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TEXT, PHOTOGRAPHIC ATLAS AND APPENDICES

THE ECOLOGICAL COMMUNITIES OF THE CONTINENTAL SLOPE AND ADJACENT REGIMES OF THE NORTHERN GULF OF MEXICO

BY

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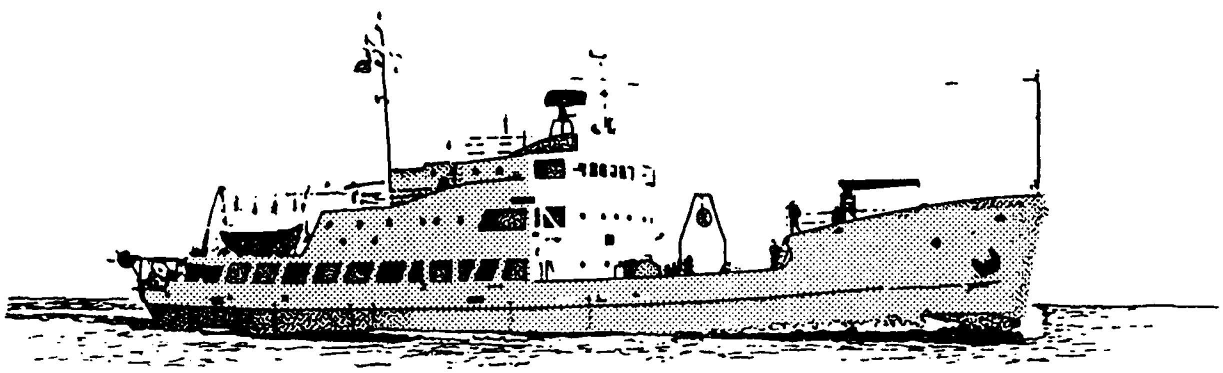

R/V ALAMINOS 1963-1974

UNITED STATES
DEPARTMENT OF THE INTERIOR
MINERALS MANAGEMENT SERVICES

TERECO CORPORATION
P.O. BOX 2848
College Station, Texas 7784

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ABSTRACT

This report deals in part with the macrofaunal assemblages that exist in that part of the offshelf Gulf of Mexico that lies north of the 25th parallel and west of the eastern wall of DeSoto Canyon. The study was based on 264 oceanographic stations occupied by R/V ALAMINOS in depths ranging from 150 to 3850 m.

Statistical analyses support subdividing the principal megabenthic components (echinoderms, crustaceans, and demersal fishes) of the assemblages into five well-defined faunal zones, four of which (Shelf-Slope Transition, Archibenthal, Upper Abyssal, and Mesoabyssal) are on the continental slope, and the fifth, the Lower Abyssal, occupies the continental rise and abyssal plain.

The faunal assemblages comprising the zones are described in considerable detail and the numerically dominant species among important systematic groups are designated within each zone and its subdivisions. The geological, physicochemical, and biological bases for existence of zones and zonal subsets are discussed in detail, including an attempt to account for faunal differences between the eastern and western parts of the Gulf.

Taking the area of the study as the deep Gulf ecosystem, the report also deals with the energy relationships among the biotic components of the system. Tentative explanations of the sources of energy that can balance the energy budget on the abyssal plain are advanced and discussed.

The report contains three substantial appendices. Appendix A is an atlas of bottom photographs selected to depict some of the biological constituents, physiography and surficial sediments of the five faunal zones. Appendix B contains a list of the species taken at the oceanographic stations and relates them to the related Lease Block. Appendix C presents an annotated bibliography of publications dealing with the oceanography of the Gulf of Mexico.

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PART I. INTRODUCTION

1. THE NATURE OF THE STUDY

HISTORICAL BACKGROUND

All of the fieldwork upon which the present study is based was carried out while most of the authors were members of the teaching or research staff or were graduate students in the Department of Oceanography of Texas A&M University. Although that department was created in 1950, it was not until 1963 that it possessed a vessel capable of conducting deep-sea benthic studies. That vessel, the R/V ALAMINOS, changed the direction of the department and in the area of biological oceanography permitted dredging and trawling the deepest parts of the Gulf of Mexico for the first time. Contrary to other beliefs, Alexander Agassiz made only five deep dredgings in the Gulf (the deepest being about 3500 m, some 350 m shallower than the Sigsbee Abyssal Plain) while aboard the U.S. Coast and Geodetic Survey Steamer BLAKE in the 1870s. To our knowledge, neither the R/V OREGON I or II ever sampled the deepest parts of the Gulf. Accordingly, some difficulties were encountered when efforts were made to identify deep-living species taken by the ALAMINOS. Fortunately, the Gulf fauna has proven to be rather closely related to that collected off parts of western Europe, e.g., the Bay of Biscay or the Azores or parts of northwest Africa. Some of these samples had been studied sufficiently and, being housed in the University of Paris or the Museum of Comparative Zoology or the U.S. National Museum of Natural History, were of immediate assistance to our taxonomical efforts. Nevertheless, many new species among diverse groups of benthic animals were collected. Some of them have already been described (see Pequegnat and Pequegnat, 1970 and 1971 for Galatheidea; Pequegnat, 1970 for Caridea; Downey, 1970, 1971, 1972, and 1973 for Asteroidea; etc.) but many more, especially among Bivalvia, Polychaeta, Porifera, etc., await publication. However, without the availability of a suitable ship, the work would not have been possible.

R/V ALAMINOS

The R/V ALAMINOS was a conversion of the former U.S. Army Transportation Corps Freighter FS 227 which was constructed in 1945. Texas A&M acquired the vessel through Surplus Property and a grant from the National Science Foundation provided the bulk of the conversion costs. Conversion was undertaken by Higgins, Inc., of New Orleans (the original builders of the vessel) and began on 24 January 1963. After conversion the vessel was 179'10" long, had a beam of 32 feet, and a loaded draft of 9'3" for a displacement of 840 tons (Figure 1).

Design of the conversion was by R.E. Schuller (Naval Architect) in association with the scientific and ship operation staff at Texas A&M. The ship's complement of 31 was composed of 17 officers and crew and 14 scientists and technicians. As stated by Schuller and McLellan (1964), "Probably one of the most important design requirements was that of habitability." This is extremely important on research vessels which carry scientific personnel who are not accustomed to extended trips at sea. These persons, while highly skilled at their trade, are not necessarily seamen and function much better in accommodations different from those normally provided for a seafaring man. Those who sailed on the ALAMINOS certainly remember her as a comfortable ship. The feeling of comfort was manifested not only by living space but also by the laboratory,

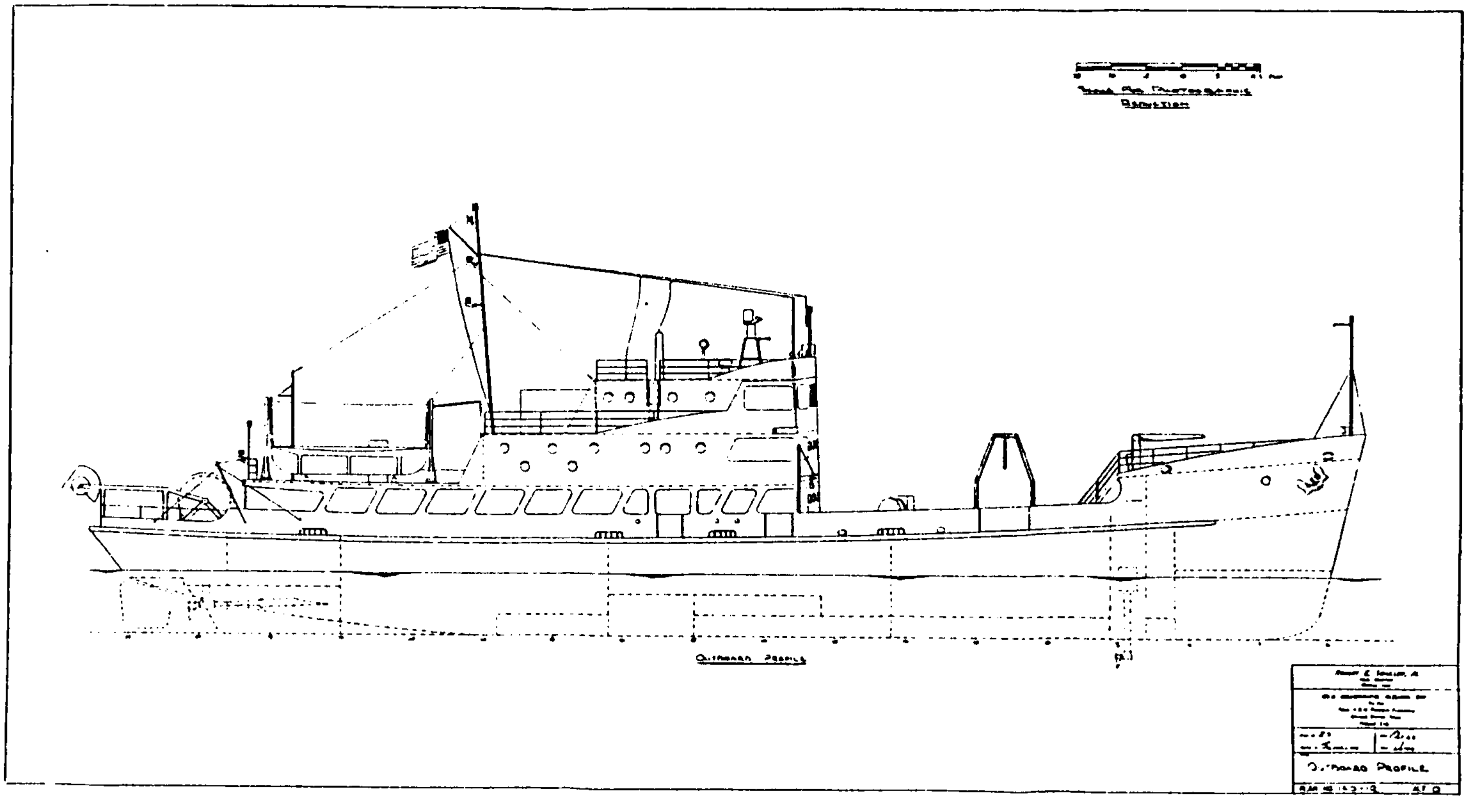

Figure 1. R/V ALAMINOS. Outboard profile of initial conversion (from Schuller and McLellan, 1964).

storage, and deck space alloted for scientific usage, viz., enclosed laboratory and work space - 2696 square feet, deck space for scientific work - 2150 square feet, and scientific living space - 579 square feet.

From the biologist's point of view, the ship's winches were the heart of its specialized equipment. The dredging and coring winch contained 9140 m of 1.1 cm wire rope and the two hydrographic winches contained 9140 m of 0.4 cm wire rope. The starboard hydrographic winch was later dedicated for use with a STD.

For ten years, the ALAMINOS was the primary oceanographic ship for Texas A&M. She was dedicated on 3 December 1963 and made her last oceanographic cruise in December 1973.

FUNDING AGENCIES

In order to have a deep-sea biological program, in contradistinction to obtaining a few samples, three ingredients are necessary and without any one then the program will not be successful: (1) personnel with deep-sea interest, (2) a vessel equipped for deep-sea investigation, and (3) long-term commitment of funds to support personnel, ship, and equipment. All three of the above culminated at Texas A&M in the mid-1960s and continued through about 1970. Prior to this time, lack of one or more of the requirements prevented all but a handful of deep Gulf biological samples.

The first requirement was filled by W.E. Pequegnat who spearheaded the deep Gulf biological program. He came to Texas A&M in the spring of 1963 and remained until his retirement in 1980. It was under his supervision and by his tutelage that the samples were collected and later investigated. The second element was fulfilled by the R/V ALAMINOS. The ALAMINOS, which was outfitted for deep-sea exploration began operation at Texas A&M in late 1963 and continued through late 1973. Funding of the program was the final ingredient in the tripartite formula. From the early 1960s to about 1970, the Office of Naval Research (ONR) was the major funding agency for oceanographic research. It was major in the sense of the way it supported oceanographic institutions. Most oceanographic cruises were truly joint ventures, involving in one way or another funds provided by A&M, ONR, NSF, AEC, and other sources. But of all the agencies ONR support provided the broadest coverage (Pequegnat, 1966). This broad coverage provided the long-term commitment of funds necessary to support a program. Both administration and scientists were appreciative of this fact. This type of funding promotes creativity which is necessary to maintain the interest and enthusium of the scientist. However, in about 1970 ONR began tightening the budget strings and the first cuts were on items that were not mission oriented. This in effect eliminated most of the funds for biological investigations of the deep Gulf. For a few years other agencies such as NSF and A&M through the State of Texas, provided stop-gap funding.

The next major funding source for biological oceanographic endeavors was the Bureau of Land Management. The funding was not earmarked for oceanographic institutions per se but instead was open for competitive bidding. Their very strict mission oriented studies involved almost wholly investigations of the continental shelf. With the exploration for minerals proceeding to deeper and deeper depths, the Minerals Management Service is obliged to delineate these areas. As has been often said, the pure science of today becomes the applied science of tomorrow.

DEFINITION OF DEEP GULF OF MEXICO

Ekman (1953) originally equated the division between shallow and deep-water systems to the division between the photic and aphotic zones. The term "bathyal" has often been used in reference to the uppermost zone of the deep ocean, and has usually been set to begin at 200-250 m depth. Hedgpeth (1957) considered that the bathyal encompassed the slope and rise together, but there is no general agreement as to the lower limit of the rise. Other deep sea investigators recognized that a "transition zone" (Zenkevitch, 1959) or an "archibenthal zone of transition" (Menzies et al., 1973) would more appropriately describe the boundary between the shallow and deep sea. The depth limits of this transition zone undoubtedly differ from ocean to ocean, due to differences in shelf morphology, sediments, temperatures, and food supply, among many other environmental variables.

The deep Gulf of Mexico is defined for purposes of this report, as beginning somewhere within the 150-450 m Shelf/Slope Transition Zone. For completeness we consider everything deeper than 150 m (approximately the depth of the shelf break) as the deep Gulf of Mexico. In the opinion of some investigators it is debatable whether or not the Gulf has an abyssal zone. A depth of 4000 m is often stated to be its upper limit, and it is noted that the deepest part of the Gulf that we have found is about 3850 m. Anton Bruun (1957) and others have stated that the abyssal zone is delineated from the bathyal region by the thermometric isotherm of 4°C. The lowest temperature that we and others have found in the deep Gulf is 4.23°C. But it would seem that these parameters are not necessarily the criteria that biologists should use in making ecological decisions. If indeed the Gulf's abyssal plain is not a true abyss it must be said that it shares many important qualities of one. Note for example that Bruun considered the holothurians as the dominant group of abyssal animals, citing such genera as *Psychropotes*, *Deima*, *Benthodytes*, and *Euphronides* as being typical. This is true of the Gulf's abyssal plain. The same close relationship can be demonstrated among asteroids, ophiuroids, and some penaeid and caridean crustaceans where even the species are the same as noted by Bruun. Moreover, as is true of other abyssal areas, there are in the Gulf sharp drops in species richness and biomass from the middle slope region to the plain. Thus, the small differences in temperatures noted above seem to form too arbitrary a criterion in face of the parallels in communities or faunal assemblages. Finally, we should note that Bruun felt that the true abyssal species do not have pelagic larvae, i.e., they "live in the abyssal zone for their entire life from egg to death." The eggs of some holothurians and echinoids found in the deep Gulf have so much yolk that it is quite evident that they have direct development.

SCOPE OF THE STUDY

GEOGRAPHIC AND BATHYMETRIC LIMITS

The geographic scope of the present study is limited to that part of the Gulf of Mexico northward from 25° north latitude (plus or minus a few minutes of latitude allowing for errors of navigation) to approximately the 150-meter isobath or the shelf break, the latter of which may be as shallow as 118 m off the Texas coast. On the east/west axis the study area extends from the east wall of DeSoto Canyon and easternmost extension of the Mississippi Fan to and across the Sigsbee Abyssal Plain and thence up the slope to a position at the shelf break south off Brownsville, Texas. Bathymetrically the study has emphasized collections made in water over 1000 m depth down to the deepest section of the western Gulf at about 3840 m. Nevertheless, in order to enhance the report's value, we have integrated this latest work with the earlier TerEco report (Pequegnat et al., 1976) to the Bureau of Land Management, which dealt primarily with the faunal assemblages found from the Outer Continental Shelf down to the 1000-m isobath east and west along the Continental Slope.

Within the area circumscribed above a total of 193 stations were mounted by the R/V ALAMINOS, as shown on the map in Figure 2. A more detailed series of descriptions of these stations including position and sampling gear used is found in Table 1.

ECOLOGIC LIMITS

By far the largest numbers of species collected during the study are best referred to as macroepibenthic, a category which is comprised of the majority of the echinoderms, crustaceans, polychaetes, mollusks, and demersal fishes that were collected aboard the ALAMINOS by means of trawls and dredges. Additionally, some macroinfaunal species were collected by means of grabs. These collections contain most of the predatory species making up the top trophic levels in the benthic ecosystems of the Gulf.

SYSTEMATIC LIMITS

Because the field aspect of this project was a pioneering effort, particularly in water deeper than 1000 m, it has not been possible to obtain identifications to the species level in all groups collected. This is particularly true of the macroinfaunal species among isopods, amphipods, and polychaetes. In some instances, the only systematics dealing effectively with particular groups were residents of foreign countries who were not constrained to work upon our samples with alacrity. In one case a cargo carrier lost a series of lots of bivalve mollusks consigned to Millport, Scotland. Old age and/or death of the only known specialists (e.g., ascidians) has forced us to withdraw consideration of certain taxa in the study. Although these matters have been frustrating and caused some delays, it is felt that they have not appreciably diminished the important thrust of the report.

OBJECTIVES AND RELATED TASKS

A comprehensive project of this type can certainly have many objectives but the number can be reduced to a manageable number if a reasonable distinction is made between objectives and tasks undertaken to accomplish the objectives. The principal objectives are the following four:

1. To describe and discuss the ecological nature and distribution of the macroepibenthic assemblages that occur in the northern Gulf of Mexico from DeSoto Canyon on the east to Brownsville, Texas on the west and from the shelf break southward across the Mississippi Fan and the Sigsbee Abyssal Plain to a line running along the 25th parallel of north latitude.

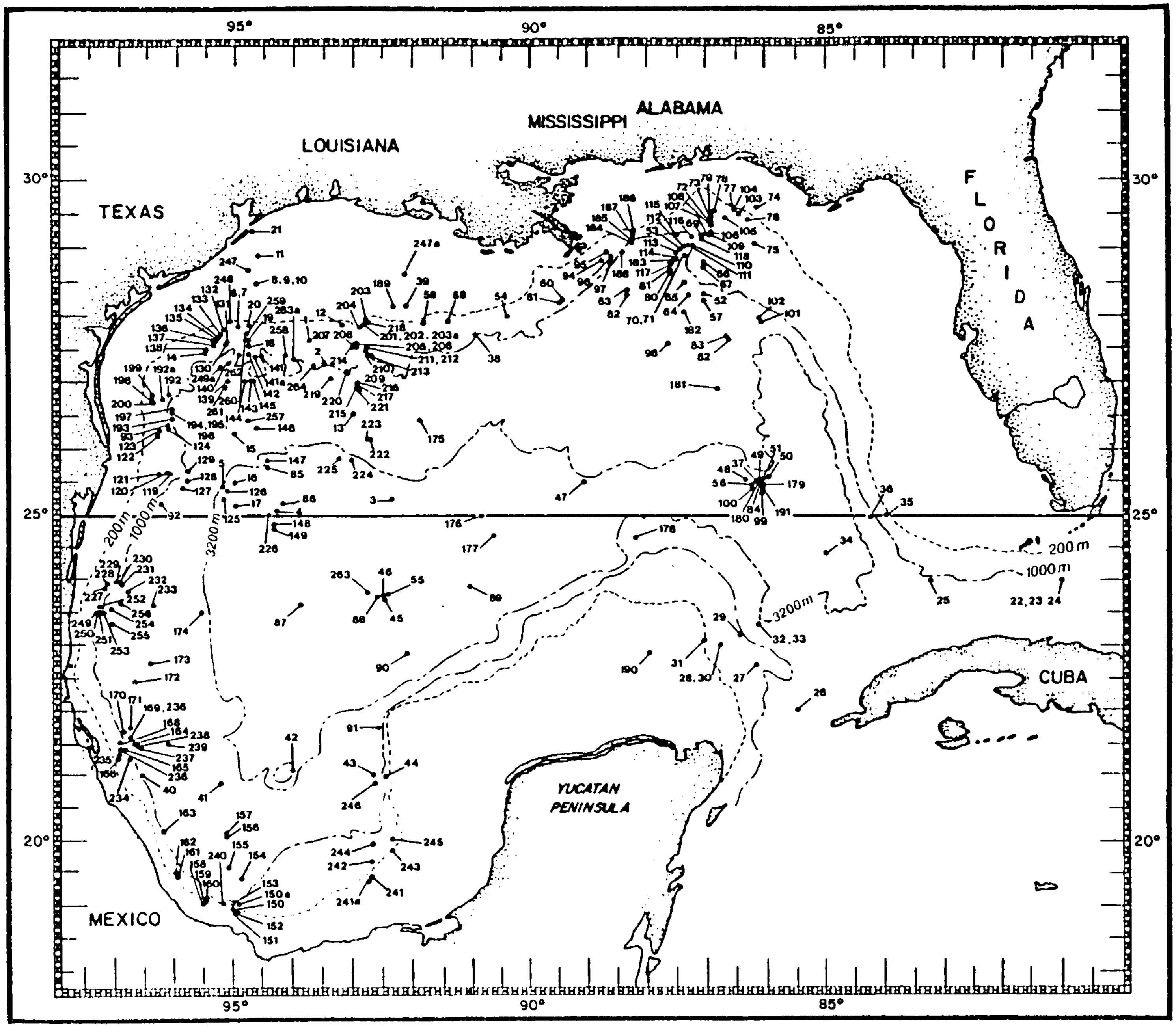

Figure 2. Locations of Gulf of Mexico benthic stations sampled by the R/V ALAMINOS between 1964 and 1973. The stations north of 25°N latitude (black horizontal line) are the stations considered in this report. See Table 1 for exact depths and positions.

Table 1. Station list for benthic stations included in the study showing the map reference number, station number, depth, position, and type of sampling gear

MAP REF. NO.	STATION	DEPTH (m)	POSITION N. LAT.	POSITION W. LONG.	SAMPLING GEAR
1.	64A10-2	379	27°40'	93°43'	Menzies Dredge
2.	64A10-3	789	27°18'	93°30'	Menzies Dredge
2a.	64A10-5	2244	25°56'	92°35'	Menzies Dredge
3.	64A10-6	3475	25°13.5'	92°23'	Menzies Dredge
3a.	64A10-6C	3356	25°13.5'	92°23'	Grab
4.	64A10-7	3801	25°04'	94°16'	Grab
4a.	64A10-7	3762	25°04'	94°16'	Menzies Dredge
5.	64A10-9	2811	25°25'	95°14'	Grab, M. Dredge
5a.	64A10-10	1756	25°27'	95°24'	Grab
5b.	64A10-10	1401	25°30'	95°30'	Dredge
6a.	64A10-11	1392	27°29'	95°31'	Grab
6b.	64A10-12	885	27°30.5'	94°57'	Grab
6c.	64A10-12	732	27°30'	94°55'	Menzies Dredge
6.	64A10-13	183	27°52.5'	94°56'	Grab
7.	64A10-13C	121- 181	27°52.5'	94°56'	Menzies Dredge
12.	64A13-1	126- 210	27°54'	93°11'	Grab, Dredge
13.	64A13-2C	549	26°34.5'	93°00'	Dredge
14.	65A3-1	827	27°30'	95°30'	Grab
15.	65A3-2	2321	26°15'	95°00'	Plow Dredge
16.	65A3-3	3717	25°30'	95°00'	Plow Dredge
17.	65A3-4	3563	25°08'	94°58'	Plow Dredge
18.	65A3-5	511- 417	27°36'	94°44'	Plow Dredge
19.	65A3-6	276	27°40'	94°45'	Grab, P. Dredge
22a.	65A9-1	190	25°12.5'	80°03'	Grab
37.	65A9-23	3206	25°31'	86°13'	Plow Dredge
38.	65A9-25	797	27°43'	90°56'	Plow Dredge
39.	65A9-26	81	28°08'	92°07'	Grab
47.	66A5-2	3341	25°30'	89°02'	Plow Dredge
48.	66A5-3	3265	25°30'	86°19.5'	Plow Dredge #1
49.	66A5-3	3109+	25°31'	86°10'	Plow Dredge #2
50.	66A5-3	3212	25°33'	85°58'	Plow Dredge #3
51.	66A5-3	3214	25°31'	86°07'	Plow Dredge #4
52.	66A5-4	1097-1189	28°20'	87°03'	Quant. Dredge
53.	66A5-5	1682	29°00'	87°29'	Quant. Dredge
54a.	66A5-6	752- 834	27°54'	90°22'	Quant. Dredge
54.	66A5-7	350	28°00'	90°25'	Quant. Dredge
56a.	66A9-13	3197	25°21'	85°59'	Grab
56.	66A9-14	3206	25°26.5'	86°15.5'	Quant. Dredge
57.	66A9-15	1200- 800	28°13.5'	87°04'	MWT on bottom
58a.	66A9-17	589	27°55'	90°20'	Grab
58.	66A16-1	329	27°47'	91°25'	Quant. Dredge
59.	66A16-2	156	27°56'	91°50.5'	Quant. Dredge
60.	67A5-1A	1020	28°13'	89°27'	Skimmer

MAP REF. NO.	STATION	DEPTH (m)	POSITION N. LAT.	W. LONG.	SAMPLING GEAR
61.	67A5-1B	1020	28°12'	89°28.5'	Quant. Dredge
62a.	67A5-2B	1869	28°21'	88°23'	Quant. Dredge
62.	67A5-2F	1869	28°20.5'	88°20.8'	Quant. Dredge
63.	67A5-2H	1829	28°23'	88°22.5'	Skimmer
64.	67A5-4G	2651	28°18'	87°21'	Skimmer
64a.	67A5-4H	2633	28°10.5'	87°21.6'	Quant. Dredge
65.	67A5-5D	1383-1524	28°32'	87°23'	Skimmer
66.	67A5-6B	788	28°48'	87°03'	Skimmer
67.	67A5-6E	788	28°46.5'	87°02'	Quant. Dredge
68.	67A5-7C	918- 788	29°10'	87°06'	Skimmer
69.	67A5-7E	752	29°13.4'	87°00'	Quant. Dredge
70.	67A5-8B	1494	28°55'	87°24'	Skimmer, Q. Dredge
72.	67A5-9A	752	29°27'	86°57'	Skimmer
73.	67A5-9E	640	29°29.5'	86°57'	Quant. Dredge
74	67A5-10A	86	29°35.2'	86°12'	Quant. Dredge
75.	67A5-10B	95	29°05'	86°14'	Skimmer
76.	67A5-11C	190	29°25'	86°21'	Quant. Dredge
77.	67A5-12A	190	29°36'	86°35.5'	Quant. Dredge
78.	67A5-13B	379	29°30.3'	86°52.4'	Quant. Dredge
79.	67A5-13E	379	29°29.9'	86°53.7'	Skimmer
80.	67A5-14A	2340-2527	28°39.9'	87°38.7'	Quant. Dredge
81.	67A5-14E	2367	28°41.5'	87°37.8'	Skimmer
82.	67A5-15F	3092	27°38.4'	86°38'	Skimmer
83.	67A5-15G	3080	27°41.4'	86°39.6'	Quant. Dredge
84.	67A5-16E	3255	25°24.3'	86°06'	Skimmer
85.	68A3-2A	3148	25°47'	94°26'	Skimmer
86.	68A3-3B	3658	25°09'	94°11'	Skimmer
92.	68A3-10B	969-1006	25°09'	96°16'	Skimmer
93.	68A3-12C	732	26°22'	96°08'	Quant. Dredge
94.	68A7-1A	864- 528	28°51'	88°47.5'	Skimmer
95.	68A7-2A	408	28°56'	88°42'	Skimmer
96.	68A7-2B	567- 622	28°53'	88°38'	Skimmer
97.	68A7-2C	677- 715	28°51.5'	88°37'	Skimmer
98.	68A7-3C	2743	27°36'	87°41.5'	Skimmer
99.	68A7-4A	3237	25°20'	86°07'	Skimmer
100.	68A7-4E	3255	25°24.8'	86°16.5'	Skimmer
101.	68A7-7A	2809	27°55'	86°07'	Skimmer
102.	68A7-7B	1097	28°00'	86°08.5'	Skimmer
103.	68A7-8A	190	29°31.7'	86°29.6'	Skimmer
104.	68A7-8C	199	29°33'	86°33.5'	Skimmer
105.	68A7-9A	384	29°27.6'	86°45.5'	Skimmer
106.	68A7-10A	566	29°15.5'	86°55'	Skimmer
107.	68A7-11A	788	29°14'	87°00'	Skimmer
108.	68A7-12A	585	29°18.4'	86°56.4'	Dredge
109.	68A7-12B	900	29°14'	86°59.7'	Skimmer
110.	68A7-13A	1061	29°03'	87°15'	Skimmer

MAP REF. NO.	STATION	DEPTH (m)	POSITION N. LAT.	W. LONG.	SAMPLING GEAR
111.	68A7-13B	1372-1426	28°59.5'	87°21.3'	Skimmer
112.	68A7-13D	1463	28°59'	87°23.3'	Skimmer
113.	68A7-14B	1829	28°56'	87°32.7'	Skimmer
114.	68A7-14C	2103	28°51'	87°31.5'	Skimmer
115.	68A7-15D	1097	29°10.3'	87°31.5'	Skimmer
116.	68A7-15H	914	29°10.5'	87°16'	Skimmer
117.	68A7-16C	2140	28°46.8'	87°36.4'	Skimmer
118.	68A7-17B	900	29°09.5'	87°02'	Skimmer
119.	68A13-1	878	25°38'	96°07.3'	Skimmer
120.	68A13-3	713	25°39'	96°11'	2m Dredge
121.	68A13-4	512	25°38.4'	96°18.3'	Skimmer
122.	68A13-5	274	26°12.5'	96°19.8'	Skimmer
123.	68A13-7	274	26°17'	96°18'	Skimmer
124.	68A13-8	732	26°18'	96°08'	Skimmer
125.	68A13-9	3365	25°14'	95°13'	Skimmer
126.	68A13-10	3385-3493	25°21'	95°08'	2m Dredge
127.	68A13-11	1061-1372	25°23'	95°57'	Skimmer
128.	68A13-12A	1061-1317	25°31'	95°51'	Skimmer
129.	68A13-14	969	25°39.5'	95°49.5'	2m Dredge
130.	68A13-15	658- 860	27°34.5'	95°10.5'	Skimmer
131.	68A13-16	713	27°37'	95°08'	2m Dredge
132.	68A13-17	183	27°50'	95°12.5'	Skimmer
133.	68A13-18	439	27°45'	95°16.2'	2m Dredge
134.	68A13-19	338- 384	27°44.9'	95°20.1'	Skimmer
135.	68A13-21	512- 640	27°38'	95°21.5'	Skimmer
136.	68A13-22	476	27°38'	95°22.5'	2m Dredge
137.	68A13-23	732	27°35'	95°23'	Skimmer
138.	68A13-24	878	27°29.5'	95°31'	Skimmer
139.	68A13-26	1372-1435	27°00.3'	95°08'	Skimmer
140.	68A13-27	1097-1170	27°17.5'	95°08.5'	Skimmer
141.	69A11-2	942	27°24.3'	94°32'	Skimmer
142.	69A11-4	1006	27°24.9'	94°44.5'	Skimmer
143.	69A11-7	1399	27°01.3'	94°43.5'	Skimmer
144.	69A11-12	1463	27°00.6'	94°50.3'	2m Dredge
145.	69A11-13	1463	27°01.6'	94°42'	Skimmer
146.	69A11-14	2432	26°18.5'	94°37.4'	Skimmer
147.	69A11-17	3292	25°50.5'	94°27'	Skimmer
175.	69A13-4	1984	26°25'	91°55'	Skimmer
176.	69A13-6	3477	25°00'	90°51'	Skimmer
179.	69A13-28	3239	25°27'	86°04'	Skimmer
180.	69A13-29	3230	25°30'	86°09'	Skimmer
181.	69A13-37	3001	26°55'	86°48'	Skimmer
182.	69A13-38	2736	28°04'	87°26'	Skimmer
183.	69A13-39	2105	28°51'	87°36'	Skimmer
184.	69A13-40	476	29°07'	88°18'	Skimmer
185.	69A13-41	311	29°11.5'	88°12.6'	Skimmer
186.	69A13-42	183	29°14'	88°15'	Otter Trawl

MAP REF. NO.	STATION	DEPTH (m)	POSITION N. LAT.	W. LONG.	SAMPLING GEAR
187.	69A13-43	210	29°13.5'	88°16.5'	Skimmer
188.	69A13-44	752	28°58'	88°28'	Otter Trawl
189.	69A13-45	82	28°08'	92°20'	Skimmer
191.	70A10-58	3248	25°21.3'	86°06.5'	20m Trawl
192a.	71A7-2	567	26°41.1'	96°13.9'	Quant. Dredge
192.	71A7-4	576	26°47.8'	96°12.5'	Skimmer
193.	71A7-7	878- 869	26°26.7'	96°06'	Skimmer
194.	71A7-9	906	26°32'	96°07'	20m Trawl
195.	71A7-10	937	26°32.9'	96°06.4'	20m Trawl
196.	71A7-11	636	26°32.3'	96°13.3'	20m Trawl
197.	71A7-16	939	26°34.7'	96°05'	Quant. Dredge
198.	71A7-17	204	26°43.1'	96°26.9'	Quant. Dredge
199.	71A7-18	229	26°46'	96°26'	20m Trawl
200.	71A7-20	229	26°42.2'	96°25.3'	Skimmer
201.	71A7-23	210	27°54.7'	92°50.5'	Skimmer
202.	71A7-24	190	27°54.5'	92°50.7'	Quant. Dredge
203.	71A7-32	192	27°55.7'	92°48.5'	Skimmer
204.	71A7-34	192	27°52'	92°55'	20m Trawl
205.	71A7-35	502- 567	27°35.7'	92°59'	Skimmer
206.	71A7-38	511- 556	27°35.6'	92°58.6'	20m Trawl
207.	71A7-40	546	27°35.2'	92°58'	Quant. Dredge
208.	71A7-41	732	27°34.8'	92°59.5'	Skimmer
209.	71A7-42	936	27°30.4'	92°49.3'	Skimmer
210.	71A7-43	887-1097	27°27.8'	92°46'	20m Trawl
211.	71A7-47	878	27°32.3'	92°47.8'	Skimmer
212.	71A7-48	890	27°32.6'	92°48.5'	Quant. Dredge
213.	71A7-49	937	27°26'	92°42'	20m Trawl
214.	71A7-56	538	27°35.8'	93°01'	20m Trawl
215.	71A7-57	1216-1234	26°55.8'	92°57.9'	20m Trawl
216.	71A7-58	1198	26°59.1'	92°58.5'	Quant. Dredge
217.	71A7-62	1198	27°00'	93°01.5'	Skimmer
218.	71A7-65	237	27°57'	92°44.9'	Skimmer
219.	71A8-3	1196	27°03'	93°23'	Skimmer
220.	71A8-4	1364	27°08.6'	93°08.4'	Skimmer
221.	71A8-5	1448	26°54'	92°54.5'	Skimmer
222.	71A8-8	2057	26°08'	92°43.9'	20m Trawl
223.	71A8-10	2077	26°09'	92°48.3'	20m Trawl
224.	71A8-11	3287	25°51'	93°03'	20m Trawl
225.	71A8-13	3267	25°52'	93°15.8'	20m Trawl
226a.	71A8-16	3517	25°04.2'	94°23.7'	Quant. Dredge
257.	72A13-32	1774	26°25'	94°47.5'	20m Trawl
258.	72A13-39	1061	27°26.4'	94°07.6'	20m Trawl
259.	72A13-45	412	27°46.7'	94°47.5'	20m Trawl
260.	72A13-49	640- 530	27°40'	94°49.8'	20m Trawl
261.	72A13-51	1399-1353	26°55.6'	95°10.5'	20m Trawl
262.	72A13-53	1161	27°24.4'	94°56.5'	20m Trawl
263a.	73A2-8	869	27°21'	94°00'	20m Trawl
264.	73A10-20	805-1134	27°15.3'	93°41.4'	20m Trawl

2. To provide a photographic documentation of the nature of the benthic environment within which these assemblages exist including portrayal of some constituent species that exist within biobathymetric zones.

3. After analyzing available data generated by the present study and found in extant literature, to describe important gaps in our knowledge of the area, its assemblages, and functioning of the deep ecosystem and then suggest study approaches to reduce these gaps.

4. Finally attempts will be made to provide a reasonable assessment of the significance of the potential impacts on the deep macrobenthic communities of oil and gas exploration and production.

In order to accomplish these objectives, TerEco Corporation has carried out the following tasks in an ordered manner:

1. To the maximum taxonomic extent possible, individual organisms were identified, tabulated, and regrouped on a station by station basis. Species richness indices were then prepared for stations grouped by depth.

2. Individual species were grouped in appropriate taxonomic categories in order to portray their depth ranges, the total number of individuals taken, frequency of collection, and depth of maximum population, and also in order to select the numerical dominants of each group.

3. Maps were prepared showing the geographic distribution in the Gulf of each dominant species, and kite diagrams were drawn for each dominant species showing its relative abundance on a vertical or isobathic scale.

4. Employing an appropriate clustering technique, a dendrogram was constructed to assist in discerning the distribution of faunal assemblages and the establishment of the limits of biobathymetric zones.

5. Chemical, geographical, and physical oceanographic data, both historical and that collected aboard ALAMINOS, were discussed and used where feasible to assist in understanding some aspects of the discontinuities between faunal assemblages.

6. Finally a conceptual model of the major ecosystem of the deep Gulf of Mexico was constructed and analyzed.

2. STUDY METHODS

SAMPLING GEAR AND THEIR USE

DREDGES

The five types of dredges employed during this study were designed and/or fabricated to meet specific sampling requirements and only one (viz., scoop dredge) had the inherent capability to collect organisms smaller than 6-7 mm. The other four dredges were designed in the main to collect organisms larger than 10 mm; however, smaller organisms were sometimes fortuitously entrapped in sediment retained in the cod ends.

The Menzies dredge (Menzies, 1963) used only on cruise 64A10, was 1 m in gape and supplied with a net bag of 1 inch stretch mesh. On cruises 65A3, 65A9, 65A14, and part of 66A5, the plow dredge was employed (James, 1972). This dredge, equipped with cultivator plows, was designed to collect deep burrowing organisms. It had a gape of 1 m and a net bag of 1/4 to 1 inch stretch mesh. The metering device consisted of a spoked wheel 1 m in circumference connected via an eccentric to a rod which depressed a thumb counter once per revolution of the wheel. The scoop dredge was used on cruises 66A5, 66A9, 66A16, 67A5, and 68A3 (James, 1972). It had a gape of 1 m, and was equipped with an adjustable cutting blade to scoop a 5-10 cm uniform layer into a canvas bag of about 360 liter capacity. A 3-meter gape skimmer (Pequegnat et al., 1970) was employed on the remaining ALAMINOS cruises reported herein. This dredge had an all steel framework lined with hardware cloth. Pequegnat et al. (1970) discussed the construction and operation of this dredge. A modified skimmer, referred to herein as a 2-meter dredge, was used on cruise 68A13. In contrast to the prototype skimmer, the 2-meter dredge had a smaller gape (2 meters), longer throat, smaller mesh, and an adjustable cutting blade.

TRAWLS

The nets used were 20-meter otter trawls having 3 inch stretch mesh at the mouth and grading to 1 inch stretch mesh in the lined cod end. The doors were metal "V" boards about 3 1/2 feet tall, 5 feet long, and weighed about 225 to 250 lbs. each. The length of the bridle was 25 m, the maximum length afforded between the ship's accumulator and outboard sheave. The ratio of wire out to depth was 3 or 4 to 1 in depths to 1000 m but this was reduced to 1.5 or 2 to 1 in depths over 3000 m. The bottom time varied from 30 minutes at shallow depths to 3 hours in depths below 3000 m.

The net was brought on board, washed with seawater, and the cod end emptied into a 100-gallon tub. Specimens collected were grossly sorted on board and then preserved.

One benthic sample used in this study was accidentally taken on cruise 66A9 with a 10-foot Isaacs-Kidd mid-water trawl.

GRABS AND CORES

A Campbell grab, as described and illustrated by Hartman (1955) was used on cruises 64A10, 65A9, and 66A5. The grab took a sample from an area of about 0.62 m^2. The grab was purchased to be used with a stereo camera but the manufacturer never produced the camera. The reliability of obtaining a sample with the grab in waters less than 200 m was satisfactory but its reliability decreased drastically with increasing depth. The use of the grab was phased out when the scoop dredge became available. The scoop dredge provided infaunal quantification as did the grab but the scoop dredge sampled a larger area (3 m^2) and was more reliable in deeper water.

Bottom sediment cores were obtained by means of a Phleger corer. The upper 10 cm were removed and properly preserved. The grain-size analysis consisted of wet-sieving an aliquot of sediment for the sand-sized fractions and then drying to get a weight percentage. The clay-silt fraction was determined on the less than 74u fraction by the pipette method outlined in Folk (1974).

CAMERAS

Two types of cameras were employed in obtaining the photographs presented herein. Both were originally off-the-shelf models, but each was modified for specific task requirements.

One camera was a 35 mm underwater multi-exposure model (Alpine Geophysical Associates, Model 314) that was triggered by bottom contact. As received from the factory, bottom contact was noted when the ping rate changed from 1 per 10 sec to 1 per sec. For our purposes this was inadequate since the winch operator's reaction time to bottom contact was several seconds after contact had been made. In addition, reaction time increased with increasing depth. The pinger supplied with the system was too weak for depths beyond 400 m and was subsequently replaced with a Benthos® pinger (Model 2216). Operation of the pinger system is discussed below. The camera was equipped with a Wollensak f/11 water corrected lens with a fixed focus of about 3 m. By placing brass shims of appropriate thickness behind the lens we were able to adjust the focus to 1 or 1.5 m. After numerous tests we settled on 1.5 m as being the most effective distance for our purposes. But in order to do this, we had to design and fabricate a closeup frame for the camera, strobes, bottom switch, and pinger. The original camera system was supplied with a single 200 watt-second strobe light, which was adequate for high-speed films. Later a second such strobe was integrated within the system, permitting the use of fine-grain films.

The other camera was a 70 mm Shipek Deep-Sea Camera (Hydro Products Model PC-700) equipped with a single 200 watt-second strobe. The focus of this camera was ordinarily set at 1.6 m.

The distance from the camera to the bottom was monitored by acoustical means. This was accomplished by attaching a pinger to the camera frame and receiving its signal with the Precision Depth Recorder's (PDR) receiver. The accuracy of the PDR print out was not adequate; thus the Y-axis of an oscilloscope was interconnected with the PDR receiver (the pulse generator of the PDR was turned off). Using the Driven Sweep Mode, the oscilloscope screen then displayed the outgoing "ping" and incoming "echo" of the pinger as separate peaks. The distance between these peaks is roughly proportional to the distance of the pinger above the bottom. The grid of the oscilloscope was calibrated in meters and the viewer relayed distances to the winch operator controlling the camera.

In actual operation, the winch operator, using the winch metering wheel, lowered the camera to within about 50 m from the bottom. The oscilloscope operator then read the true distance between camera and bottom and instructed the winch operator accordingly to lower to 5 m. At this time a final lowering distance was given to the winch operator. If the camera was on automatic mode, the focus distance was maintained by coordination of the oscilloscope and winch operators. If the camera was bottom actuated, it was lowered to the depth that would trip the switch then was immediately raised up 5 m, and the process was repeated until the desired number of photographs were taken.

All film was developed on board the ship in order to assure that (1) camera systems were functioning, (2) film and camera setting were properly matched, and (3) focus was properly set.

PROCESSING OF SAMPLES

Specimens that were preliminarily sorted and preserved in formalin aboard the ship were transported to the laboratories at the Texas A&M University Department of Oceanography after each cruise during the years of collection from 1964 to 1973. Certain taxonomic groups were studied by researchers and/or graduate students for thesis or dissertation study in Oceanography at Texas A&M or sent off to certain taxonomic specialists at an earlier time than other taxonomic groups. In general the Decapod Crustacea, Echinodermata, palaeotaxodont bivalve mollusks, and fishes were worked up earlier than many of the remaining groups because people were available to work on those groups at the time. Specimens were transferred from the formalin preservative to ethyl alcohol when possible to prevent erosion of calcareous parts by the acidic formalin. Unfortunately, funds for proper curatorial assistance were not available during the early years, and care of the samples fell into the hands of whichever generous and eager biologists or students who were interested in caring for samples of certain taxonomic groups.

In 1973, the Systematic Collection of Marine Organisms was organized by Dr. L.H. Pequegnat in the Oceanography Department at Texas A&M University for the primary purpose of housing, curating, and preserving for future study the identified specimens from these and other marine collections made by Texas A&M. As specimens were worked up and identified in the various taxonomic groups, the identification data were entered on master sheets for each station sampled as well as on species identification cards. The identified specimens were then catalogued into the Systematic Collection of Marine Organisms.

As storage of the unidentified biological material and nonbiological samples (e.g., sediment samples) became more of a problem as the years went on, many samples were moved to off-campus storage facilities. When the time came in 1981 to coordinate the deep-sea Gulf of Mexico data in preparation for this report, the job of rounding up all of the stored unidentified materials from all of the deep Gulf cruises became a difficult, time consuming task, which ultimately uncovered stored materials that had not been inventoried previously. It also uncovered materials that were seriously in need of curating and replacement or renewal of preservatives.

A large and time consuming part of the early phases of this project was concerned with gathering together, sorting, re-bottling, re-preserving, and inventorying the materials that still needed to be worked on to complete the data base required for this project.

Taxonomic specialists were contacted to work up the remaining relevant taxonomic groups, and materials were hand delivered when possible or very carefully packaged up for mailing to more distant locations.

STUDY BY SPECIALISTS

Taxonomic specialists from all over the world were utilized to identify the deep-sea specimens that are covered in this report. Because less than minimal funds were available to pay for taxonomic consultants, many taxonomists were asked to donate their services in exchange for use of the specimens in their ongoing systematic studies. The taxonomists that were paid were grossly underpaid, but they, too, agreed to accept the small remuneration for the privilege of utilizing the systematic and distributional data in connection with their own studies. Were it not for the generosity of these taxonomists and their friendly responses to the requests of the senior scientists in charge of this project, this project could not have been done for anywhere near the budgeted amount.

A great disservice is being done to taxonomic specialists to assume that they will continue to donate their time for identifications on otherwise well-funded projects. Future contracts should contain generous allowances for taxonomic consultants if quality work and consistent identifications from competent experts is expected. Taxonomy of deep-sea organisms is especially difficult because of the many rare, new, and little known species and because of the lack of consolidated literature or identification keys for deep-sea species. As a result, a wide range of literature in the form of old expedition reports, monographs, etc. must be consulted by established specialists in each taxonomic group. The identification of deep-sea material simply cannot be given to graduate assistants or technicians for quick results.

To illustrate some of the new records and new species recorded from the deep-sea Gulf of Mexico material identified by specialists recently (1981 and 1982) for this report, but not yet published in the scientific literature, are the following comments from specialists of the following taxonomic groups:

GASTROPODA (P. Bouchet): "There are a number of species that had never been recorded from the Gulf of Mexico. There are probably some undescribed ones in those that are identified only at genus level..."

SCLERACTINIA (S. Cairns): "*Thalamophyllia riisei* (new record for the Gulf)."

HYDROIDEA (D. Calder): "*Cladocarpus flexuosus*...represent the first records of the species since it was originally described in 1900 by Nutting. In addition, Nutting's type material lacked gonophores whereas the specimens from 68A7-14B were fertile."

STOMATOPODA (D. Camp): "...*Heterosquilla armata* (Smith)...known only from a few specimens collected off New England and one female collected off southeastern Florida. Your specimen from off Texas would represent a significant range extension..."

PYCNOGONIDA (C.A. Child): "*Paranymphon spinosum* Caullery...you sent a specimen of the same species from almost the same place in 1969, my records show... they are the only two we have from the Gulf."

ASTEROIDEA (M. Downey): "*Evoplosoma*, n. sp."

POLYCHAETA: OWENIIDAE (S. Gardiner): "*Myriochele* sp. A is a new species... *Myriochele* sp. B may be a new species."

TANAIDACEA (R. Heard): "*Sphyrapus* n. sp. (near *S. dispar* Lang, 1968). *Apseudes* (*Leiopus*) sp. D — these 2 specimens may represent a new species related to *Apseudes sibogae* Nierstrasz."

MALDANIDAE (W. Light): "*Asychis* sp. nov. (new unidentified species); *Johnstonia* sp. (unusual - first he has ever seen and not recorded from this area."

AMPHIPODA (L. McKinney): "*Epimera* sp. A (n. sp.)."

CIRRIPEDIA (H. Spivey): "Four species, although occurring in adjacent water have not been recorded previously from the Gulf of Mexico: *Scalpellum spicatum*, *S. svetlanae*, *Arcoscalpellum vitreum*, and *A. albatrossianum*."

The following taxonomic groups studied in this project were identified by the following specialists:

Porifera (sponges), Dr. K. Ruetzler; alcyonarian coelenterates (horny corals and sea pens), Dr. J.S. Lowry; hydrozoan coelenterates, Dr. D. Calder; scleractinian coelenterates (stony corals), Dr. S. Cairns; Polychaeta: Amphionomidae, Capitellidae, Chaetapteridae, Flabelligiridae, Glyceridae, Goniadidae, Nereidae, Opheliidae, Orbiniidae, Phyllodocidae, Sabellariidae, Sabellidae, Serpulidae, and Spionidae, G.F. Hubbard; Polychaeta: Arabellidae, Eunicidae, Lumbrineridae, and Onuphidae, Dr. K. Fauchald; Polychaeta: Acoetidae, Polynoidae, and Sigalionidae, Dr. M.H. Pettibone; Ampharetid polychaetes, Dr. R. Zottoli; Maldanid polychaetes, Dr. W. Light; Oweniid polychaetes, Dr. S.L. Gardiner; Terebellid polychaetes, Dr. P. Hutchings.

MOLLUSCA: Bivalvia (Palaeotaxodonta), Dr. B.M. James; Bivalvia (Propeamussidae), Dr. T.R. Waller; Cephalopoda, Dr. D.A. Lipka; Gastropoda, Dr. P. Bouchet and Dr. A. Waren.

Bryozoa (Ectoprocta), Dr. A.J.J. Leuterman; Brachiopoda, Dr. G.A. Cooper; Sipuncula, Dr. M.E. Rice; Pycnogonida, C.A. Child.

CRUSTACEA: Amphipoda, Dr. L. McKinney; Cirripedia (barnacles), H.R. Spivey; Isopoda, Dr. W.E. Pequegnat; Stomatopoda, D.K. Camp; Tanaidacea, Dr. R. Heard.

CRUSTACEA: DECAPODA: Galatheoidea, Drs. L.H. and W.E. Pequegnat, Paguroidea, P. McLaughlin, and R. Lemaitre; Brachyura, Dr. W.E. Pequegnat; Macrura (Nephropidae and Polychelidae), Dr. R.W. Firth and B. Andryszak; penaeid shrimps, Dr. T.W. Roberts and Dr. L.H. Pequegnat; caridean shrimps, Dr. L.H. Pequegnat.

ECHINODERMATA: Asteroidea, M.E. Downey and L. Mukai; Crinoidea, Dr. C.G. Messing; Echinoidea, C. Venn, R. Britton, and Dr. D.L. Pawson; Holothuroidea, Dr. R.S Carney; Ophiuroidea, R.L. Britton and Dr. Gordon Hendler.

FISH: Dr. J. McEachran and R.E. Matheson.

Identifications and other data were also obtained from theses and dissertations by graduate students at Texas A&M University who studied the deep Gulf ALAMINOS collections. These studies include palaeotaxodont mollusks (James, 1972), cephalopod mollusks (Lipka, 1970 and 1975), penaeid shrimp (Roberts, 1970), caridean shrimp (L. Pequegnat, 1970), deep-sea lobsters (Firth, 1971), asteroids (Mukai, 1974), echinoids (Booker, 1971), holothuroids (Carney, 1971), and general deep-sea ecological studies (Kennedy, 1976; Roberts, 1977; Rowe, 1966; and Rayburn, 1975).

Specialists were either not available or were not able to perform identifications for us on the tunicates and sea anemones. These groups, being not very numerically abundant in our samples, caused no serious problems by this absence in our data.

ULTIMATE DISPOSITION OF SPECIMENS

The bulk of the identified deep Gulf of Mexico specimens are being deposited in the Texas A&M University (Department of Oceanography) Systematic Collection of Marine Organisms. Dr. T.J. Bright is the present curator of this collection. Exceptions to this are 1) the deep-sea fishes which are housed in the Texas Cooperative Wildlife Collection at Texas A&M University under the care of Dr. John McEachran of the Department of Wildlife and Fisheries Science; 2) those familes of polychaete worms that were not retained by the U.S. National Museum of Natural History were given to Barry A. Vittor and Associates, Environmental Research and Consulting firm, Mobile, Alabama, for use in their Gulf of Mexico Polychaete Study supported by MMS; and 3) the tanaidacean crustaceans were retained by Dr. R.W. Heard at Ocean Springs, Mississippi for his continuing taxonomic studies of this group.

In cases where the systematic specialist was interested in retaining the specimens in the collections of a major museum with which he or she was associated, they were allowed to do so, but were requested to provide a reference collection of one specimen of each species for deposition in the Texas A&M University Systematic Collection of Marine Organisms. This includes the following major groups which have been deposited at the U.S. National Museum of Natural History in Washington, D.C.: Sponges, crinoids, Polychaeta of the familes Acoetidae, Arabellidae, Eunicidae, Lumbrineridae, Oweniidae, Polynoidea, and Sigalionidae. Terebellid polychaetes were retained by Dr. Pat Hutchings, Curator of Worms, the Australian Museum, Sydney, Australia. The sipunculan worms were retained by Dr. Mary Rice at the Smithsonian Institution, Fort Pierce Bureau at Fort Pierce, Florida.

In addition, the gastropod mollusks, except for a reference collection, were retained at the Paris Museum of Natural History, Laboratoire de Biologi des Invertebres Marins et Malacologi in Paris, France under the care of Dr. Philippe Bouchet. Most of the hydrozoan coelenterates are being retained at the Royal Ontario Museum, Toronto, Canada under the care of Dr. Dale R. Calder.

In the case of new species yet to be described or rare species that were of particular scientific interest to the ongoing studies of the specialist concerned, the specimens were retained by the specialist until completion of his work on them. It was stipulated that any type-specimens of newly described species would be deposited with the U.S. National Museum of Natural History. Type-specimens of the new species that have already been described from the deep-sea ALAMINOS material have been deposited at the U.S. National Museum. They include the following taxa:

CRUSTACEA: DECAPODA

Bathypalaemonella serratipalma L. Pequegnat, 1970
Bathypalaemonella texana L. Pequegnat, 1970
Munidopsis alaminos Pequegnat and Pequegnat, 1970
Munidopsis geyeri Pequegnat and Pequegnat, 1970
Munidopsis gulfensis Pequegnat and Pequegnat, 1970
Munidopsis subspinoculata Pequegnat and Pequegnat, 1970
Parapandalus willisi L. Pequegnat, 1970
Plesionika polyacanthomerus L. Pequegnat, 1970
Sabinea tridentata L. Pequegnat, 1970

ECHINODERMATA: ASTEROIDEA

Ampheraster alaminos Downey, 1971
Doraster constellatus Downey, 1972
Evoplosoma virgo Downey, 1982
Midgardia xanadaros Downey, 1972
Pteraster acicula (Downey, 1970)

It is unfortunate that some taxonomic groups have become lost or unaccounted for during the years between the collection and finalization of this deep-sea Gulf of Mexico work. These include the following: (1) Bivalve mollusks, except for the Palaeotaxodonta and Propeamussidae; the remaining bivalves were lost during shipping to the taxonomic specialist for identification and have not been found in spite of numerous efforts to trace the missing parcel; (2) isopod crustaceans, except for *Bathynomus giganteus*, were sent to Dr. Robert Menzies many years ago. After his death, the ALAMINOS isopods have still not been located.

3. RESULTS OF PREVIOUS INVESTIGATIONS

CRUISES IN THE 19th CENTURY

No significant biological surveys were made in the deeper areas of the Gulf of Mexico until the 19th century. Before that time explorations in the Gulf were confined primarily to geographical studies for the purpose of charting and mapping. Some plotting of currents also occurred before the 19th century, but biological observations were only incidentally made and occasionally reported by seafaring captains.

The first systematic deep-sea explorations in the Gulf were made in 1867 and 1868 by Pourtalès and Mitchel on the United States Coast Survey Ships CORWIN and BIBB which, according to Galtsoff (1954), "consisted in dredging between Florida and Cuba, at some places at a depth of 850 fathoms (1554 m). Many new types discovered in these collections and the finding of species of corals and echinoderms which were considered related to an antique fauna of the Cretaceous period, proved that a study of bottom organisms thriving along the course of the Gulf Stream is of great scientific interest."

The biological collections from these dredgings were reported on by Pourtales, 1870 (crustaceans), A. Agassiz, 1863-69 (echinoderms) and 1878 (echinoderms, crinoids, and corals).

Of special significance to early deep-sea biological investigations in the Gulf of Mexico were the explorations of the U.S. Coast and Geodetic Steamer BLAKE starting in 1872. Alexander Agassiz, director of the Harvard Museum of Comparative Zoology, was in charge of dredging operations on the BLAKE. According to Galtsoff (1954), "Three cruises of the BLAKE, from 1877 to 1880, represent an outstanding event in the history of scientific exploration of the Gulf of Mexico. The expeditions obtained a wealth of information regarding the oceanography and biology of the Gulf, and the two volumes describing the work of the BLAKE written by A. Agassiz (1888) until the present day remain an important source of reference concerning the bottom fauna, the structure and origin of coral reefs, and the distribution of invertebrates and fishes at depths extending to 2000 fathoms" (3658 m).

A large measure of the success of the deep dredging of the BLAKE was due to the ingenuity of Alexander Agassiz and his use of the "Blake Dredge" and the "Blake Trawl", which were modified versions of the standard trawls and dredges of the day that enabled them to sample the deeper depths more effectively. He also used wire cable of much smaller diameter than the bulky and heavy hemp rope that was used on previous expeditions. The biological collections of the BLAKE were studied and reported upon by Pourtalès, 1880 (corals); A. Agassiz, 1883 (echinoderms); Theel, 1886 (holothurians); Clarke, 1879 (hydroids); Ehlers, 1879 (polychaete annelids); Dall, 1880, 1886, 1889 (mollusks); A. Milne-Edwards 1880 (brachyuran and anomuran crustaceans); 1881 (caridean shrimps); and 1883 (illustrations of decapod crustaceans); Smith, 1882 (decapod crustaceans); A. Milne-Edwards and Bouvier, 1894, 1897 (galatheid crabs) and 1909 (penaeid and stenopodian shrimps); and Bouvier, 1925 (macruran decapods).

Most of the publications dealing with the deep-sea benthic organisms collected by the BLAKE are systematic in nature and can be found in the first 19 volumes of the Bulletin of the Harvard Museum of Comparative Zoology. In spite of the wealth of information and specimens gathered by the BLAKE, it sampled in only a small portion of the Gulf of Mexico (see Figure 3). No sampling was done in the western Gulf and very few successful stations were in continental slope depths of the northern Gulf.

The U.S. Fish Commission vessel, ALBATROSS, occupied dredging stations in a small area of the eastern Gulf and in the Yucatan Strait area in 1884 and 1885 during efforts to explore the fishery resources of the Gulf and Caribbean (Figure 3).

The 1932 Yale Oceanographic Expedition of the MABEL TAYLOR, sponsored by the Bingham Oceanographic Foundation, covered a relatively widespread area of the Gulf, especially the western Gulf for the first time, occupying a total of 87 stations, but was limited to hydrographic and chemical measurements such as temperature, salinity, and oxygen.

The ATLANTIS of the Woods Hole Oceanographic Institution undertook a series of hydrographic, geological, and paleontological studies in the Gulf in 1934, 1937, 1947, and 1951, part of which were in cooperation with the Bingham Oceanographic Foundation and the Geological Society of America. Biological samplings were made during the ATLANTIS' "Harvard-Havana Expedition" of 1938-39 in the vicinity of Cuba. Reports of decapod Crustacea from this expedition were reported on by Chace, 1939 (descriptions of new species of Decapoda and Stomatopoda), 1940 (brachyuran crabs) and 1942 (anomuran crabs).

INVESTIGATIONS IN THE 20th CENTURY

The Bureau of Commercial Fisheries, Fish and Wildlife Service, Exploratory Fishing and Gear Research Base at Pascagoula, Mississippi (now the National Marine Fisheries Service, Southeast Fisheries Center) began dredging and trawling work in the Gulf of Mexico with the OREGON, SILVER BAY, COMBAT, and PELICAN in the 1950s. Their operations included numerous continental shelf and shallow slope stations in the Northeast Gulf, but only a few stations in the western Gulf, and very little from the very deep areas of any part of the Gulf. Some of these collections of fishes and invertebrates were presented, primarily as lists, by Springer and Bullis (1956) and Bullis and Thompson (1965). The OREGON II, from 1967 until the present time, has continued and extended the trawling for fisheries investigations in the Gulf. Many of the specimens collected by the OREGON and OREGON II in the deeper areas of the Gulf were made available to taxonomic specialists at the Smithsonian Institution and elsewhere, and these, together with the ALAMINOS deep Gulf collections, have provided the major material for recent systematic and distributional studies and publications on deep Gulf of Mexico biota.

