histiobranchus* and *Diastobranchus*) have not been reported from the Gulf. Synphobranchidae tend to occur within a narrow range of temperatures compared to the North Atlantic synphobranchid eels. However, distribution of these eels in the deeper parts of the Gulf appears to be correlated more to change in depth than to temperature, salinity, or dissolved oxygen. The distribution at the shallower limits of their depth range appear to be a result of synergistic effects of the dissolved oxygen demand and the change in temperature. The synphobranchid eels' apparent preferences for particular types of substrata are probably associated with the organisms preyed on rather than direct selection of bottom type by the eels. These eels are opportunistic feeders, feeding primarily on fish, squid, and crustaceans. Synphobranchidae are frequently infested with parasites, but there do not appear to be any serious abnormal morphological results.

INTRODUCTION

Investigation of the deep-sea ichthyofauna has usually been conducted on a broad survey basis. Investigators have compiled lists and descriptions of families, genera, and species occurring throughout a particular area with a limited number of studies of the distributional and ecological aspects of individual groups of fishes. Springer and Bullis (1956) and Bullis and Thompson (1965) published a list of fishes collected in the Gulf of Mexico by the U.S. Fish and Wildlife Service research vessels which contained station locations, depths of capture, and for some stations, bottom type and temperature. Also, from these cruises Grey (1956, 1958, and 1959) published descriptions of the abyssal benthic fishes with short remarks about their general distribution and depths of capture. However, only a few investigations dealing with the distribution and ecology of particular families exist; most are lists (Mead 1952) or annotated checklists with some discussion of distribution and ecological factors included (Bright 1967). This investigation is particularly concerned with the eel group, about which ecological studies are practically nonexistent. Specifically, the purposes of this study are to describe the distribution and ecology of the family Synphobranchidae for the Gulf of Mexico.

The paucity of information, until recently, on the distribution of synphobranchid eels in the Gulf of Mexico and Caribbean Sea reflects the absence of intensive deep-sea exploration of this region. Synphobranchid eels were first recorded in the Gulf of Mexico by Agassiz (1888) while working on the Blake collections. Adjacent to the Gulf, Parr (1932) working with collections from the PAWNEE expedition reported captures of *Ilyophis* and *Synphobranchus* specimens from the Great Bahama Banks south-

east of the Straits of Florida.

Castle (1960) described a new species of synphobranchid eel, *Synphobranchus oregoni*, from the Gulf and reported the occurrence of *Synphobranchus brevidorsalis*, previously reported as *Synphobranchus kaupi* by Grey (1956). In a doctoral dissertation on the deep-sea fish of the Gulf of Mexico, Bright (1967) noted the occurrence of several species of synphobranchid eels with their distribution and some important ecological factors. Robins (1968) discussed some aspects of the distribution and general ecology of the family Synphobranchidae in the Straits of Florida.

METHODS

Eel samples for this investigation were collected during cruises of the R/V ALAMINOS under the direction of Dr. Willis Pequegnat. Collections for this study were made with the benthic skimmer (Pequegnat, Bright, and James 1970), 2-m dredge, and the 20-m otter trawl. Table 1 is a summary of pertinent station information. Cruises of the R/V ALAMINOS are designated by a number and letter system. For example, in the series 71A1710 the first two digits refer to the year, the letter A is for ALAMINOS, the next two digits denote the number of the cruise, and the final two digits indicate the station number. On occasion, the station number will be followed by a letter which indicates more than one haul made at that station. Identification was accomplished by radiographing each specimen and counting vertebrae.

Hydrographic data (temperature, salinity, and dissolved oxygen) and sediment samples were collected at most stations; however, in some instances it was necessary to supplement the existing data with data collected during physical and geological cruises in the same area. The hydrographic data were taken approximately 1 meter from the bottom which is within the range of occurrence of the Synphobranchidae.

TABLE 1

Summary of station data. Indicates cruise, number of specimens, depth, equipment, location, and species taken at each station.

Station	Number of Species	Depth (m)	Equipment	Latitude N	Longitude W	Species
Cruise 68A7 July 25–August 11						
12B	3	900	Skimmer	29°14.0'	86°59.7'	<i>S. oregoni</i>
13A	8	1060	Skimmer	29°03.0'	87°15.0'	<i>S. oregoni</i> (4) <i>I. brunneus</i> (4)
13D	1	1463	Skimmer	28°59.0'	87°23.3'	<i>S. oregoni</i>
15D	3	1097	Skimmer	29°10.3'	87°31.5'	<i>S. oregoni</i> (1) <i>I. brunneus</i> (2)
15H	11	914	Skimmer	29°10.5'	87°16.0'	<i>S. oregoni</i> (10) <i>I. brunneus</i> (1)
17B	1	900	Skimmer	29°09.5'	87°02.0'	<i>S. oregoni</i>
Cruise 68A13 November 12–21						
1	6	878	Skimmer	25°38.0'	96°07.3'	<i>S. oregoni</i>
3	1	714	2-m dredge	25°39.0'	96°11.0'	<i>S. oregoni</i>
4	1	512	Skimmer	25°38.4'	96°18.3'	<i>S. oregoni</i>
8	5	732	Skimmer	26°18.0'	96°08.0'	<i>S. oregoni</i>
12A	4	1060–1317	Skimmer	25°31.0'	95°51.0'	<i>S. oregoni</i>
14	1	969	2-m dredge	25°39.5'	95°49.5'	<i>S. oregoni</i>
15	1	659–860	Skimmer	27°34.5'	95°10.5'	<i>S. oregoni</i>
16	1	714	2-m dredge	27°37.0'	95°08.0'	<i>S. oregoni</i>
23	2	732	Skimmer	27°35.0'	95°23.0'	<i>S. oregoni</i>
26	1	1371–1435	Skimmer	27°00.3'	95°08.0'	<i>S. oregoni</i>
Cruise 69A11 August 5–27						
4	8	1005	Skimmer	27°24.9'	94°44.5'	<i>S. oregoni</i>
27	2	778	Skimmer	18°54.0'	94°58.8'	<i>S. oregoni</i> <i>I. brunneus</i>
69	1	1371	Skimmer	20°07.5'	96°10.5'	<i>S. oregoni</i>
75	1	1134	Skimmer	21°26.0'	96°48.5'	<i>S. oregoni</i>
78	8	677–732	Skimmer	21°30.0'	96°55.0'	<i>S. oregoni</i>
83	1	1236	Skimmer	21°35.0'	96°45.0'	<i>S. brevidorsalis</i>
86	4	969–1097	Skimmer	21°41.0'	96°51.0'	<i>S. oregoni</i>
Cruise 69A13 October 4–16						
44	19	752	20-m trawl	28°58.0'	88°28.0'	<i>S. oregoni</i>
Cruise 70A10 July 4–30						
9	8	1146	20-m trawl	18°57.0'	87°09.0'	<i>S. brevidorsalis</i>
16	1	833–878	20-m trawl	16°11.1'	84°48.0'	<i>S. affinis</i>
29	1	1146	20-m trawl	11°31.8'	74°24.5'	<i>I. brunneus</i>
40	4	622–659	20-m trawl	12°40.0'	72°00.0'	<i>S. oregoni</i>
51	7	1097	20-m trawl	17°17.1'	79°50.6'	<i>S. brevidorsalis</i>
Cruise 71A7 July 13–25						
9	8	906	20-m trawl	26°32.0'	96°07.0'	<i>S. oregoni</i> (7) <i>I. Brunneus</i> (1)
10	6	936	20-m trawl	26°32.9'	96°06.4'	<i>S. oregoni</i>
11	4	637	20-m trawl	26°32.3'	96°13.3'	<i>S. oregoni</i>
43	61	1005–1847	20-m trawl	27°27.8'	92°46.0'	<i>S. oregoni</i>
49	42	936	20-m trawl	27°26.0'	92°42.0'	<i>S. oregoni</i> (41) <i>I. brunneus</i> (1)
57	10	1216–1234	20-m trawl	26°55.8'	92°57.9'	<i>S. oregoni</i>
Cruise 71A8 July 29–August 15						
24	12	659–695	20-m trawl	23°56.8'	97°05.0'	<i>S. oregoni</i>
29	34	936	20-m trawl	23°54.7'	96°59.9'	<i>S. oregoni</i>
36	2	2151	20-m trawl	23°35.6'	96°25.5'	<i>S. brevidorsalis</i>
47	35	936	20-m trawl	21°35.6'	96°54.6'	<i>S. oregoni</i>
60	77	1097–1134	20-m trawl	19°00.3'	95°11.1'	<i>S. oregoni</i>

Figure 1. Distribution of the family Synphobranchidae in the Gulf of Mexico. Data are derived from the collections of NMFS, UMML, and TAMU. The open circles show stations made by TAMU where no synphobranchid eels were collected.

Sediment samples were collected with piston and gravity corers. Sediment size analyses were performed on the upper surface of the piston core samples for percent sand, silt, and clay. The upper surfaces of gravity cores were analyzed for percent sand and the remaining core fractions were analyzed for percent silt and clay combined.

DISTRIBUTION

Synphobranchidae occur within a narrow depth range primarily around the northern, western, and southeastern areas of the Gulf of Mexico, which was determined from the collections of the University of Miami Marine Laboratory (UMML), the National Marine Fisheries Service (NMFS), and Texas A&M University (TAMU) (Figure 1). The open circles indicate trawl stations and benthic skimmer stations made by the R/V ALAMINOS where no synphobranchid eels occurred. Limited sampling of the Yucatan Peninsula prevents any inference concerning the absence of synphobranchid eels from that area. For the purpose of this investigation, the Gulf of Mexico was considered to extend no

further than 80° west longitude. Therefore, a number of occurrences of synphobranchid eels reported by Robins (1968) from the Straits of Florida do not appear on the distributional maps.

Between 1968 and 1971, 133 benthic stations were made by TAMU in the Gulf, 99 were taken with the benthic skimmer and 2-m dredge (modified skimmer). The remaining 34 stations were made with a 20-m otter trawl which was the most successful piece of sampling gear for taking demersal fishes. Of the skimmer stations, 25 contained 76 specimens of synphobranchid eels. But from the 34 trawl stations, 11 contained 322 specimens representing approximately 78% of the collection.

The depth distribution of bottom stations made in the Gulf by TAMU, and the number of stations within a particular depth interval which contained synphobranchid eels are presented in Table 2. An estimate of the probability of taking a species of the family Synphobranchidae within a given depth range is included, together with the 95% confidence limits.

Depth distribution and total number of each species taken within a particular depth interval are shown in Table 3 and establish the depth range of each species. The depth ranges in the upper 1,500 m are considered closely representative of the actual distributions for these species. Below this depth, sampling is too sparse to make any conjectures as to the vertical limits of occurrence for the deeper dwelling members of the family. An examination of Tables 2 and 3 suggests that the synphobranchid eels are primarily situated on the upper part of the continental slope

TABLE 2

Depth distribution of bottom stations in the Gulf by TAMU (sample size) with number of stations containing synphobranchid eels (occurrences), and the probability of occurrence of a species of the family in a particular depth interval with the associated confidence limit.

Depth (m)	Sample Size (n)	Occurrence (r)	Probability of Occurrence ($p = \frac{r}{n}$)	Confidence Limits (95%)
100-600	40	1	.02	.00-.05
600-1100	40	1	.63	.48-.78
1100-1600	23	8	.35	.15-.54
1600	30	1	.03	.00-.01

CONFIDENCE LIMITS = $p \pm 1.96 \sqrt{\frac{p(1-p)}{n}}$ (R. V. Hogg and E. A. Tanis 1977).

TABLE 3

General depth distribution of synphobranchid eels collected in the Gulf by UMML, NMFS, and TAMU. The values in each column represent the combined number of that species taken within the corresponding depth interval.

Depth (m)	<i>S. oregoni</i>	<i>S. brevidorsalis</i>	<i>S. affinis</i>	<i>I. brunneus</i>
100-199				
200-299				
300-399				
400-499				
500-599	1			
600-699	27		1	
700-799	57		9	6
800-899	22		12	1
900-999	152		2	7
1000-1099	84		1	6
1100-1199	77			1
1200-1299	12			
1300-1399	3	1		
1400-1499	1			
1500-1599				
1600-1699				
1700-1799				
1800-1899				
1900-1999				
2000-2099				
2100-2199		5		
2200-2299				

between 500 and 1,500 m, with only one species occurring below 2,000 m.

The family Synphobranchidae contains four genera and eight species (Castle 1964), but only two genera and five species are recorded from the Gulf of Mexico. These are *Synphobranchus oregoni* Castle, *S. brevidorsalis* Gunther, *S. affinis* Gunther, *S. kaupi* Johnson, and *Ilyophis brunneus* Gilbert. The two genera not represented are *Histiobranchus* and *Diastobranchus*. *Synphobranchus kaupi* was not collected at any TAMU stations. The only occurrences recorded were taken by NMFS. Identification of these specimens was made in the field (Richard Roe, personal communication) and these could have been *S. affinis*, since the two species have a very similar scale pattern (Castle 1964). A histogram showing the frequency of distribution with depth for each species is presented in Figure 2 (a-d) and the horizontal distribution for each species is shown in Figure 3.