In the early 1960s comprehensive studies and collection of benthic, midwater, and planktonic specimens as well as hydrographic, geologic, and photographic investigations were begun by Texas A&M University on the R/V ALAMINOS under the direction of Dr. W.E. Pequegnat. These collections were made from the outer shelf, continental slope, and abyss in all areas of the Gulf of Mexico. This marked the first such extensive collecting in these areas of the Gulf for the purpose of ecological studies of the entire water column. It is the deep benthic collection of the ALAMINOS that are the basis for the present report. Theses, dissertations, and publications emanating from these collections include reassessments of populations of benthic and pelagic organisms, systematic

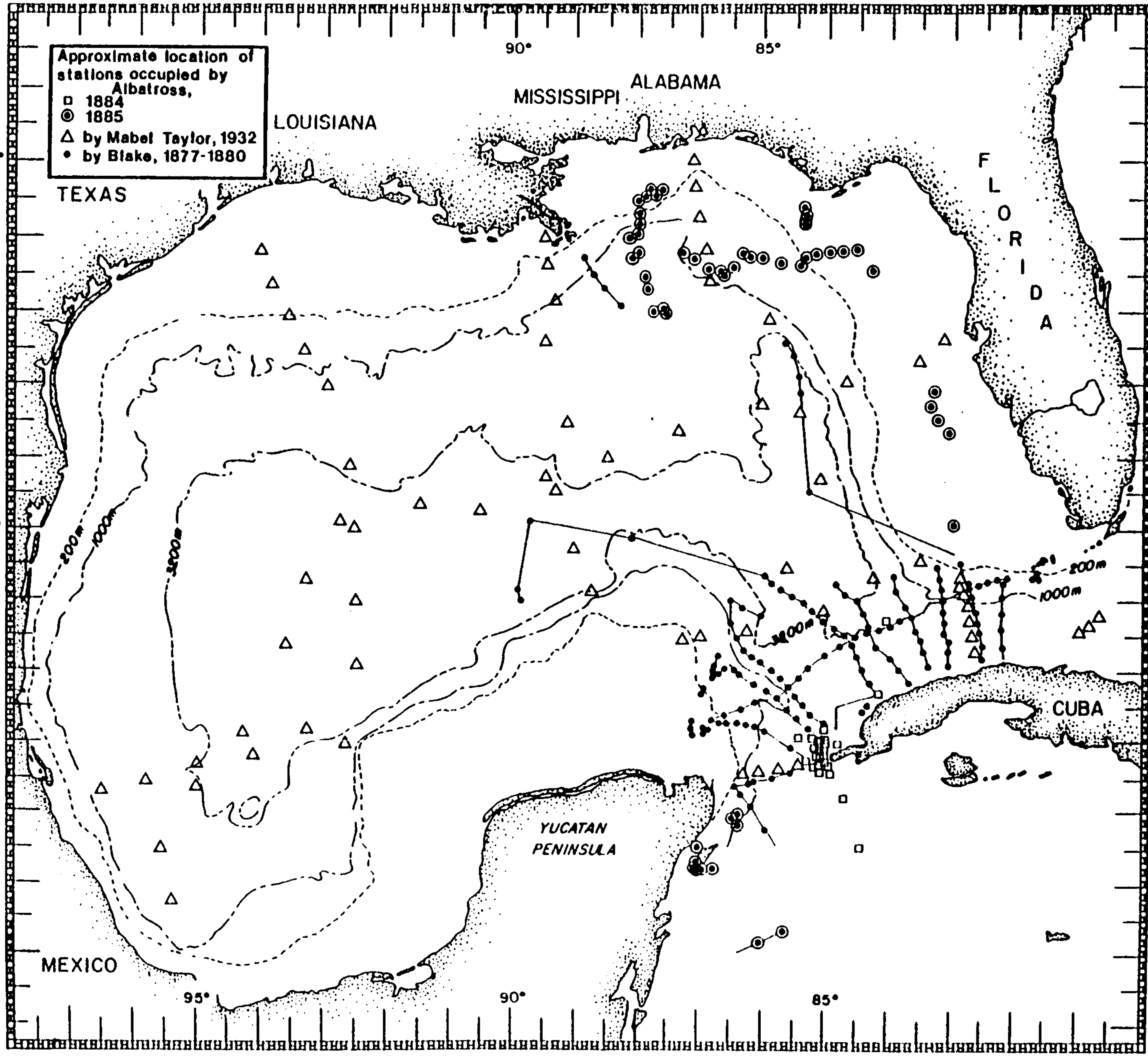

Figure 3. Approximate location of stations occupied by early cruises in the Gulf of Mexico (after Galtsoff, 1954).

and taxonomic studies of specific groups, new distribution records, and descriptions of new species (Pequegnat and Chace, 1970; Pequegnat and Pequegnat, 1971; Pequegnat et al., 1971; and Downey, 1970, 1971, 1972, and 1973).

The University of Miami deep-sea biological investigations, which were directed by G.L. Voss after the mid-1960s, dealt with the development, behavior, ecology, geographical distribution, and systematics of numerous invertebrates and many fishes. Most of these collections, however, were made in the Straits of Florida and especially in the Caribbean Sea; hence they do not cover the northern Gulf of Mexico continental slope or adjacent areas. Nevertheless, their studies on systematics and geographic distributions, published primarily in numerous papers in the Bulletin of Marine Science over the past fifteen years, have added greatly to knowledge of the entire western Atlantic deep-sea fauna, and have indirectly contributed to similar studies in the Gulf of Mexico.

Rowe and Menzel (1971) in a study of quantitative benthic samples and measurements of deep-sea biomass based upon thirteen anchor dredge stations from the southern and eastern Gulf in depths of 200-3780 m (only 5 of which were shallower than 2000 meters), remark upon the depauperate nature of the deep benthic fauna of the Gulf compared to other ocean basins. They showed that infaunal biomass decreased logarithmically with depth suggesting "considerable energy loss in the passage of food along a complex food ladder in the water column." No specific faunal components were given in this study, however.

PART II. SOME OCEANOGRAPHIC ASPECTS OF THE NORTHERN GULF

4. DEEP BENTHIC ECOSYSTEMS: SPECIES AND THEIR DISTRIBUTIONS

THE INVERTEBRATE BENTHOS

DEFINITIONS

The present study is concerned primarily with the benthos, which are the animals that live upon or in the bottom or, if they are free-swimming, obtain most of their food from the seabed. Fishes which belong in this latter category are referred to as demersal fishes. Those benthic organisms that live upon the surface of the bottom are called epifaunal even though they may retreat to burrows for refuge or breeding. Those species that live encased in the sediments as adults are referred to as infaunal species. Whereas the epifaunal species are collected by means of dredges and trawls, infaunal species are generally sampled through use of grabs of various types or box cores.

Most benthic studies deal with one or more of three size categories: meiofauna, ranging between 63 and 500 um, macrofauna that have a lower size of about 500 um and range up to an indefinite point that they share with the megafauna. Originally the term megafauna was used to designate animals (epifaunal) that were large enough to be photographed in their natural habitat. Rowe and Haedrich (1979) state essentially the same thing, "Megafauna, defined roughly as those organisms that are big enough to be easily visible,----." The most important megafaunal groups in the deep sea are the echinoderms, crustaceans, and demersal fishes. It is, therefore, these groups that are featured in this section. Finally, we shall discuss two important infaunal groups, viz., most of the polychaete worms and bivalve mollusks.

EXPLANATIONS OF THE TABLES AND DISTRIBUTION DIAGRAMS IN PART II

Numerical and depth data on all species in each taxonomic category of organisms under consideration are summarized in Table 3 and analogous tables. Column A (I) contains for each species the actual number of specimens collected in the entire study. Column B (I) gives the product of the number of stations at which the species was collected multiplied by 5. Breadth of distribution is considered to be an important parameter of numerical dominance; hence by multiplying an advantage is given to a wide-ranging species. For example, two different species might have had a total of individuals of 40, but one was dominant at only 1 station, giving 1 x 5 x 40 = 200, whereas the other was dominant at 4 stations, giving 4 x 5 x 40 = 800. Column C contains the products given in these examples. In part II of each table, those species having the highest dominance values are listed in descending numerical order. The cut-off point was judgmental but was ordinarily placed where there was a significant break in the numerical values.

At this point, also, a short explanation of the distribution diagrams of Figure 5 and analogous figures throughout this text is appropriate. The map of the Gulf of Mexico exhibits the horizontal geographic distribution by sampling station location of each species regardless of numbers. The latter information is supplied by the "kite" diagram which gives the depths of occurrence and the relative population densities of selected species, using the common logarithm of the average number of individuals per hectare, from all stations grouped by

50 m isobath intervals. For example, in Figure 5 the average density of Nymphaster arenatus at 400 m was 0.14 individuals per hectare; at 450, 0; at 500, 0; at 550, 20.5; and so on. Apparent discontinuities in distribution merely indicate that no individuals of a species were collected at those depths and may be due to either a lack of sampling at those particular depths or an absence of organisms, perhaps because of an abrupt change of bottom characteristics (e.g., a scarp).

The "per hectare" values were determined by adjusting the actual number of individuals collected at a given station to a hectare basis. To do this required estimating the actual time the sampler remained on the bottom and noting the speed in knots (1 knot = 1853 m/hr) of the ship relative to the bottom. This product times the effective collecting gape of the sampler gave the square meters covered, during sampling. It was then possible to calculate the number of (or fraction of) hectares covered at the station. For example, 40 individuals of species S were collected at Station 10 (400 m depth), which covered 5000 m^2; hence the number of individuals of species S per hectare at this 400-m station would be 10,000 m^2/5000 m^2 = 2 x 40 = 80. Obviously these are only gross estimates, but their relative values are increased by the uniform application of the method by the same person to most stations.

SPECIES NOMENCLATURE CHANGES

Various taxonomic specialists who have worked on the deep-sea biological material that is the ultimate basis for this report, have pointed out nomenclatural changes in the names of certain organisms that should be used at this time. In many cases these changes have resulted in the use of a different name for the organisms than was used in TerEco's previous report for BLM (Pequegnat et al., 1976) or in other previous literature. Below is a list of some of these nomenclatural changes.

OLD NAME	NEW NAME
FISH	
Bathygadus vallainti	Bathygadus melanobranchus
Callionymus himantophorous	Callionymus agassizi
Cariburus mexicanus	Coryphaenoides mexicanus
Coelorhynchus carminatus	Coelorinchus coelorhynchus carminatus
Cristulata cristulata	Trachyscorpia cristulata
Grenurus grenadae	Sphagemacrurus grenadae
Hymenocephalus cavernosus	Hymenocephalus italicus
Malacocephalus occidentalis	Ventrifossa occidentalis
Merluccius magnoculus (formerly MERLUCCIIDAE)	now Merluccius albidus in GADIDAE
Mixonus pectoralis	Bathyonus pectoralis
Mystriophis mordax	Echiophis mordax
Nezumia hildebrandi	Nezumia aequalis
Oxygadus occa	Coelorinchus occa
Pawnurus occidentalis	Ventrifossa occidentalis
Porichthys porosissimus	Porichthys plectrodon
Promyllantor schmitti	Pseudophichthys laterodorsalis
Promyllantor sp.	Pseudophichthys sp.

OLD NAME	NEW NAME
FISH continued	
Raja bathyphila	Raja bigelowi
Raja lentiginosa	Raja garmani
Scylliorhinus profundorum	Apristurus profundorum
Squalogadus intermedius	Squalogadus modificatus
Talismania sp.	Bathytroctes sp.
Trachonurus sulcatus	Trachonurus villosus
Urophycis chesteri	Phycis chesteri
Urophycis cirratus	Urophycis cirrata
Urophycis floridanus	Urophycis floridana
Urophycis regius	Urophycis regia
Uraleptus maraldi	Gadella maraldi
PENAEIDAE	
Penaeopsis megalops	Penaeopsis serrata
CARIDEA	
Systellaspis affinis (Faxon, 1896)	Systellaspis pellucida (Filhol, 1885)
STOMATOPODA	
Heterosquilla armata	Heterosquilloides armata
BIVALVIA	
Bathyarca orbiculata	Arca orbiculata
SCAPHOPODA	
Antalis obscurum	Dentalium obscurum
OPHIUROIDEA	
Ophiosphalma monoplax	Ophiomusium monoplax
CRINOIDEA	
Neocomatella alata	Neocomatella pulchella
HOLOTHUROIDEA	
Benthodytes janthina	Benthodytes lingua
Deima blakei & Deima sp.	Deima validum
Euphronides anchora and Euphronides kerhervei	Psychropotes semperiana
Euphronides violacea	Psychropotes depressa
Paelopatides sp.	Paelopatides cf. gigantea
Paroriza sp.	Paroriza prouhoi
Psychropotes anchora	Psychropotes semperiana

EPIFAUNA OF SOFT BOTTOMS

Echinodermata

One hundred eighty-seven species of echinoderms were collected from the deep Gulf of Mexico extending from the shelf break to the abyss. But, as emphasized above, sampling was carried out principally in the clastic sediments from DeSoto Canyon to the region south of Brownsville, Texas. Only on a few occasions was sampling carried out in the carbonate sediments that stretch eastward from DeSoto Canyon. Asteroids accounted for about one-third of the total, followed by ophiuroids, holothurians, echinoids, and crinoids (Table 2). Approximately half of the echinoderm species (51%) extended their bathymetric range below the 1000-m isobath, but as one might expect it is the sea cucumbers that predominate in the deep Gulf. Some 73 percent of the holothurian species occur below 1000 m and, indeed, the median depth above and below which equal numbers of species were collected is 2300 m, a depth almost twice that of the asteroids and ophiuroids and six times that of the echinoids and crinoids. These distributional patterns reflect not only the well known relationship between solubilities of carbonates and echinoderm skeletons but also significant differences in food sources and feeding strategies.

Table 2. Number of species collected in echinoderm classes and their bathymetric distribution with median depth.

	No. of Species	% of all echinoderm spp.	No. species below 1000 m	% of group below 1000 m	Median depth (m)
Asteroidea	61	33	34	56	1050
Ophiuroidea	43	23	23	53	1200
Holothuroidea	37	20	27	73	2300
Echinoidea	31	17	8	26	450
Crinoidea	14	7	3	21	400
Total	186	100	95		$\bar{x}$ 1080

Interestingly we were fortunate while aboard the R/V ALAMINOS to have collected in the Gulf of Mexico both the largest and the smallest known asteroids in the world, namely, *Midgardia xandaros* and *Poranisca lepida*, respectively.

Reference to Figure 4 reveals some interesting points about the distribution of megafaunal echinoderms in the deep Gulf. First, the asteroids, echinoids, crinoids (not shown), and ophiuroids achieve their greatest species diversities at depths less than 1000 m. The crinoids follow the same pattern. The holothurians, on the other hand, predominate in the deeper Gulf, achieving their greatest diversity in a deeper band around 1850 m, which is about midway down the continental slope.

All but three of the top eleven asteroids reach their peak populations at depths around or less than 1000 m. And in this band they are spaced quite well vertically. The fact that only three of the 11 top species have even reasonably large populations (5-figure numbers in Column C of Table 3) would support the belief that the slope of the Gulf of Mexico is not very productive. On the other hand, the fact that eight of the 11 top holothuroids have relatively large populations supports the concept that they are feeding at a lower trophic level than most of the asteroids. Essentially the same is true of the echinoids. The ophiuroids, on the other hand, show only three numerically dominate species that have 5-figure numbers in Column C of Table 7.

Asteroidea (Starfish)

Sixty-one species of starfishes were collected and identified in this study (Table 3 I). Thirty-four or 56% of these species occur below 1000 m depth (Table 2). In fact the median depth for all asteroid species from the shelf break onto the abyssal plain is 1050 m in the middle section of the continental slope. The distribution of asteroid species within each bathymetric zone (Table 4 and Figure 4) clearly illustrates the greater abundance of asteroids about the median depth. The two must numerically abundant asteroids in the northern Gulf, viz., Nymphaster arenatus (Figure 5) and Plutonaster intermedius (Figure 6) attain peak populations near the median isobath. The 11 numerically dominant asteroids (Figures 5-11) have peak populations ranging in depth from 150 m for Astropecten nitidus (Figure 8) to 3250 m for Dytaster insignis (Figure 7) and Litonotaster intermedius (Figure 9). Dytaster exhibits the largest bathymetric range, some 3000 plus m, from 800 m in DeSoto Canyon to 3850 m in the Sigsbee Deep. Incidentally this is the only asteroid collected at this the greatest known depth in the Gulf.

There are some major differences in the deep asteroid fauna between the east and west Gulf. For instance, 30 of the total of 61 asteroid species are found only west of 90°W longtitude, whereas only 10 are limited to the east. Moreover, two of the numerical dominants are limited to the west (Cheiraster mirabilis and Benthopecten simplex), whereas only one, Astropecten nitidus, is limited to the east. If we assume that the asteroids are either at or only one trophic level removed from the top of the food chain, then it follows that so far as the Gulf is concerned the western portion must be quite productive to sustain so many top predators. Stomach analyses performed on Gulf asteroids revealed them to have fed upon sponges, bivalves, gastropods, cumaceans, echinoids, sargassum, and tar (Pequegnat, 1979). One possible explanation of this geographic difference relates to the fact that large quantities of land vegetation are imported to the west by the Mississippi River, the rivers of Texas, and many of those in Mexico. During the heavy rains of summer in Mexico huge quantities of terrestrial vegetation (riparian and aquatic) are rafted into the Gulf and are then carried northward into the region of this study by the current regime that brought IXTOC oil to the Texas coast. When the vegetation sinks to the bottom it gives rise to detritus that sustains some of the species that comprise the food of asteroids. The typical habitats of representative asteroids are depicted in the photographs of Plate 1 (page 197).

Echinoidea (Sea Urchins)

Thirty-one species of echinoids were collected from the offshelf seabed of the northern Gulf (Table 5). Eight of these species (26%) occur below the 1000-m isobath down to 3300 m; however, the median depth of echinoids from the shelf break to the abyss is only 450 m (Table 2 and Figure 4). This shallower distribution of echinoids is outlined in Table 6, with over half of the species having maximum populations in the Shelf/Slope Transition Zone. Within this bathymetric range the shallow end of some 200 m is dominated by the Brissopsis complex of species (Figures 14 and 15), whereas Phormosoma placenta (Figure 13) and Plesiodiadema antillarum (Figure 12) predominate in the depth range of 700 to 900 m. It is interesting that the highly calcified Brissopsis has a narrow depth range from 150-400 m, whereas both Phormosoma and Plesiodiadema have depth ranges of 1950 and 1550 m, respectively. The lower depth limit for both of the latter species is around the 2100-2300 m isobath, which happens to mark the upper limit of the Sigsbee Escarpment of the Lower Continental Slope. It is noteworthy that Phormosoma (Plate 2 A), although large is little calcified, whereas Plesiodiadema (Plate 2 D) is very small and not well calcified. The only echinoids that penetrate deeper than 2300 m are both very small. In addition to the problem of calcification, the distribution of food resources probably accounts for the observed distribution patterns. Brissopsis is a scavenger that feeds to a large extent on plant detritus, which is more plentiful on the outer continental shelf and upper slope than deeper. Whereas Plesiodiadema scavenges plant materials, Phormosoma engulfs sediments (Booker, 1971), as do the small deep-living echinoids. Thus, there is little if any competition between the three echinoid dominants.

There are some interesting differences in the deep echinoid fauna between the east and west Gulf. Although in this study some 16 species occur only in the eastern half and 6 in the western half, this disparity results largely from a few samples taken on the carbonates of the west Florida region. More representative of the situation is that the three numerical dominants (Table 5 II) are either restricted to the west (Brissopsis) or are much more abundant there than in the eastern half. Again this may well reflect the greater input of terrestrial vegetation in the western half (see discussion of Asteroidea).

Ophiuroidea (Serpent Stars)

Forty-three species of ophiuroids were collected and identified in this study (Table 7 I). At least twice as many species occur in the Archibenthal Zone than in any other zone (Table 8), but 23 or 53% of these species occur at or below the 1000-m isobath. The median depth of distribution of these species is about 1200 m (Table 2 and Figure 2), which is somewhat deeper than that of the asteroids but only half that of the holothurians. It is, however, about three times the median depth distribution of both the crinoids and echinoids. We note also in Table 7 II and Figures 17-20 that the numerical dominants reach their peak populations in quite deep water, ranging from 600 to 3250 m. In fact the most abundant deep-water ophiuroid obtained in this study (Ophiomusium planum) attains peak populations on the Continental Rise at 3250 m depth.

About twice as many ophiuroid species are limited to the western Gulf (23) as to the eastern half (12). Very little is known about the food habits of these ophiuroids; however, at least two of the numerical dominants have contained detritus-feeding palaeotaxodont bivalves. These bivalves are abundant in deep water of the western Gulf. The deep-sea photographs of Plate 3 show three different ophiuroid species, one of which is apparently exhibiting feeding behavior.

Holothuroidea (Sea Cucumbers)

Thirty-eight species of sea cucumbers were collected and identified in this study (Table 9). Twenty-seven (73%) of these species occur below the 1000-m isobath (Table 2), and as many as 10 species occur in the Lower Abyssal Zone, five of these having maximum populations there (Table 10). Even more indicative of the predilection of this group for deep-water is the fact that the median depth of their distribution is 2300 m. Moreover, eight of the 11 numerical dominants reach peak populations at depths 1000 m or over (Table 9 II and Figures 21-30). In fact, the bathymetric range for peak populations is 900 to 3700 m, which differs markedly from that of the asteroids. Although Benthodytes typica is the most abundant holothurian in the deep Gulf (Table 9 II and Figure 21), reaching peak populations at 3250 m, it is certainly outranked in biomass by the much larger Mesothuria lactea.

The holothurian species are much more evenly divided among those restricted to the western (11 species) and eastern (8 species) halves of the Gulf. Only two of the numerical dominants Benthodytes sanguinolenta and Psychropotes semperiana are restricted to the west Gulf and none to the east. It is interesting to compare the geographic and bathymetric distributions of the two top dominants (Figures 21 and 22). Both are widely distributed but whereas Mesothuria lactea is abundant in DeSoto Canyon, Benthodytes typica does not occur there. On the other hand, Benthodytes is abundant on the abyssal plain, whereas Mesothuria does not occur there. Their bathymetric distributions are complementary with only minor overlap in the 1400-2000 m band. Benthodytes typica collected near the end of August contained large orange eggs. At the same time numerous small individuals of the species (4 to 5 cm in length) were collected in groups. It is assumed that these were one year of age. The ova were so large that it seems likely that this species has direct, nonpelagic development. Carney (1971) concluded that Mesothuria lactea also exhibited the potential for nonpelagic development. These two species contrast in regard to their relative abundances in their bathymetric range. Whereas, Mesothuria is much more abundant in the upper part of its range, Benthodytes is almost equally abundant throughout its range. This suggests that Mesothuria may be more dependent on sediments enriched by plant debris than is Benthodytes, which tends to be abundant in pteropod ooze. This possibility is strengthened by our finding that B. typica is about the only megafaunal species living on the seaward slope of the deepest ridge of the Mexican Ridge System in the western Gulf at depths of 2900 to 3000 m. Psychropotes semperiana (Figure 29) exemplifies those holothurians that are confined to the abyss; its depth of occurrence ranges from 3300 to 3840 m in the western Gulf. P. semperiana and two other species of Psychropotes are shown in their typical habitats on Plate 4 A-C. Five other holothurian genera are pictured in Plate 4 D and Plate 5.

Crinoidea (Sea Lilies)

Few crinoids occur in the Gulf, compared to the other classes of echinoderms, and very few are part of the deep Gulf fauna (Table 11). Only four species occur below 1000 m and none occur deeper than the Upper Abyssal Zone (Table 12).

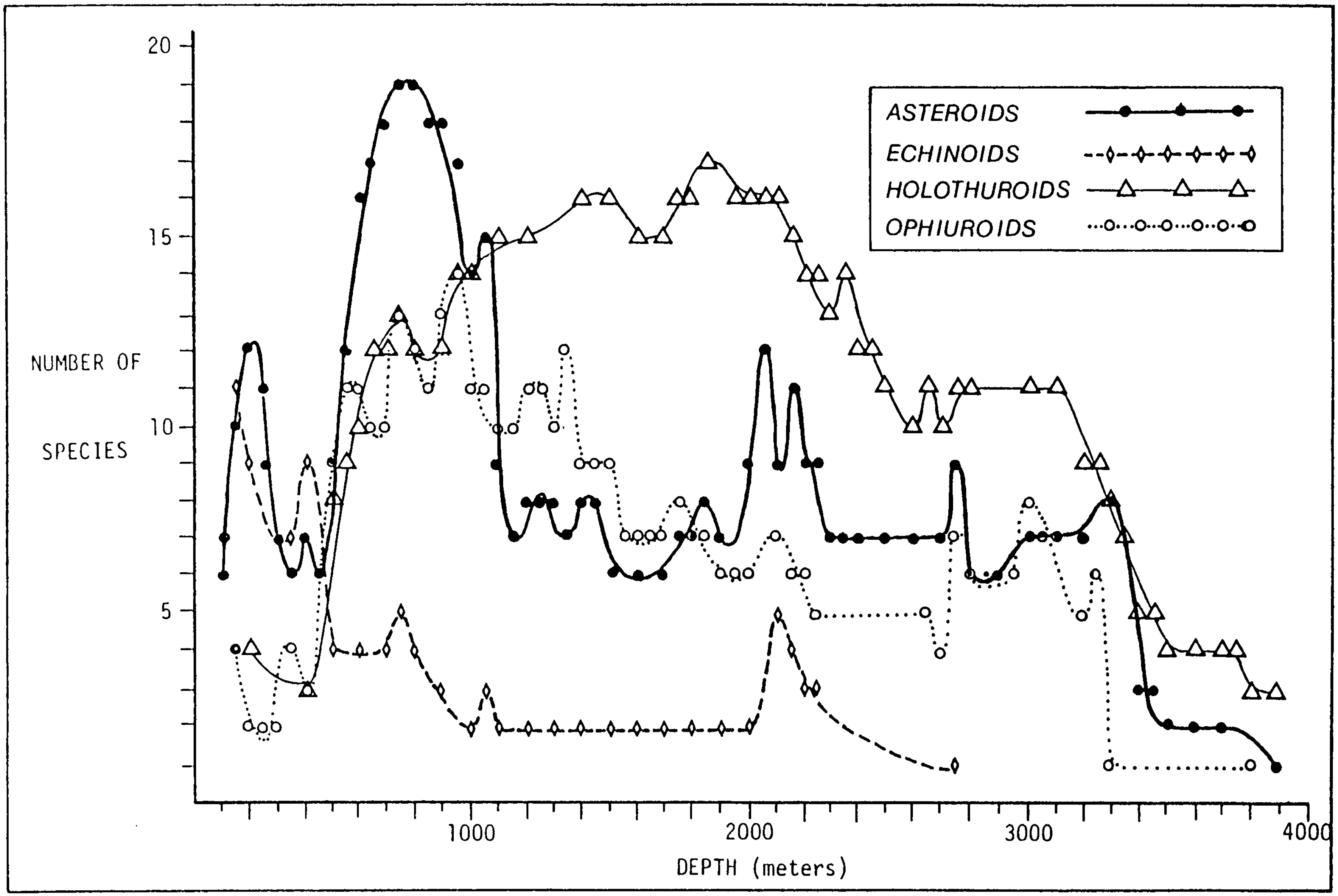

Figure 4. Number of species of the classes of echinoderms plotted against depth.

Table 3. (I) Asteroidea found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of starfishes in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Goniaster tessellatus	1	0	-	shelf-100	*
Astropecten cingulatus	7	5	35	shelf-100	*
Astropecten nitidus	44	20	880	shelf-200	150
Astropecten alligator	4	5	20	shelf-350	200
Coronatus briareus	1	0	-	150 only	150
Astropecten nitidus forcipatus	1	0	-	150 only	150
Luidia barimae	1	0	-	200 only	200
Astropecten duplicatus	4	5	20	200 only	200
Tethyaster grandis	38	5	190	shelf-250	200
Anthenoides piercei	66	35	2310	shelf-250	200
Rosaster alexandri	14	5	70	150-300	200
Luidia elegans	41	5	205	200 only	200
Luidia clathrata	1	5	5	250 only	250
Luidia barbadensis	2	5	10	150-400	250
Cheiraster echinulatus	40	10	400	150-800	400
Benthopecten sp.	3	0	-	600 only	600
Pseudarchaster gracilis	4	0	-	550-750	600
Cheiraster enoplus	21	15	315	550-700	600
Pteraster militaroides	1	0	-	600 only	600
Astropecten americanus	92	35	3220	300-1050	600
Midgardia xandaros	20	10	200	500-1100	600
Persephonaster echinulatus	46	10	460	500-950	650
Doraster constellatus	37	5	185	400-1050	700
Ceramaster grenadensis	6	0	-	200-950	700
Psilaster cassiope	6	0	-	550-900	700
Cheiraster sp.	4	5	20	700 only	700
Brisingella verticellata	5	5	25	750 only	750
Cheiraster mirabilis	20	20	400	650-950	750
Goniopecten demonstrans	38	10	380	600-1050	800
Pseudarchaster sp.	4	0	-	600-1050	850
Psilaster patagiatus	14	5	70	800-950	850
Plinthaster dentatus	29	10	290	500-2750	900
Nymphaster arenatus	221	110	24310	400-3300	900
Astropecten sp.	60	10	600	100-1050	900
Zoroaster fulgens	33	5	165	650-2750	900
Mammaster sigsbeei	1	0	-	1000 only	1000
Brisinga costata	3	10	30	650-1300	1000

* Unknown

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Odontaster hispidus	17	0	-	1050 only	1050
Plutonaster intermedius	441	55	24255	750-1450	1050
Poranisca lepida	1	0	-	1050 only	1050
Pteraster acicula	9	5	45	1200-1450	1300
Pteraster abyssorum	1	5	5	1400 only	1400
Astropecten antillensis	5	5	25	1850 only	1850
Hymenaster anomalus	5	0	-	2000 only	2000
Evoplosoma n. sp.	1	0	-	2050 only	2050
Pteraster personatus	2	0	-	1750-2250	2050
Ceramaster sp.	1	0	-	2050 only	2050
Drachmaster sp.	1	0	-	2050 only	2050
Hymenaster rex	3	0	-	2100-2250	2150
Marsipaster sp.	1	0	-	2050 only	2050
Near *Marsipaster*	3	0	-	2100 only	2100
Hymenaster modestus	1	0	-	2150 only	2150
Calyptraster coa	1	0	-	2150 only	2150
Benthopecten simplex	68	20	1360	2000-3300	2750
Psilaster sp.	1	5	5	2750 only	2750
Dipsacaster antillensis	3	5	15	750-3700	3050
Ampheraster alaminos	130	40	5200	2750-3300	3250
Dytaster insignis	191	80	15280	800-3840	3250
Litonotaster intermedius	79	30	2370	1450-3450	3250
Paragonaster subtilis	16	10	160	3000-3250	3250
Hydrasterias ophidion	20	5	100	3300 only	3300

(II) Dominant starfishes presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Nymphaster arenatus	900
Plutonaster intermedius	1050
Dytaster insignis	3250
Ampheraster alaminos	3250
Astropecten americanus	600
Litonotaster intermedius	3250
Anthenoides piercei	200
Benthopecten simplex	2750
Astropecten nitidus	150

Table 4. Distribution of species of asteroids among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	13	5	18
Archibenthal Zone (475-950 m)	20	5	25
Upper Abyssal (975-2250 m)	18	13	31
Mesoabyssal (2275-3200 m)	3	7	10
Lower Abyssal (3225-3850)	5	3	8

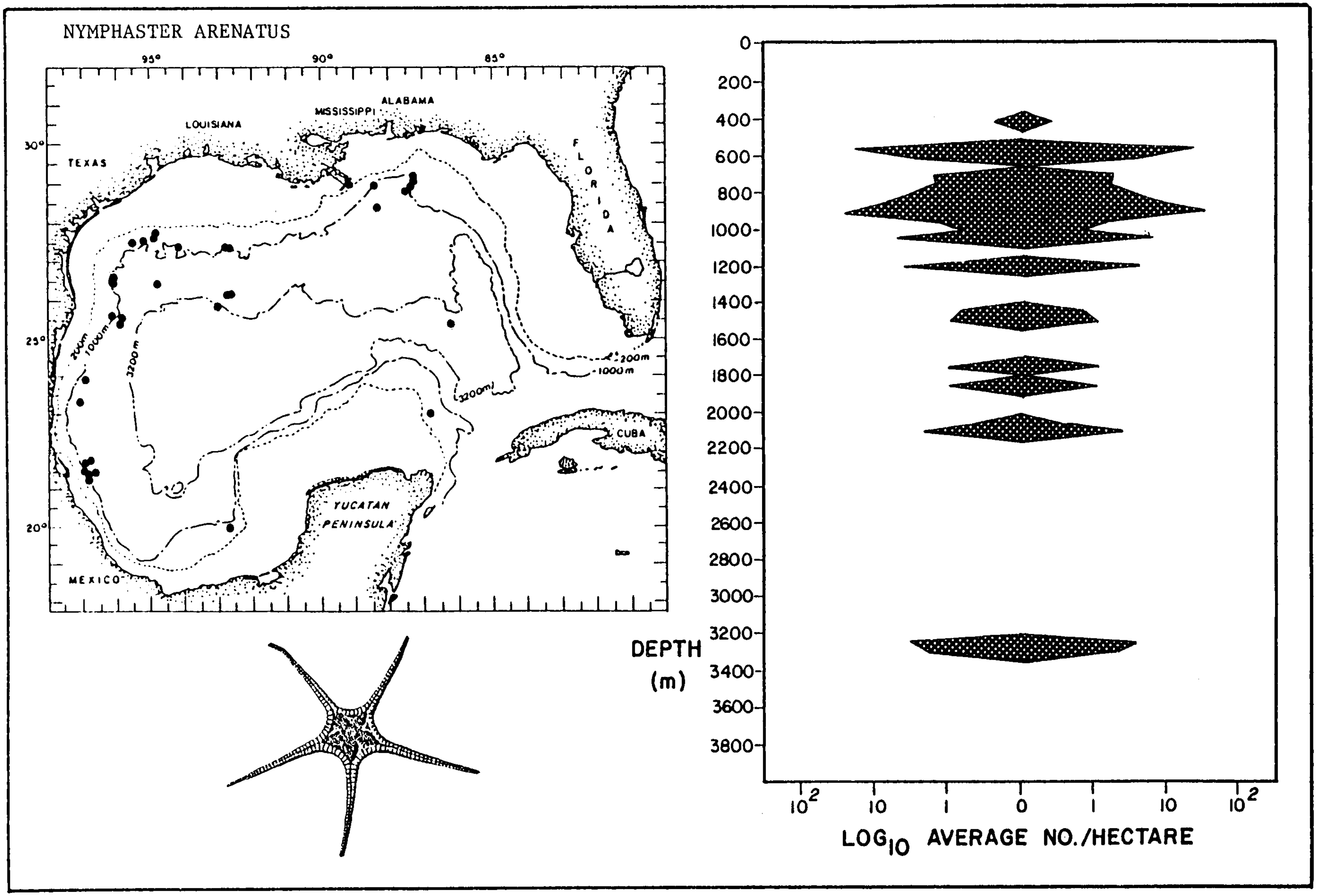

Figure 5. Horizontal and vertical distribution (including population density) of the asteroid <u>Nymphaster arenatus</u> in the deep Gulf of Mexico. (See page 23 for explanation of kite diagrams.)

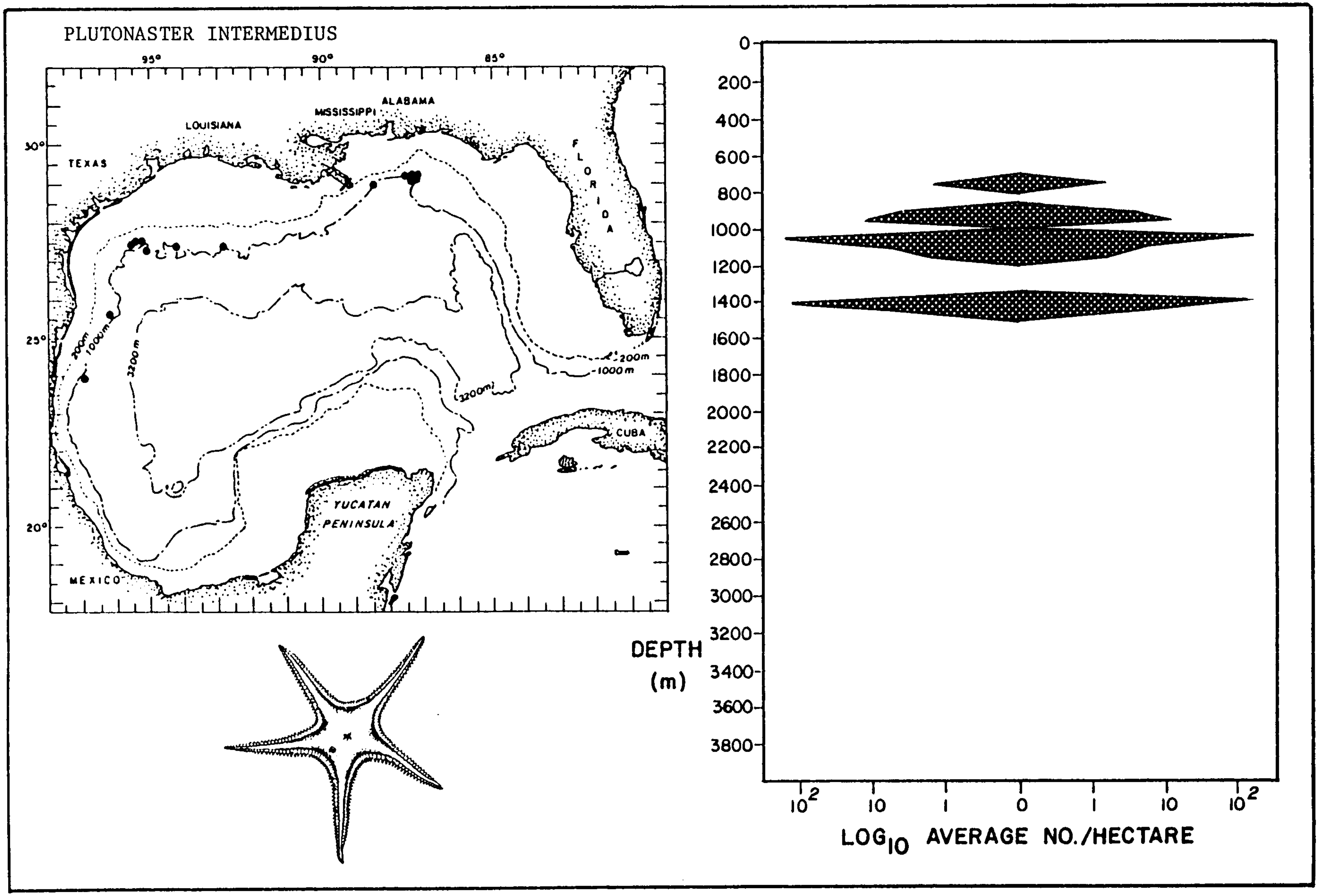

Figure 6. Horizontal and vertical distribution (including population density) of the asteroid <u>Plutonaster</u> <u>intermedius</u> in the deep Gulf of Mexico.

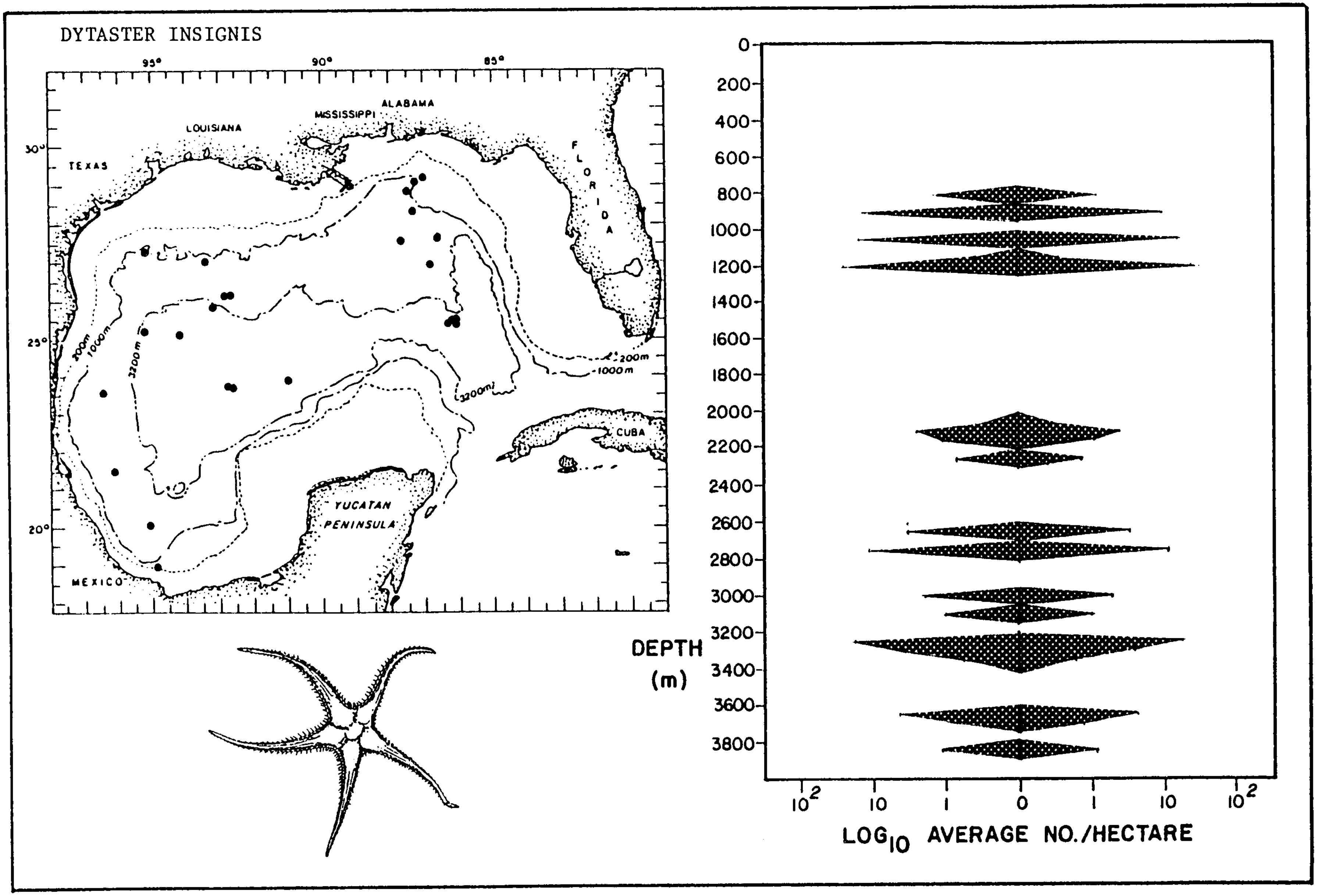

Figure 7. Horizontal and vertical distribution (including population density) of the asteroid *Dytaster insignis* in the deep Gulf of Mexico.

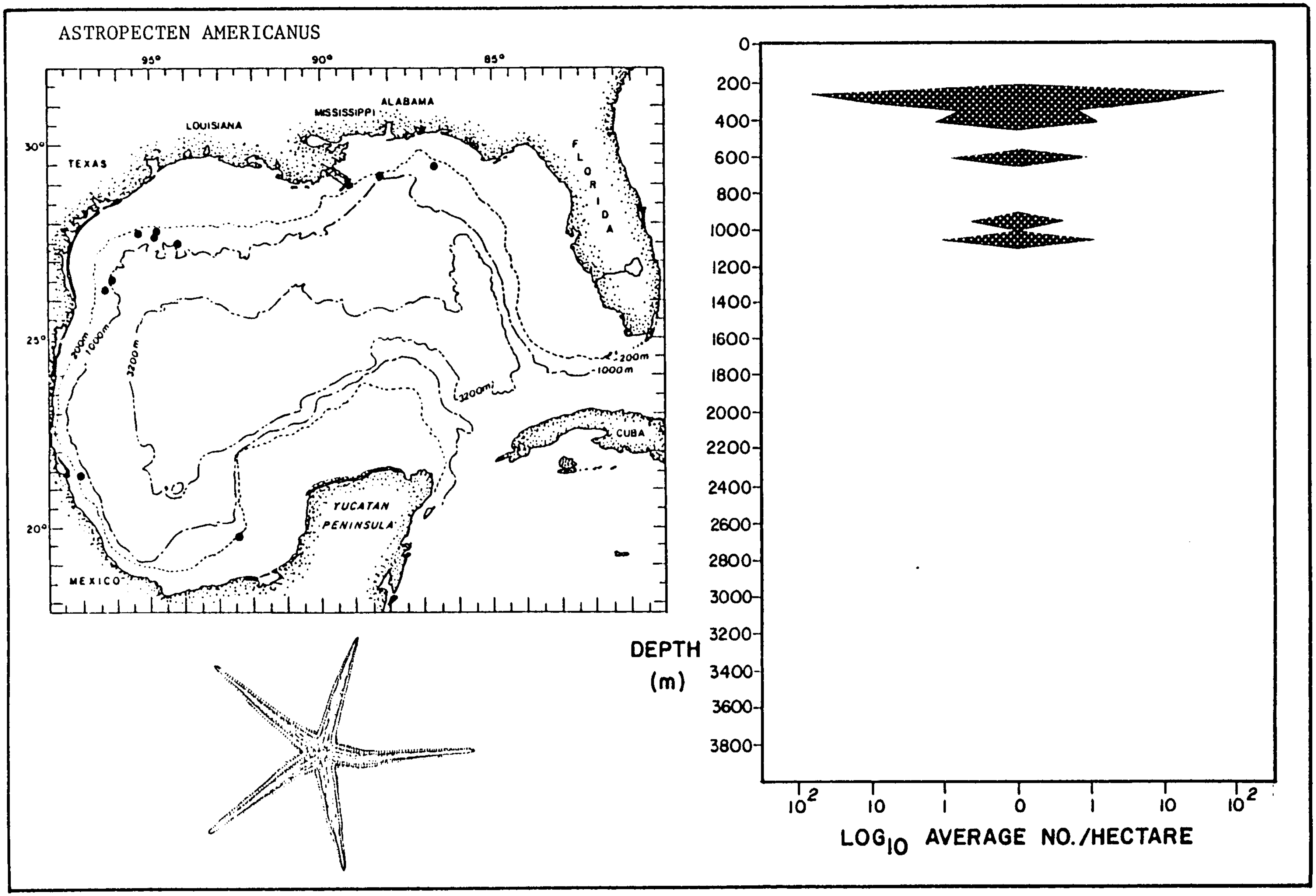

Figure 8. Horizontal and vertical distribution (including population density) of the asteroid <u>Astropecten americanus</u> in the deep Gulf of Mexico.

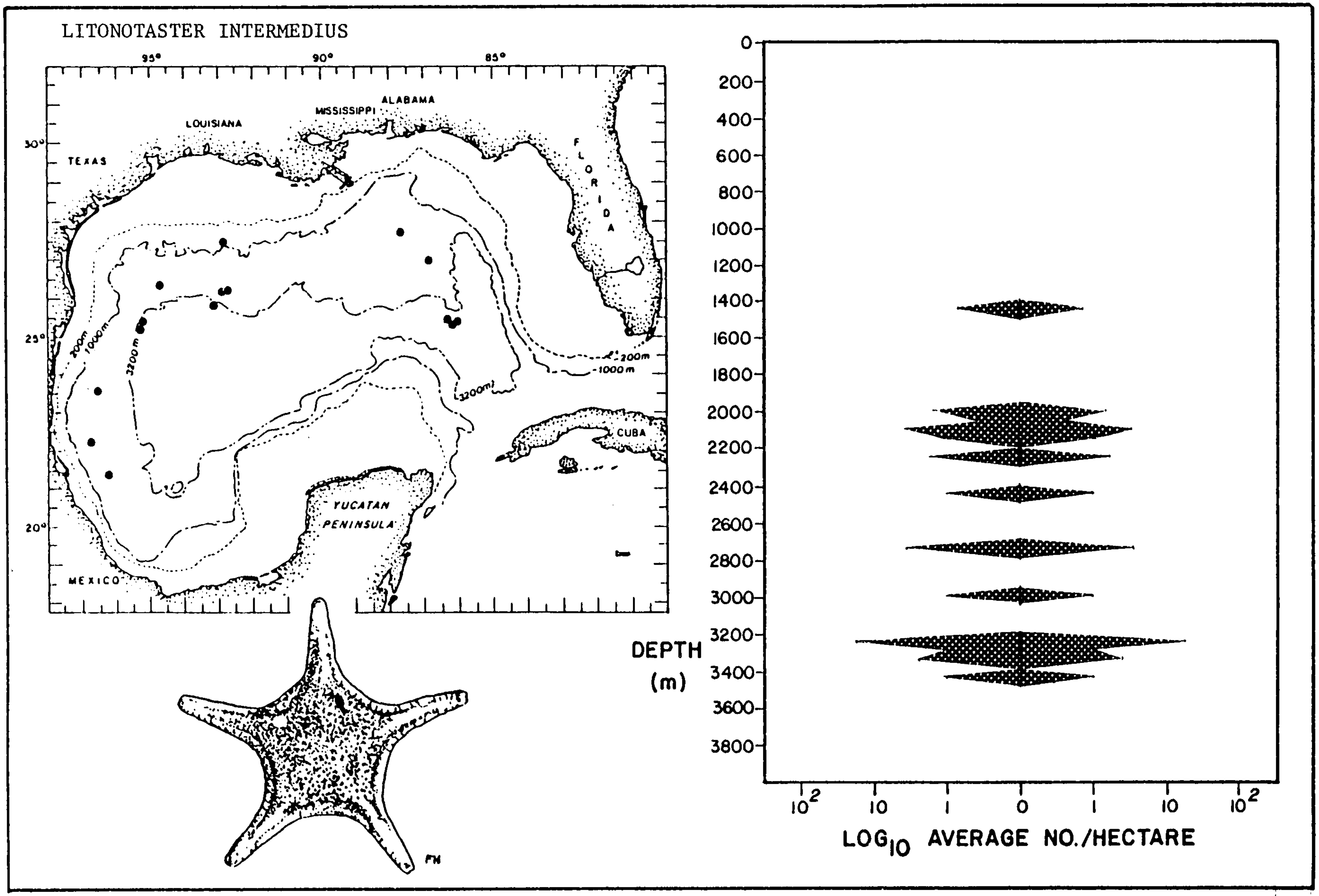

Figure 9. Horizontal and vertical distribution (including population density) of the asteroid <u>Litonotaster intermedius</u> in the deep Gulf of Mexico.

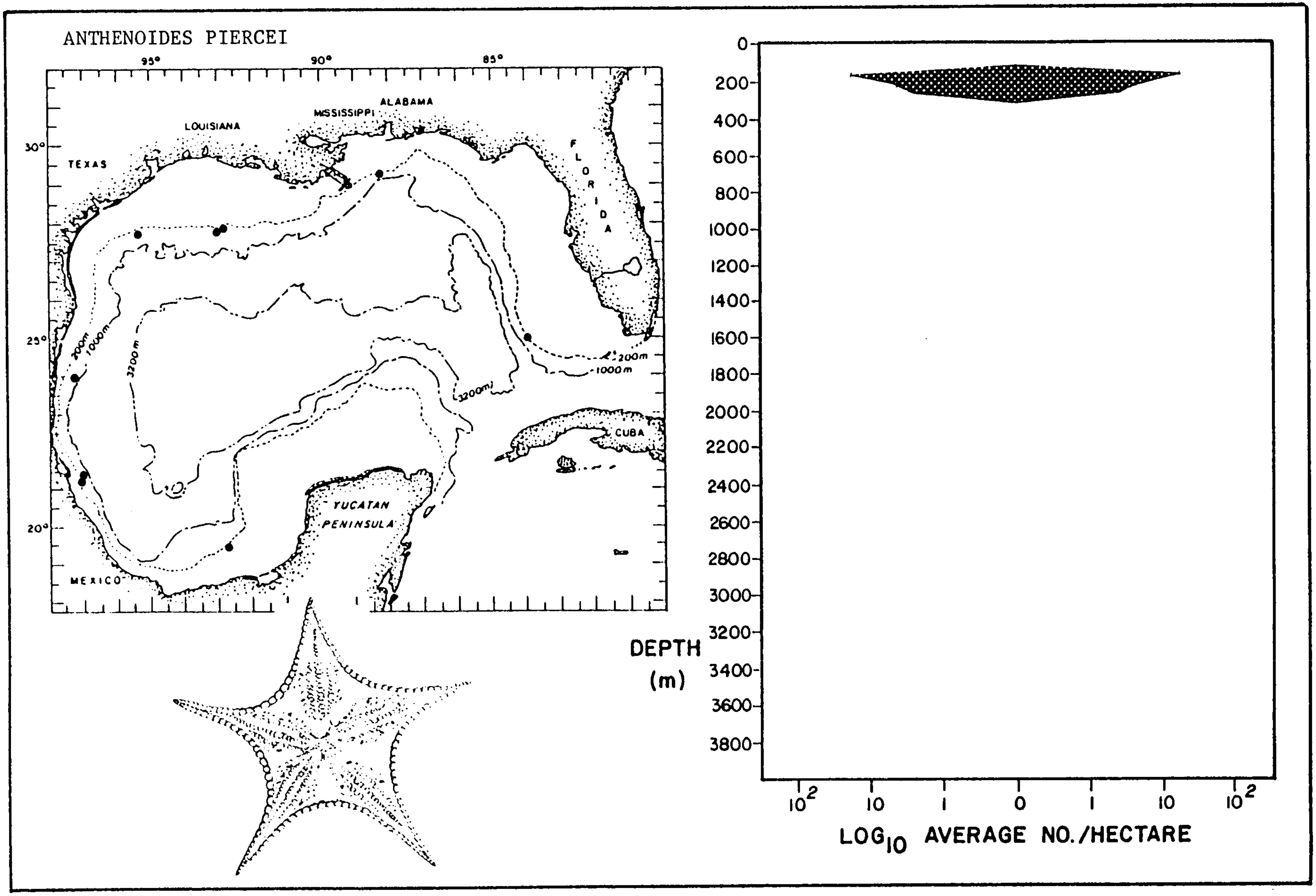

Figure 10. Horizontal and vertical distribution (including population density) of the asteroid *Anthenoides piercei* in the deep Gulf of Mexico.

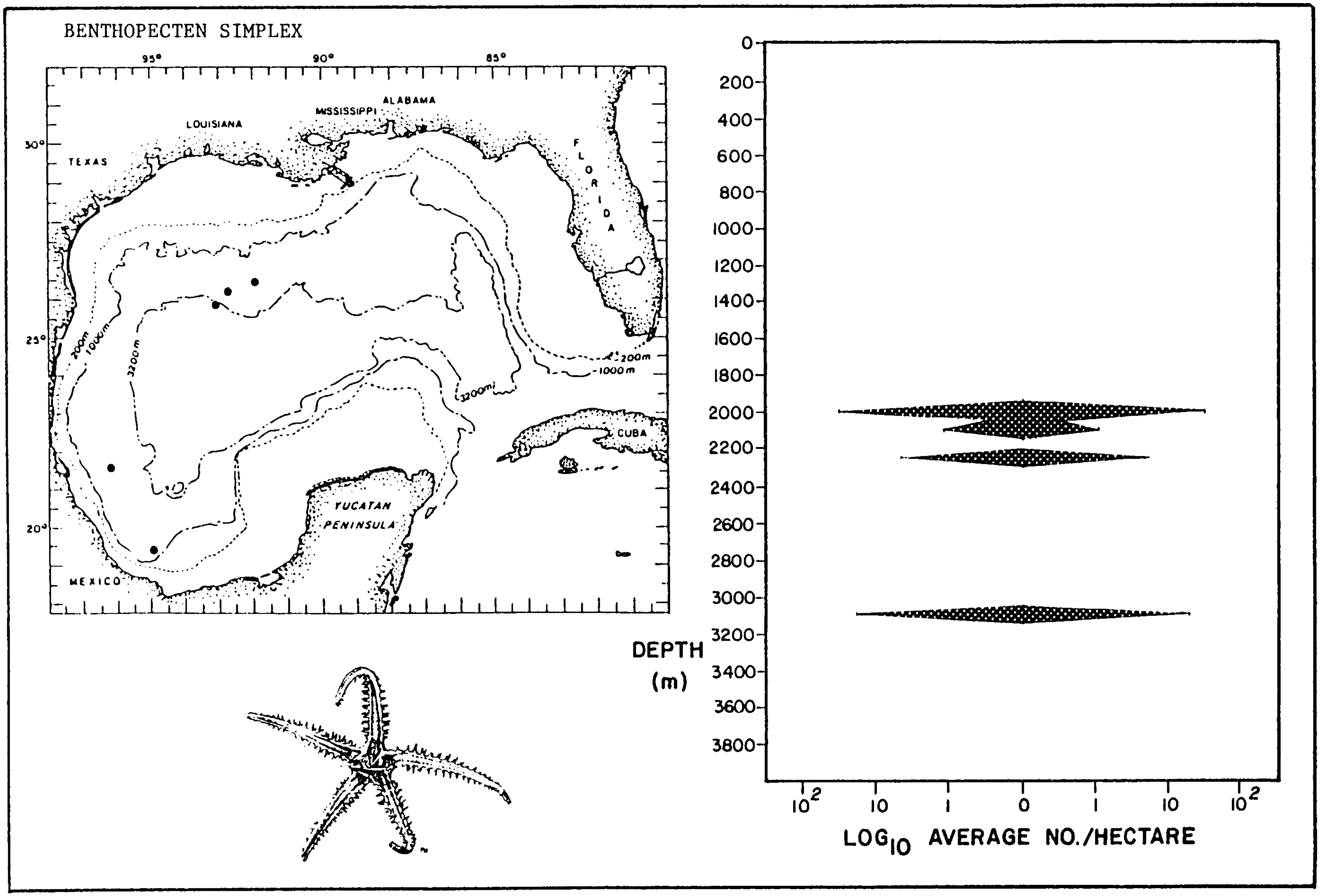

Figure 11. Horizontal and vertical distribution (including population density) of the asteroid <u>Benthopecten simplex</u> in the deep Gulf of Mexico.

Table 5. (I) Echinoidea found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of sea-urchins in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Clypeaster ravenelii	12	10	120	shelf only	*
Coelopleurus floridanus	1	0	-	shelf-150	*
Lytechinus euerces	1	0	-	shelf-150	*
Echinocardium cordatum	1	0	-	shelf-150	*
Conolampas sigsbei	1	0	-	shelf-150	*
Genocidarus maculata	6	5	30	shelf-150	*
Stylocidaris sp.	5	0	-	shelf-150	*
Stylocidaris affinis	83	10	830	150-400	150
Echinolampas depressa	14	5	70	150-800	200
Brissopsis elongata	26	0	-	200 only	200
Brissopsis alta	297	40	11880	150-300	200
Brissopsis alta-elongata	1103	5	5515	200 only	200
Brissopsis atlantica	3688	30	110640	150-400	200
Brissopsis elongata-atlantica	524	10	5240	200 only	200
Hypselaster limicolus	248	10	2480	150-300	200
Brissopsis sp.	1220	15	18300	200-800	250
Araeosoma fenestratum	1	0	-	400 only	400
Palaeobrissus hilgardi	1	0	-	400 only	400
Podocidaris sculpta	1	0	-	400 only	400
Agassizia excentrica	4	10	40	300-500	400
Echinocyamus sp.	1	5	5	600 only	600
Homolampas fragilis	3	5	15	700 only	700
Phormosoma placenta	2121	140	296940	400-2350	700
Hemiaster expergitus	1	0	-	750 only	750
Plesiodiadema antillarum	23658	130	3075540	700-2250	900
Hypselaster brachypetalus	12	5	60	900 only	900
Echinus alexandri	1	5	5	1050 only	1050
Echinocyamus grandiporus	6	5	30	2100 only	2100
Hygrosoma petersii	13	0	-	2100-2150	2150
Phormosa placenta sigsbei	12	0	-	2100-2250	2250
Sarsiaster griegii	100	5	500	2750 only	2750
Aceste bellidifera	1	5	5	3350 only	3350

* Unknown

(II) Dominant sea-urchins presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Plesiodiadema antillarum	900
Phormosoma placenta	700
Brissopsis atlantica/alta/elongata	200
Brissopsis sp.	250
Hypselaster limicolus	200
Stylocidaris affinis	150
Sarsiaster griegii	2750

Table 6. Distribution of species of echinoids among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	13	7	20
Archibenthal Zone (475-950 m)	6	3	9
Upper Abyssal (975-2250 m)	4	2	6
Mesoabyssal (2275-3200 m)	1	1	2
Lower Abyssal (3225-3850)	1	0	1

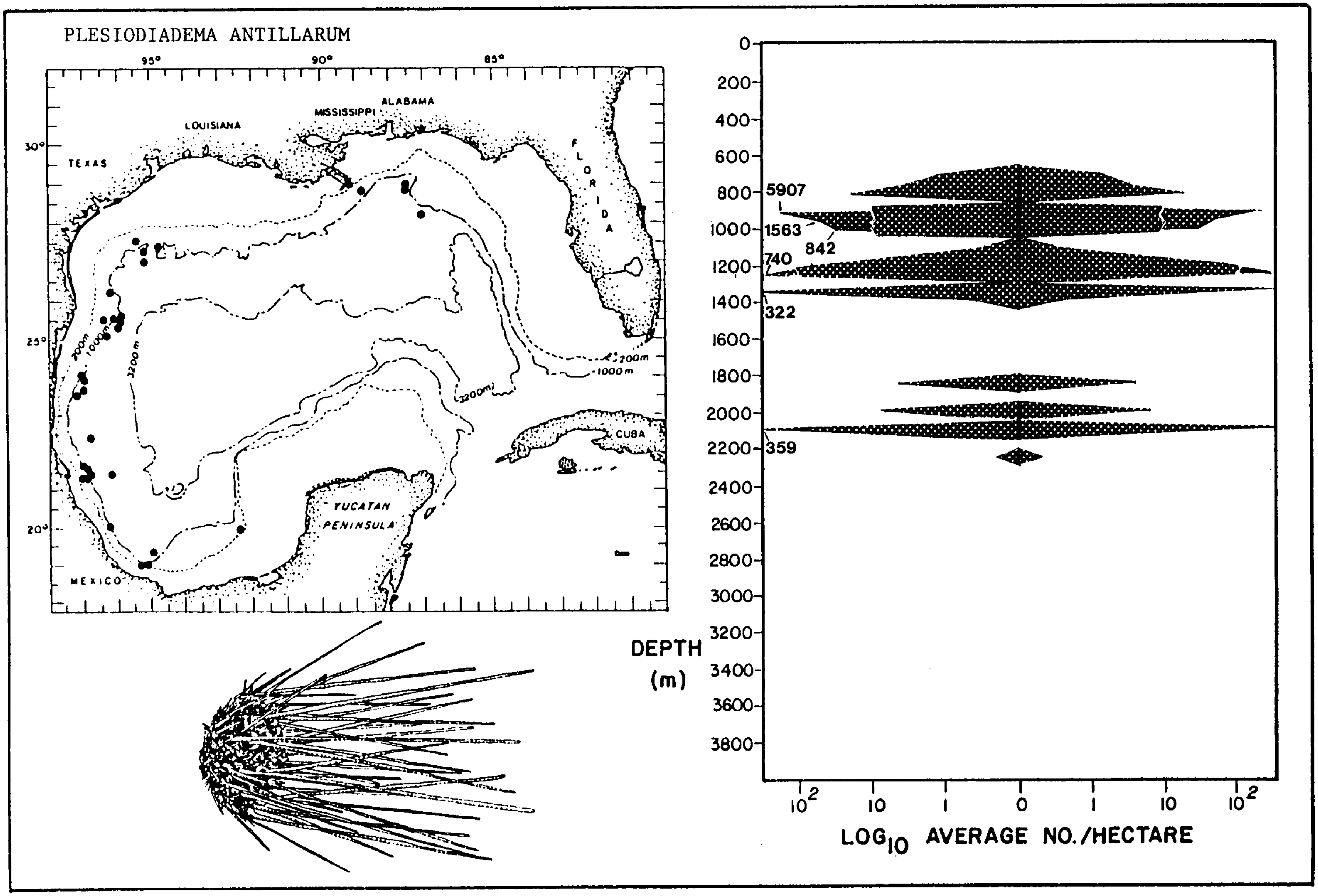

Figure 12. Horizontal and vertical distribution (including population density) of the echinoid Plesiodiadema antillarum in the deep Gulf of Mexico.