Synphobranchus oregoni Castle, 1960

Vertical Distribution

The vertical range of *S. oregoni*, the most frequently occurring species collected by TAMU, is between 500 and 1,500 m (Figure 2a) placing this species in the upper continental slope fauna. Most specimens were collected between

Figure 2 a-d. Frequency distribution with depth for *S. oregoni* (a), *S. affinis* (b), *S. brevidorsalis* (c), and *I. brunneus* (d).

Figure 3. Horizontal distribution of *S. oregoni*, *S. affinis*, *S. brevidorsalis*, and *I. brunneus*.

900 and 1,000 m. The shallowest and deepest occurring specimens were recorded from the western Gulf at 512 m and 1,463 m, respectively. When comparing depths of maximum occurrence of *S. oregoni* from the western Gulf (936 to 1,134 m) with those reported by Robins (1968) from the Straits of Florida (750 to 823 m), there is a significantly wider and deeper range of occurrence for this species in the western Gulf. There does not appear to be any significant change in the depth of maximum occurrence in populations from north to south in the western Gulf based on the data from TAMU collections (Table 1).

Horizontal Distribution

Figure 3 shows the horizontal distribution of *S. oregoni* and indicates its occurrence throughout the Gulf. The absence of synphobanchid eels off Yucatan was considered previously.

Robins (1968) reports a northern limit (Lat. $24^{\circ}51'N$) for *S. oregoni* in the Straits of Florida. From the data available for this investigation, the northern limit of *S. oregoni*

for the Gulf proper is considered to be Lat. $29^{\circ}18'N$. However, there is an area farther north within the depth range of this species that has not been sampled by TAMU, but has been sampled extensively by the NMFS at Pascagoula, Mississippi (unpublished cruise report). It appears that the absence of *S. oregoni* in this area is due to limiting environmental factors which will be discussed in the Ecology Section. The apparent southernmost occurrence for *S. oregoni* in the Gulf of Mexico is Lat. $18^{\circ}54'N$. However, this is possibly due to insufficient sampling and may not be related to physical conditions.

Synphobanchus affinis Gunther, 1877

Vertical Distribution

Synphobanchus affinis was not collected at any of the TAMU stations. Therefore, the following discussion is based primarily on Robins (1968) and a species list supplied by the NMFS at Pascagoula, Mississippi. A large number of the specimens reported by Robins are not included here since

most were collected east of Long. 80°00'W, and, for the purpose of this study, are considered to be outside the Gulf of Mexico proper.

The vertical range of *S. affinis* for the Gulf is between 600 and 1,000 m, with the largest number being collected from the 800 to 900 m depth interval (Figure 2b). From Robins' (1968) data for the Gulf, the shallowest and deepest depths of occurrence for the species were reported at 671 m and 1,015 m, respectively.

Horizontal Distribution

The most significant aspects of the distribution of this species is its apparent absence from the western Gulf (Figure 3). Robins (1968) reported that *S. affinis* occurred most frequently north of Lat. 25°00'N, the largest concentration being found in the Straits of Florida. The most northern and western stations where *S. affinis* have been taken are Lat. 29°17'N and Long. 87°09'W, respectively. Figure 1 indicates the extensive sampling carried out in the western Gulf. Such extensive sampling without capture makes it highly probable that *Synaphobranchus affinis* is limited to the eastern section of the Gulf of Mexico.

Synaphobranchus brevidorsalis Gunther, 1887

Vertical Distribution

Figure 2c shows the vertical range of *S. brevidorsalis* to be approximately 1,300 to 2,200 m. The largest number of specimens occurred within the 2,100 to 2,200 m depth interval. Shallowest occurrence was at 1,326 m and the deepest was 2,151 m. Absence of *S. brevidorsalis* captures between 1,326 and 2,151 m is peculiar, and is not due to the lack of sampling. Table 2 shows extensive sampling over that depth interval. It is possible that this shallow specimen was *S. oregoni* with a reduced vertebral count or a migrant *S. brevidorsalis* from the Caribbean.

Horizontal Distribution

This species of synphobranchid eel, although widespread, has not been collected in abundance from the Gulf of Mexico. At the present, only six specimens have been reported, three taken by the NMFS from the northeastern section, and three collected from the southwestern section by TAMU.

Figure 3 shows the locations where *S. brevidorsalis* have been collected. The small size of the population and wide horizontal distribution of this species is apparent when comparing the number of stations (3) containing *S. brevidorsalis* with the number of stations (33) containing other synphobranchid eels.

The occurrence of *S. brevidorsalis* in the Gulf of Mexico presents an interesting distributional problem. Heretofore, this species had been reported from the Gulf of Mexico and the Indian and Pacific Oceans (Bruun 1937 and Grey 1956). Robins (1968), working with a large collection of synpho-

branchid eels did not report any *S. brevidorsalis* from the Straits of Florida.

Two samples containing 15 specimens were taken in the Caribbean by TAMU in 1970. One station at 1,097 m contained seven specimens and the other from 1,146 m had eight. More extensive sampling is needed off the northeastern coast of South America to further elucidate the distribution of *Synaphobranchus brevidorsalis*.

Ilyophis brunneus Gilbert, 1891

Vertical Distribution

Ilyophis brunneus was the second most frequently occurring synphobranchid eel, although it was generally not collected in large numbers (the most taken in any trawl was four). Usually, *I. brunneus* was captured singly or in pairs; perhaps this is due to the eel's burrowing habits.

Figure 2d shows the vertical range of *Ilyophis brunneus* to be 700 to 1,200 m with the maximum number of specimens collected from 900 to 1,100 m. A second peak (700 to 800 m) in the frequency distribution histogram implies that *I. brunneus* possibly occurs in equal numbers throughout its vertical range. Robins (Figure 33, 1968) also shows a maximum occurrence within the 700 to 800 m depth interval for *I. brunneus* in the Straits of Florida; however, the data do not indicate a second area of maximum occurrence within the 900 to 1,100 m depth interval. This could indicate that there are factors affecting the vertical distribution of this species in the Straits of Florida which are not found at those depths in the Gulf proper.