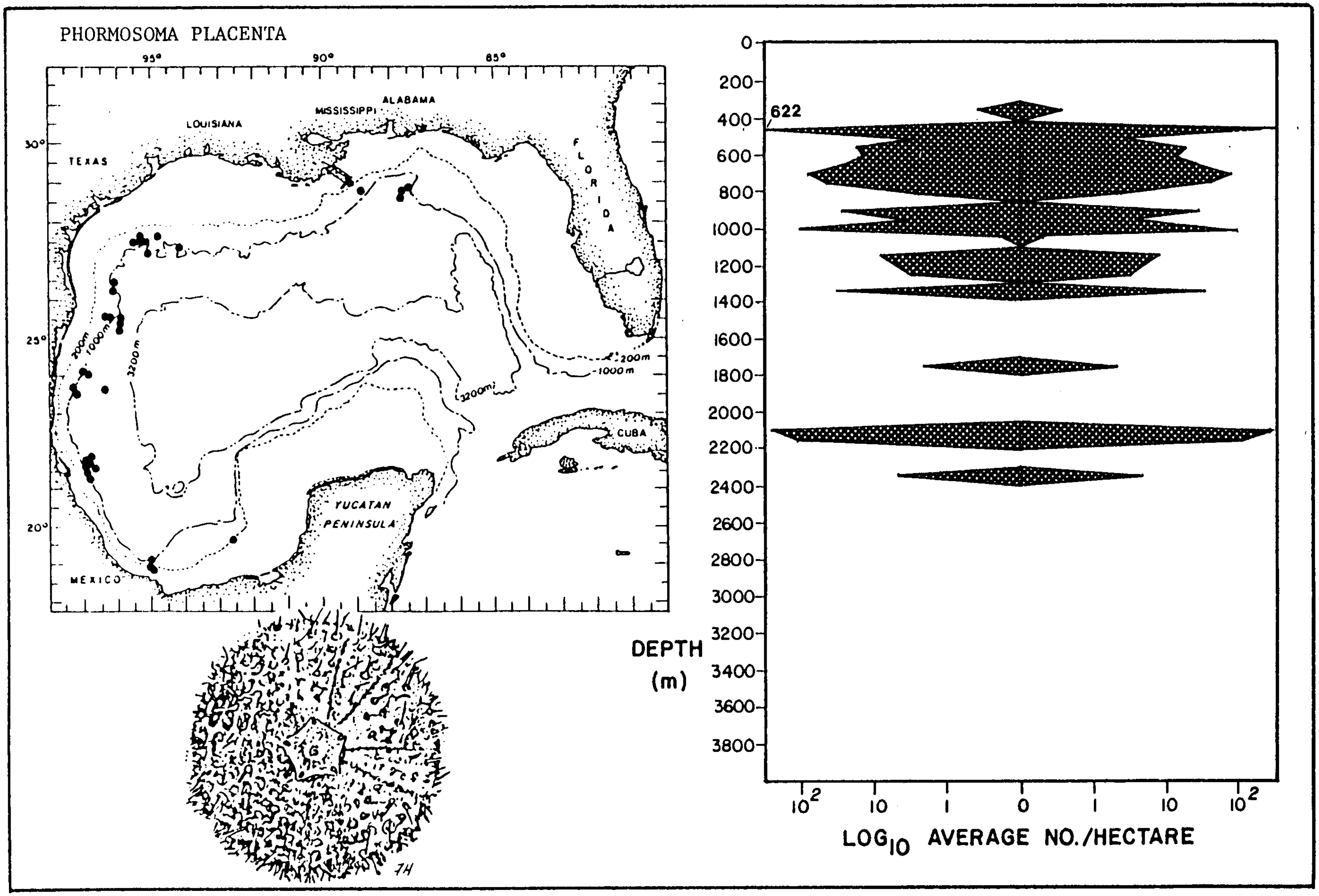

Figure 13. Horizontal and vertical distribution (including population density) of the echinoid <u>Phormosoma placenta</u> in the deep Gulf of Mexico.

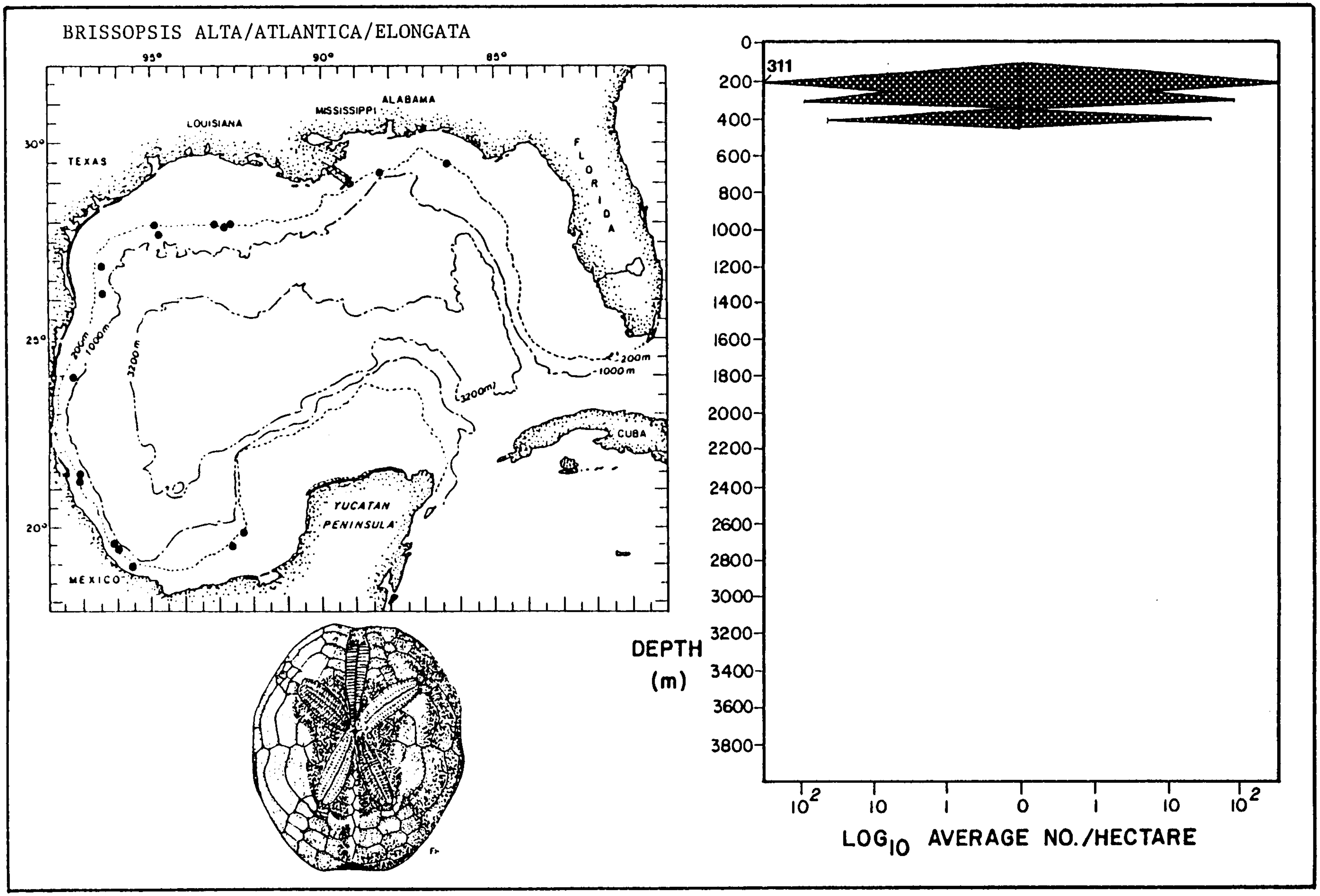

Figure 14. Horizontal and vertical distribution (including population density) of the echinoid <u>Brissopsis</u> <u>alta</u>/<u>atlantica</u>/<u>elongata</u> in the deep Gulf of Mexico.

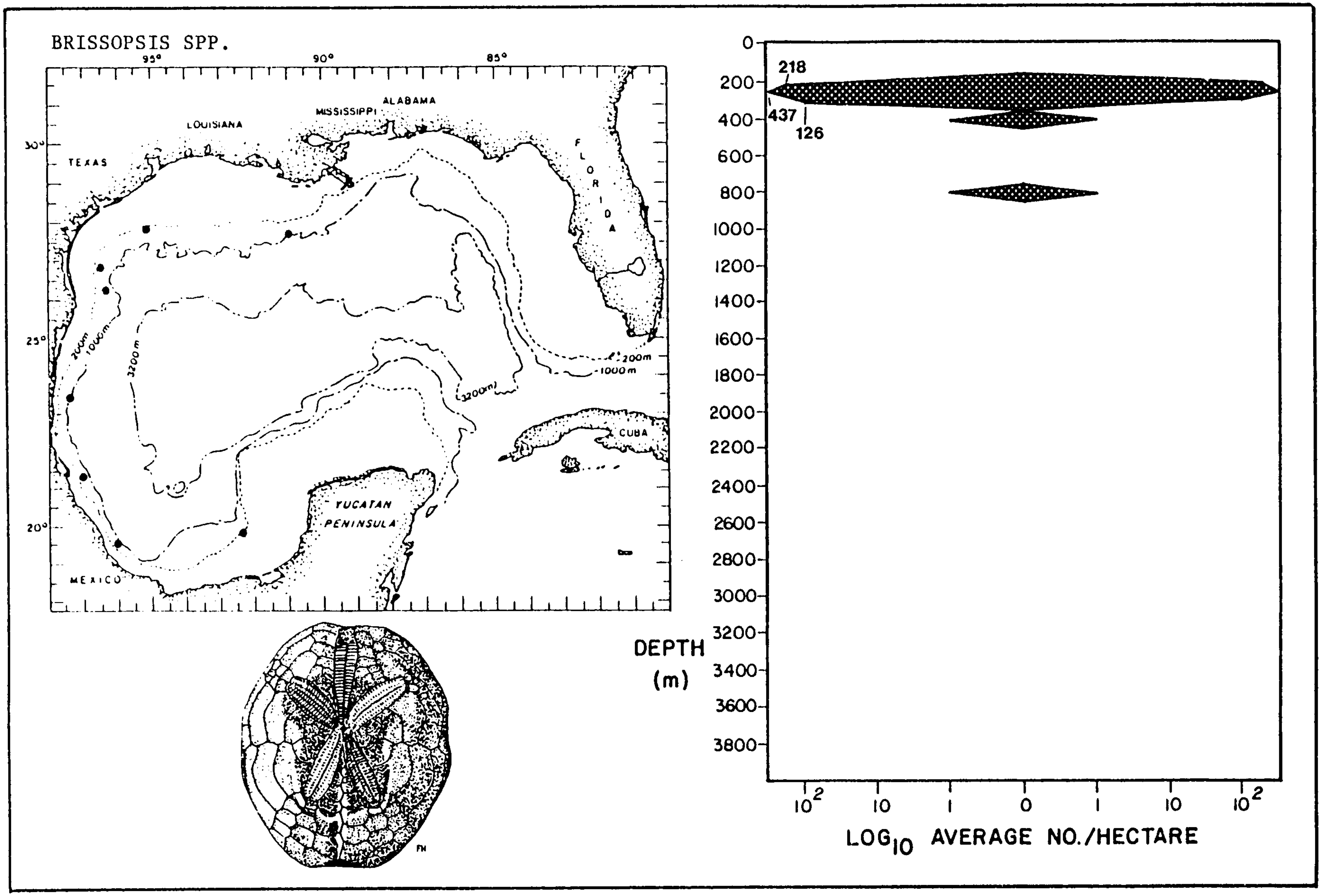

Figure 15. Horizontal and vertical distribution (including population density) of the echinoid <u>Brissopsis</u> spp. in the deep Gulf of Mexico.

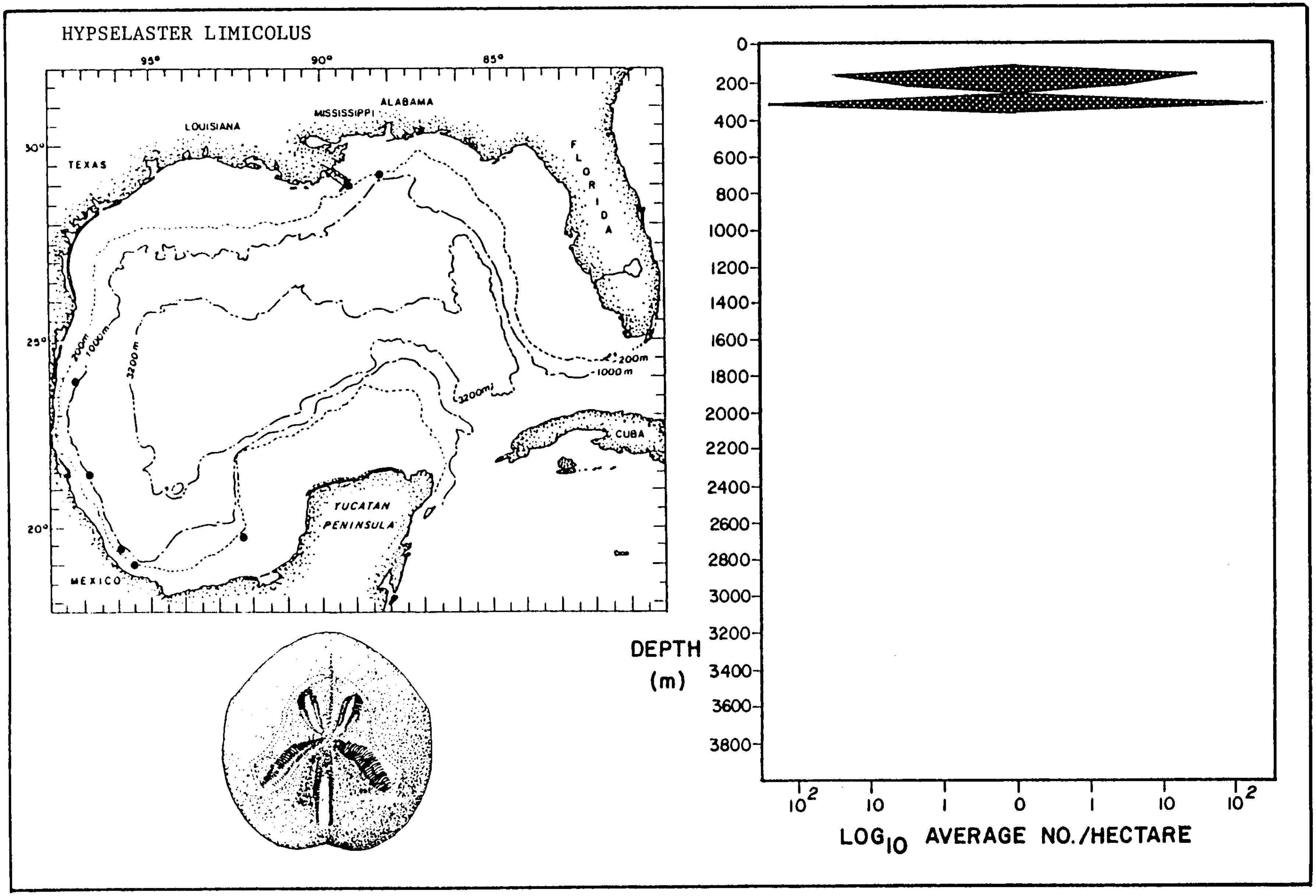

Figure 16. Horizontal and vertical distribution (including population density) of the echinoid *Hypselaster limicolus* in the deep Gulf of Mexico.

Table 7. (I) Ophiuroidea found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of brittle stars in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Ophiophragmus filograneus	1	0	-	150 only	150
Ophiostigma isacanthum	10	5	50	150 only	150
Ophioderma sp.	1	0	-	150 only	150
Ophiolepis sp.	44	5	220	350 only	350
Amphiura semiermis	11	5	55	350-500	450
Amphichilus dalous	44	0	-	450 only	450
Amphioplus tumidus	44	0	-	450 only	450
Amphitarsus nike	3	0	-	500 only	500
Ophioplax ljungmani	2	0	-	500-600	550
Ophioleptoplax sp.	1	0	-	550 only	550
Ophiernus adspersum	745	75	55875	450-1850	600
Ophiopyren sp.	39	0	-	500-750	600
Ophiochiton grandis	18	10	180	500-1050	600
Bathypectinura lacertosa	1	0	-	600 only	600
Ophiocamax fasciculata	26	5	130	700 only	700
Bathypectinura heros	255	90	22950	550-3250	750
Ophiomusium monoplax	1	0	-	750 only	750
Ophiura lepida	42	5	210	750 only	750
unidentified Ophiuroidae	2	15	30	200-1350	800
Ophiomusium sp.	1	0	-	800 only	800
Amphiophiura sp.	2	0	-	500-1200	850
unidentified Amphiuridae	2	5	10	900 only	900
unidentified Ophiuroidea	1084	0	-	150-3250	950
Ophioplinthaca dipsacos	17	10	170	900-950	950
Ophiodictys sp.	1	0	-	950 only	950
unidentified Ophiocomidae	1	0	-	950 only	950
Amphiura spp.	5	15	75	750-1500	1150
Homalophiura sp.	243	5	1215	1200 only	1200
Ophiura spp.	62	20	1240	1250-1500	1350
Amphichilus incisus	2	0	-	1350 only	1350
Amphiura otteri	2	0	-	1350 only	1350
Bathypectinura sp.	10	0	-	700-2200	1450
Ophiomusium sp.	6	5	30	800-2650	1750
Ophiopyren cf. *longispinus*	1	5	5	1750 only	1750
Amphioplus sp.	2	5	10	550-3100	1800
Ophiomusium eburneum	4	0	-	500-3250	1850
Ophiomusium spinigerum	1	5	5	2100 only	2100
Silax verrilli	15	0	-	2750 only	2750
Homalophiura cf. *inornata*	19	5	95	2750-3100	3000
Homalophiura abyssorum	16	5	80	3000 only	3000
Amphilepis norvegica	7	0	-	3000-3250	3150
Ophiomusium planum	1222	55	67210	2750-3750	3250
Amphilepis sp.	3	0	-	3250 only	3250

(II) Dominant brittle stars presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Ophiomusium planum	3250
Ophiernus adspersum	600
Bathypectinura heros	750
Ophiura spp.	1350
Homalophiura sp.	1200

Table 8. Distribution of species of ophiuroids among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	7	3	10
Archibenthal Zone (475-950 m)	19	6	25
Upper Abyssal (975-2250 m)	11	6	17
Mesoabyssal (2275-3200 m)	4	6	10
Lower Abyssal (3225-3850)	2	4	6

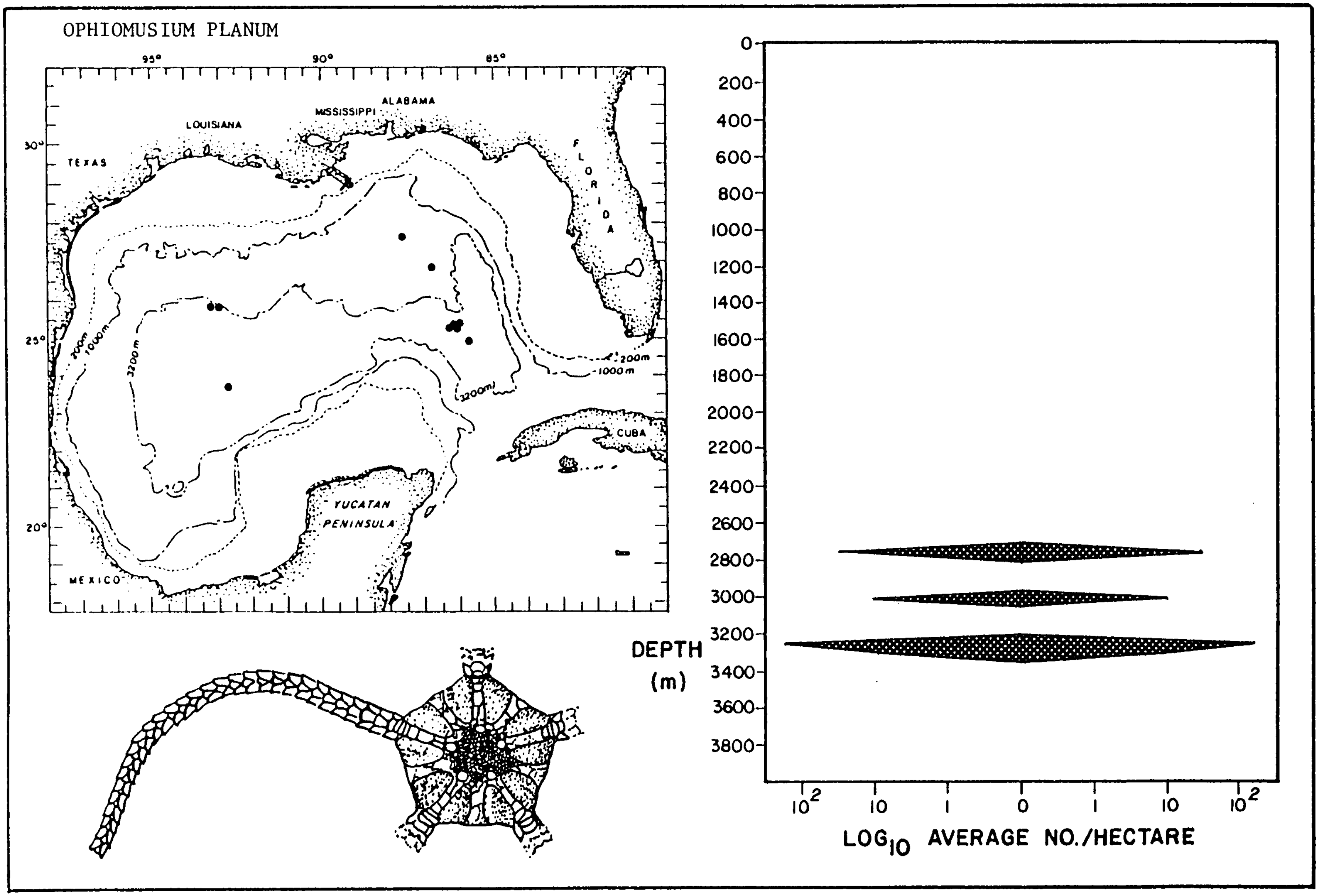

Figure 17. Horizontal and vertical distribution (including population density) of the ophiuroid <u>Ophiomusium planum</u> in the deep Gulf of Mexico.

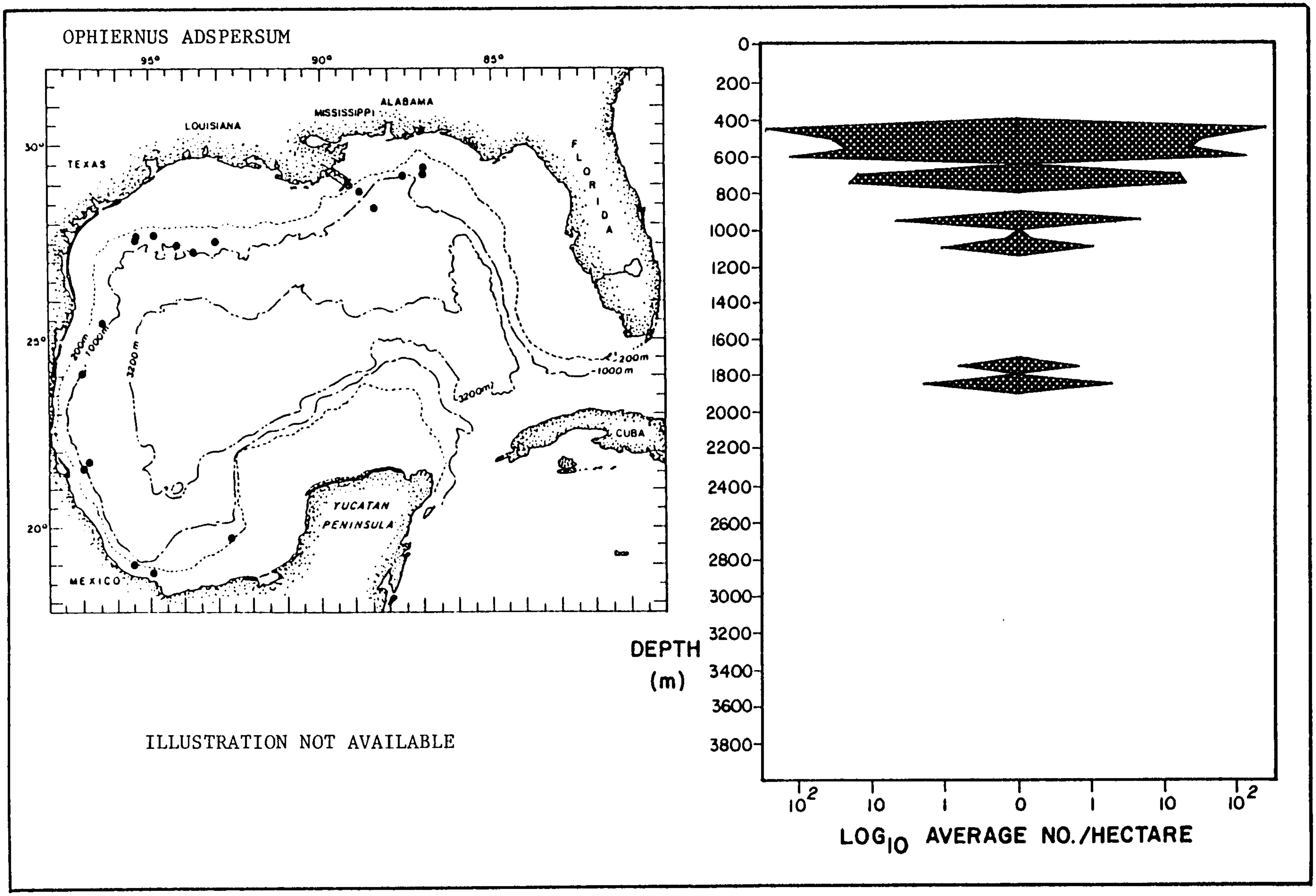

Figure 18. Horizontal and vertical distribution (including population density) of the ophiuroid <u>Ophiernus adspersum</u> in the deep Gulf of Mexico.

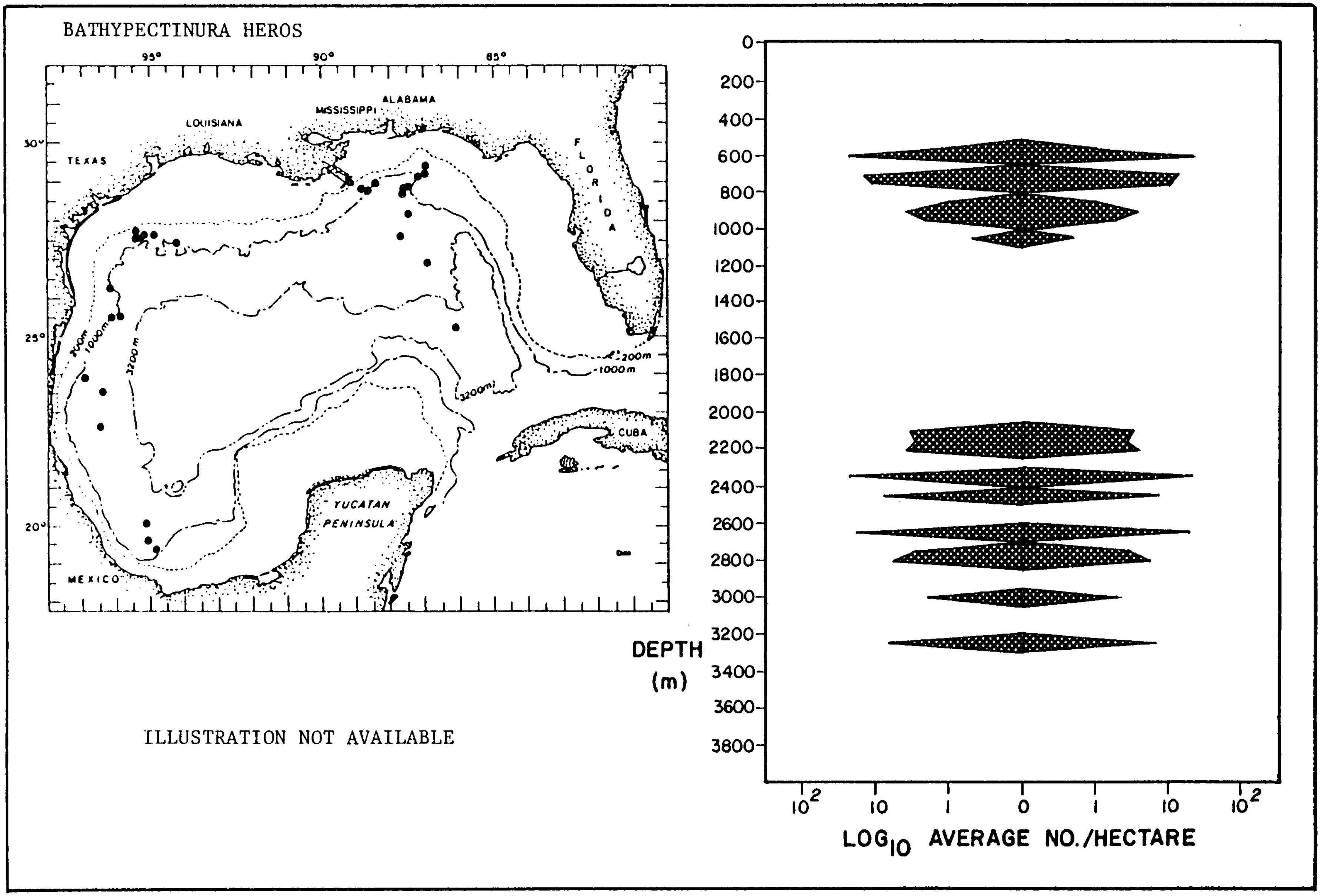

Figure 19. Horizontal and vertical distribution (including population density) of the ophiuroid <u>Bathypectinura heros</u> in the deep Gulf of Mexico.

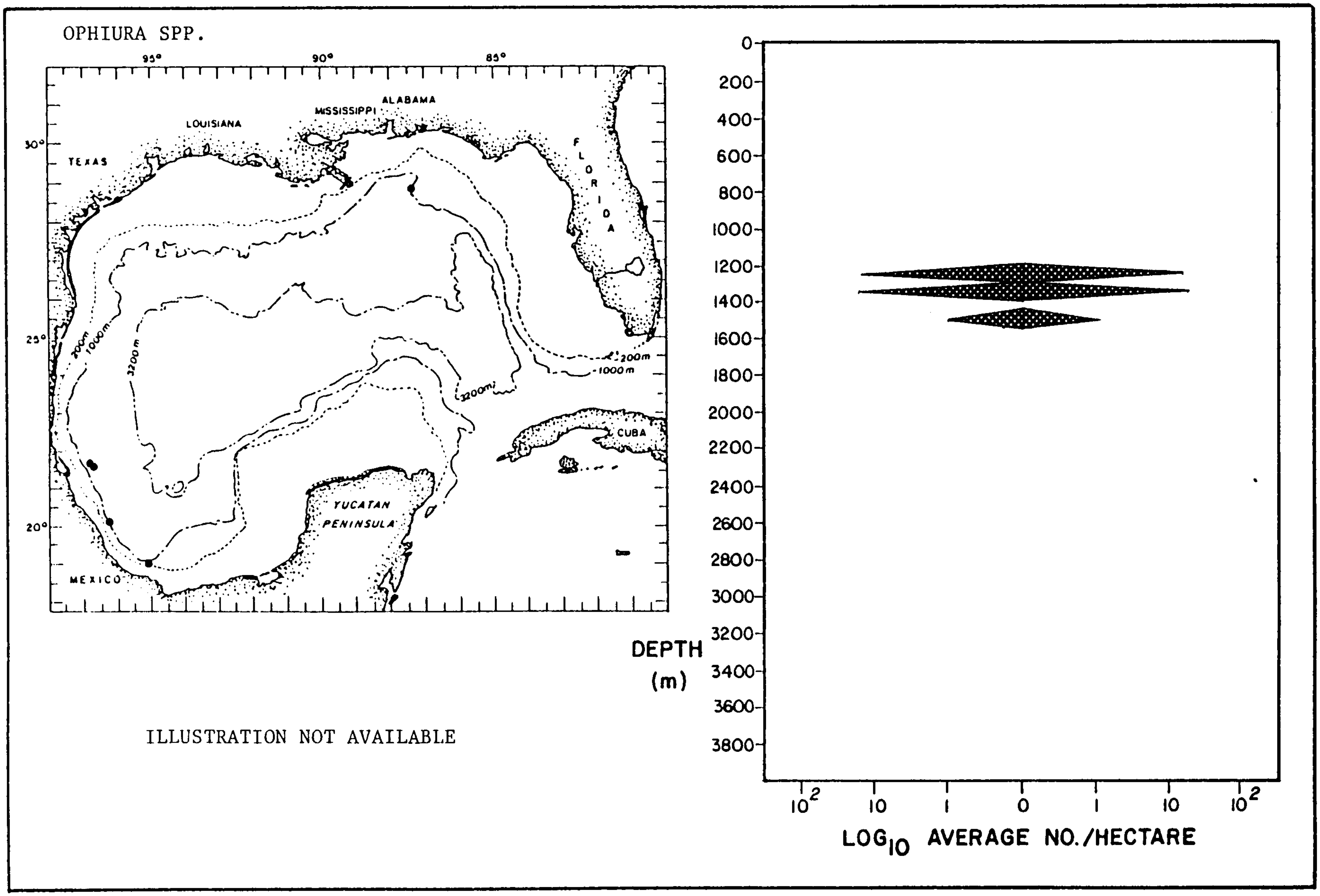

Figure 20. Horizontal and vertical distribution (including population density) of the ophiuroid <u>Ophiura</u> sp. in the deep Gulf of Mexico.

Table 9. (I) Holothuroidea found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of sea cucumbers in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Holothuria imperator	3	5	15	200 only	200
Bathyplotes natans	23	10	230	500-950	500
Molpadia cubana	11	20	220	200-1200	550
Hedingia albicans	18	15	270	500-750	600
Ypsilothuria talismani	35	5	175	550-600	600
Paracaudina sp.	4	5	20	650 only	650
Bathyplotes pourtalesi	2	5	10	650 only	650
Molpadia oolitica	7	5	35	500-3450	700
Protankyra sluiteri	1	5	5	750 only	750
Protankyra abyssicola	4	5	20	750-950	850
unidentified Holothuroidea	558	30	16740	200-3350	900
Molpadia barbouri	341	70	23870	200-2050	950
Molpadia musculus	423	60	25380	500-2050	950
Molpadia sp.	2	0	-	950 only	950
Benthodytes sanguinolenta	51	50	2550	700-2250	1000
Echinocucumis hispida	72	40	2880	800-1500	1000
Bathyplotes sp.	1	0	-	1000 only	1000
Mesothuria lactea	614	135	82890	500-2100	1050
Scotoanassa sp.	3	0	-	700-2350	1500
Enypniastes ecalcarea	4	0	-	950-2500	1750
Deima validum validum	24	20	480	1000-1850	1850
Molpadia blakei	50	35	1750	550-3350	2100
Paelopatides cf. *gigantea*	54	15	810	1000-3250	2100
Peniagone cf. *islandica*	4	0	-	2100 only	2100
Paroriza prouhoi	28	5	140	1100-2150	2150
Protankyra brychia	7	10	70	1850-2450	2350
Synallactidae	24	0	-	2150-3100	2350
Peniagone cf. *azorica*	1	0	-	2350 only	2350
Peniagone sp.	2	5	10	2650 only	2650
Psychropotes depressa	134	40	5360	1750-3850	2750
Mesothuria verrilli	29	5	145	2100-2750	2750
Mesothuria candelabri	4	5	20	2800 only	2800
Benthodytes lingua	48	10	480	950-3250	3250
Benthodytes typica	1125	110	123750	1350-3750	3250
Pseudostichopus sp.	10	10	100	1400-3840	3250
Pseudostichopus sp. A	15	0	-	2750-3300	3250
Psychropotes semperiana	43	25	1075	3300-3840	3700
Psychropotes cf. *longicauda*	3	0	-	3400-3800	3800

(II) Dominant sea cucumbers presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Benthodytes typica	3250
Mesothuria lactea	1050
Molpadia musculus	950
Molpadia barbouri	950
unidentified Holothuroidea	900
Psychropotes depressa	2750
Echinocucumis hispida	1000
Benthodytes sanguinolenta	1000
Molpadia blakei	2100
Psychropotes semperiana	3700
Benthodytes lingua	3250

Table 10. Distribution of species of holothurians among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	1	3	4
Archibenthal Zone (475-950 m)	13	7	20
Upper Abyssal (975-2250 m)	11	12	23
Mesoabyssal (2275-3200 m)	7	10	17
Lower Abyssal (3225-3850)	5	5	10

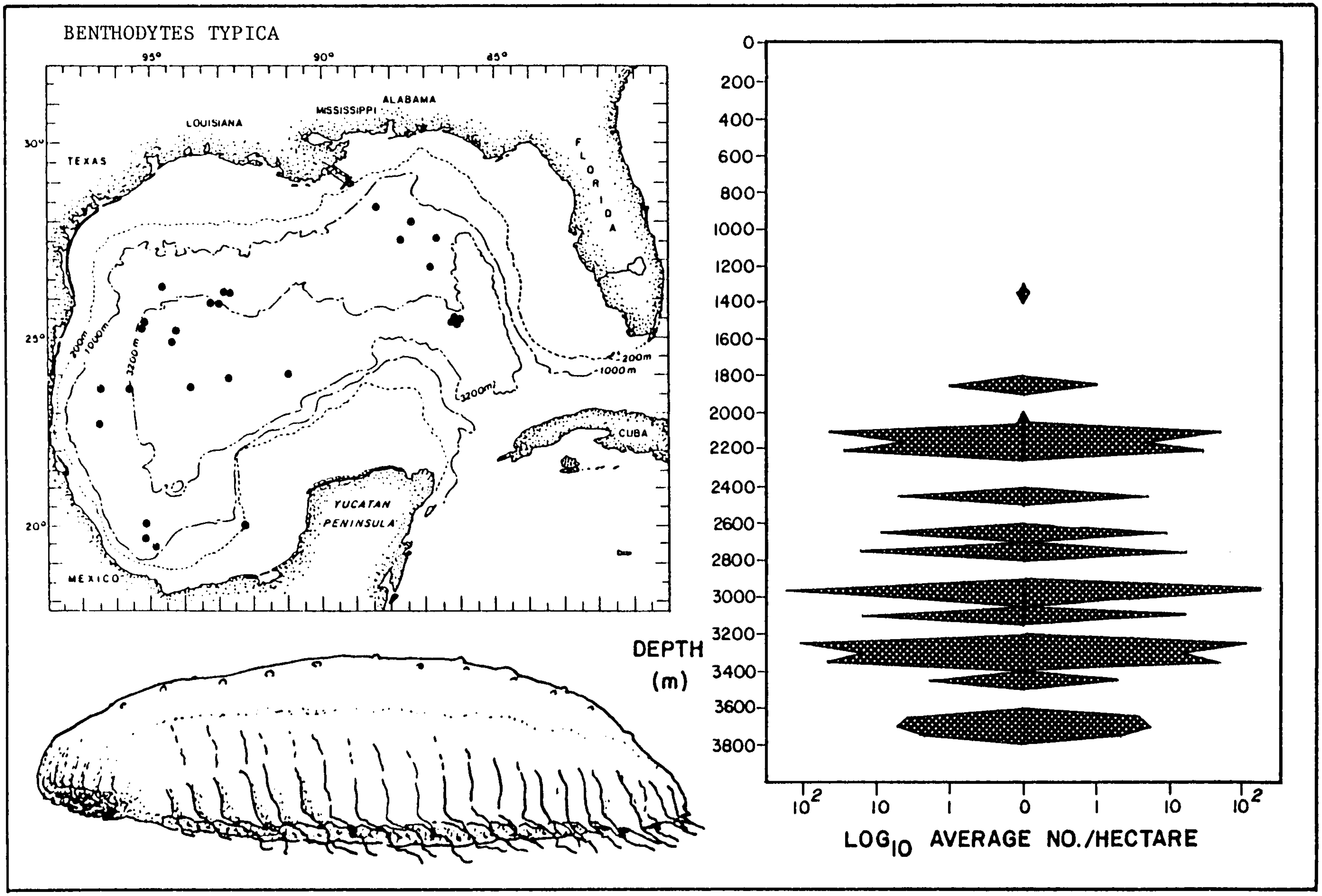

Figure 21. Horizontal and vertical distribution (including population density) of the holothuroid Benthodytes typica in the deep Gulf of Mexico.

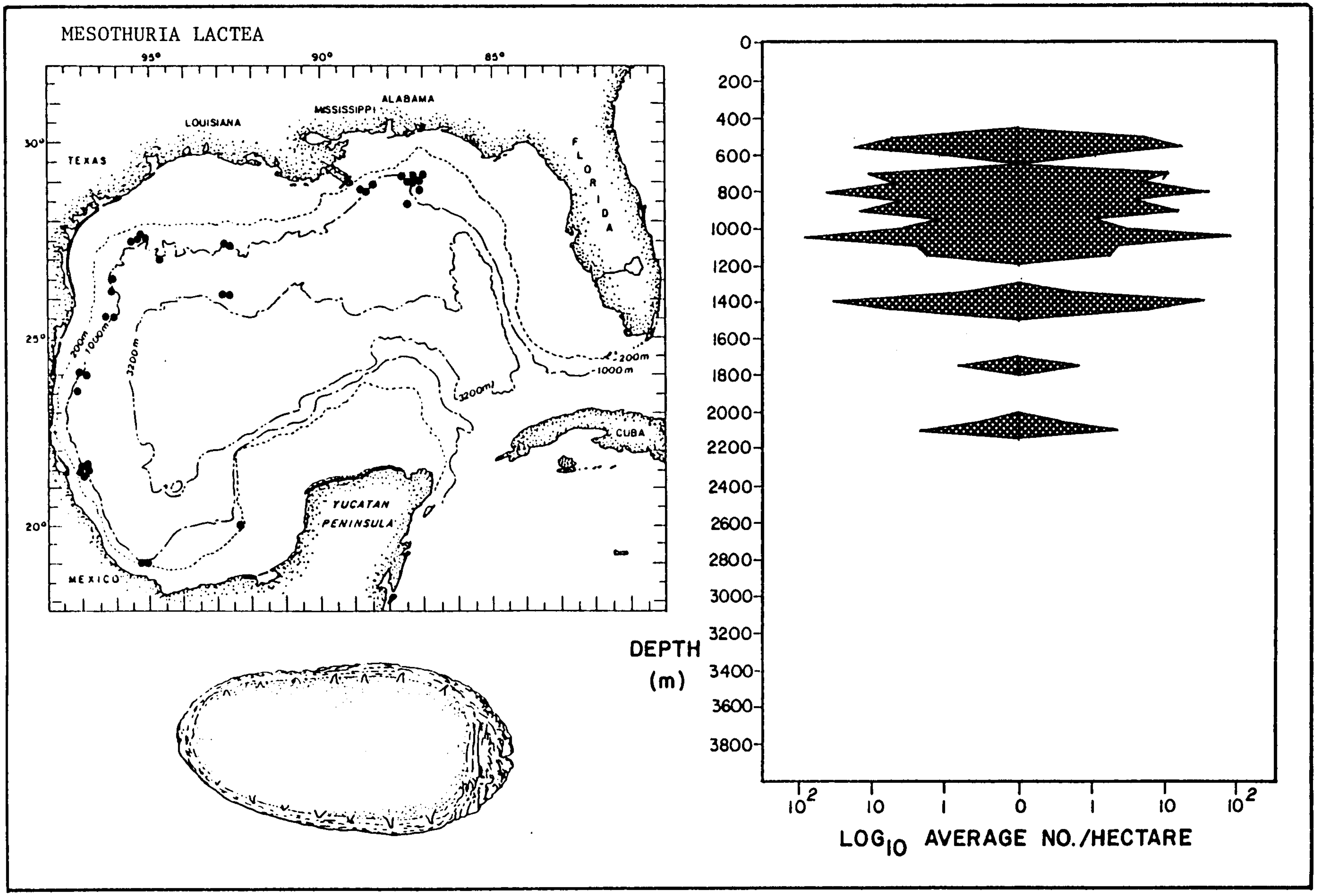

Figure 22. Horizontal and vertical distribution (including population density) of the holothuroid Mesothuria lactea in the deep Gulf of Mexico.

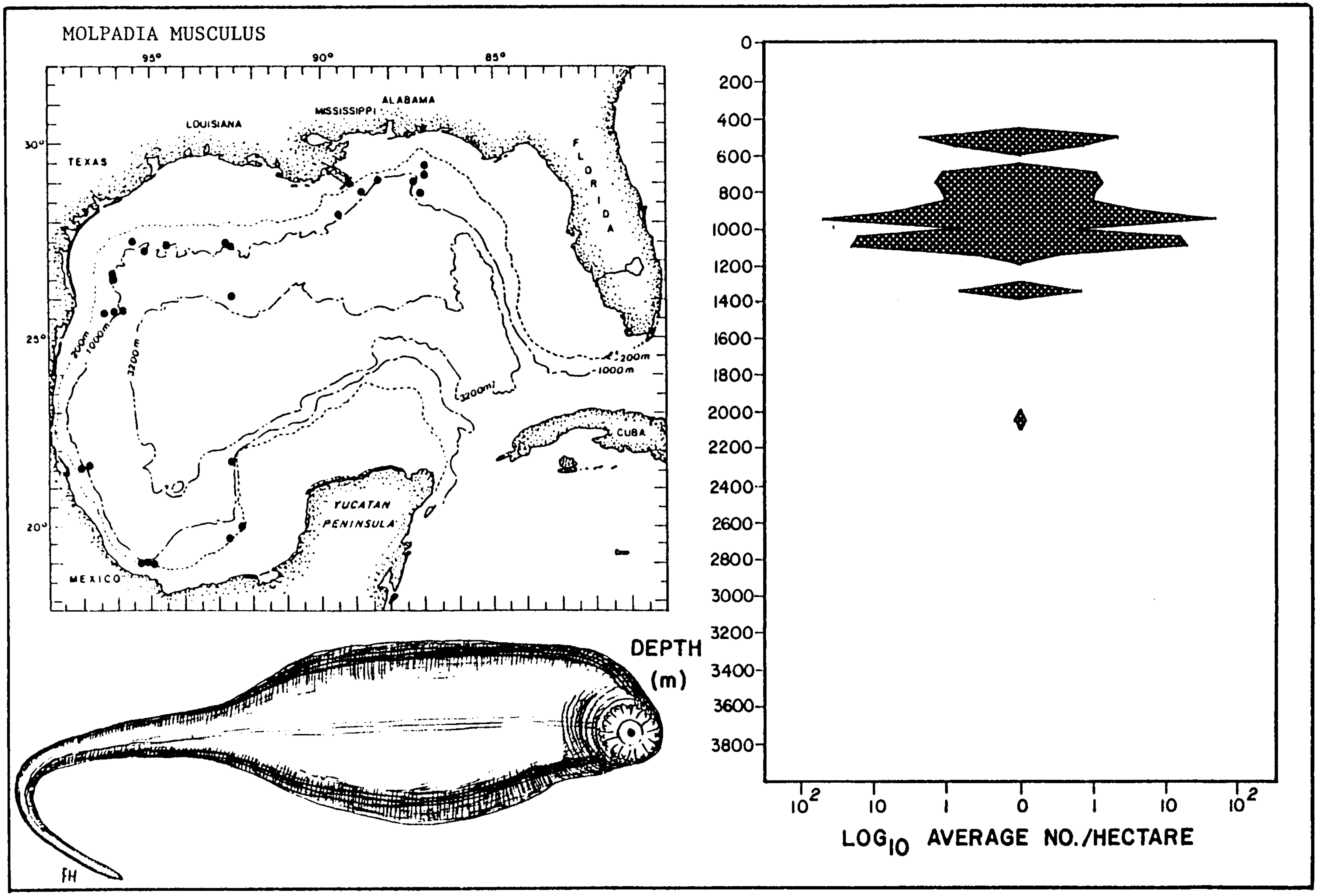

Figure 23. Horizontal and vertical distribution (including population density) of the holothuroid *Molpadia musculus* in the deep Gulf of Mexico.

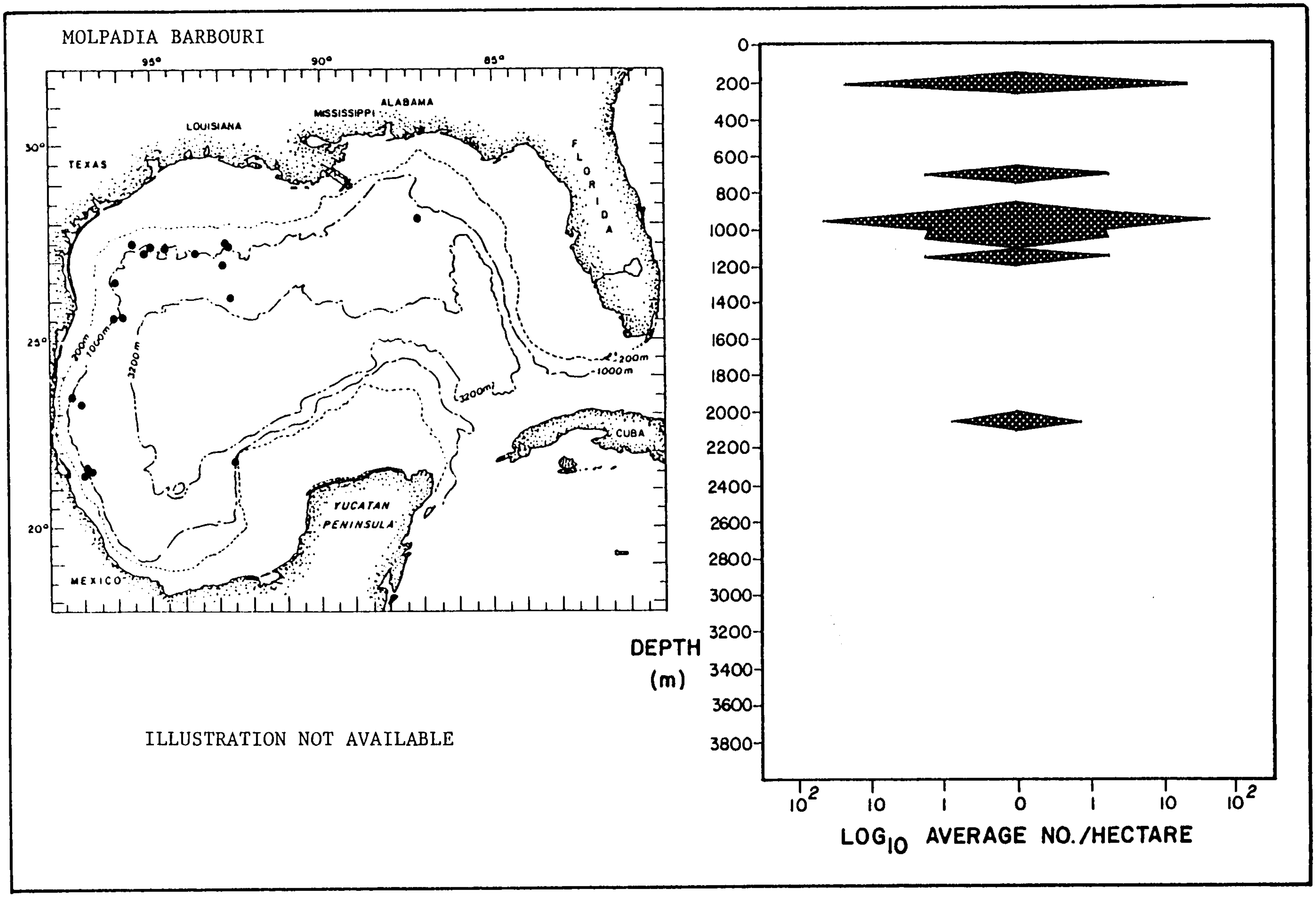

Figure 24. Horizontal and vertical distribution (including population density) of the holothuroid <u>Molpadia</u> <u>barbouri</u> in the deep Gulf of Mexico.

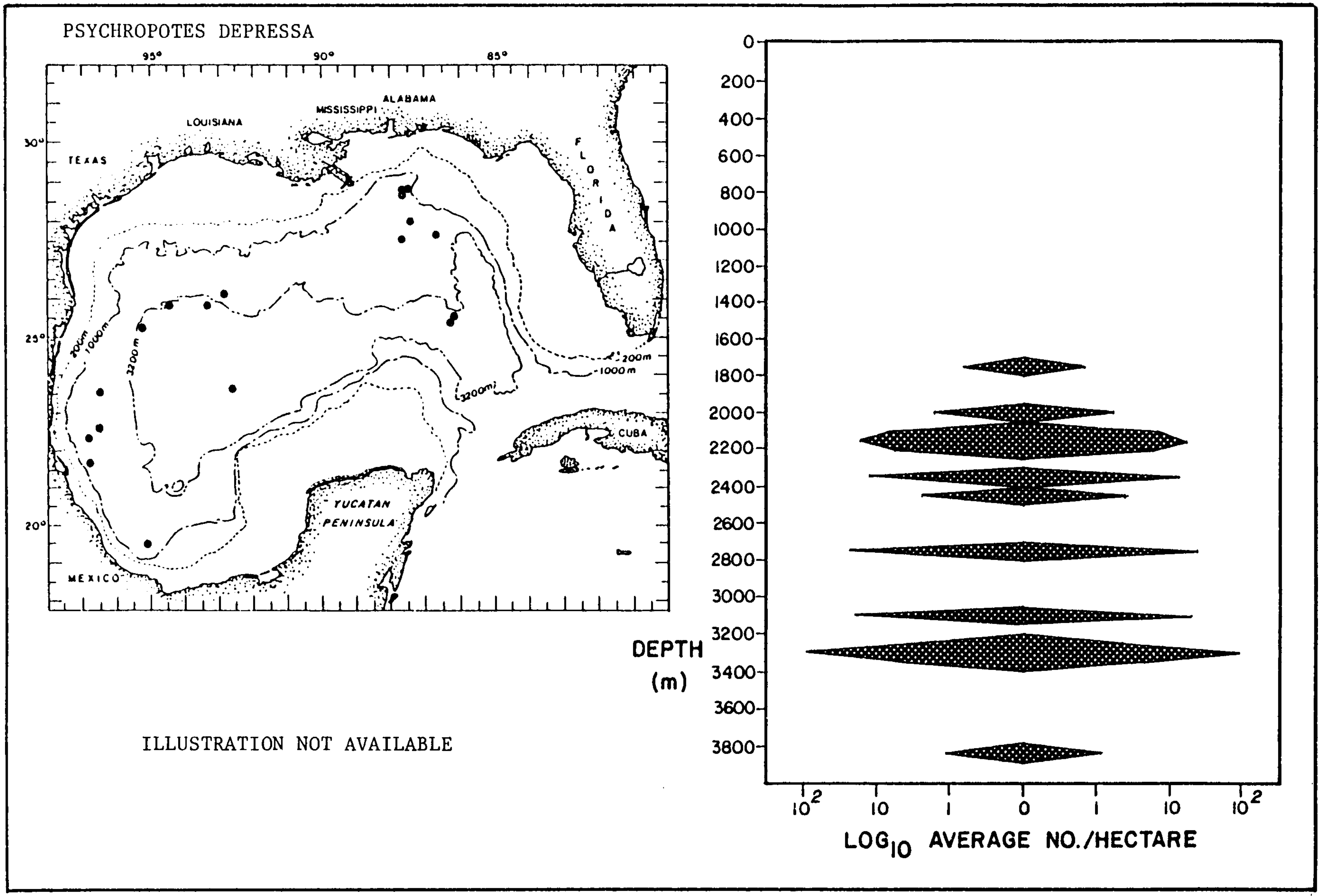

Figure 25. Horizontal and vertical distribution (including population density) of the holothuroid Psychropotes depressa in the deep Gulf of Mexico.

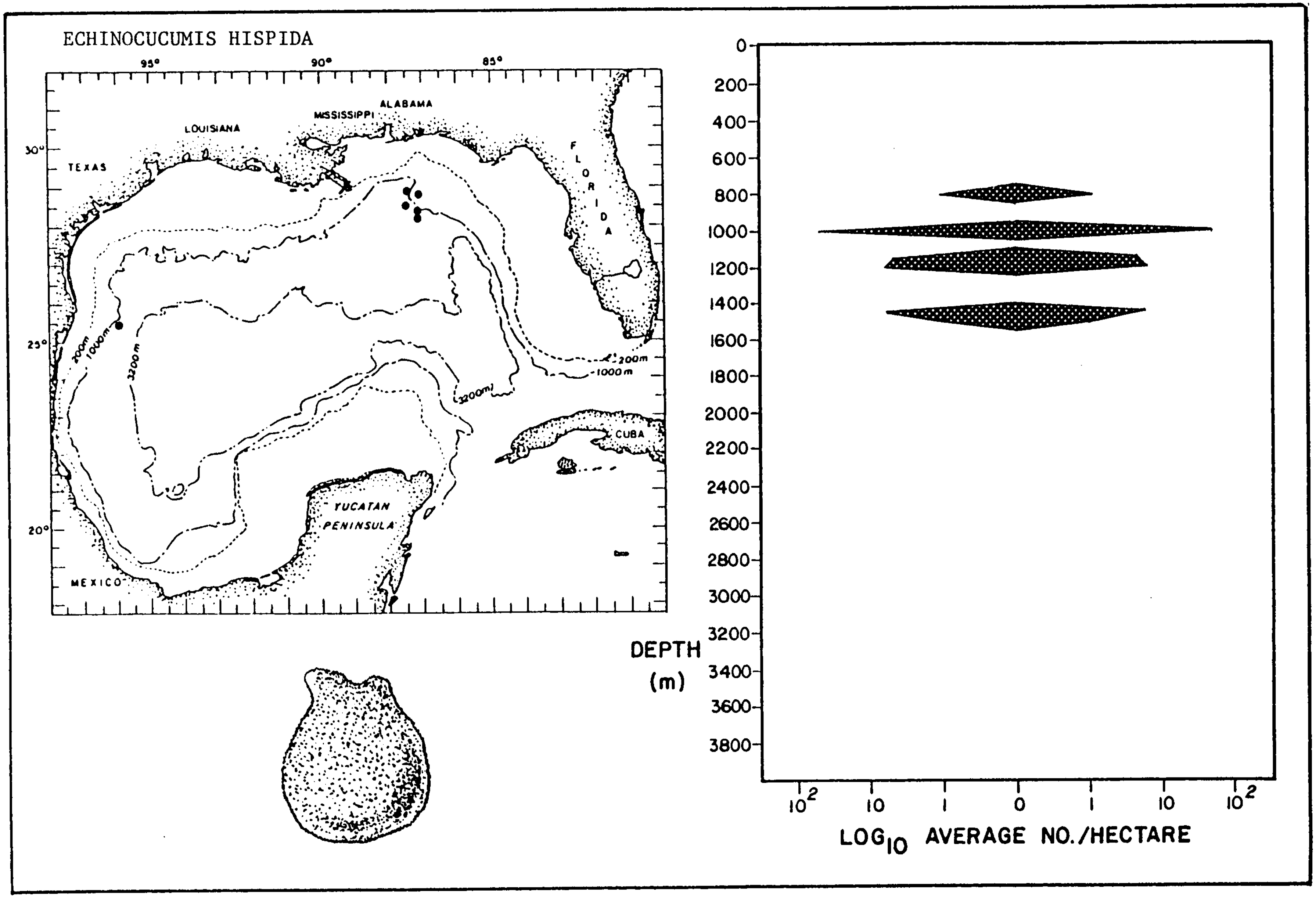

Figure 26. Horizontal and vertical distribution (including population density) of the holothuroid <u>Echinocucumis hispida</u> in the deep Gulf of Mexico.

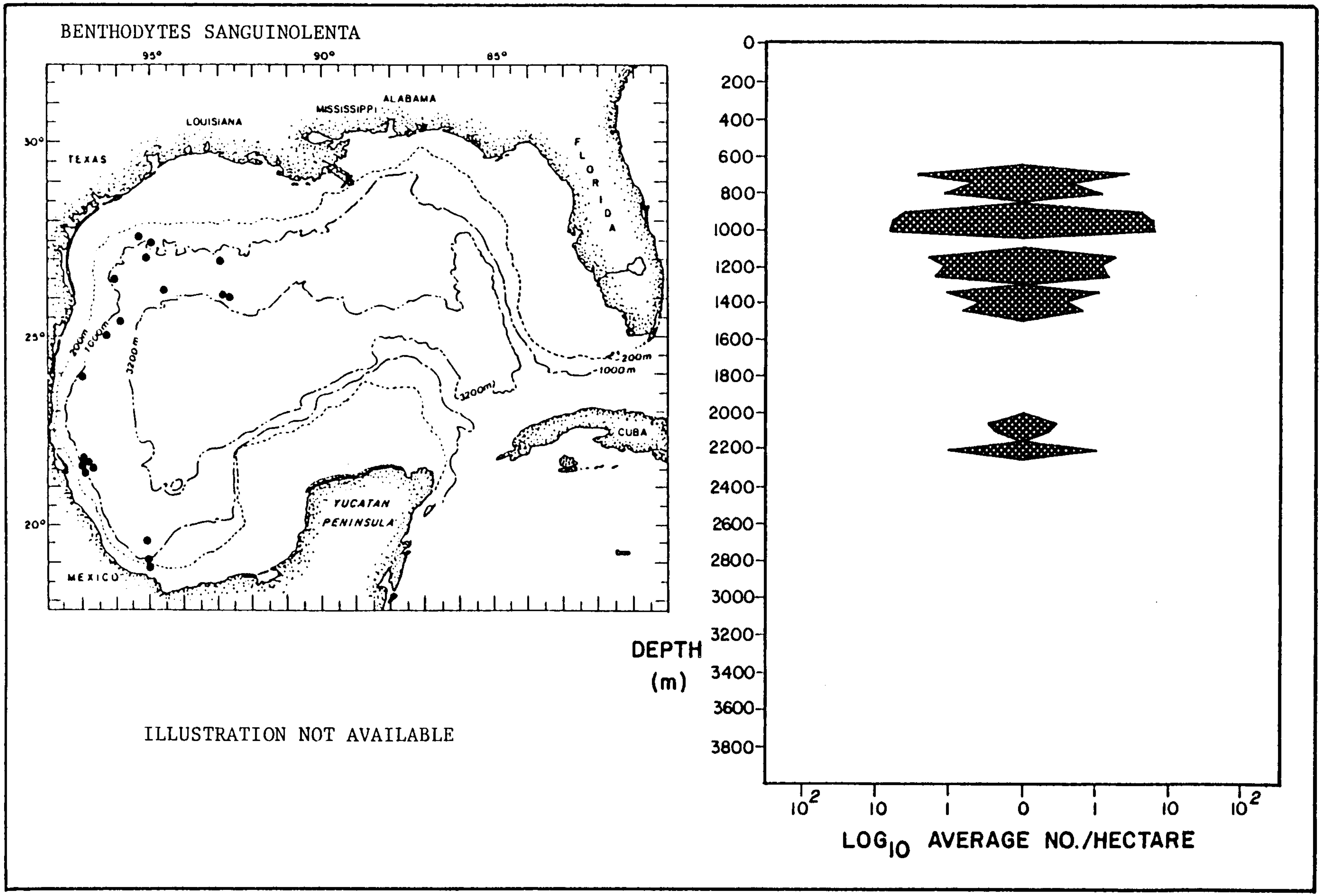

Figure 27. Horizontal and vertical distribution (including population density) of the holothuroid Benthodytes sanguinolenta in the deep Gulf of Mexico.

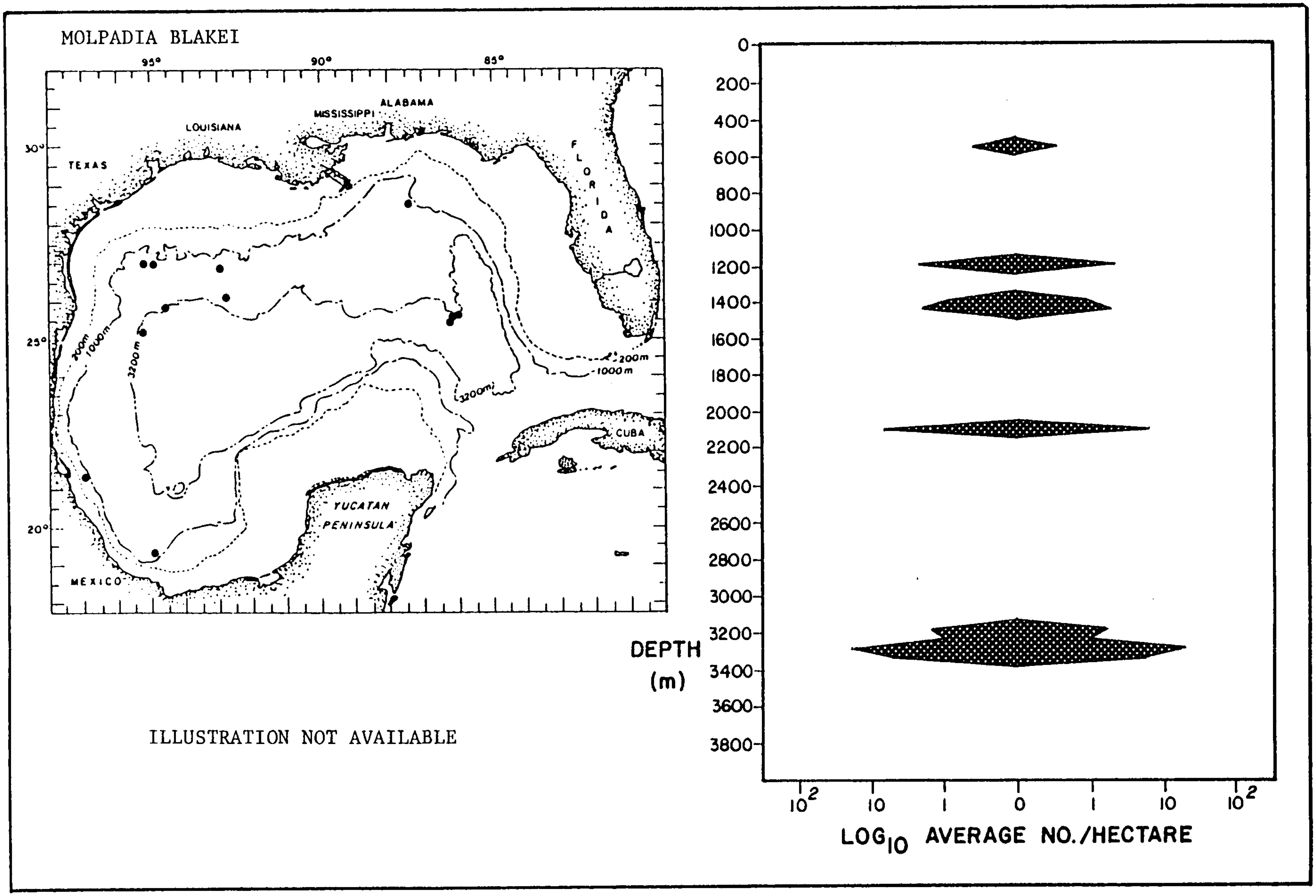

Figure 28. Horizontal and vertical distribution (including population density) of the holothuroid Molpadia blakei in the deep Gulf of Mexico.

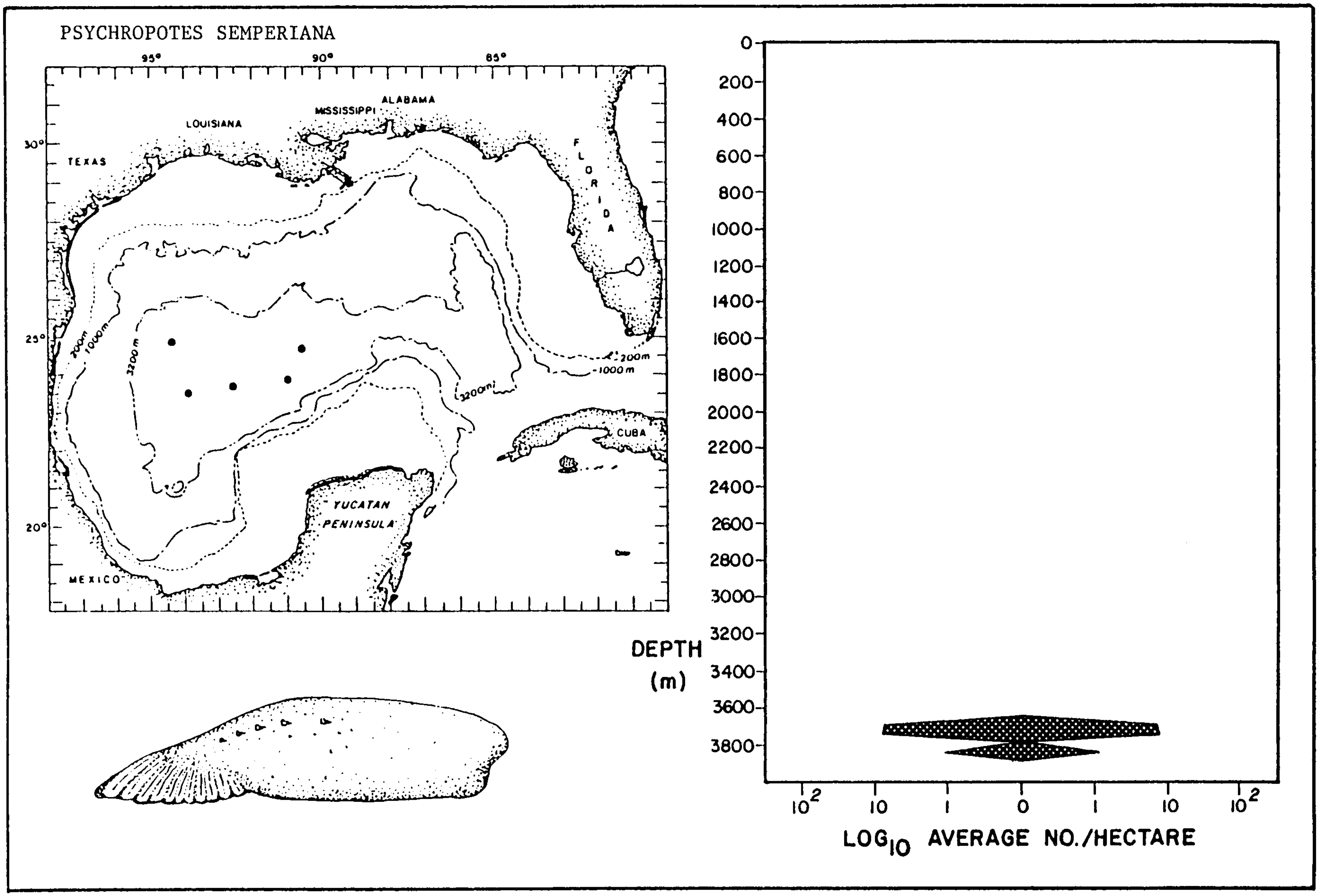

Figure 29. Horizontal and vertical distribution (including population density) of the holothuroid Psychropotes semperiana in the deep Gulf of Mexico.

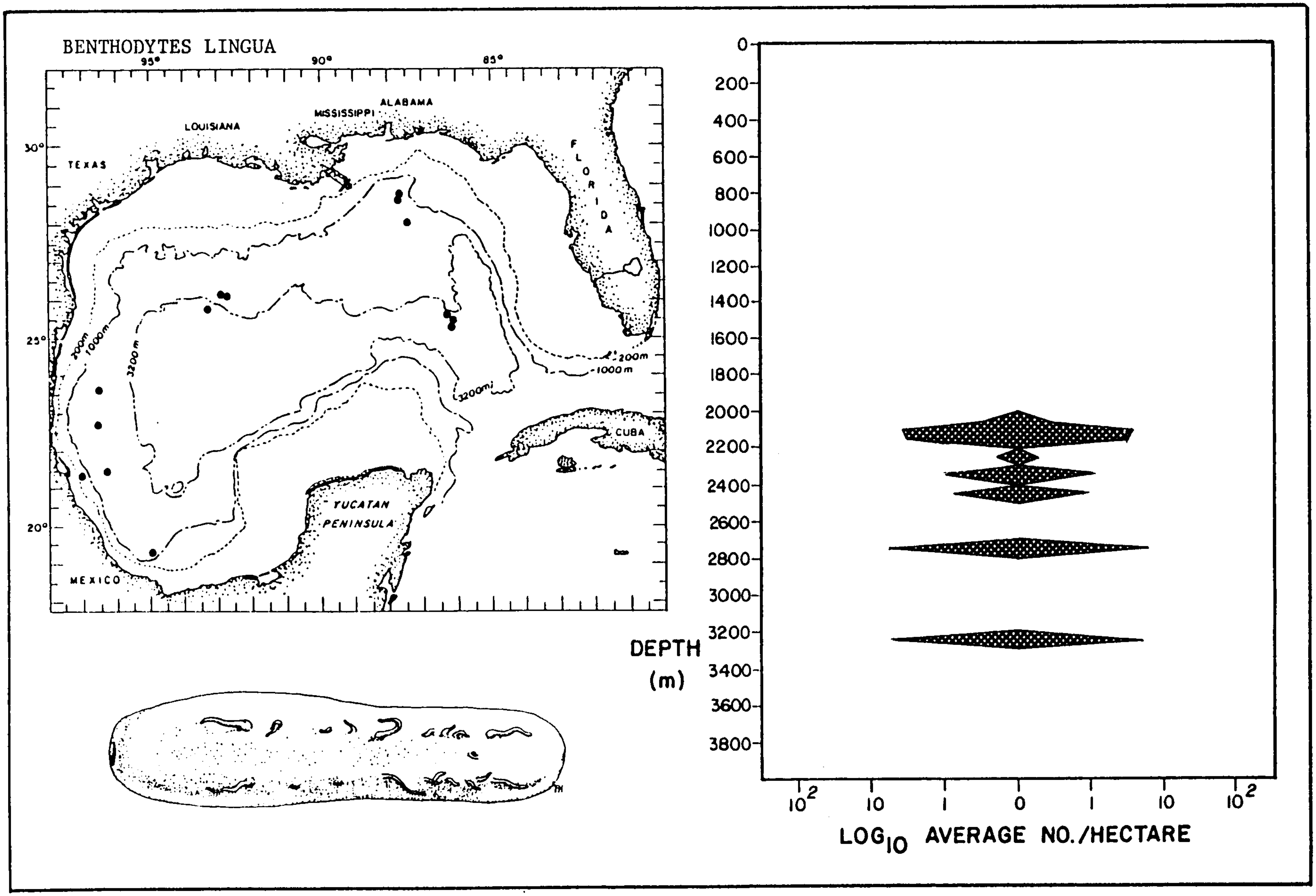

Figure 30. Horizontal and vertical distribution (including population density) of the holothuroid Benthodytes lingua in the deep Gulf of Mexico.

Table 11. (I) Crinoidea found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of crinoids in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Comactinea meridionalis	17	0	-	50-150	*
Neocomatella pulchella	17	5	85	150 only	150
Leptonemaster venustus	5	0	-	150 only	150
Comactinea echinoptera	4	0	-	150 only	150
Crinometra brevipinna	11	0	-	150 only	150
Stylometra spinifera	1	0	-	150 only	150
Crinometra sp.	arms only	5	-	400 only	400
Neocomatella sp.	arms only	5	-	400 only	400
Caryometra cf. *alope*	19	10	190	500-600	500
Antedonidae	4	10	40	550-750	700
Atelecrinus balanoides	8	20	160	500-1400	750
Democrinus sp.	124	65	8060	150-1050	900
Monachocrinus caribbeus ?	1	0	-	1000 only	1000
Bathycrinidae	4	0	-	1450-1700	1600

(II) Dominant crinoids presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Caryometra cf. *alope*	500
Atelecrinus balanoides	750
Neocomatella alata	150

* Unknown

Table 12. Distribution of species of crinoids among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	7	2	9
Archibenthal Zone (475-950 m)	4	0	4
Upper Abyssal (975-2250 m)	2	2	4
Mesoabyssal (2275-3200 m)	0	0	0
Lower Abyssal (3225-3850)	0	0	0

Crustacea

One hundred ninety-two species of benthic crustaceans were collected by the ALAMINOS in the offshelf waters of the Gulf. Although brachyuran crabs yielded the most species (Table 13), they are for the most part confined to the shelf and upper slope. In fact, the median depth for the 46 species collected is only 300 m (Figure 31). The number of individuals of brachyurans also show highest levels in the shallower depths (Figure 32). Two other diverse groups are the caridean shrimps with 33 species and the galatheid anomurans with 30 species. Emphasis must be placed on the fact that some groups such as the Gammaridea and Isopoda are not uniformly represented in the present collection in part because of their generally small size. Also, the majority of our collection of isopods was sent to Dr. Robert Menzies for identification, but no one has been able to find the specimens after his untimely death.

Table 13. Number of species collected in crustacean taxa with their bathymetric distribution including median depth.

	No. of species	% of all crustacean spp.	No. species below 1000 m	% of group below 1000 m	Median depth (m)
Penaeidea	22	17	14	64	1250
Caridea	33	17	16	48	1000
Anomura					
Paguridae, etc.	24	13	4	17	
Galatheidae					
Munida	8	4	1	13	450
Munidopsis	22	11	13	59	1150
Macrura					
Polychelidae	5	3	4	80	1000
Nephropidae	4	2	2	50	650
Brachyura	46	24	4	9	300
Tanaidacea	8	4	3	38	NA
Other Macrura	4	2	0	0	NA
Total	192	100	68		

Approximately one-third (35%) of the crustacean species extend their bathymetric range below the 1000-m isobath. Among these it is the penaeid natantians, munidopsid galatheids, and polychelids that as groups predominate in the deep Gulf. Although the diversity of carideans is markedly greater than that of the penaeids down to 1000 m, below that point the latter supersedes the carideans (Figure 33). It is interesting to note in Figure 34 that whereas individuals of penaeid species outnumber those of carideans down to a depth of 400 m, the reverse is true from there down to 2900 m where again the penaeids outnumber the carideans by a substantial margin. Since penaeids and carideans are about of equal size, this means that carideans have the larger biomass on the slope, whereas penaeids predominate on the shelf and transition zone and again on the rise and abyssal plain. In the galatheid crabs, species of *Munida* are confined primarily to shallower areas and have a median depth of only 450 m whereas *Munidopsis* has greater numbers of species and individuals at deeper levels and has a median depth of 1150 m (Figures 35 and 36).

Cirripedia (Barnacles)

The cirripedes were not a particularly abundant group among the Crustacea. Nineteen species are listed for the Gulf (Table 14); roughly half of these occur in waters deeper than 1000 m. More species occur in the Archibenthal Zone than in any other zone. Both of the two most abundant species, *Arcoscalpellum regina* and *Verruca* sp. 1, had peak populations in Horizon B of the Archibenthal Zone. *A. regina*, a large, leathery gooseneck barnacle (Family Scalpellidae) exhibits a broad geographic distribution in the Gulf, although it seems confined to the upper continental slope (Figure 37).

Tanaidacea

Eight macrofaunal species of tanaids were collected in the offshelf seabed. As can be seen in Table 15 all of these occurred in deep water from the middle slope onto the continental rise. All of the species are new and except for one belong to the genus *Apseudes* or *Neotanais*.

Amphipoda

Eleven species of gammarid amphipods were collected in grab samples (Table 15). Among them were two new genera and several new species. Most were represented by only one or two individuals.

Isopoda

As noted elsewhere most of our isopod collection was lost by a taxonomic specialist. However, the most unique and important megafaunal species of the group is the giant cirolanid *Bathynomus giganteus*, which occurs widely in the Gulf from 400 to 2250 m depth with a peak population around the 1200-m isobath (Table 15 and Figure 38). The largest of our specimens has an overall length of about 32 cm. It is confined to the continental slope throughout its life cycle. Being a peracaridean, it broods its young. The smallest specimens in our collection measure 5.5 and 5.6 cm in length. Both were collected in July at depths ranging between 585 and 675 m.

Stomatopoda

Only two species of stomatopods were collected in this study. Both probably occur on the shelf since we took them from depths ranging from 150 to 250 m.

Pycnogonida

Only one megafaunal species of pycnogonid was obtained in this study at a depth of 1000 m.

Natantia: Penaeidea

Twenty-two species of benthonic penaeid shrimps occur in the offshelf waters of the Gulf of Mexico (Table 16). Fourteen (64%) of these species occur below the 1000-m isobath (Table 13). The distribution of penaeid species within each bathymetric zone (Table 17) illustrates the greater abundance of penaeid species in the abyssal zones. Although the numerical dominant in the group, *Penaeopsis serrata* (Figure 39), has its peak populations along the 300-m isobath, three other dominants peak below 3000 m and well over half the species peak below 1000 m. For instance, the second most abundant penaeid, Benthesicymus bartletti (Figure 40), is most abundant along the 1050-m isobath from which it extends down to 2250 m. The most abundant abyssal penaeid is Benthesicymus cereus/iridescens (Figure 44), which peaks at 3250 m on the continental rise but extends down to and across the abyssal plain to 3850 m where it is confined to the western Gulf.

There are major differences in the geographic distribution of the penaeids. For instance, eight of the 22 species are found only in the western Gulf, and although some species such as Hymenopenaeus debilis are much more abundant in the east around DeSoto Canyon than west, none is limited to the eastern Gulf. As might be expected, most of those species that are limited to the west were taken only in small numbers and usually occurred in the southern Gulf as well. The genus Hymenopenaeus exhibited the most species (4) of the deep penaeid genera. But the four attained peak populations at different depths from H. tropicalis at 150 m through H. robustus and H. debilis at 500 and 600 m, respectively, to H. aphoticus at 2100 m. Both the genera Plesiopenaeus and Benthesicymus are represented by three species which have marked bathymetric separations. It appears that the deep benthonic penaeids can be divided into three bathymetric groups. The first group of 10 species finds its center of distribution on the upper slope. The numerical dominants here are Penaeopsis serrata (Figure 39) followed by Parapenaeus longirostris. The second group of five species occupies the middle portion of the slope where the numerical dominant is Benthesicymus bartletti (Figure 40). The third group has those seven species that reach maximum numbers on the lower slope and rise where the predominant species is Benthesicymus cereus/ iridescens (Figure 44).

Natantia: Caridea

Thirty-three species of benthonic caridean shrimps were collected in the deep Gulf (Table 18). Sixteen (48%) of these occur below the 1000-m isobath (Table 13). The distribution of caridean species within each bathymetric zone (Table 19) points out their greater abundances of species in the Archibenthal Zone compared to the shallower or deeper zones in contrast to the penaeid shrimp, whose greatest species abundance is in the deeper zones (Table 17). It is interesting that the top five of the numerical dominants (Figures 45-51) belong to only two genera, Nematocarcinus and Glyphocrangon (Table 18 II). Moreover, the top two species, viz., Nematocarcinus rotundus (Figure 45) and Glyphocrangon nobilis (Figure 46), attain peak populations along the same isobath. Since they occur in the same geographic region, it is apparent that there must be a distinct ecological separation. For one thing, Glyphocrangon is known to be a burrower (Plate 6 A,B), whereas it is suspected that Nematocarcinus is not. On the abyssal plain Nematocarcinus ensifer (Figure 49) is the dominant caridean followed by the moderately common Acanthephyra microphthalma and the very rare Pontophilus talismani. Although most species of Acanthephyra are pelagic, our collection data, as shown in Table 18 I, indicate that A. armata, A. acutifrons, and A. microphthalma are probably benthopelagic.

Although five species of carideans are limited to the western Gulf, four are rare and only one (Heterocarpus ensifer) is moderately common. The two species that are limited to the eastern Gulf, viz., Nematocarcinus cursor and Sabinea tridentata are together represented by four specimens. It is interesting to note that although carideans are represented by more species than penaeids between 300 m and 1000 m depth, the reverse is true from about 1200 m down to 3850 m depth (Figure 33). However, the number of individuals in these species follows another pattern (Figure 34) with carideans being more numerous from 500 m to 2900 m whereafter penaeids are far more abundant than carideans.

Macrura

The macruran decapod crustaceans are represented in the offshelf waters of the Gulf by 12 species of which the polychelids and nephropids are the most important. Among the polychelids or flatback lobsterettes Stereomastis sculpta is by far the most abundant (Table 20) and Willemoesia forceps, represented in our collection by a single individual, is the rarest. Their habits as adults are almost entirely unknown. In fact, no one to our knowledge has photographed any one of the group. Yet Stereomastis was taken at 74 stations in the Gulf. It is known that they have a deep-sea pelagic larva known as the eryonid. In some ways the genus Willemoesia reminds one of a neotonic eryonid. In general the polychelids live deeper than the nephropids (Tables 21 and 22). Although the nephropids or deep-sea lobsters are not as common as the polychelids, we have bottom photographs of two of the four species in our collection. Moreover, it is quite likely that the nephropids live in burrows. Horizontal and vertical distributions of the dominant species of polychelids are shown in Figures 52-54 and of the dominant species of nephropids in Figures 55-57.

The remaining macrurans (Table 23) occur on the upper slope where their burrowing habits preclude capture by ordinary deep-sea collecting gear.

Anomura

The Anomura are represented in the deep Gulf by the following five families: the Galatheidae with the genera Munida and Munidopsis; the Paguridae represented by numerous species, some of which are undescribed; the Lithodidae with the crablike Lithodes agassizii; the Chirostylidae with two species, Gastroptychus spinifer and Uroptychus nitidus; and finally the Porcellanidae which has the species Porcellana sigsbeiana that ranges from the shelf down to 950 m depth.

The vertical distribution of the galatheids is quite interesting. Note in Table 24 I that all species of Munida except one occur no deeper than 750 m. Munida microphthalma has a narrow bathymetric range from 1100 to 1350 m depth where it is rarely collected. Munidopsis on the other hand is represented by three times as many species as Munida (Table 24 I) and it ranges down over the continental rise to a depth of 3300 m (Figure 35). The distribution of species and individuals of Munida and Munidopsis among the bathymetric zones are shown in Tables 25 and 26. Interestingly three of the numerically dominant species of galatheids belong to the genus Munida (Table 24 II) and only one of the deep-living Munidopsis (below 3000 m) is even reasonably abundant (M. bermudezi at 3300 m). These points can best be seen in Figure 36 where the numbers of individuals in each genus are plotted against depth. Horizontal and vertical distributions of the dominant galatheid species are shown in Figures 58-63.

The Paguridae of the Gulf are a very complex group and their systematics is only now being pursued agressively. Not only are several new species to be described from our collection by specialists, but individuals now assigned to Parapagurus will very likely be split into at least two and possibly more species (Table 27 I). The distribution of pagurid species and individuals by zones is shown in Table 28.

Lithodes agassizii at first glance resembles a majid brachyuran crab but its anomuran relationship is belied by the presence of only four pairs of walking legs - the fifth pair being carried forward along the carapace. It is, of course, closely related to the Alaska King Crab.

Uroptychus nitidus has a very restricted habitat living as it does only on the relatively small gorgonian corals Chrysogorgia elegans down to depths of 1000 m, and Acanella arbuscula from there to 1350 m.

The family Porcellanidae is comprised primarily of species that live in shallow water, including the intertidal zone. As a result, only one species, Porcellana sigsbeiana, is found in offshelf waters, but it ranges onto the slope from the continental shelf down to 950 m depth. However, only juveniles are found at the greater depths. Since the maximum populations are found around 200 m, it is suspected that these juveniles will move up the slope as they mature. Horizontal and vertical distributions of the dominant nongalatheid anomurans are shown in Figures 64-68.

Brachyura

It is clear from Table 29 I and Figure 31 that the brachyuran crabs are a relatively shallow group with only four species occurring below 1000 m. Note also that 38 of the 46 species present in offshelf waters reach maximum populations no deeper than 550 m, which is well up on the continental slope. Moreover, all of the four species except Geryon quinquedens that occur below 1000 m are very small and delicate indicating a very specialized mode of feeding. Actually the Geryon that were collected below 1500 m were only small juveniles. The distribution of brachyurans according to zones (Table 30) illustrates their greater abundance in the shallower zones. Horizontal and vertical distributions of the dominant brachyuran species are shown in Figures 69-73.

Considering the trophic-level position of the Brachyura, the fact that their diversity and numbers of individuals decline drastically below 400 m (the average depth of maximum population is 390 m) seems to support the concept that this relatively shallow area is a very productive part of the Gulf. In addition, the similarity of the above with the bathymetric distribution of the bulk of asteroids and considering that both groups possess many predatory species indicate that food for carnivores must become a severe limiting factor below depths of about 900 m in the Gulf.

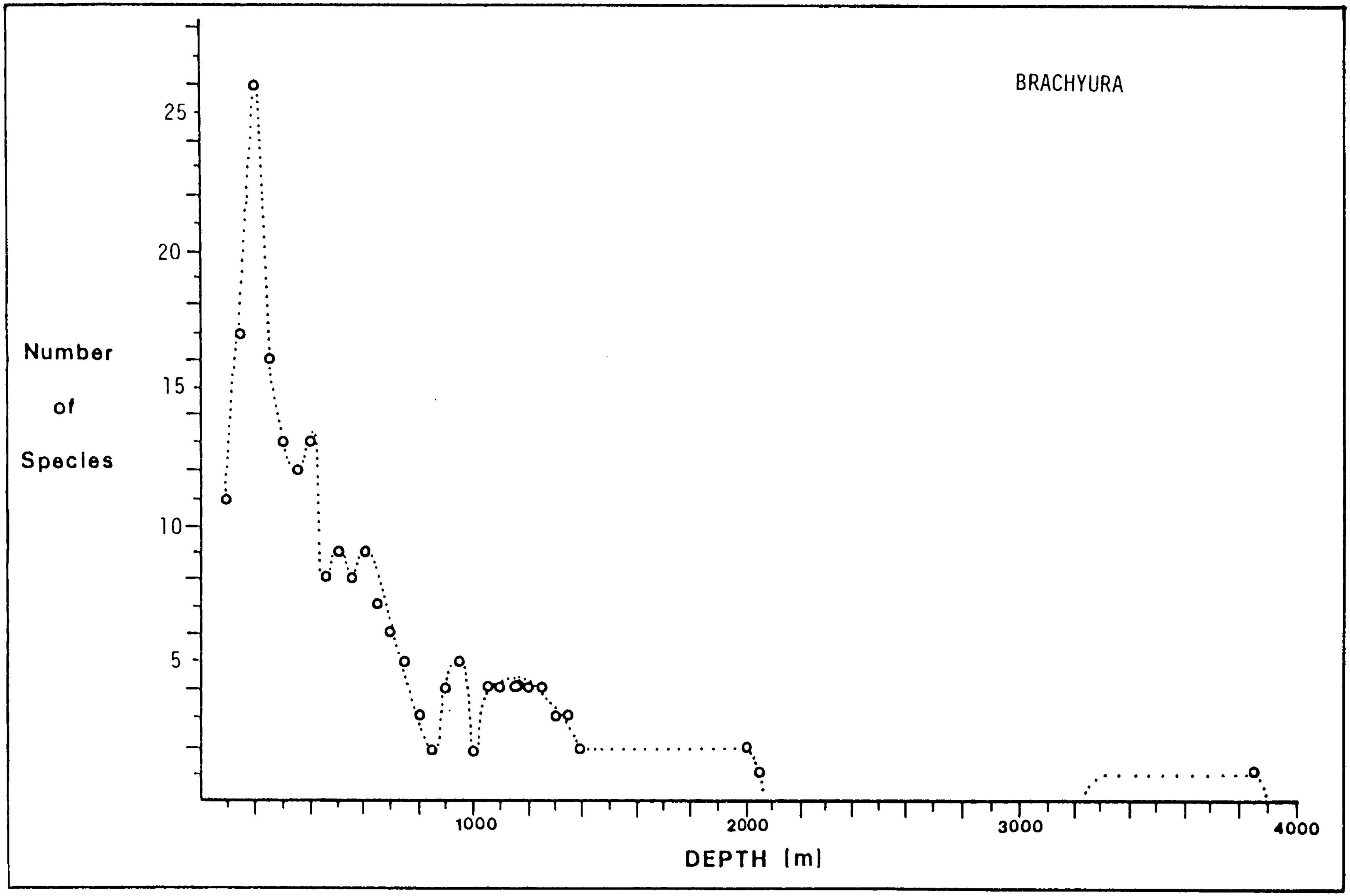

Figure 31. Number of species of brachyuran crabs plotted according to depth.

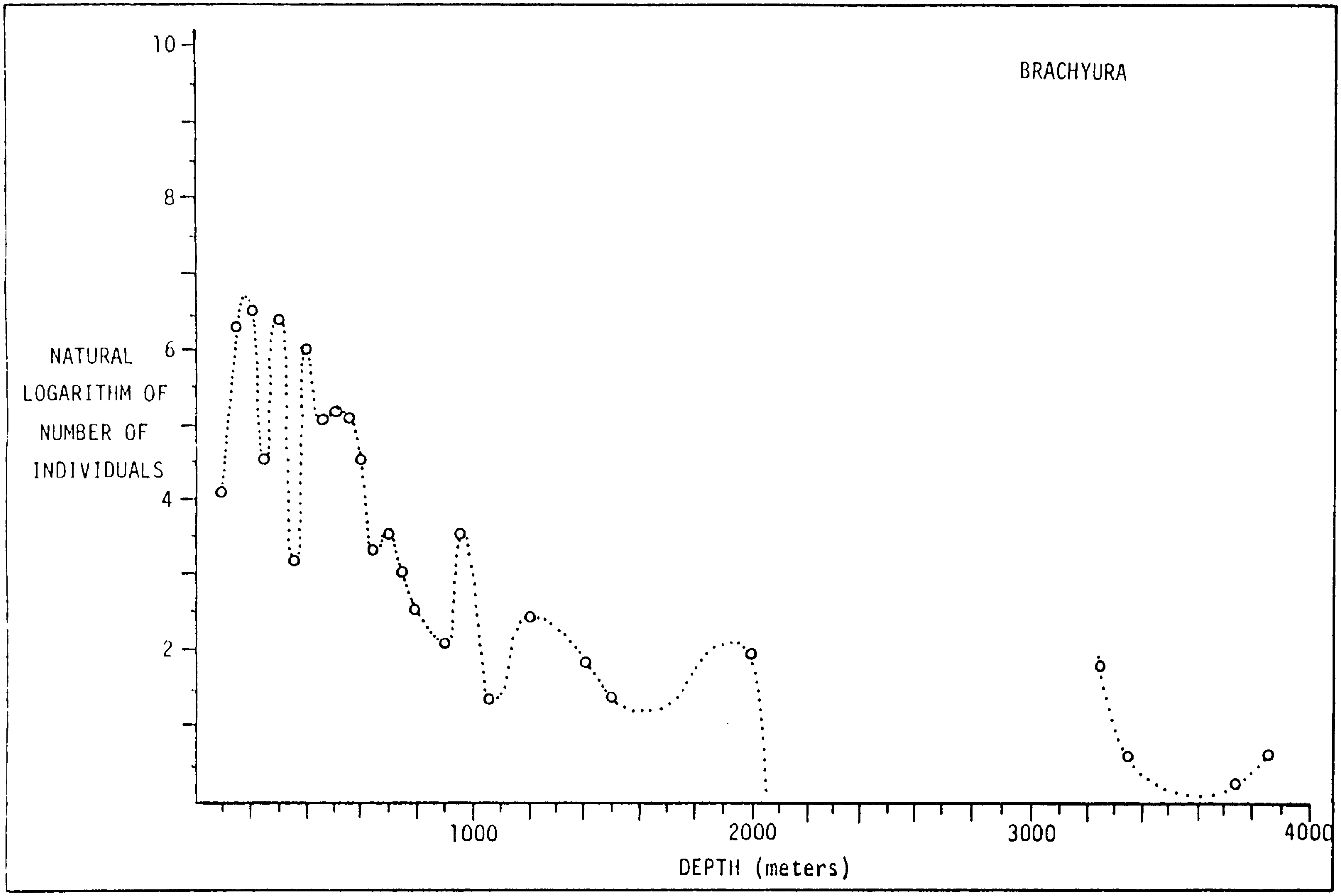

Figure 32. Natural logarithm of number of individuals of brachyuran crabs plotted according to depth.

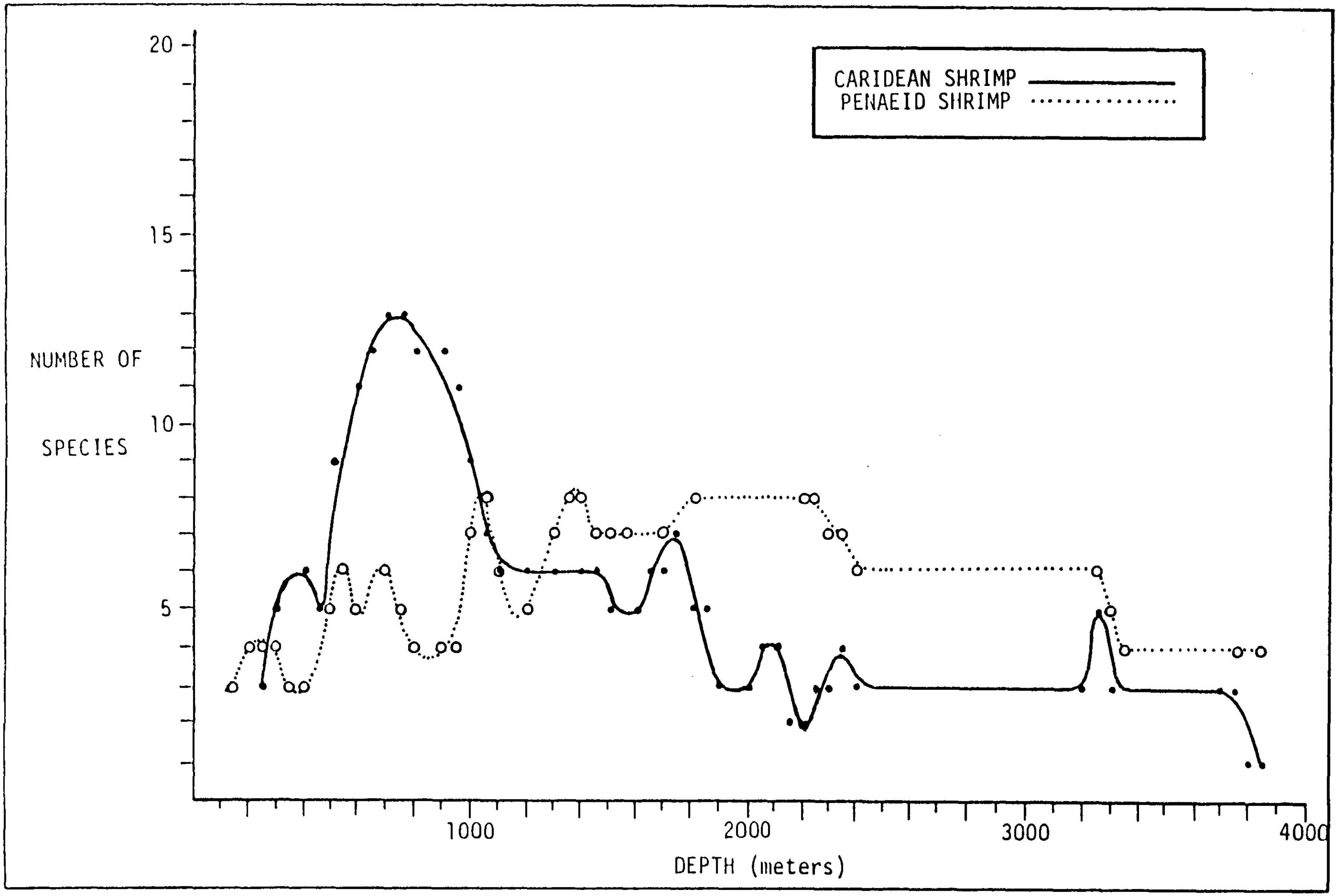

Figure 33. Number of species of caridean and penaeid shrimp plotted against depth.

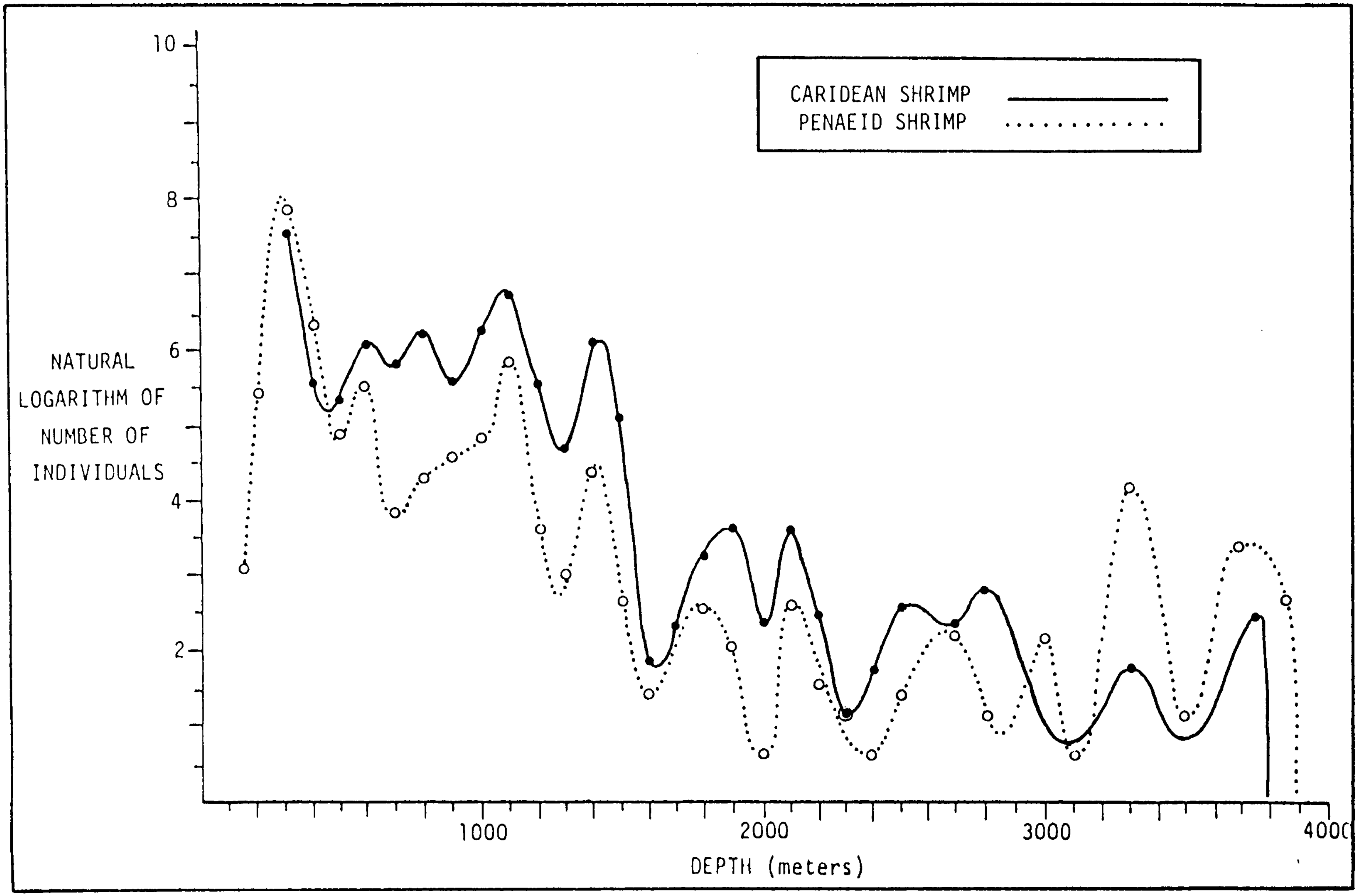

Figure 34. Natural logarithm of number of individuals of caridean and penaeid shrimp plotted against depth.

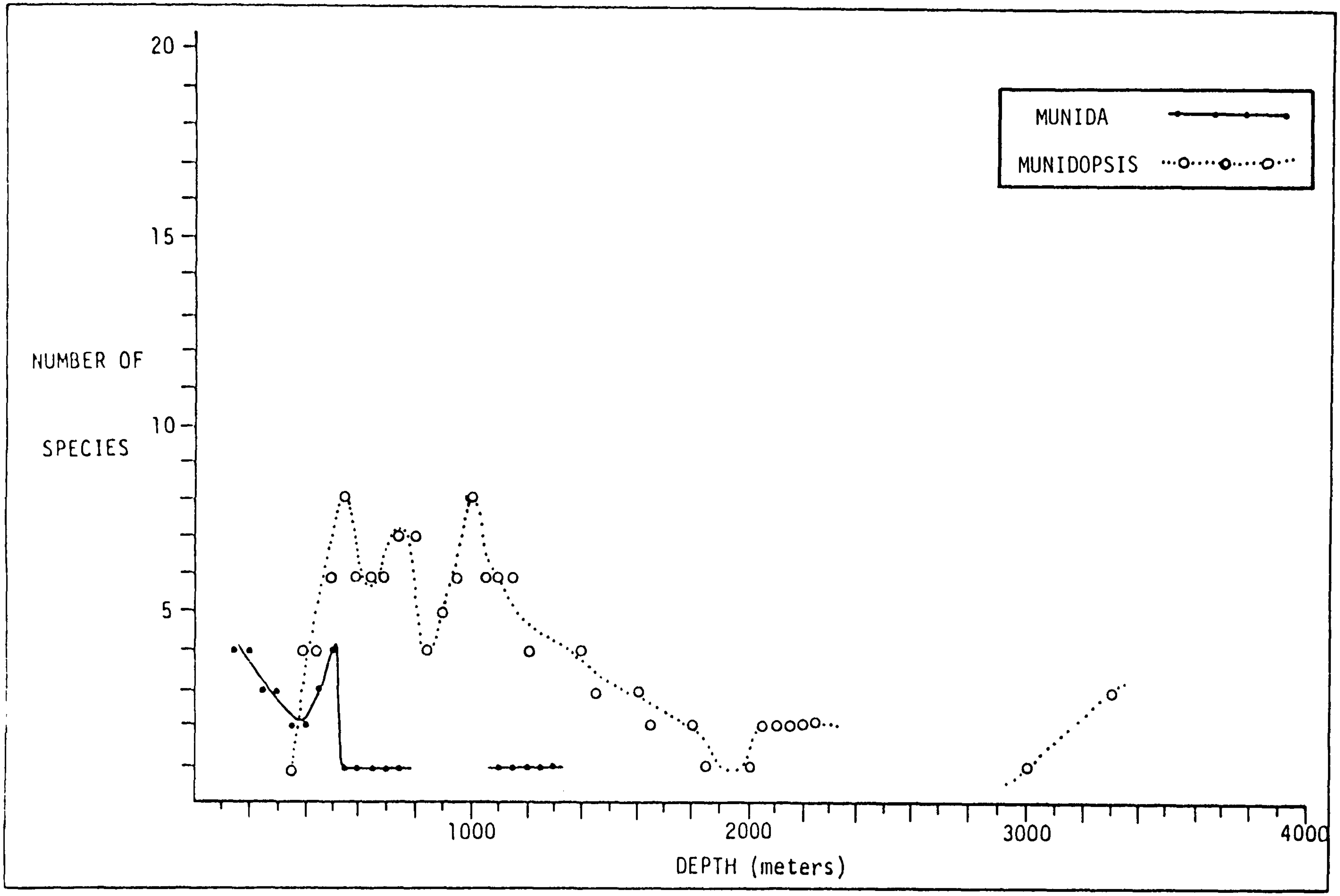

Figure 35. Number of species of Munida and Munidopsis plotted according to depth.

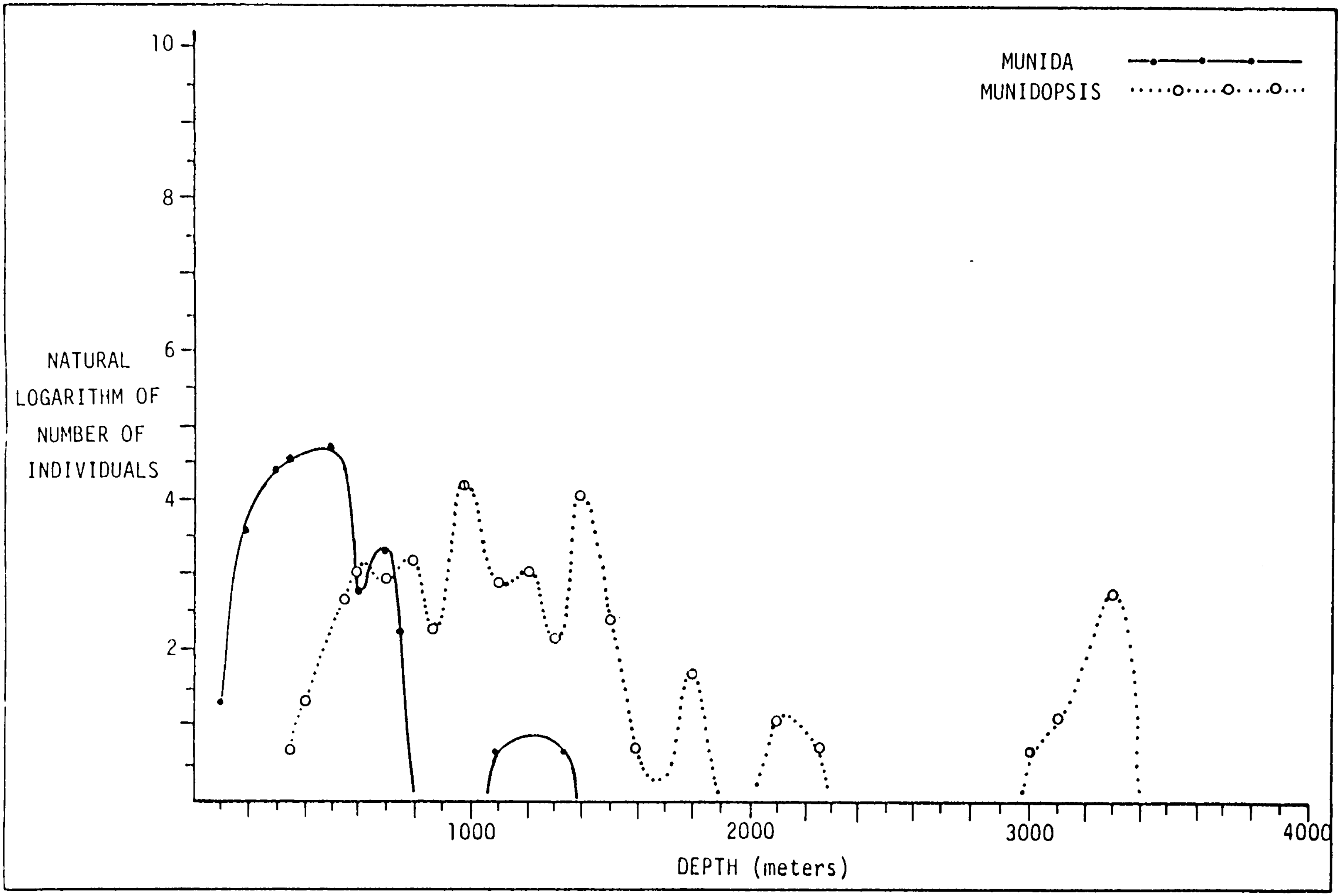

Figure 36. Natural logarithm of number of individuals of <u>Munida</u> and <u>Munidopsis</u> plotted according to depth.

Table 14. (I) Cirripedia found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of barnacles in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Balanus sp. aff. *calidus*	2	10	20	100-200	*
Arcoscalpellum portoricanum	8	10	80	200 only	200
Scalpellum portoricanum	8	15	120	250-600	250
Megalasma gracile gracilius	1	0	-	500 only	500
Arcoscalpellum semisculptum	1	0	-	550 only	550
Verruca sp. 3	18	10	180	550-600	550
Verruca sp. 2	1	0	-	750 only	750
Scalpellum gracilius	2	5	10	800 only	800
Arcoscalpellum regina	178	80	14240	350-1050	900
Verruca sp. 1	599	5	2995	950 only	950
Arcoscalpellum idioplax	1	5	5	950 only	950
Trilasmis kaempferi inaequilaterale	7	5	35	1000 only	1000
Arcoscalpellum antillarum	3	0	-	1000 only	1000
Arcoscalpellum albatrossianum	2	10	20	900-2250	1600
Scalpellum svetlanae	1	5	5	1750 only	1750
Verruca sp.	1	5	5	2050 only	2050
Scalpellum sp.	1	5	5	3100 only	3100
Arcoscalpellum vitreum	6	5	30	3350-3840	3350
Scalpellum spicatum	3	5	15	3840 only	3840

(II) Dominant barnacles presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Arcoscalpellum regina	900
Verruca sp. 1	950
Verruca sp. 3	550
Scalpellum portoricanum	250

* Unknown

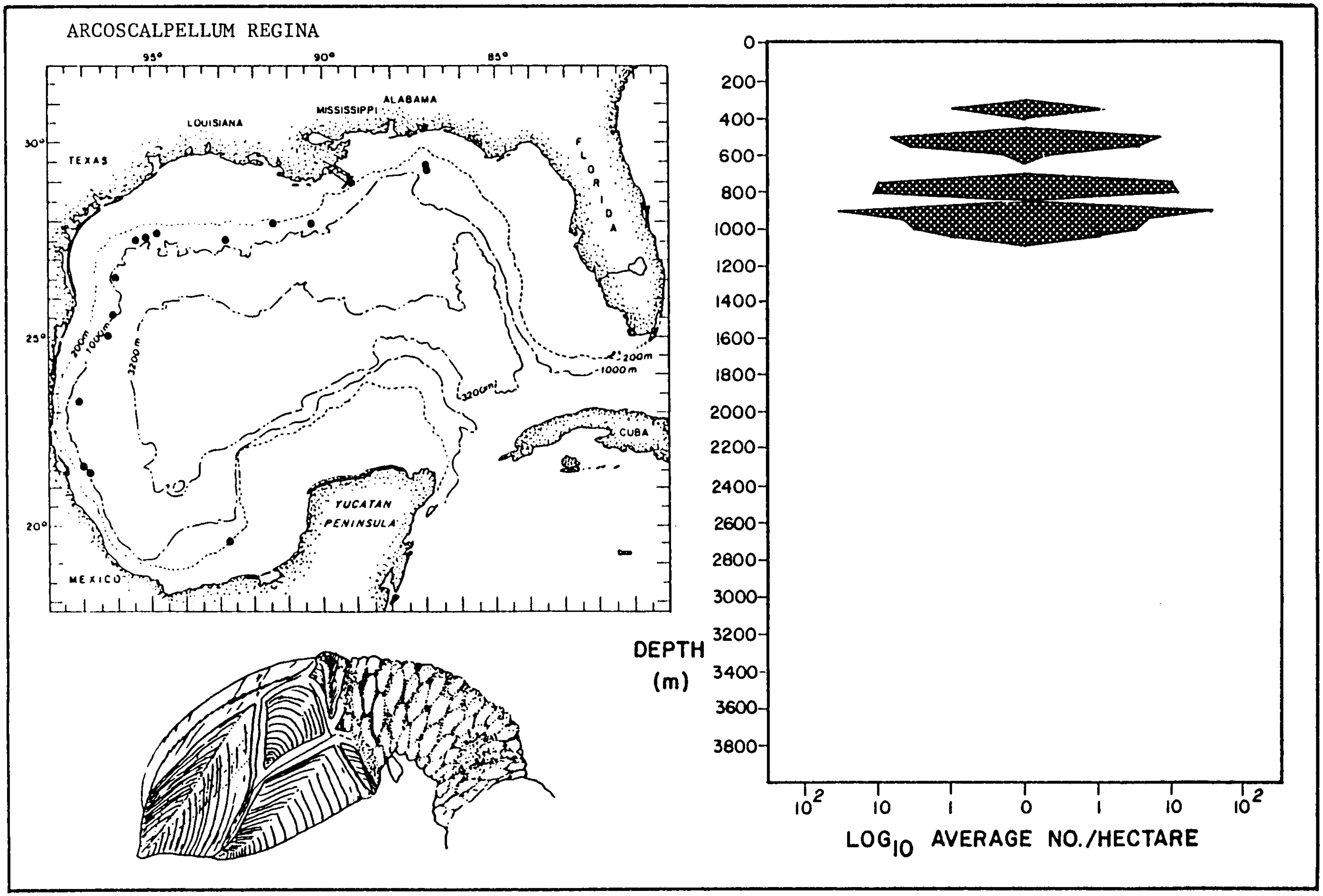

Figure 37. Horizontal and vertical distribution (including population density) of the barnacle <u>Arcoscalpellum regina</u> in the deep Gulf of Mexico.

Table 15. (I) Miscellaneous Crustacea found in the deep Gulf of Mexico.

(I) Inventory of Tanaidacea, Gammaridea, Isopoda, Stomatopoda, Pycnogonida, and Stenopodidea in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
TANAIDACEA					
Apseudes (*Leiopus*) sp. A	1	0	-	1000 only	1000
Apseudes (*Leiopus*) sp. B	1	0	-	1000 only	1000
Apseudes sp. C (*A. propinquus* complex)	5	5	25	1000 only	1000
? *Paranarthrura* sp. A	1	0	-	1000 only	1000
Neotanais sp. A	2	0	-	1000 only	1000
Sphyrapus n. sp. (cf. *dispar*)	4	0	25	1000-1150	1100
Neotanais armiger	1	5	5	1700 only	1700
Apseudes (*Leiopus*) sp. D (cf. *S. sibogae*)	2	5	10	3400 only	3400
AMPHIPODA					
Elasmopus sp.	1	5	5	150 only	150
Urothoides sp.	1	5	5	750 only	750
Rhachotropis (n. sp. ?)	1	5	5	1000 only	1000
cf. *Cyclocaris* sp.	1	5	5	1000 only	1000
Cyphocarid genus	1	5	5	1000 only	1000
Genus *Halicreion*	1	5	5	1000 only	1000
Trischizostoma longirostre	2	10	20	1000-1400	1200
Valettiopsis cf. *dentatus*	1	5	5	1200 only	1200
Epimera sp. A (n. sp.)	7	25	175	600-1400	1250
Lysianassidae n. genus	1	5	5	1500 only	1500
Oediceroides cf. *rostratus*	1	5	5	1700 only	1700
ISOPODA					
Bathynomus giganteus	49	160	7840	400-2250	1200
Ianirella caribbica	1	5	5	2250 only	2250
STOMATOPODA					
? *Heterosquilloides armata*	1	5	5	150 only	150
Squilla edentata	21	35	735	150-250	250
PYCNOGONIDA					
Paranymphon spinosum	1	5	5	1000 only	1000
STENOPODIDEA					
Richardina spinicincta	1	5	5	700 only	700

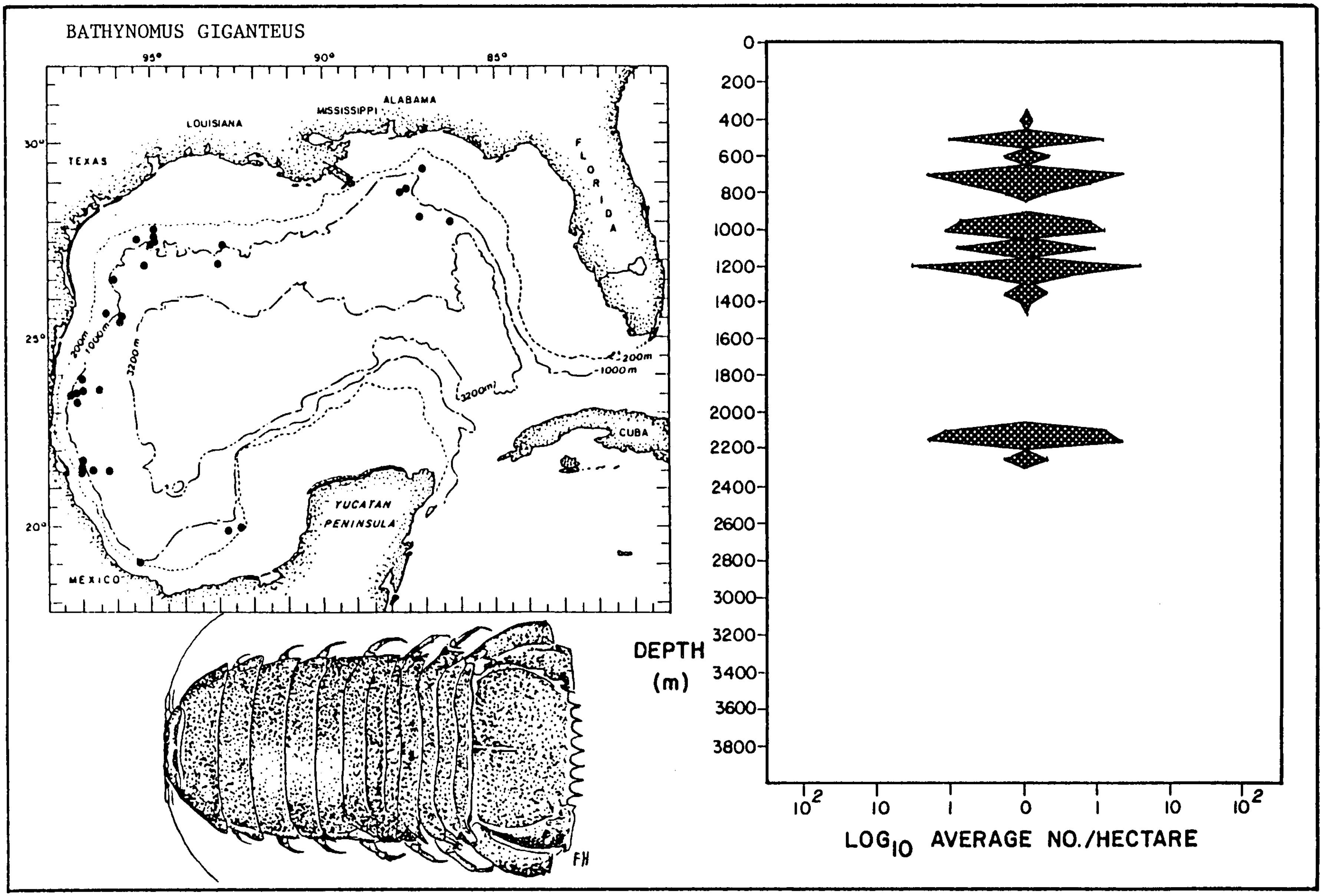

Figure 38. Horizontal and vertical distribution (including population density) of the isopod <u>Bathynomus giganteus</u> in the deep Gulf of Mexico.