Horizontal Distribution

Figure 3 shows that *I. brunneus* is distributed throughout the Gulf, being collected from every major geographic section. *Ilyophis brunneus* appears to occur more frequently in the eastern and northern sections. This is indicated by a comparison of the number of captures with the number of trawl stations within each major geographic section (Table 1).

ECOLOGY

Ecological investigations of deep-sea fishes for the Gulf are few and ecological studies for deep-sea eels are nonexistent. One of the purposes of this study is to document the physical habitat and to some extent, the niche that the synphobranchid eels occupy in the Gulf of Mexico. For the purpose of discussion, the ecology section is divided into two parts: (1) physical parameters where the temperature, salinity, dissolved oxygen, and sediment data are reported for each species, and (2) biological parameters where feeding habits and parasites are discussed.

Hydrographic data (Table 4) and sediment data (Table 5) were taken in the vicinity of, and on the same cruises as, the trawl stations where synphobranchid eels were collected. Close proximity of these hydrographic, sediment, and

TABLE 4
Hydrographic Data

Station	Lat. (N)	Long. (W)	Depth (m)	T (C)	S (ppt)	O ₂ (ml/l)
71A7-25	27°54.6'	92°49.9'	209	13.95	35.783	2.608
71A7-21H	26°43.6'	96°25.5'	227	12.98	35.597	2.425
67A5-13C	29°30.0'	86°52.5'	350	10.75	35.305	2.835
71A7-36	27°36.5'	92°58.4'	460	8.84	35.076	2.536
71A8-69	19°39.3'	92°40.8'	536	7.69	34.988	2.658
71A8-45	21°25.5'	96°55.8'	547	7.56	34.928	2.631
71A8-5H	26°38.0'	96°15.0'	582	7.32	34.879	2.794
67A5-9B	29°27.0'	86°51.1'	676	6.62	34.883	3.104
67A5-6F	28°47.3'	87°02.8'	750	5.73	34.885	3.511
66A5-5	27°52.5'	90°22.0'	785	5.77	34.895	3.450
65A3-1	27°30.0'	95°30.0'	813	5.52	34.899	3.870
67A5-7G	29°15.5'	86°59.0'	867	5.32	34.902	3.735
71A8-28	23°56.1'	97°01.3'	903	5.03	34.941	3.886
71A7-44	27°30.4'	92°49.3'	924	5.09	34.914	3.781
69A11-6	27°25.0'	94°45.6'	937	4.88	34.936	3.923
71A7-8H	26°31.2'	96°05.5'	957	5.02	34.876	3.861
71A8-62	19°01.0'	95°11.0'	1034	4.75	34.945	4.046
68A3-15B	26°28.8'	95°59.0'	1086	4.52	34.948	4.515
71A7-59	26°59.1'	92°58.5'	1193	4.38	—	4.429
71A8-77	20°06.8'	92°20.4'	1316	4.28	34.964	4.638
71A8-53	21°37.1'	96°09.7'	1818	4.22	34.936	4.819
71A8-9	26°07.5'	92°42.0'	2043	4.20	34.987	4.813
71A8-35	23°39.0'	96°26.5'	2123	4.23	34.980	4.834
71A8-39	23°28.3'	95°30.3'	3006	—	34.981	4.936
69A13-34	26°50.5'	86°40.0'	3074	4.32	34.780	5.024
66A5-3	25°25.0'	86°13.0'	3204	4.28	34.974	5.090
69A13-31	25°26.0'	86°09.0'	3221	4.33	34.876	4.990
68A7-4C	25°25.3'	86°05.3'	3246	4.32	35.143	5.388
71A8-15	25°05.8'	94°23.1'	3665	4.42	34.972	4.804

trawl stations presents an opportunity to compare the occurrence of some species of synphobanchid eels with, essentially, direct observations of the environmental parameters. The hydrographic data were collected during spring, summer, and fall cruises and show little variation seasonally at the depths occupied by synphobanchids. To further show the uniform nature of the bottom temperature, salinity, and dissolved oxygen along the slope, data from Table 4 were plotted in Figure 4 (A–C) on a hydrographic transect (solid line) across the northern slope between 26° to 28° north latitude and 92° to 93° west longitude. The close fit of the data to the profiles of the transect indicate uniform conditions horizontally and are considered to be representative of the condition under which the eels generally occur.

PHYSICAL PARAMETERS

Temperature

A discussion of temperature effect on animal distribution and behavior was presented by Gunter (1957), where he considered the magnitude of change of the temperature to be of major importance. Table 4 shows that the temperature decreased with increasing depth to about 2,000 m,

where it reached a minimum of 4.20°C and then increased to 4.42°C due to adiabatic heating. Figure 4A is a transect of bottom temperatures (solid line) across the northern slope. It is clear from the slope of the temperature profile that the variability of the temperature range also decreased with increasing depth to approximately 1,300 m. The temperature varies by less than 0.10°C between 1,300 and 2,000 m.

Synphobanchus oregoni. There was a gradual decrease in the bottom temperatures with depth through the 500 to 1,500 m vertical range of *S. oregoni*. The temperature ranged from 7.70°C to 4.24°C over this depth interval (Figure 4A), representing a temperature difference of 3.46°C. The largest number of specimens occurred within the 900 to 1,000 m range with a corresponding temperature range of 5.20°C to 4.75°C or a variation of 0.45°C. *Synphobanchus oregoni* tended to occur most frequently at depths where the temperature begins to vary the least. This is illustrated in Figure 2a, where the frequency of distribution is shown to be skewed toward the deeper depths with the least variable temperature. Table 2 also shows that the probability of capturing *S. oregoni* below 600 to 1,100 m was higher than above that depth interval. The equal number of attempts within each interval indicated