Table 16. (I) Penaeidae found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of penaeid shrimps in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Hymenopenaeus tropicalis	2	5	10	150 only	150
Solenocera vioscai	92	30	2760	150-250	200
Solenocera necopina	15	0	-	200-250	200
Parapenaeus longirostris	601	55	33055	150-300	250
Penaeopsis serrata	2554	60	153240	200-550	300
Hymenopenaeus robustus	209	55	11495	300-750	500
Aristaemorpha foliacea	17	10	170	500-700	550
Hymenopenaeus debilis	286	45	12870	300-1050	600
Aristaeus antillensis	7	0	-	500-950	700
Plesiopenaeus edwardsianus	53	40	2120	550-1050	950
Benthesicymus bartletti	686	215	147490	700-2250	1050
Funchalia taaningi	2	0	-	1000-1100	1100
Benthesicymus carinatus	3	0	-	1000-1400	1200
Funchalia cf. *villosa*	1	0	-	1300 only	1300
Benthonectes filipes	1	0	-	1350 only	1350
Hymenopenaeus aphoticus	33	25	825	1000-3250	2100
Plesiopenaeus coruscans	3	0	-	1300-2350	2150
Hepomadus tener	12	25	300	1000-3850	2400
Plesiopenaeus armatus	15	40	600	1800-3750	3100
Benthesicymus cereus/iridescens	31	50	1550	1450-3850	3250
Hemipenaeus carpenteri	34	15	510	1050-3300	3300
Hepomadus ? glacialis	2	5	10	1300-3850	3250

(II) Dominant penaeid shrimps presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Penaeopsis serrata	300
Benthesicymus bartletti	1050
Parapenaeus longirostris	250
Hymenopenaeus debilis	600
Hymenopenaeus robustus	500
Solenocera vioscai	200
Plesiopenaeus edwardsianus	950
Benthesicymus cereus/iridescens	3250
Hymenopeneaus aphoticus	825
Plesiopenaeus armatus	3100
Hemipenaeus carpenteri	3300

Table 17. Distribution of species of Penaeidae among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	5	2	7
Archibenthal Zone (475-950 m)	5	2	7
Upper Abyssal (975-2250 m)	7	7	14
Mesoabyssal (2275-3200 m)	2	5	7
Lower Abyssal (3225-3850)	3	3	6

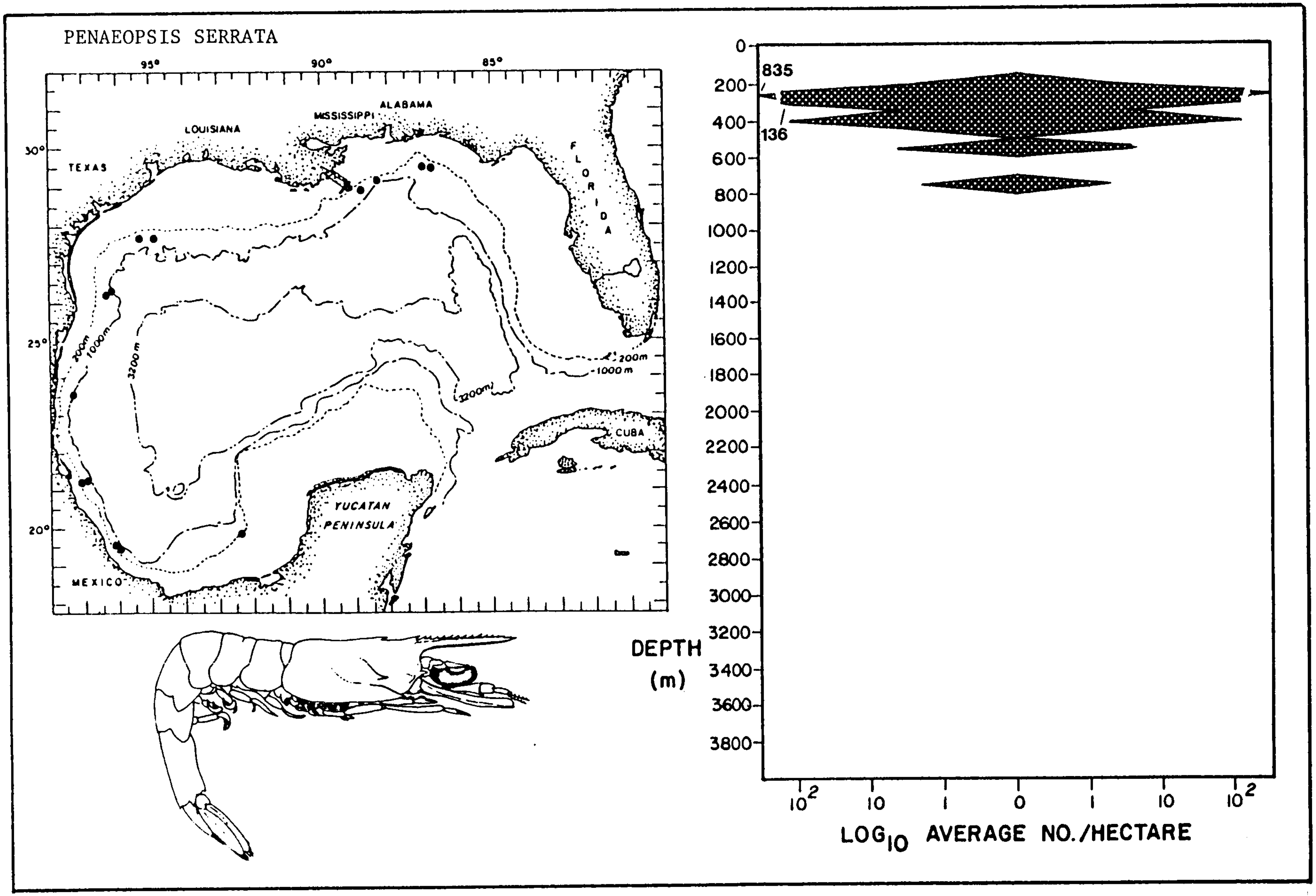

Figure 39. Horizontal and vertical distribution (including population density) of the penaeid shrimp <u>Penaeopsis</u> <u>serrata</u> in the deep Gulf of Mexico.

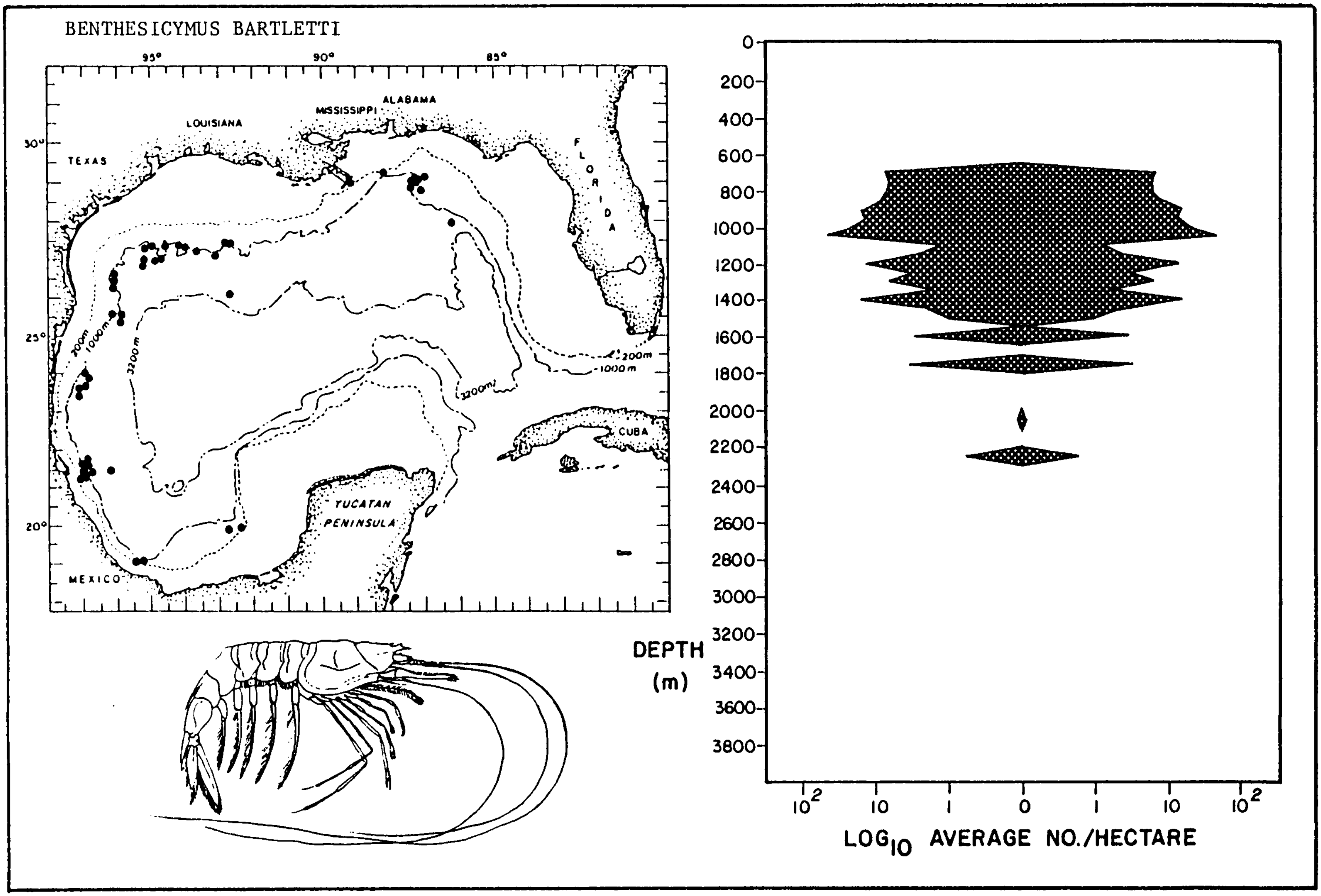

Figure 40. Horizontal and vertical distribution (including population density) of the penaeid shrimp <u>Benthesicymus</u> <u>bartletti</u> in the deep Gulf of Mexico.

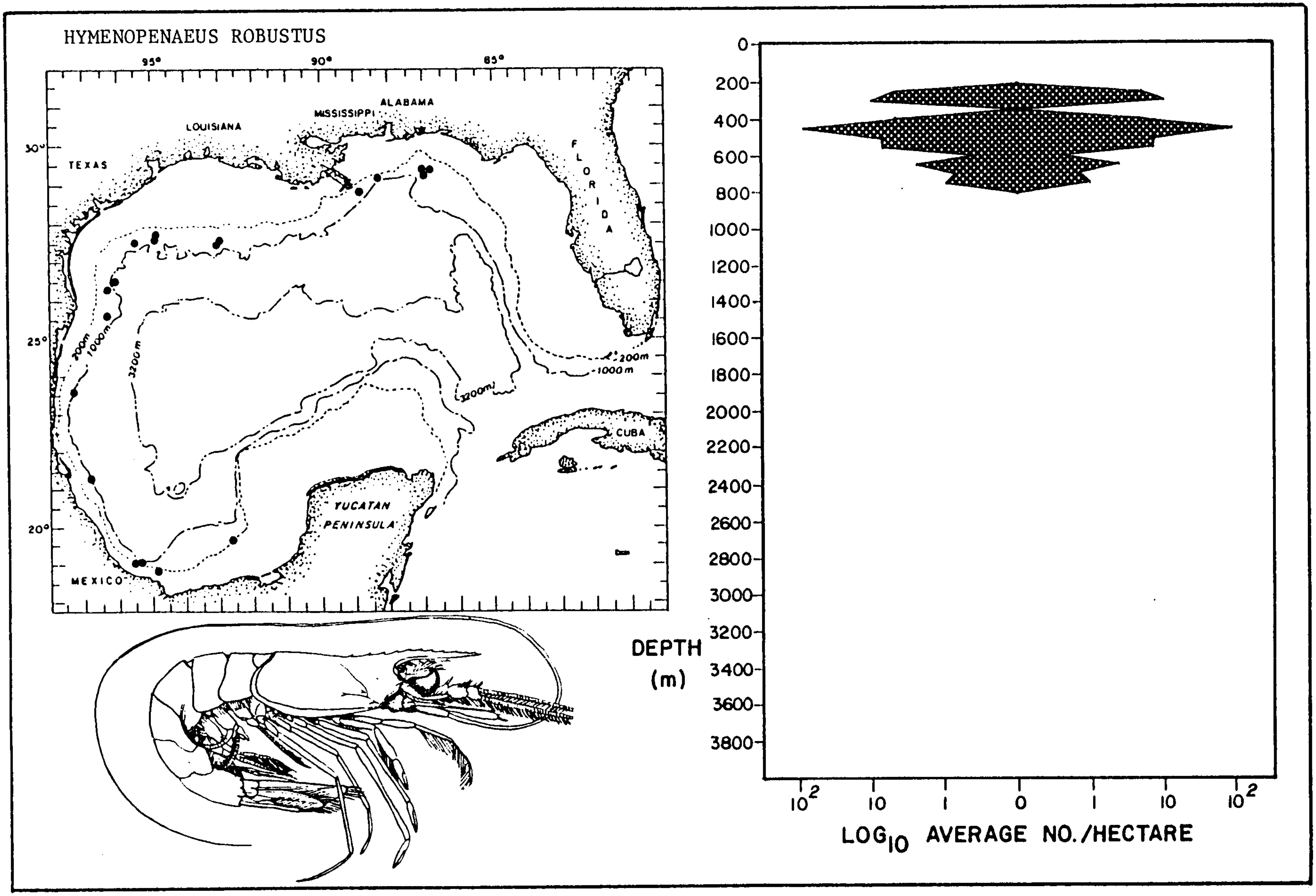

Figure 41. Horizontal and vertical distribution (including population density) of the penaeid shrimp <u>Hymenopenaeus robustus</u> in the deep Gulf of Mexico.

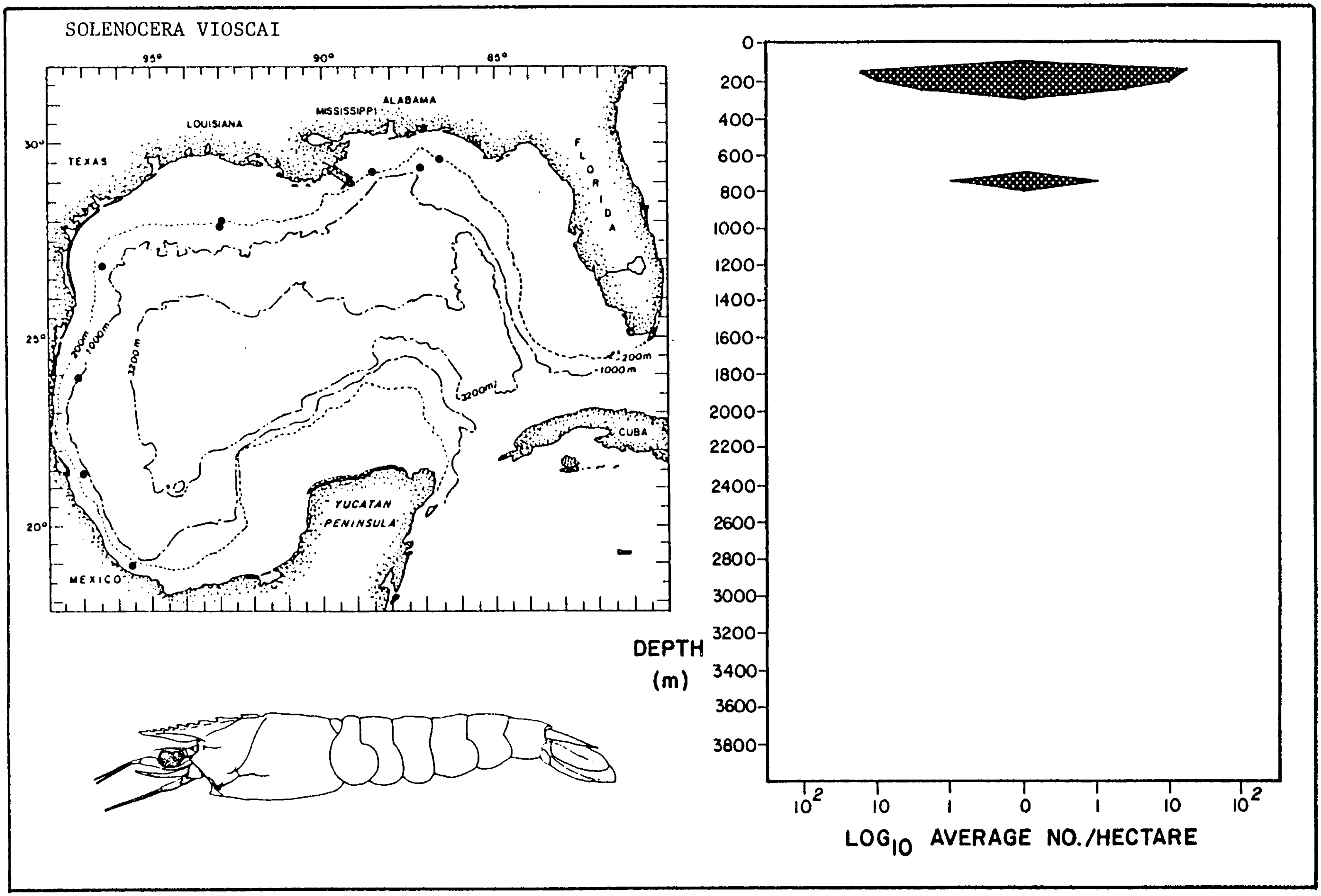

Figure 42. Horizontal and vertical distribution (including population density) of the penaeid shrimp <u>Solenocera</u> <u>vioscai</u> in the deep Gulf of Mexico.

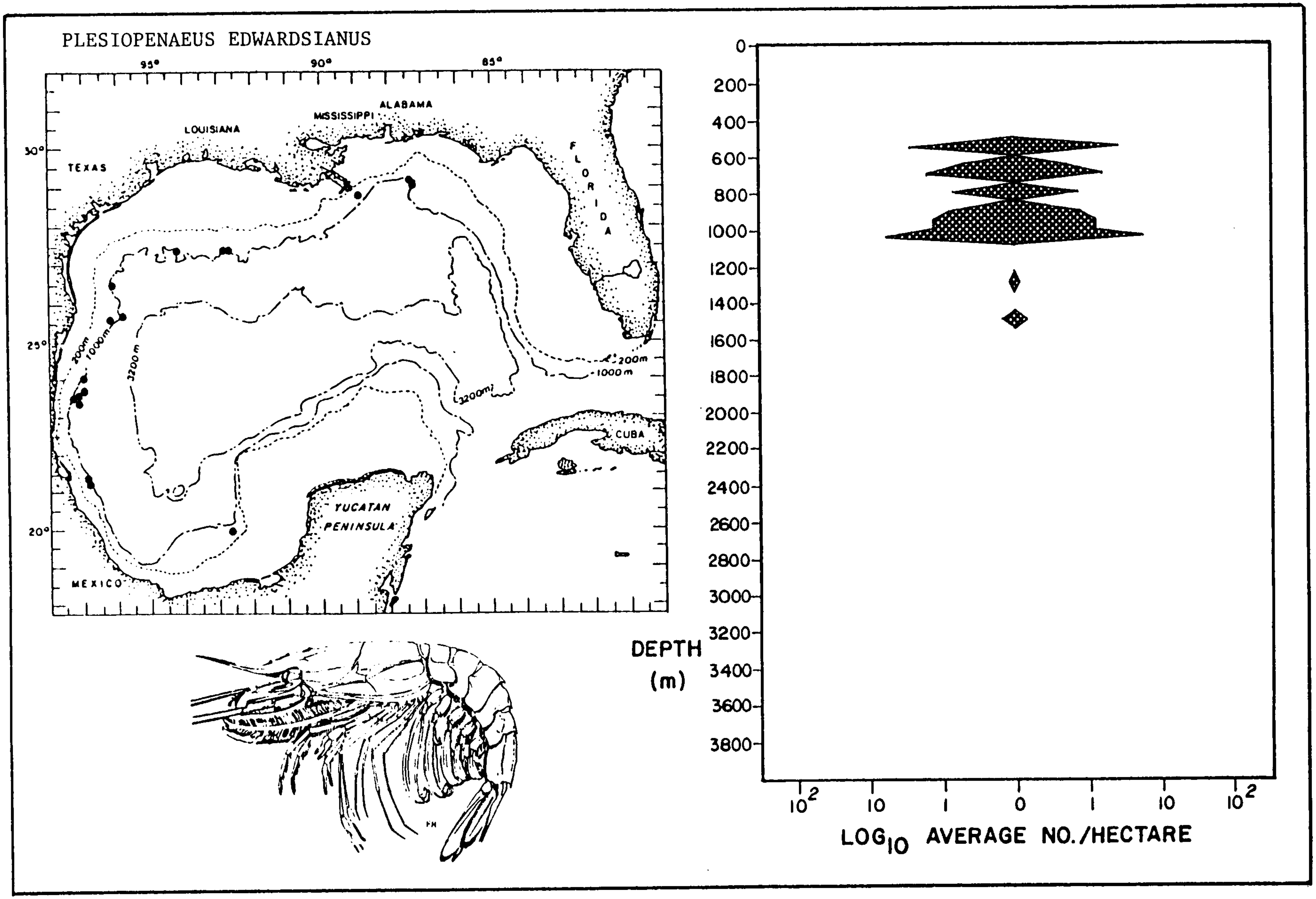

Figure 43. Horizontal and vertical distribution (including population density) of the penaeid shrimp <u>Plesiopenaeus edwardsianus</u> in the deep Gulf of Mexico.

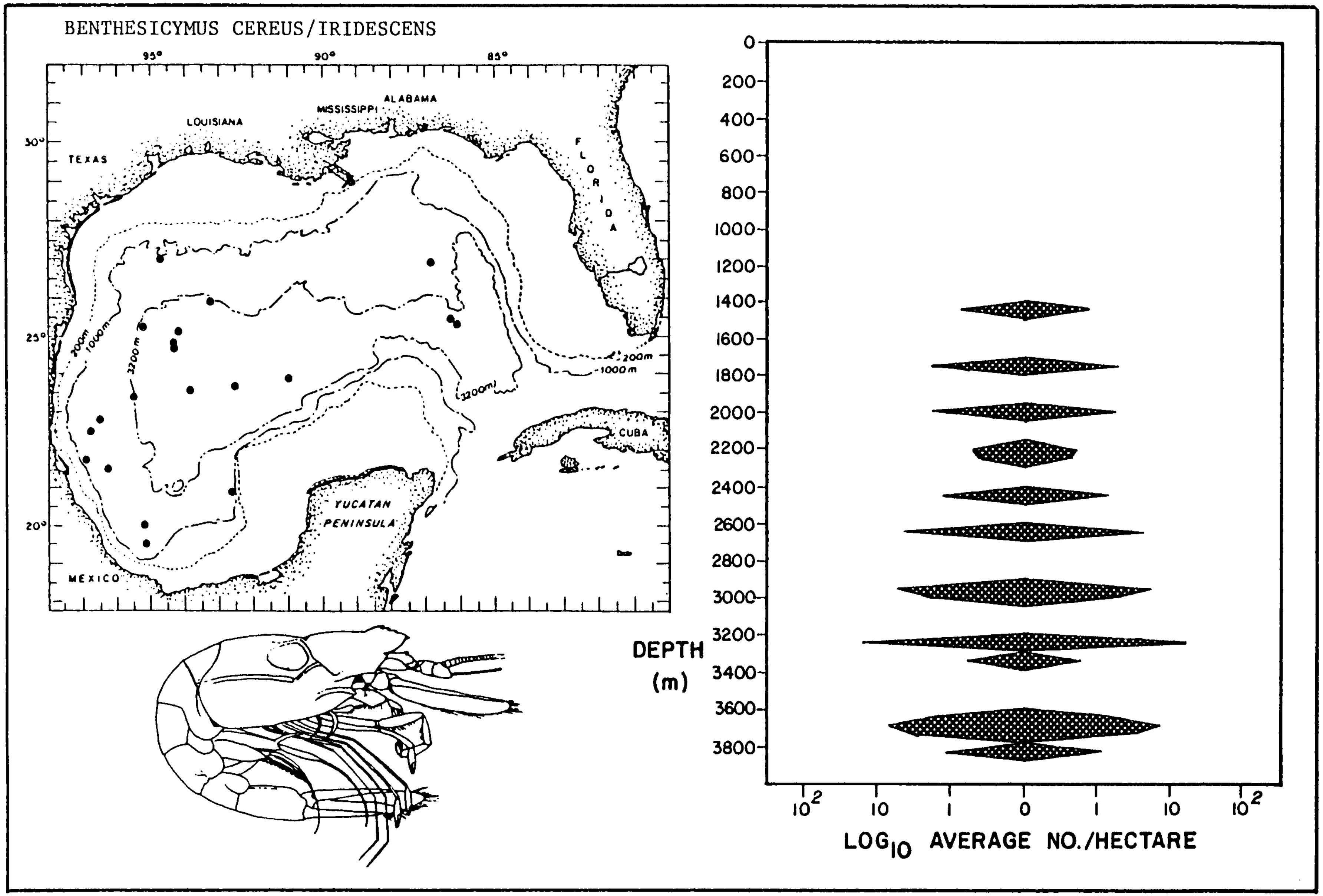

Figure 44. Horizontal and vertical distribution (including population density) of the penaeid shrimp <u>Benthesicymus cereus/iridescens</u> in the deep Gulf of Mexico.

Table 18. (I) Caridea found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of carideans in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Plesionika tenuipes	76	25	1900	250-450	250
Systellaspis pellucida	1417	5	7085	250-1000	300
Pontocaris caribbaeus	32	0	-	one sta only	300
Parapandalus willisi	255	35	8925	250-400	400
Plesionika edwardsii	11	0	-	400 only	400
Sabinea tridentata	3	5	15	400 only	400
Heterocarpus ensifer	178	5	890	450 only	450
Plesionika martia	4	0	-	500 only	500
Glyphocrangon longleyi	73	25	1825	500-650	550
Pasiphaea merriami	680	5	3400	300-800	600
Plesionika acanthonotus	45	0	-	550-750	600
Psalidopus barbouri	5	0	-	600-950	600
Plesionika holthuisi	222	55	12210	500-900	650
Psathyrocaris infirma	25	0	-	650 only	650
Plesionika sp. (cf. *acanthonotus*)	7	0	-	500-750	700
Plesionika polyacanthomerus	33	0	-	500-900	700
Glyphocrangon alispina	389	60	23340	600-1050	750
Pontophilus gracilis	79	10	790	450-1400	850
Acanthephyra armata	17	0	-	700-1000	900
Heterocarpus oryx	297	20	5940	700-1750	950
Nematocarcinus cursor	1	5	5	950 only	950
Glyphocrangon nobilis	746	50	37300	700-2100	1050
Nematocarcinus rotundus	1488	145	215760	500-1850	1050
Glyphocrangon aculeata	371	65	24115	800-1750	1150
Bathypalaemonella serratipalma	15	0	-	900-1850	1400
Bathypalaemonella texana	1	0	-	1450 only	1450
Glyphocrangon longirostris	7	0	-	1750-2350	2050
Glyphocrangon sculptus	4	0	-	2050-2100	2100
Nematocarcinus ensifer	138	125	17250	1650-3750	2100
Pontophilus talismani	5	5	25	2350-3750	2650
Nematocarcinus acanthitelsonis	6	0	-	2250-3250	2950
Acanthephyra acutifrons	7	5	35	3250 only	3250
Acanthephyra microphthalma	19	20	380	3250-3840	3550

(II) Dominant carideans presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Nematocarcinus rotundus	1050
Glyphocrangon nobilis	1400
Glyphocrangon aculeata	1150
Glyphocrangon alispina	750
Nematocarcinus ensifer	2100
Plesionika holthuisi	650
Parapandalus willisi	400
Systellaspis pellucida	300
Heterocarpus oryx	950
Pasiphaea merriami	600

Table 19. Distribution of species of Caridea among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	7	2	9
Archibenthal Zone (475-950 m)	14	5	19
Upper Abyssal (975-2250 m)	8	6	14
Mesoabyssal (2275-3200 m)	2	2	4
Lower Abyssal (3225-3850)	2	3	5

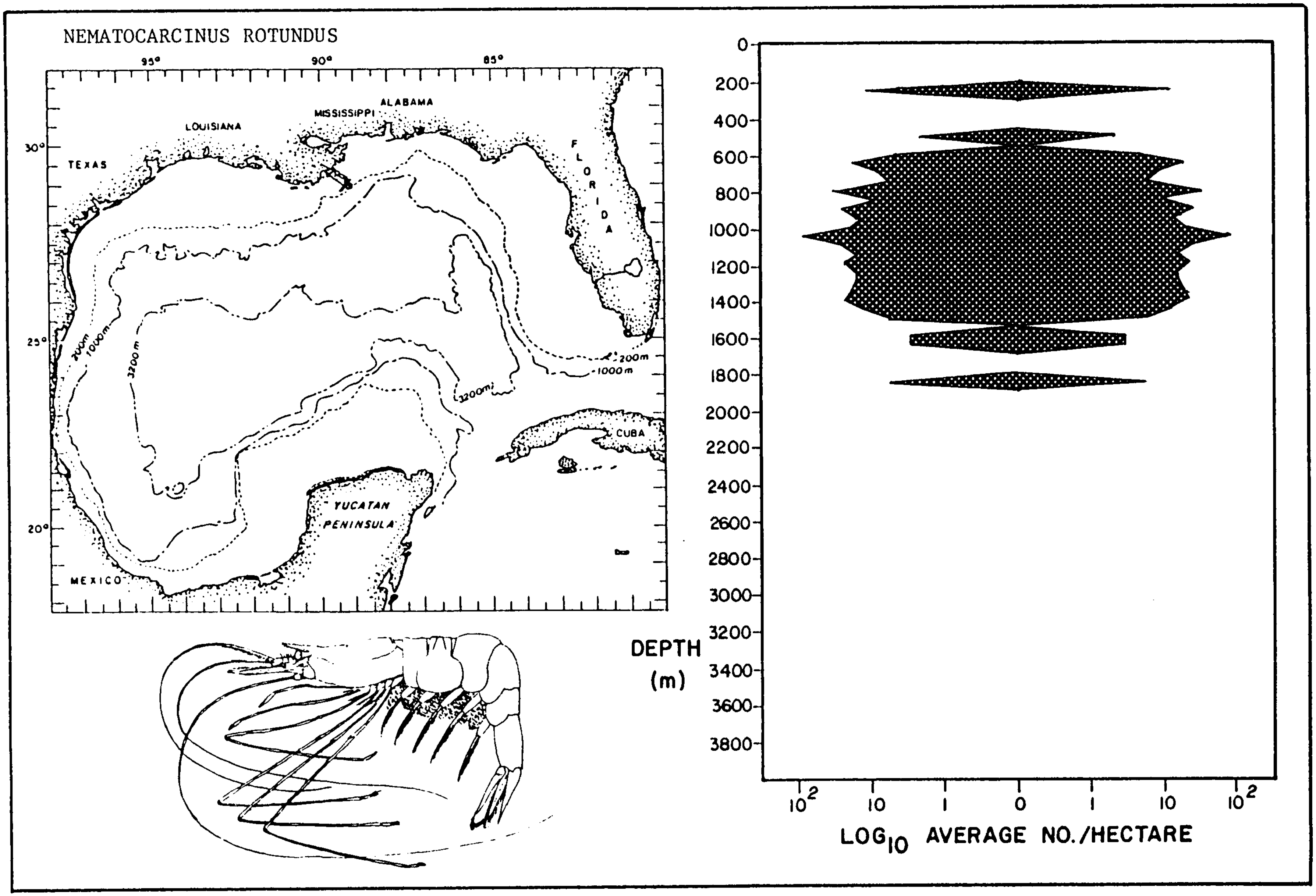

Figure 45. Horizontal and vertical distribution (including population density) of the caridean shrimp <u>Nematocarcinus rotundus</u> in the deep Gulf of Mexico.

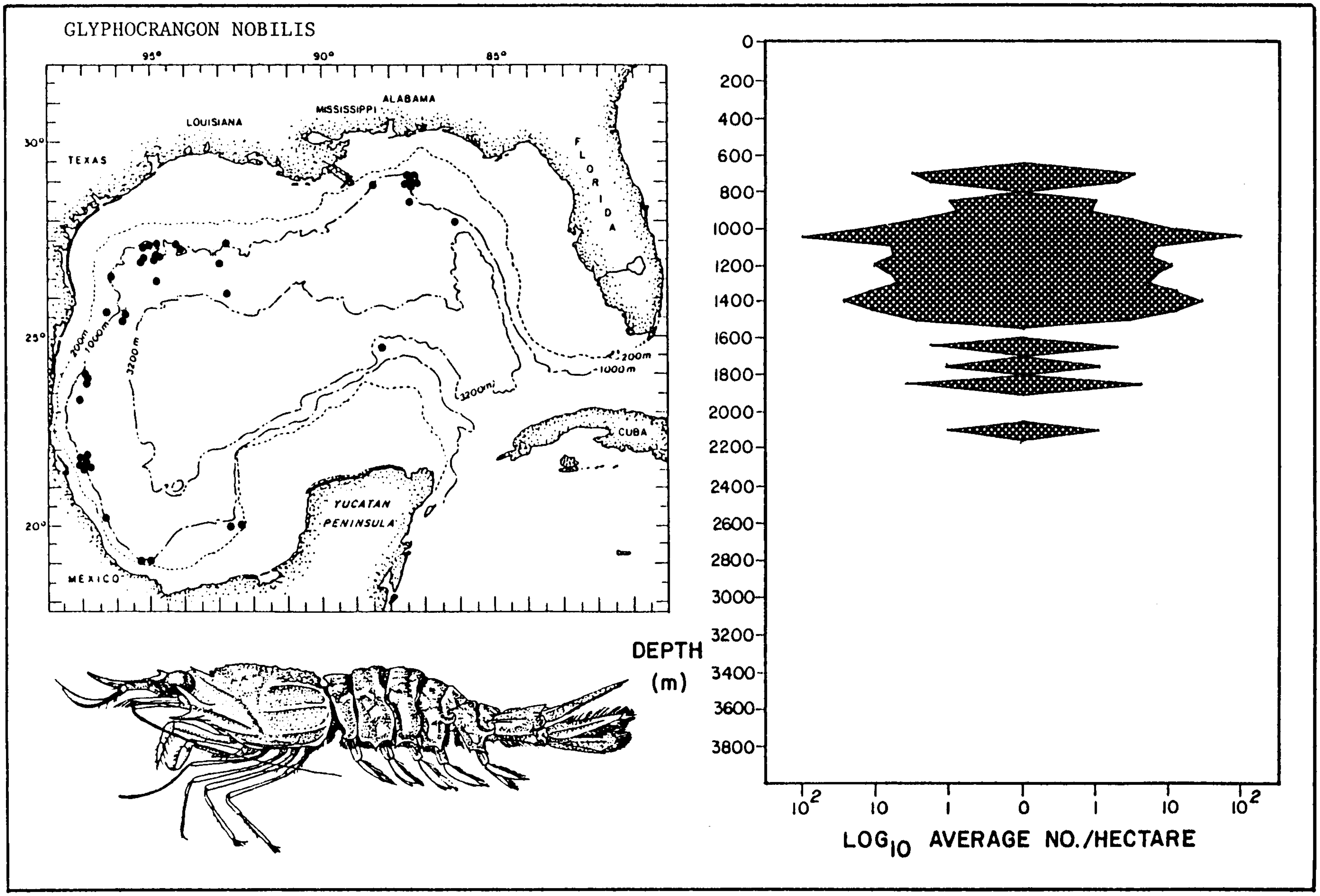

Figure 46. Horizontal and vertical distribution (including population density) of the caridean shrimp <u>Glyphocrangon nobilis</u> in the deep Gulf of Mexico.

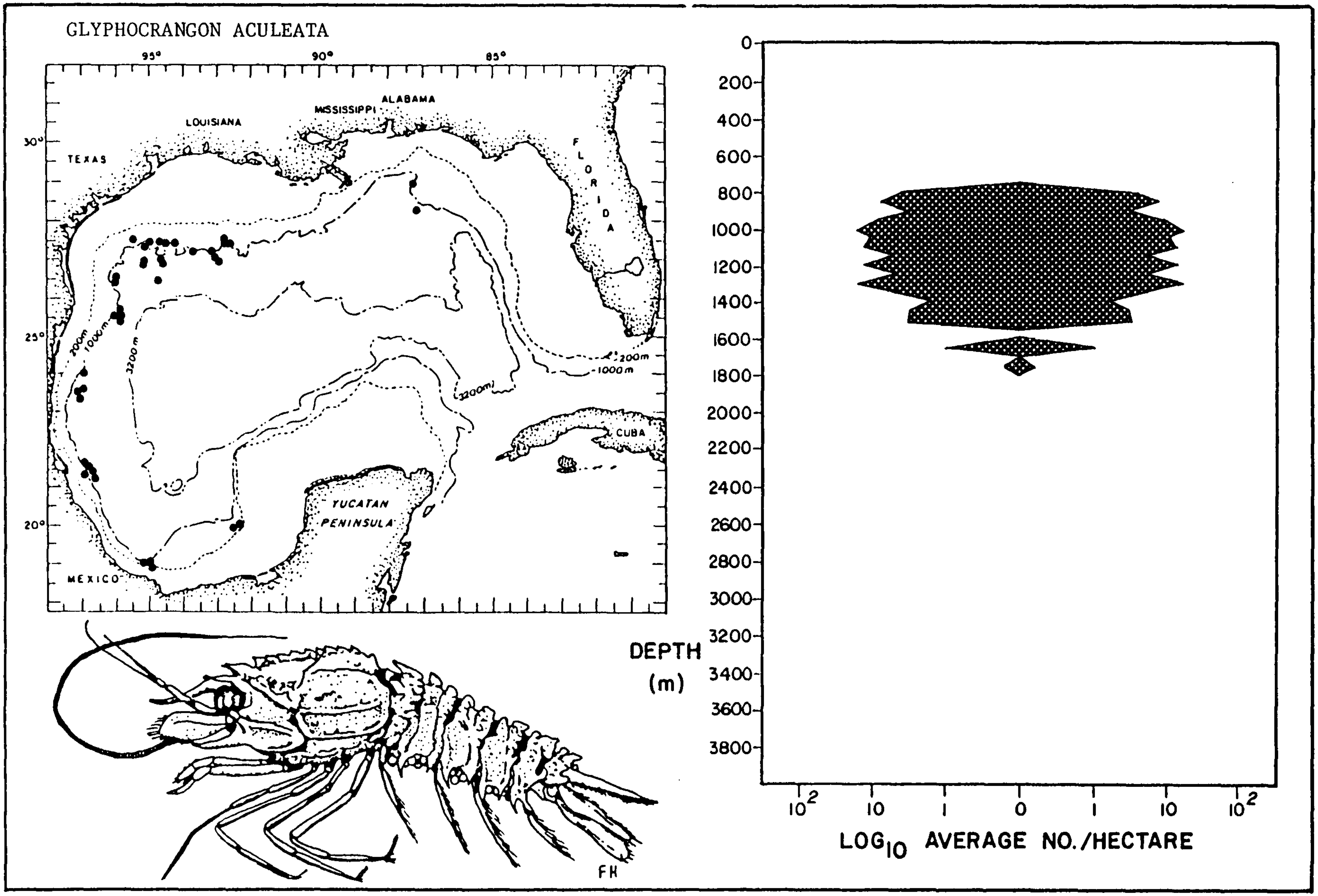

Figure 47. Horizontal and vertical distribution (including population density) of the caridean shrimp Glyphocrangon aculeata in the deep Gulf of Mexico.

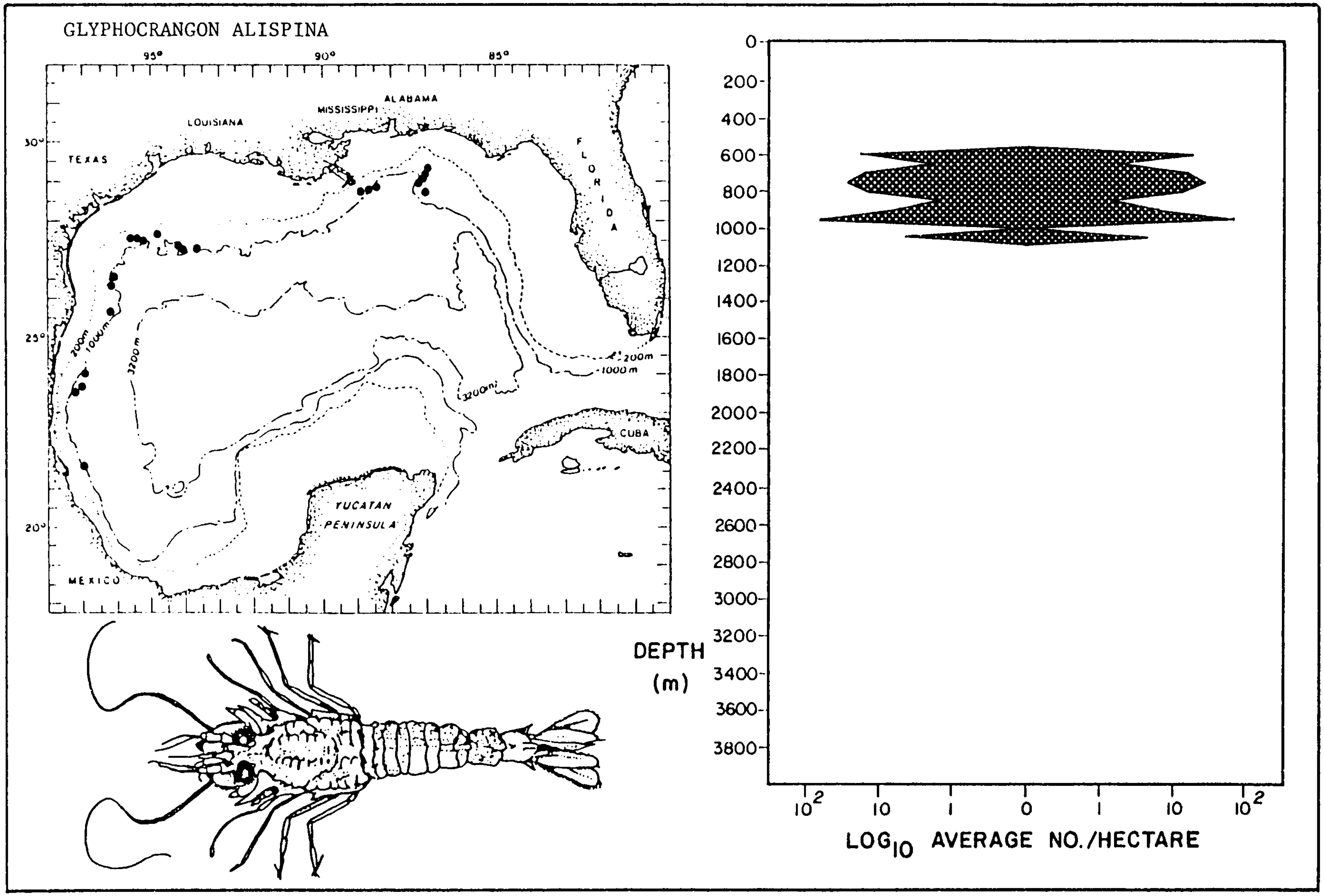

Figure 48. Horizontal and vertical distribution (including population density) of the caridean shrimp <u>Glyphocrangon</u> <u>alispina</u> in the deep Gulf of Mexico.

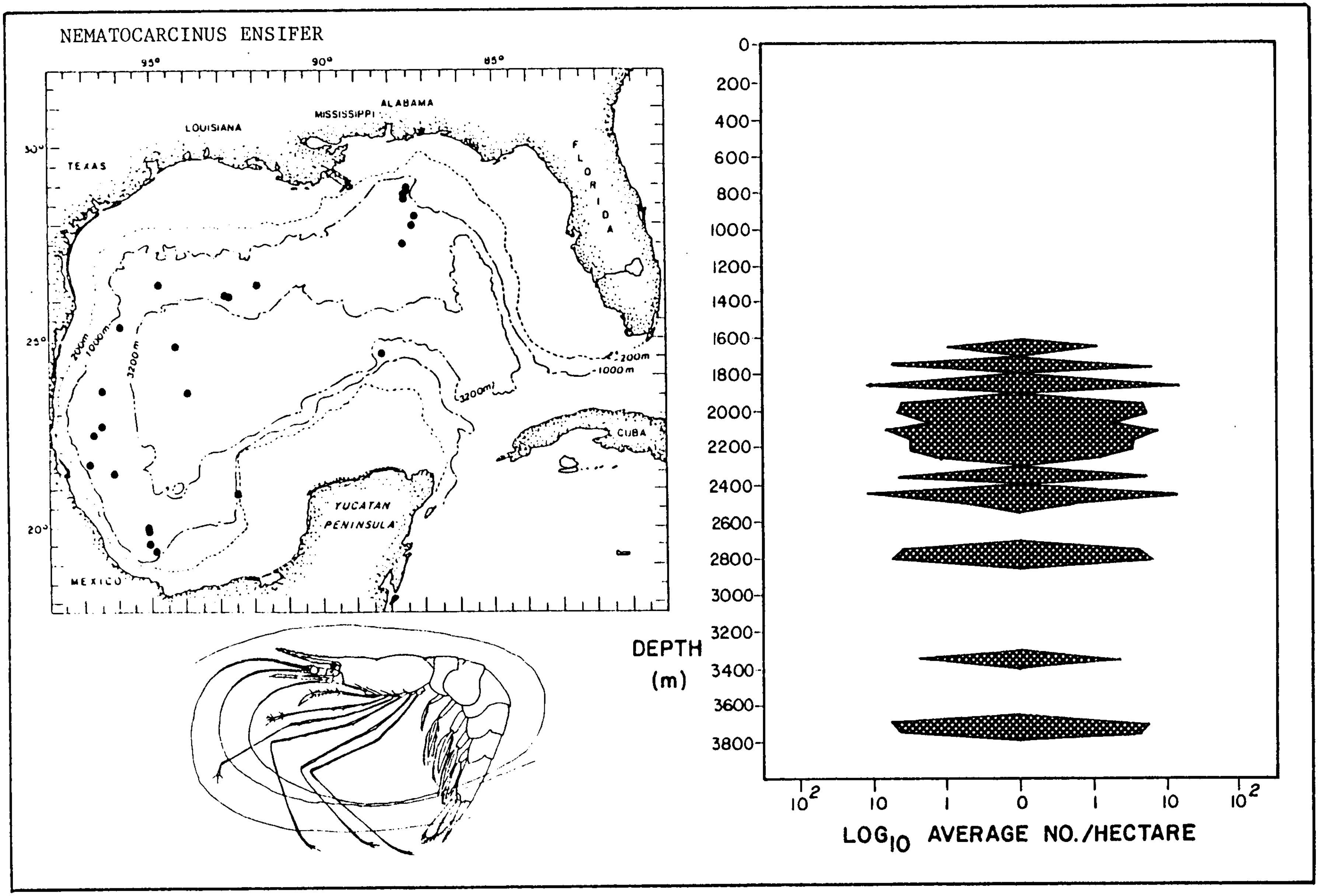

Figure 49. Horizontal and vertical distribution (including population density) of the caridean shrimp Nematocarcinus ensifer in the deep Gulf of Mexico.

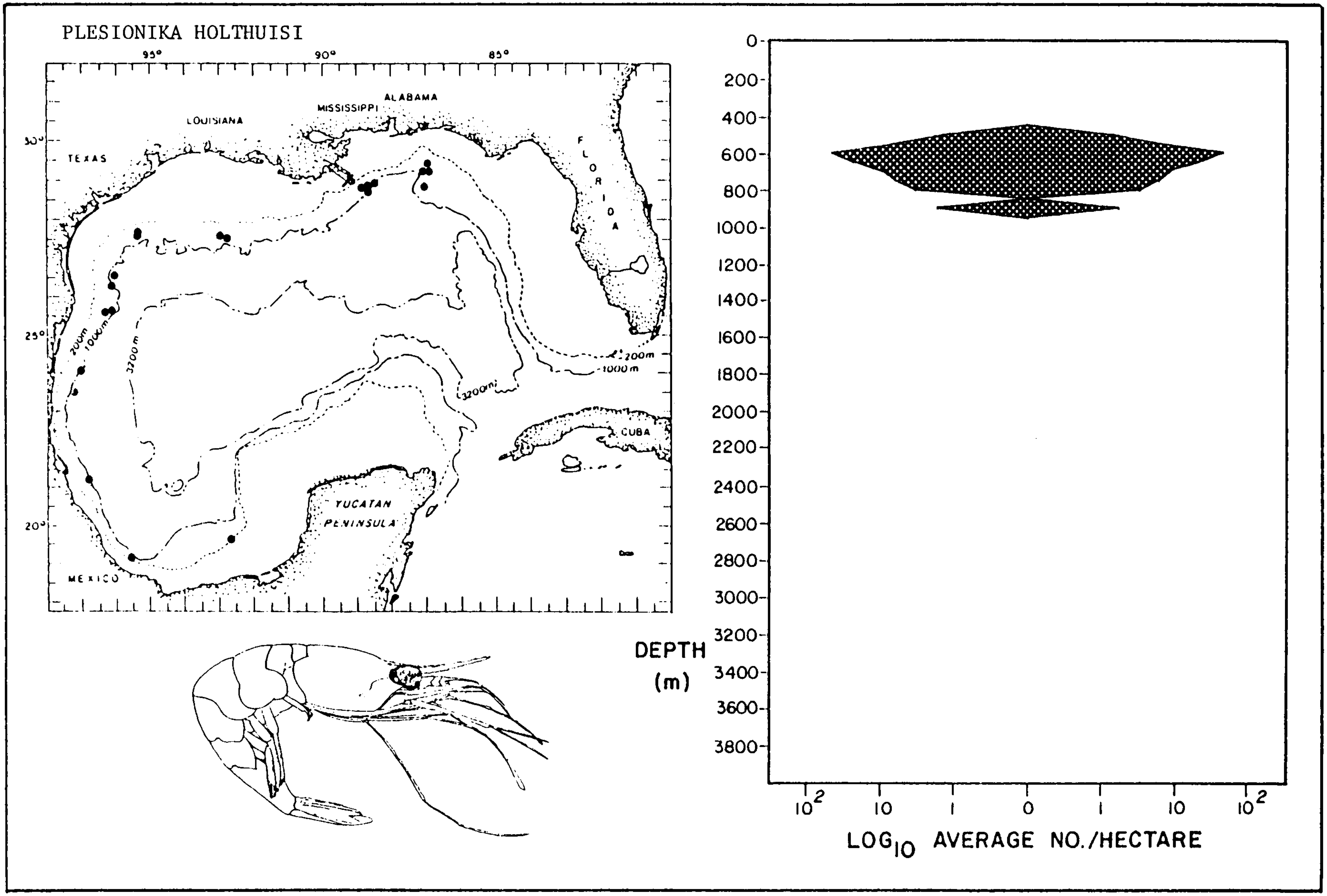

Figure 50. Horizontal and vertical distribution (including population density) of the caridean shrimp Plesionika holthuisi in the deep Gulf of Mexico.

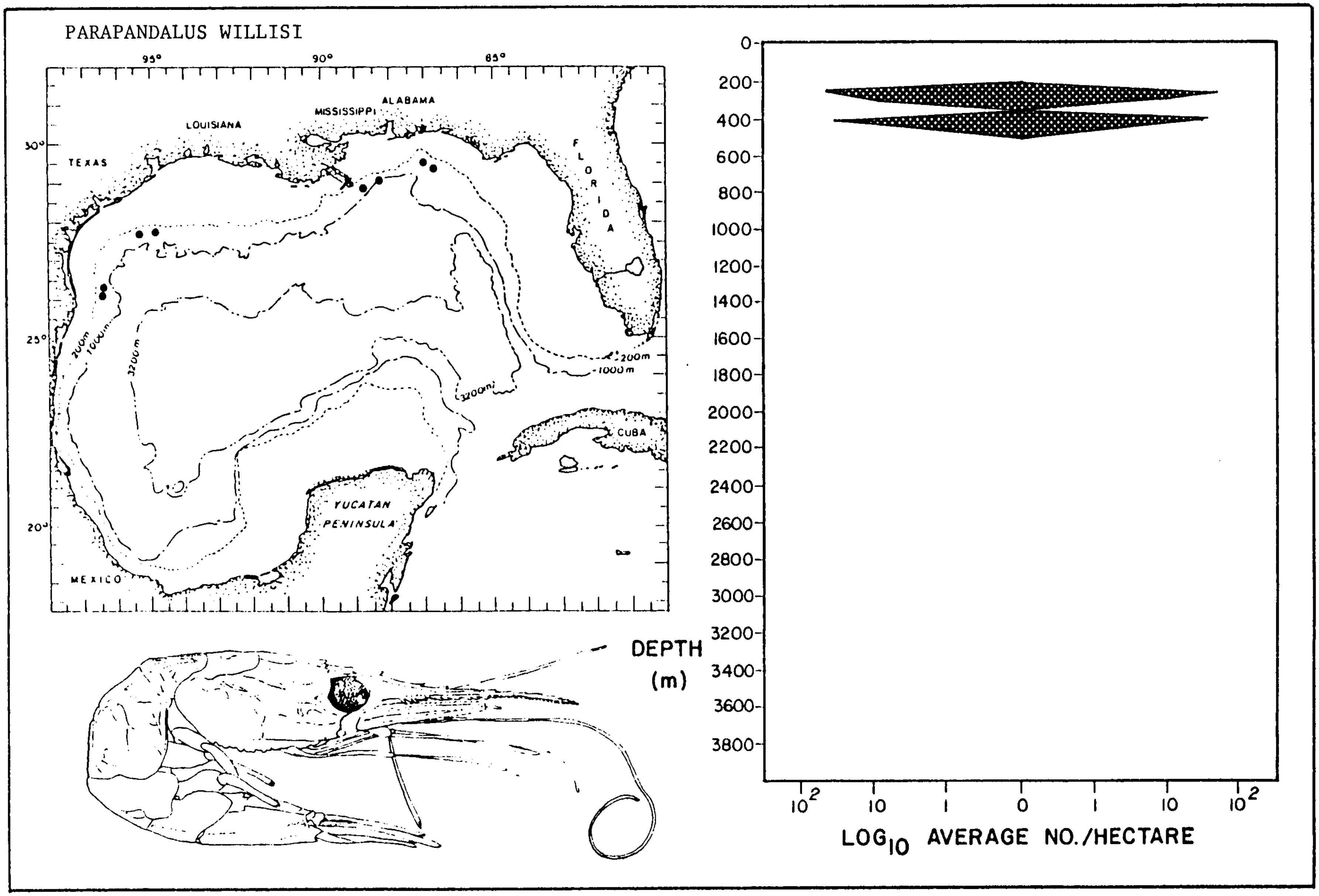

Figure 51. Horizontal and vertical distribution (including population density) of the caridean shrimp Parapandalus willisi in the deep Gulf of Mexico.

Table 20. (I) Polychelidae and Nephropidae found in the deep Gulf of Mexico
(II) Dominant species in rank order.

(I) Inventory of polychelid and nephropid crustaceans in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Polychelidae					
Polycheles typhlops	90	30	2700	350-800	500
Stereomastis sculpta sculpta	1409	370	521300	500-2750	1050
Polycheles crucifer	4	5	20	1000-1400	1200
Polycheles validus	32	60	1920	1300-3350	2100
Willemoesia forceps	1	5	5	3250 only	3250
Nephropidae					
Nephropsis aculeata	65	65	4225	350-1350	500
Nephropsis rosea	12	25	300	500-750	600
Acanthacaris caeca	3	5	15	500-900	700
Nephropsis agassizii	54	60	3240	900-1600	950

(II) Dominant polychelid and nephropid crustaceans presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Polychelidae	
Stereomastis sculpta sculpta	1050
Polycheles typhlops	500
Polycheles validus	2100
Nephropidae	
Nephropsis aculeata	500
Nephropsis agassizii	950
Nephropsis rosea	600

Table 21. Distribution of species of Polychelidae among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	0	1	1
Archibenthal Zone (475-950 m)	1	1	2
Upper Abyssal (975-2250 m)	3	0	3
Mesoabyssal (2275-3200 m)	0	2	2
Lower Abyssal (3225-3850)	1	1	2

Table 22. Distribution of species of Nephropidae among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	0	1	1
Archibenthal Zone (475-950 m)	4	0	4
Upper Abyssal (975-2250 m)	0	2	2
Mesoabyssal (2275-3200 m)	0	0	0
Lower Abyssal (3225-3850)	0	0	0

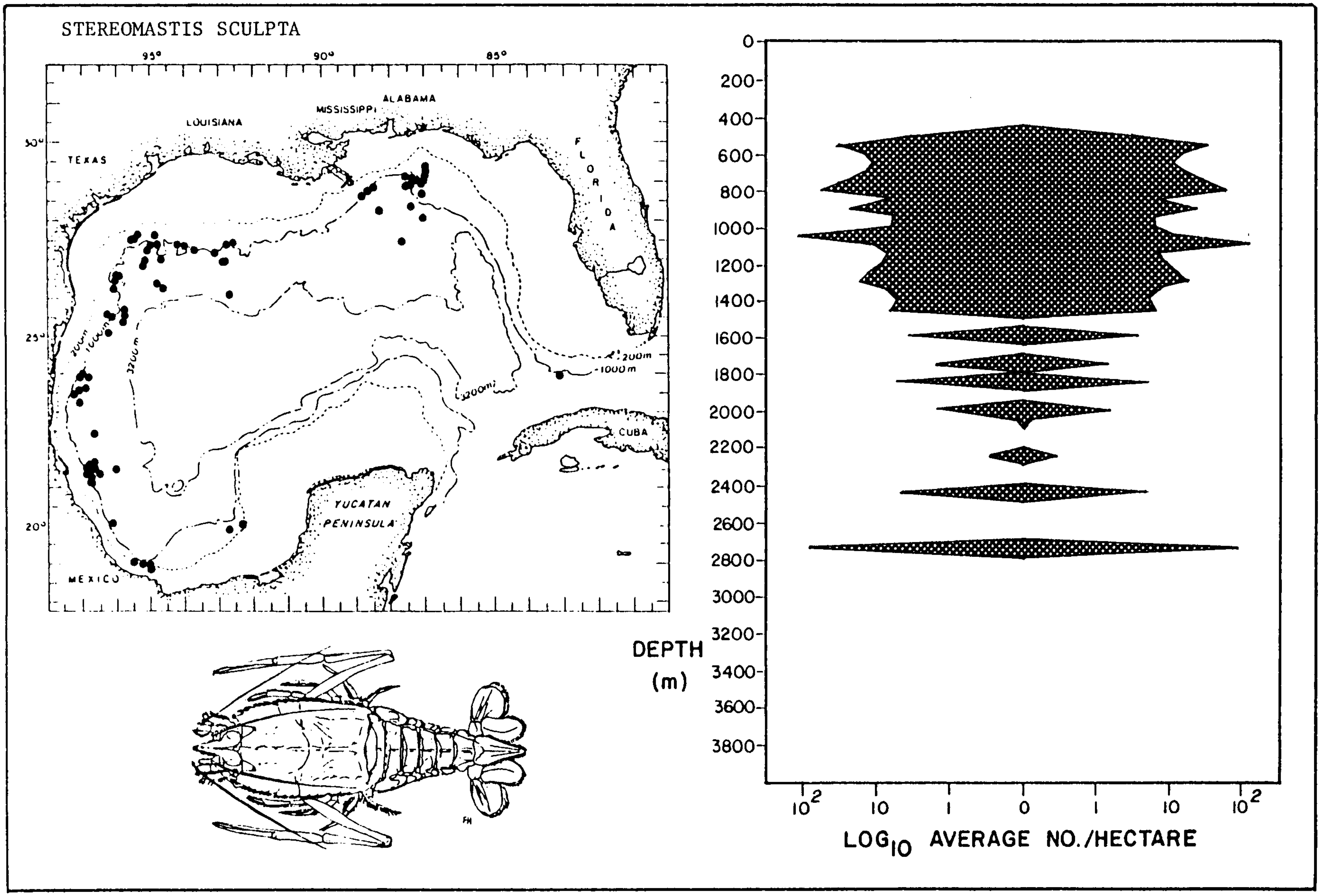

Figure 52. Horizontal and vertical distribution (including population density) of the polychelid lobster Stereomastis sculpta in the deep Gulf of Mexico.

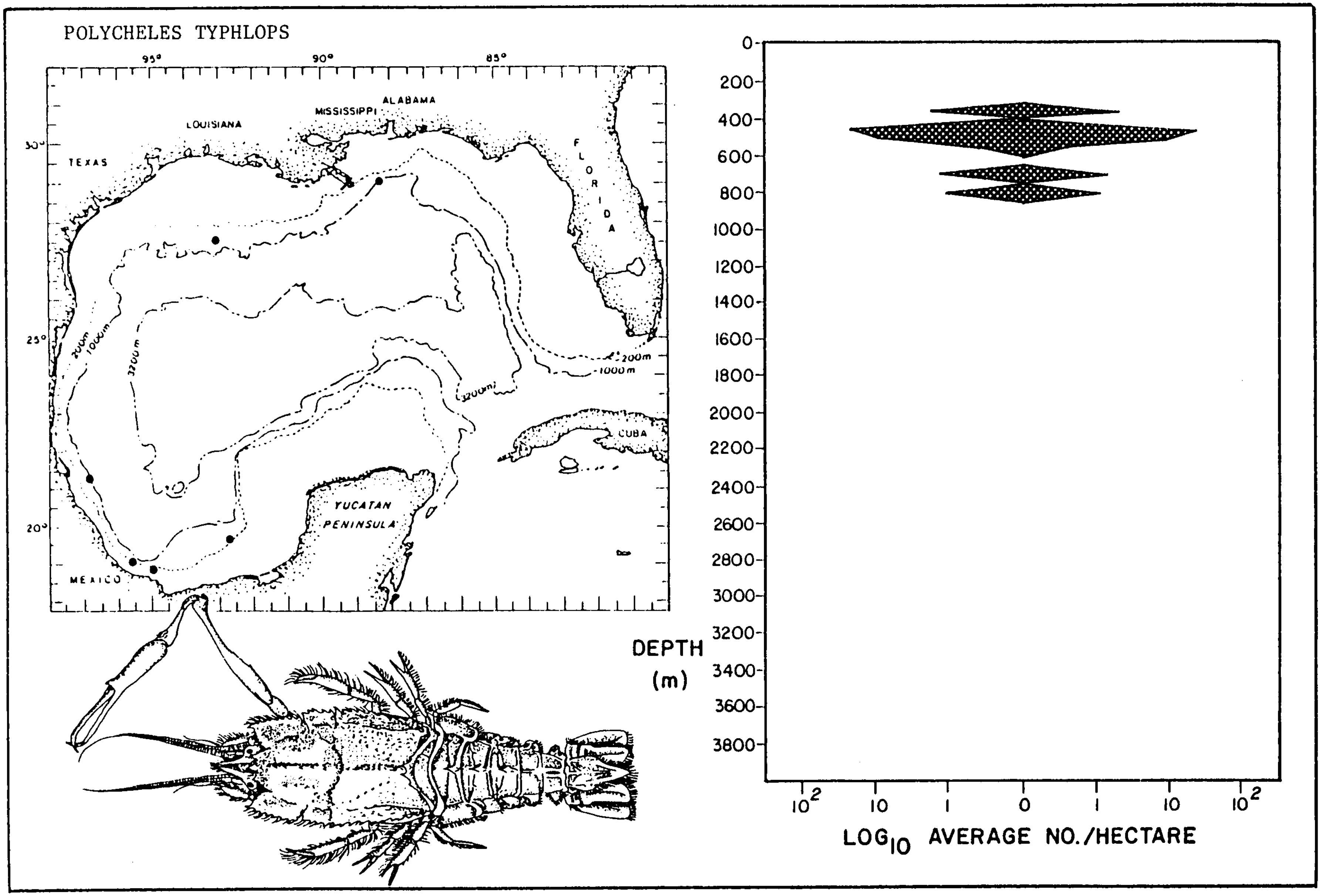

Figure 53. Horizontal and vertical distribution (including population density) of the polychelid lobster <u>Polycheles typhlops</u> in the deep Gulf of Mexico.

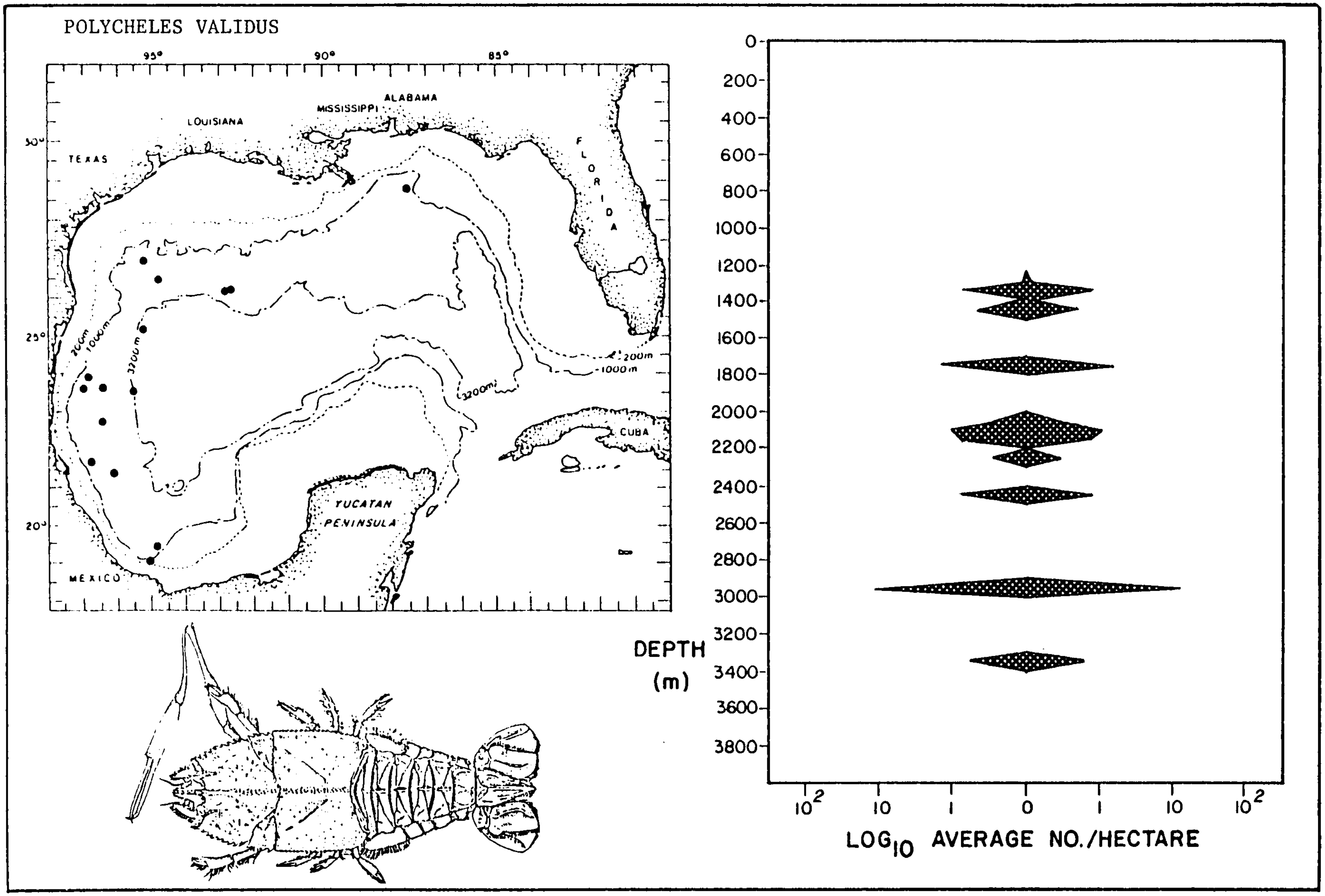

Figure 54. Horizontal and vertical distribution (including population density) of the polychelid lobster Polycheles validus in the deep Gulf of Mexico.

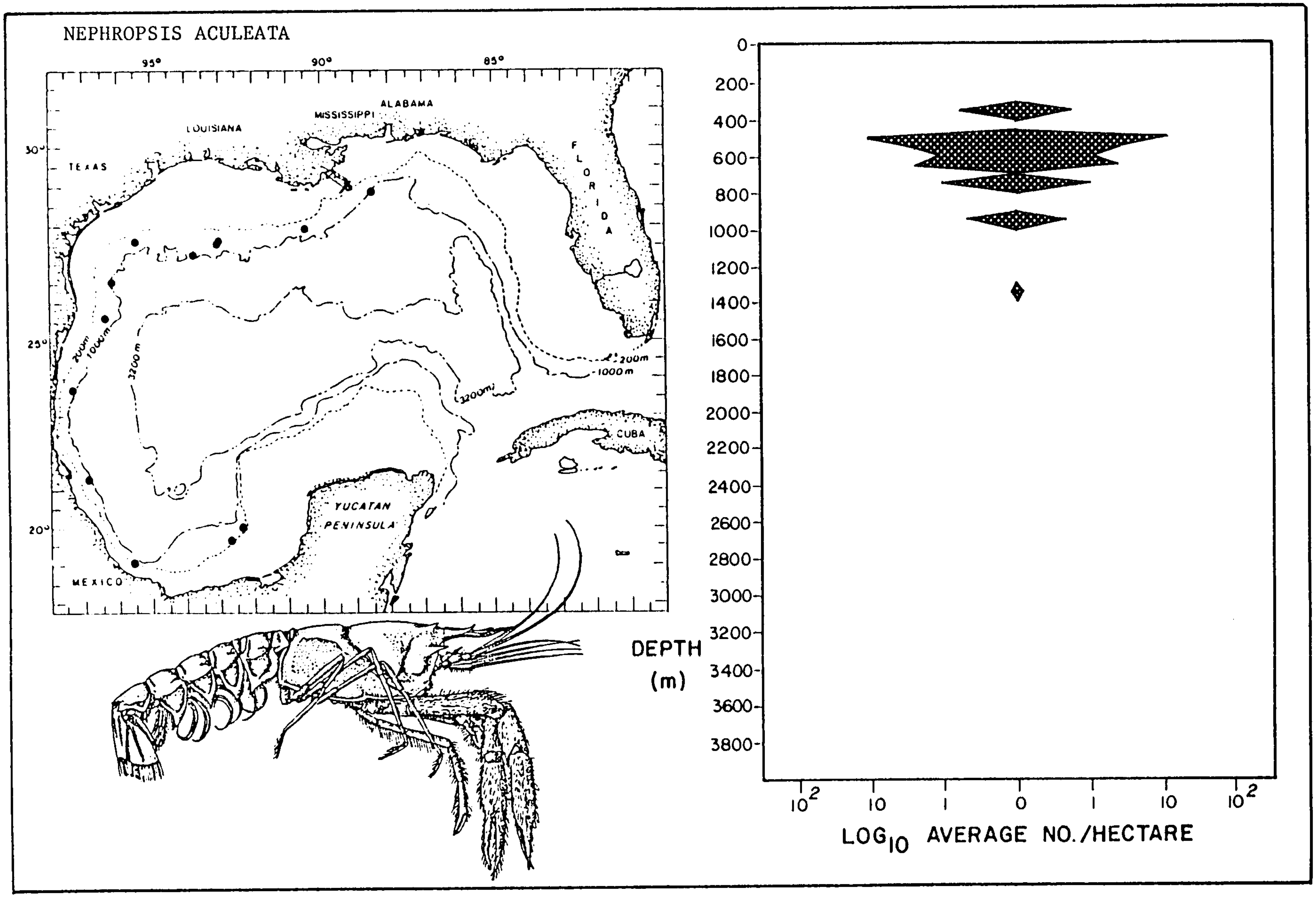

Figure 55. Horizontal and vertical distribution (including population density) of the nephropid lobster <u>Nephropsis</u> <u>aculeata</u> in the deep Gulf of Mexico.

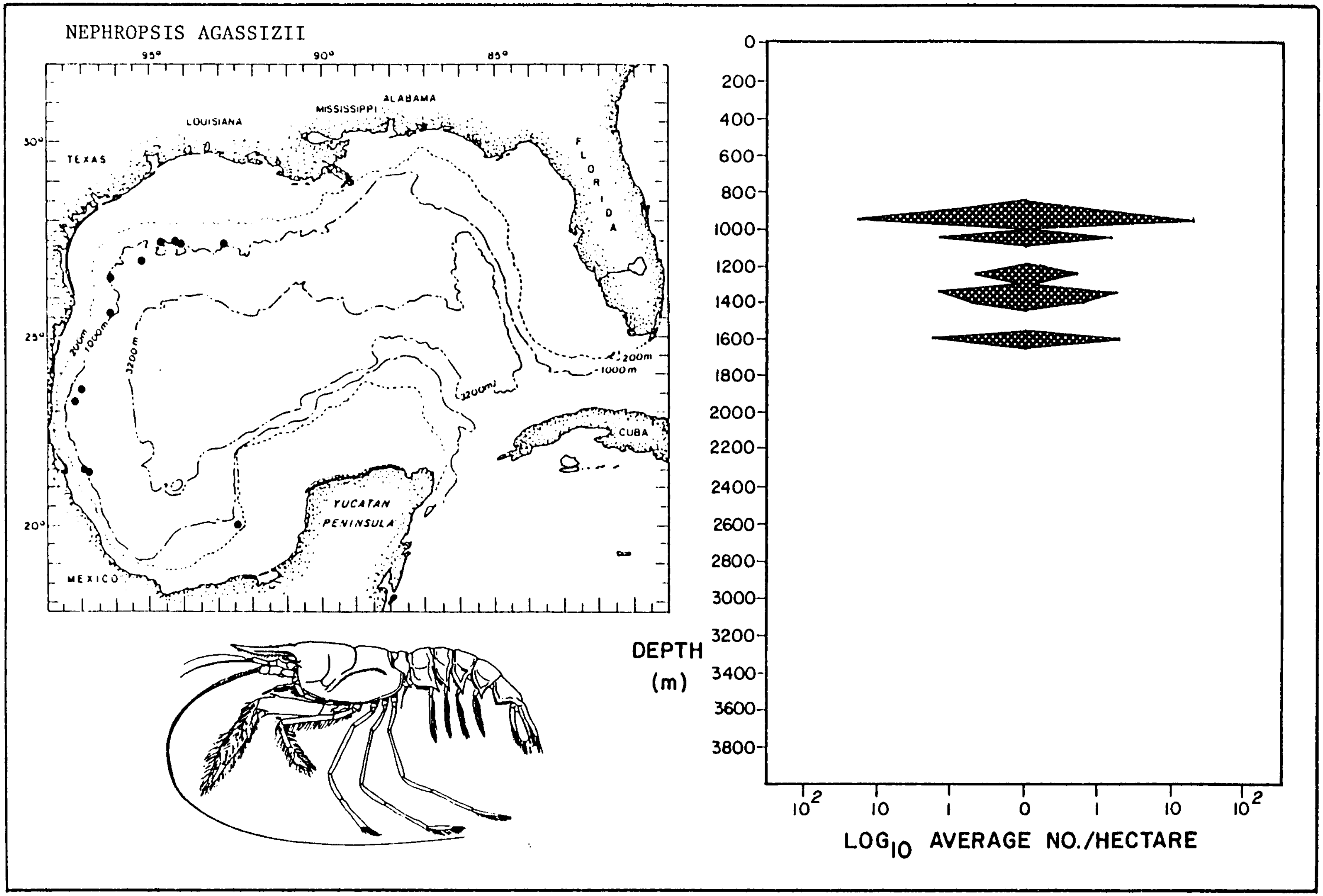

Figure 56. Horizontal and vertical distribution (including population density) of the nephropid lobster Nephropsis agassizii in the deep Gulf of Mexico.

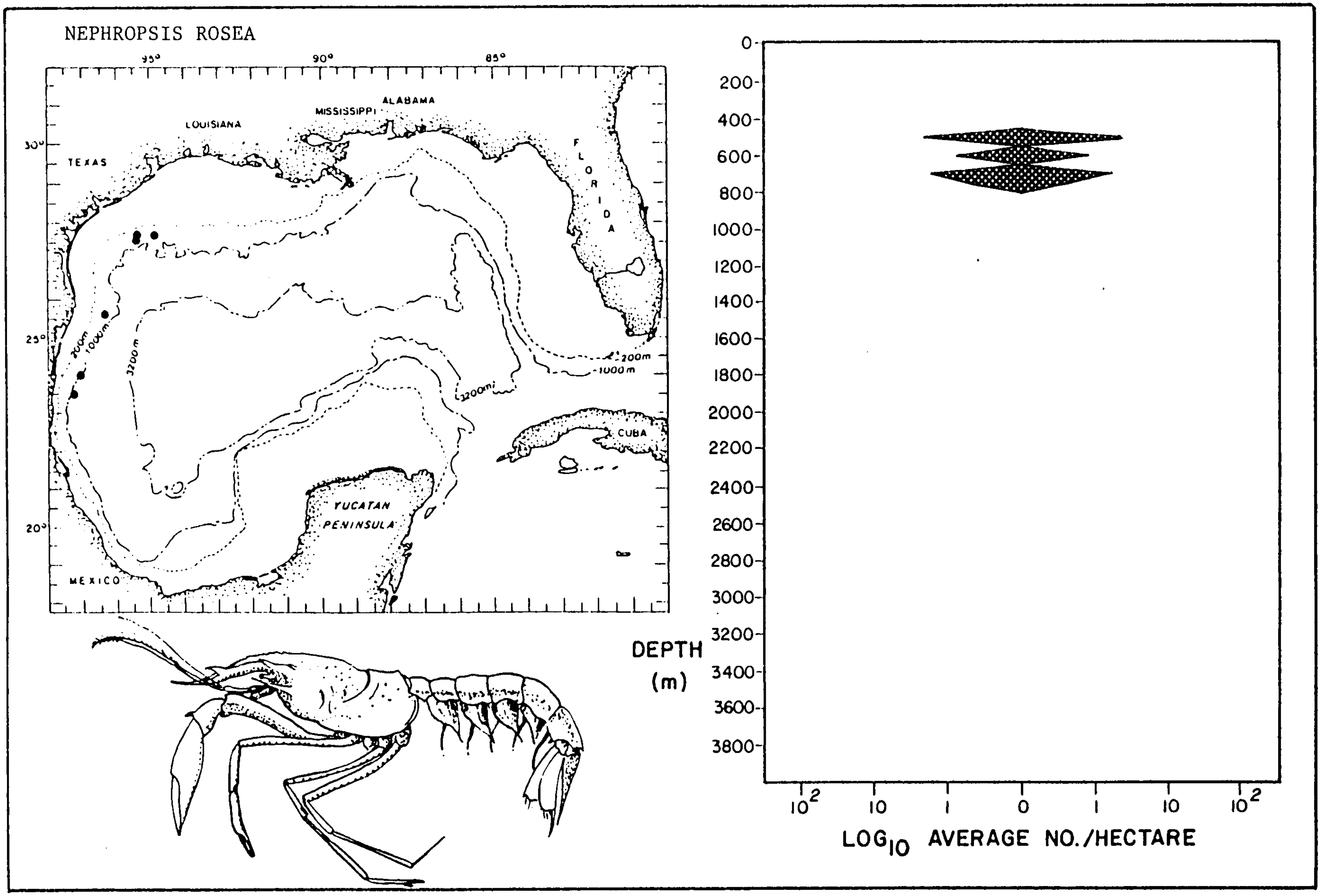

Figure 57. Horizontal and vertical distribution (including population density) of the nephropid lobster *Nephropsis rosea* in the deep Gulf of Mexico.

Table 23. (I) Macrura (except Polychelidae and Nephropidae) found in the deep Gulf of Mexico.

(I) Inventory of macrurans in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Callianassa latispina	2	5	10	200 only	200
Scyllarus depressus	3	5	15	200 only	200
Axiidae	16	5	80	300 only	300
Callianassa marginata	10	20	200	200-650	350

Table 24. (I) Galatheidae found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of galatheids in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Munida irrasa	4	10	40	150-300	150
Munida sculpta	1	5	5	150 only	150
Munida forceps	39	35	1365	150-500	200
Munida flinti	5	20	100	200 only	200
Munida longipes	226	85	19210	150-500	400
Munidopsis robusta	19	15	285	400-1000	500
Munidopsis polita	5	5	25	400-750	500
Munida iris	1	0	-	500 only	500
Munidopsis n. sp. (cf. *abreviata*)	2	5	10	550 only	550
Munidopsis serratifrons	1	0	-	550 only	550
Munidopsis tridentata	3	10	30	400-800	600
Munidopsis erinaceus	14	5	70	500-750	600
Munida valida	114	95	10830	450-750	650
Munidopsis longimanus	32	35	1120	350-1150	750
Munidopsis alaminos	15	15	225	500-800	800
Munidopsis subspinoculata	1	5	5	800 only	800
Munidopsis sigsbei	125	120	15000	750-1600	950
Munidopsis riveroi	1	0	-	1000 only	1000
Munidopsis spinosa	3	10	30	800-1050	1000
Munidopsis spinoculata	5	5	25	950-1350	1050
Munidopsis abreviata	8	5	40	900-1150	1050
Munida microphthalma	2	5	10	1100-1350	1250
Munidopsis simplex	29	45	1305	1000-1800	1350
Munidopsis nitida	11	20	220	1100-2100	1350
Munidopsis gulfensis	1	0	-	1400 only	1400
Munidopsis rostrata	2	5	10	2050-2250	2150
Munidopsis geyeri	6	5	30	3000 only	3000
Munidopsis sundi	2	5	10	3300 only	3300
Munidopsis columbiana	2	5	10	3300 only	3300
Munidopsis bermudezi	21	10	210	3300 only	3300

(II) Dominant galatheids presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Munida longipes	400
Munidopsis sigsbei	950
Munida valida	650
Munida forceps	200
Munidopsis simplex	1350
Munidopsis longimanus	750

Table 25. Distribution of species of Galatheidae (Munida only) among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	5	1	6
Archibenthal Zone (475-950 m)	2	2	4
Upper Abyssal (975-2250 m)	1	0	1
Mesoabyssal (2275-3200 m)	0	0	0
Lower Abyssal (3225-3850)	0	0	0

Table 26. Distribution of species of Galatheidae (Munidopsis only) among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	0	4	4
Archibenthal Zone (475-950 m)	10	3	13
Upper Abyssal (975-2250 m)	8	3	11
Mesoabyssal (2275-3200 m)	1	0	1
Lower Abyssal (3225-3850)	3	0	3

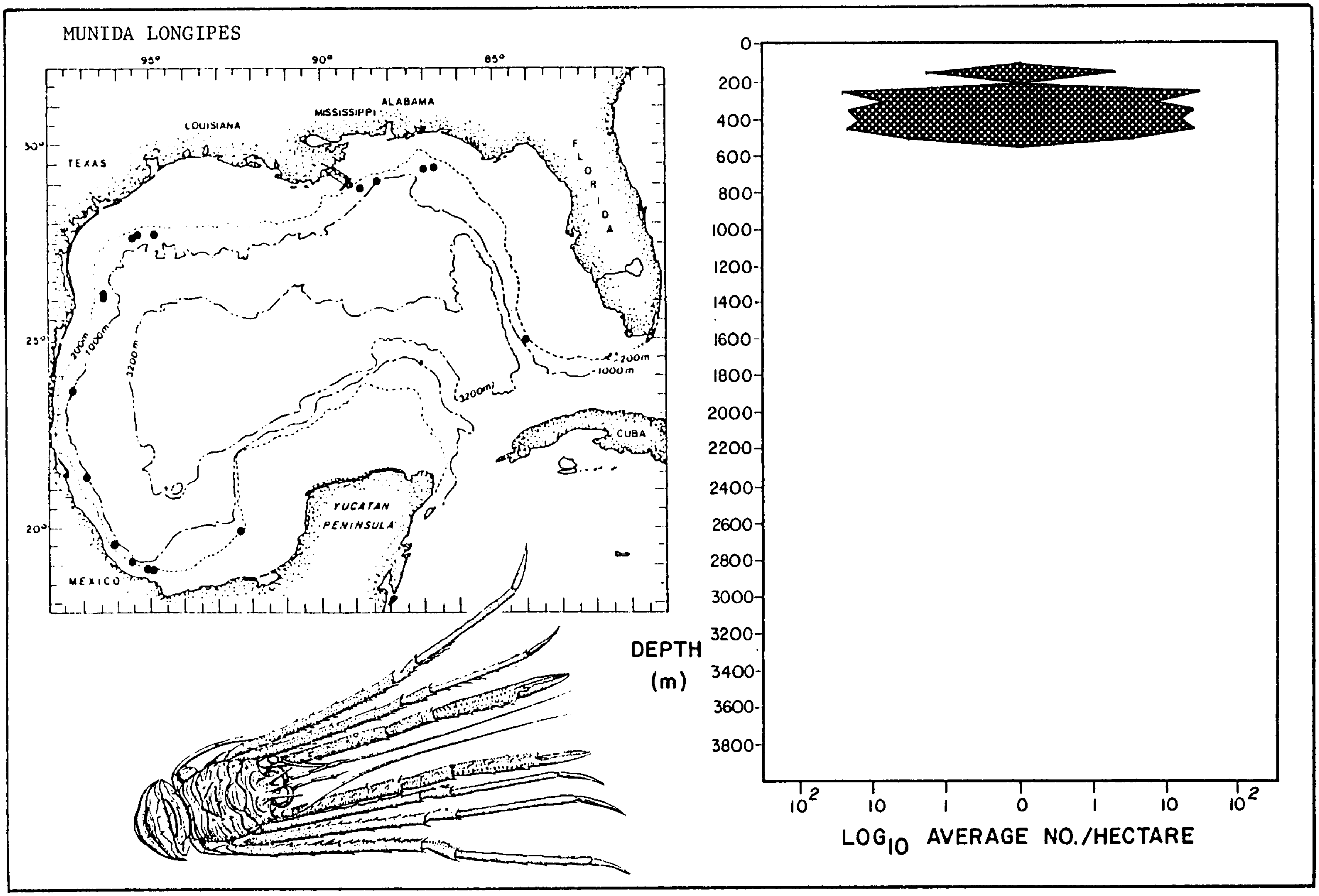

Figure 58. Horizontal and vertical distribution (including population density) of the galatheid crab <u>Munida longipes</u> in the deep Gulf of Mexico.

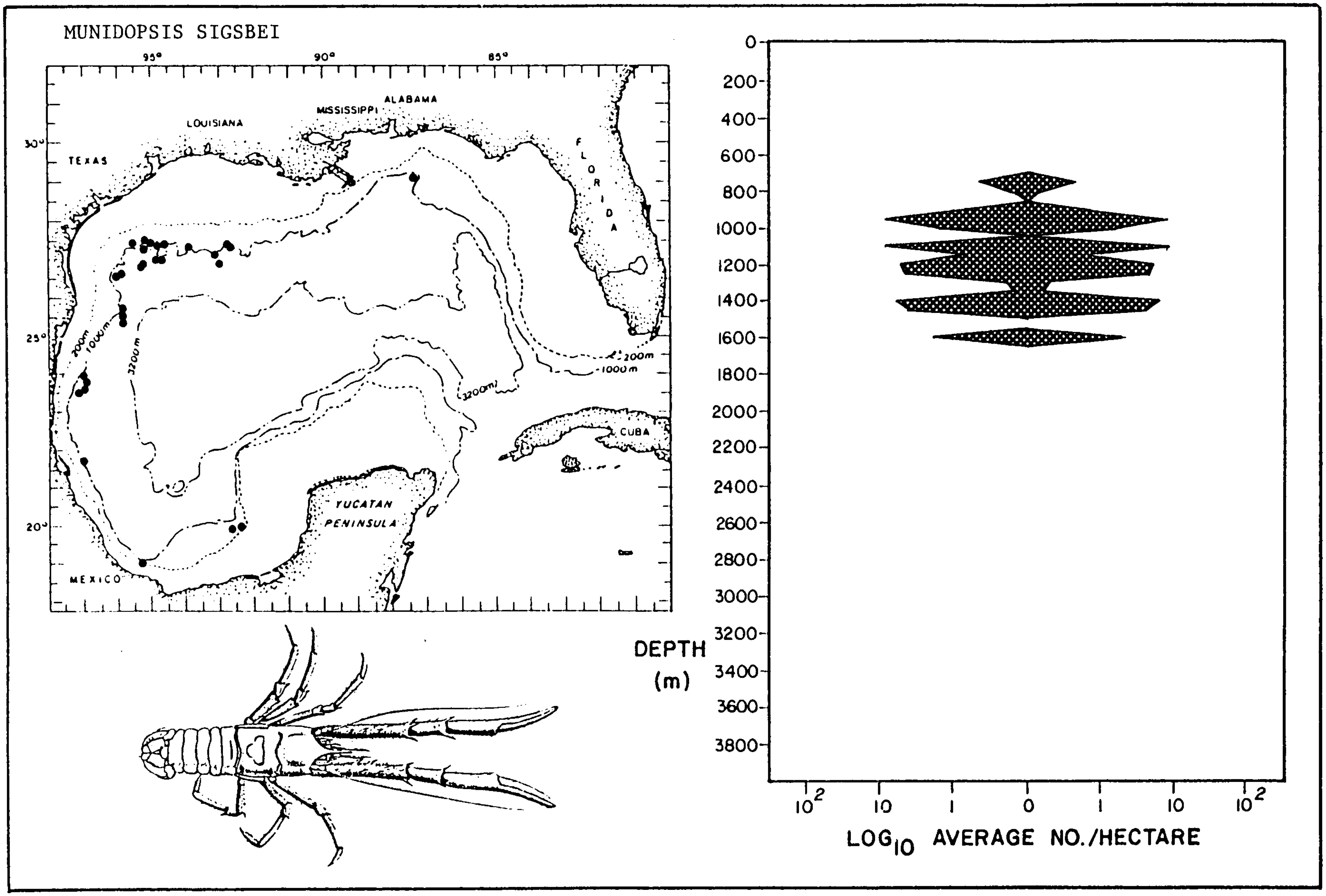

Figure 59. Horizontal and vertical distribution (including population density) of the galatheid crab Munidopsis sigsbei in the deep Gulf of Mexico.

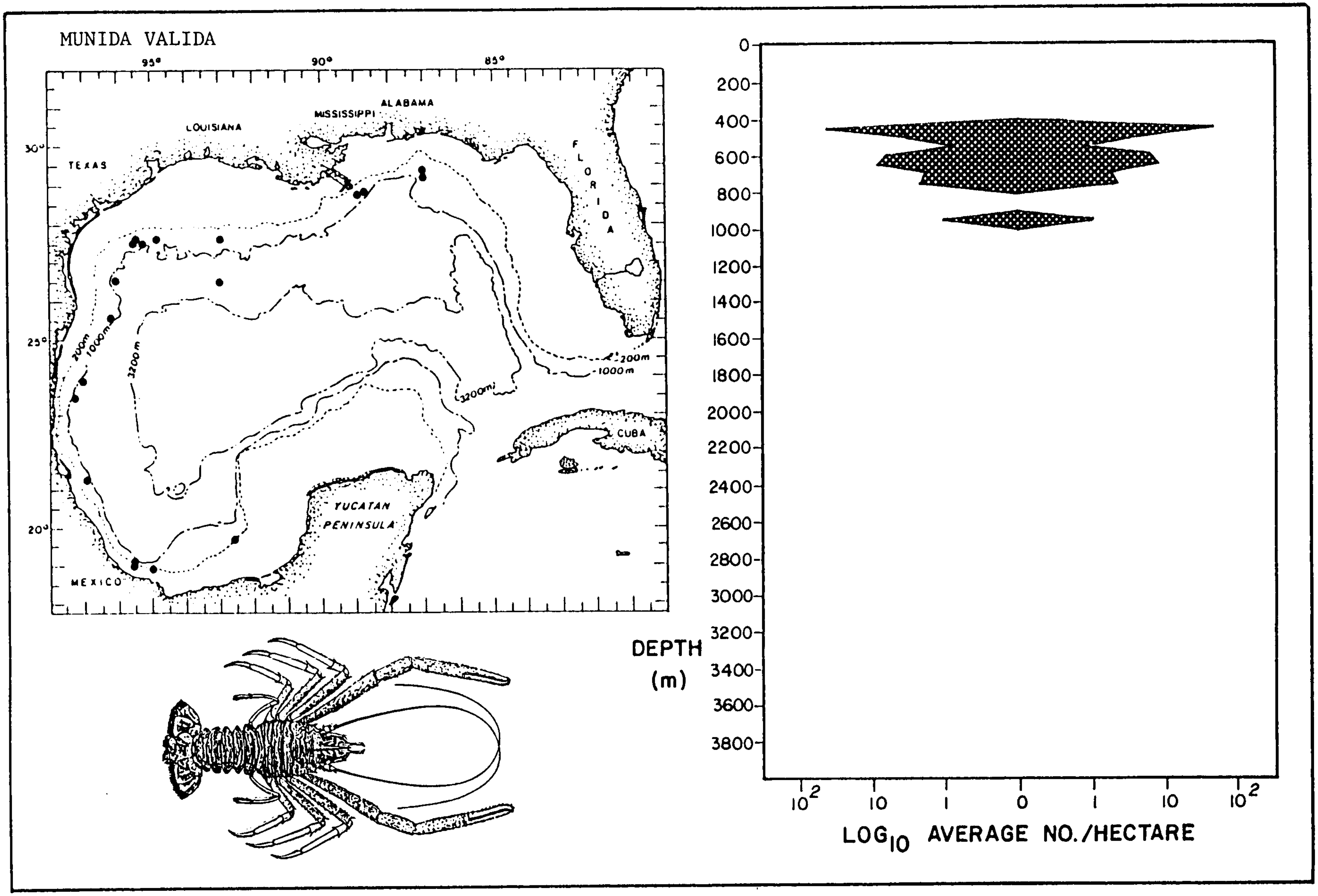

Figure 60. Horizontal and vertical distribution (including population density) of the galatheid crab *Munida valida* in the deep Gulf of Mexico.

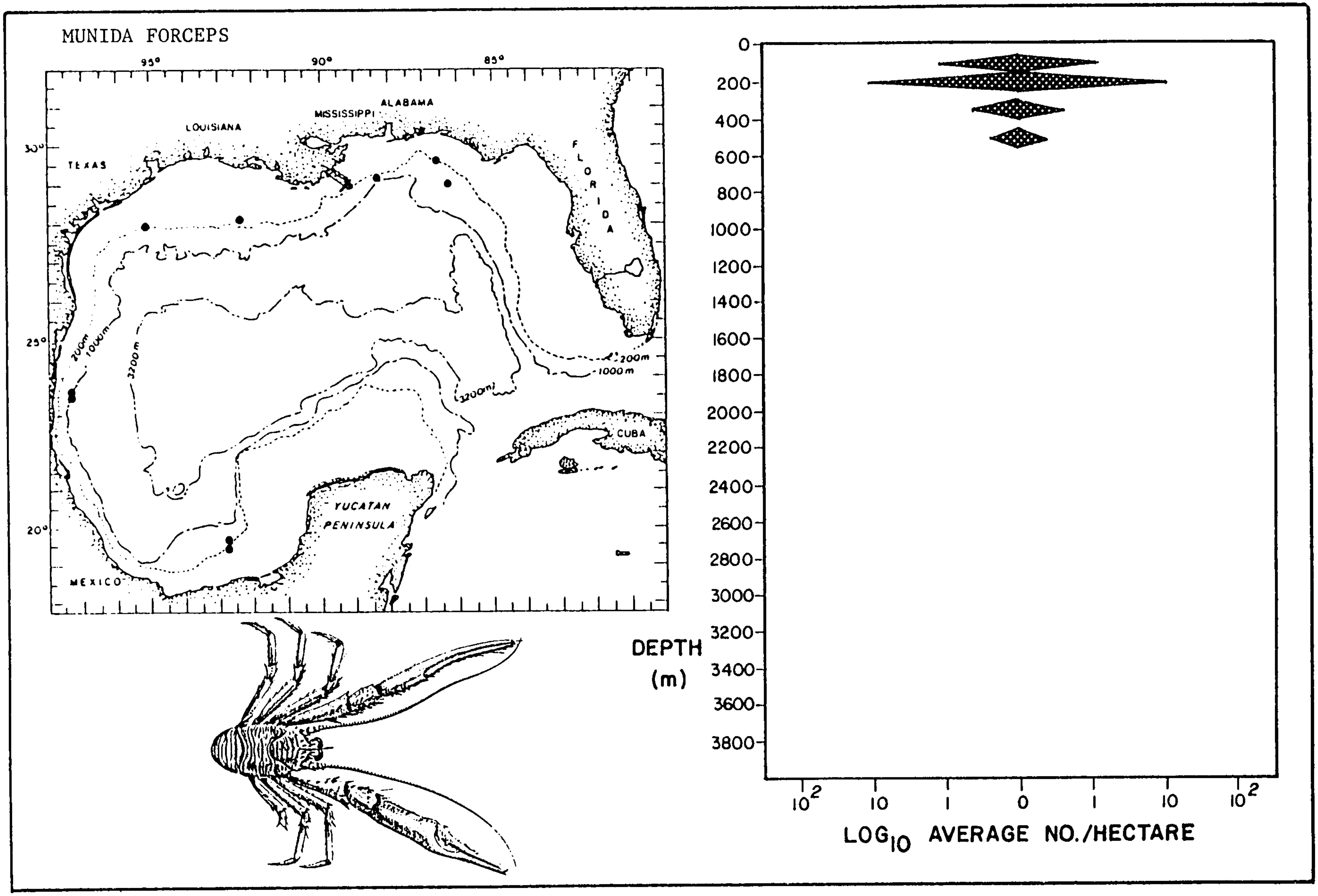

Figure 61. Horizontal and vertical distribution (including population density) of the galatheid crab Munida forceps in the deep Gulf of Mexico.

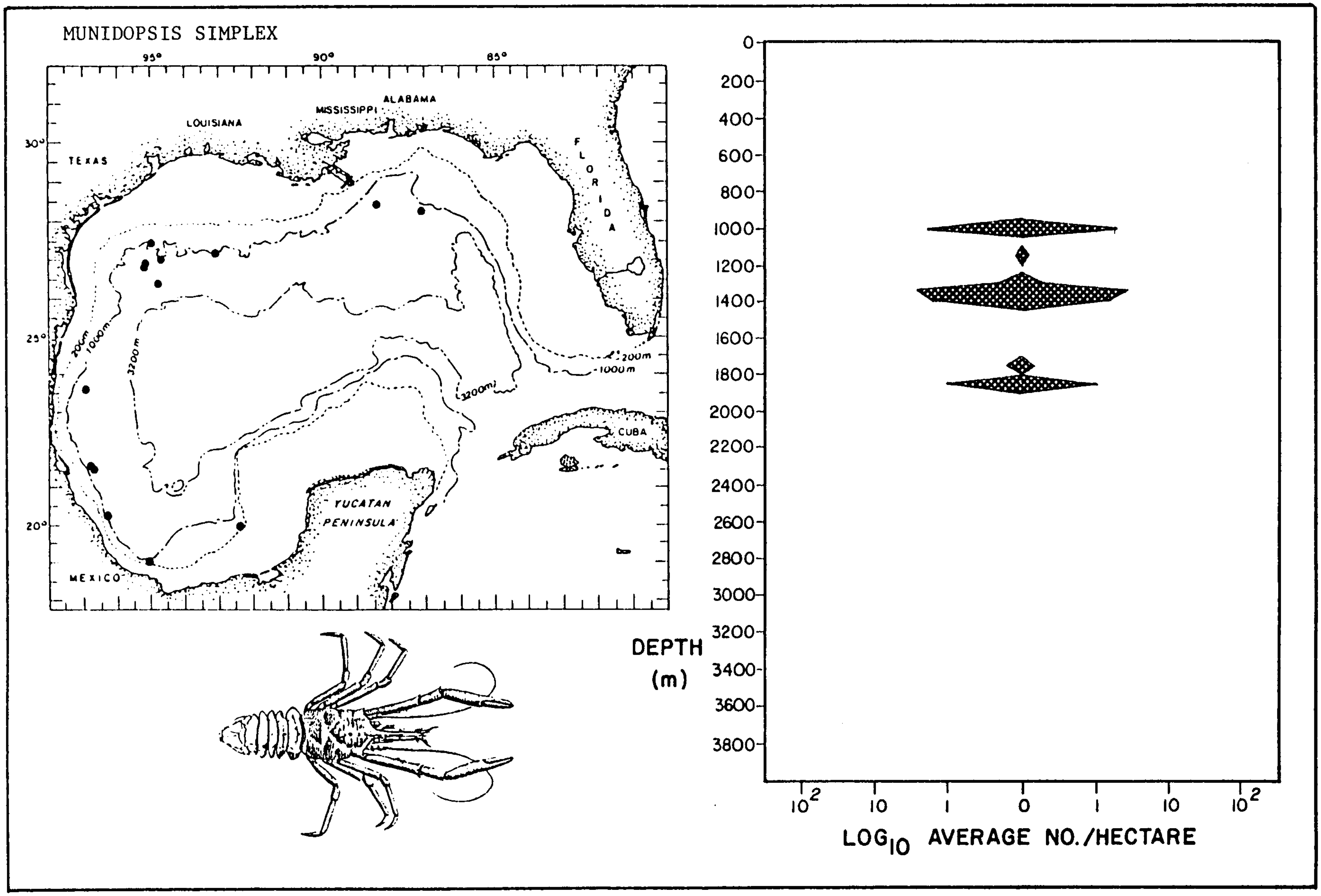

Figure 62. Horizontal and vertical distribution (including population density) of the galatheid crab <u>Munidopsis</u> <u>simplex</u> in the deep Gulf of Mexico.

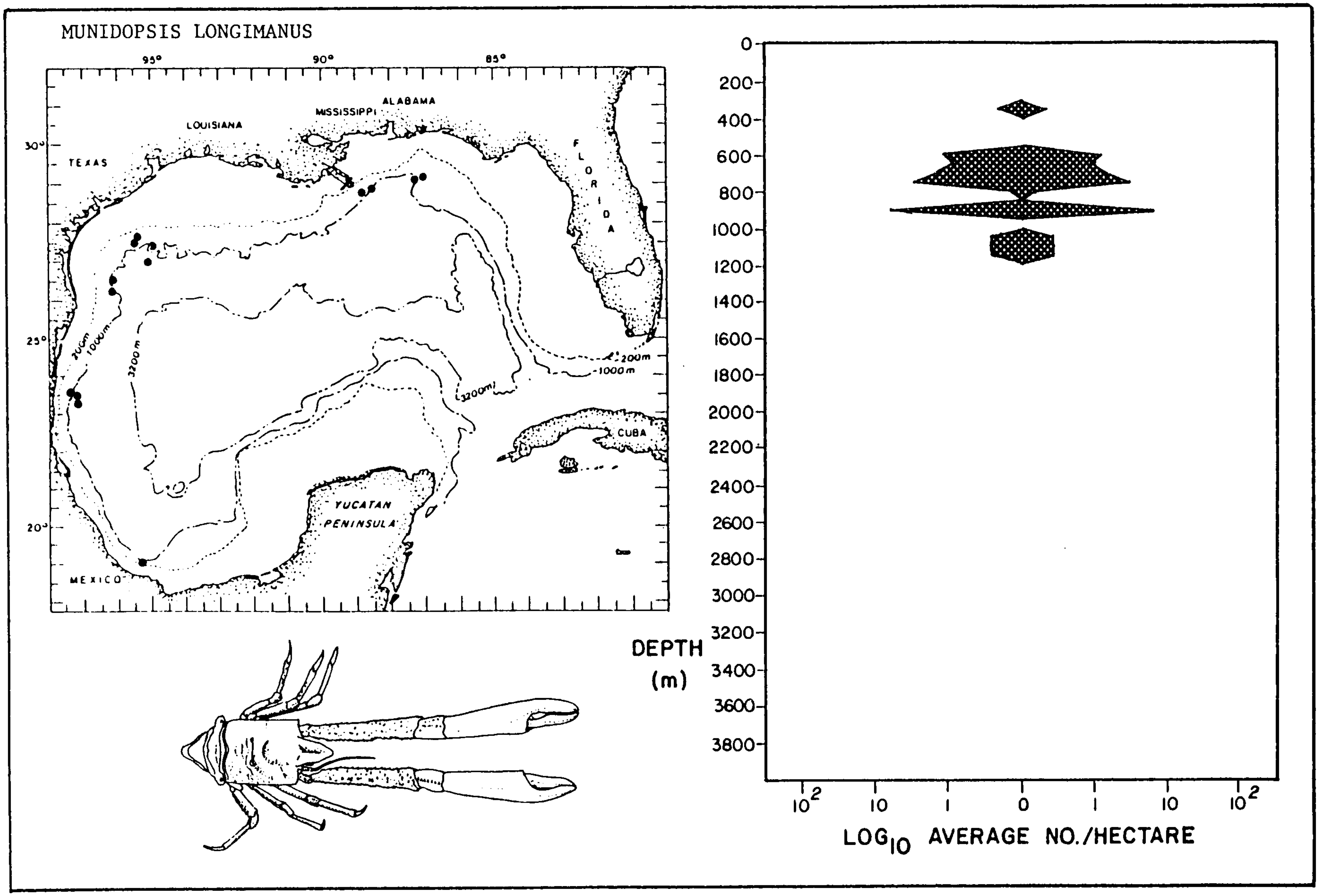

Figure 63. Horizontal and vertical distribution (including population density) of the galatheid crab Munidopsis longimanus in the deep Gulf of Mexico.

Table 27. (I) Anomura except Galatheidae found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of Paguridae, Lithodidae, Uroptychidae, and Porcellanidae in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Paguristes spinipes	4	0	-	shelf-150	*
Pylopagurus sp.	2	0	-	shelf-150	*
Agaricochirus boletifer	2	0	-	shelf-150	*
Anisopagurus bartletti	3	0	-	shelf-150	*
Cancellus ornatus	1	0	-	shelf-150	*
Rhodochirus rosaceus	5	5	25	shelf-150	*
Solenopagurus lineatus	1	0	-	shelf-150	*
Dardanus insignis	7	5	35	100-600	150
Paguristes oxyophthalmus	21	15	315	150-700	200
Pagurus bullisi	12	20	240	shelf-200	200
Paguristes sp. A	6	0	-	150-400	200
Porcellana sigsbeiana	83	50	4150	shelf-950	200
Pagurus rotundimanus	18	20	360	300-400	300
Pylocheles scutata	2	5	10	400 only	400
Paguristes sp. B	1	0	-	400 only	400
Gastroptychus spinifer	1	0	-	500 only	500
Sympagurus pictus	18	15	270	500-700	550
Xylopagurus	2	0	-	600 only	600
Paguristes planatus	4	5	20	600 only	600
Sympagurus pilimanus	12	5	60	500-900	700
Uroptychus nitidus	37	30	1110	550-1350	950
Parapagurus spp.	1782	325	579150	200-3650	1050
Lithodes agassizii	8	15	120	900-1350	1100
Catapaguroides microps	16	20	320	1000-1500	1350

(II) Dominant Anomura presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Parapagurus spp.	1050
Porcellana sigsbeiana	200
Uroptychus nitidus	950
Pagurus rotundimanus	300
Catapaguroides microps	1350
Lithodes agassizii	1100
Sympagurus pictus	550
Paguristes oxyophthalmus	200
Pagurus bullisi	200
Sympagurus pilimanus	700

* Unknown

Table 28. Distribution of species of Anomura (Paguridae) among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	8	8	16
Archibenthal Zone (475-950 m)	6	5	11
Upper Abyssal (975-2250 m)	3	1	4
Mesoabyssal (2275-3200 m)	0	1	1
Lower Abyssal (3225-3850)	0	1	1

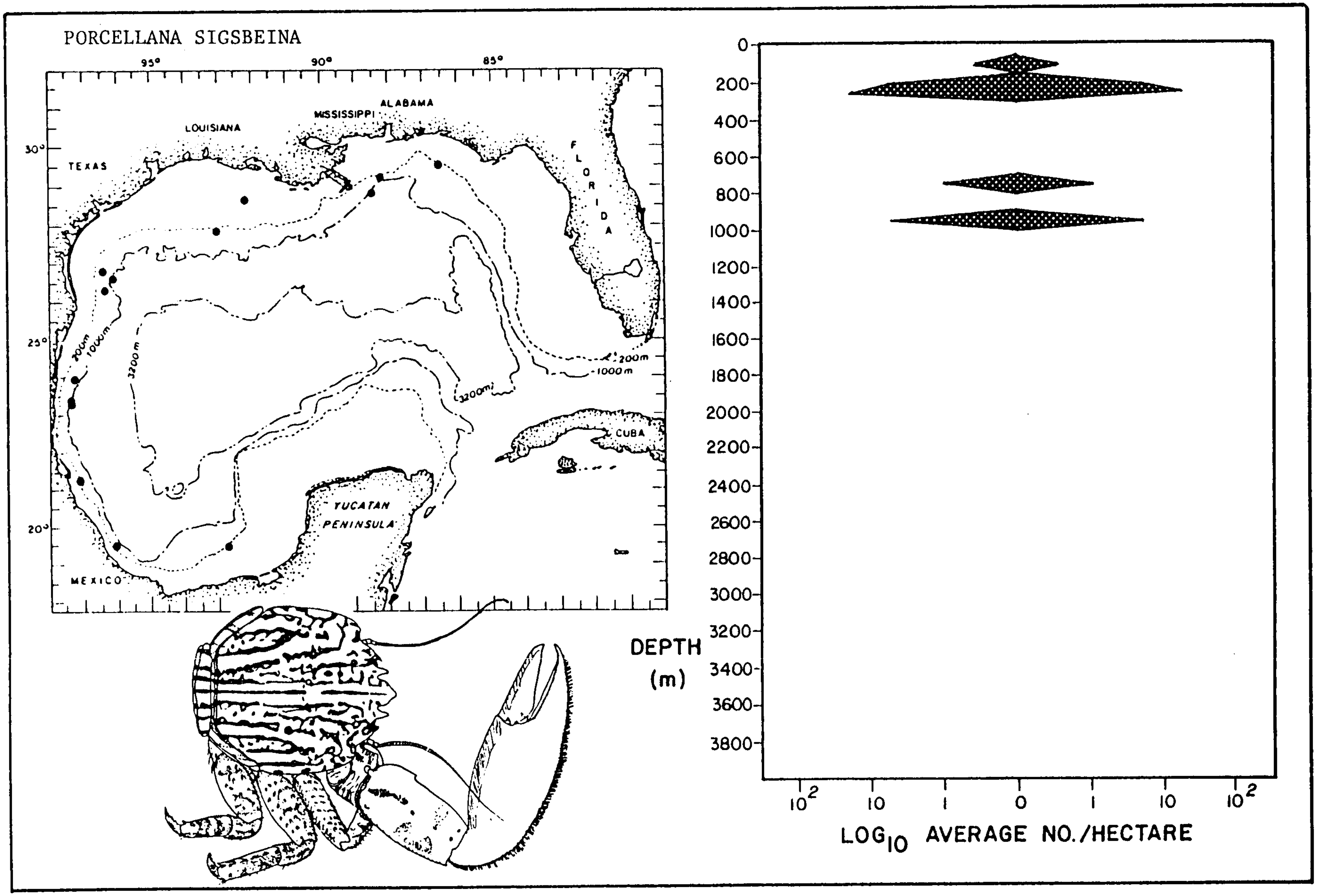

Figure 64. Horizontal and vertical distribution (including population density) of the anomuran crab Porcellana sigsbeiana in the deep Gulf of Mexico.

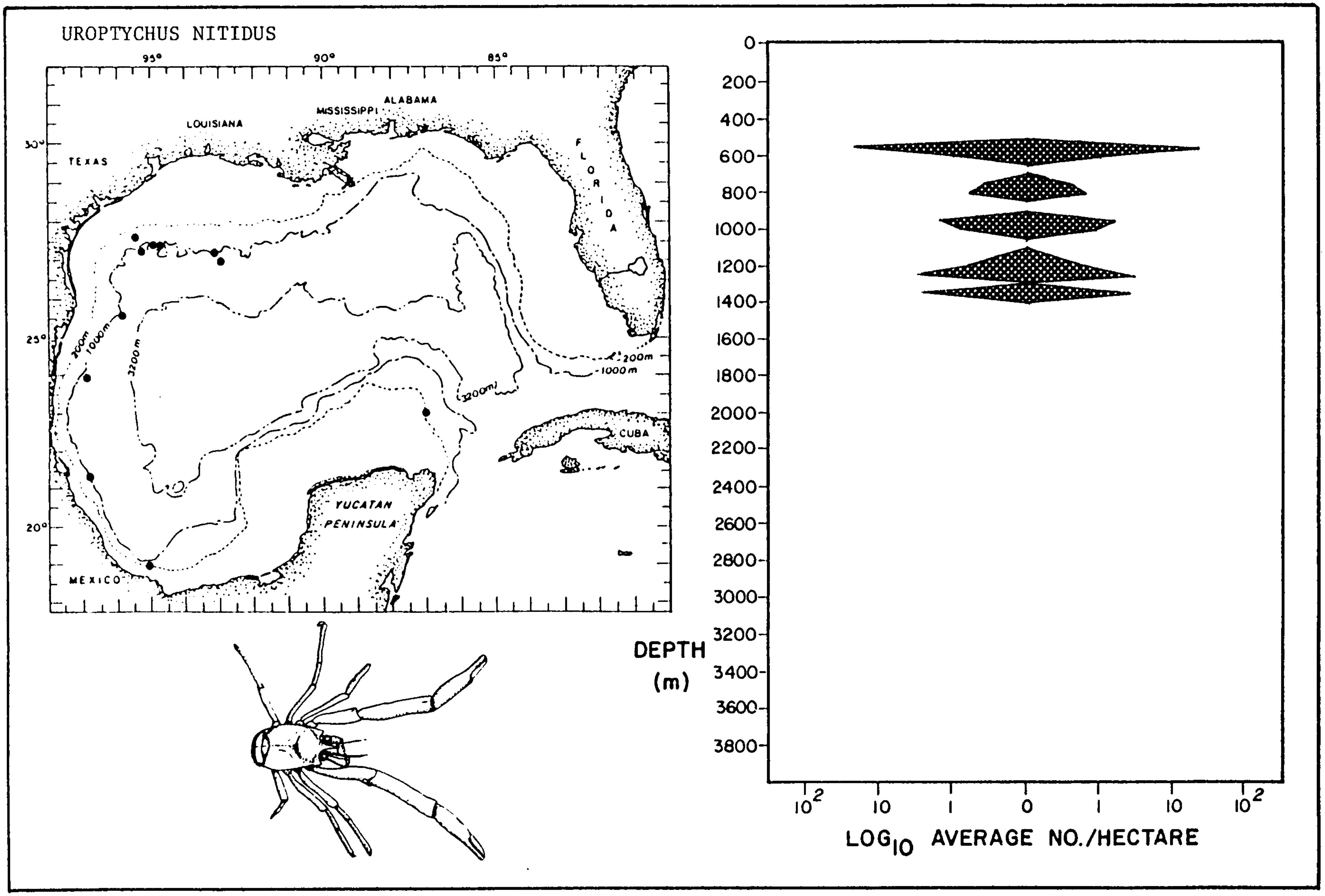

Figure 65. Horizontal and vertical distribution (including population density of the anomuran crab <u>Uroptychus nitidus</u> in the deep Gulf of Mexico.

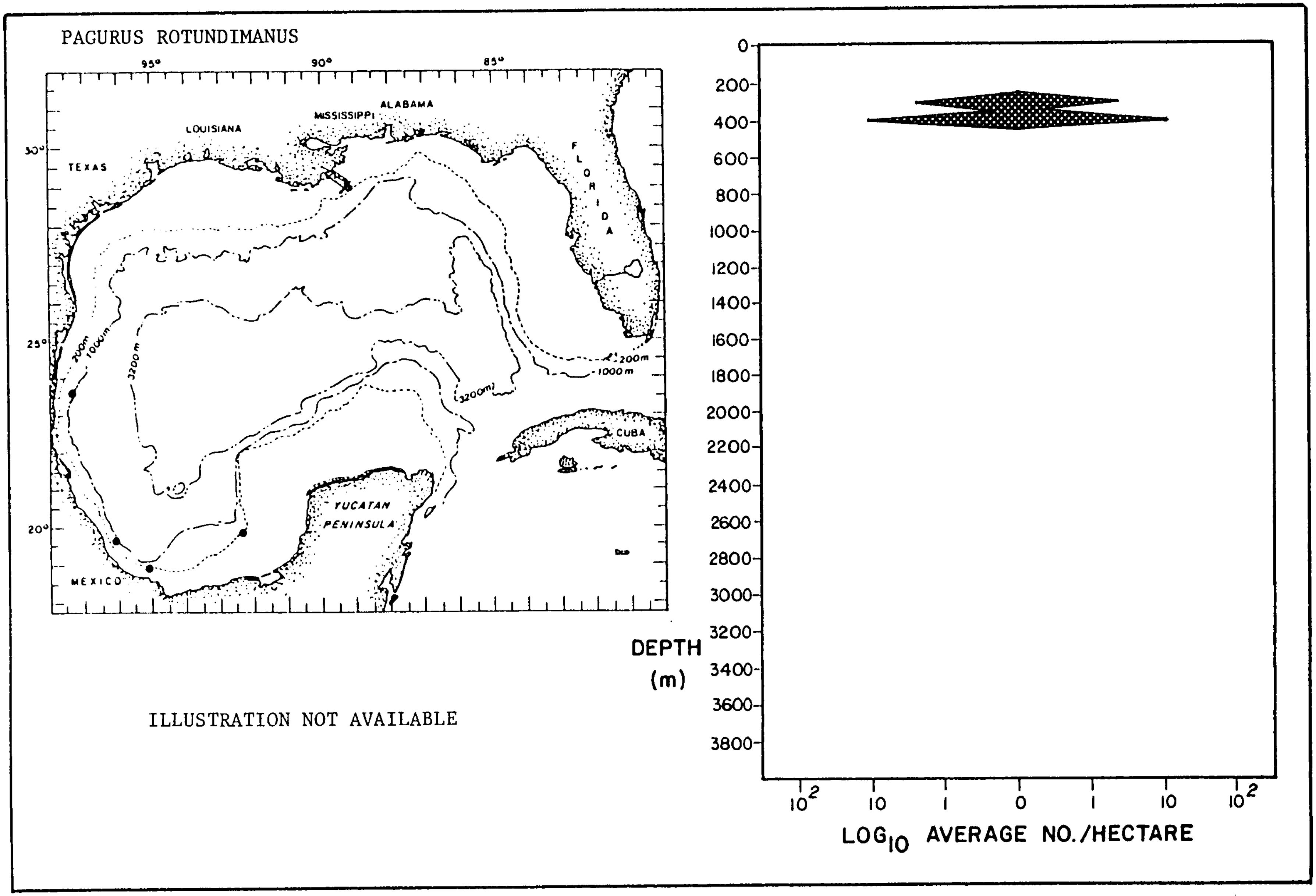

Figure 66. Horizontal and vertical distribution (including population density) of the anomuran crab <u>Pagurus rotundimanus</u> in the deep Gulf of Mexico.

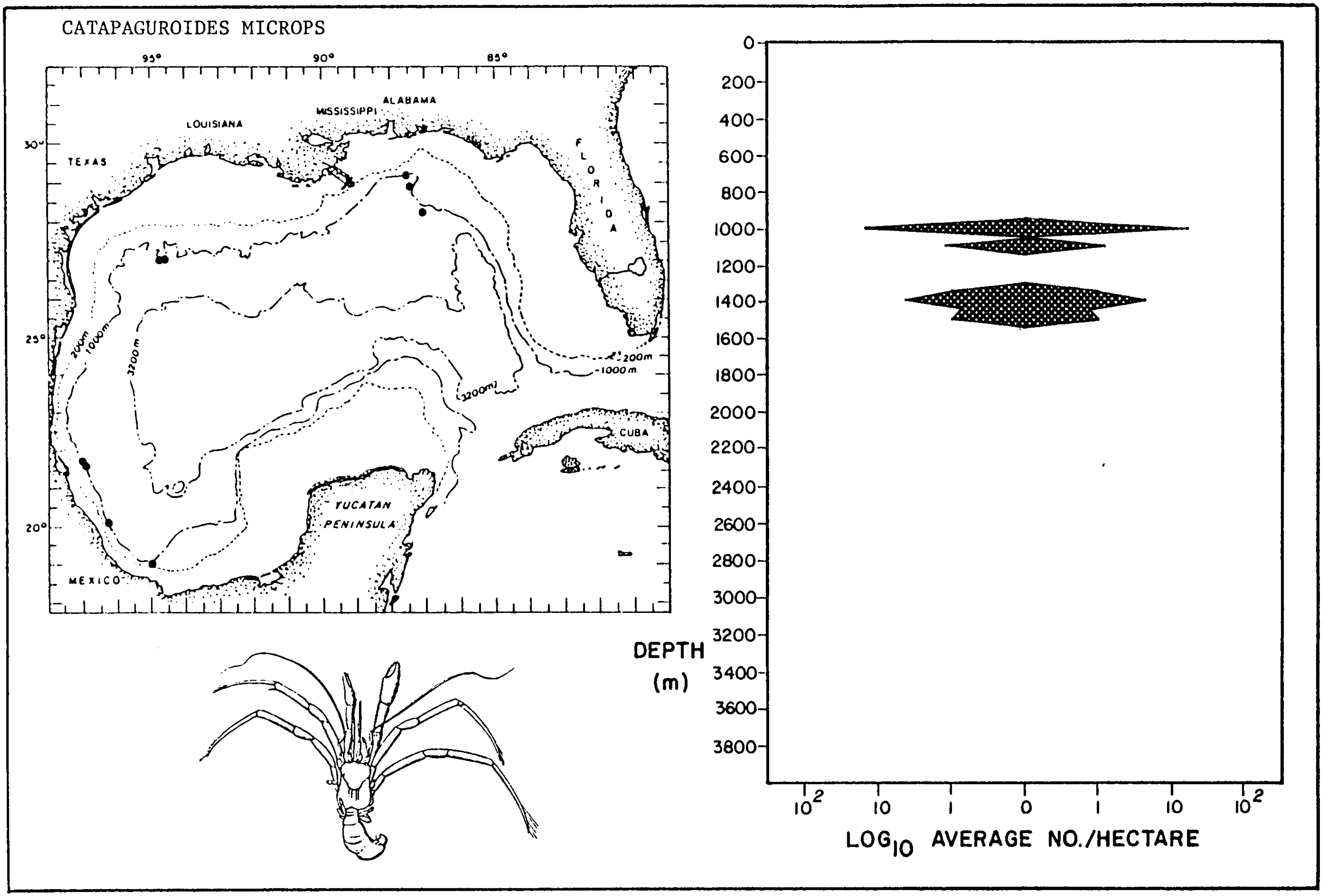

Figure 67. Horizontal and vertical distribution (including population density) of the anomuran crab Catapaguroides microps in the deep Gulf of Mexico.

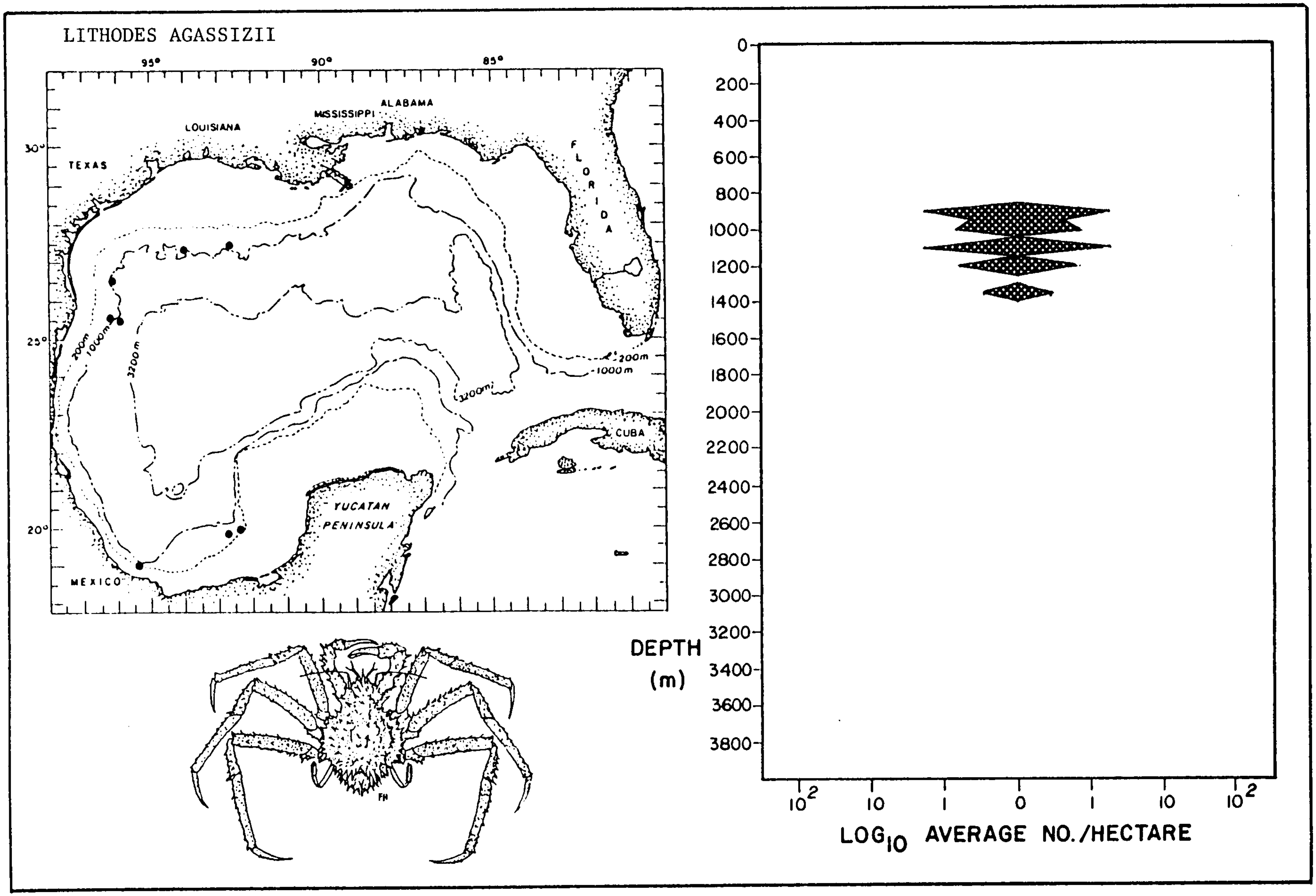

Figure 68. Horizontal and vertical distribution (including population density) of the anomuran crab Lithodes agassizii in the deep Gulf of Mexico.