TABLE 5
Sediment Data

Station	Lat. (N)	Long. (W)	Depth (m)	Sand (%)	Silt (%)	Clay (%)	Silt-Clay (%)
68A3-11C	26°18.5'	96°22.0'	91	89.4			10.6
71A8-42	21°21.7'	97°01.5'	179	0.9			99.1
67A5-11B	29°25.0'	86°20.0'	190	26.8			73.2
67A5-13D	29°30.0'	86°52.0'	379	28.1			71.9
71A8-68	19°39.3'	92°40.8'	528	2.7			97.3
71A8-44	21°25.3'	96°55.8'	565	2.0			98.0
70A8-8	29°17.5'	87°09.0'	686	2.7	14.5	82.8	97.3
68A3-12B	26°21.0'	96°08.5'	752	3.0			97.0
71A8-28	23°56.1'	97°01.3'	900	1.3			98.7
67A5-7B	29°08.0'	87°09.5'	918	13.2			86.8
68A3-14B	26°25.0'	96°03.8'	955	2.7			97.3
71A8-61	19°00.0'	95°11.0'	1057	3.4			96.6
68A3-15C	26°28.8'	95°59.0'	1104	1.6			98.4
71A7-60	26°57.4'	92°58.5'	1216	9.3			90.7
70A8-11	28°30.7'	87°20.6'	1335	2.9	16.7	80.4	97.1
71A8-76	20°06.4'	92°19.2'	1337	4.3			95.7
70A8-34	26°43.2'	93°38.2'	1348	6.9	14.5	78.6	93.1
67A5-5	28°27.2'	87°20.0'	1476	8.4			91.6
70A8-12	27°32.1'	85°23.1'	1646	20.2	30.0	49.8	79.8
70A8-9	29°00.8'	87°29.3'	1650	1.5	12.3	86.2	98.5
70A8-33	26°45.2'	94°10.6'	1716	1.7	16.9	81.4	98.3
70A8-32	26°39.0'	94°44.0'	1778	5.0	13.8	81.2	95.0
71A8-7	26°07.0'	92°56.0'	2113	12.9			87.1
70A8-10	28°43.2'	87°45.5'	2158	3.8	13.5	82.7	96.2
68A3-3D	25°09.0'	94°11.0'	3658	2.2			97.8

that the probabilities were not greatly biased by sample size, and since all trawls were fished about 30 minutes, approximately the same amount of bottom was covered for each station.

The maximum and minimum temperatures recorded within the range of distribution of *S. oregoni* in the Gulf of Mexico were 7.70°C and 4.24°C, respectively. As noted above, a minimum temperature of 4.20°C. occurred at approximately 2,000 m and beyond that depth the temperature increased to 4.42°C as a result of pressure. These data show only a 0.04°C change in temperature from 1,500 to 2,000 m, which indicates that either these eels were unable to adapt to the temperature differential for physiological reasons at 2,000 m depth (at which the ambient temperature beings to increase), or that some other limiting factors (such as sediment type or pressure) were involved in restricting *S. oregoni* from inhabiting the lower continental slope or rise.

Synaphobranchus affinis. The temperature ranged from 6.30°C to 4.70°C over the depth interval 600 to 1,000 m from which *S. affinis* was collected (Figure 4A). *Synaphobranchus affinis* was reported most frequently from 800 to 900 m where the temperature ranged from 5.90°C to 5.20°C. Temperature varied by 1.60°C over the 400 m depth span from which *S. affinis* was collected and by 0.70°C over the depth interval from which this species was most frequently reported.

Synaphobranchus brevidorsalis. The temperature range over the depth interval 1,300 to 2,200 m from which *S. brevidorsalis* was reported was 4.30°C to 4.12°C (Figure 4A), a variation of 0.18°C. Although this species of synaphobranchid had a wide vertical distribution, it occurred at depths where temperature varied at most by 0.10°C and was most frequently collected at depths where the temperature varied by less than 0.03°C.

Ilyophis brunneus. The temperature range for *I. brunneus* was 6.50°C to 4.50°C, based on the vertical range established in Figure 2d. *Ilyophis brunneus* was collected most frequently between 900 and 1,100 m, which had a temperature range of 5.20°C to 4.50°C (Figure 4A); and in almost equal numbers from the 700 to 800 m depth interval, which had a temperature range of 6.50°C to 5.90°C.

Salinity

There are few reports relating salinity to distribution of deep-sea fishes in the Gulf of Mexico. Although salinity is considered a rather stable factor in the deep waters of the Gulf, Ichiye and Sudo (1971) have shown that long-term secular variations of a few hundredths of a ppt over 5-year periods do occur within the depth range of the Synaphobranchidae. Another interesting feature of the vertical distribution of salinity is the presence of high-salinity water (over 35.000 ppt) which flows westward along the southern

Figure 4 A–C. Transect of hydrographic data (solid line) from the northern continental slope of the Gulf of Mexico.

continental slope and northward along the western slope (Ichiye and Sudo 1971).

A salinity profile indicates a general trend of decreasing bottom salinity with increasing depth to about 900 m where the salinity begins to increase with depth (Table 4). When bottom salinities from other stations in the Gulf are plotted on the northern slope transect, a slightly variable structure of salinity (horizontally) is evident.

***Synaphobranchus oregoni*.** The salinity between 500 and 1,500 m decreases from 34.99 ppt at 536 m to 34.88 ppt at 957 m where the salinity then begins to increase to approximately 34.90 ppt at 1,500 m (Table 4). The salinity is slightly more variable horizontally at 500 m (approximately

0.14 ppt) than it is at the deeper depths (approximately 0.04 ppt). *Synaphobranchus oregoni* was most frequently collected within 900 to 1,000 m where the salinity range was typically 34.94 to 34.91 ppt and could be expected to vary by about 0.04 ppt horizontally.

***Synaphobranchus affinis*.** The salinity range for *S. affinis* is from 35.00 to 34.88 ppt (Figure 4C) based on the vertical range established in Figure 2b. *Synaphobranchus affinis* was most frequently collected from 800 to 900 m, which had a salinity range of 34.93 to 34.91 ppt with expected horizontal variations of up to 0.02 ppt.

***Synaphobranchus brevidorsalis*.** Salinity within the 1,300 to 2,200 m depth interval increases slightly from 34.96 to 34.98 ppt which indicates a salinity change of less than 0.02 ppt. *Synaphobranchus brevidorsalis* was reported most frequently from 2,100 to 2,200 m where salinities were typically 34.98 ppt and is shown (Table 4) to vary by less than 0.01 ppt from 2,000 to 3,000 m.

***Ilyophis brunneus*.** Within the 700 to 1,200 m depth interval from which *I. brunneus* was reported, the salinity (Table 4) decreases from 34.96 to 34.88 ppt at 957 m and then increases to 34.92 ppt at 1,200 m. *Ilyophis brunneus* was most frequently collected from 900 to 1,100 m and the salinity ranged from 34.92 to 34.91 ppt and varied horizontally by approximately 0.02 ppt (Figure 4C).

Dissolved Oxygen

The distribution of dissolved oxygen differs from that of the conservative properties of sea water (temperature, salinity, etc.), since oxygen concentration is affected by biological and chemical processes. Richards (1957) discussed at length the processes which affect the distribution of dissolved oxygen in the oceans and various concepts on the origin of the oxygen minimum zone.

The oxygen-minimum layer (2.50 ml/l) for the Gulf of Mexico has been described by Nowlin (1971) and occurs at approximately 300 m in the western Gulf, 600 m in the eastern Gulf, and 700 m near the Yucatan Straits. There is a secondary oxygen-minimum layer (3.50 ml/l) which occurs at approximately 250 m in the eastern Gulf and Yucatan Straits.

Bruun (1957) stated that a correlation between concentration of dissolved oxygen and distribution of organisms may be expected, but it is not possible to demonstrate. There does not appear to be any conclusive evidence in the literature that dissolved oxygen concentration in the deep sea is low enough to have a direct effect on the distribution of deep-sea organisms by putting them under physiological stress. Oxygen levels may in some cases be indicators of reduced concentrations of other nutrient elements which have a limiting effect on the occurrence of organisms, such as the concentration of phosphate and nitrate, which is inversely proportional to the oxygen concentration (Richards 1957).

Figure 4B shows a profile of bottom oxygen concentrations for a transect of hydrographic stations from the northern slope of the Gulf of Mexico. The dissolved oxygen concentration increases rather rapidly with increasing depth from 500 to 1,200 m. Below 1,200 m, oxygen continues to increase but more slowly. Other important features of the oxygen profile which should be noted are the occurrence of the oxygen-minimum layer between 200 and 400 m and the variable nature of the oxygen concentration levels below 3,000 m. These two features, however, do not occur within the reported depth range of the Synphobranchidae.

Synphobranchus oregoni. The dissolved oxygen concentration increased from 2.66 to 4.64 ml/l (Figure 4B), a change of 1.98 ml/l within the 500 to 1,500 m depth interval. Most of the *S. oregoni* specimens were collected from 900 to 1,000 m where oxygen levels range from 3.89 to 4.05 ml/l, a 0.16 ml/l range. Based on the oxygen distribution shown in Figure 4C and the oxygen range established for *S. oregoni* with this investigation, it was apparent that the dissolved oxygen concentration was not a major factor influencing the distribution of *S. oregoni* to deeper parts of the slope. Oxygen could, however, be an important factor limiting the distribution of *S. oregoni* into shallower depths. A gradual increase in the depth of the oxygen-minimum layer from west to east coincides with the reported minimum depths of occurrence of *S. oregoni*. Robins (1968) reported an upper limit of 679 m for *S. oregoni* in the Straits of Florida, where the oxygen-minimum layer is around 600 m.

Synphobranchus affinis. The dissolved oxygen concentration increased from 2.79 to 4.32 ml/l (Figure 4B) over the reported vertical range of 600 to 1,100 m for *S. affinis* as shown in Figure 2b. This represented a 1.53 ml/l change in oxygen concentration over the depth of occurrence. *Synphobranchus affinis* was reported most frequently from the 3.38 to 3.89 ml/l oxygen range which indicated a 0.51 ml/l change in oxygen within the 800 to 900 m depth interval. Dissolved oxygen may have a similar limiting influence on the vertical distribution of *S. affinis* as that described for *S. oregoni*.

Synphobranchus brevidorsalis. The dissolved oxygen concentration increased slightly from 4.64 to 4.83 ml/l (Figure 4B) within the reported vertical range (1,300 to 2,200 m) of *S. brevidorsalis*, which represented a 0.20 ml/l range in oxygen concentration.

The oxygen concentration changes by 0.20 ml/l over the 1,300 to 2,200 m depth interval reported for *S. brevidorsalis* and this eel was most frequently collected within the 2,100 to 2,200 m depth interval, where the dissolved oxygen concentration is shown to change very little both vertically and horizontally (Figure 4C). At 1,300 m the slope of the oxygen profile begins to change rather rapidly with decreasing depth. The oxygen concentration decreased by about 35% within approximately 200 m (1,300 to 1,100 m), which represents a substantial change to an

animal whose environment is constantly at a low temperature and a high oxygen content.

Ilyophis brunneus. The dissolved oxygen concentration increased from 3.10 to 4.43 ml/l (Figure 4B) over the 700 to 1,200 m depth interval from which *Ilyophis* was collected and represented a 1.33 ml/l range. *Ilyophis brunneus* was most frequently collected within the 3.89 to 4.28 ml/l oxygen range (900 to 1,100 m) which corresponds to a 0.39 ml/l change in oxygen.

Ilyophis occurs in rather equal numbers throughout its vertical range, therefore, it has a rather wide dissolved oxygen range, comparable to that of *S. oregoni* (1.98 ml/l).

Dissolved oxygen may not influence the movement of *I. brunneus* into deeper parts of the Gulf; however, it may play an important role in affecting the upper limit of vertical distribution of *Ilyophis*. The burrowing habit of *Ilyophis* was reported by Robins (1968), and Richards (1957) found that the oxygen concentration of the water adjacent to the bottom was less than that of the water several meters above the bottom by approximately 0.27 ml/l. The dissolved oxygen of the water next to the bottom at 700 m is probably close to 2.83 ml/l, based on the 3.10 ml/l observed several meters above the bottom. The basic relationship of temperature, metabolic rate, and oxygen requirements could possibly have an important effect on the distribution of *I. brunneus*.

Sediment

Substratum was considered by Thorson (1956) to be the primary factor which influenced the composition of marine level-bottom communities. The animal-sediment relationship was discussed by Sanders (1958); Wigley and McIntyre (1964); Sanders, Hessler, and Hampson (1965); and Day and Percy (1968). Of these studies, only Day and Percy dealt with benthic fishes, the others were concerned with invertebrate communities. For the invertebrates, a definite correlation between sediment type and distribution was observed. Benthic fishes on the other hand showed a correlation between sediment type and species association; however, some of the species groups did not coincide exactly with a particular substratum.

Table 5 shows the sediment composition with depth for a number of gravity and piston cores taken by TAMU. The continental shelf and slope transition zone (at 200 m) is composed primarily of coarse grained sediments. The slope (200 to 2,900 m) sediments in general are composed of clayey silts, although three stations had high percentages of sand (12.9, 13.2, and 20.2%) and indicate the presence of sediments from the Mississippi Cone.

Synphobranchus oregoni. The sediment texture of the slope within the 500 to 1,500 m depth interval of *S. oregoni* ranged from 13.2 to 1.3% sand, 16.7 to 14.5% silt, and 82.8 to 78.6% clay. The combined silt-clay fraction ranged from 98.7 to 86.8% (Table 5). The largest numbers of *S. oregoni* were collected from areas where the sand fraction was

3.4 to 1.3% and the combined silt and clay fraction was 98.7 to 96.6%.