Table 29. (I) Brachyura found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of brachyuran crabs in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Portunus spinicarpus	37	15	555	100 only	100
Callapa sulcata	6	0	-	shelf-100	<100
Portunus sayi	1	0	-	100 only	100
Goneplax barbata	1	0	-	100 only	100
Anasimus latus	21	0	-	shelf-300	100
Callapa springeri	2	0	-	100 only	100
Stenocionops spinimana	4	0	-	150 only	150
Palicus dentatus	1	0	-	150 only	150
Pyromaia cuspidata	3	0	-	100-200	150
Parthenope pourtelesii	2	0	-	150 only	150
Parthenope agona	9	5	45	150-400	150
Palicus sicus	7	0	-	150-400	150
Iliacantha subglobosa	12	15	180	shelf-200	150
Pyromaia arachna	36	5	180	150-700	200
Chasmocarcinus cylindricus	22	15	330	100-200	200
Podochela sidneyi	2	0	-	150-200	200
Podochela sp.	1	0	-	200 only	200
Raninoides louisianensis	63	25	1575	shelf-350	200
Solenolambrus typicus	1	0	-	200 only	200
Thalassoplax angusta	75	25	1875	200-400	200
Tetraxanthus rathbunae	7	0	-	200 only	200
Eucratodes agassizii	16	0	-	200 only	200
Osachila tuberosa	8	5	40	150-200	200
Myropsis quinquespinosa	59	10	590	200-250	200
Collodes leptocheles	19	0	-	200-400	200
Ethusa microphthalma	95	15	1425	150-500	200
Palicus obesus	18	0	-	150-250	200
Acanthocarpus alexandri	117	50	5850	100-400	200
Callapa angusta	5	0	-	150-200	200
Stenocionops spinosissima	7	0	-	200-250	250
Euphrosynoplax clausa	8	0	-	200-250	250
Palicus gracilis	22	0	-	300-600	300
Lyreidus bairdii	262	90	23580	200-800	300
Cyclodorrippe antennaria	6	5	30	200-400	300
Dicranodromia ovata	1	0	-	400 only	400
Benthochascon schmitti	114	30	3420	200-650	400
Bathyplax typhla	603	90	54270	450-950	550
Rochinia crassa	26	10	260	400-750	550

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Ranilia constricta	2	5	10	600 only	600
Trichopeltarion nobile	24	20	480	500-750	700
Rochinia umbonata	3	5	15	900-950	900
Cymonomus sp. cf. *quadratus*	1	5	5	950 only	950
Geryon quinquedens	107	115	12305	400-2000	950
Homolodromia paradoxa	2	5	10	1050-1250	1150
Homologenus rostratus	3	10	30	1050-1350	1300
Ethusina abyssicola	8	40	320	900-3850	3250

(II) Dominant brachyuran crabs presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Bathyplax typhla	550
Lyreidus bairdii	300
Geryon quinquedens	950
Acanthocarpus alexandri	200
Benthochascon schmitti	400
Thalassoplax angusta	200
Raninoides louisianensis	200
Ethusa microphthalma	200
Myropsis quinquespinosa	200
Portunus spinicarpus	100

Table 30. Distribution of species of Brachyura among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	30	4	34
Archibenthal Zone (475-950 m)	7	6	13
Upper Abyssal (975-2250 m)	2	2	4
Mesoabyssal (2275-3200 m)	0	1	1
Lower Abyssal (3225-3850)	1	0	1

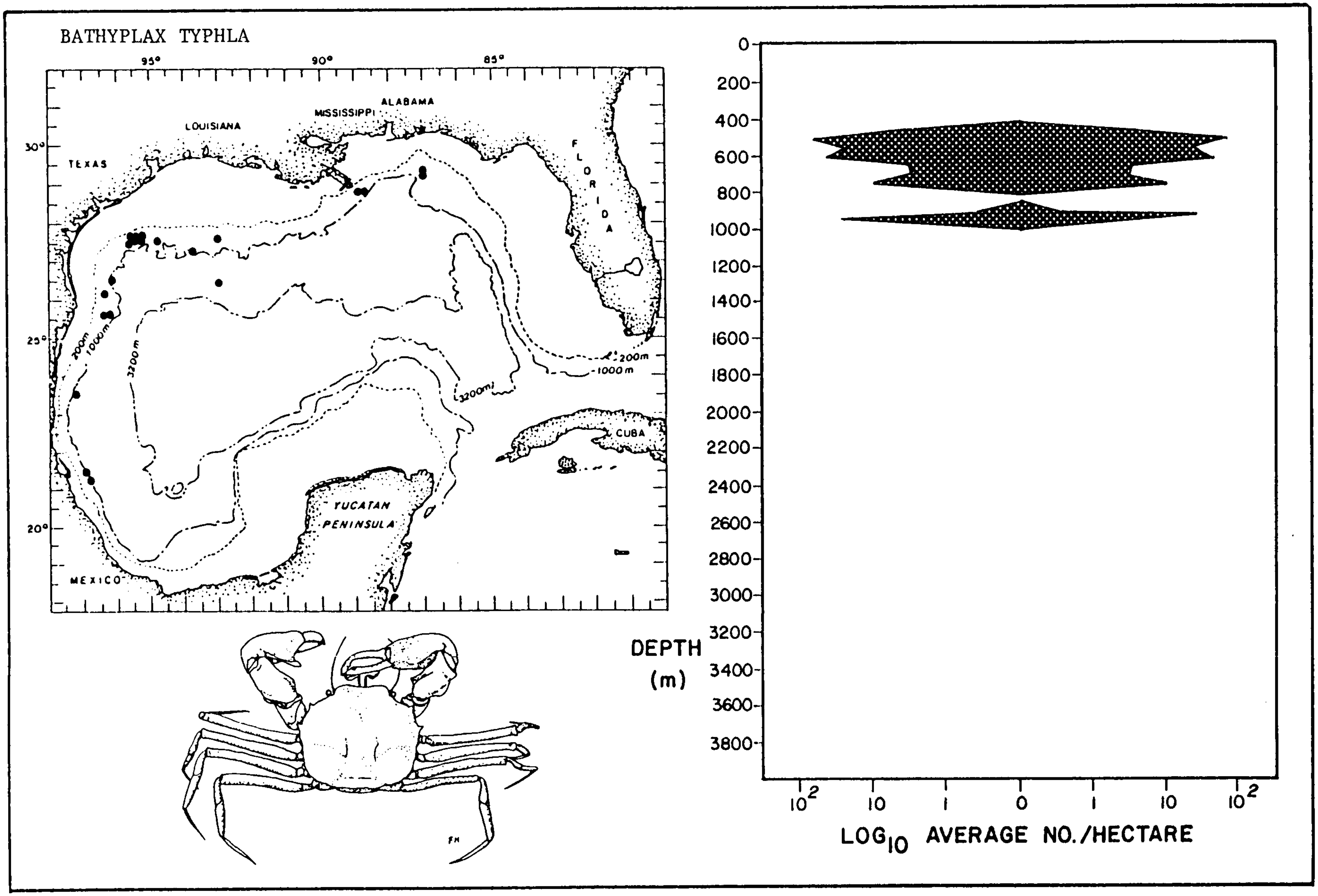

Figure 69. Horizontal and vertical distribution (including population density) of the brachyuran crab Bathyplax typhla in the deep Gulf of Mexico.

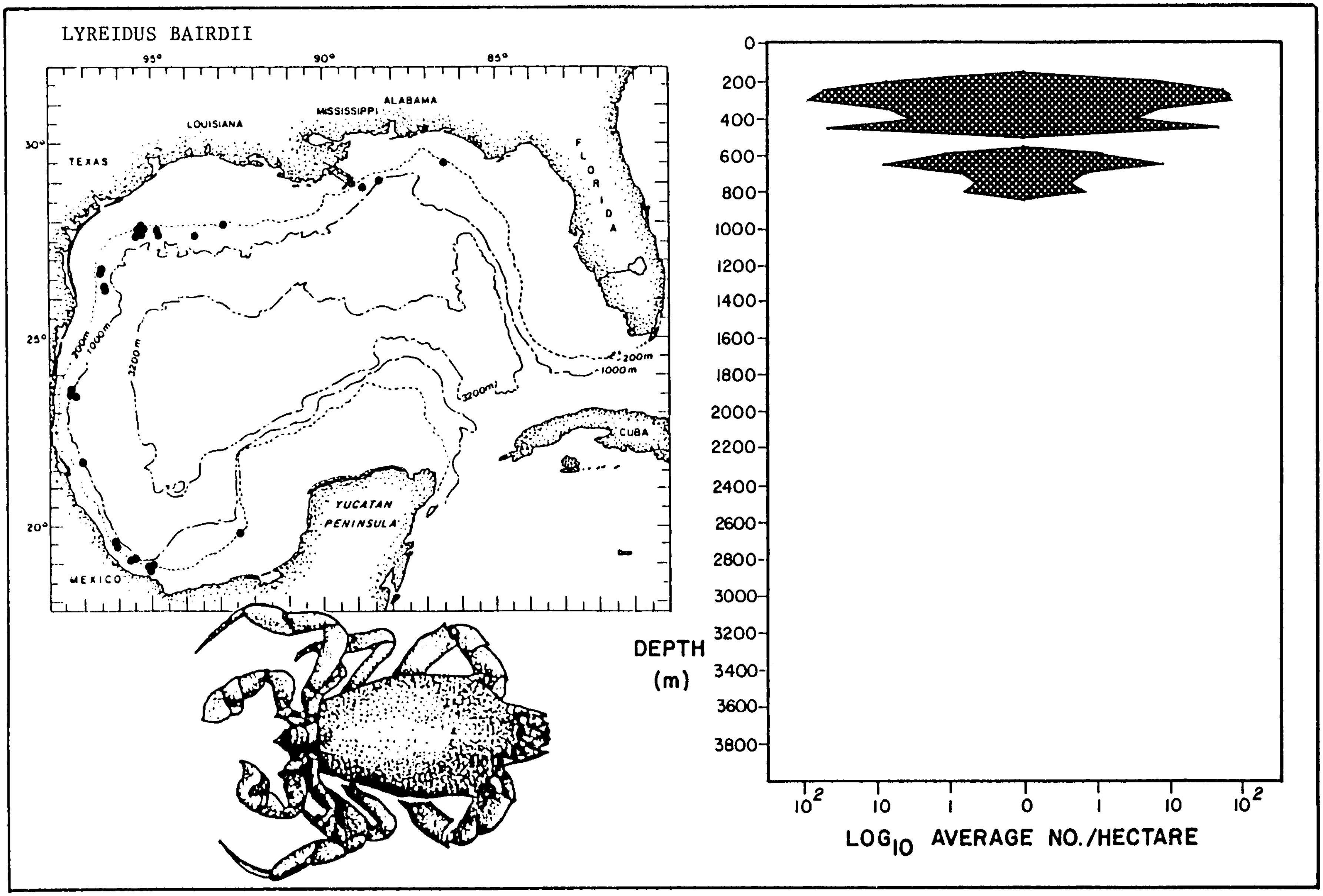

Figure 70. Horizontal and vertical distribution (including population density) of the brachyuran crab Lyreidus bairdii in the deep Gulf of Mexico.

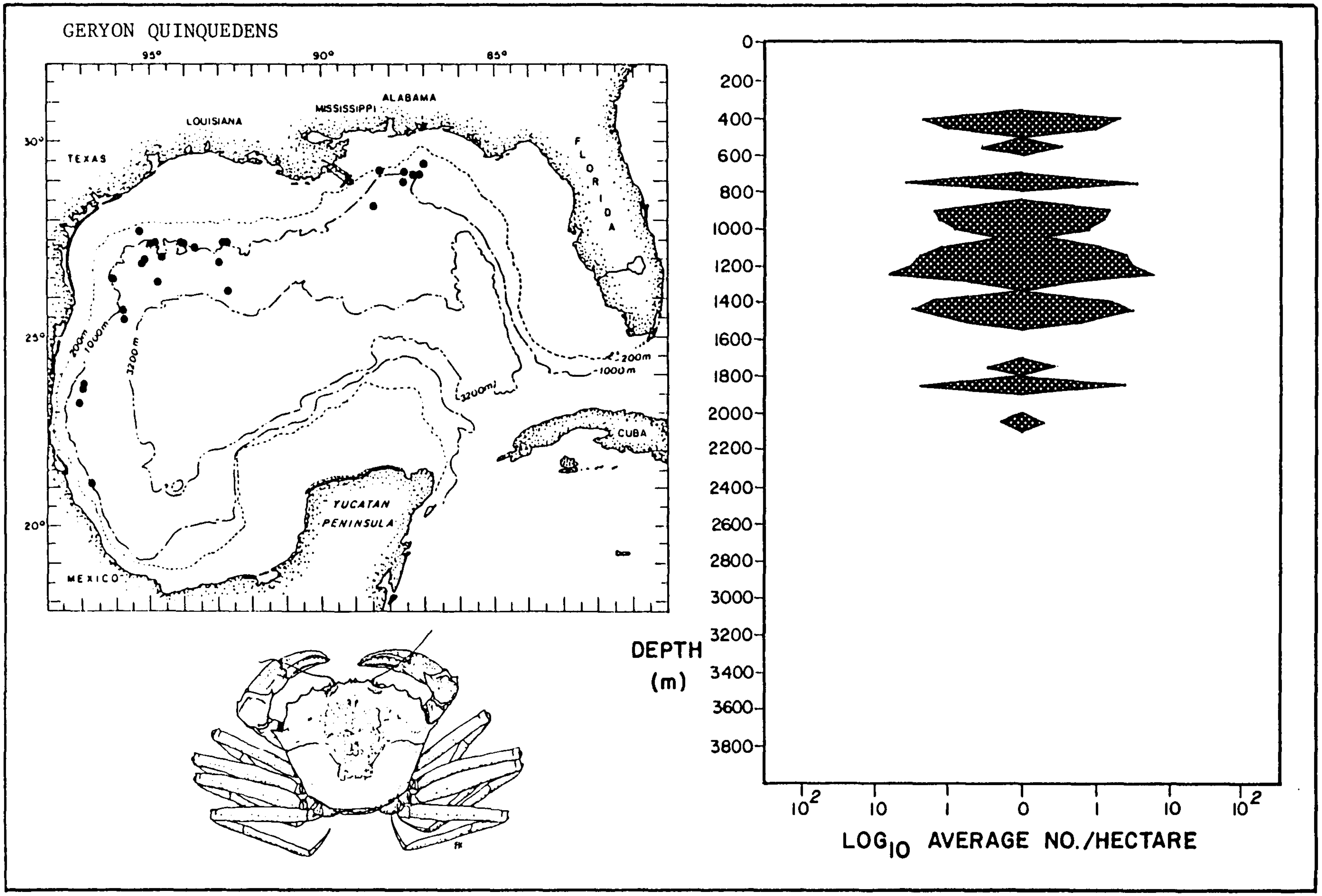

Figure 71. Horizontal and vertical distribution (including population density) of the brachyuran crab Geryon quinquedens in the deep Gulf of Mexico.

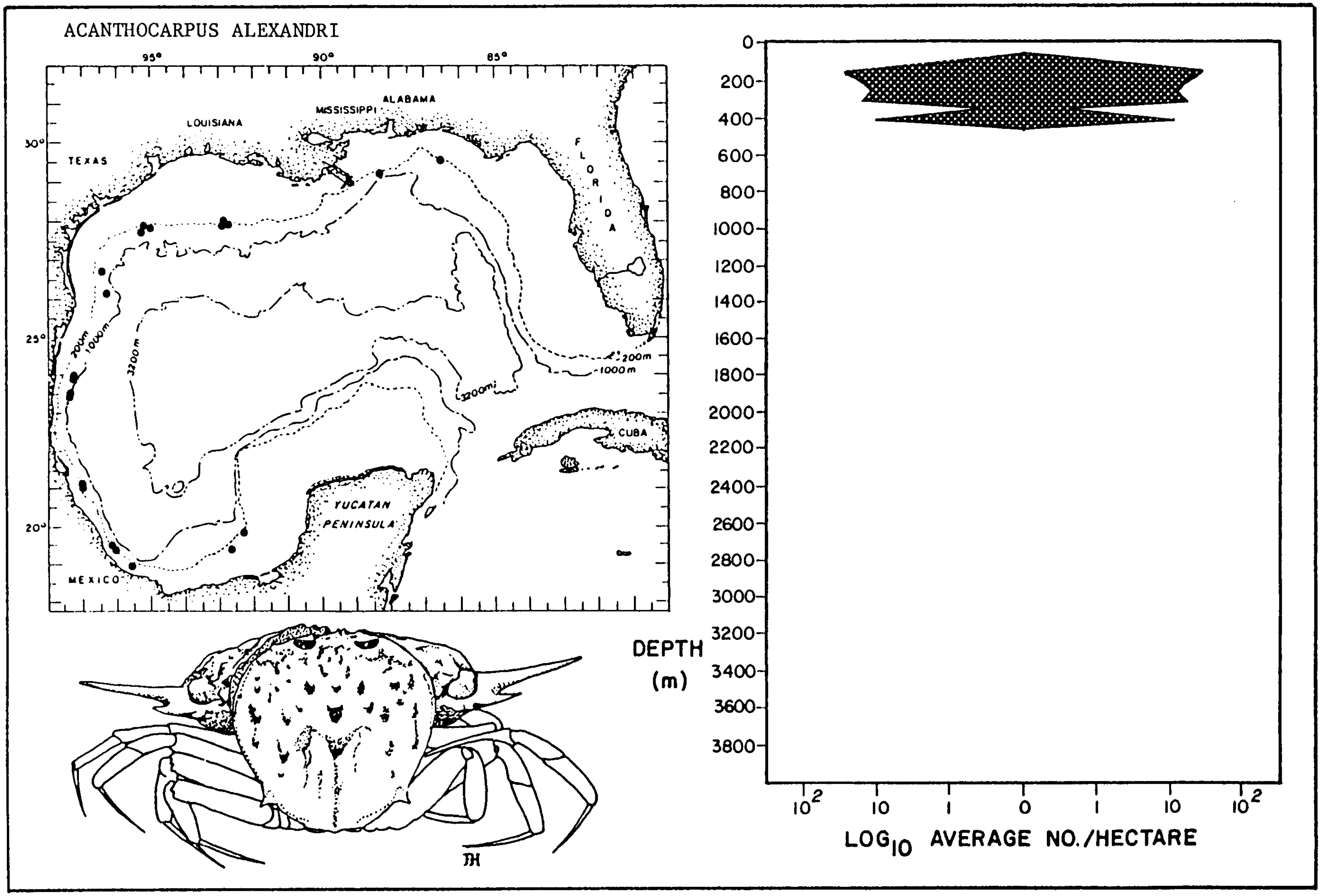

Figure 72. Horizontal and vertical distribution (including population density) of the brachyuran crab Acanthocarpus alexandri in the deep Gulf of Mexico.

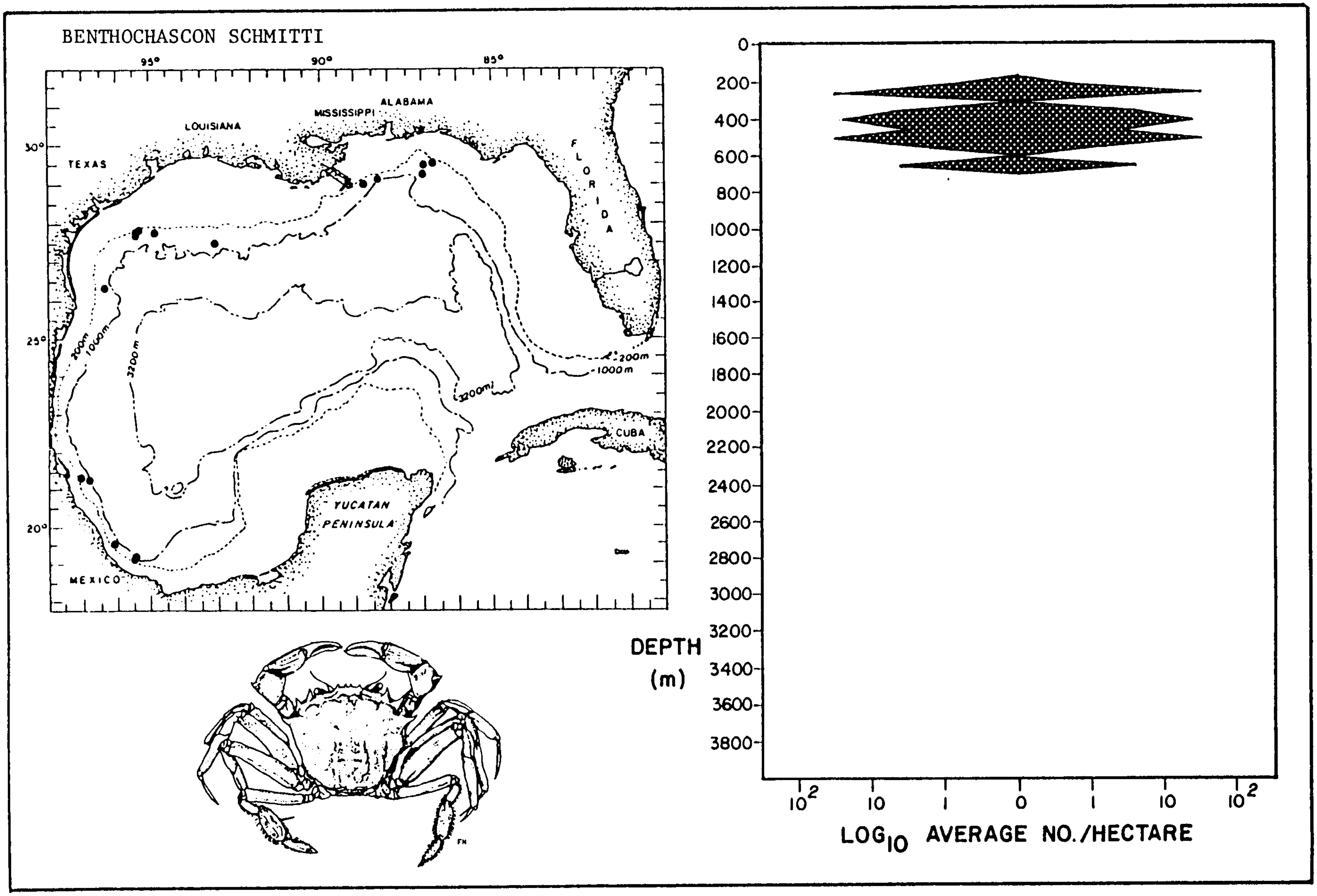

Figure 73. Horizontal and vertical distribution (including population density) of the brachyuran crab <u>Benthochascon schmitti</u> in the deep Gulf of Mexico.

Fish

A total of 206 demersal fish species within 47 families were collected by the R/V ALAMINOS during the deep Gulf of Mexico cruises between 1964 and 1973. Seventy-nine species ranged into waters 1000 m or more in depth while 59 species had peak populations at 1000 m or deeper.

The Macrouridae was the most speciose family represented by 30 species, followed by Ophidiidae (23), Alepocephalidae (12) and Gadidae (11) which together constitute over one-third of the total number of species (Table 31).

Table 31. Number of species collected in the fish taxa and their bathymetric distribution with median depth.

	No. of Species	% of all fish spp.	No. species below 1000 m	% of group below 1000 m	Median depth (m)
Macrouridae	30	15	19	63	850 ± 300
Ophidiidae	23	11	15	65	1750 ± 1150
Alepocephalidae	12	6	10	83	1450 ± 700
Gadidae	11	5	0	-	450 ± 150
Bothidae	9	4	0	-	200 ± 50
Rajidae	8	4	3	38	750 ± 300
Bathypteroidae	7	3	6	86	1700 ± 800
Scorpaenidae	7	3	0	-	250 ± 150
Nettastomatidae	6	3	1	17	450 ± 450
Ogcocephalidae	6	3	2	33	400 ± 450
Triglidae	6	3	0	-	250 ± 150
Congridae	6	3	0	-	550 ± 300
Other	75	37	23	31	
Total	206	100	79		$\bar{x}$ 800

The depth distribution of each of these four major families is illustrated in Figure 74. A list of the 206 fish species by depth and a list of the dominant species in rank order are presented in Table 32. Table 33 shows the distribution of species and individuals by bathymetric zones.

The family Gadidae (codfishes) is a dominant group on the upper continental slope between the shelf break and about 500 m. As expected the cods were restricted to the upper slope; no species occurred below 800 m. *Urophycis cirrata* and *Merluccius bilinearis* are the abundant codfishes in the deep Gulf. Most gadids feed on crustaceans, worms, fish, and squid, but no stomach content data are available for *U. cirrata* and *M. bilinearis* collected from deeper parts of the Gulf. All codfishes have pelagic eggs and larvae.

Macrourids were present from the shelf to 3350 m and predominated on the slope in the Archibenthal Zone and into the Upper Abyssal Zone to about 1500 m (Figure 74). Five macrourids are considered dominant species among the fish catches: *Bathygadus melanobranchus* (Figure 84), *Coryphaenoides mexicanus* (Figure 90), *Gadomus longifilis* (Figure 75), *Hymenocephalus italicus* (Figure

81), and Nezumia aequalis (Figure 79). Rayburn (1975) conducted a study on the feeding of selected deep Gulf fish species and classified B. melanobranchus and N. aequalis as "suckers" which feed by grubbing through the sediment and sucking food into their mouths, and consequently have a lot of sediment in their guts. Polychaetes and copepods were the most abundant prey items found in their stomachs. Bathygadus melanobranchus was classifed as a "grazer", which fed by browsing on plankton and benthic organisms such as copepods and other small crustaceans, without ingesting much sediment. In another study (Hureau et al., 1979) Nezumia aequalis was classified as a benthopelagic feeder (between 30 and 70% pelagic prey) while Hymenocephalus italicus was listed as a pelagic type feeder (greater than 70% pelagic prey). Reproductive patterns among macrourids is poorly known, but at least some species are seasonally reproductive (Geistdoerfer, 1979).

Ophidiids (cusk eels and brotulas) ranged from the shelf to the deepest part of the Gulf of Mexico. The distribution of ophidiid species with depth is fairly uniform. A gradual replacement of species along the depth gradient seems to be the trend, although more species were captured from the Upper Abyssal Zone and Horizon B than in the adjacent faunal zones. Of the 23 ophidiid species collected, the two most abundant, Dicrolene intronigra (Figure 76) and Monomitopus agassizi (Figure 86) were dominant members of the fish catches. Their distributions and abundances are remarkably similar and they were often collected together between 700 and 1200 m. Both species were collected at 21 of the 25 stations occupied by M. agassizi. However, D. intronigra ranges deeper onto the slope (700-2250 m) than does M. agassizi (700-2100 m). Rayburn (1975) classified both species as grazers, although D. intronigra seemed to feed more heavily on polychaetes than did M. agassizi.

Alepocephalids (stickheads) generally occurred deeper than the other aforementioned fish families. Only 4 species were collected from shallower than 750 m. Nearly all of the alepocephalids seem to have a center of distribution within the Upper Abyssal Zone (975-2250 m). Although alepocephalids are characteristic deep-sea fish, no species in our collections was dominant, probably because single specimens were usually captured at a station.

Another fish family which deserves mention is the Halosauridae. Only 3 species of halosaurs were collected, Aldrovandia affinis (Figure 87), A. gracilis (Figure 82), and Halosaurus guentheri (Figure 88), but all were abundant enough to be ranked as dominant species. H. guentheri is most abundant on the upper slope while A. affinis and A. gracilis are most abundant on the middle slope. The latter two species have very similar depth distribution but only about 20% of the stations were common to both.

The two eels Synaphobranchus oregoni and S. brevidorsalis are combined because of the difficulty of identifying the two species. Synaphobranch eels were collected from 500-2150 m at a total of 40 stations but nearly all were taken from 650-1450 m. They are commonly seen in deep-sea photographs. Synaphobranchs are evidently active predators. Stomach content analyses revealed that they feed on rather large crustaceans like polychelids. An interesting note here is that synaphobranchs in turn are fed upon by the giant isopod, Bathynomus giganteus.

Six species of Ogcocephalidae (batfishes) were collected. Four occurred in waters less than 200 m deep and two ranged onto the slope past 1000 m depth.

Dibranchus atlanticus (Figure 78) was very abundant and was most common on the upper slope to about 900 m. *D. atlanticus* is reported to feed on bivalves in the shallower depths of its range and more on polychaetes and small crustaceans in the deeper depths (Rayburn, 1975).

Stephanoberyx monae (Stephanoberycidae) was the only other dominant species (Figure 83) centered in the deeper parts of the Gulf of Mexico. The remaining dominant species, *Poecilopsetta beani* (Pleuronectidae), *Pontinus longispinus* (Scorpaenidae), *Pristipomoides aquilonaris* (Lutjanidae), *Monolene* sp. (Bothidae), and the percophiids *Bembrops anatirostris* and *B. gobioides* occurred mainly within the Shelf/Slope Transition Zone (150-450 m).

Plate 7 shows *in situ* photographs of typical habitats of characteristic deepwater fish.

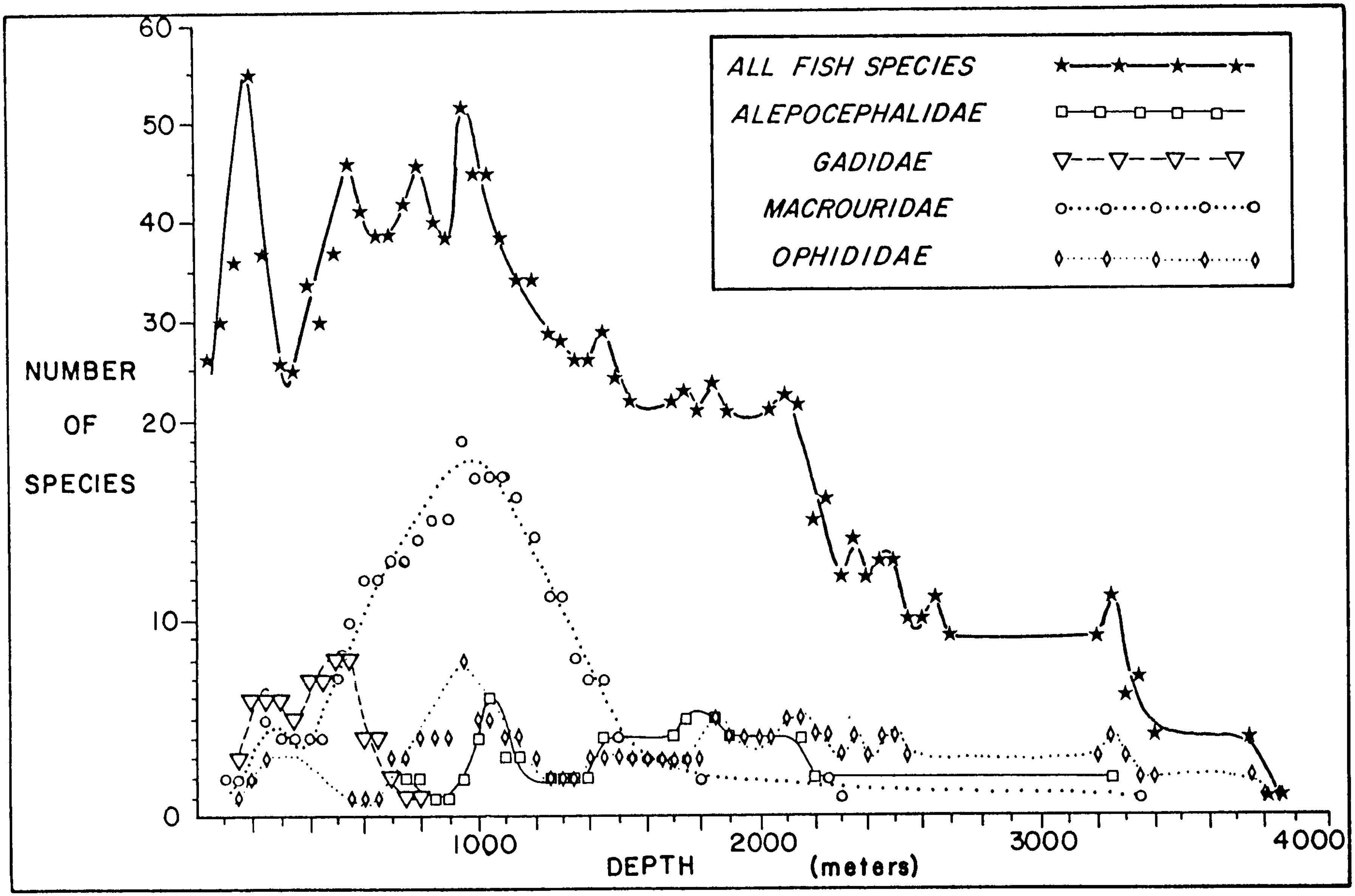

Figure 74. Depth distribution of number of all fish species and of the species of four major families of fish in the Gulf of Mexico ALAMINOS collections.

Table 32. (I) Fishes found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of deep water Pisces in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Gymnothorax ocellatus	1	5	5	shelf only	*
Peristedion gracile	1	0	-	shelf only	*
Kathetostoma albigutta	1	0	-	shelf only	*
Engyophrys senta	2	0	-	shelf-100	*
Centropristis philadelphica	4	0	-	shelf-150	*
Decodon puellaris	2	5	10	shelf-200	*
Zalieutes mcgintyi	72	5	360	shelf-200	*
Echiophis mordax	2	10	20	shelf-200	*
Neomerinthe hemingwayi	3	0	-	shelf-200	*
Saurida brasiliensis	8	5	40	shelf-200	*
Synodus foetens	8	0	-	shelf-200	*
Rypticus maculatus	2	0	-	shelf only	*
Cyclopsetta chittendeni	2	0	-	shelf-100	*
Caulolatilus sp.	8	0	-	shelf-200	100
Ogcocephalus parvus	1	5	5	100 only	100
Hemanthias vivanus	6	5	30	shelf-400	150
Congrina flava	3	5	15	shelf-200	150
Mustelus canis	1	0	-	150 only	150
Syacium papillosum	1	0	-	150 only	150
Ogcocephalus vespertilio	1	0	-	150 only	150
Scorpaena agassizi	2	0	-	150 only	150
Synodus poeyi	2	0	-	150 only	150
Halieutichthys aculeatus	23	5	115	150-200	150
Bellator militaris	2	0	-	150-250	150
Prionotus rubio	19	0	-	shelf-200	200
Prionotus stearnsi	19	0	-	shelf-200	200
Trichopsetta ventralis	51	5	255	shelf-250	200
Pristipomoides aquilonaris	168	15	2520	shelf-250	200
Pontinus longispinus	123	25	3075	shelf-250	200
Bembrops anatirostris	115	10	1150	100-550	200
Citharichthys cornutus	13	0	-	150-200	200
Monolene sp.	84	25	2100	150-250	200
Ancylopsetta dilecta	6	0	-	150-250	200
Lepophidium brevibarbe	19	5	95	150-250	200
Raja garmani	1	0	-	200 only	200
Citharichthys gymnorhinus	1	0	-	200 only	200
Uroconger syringinus	2	0	-	200 only	200

* Unknown

continued

Table 32 continued

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Urophycis floridana	4	0	-	200 only	200
Muraenesox sp.	1	0	-	200 only	200
Hoplunnis macrurus	1	0	-	200 only	200
Hoplunnis schmidtii	3	0	-	200 only	200
Nettenchelys pygmaeus	1	0	-	200 only	200
Ophichthus sp.	40	5	200	200 only	200
Neomerinthe beanorum	10	0	-	200 only	200
Gonioplectrus hispanus	5	0	-	200 only	200
Hollardia hollardia	1	0	-	200 only	200
Parahollardia lineata	1	0	-	200 only	200
Prionotus beani	1	0	-	200 only	200
Hoplunnis tenuis	4	0	-	200-250	200
Neobythites gilli	7	5	35	200-250	200
Physiculus fulvus	5	0	-	200-550	200
Myrophis punctatus	4	5	20	200-650	200
Poecilopsetta beani	372	20	7440	shelf-1450	250
Parasudis truculenta	81	0	-	shelf-500	250
Steindachneria argentea	81	0	-	150-300	250
Squalus cubensis	1	0	-	250 only	250
Argentina striata	1	0	-	250 only	250
Monolene sessilicauda	7	0	-	250 only	250
Paraxenomystax bidentatus	7	0	-	250 only	250
Mystriophis sp.	3	5	15	250 only	250
Lepophidium sp.	3	0	-	250 only	250
Coelorinchus caribbaeus	99	10	990	shelf-650	300
Hemanthias leptus	19	0	-	150-300	300
Callionymus agassizi	6	0	-	200-450	300
Gnathagnus egregius	14	0	-	200-550	300
unidentified Congridae	10	10	100	200-1000	300
Laemonema sp.	16	0	-	300 only	300
Neoraja sp.	1	0	-	350 only	350
Saccogaster maculatus	1	0	-	350 only	350
Bembrops gobioides	144	15	2160	100-550	400
Polymixia lowei	19	0	-	100-650	400
Symphurus piger	8	0	-	200-500	400
Urophycis regia	31	0	-	200-550	400
Chlorophthalmus chalybeius	5	0	-	300-400	400
Scorpaena cf. *plumieri*	3	0	-	400 only	400
Setarches guentheri	3	0	-	400 only	400
Trachyscorpia cristulata	2	5	10	400 only	400
Hoplostethus mediterraneus	1	0	-	400 only	400
Urophycis cirrata	113	5	565	shelf-650	450
Hymenocephalus italicus	218	20	4360	250-600	450
Scytalichthys cf. *miuris*	45	5	225	450 only	450

continued

Table 32 continued SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Merluccius albidus	14	0	-	250-650	500
Urophycis tenuis	5	5	25	400-500	500
Breviraja sinusmexicanus	7	0	-	400-600	500
Nezumia cf. *sclerorhynchus*	3	0	-	500 only	500
Conger oceanicus	2	0	-	500-600	500
Merluccius bilinearis	26	0	-	shelf-800	550
Lophius sp.	2	0	-	200-550	550
Coelorinchus coelorhinchus carminatus	68	5	340	250-650	550
Ventrifossa occidentalis	74	5	370	250-1050	550
Epigonus pandionus	7	0	-	400-550	550
Chlorophthalmus agassizi	20	0	-	400-600	550
Gadella maraldi	10	0	-	400-700	550
Peristedion greyae	44	0	-	400-700	550
Symphurus marginatus	99	10	990	450-750	550
Phycis chesteri	11	0	-	500-550	550
Epigonus occidentalis	11	0	-	500-1050	550
Raja sp.	1	0	-	550 only	550
Physiculus kaupi	1	0	-	550 only	550
Laemonema barbatulum	1	0	-	550 only	550
Neobythites marginatus	1	0	-	550 only	550
Gadomus sp.	3	0	-	550-950	550
Bythites sp.	10	0	-	200-650	600
Hydrolagus alberti	3	0	-	500-1100	600
Chaunax nuttingii	2	0	-	550-600	600
Ventrifossa atlantica	9	0	-	550-700	600
Raja clarki	3	0	-	550-900	600
Etmopterus spinax	22	5	110	550-1000	600
Dibranchus atlanticus	287	45	12915	150-1350	650
Bathygadus macrops	66	10	660	500-950	650
Yarrella blackfordi	106	0	-	500-1200	650
Brosmiculus imberbis	1	0	-	650 only	650
Etmopterus pusillus	7	5	35	650 only	650
Chimaera monstrosa	3	0	-	650-900	650
Chaunax pictus	24	0	-	400-800	700
Diplacanthopoma brachysoma	13	5	65	600-800	700
Luciobrotula sp.	2	0	-	600-1050	700
Hydrolagus sp. (cf. *media*)	1	5	5	700 only	700
unidentified Lophiiformes	3	0	-	700 only	700
unidentified Ophidiidae	14	5	70	700-3850	700
Pseudophichthys laterodorsalis	30	20	600	250-900	750
Bathygadus sp.	3	0	-	600-750	750
Hydrolagus mirabilis	2	5	10	700-850	750

continued

Table 32 continued SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Etmopterus schultzi	3	0	-	750 only	750
Leptoderma macrops	3	0	-	750 only	750
Polymetme corythaeola	1	0	-	750 only	750
Bathyuroconger vicinus	3	0	-	700-950	800
Nettastoma melanura	4	0	-	700-950	800
Myxine sp.	7	0	-	800 only	800
Bathytroctes antillarum	1	0	-	800 only	800
Pseudoxenomystax dubius	1	0	-	800 only	800
Cynomacrurus sp.	1	0	-	800 only	800
Coelorinchus occa	4	0	-	700-1050	850
Nezumia cyrano	30	10	300	850-1000	850
Nezumia aequalis	254	30	7620	500-1300	900
Halosaurus guentheri	94	15	1410	550-1100	900
Bathygadus melanobranchus	128	20	2560	550-1750	900
Trachonurus villosus	11	0	-	750-1200	900
Raja bigelowi	2	0	-	900 only	900
Coryphaenoides colon	56	0	-	600-1200	950
Gadomus arcuatus	9	0	-	700-1200	950
Neoscopelus macrolepidotus	4	0	-	750-950	950
Bathypterois viridensis	1	0	-	950 only	950
Diplacanthopoma sp.	2	0	-	950 only	950
Lamprogrammus niger (?)	1	0	-	950 only	950
Penopus macdonaldi	1	0	-	950 only	950
Howella sp.	1	0	-	950 only	950
Histiobranchus bathybius	1	0	-	950 only	950
Nezumia bairdii	7	0	-	950-1150	950
Synaphobranchus oregoni-brevidorsalis	243	65	15795	500-2150	1000
Monomitopus sp.	16	5	80	800-1150	1000
Raja fuliginea	2	0	-	950-1050	1000
Alepocephalus agassizii	6	0	-	950-1050	1000
Barathronus sp.	3	0	-	950-1100	1000
Diplolychnus sp.	2	0	-	1000 only	1000
Bathytroctes melanocephalus	3	0	-	1000-1050	1000
Apristurus profundorum	6	0	-	550-1100	1050
Gadomus longifilis	463	40	18520	550-1450	1050
Monomitopus agassizi	175	10	1750	700-1200	1050
unidentified Synaphobranchidae	48	15	720	700-3650	1050
Ilyophis brunneus	80	0	-	800-3700	1050
Squalogadus modificatus	33	0	-	950-1100	1050
Raja oregoni	1	0	-	1050 only	1050
Platytroctes apus	1	0	-	1050 only	1050
Conocara cf. *macroptera*	36	5	180	1050-1200	1050
Bathygadus favosus	16	5	80	800-1300	1100

continued

Table 32 continued SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Raja purpuriventralis	1	0	-	1100 only	1100
Chalinura carapina	3	0	-	1100-2250	1100
Coryphaenoides sp.	11	5	55	700-3350	1150
Cetonurus globiceps	5	0	-	950-1300	1150
Sphagemacrurus grenadae	20	0	-	950-1450	1150
Bathypterois quadrifilis	48	15	720	950-2500	1150
Venefica procera	29	20	580	550-2150	1200
Dicrolene intronigra	323	50	16150	700-2250	1200
Coryphaenoides mexicanus	68	15	1020	800-1500	1200
Stephanoberyx monae	86	30	2580	950-1500	1200
Barbantus curvifrons	1	0	-	1200 only	1200
Polyacanthonotus africanus	6	0	-	1200-1750	1200
Bathypterois sp.	1	0	-	1250 only	1250
Bathypterois longipes	5	5	25	750-2100	1400
Aldrovandia affinis	47	35	1645	800-2250	1400
Conocara mcdonaldi	33	10	330	1000-1850	1400
Bathylagus cf. *longirostris*	1	0	-	1450 only	1450
Dicrolene sp.	12	5	60	950-2150	1450
Aldrovandia gracilis	115	30	3450	950-2500	1450
Coryphaenoides macrocephalus	2	0	-	1100-1450	1450
Narcetes stomias	2	0	-	1450-2150	1450
Bathypterois phenax	2	0	-	1400-2100	1800
Alepocephalus sp.	3	0	-	1450-2100	1850
Bassozetus catena	1	0	-	1850 only	1850
Xyelacyba myersi	1	5	5	1850 only	1850
Bathytroctes sp.	10	10	100	750-3250	1900
Cataetyx sp.	11	5	55	1150-2150	1900
Ipnops murrayi	23	25	575	1200-2650	2000
Porogadus catena	18	20	360	1850-2450	2100
Benthosaurus grallatar	1	0	-	2150 only	2150
Leptochilochthys agassizi	1	0	-	2150 only	2150
Epigonus sp.	1	0	-	2250 only	2250
Dicrolene kanazawai	1	5	5	2350 only	2350
Lamprogrammus sp.	1	5	5	2500 only	2500
Chlorophthalmus sp.	3	5	15	2650 only	2650
Bathyonus pectoralis	13	20	260	2450-3750	2900
Bassozetus normalis	20	30	600	1400-3840	3200
Barathronus bicolor	12	10	120	600-3750	3250
Bathytroctes macrolepis	11	10	110	1750-3250	3250
Hemipterois sp.	9	5	45	2100-3250	3250
Bassozetus sp.	13	15	195	2100-3250	3250
Acanthonus armatus	7	5	35	3250 only	3250
Haptenchelys texis	4	0	-	3250 only	3250
Tauredophidium hextii	2	5	10	3300 only	3300
Bassogigas sp.	1	5	5	3750 only	3750

continued

Table 32 continued

(II) Dominant fishes presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Gadomus longifilis	1050
Dicrolene intronigra	1200
Synaphobranchus oregoni-brevidorsalis	1000
Dibranchus atlanticus	650
Nezumia aequalis	900
Poecilopsetta beani	250
Hymenocephalus italicus	450
Aldrovandia gracilis	1450
Pontinus longispinus	200
Stephanoberyx monae	1200
Bathygadus melanobranchus	900
Pristipomoides aquilonaris	200
Bembrops gobioides	400
Monolene sp.	200
Monomitopus agassizi	1050
Aldrovandia affinis	1400
Halosaurus guentheri	900
Bembrops anatirostris	200
Coryphaenoides mexicanus	1200
Coelorinchus caribbaeus	300
Symphurus marginatus	550

Table 33. Distribution of species of demersal fishes among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	66	24	90
Archibenthal Zone (475-950 m)	68	40	108
Upper Abyssal (975-2250 m)	49	23	72
Mesoabyssal (2275-3200 m)	5	13	18
Lower Abyssal (3225-3850)	8	7	15

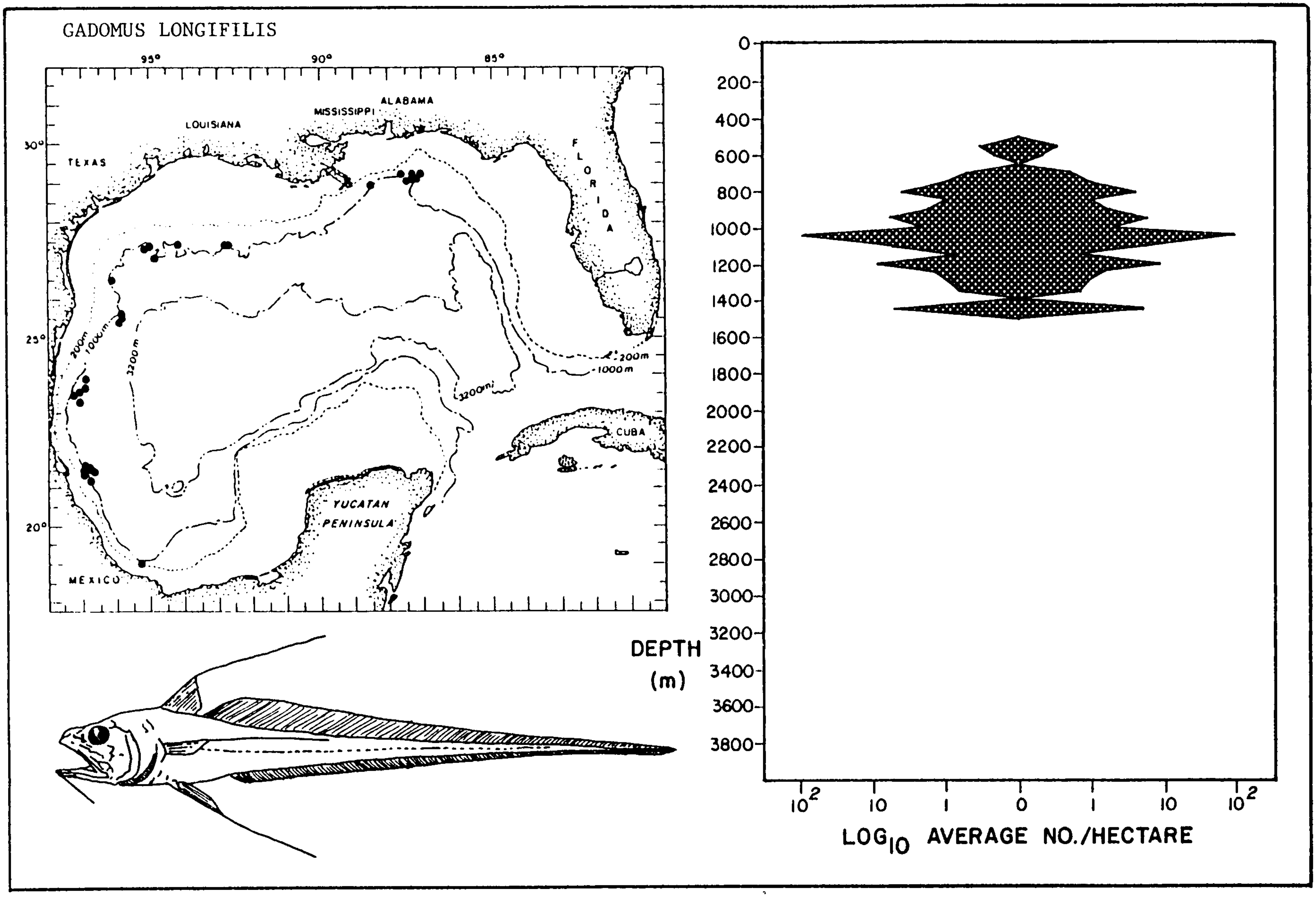

Figure 75. Horizontal and vertical distribution (including population density) of the macrourid fish <u>Gadomus longifilis</u> in the deep Gulf of Mexico.

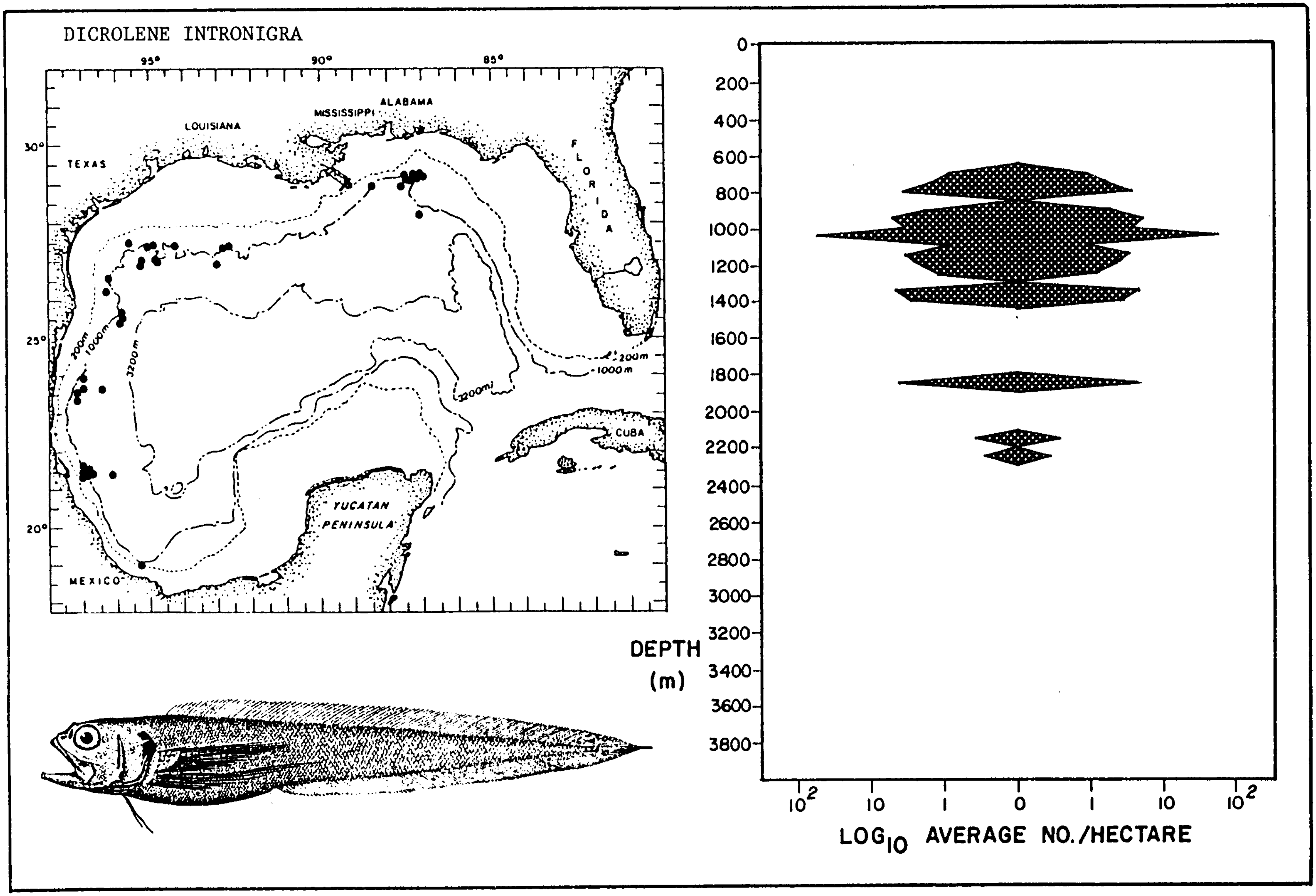

Figure 76. Horizontal and vertical distribution (including population density) of the ophidiid fish <u>Dicrolene intronigra</u> in the deep Gulf of Mexico.

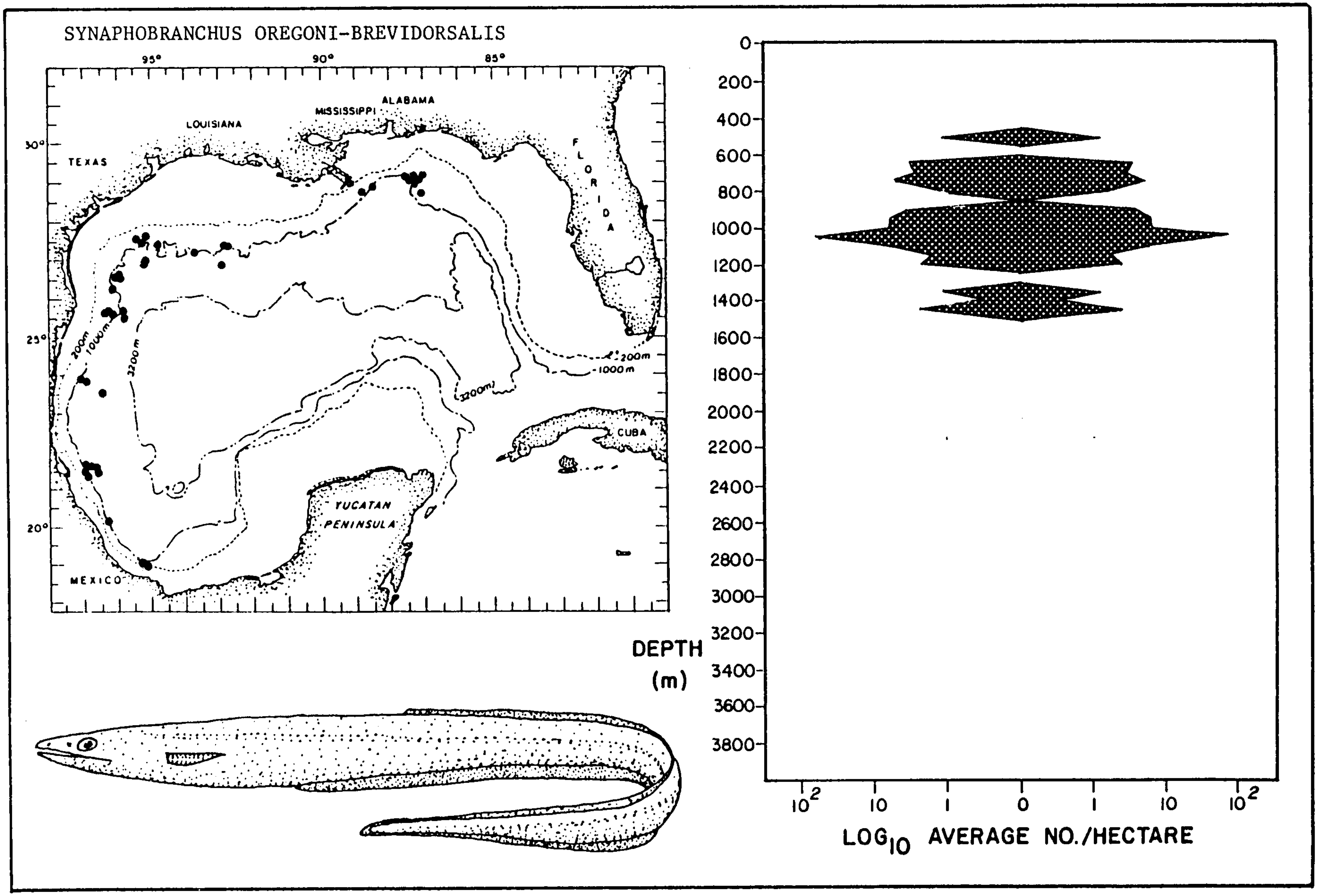

Figure 77. Horizontal and vertical distribution (including population density) of the synaphobranchid fish Synaphobranchus oregoni-brevidorsalis in the deep Gulf of Mexico.

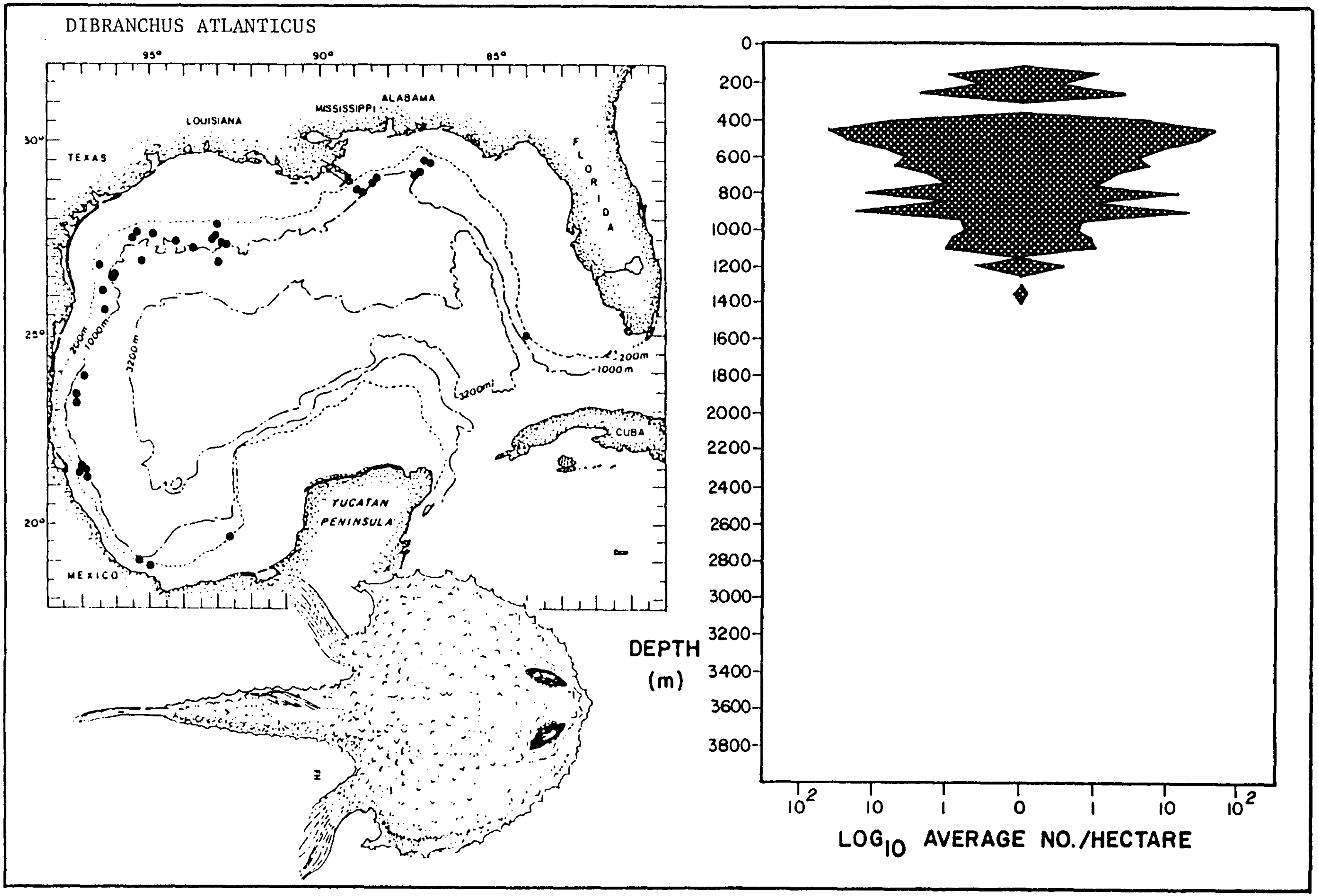

Figure 78. Horizontal and vertical distribution (including population density) of the ogcocephalid fish Dibranchus atlanticus in the deep Gulf of Mexico.