Three stations (70A8-8, -11, and -34) within the 500 to 1,500 m depth interval were analyzed for the percent sand, silt, and clay. Stations 70A8-8 and 70A8-11 occurred in an area where numerous captures of *S. oregoni* were reported, and is considered to represent the typical sediment texture over which this species was most frequently found (Table 5). Station 34 occurred in an area where relatively few specimens of *S. oregoni* were taken, despite numerous attempts, and showed some slight differences in textural composition. These textural differences may seem insignificant. However, Sanders (1958) showed that small changes in particle size influenced the composition of invertebrate communities; therefore, the type of food available to *S. oregoni*.

Synaphobranchus affinis. The substratum over which *S. affinis* was collected ranged from coarse-grained (13.2% sand and 86.8% silt-clay) sediment, such as that found on the northeastern slope at the westernmost and northernmost extensions of the distribution of *S. affinis* (Figure 3), to limestone and coral rock which is found along the eastern slope of the Gulf and northern part of the Straits of Florida. The preference by *S. affinis* for a hard substratum was pointed out by Robins (1968), and appears to be confirmed by the distribution established here for this species. It is apparently restricted to the eastern Gulf. Sediment data presented in Table 5 indicate that within the vertical range of *S. affinis* (Figure 2b) in the western section, sediment textures are primarily soft muds composed of 3.4 to 1.3% sand and 96.6 to 98.7% silt-clay. The absence of *S. affinis* from the western Gulf of Mexico could indicate an avoidance of soft sediment by this species.

Synaphobranchus brevidorsalis. The sediment texture within the 1,300 to 1,400 m depth interval of *S. brevidorsalis* was 6.9 to 2.9% sand, 16.7 to 14.5% silt, 80.4 to 78.6% clay, and 97.1 to 93.1% silt-clay combined (Table 5). Gravity core station 71A876 was taken in the vicinity of trawl station 69A1183 (Table 1) where *S. brevidorsalis* was collected and had a 4.3% sand fraction and a 95.7% silt-clay fraction. Core station 70A810 was taken within the 2,100 to 2,200 m depth interval and was near trawl station 1303 where three specimens of *S. brevidorsalis* were collected by the NMFS R/V OREGON. The sediment composition was 3.8% sand, 13.5% silt, 82.7% clay (96.2% silt-clay fraction combined). The data indicated that *S. brevidorsalis* occurred over soft mud bottoms. Sediment of this composition is predominant on the lower part of the western and northern continental slopes of the Gulf (Lynch 1954). The absence of *S. brevidorsalis* from the northern Straits of Florida was considered to be partly due to the hard substratum found in that section of the Gulf. However, since calcareous muds are predominant in the southern part of the Straits of Florida, other limiting factors must be influencing the distribution of *S. brevidorsalis* in this area.

Ilyophis brunneus. *Ilyophis* was collected over the 700 to 1,200 m depth interval which had a sediment composition of 13.2 to 1.3% sand and 98.7 to 86.8% silt-clay (Table 5). Gravity core stations from this depth interval were not analyzed for the silt and clay fractions. Silt and clay are reported as a combined silty sand or clayey silt substrate, which was in agreement with the conditions reported by Robins (1968) for this species in the Straits of Florida. This preference of *I. brunneus* for a soft substratum is reflected in the eel's external morphology which indicates an adaptation for burrowing (Robins 1968).

BIOLOGICAL PARAMETERS

Food Habits

Little information has been published on the food of the Synaphobranchidae. Robins (1968) reported that synaphobranchid eels fed on fish and crustaceans. Information on food habits is reported here to determine if the synaphobranchid eels exhibit any food specialization. The generally accepted ideas on the availability of food in the deep sea are discussed in light of the data obtained from stomach content analyses of 153 specimens of synaphobranchid eels.

Synaphobranchus oregoni. A total of 135 specimens of *S. oregoni* were examined and 53 (39%) were found to contain fish, squid, and crustaceans. Fish and fish parts represented 31% of the identifiable food items; squid and crustaceans each represented 17%. The remaining 35% of the stomach contents could not definitely be classified as belonging to any of the three groups. However, the majority of the food items that were not identifiable were pieces of muscle fiber which resembled fish flesh. Only two of the fish removed were in good enough condition for reliable identification. One was *Canthidermis sufflamen* of the family Balistidae (a surface fish) and the other was a young eel. Based on the condition of *Canthidermis*, it is highly probable that it was captured at the surface and swallowed in the trawl. It appeared from the size, shape, and texture of the fish particles, particularly the vertebrae and jaws removed from the stomach of *S. oregoni*, that no specific family of fish was predominant as a food item.

The squid and crustacean parts tended to be in much better condition for identification than the fish parts. The squid were identified from several mantles and numerous beaks, and all belonged to the order Teuthoides and the suborder Oegopsida. The identifications of two families, Ommastrephidae and Onychoteuthidae are questionable.

The crustaceans removed represented four orders and six families. Decapods were predominant, with sergestid and penaeid shrimp constituting the most numerous food items of the crustaceans. A large flatbacked lobsterette (*Polycheloides valida*) was removed from one of the large specimens of *S. oregoni*.

Synaphobranchus brevidorsalis. Of the 10 specimens examined, two (20%) contained food items. Fish eyes were

removed from one eel and a large squid (*Ommastrephes bartrami*) was removed from the other.

Ilyophis brunneus. Eight specimens of *I. brunneus* were examined and two (25%) were found to contain food items. Only one had identifiable contents. It contained one adult isopod (*Aega grarcililes*) which had five young isopods in the brood pouch. *Aega* is a common ectoparasite that is free-living while gravid.

Parasites

Synphobranchid eels are parasitized by nematodes, trematodes, cestodes, and copepods (Robins 1968). Of the 153 synphobranchid eels examined for parasites, 131 (86%) were found to be infested. Cestodes occurred most frequently, with nematodes and trematodes appearing moderately. One eel had a parasitic copepod attached to the conjunctive membrane of the eye.

Four new host records for digenetic trematodes and a new species, *Helicometra robinsorum*, were found in the synphobranchid eels from the Gulf of Mexico (Overstreet and Martin 1974).

Chandler (1954) reports that fish are commonly the intermediate hosts for larval cestodes. It appears probable that the adult cestodes infesting synphobranchid eels were ingested while feeding on infested fish. This is based on the number of the adult cestodes removed from the abdominal cavity.

The digenetic trematodes are reported to be host specific and usually occur in hosts which are within the same phyla. The intermediate hosts of Digenenea are generally considered to be a mollusk (Manter 1954). Overstreet and Martin (1974) reported *S. oregoni* to be moderately infested with trematodes and stomach content analysis indicated that fish and squid were common food items for *S. oregoni*. It is apparent that both fish and squid are probably important intermediate hosts for the trematodes that infest the synphobranchid eels.

CONCLUSIONS

The synphobranchid eels of the Gulf of Mexico are considered an important part of the upper continental slope ichthyofauna, with four species (*Synphobranchus oregoni*, *S. affinis*, *S. kaupi*, and *Ilyophis brunneus*) occurring within the 500 to 1,500 m depth interval and only one species (*S. brevidorsalis*) occurring below 2,000 m.

Synphobranchus oregoni and *Ilyophis brunneus* were the most frequently captured synphobranchid eels and occurred rather uniformly throughout the various geographic sections of the Gulf. *Synphobranchus brevidorsalis* was less frequently collected and occurred only in the northern and western sections. *S. affinis* occurred only in the eastern section. Extensive trawling from the other sections of the Gulf seems to substantiate the distributional pattern shown in Figure 3. The absence of *Histiobranchus* and *Diastobranchus* from the Gulf was reported and is considered

valid since 29 trawl stations were taken below 1,800 m, within the reported depth range of both genera.

Vinogradova (1959) considered macro-relief as an important factor affecting the distribution of deep-sea benthic fauna. A thorough investigation of the geomorphology of the continental slopes of the Gulf of Mexico indicates that there are no major topographic features along the slopes with sufficient relief to affect the horizontal distribution of the synphobranchid eels (Bergantino 1971 and Wilhelm and Ewing 1972).

Synphobranchid eels of the Gulf of Mexico occurred over a rather narrow range of temperature (7.70 to 4.20°C) compared to that reported by Bruun (1937) for the Synphobranchidae of the North Atlantic (12.0 to 0.0°C). The largest number of synphobranchid eels occurred within the 700 to 1,000 m depth interval which had a temperature range of 6.50 to 4.75°C and represented only a 1.75°C change in temperature over 300 m.

A most interesting feature of the temperature regime is the 4.20°C minimum that occurs at approximately 2,000 m. When trying to assess the importance of the effect of temperature on the vertical distribution of the Synphobranchidae, one has to speculate on the ability of the synphobranchid eels to cross this few hundredths of a degree temperature gradient to a depth where the temperature begins to increase to a maximum of 4.42°C at approximately 3,700 m.

From the data, one would expect *S. oregoni* to have little difficulty in adapting to a 0.04°C change in temperature. It is therefore suggested that change in pressure is more effective in restricting the downward distribution of *S. oregoni* to the lower slope than temperature. *Synphobranchus oregoni* would have to adapt to a 667 psi change in pressure to move from 1,500 m to 2,000 m which may be more significant than a 0.04°C change in temperature. *Synphobranchus affinis*, on the other hand, would have to adjust to a 0.50°C change in temperature and a 1,335 psi change in pressure; therefore, it is felt that the combination of temperature and pressure are limiting factors which restrict *S. affinis* from moving to the lower continental slope. Since *I. brunneus* occupies a position on the slope similar to that of *S. affinis*, temperature and pressure are considered to have comparable limiting effects on both species.

Salinity within the depth range of the Synphobranchidae decreases from 34.99 ppt at 500 m to 34.88 ppt at approximately 900 m, then increases to 34.95 ppt at 1,500 m. It was slightly more variable horizontally at 500 m than at the deeper depths.

The salinity data from the Gulf tend to support the contention of Bruun (1957) that the small variations in salinity do not appear to have any significant effect on the distribution of Synphobranchidae either horizontally or vertically. This was determined by comparing the number of synphobranchid eels collected at approximately the same

depth with the corresponding salinities from nearby hydrographic stations (Table 4).

The dissolved oxygen concentration was shown to increase with depth throughout the depth range of the Synphobranchidae. The occurrence of the oxygen minimum layer in the eastern and western Gulf was noted and considered to be correlated with the distribution of synphobranchid eels at the shallower limits of their depth range. This may be due to the basic relationship of increasing temperature with decreasing depth which causes an increase in metabolic rate, resulting in an increased oxygen requirement at depths where oxygen approaches minimum values. The dissolved oxygen concentration was not considered to be a limiting factor on the distribution of synphobranchid eels into the deeper depths of the Gulf of Mexico.

Although synphobranchid eels were associated with substrata from clayey silts to hard substratums such as limestone and coral rock, certain species were shown to occur over areas of a particular sediment texture. For instance, *Synphobranchus oregoni*, *S. brevidorsalis*, and *Ilyophis brunneus* were collected over sediments which ranged from 13.2 to 1.3% sand, 16.7 to 14.5% silt, and 82.8 to 78.6% clay. *Synphobranchus affinis* occurred over sediment textures which ranged from coarse-grained sand to limestone.

Synphobranchid eels have been described as opportunistic feeders or "croppers" (Dayton and Hessler 1972). Based on the size and condition of food items removed from their stomachs, it is assumed that the Synphobranchidae forage on both live and dead organisms which consist primarily of fish, squid, and crustaceans. It was impossible to identify the fish to family but, based on the size and shape of the numerous fish parts removed, it was evident that several fish families were represented. Seven crustacean families were represented. The squid ingested were confined to the suborder Oegopsida, where two families, Ommastrephidae and Onychoteuthidae, were tentatively identified. If one considers food niche specialization to exist only where a narrow range of food items are in-

gested, the Synphobranchidae do not exhibit food niche specialization. However, niche specialization probably occurs with the manner in which the synphobranchid eels search out and ingest their food.

The availability of food in the deep sea has been reported to be an important limiting resource (Bruun 1957 and Dayton and Hessler 1972). It seems significant that of the 153 synphobranchid eels examined for stomach contents, 57 (38%) contained food items. Considering the general knowledge that deep-sea fish usually regurgitate stomach content when brought to the surface, this value probably represents a minimum estimate of the percentage of eels which had fed shortly before capture. On an individual station basis, 24 to 33% of the eels examined contained food.

Synphobranchid eels were heavily infested with cestodes. Nematodes and trematodes occurred moderately. There was one parasitic copepod attached to the conjunctive membrane of the eye of *S. oregoni*.

There were no apparent harmful morphological effects on the synphobranchid eels infested with parasites. Hopkins (1957) reported that infested hosts usually compensate for loss of nourishment due to parasites by ingesting more food, and that under conditions of food scarcity the infested host might show harmful effects. This tends to indicate that food may not be quite as scarce in the deep sea as has been reported.

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