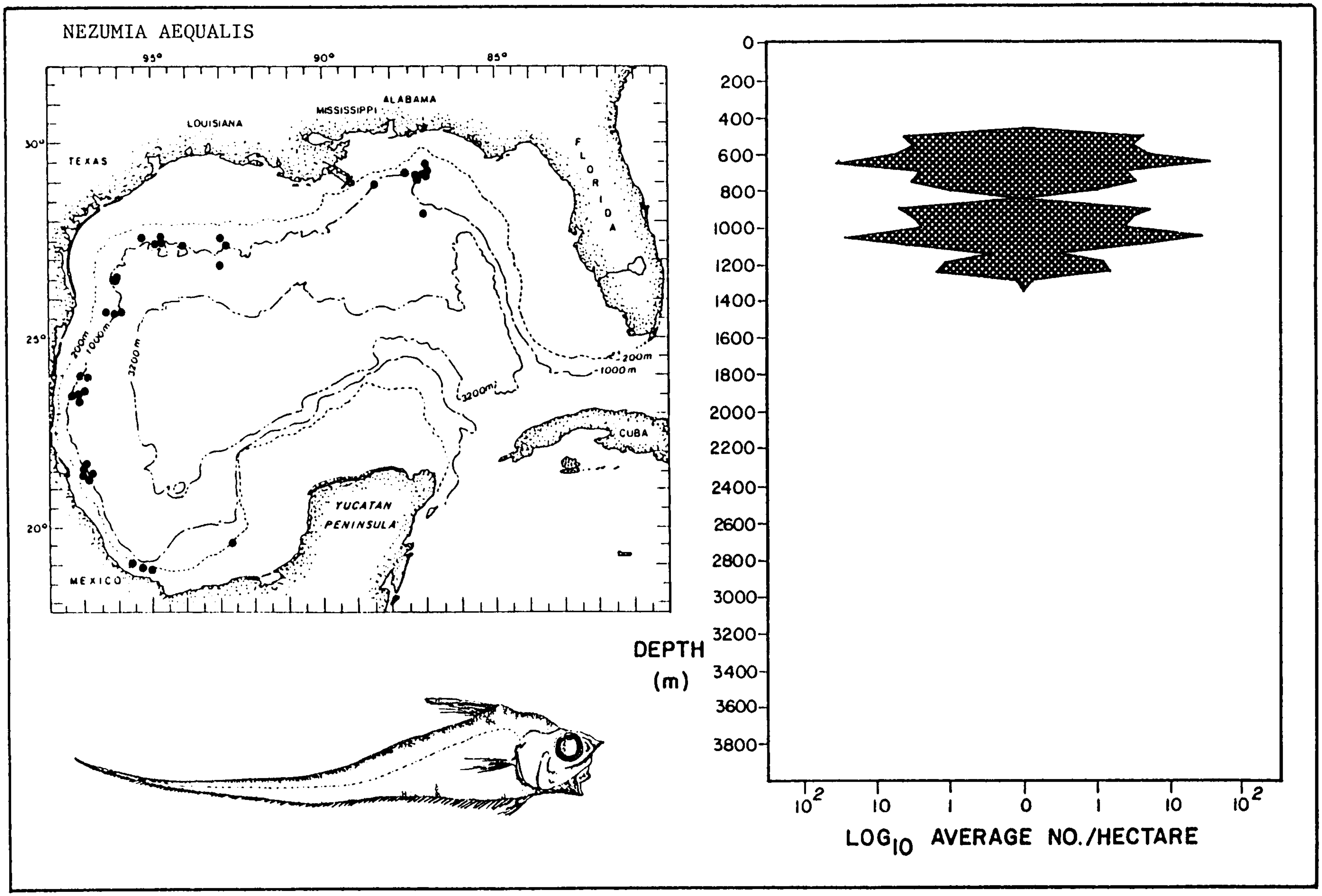

Figure 79. Horizontal and vertical distribution (including population density) of the macrourid fish <u>Nezumia aequalis</u> in the deep Gulf of Mexico.

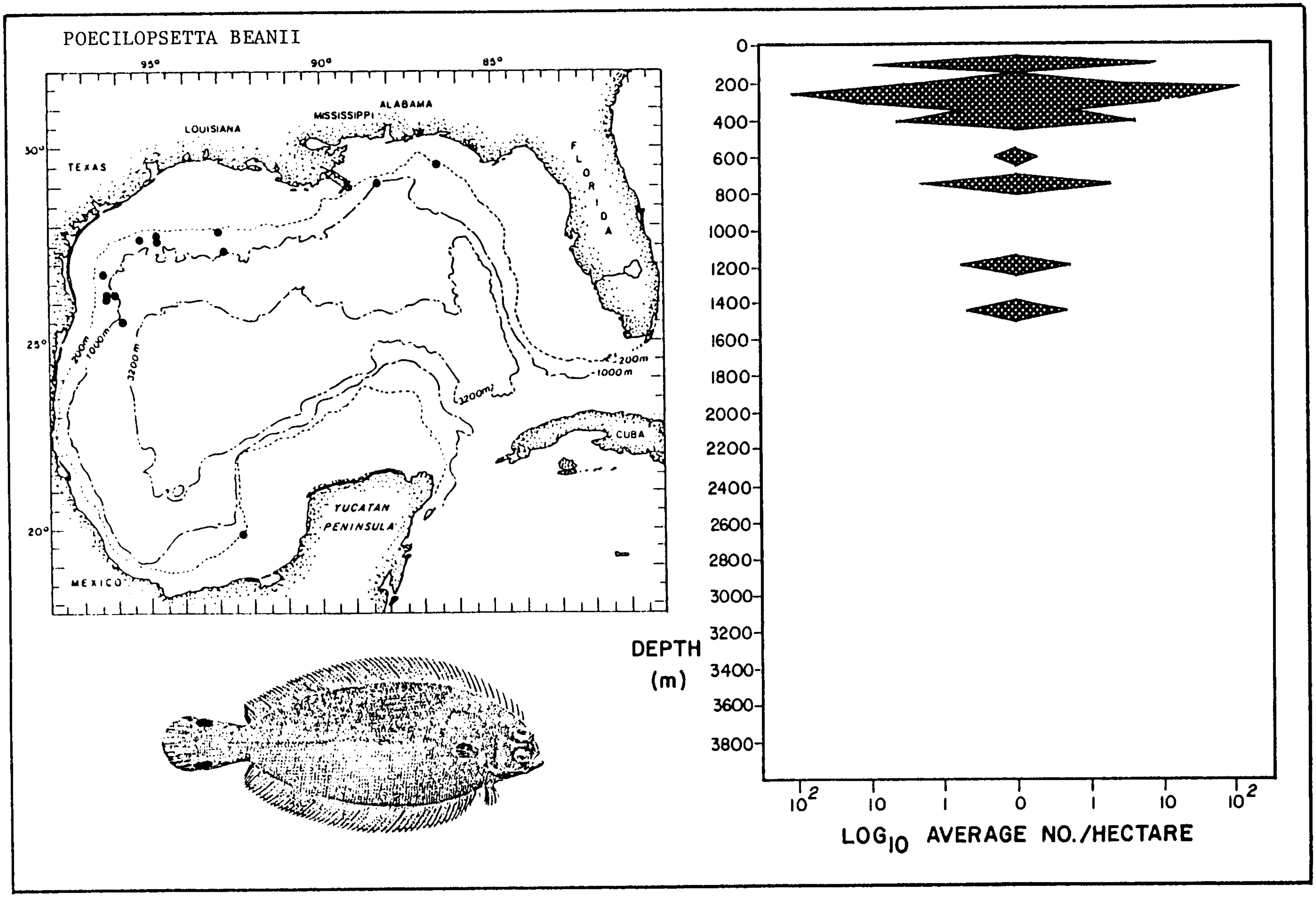

Figure 80. Horizontal and vertical distribution (including population density) of the pleuronectid fish *Poecilopsetta beanii* in the deep Gulf of Mexico.

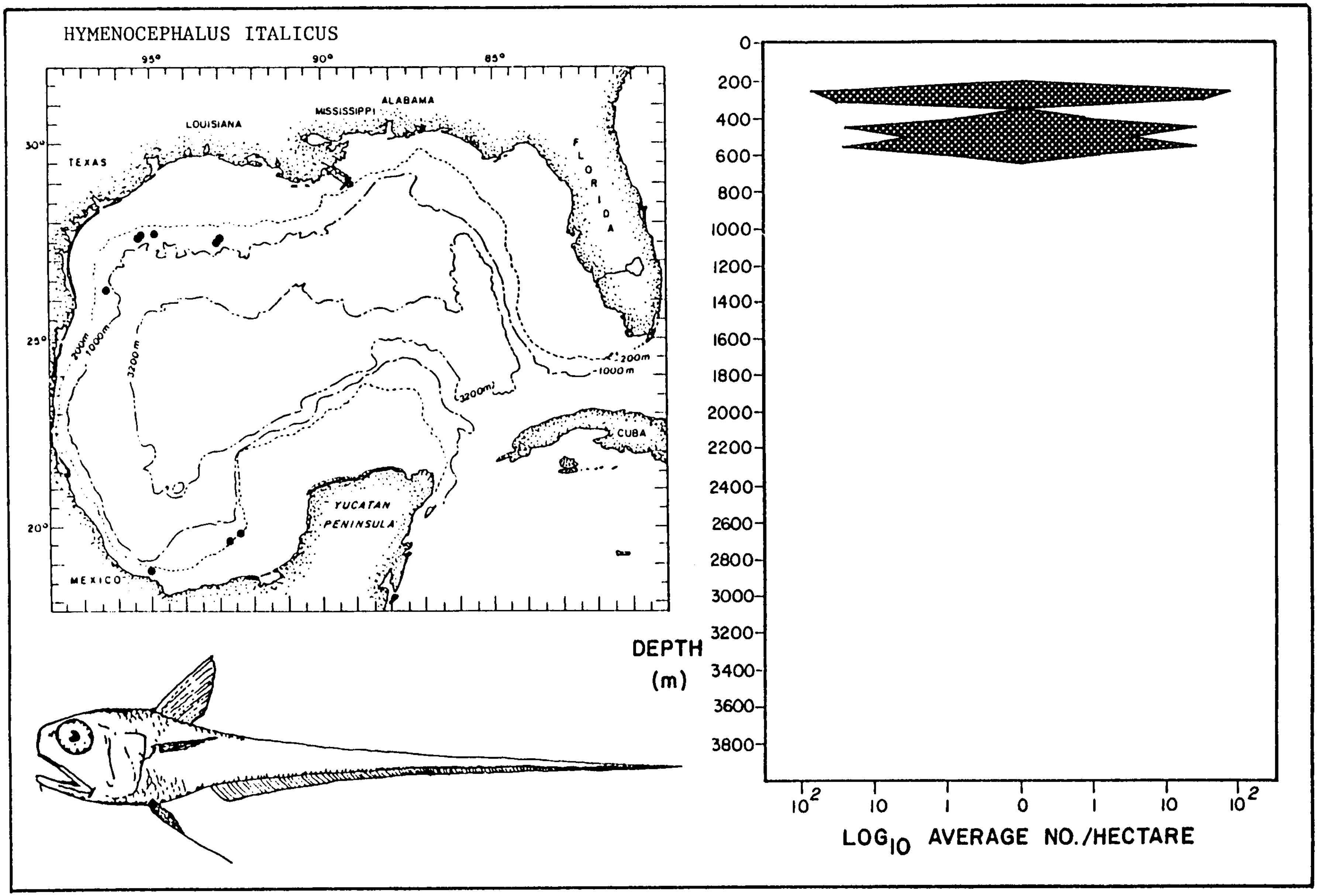

Figure 81. Horizontal and vertical distribution (including population density) of the macrourid fish *Hymenocephalus italicus* in the deep Gulf of Mexico.

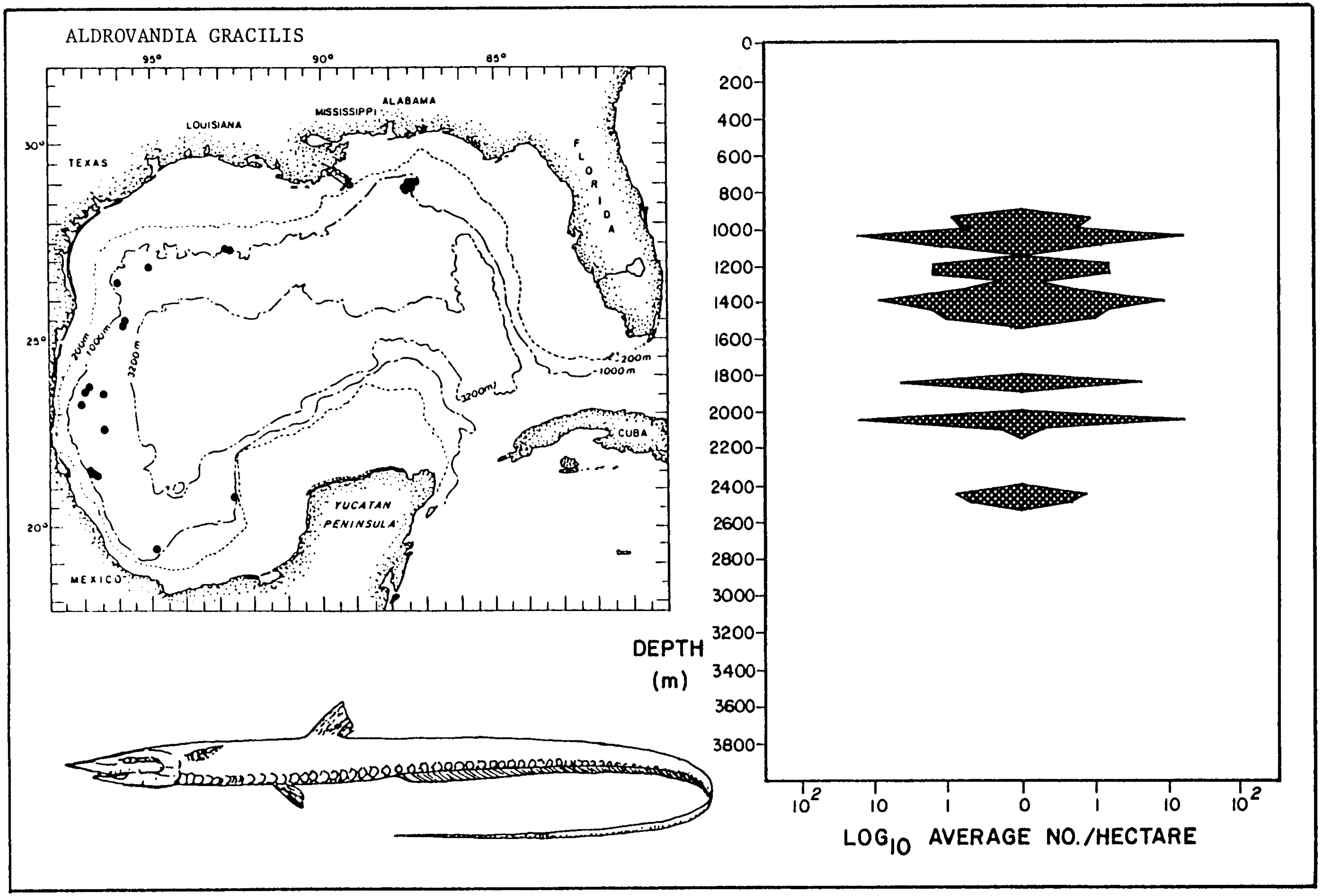

Figure 82. Horizontal and vertical distribution (including population density) of the halosaurid fish Aldrovandia gracilis in the deep Gulf of Mexico.

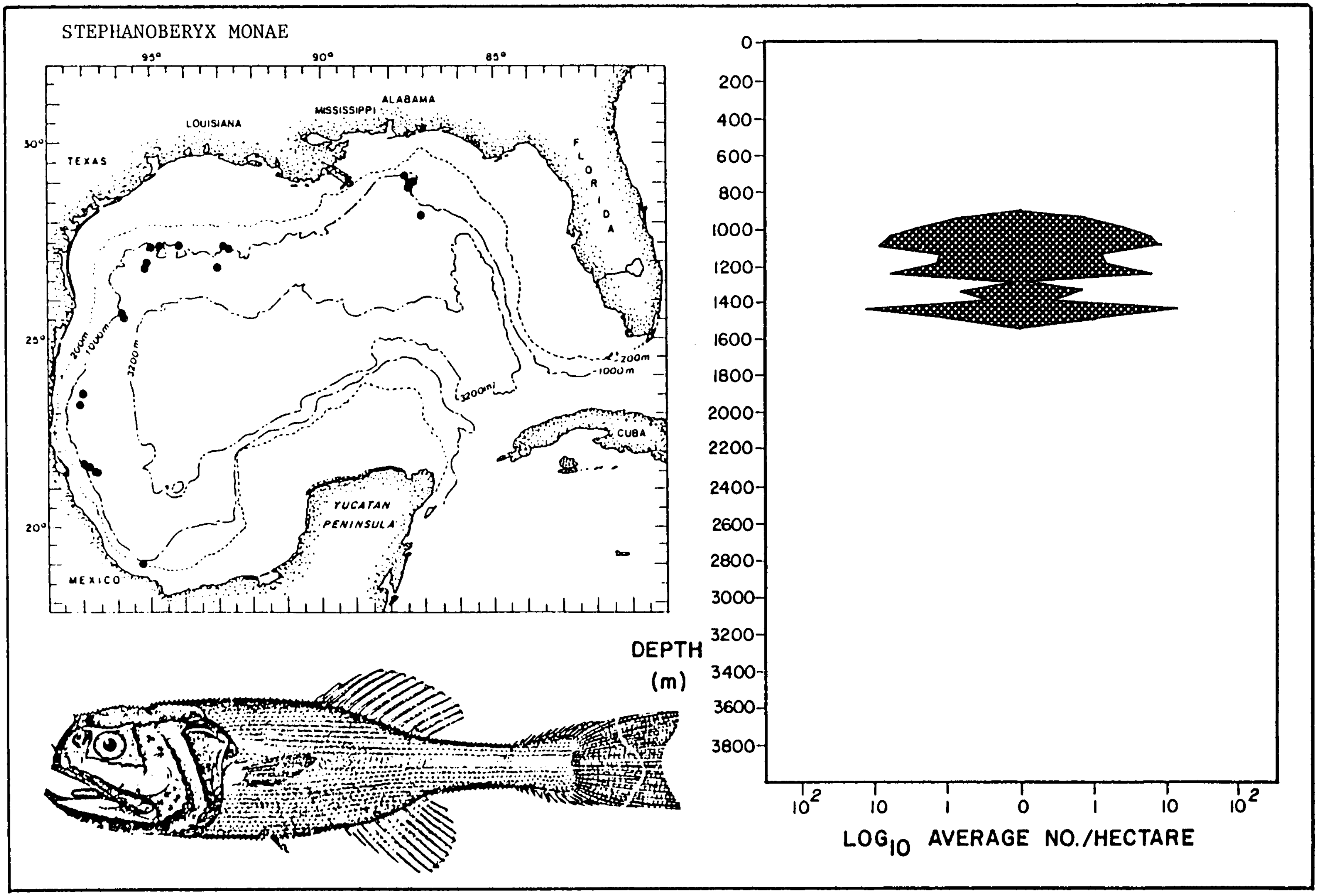

Figure 83. Horizontal and vertical distribution (including population density) of the stephanoberycid fish Stephanoberyx monae in the deep Gulf of Mexico.

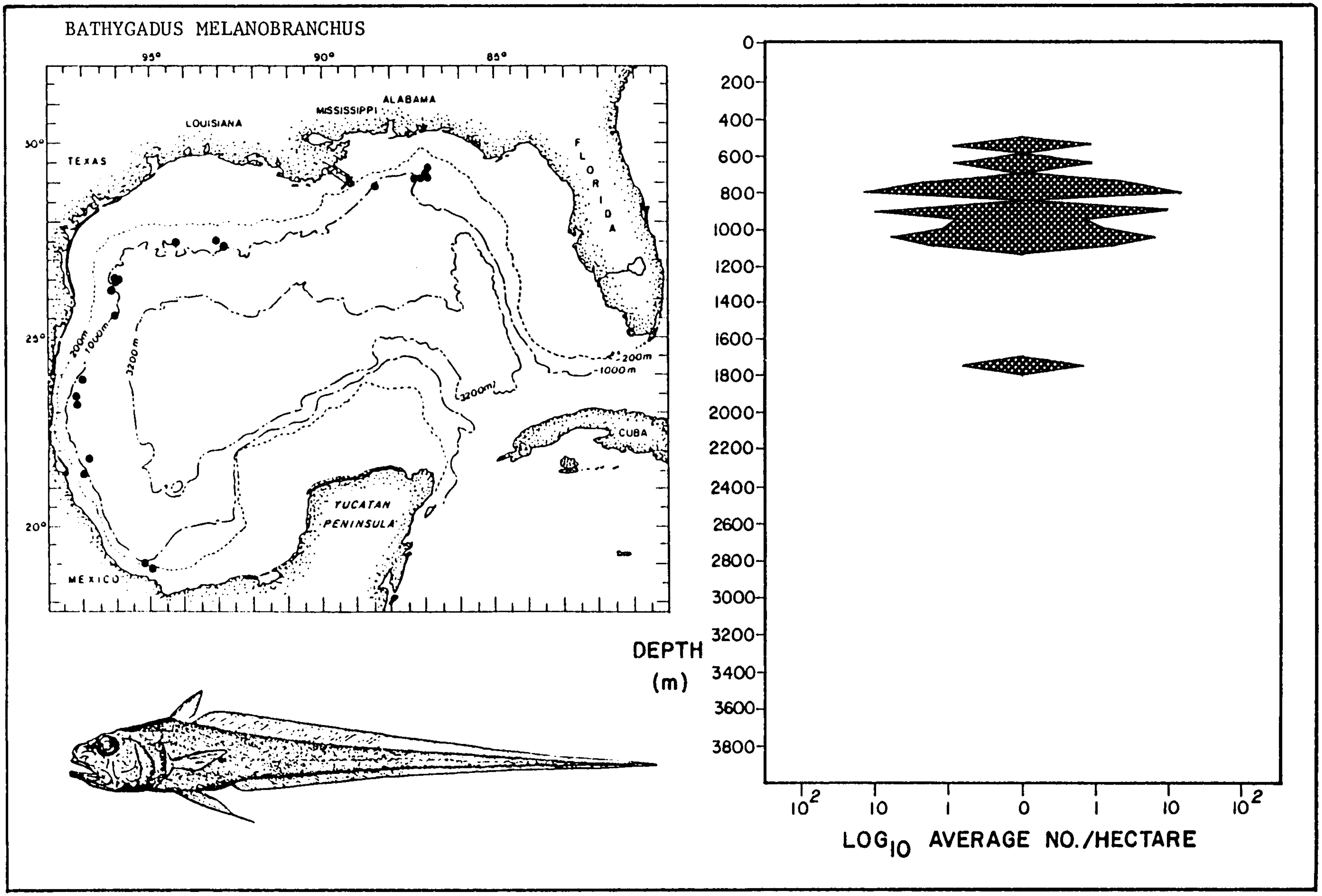

Figure 84. Horizontal and vertical distribution (including population density) of the macrourid fish Bathygadus melanobranchus in the deep Gulf of Mexico.

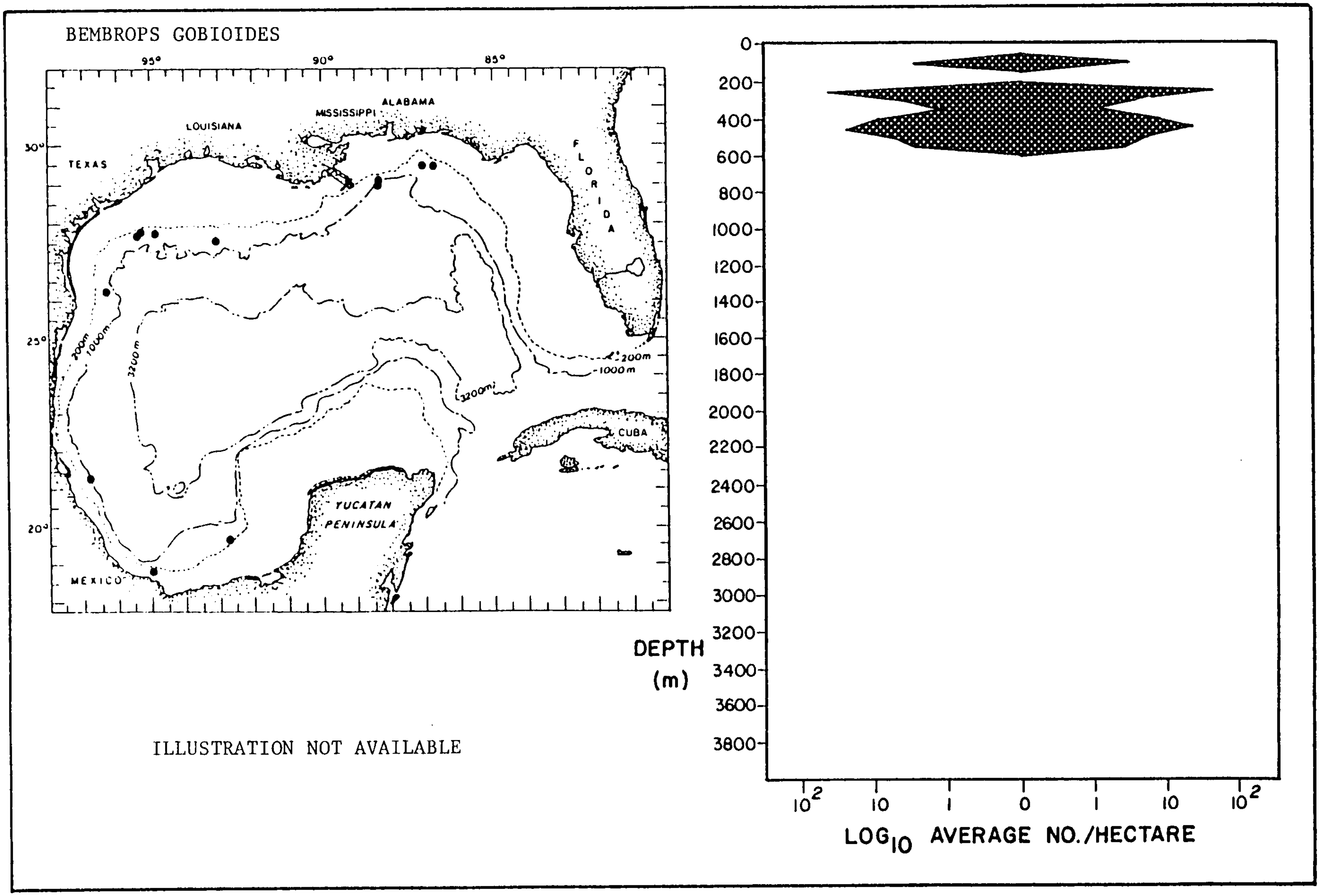

Figure 85. Horizontal and vertical distribution (including population density) of the percophiid fish *Bembrops gobioides* in the deep Gulf of Mexico.

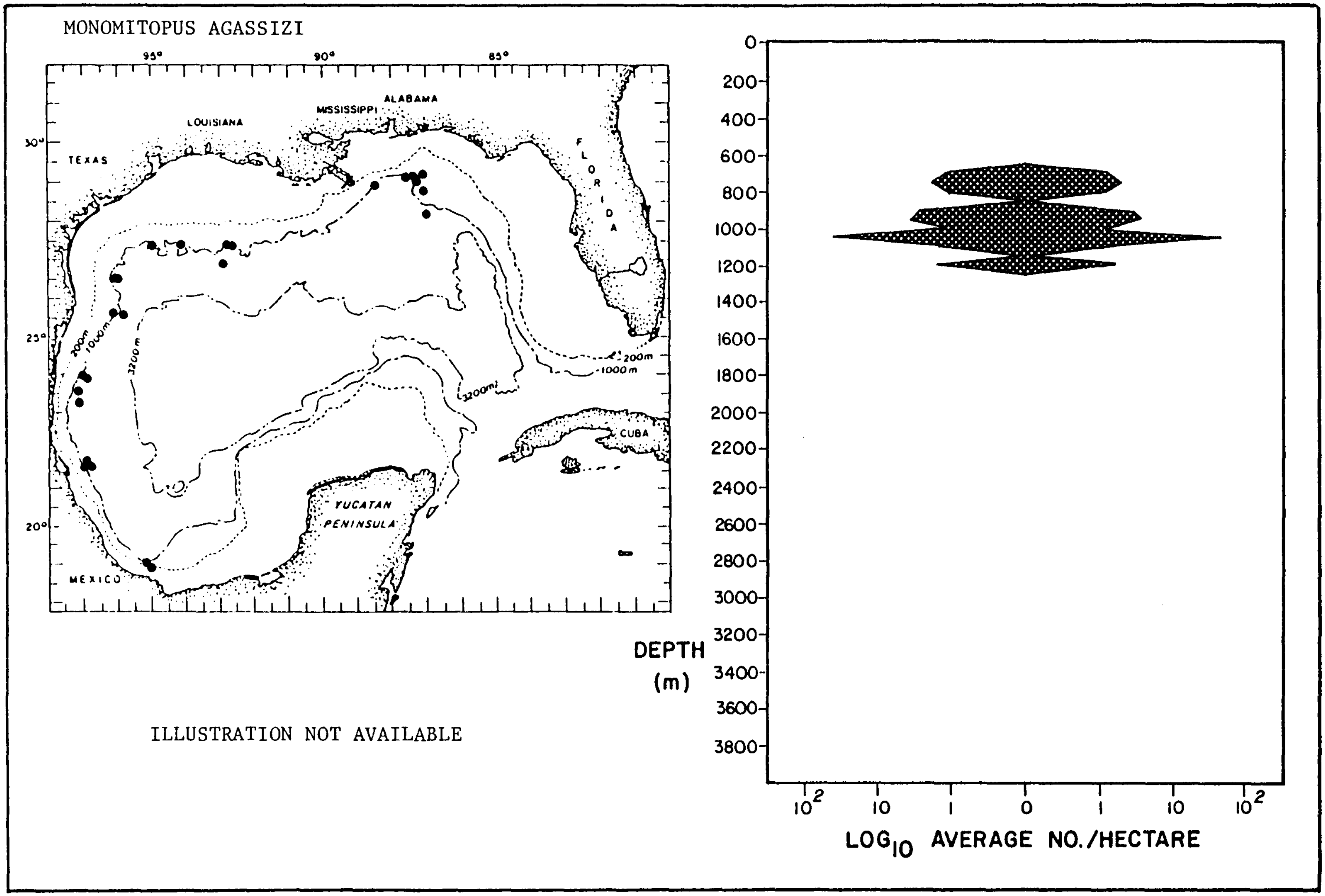

Figure 86. Horizontal and vertical distribution (including population density) of the ophidiid fish <u>Monomitopus agassizi</u> in the deep Gulf of Mexico.

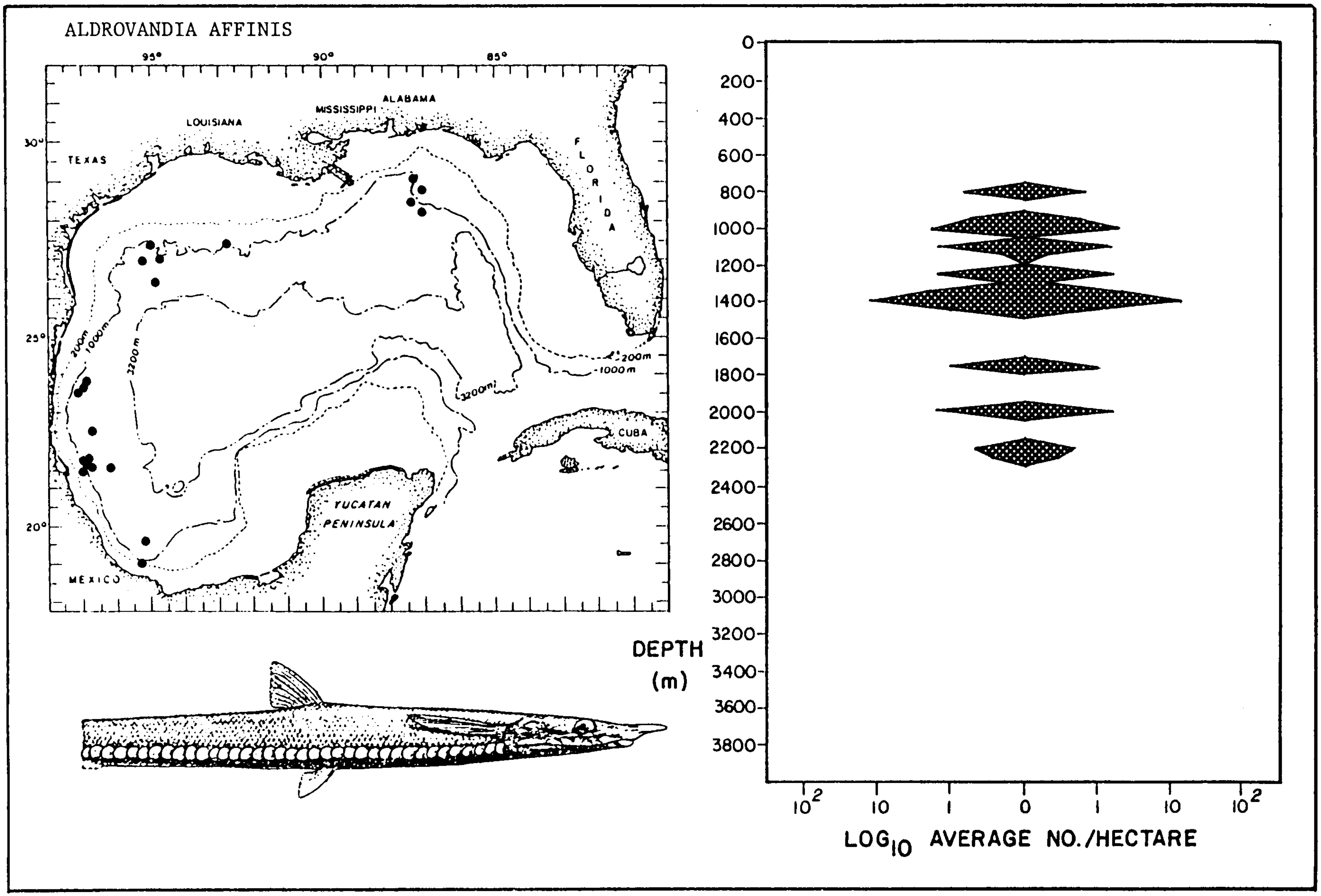

Figure 87. Horizontal and vertical distribution (including population density) of the halosaurid fish <u>Aldrovandia affinis</u> in the deep Gulf of Mexico.

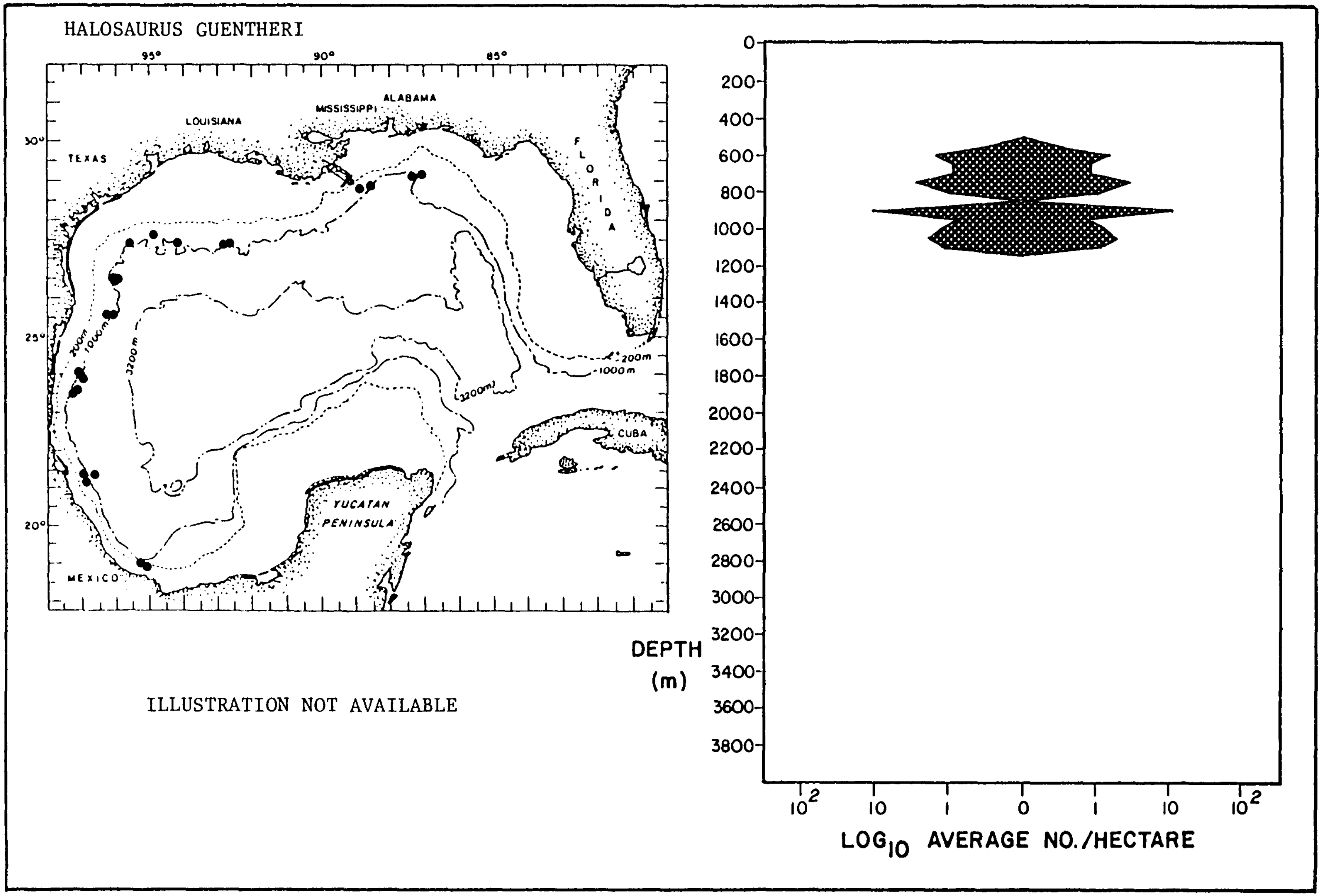

Figure 88. Horizontal and vertical distribution (including population density) of the halosaurid fish <u>Halosaurus</u> <u>guentheri</u> in the deep Gulf of Mexico.

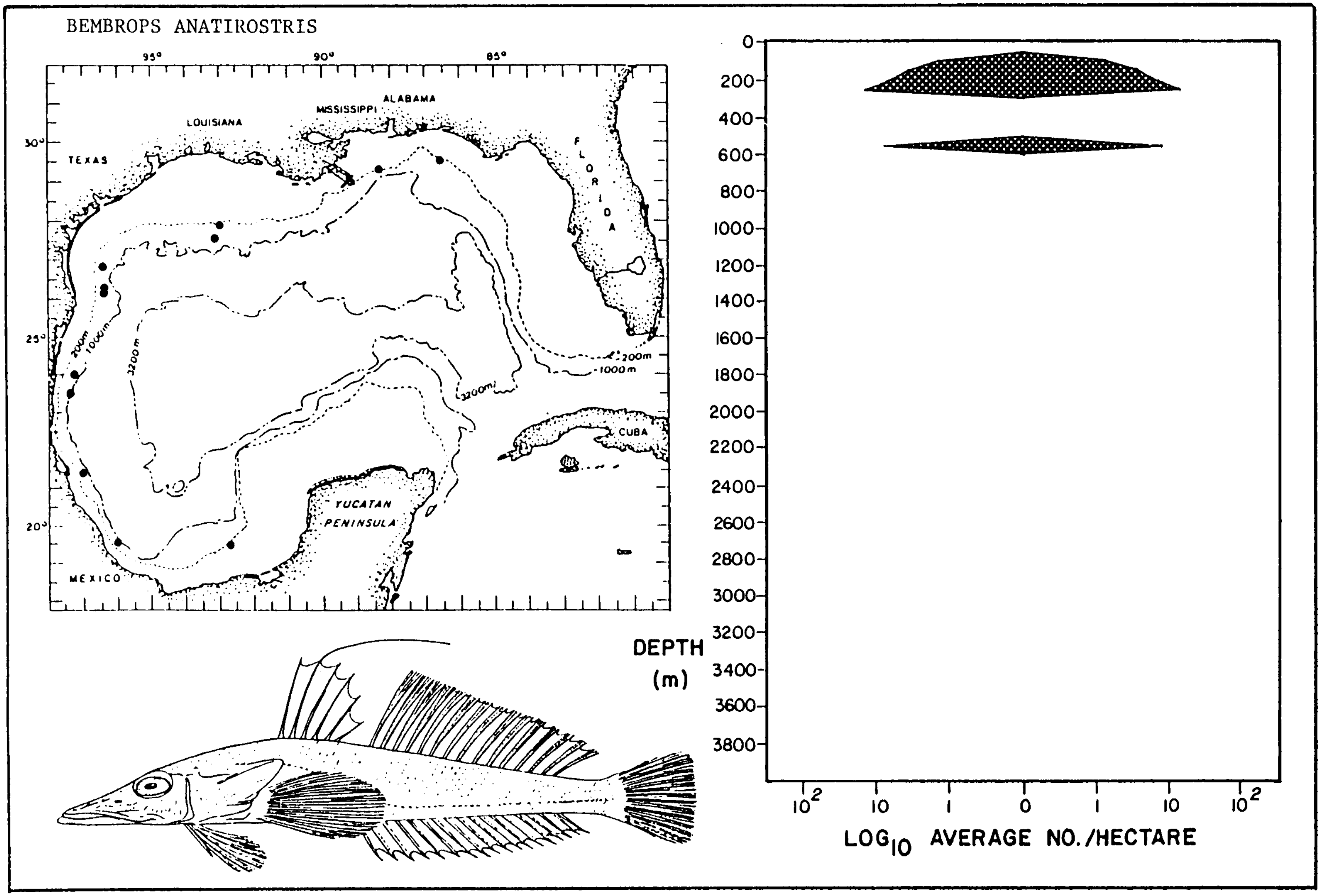

Figure 89. Horizontal and vertical distribution (including population density) of the percophid fish Bembrops anatirostris in the deep Gulf of Mexico.

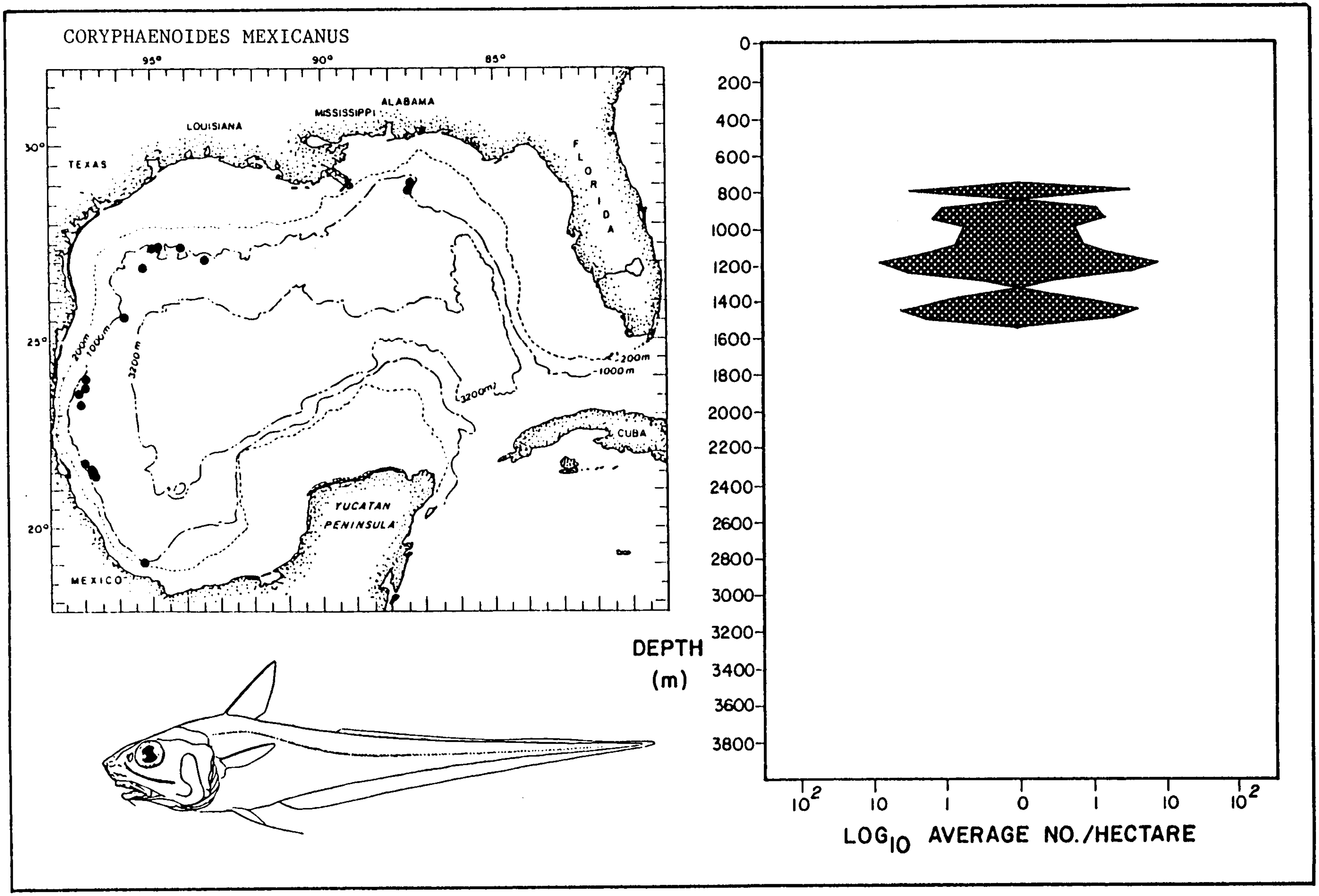

Figure 90. Horizontal and vertical distribution (including population density) of the macrourid fish <u>Coryphaenoides mexicanus</u> in the deep Gulf of Mexico.

Mollusca

The benthic Gastropoda and Cephalopoda, which are considered to be primarily epifaunal (or in the case of some cephalopods benthopelagic), are covered in this section. The Bivalvia and Scaphopoda, which are primarily infaunal, i.e., living within the sediments rather than on top of the sediments are covered in the next section along with the Polychaeta under the Infauna.

Depth distributions of the numbers of species in each of the molluscan classes are shown in Figure 91. The gastropods which appear to be the most diverse group of the Mollusca in the deep Gulf, exhibit their greatest diversity between the 500-1500 m depths. The bivalves (which are only complete in the Palaeotaxodonta and the family Propeamussidae due to the loss of the remaining bivalve specimens during shipment to the taxonomic specialist) show their peak diversity between about 1000-1400 m, i.e., in the Upper Abyssal Zone, according to Figure 91. The cephalopods and gastropods have less definitive peaks of maximum diversity but they tend to show somewhat greater diversity of species in the Upper Abyssal Zone between about 1000-1400 m.

Gastropoda

A total of 40 gastropod families are included in the collection. Nineteen families had three or more species (Table 34); the remaining 21 families were represented by only one or two species and comprised only 6.1% of the total number of individuals. The Gastropoda collected during the study include 194 species (Table 35) some of which are new records for the Gulf of Mexico or new species entirely. In terms of numbers of species, gastropods were much more prevalent between 500 and 1500 m depth than either shallower (excluding the shelf) or deeper (Figure 91). The greatest number of species occurred between 800 and 1200 m. This broad spike is partially due to a highly diverse sample from below DeSoto Canyon (Station 66A9-15, 800-1200 m)* which yielded 47 species of gastropods, 14 of which were collected only from that station during the entire study. The distribution of gastropod species by bathymetric zones is shown in Table 36.

Clearly the Turridae is the numerically dominant gastropod family, containing over 36% of the total species and 64% of the total number of individuals. To no surprise then, half of the 16 dominant gastropods were also turrids. These are: *Gemmula periscelida*, *Leucosyrinx tenoceras*, *L. verrilli*, *Gymnobela ipara*, *Ancistrosyrinx* sp., and *Theta pandionis*. Turrids are specialized predators on macrobenthos, including other gastropods, and about half of the species have planktonic larvae. Although the Turridae were numerically important in the samples, they will not be discussed in great detail here because of their small size which renders them 1) an unimportant group based on their low biomass (Philippe Bouchet, pers. comm., 1983)** and 2) an inadequately sampled group since the small species could pass through the 6.4 mm mesh of the skimmer and the 20-m trawl.

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* Station 66A9-15 was actually a midwater trawl station where the fast-moving trawl hit bottom at 1200 m and dredged a section of the slope below DeSoto Canyon which ranged from 1200 to 800 m depth.

** Museum National d'Histoire Naturelle, Paris, France.

Table 34. Number of species, number of individuals, and percent of the total number of individuals within the gastropod families collected by the R/V ALAMINOS from the Gulf of Mexico, 1964-1973.

	No. of Species	No. of Individuals	Percent Total No. of Individuals
Turridae	70	3248	64.7
Trochidae	22	400	8.0
Scaphandridae	7	279	5.6
Muricidae	6	183	3.6
Tonnidae	6	151	3.0
Rissoidae	3	105	2.1
Pyramidellidae	3	89	1.8
Buccinidae	4	85	1.7
Seguenziidae	6	41	0.8
Fusinidae	3	25	0.5
Acteonidae	6	22	0.4
Columbellidae	5	22	0.4
Volutidae	3	15	0.3
Naticidae	5	13	0.3
Retusidae	3	10	0.2
Epitoniidae	5	8	0.2
Eulimidae/Aclidae	6	7	0.1
Cylichnidae	3	6	0.1
Cyclostrematidae	4	4	0.1
Others	25	305	6.1
Total	195	5018	100.0

The Trochidae ranked second in numbers of species and numbers of individuals. _Gaza superba_ and _G. fischeri_ are both fairly large trochids. _G. superba_, one of the dominant gastropods in this study, was characteristic of the Archibenthal Zone. Both _G. superba_ and _G. fischeri_ are sediment feeders. Both also have nonplanktotrophic development which follows the trends noted for gastropods by Rex and Waren (1982); that is, gastropods of the inner shelf, continental rise, and abyssal plain are likely to have planktotrophic development while those of the outer shelf and slope usually have nonplanktotrophic development.

Oocorys bartschi and _O. sulcata_, both listed as dominants, are also fairly large gastropods. _O. bartschi_ has a similar distribution to _Gaza superba_, while _O. sulcata_ is centered around 950 m depth and ranges to the deepest part of the Gulf. _Oocorys_ species have planktonic larvae and feed on both live and dead invertebrates.

The three _Scaphander_ species, _S._ cf. _clavus_, _S. watsoni_, and _S. mundus_, are actually infaunal. _S. watsoni_ was a rather shallow species, and occurred only on the upper slope. _S. mundus_ and _S._ cf. _clavus_ were distributed similarly to _Gaza superba_ and _Oocorys bartschi_ both bathymetrically and geographically, but differ in their feeding from _Gaza_ and _Oocorys_ in that their prey are forams, scaphopods, and small bivalves. The Scaphander species probably have planktonic development (Philippe Bouchet, pers. comm., 1983)*.

Tables 34 and 35 may be overestimates of the actual gastropod numbers collected, particularly of the smaller species collected by the dredge and grab, because of the difficulty in determining whether the animals were live or merely empty shells. However, the tables include only material of species which normally occur at the sampled depth, so no erroneous data based on empty shells perhaps transported out of a species range are reported.

Cephalopoda

Some 85 species of Cephalopoda are reported to occur in the deep Gulf of Mexico (Table 37). Only 11 of these species (Table 38) are confirmed benthic or benthopelagic species. Most of these species were collected only rarely, which is probably due to two factors. First, like the fishes, cephalopods are agile swimmers and can avoid most collecting devices. All but one of the stations where benthic cephalopods were taken were sampled with either the fast-moving skimmer or 20-m trawl. Second, most of these listed cephalopods are not truly benthic but rather benthopelagic. All of the deep-sea photographs of cirrate cephalopoda presented by Roper and Brundage (1972) show the animals above the bottom by as much as 4 m. Thus, the collecting devices may not have actually sampled through the cephalopod habitat. Plate 9A shows an octopus photographed above the bottom in its typical habitat.

Table 38 includes one cirrate octopod, Grimpoteuthis sp. A, and three incirrate octopods: Pteroctopus tetracirrhus, Benthoctopus januari, and Opisthoteuthis agassizi. B. januari, the most abundant cephalopod taken, occurred at six stations, five of which were between 450 and 850 m and one which was at 2100 m, the deepest record for the species (Lipka, 1975). Grimpoteuthis sp. A is the only truly abyssal cephalopod collected from the Gulf (Lipka, 1975). This species and other Grimpoteuthis species certainly have a close association with the bottom, as determined by the presence of polychaetes, calanoid copepods, and other benthic animals in their stomachs (Roper and Brundage, 1972; Lipka, 1975).

All of the other cephalopods taken were squids of the subfamily Rossiinae. Lipka (1975) noted that the three rossiid genera taken in the Gulf, Semirossia, Rossia, and Neorossia, seemed to occupy distinct bathymetric zones on the continental slope. The Semirossia species are primarily on the outer continental shelf but extend onto the upper continental slope, species of Rossia occur somewhat deeper on the slope, while the Neorossia species are the deepest benthic squids of the Gulf, ranging on the slope from 950 to 1400 m. The distribution of cephalopods by zones in shown in Table 39.

* Museum National d'Histoire Naturelle, Paris, France.

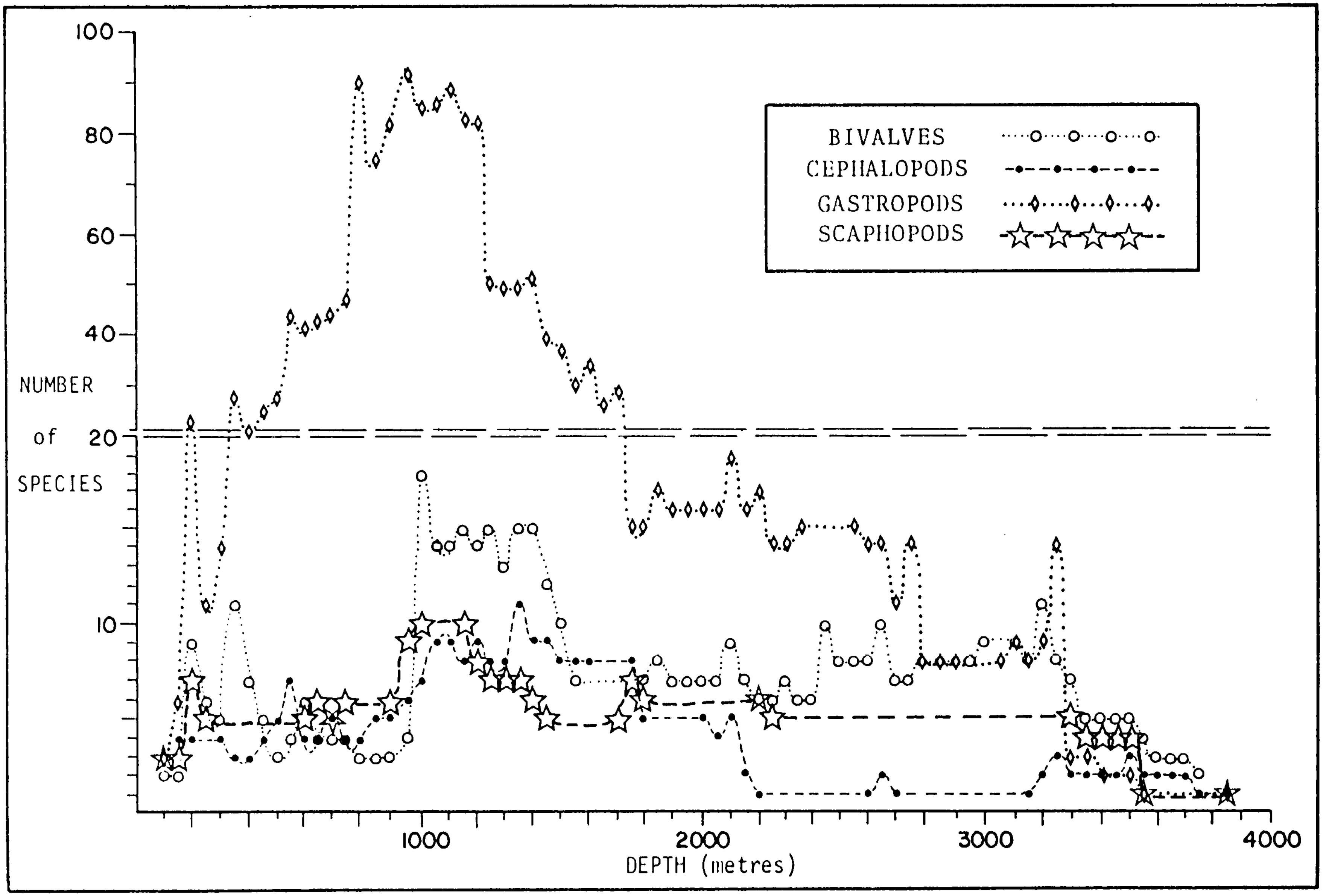

Figure 91. Depth distribution of the number of species of molluscan classes in the deep Gulf of Mexico.

Table 35. (I) Gastropoda found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of gastropods in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Antillophos candaei	20	5	100	100-400	100
Polystira albida	80	5	400	100-800	200
Sconsia striata	41	5	205	150-300	200
Murex beauii	135	25	3375	150-350	200
Conus mazei	99	10	990	150-800	200
Antillophos sp.	3	0	-	200 only	200
Acamptochetus sp.	2	0	-	200 only	200
Niso aeglees (?)	2	0	-	200 only	200
unidentified Muricidae	1	5	5	200 only	200
Natica sp. ?	4	0	-	200 only	200
Sinum maculatum	1	5	5	200 only	200
Calliostoma bairdi oregon	8	0	-	200 only	200
Calliostoma rosewateri	5	0	-	200 only	200
Clathodrilla haliostriphis	1	5	5	200 only	200
Phalium granulatum	3	0	-	200 only	200
Scaphella sp.	2	0	-	200 only	200
Hindsiclava alesidota	4	0	-	200 only	200
Polystira tellea	73	10	730	200 only	200
Scaphella dubia	11	0	-	200-350	200
unidentified Turridae	6	5	30	200-2450	200
Euchelus carbis	1	5	5	250 only	250
Scaphander watsoni	150	20	3000	200-650	300
Compsodrillia halistrephis	6	0	-	300-350	300
Astyris diaphana	3	0	-	350 only	350
Niso sp.	1	0	-	350 only	350
Mathilda sp.	1	0	-	350 only	350
Scaphander sp.	1	0	-	350 only	350
Homalopoma linnei	1	0	-	350 only	350
Suavotrochus iridea	5	5	25	350 only	350
Gymnobela sp.	1	0	-	350 only	350
Turridae sp. 7	1	0	-	350 only	350
Inodrillia (?)	10	5	50	350-1600	350
Glyphostoma sp.	3	0	-	350-1600	400
Cerithium sp.	2	5	10	400 only	400
Solariella sp.	10	0	-	400 only	400
Buccinidae sp. 1	46	5	230	100-650	450
Gemmula periscelida	1286	40	51440	200-1100	450
Leucosyrinx sp.	116	5	580	300-750	450
Tugurium longleyi	50	0	-	350-750	450
Compsodrillia acestra	8	0	-	450 only	450
Turridae sp. 3	48	0	-	450-950	450
Gymnobela tanneri	50	5	250	450-1300	450

continued

Table 35 continued

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Eulima sp.	1	0	-	550 only	550
Pyramidellidae sp. 1	1	0	-	550 only	550
Solariella lamellosa	1	5	5	550 only	550
Scaphella cf. *gouldiana*	2	5	10	500-700	600
Hyalorissia galeus	2	5	10	500-700	600
Gaza superba	114	35	3990	500-900	600
Oocorys bartschi	61	20	1220	300-1050	650
Amerstroryrinz elegans	4	0	-	450-800	650
Gymnobela edgariana	1	0	-	550-850	700
Scaphander cf. *clavus*	75	30	2250	550-1000	700
Leucosyrinx cf. *subgrundifera*	7	0	-	700-800	700
Pyrunculus ovatus	2	0	-	350-1200	750
Drilleea horrenda	4	0	-	450-800	750
Homalopoma sp.	4	0	-	550-950	750
Corinnaeturris incilis	2	0	-	550-950	750
Lusitanops sp.	1	0	-	750 only	750
Nassarina columbellata	1	0	-	800 only	800
Distorsio macgintyi	1	0	-	800 only	800
Epitonium pyrrhias	2	5	10	800 only	800
Fusinus eucosmius	1	0	-	800 only	800
Latirus aff. *varai*	7	5	35	800 only	800
Hipponicidae sp. n. ?	2	0	-	800 only	800
Coralliophila sp.	1	0	-	800 only	800
Murex recurvirostris	1	0	-	800 only	800
Murex sp.	1	0	-	800 only	800
Trivia sp.	1	0	-	800 only	800
Homalopoma albida	1	0	-	800 only	800
"Bulla" abyssicola	3	5	15	500-950	900
Scaphander mundus	48	30	1440	650-1400	900
Gaza fisheri	5	10	50	800-1050	900
Cocculina sp.	1	0	-	900 only	900
Gymnobela agassizi	3	0	-	900-950	900
Cylichnium spatha	4	0	-	900-1450	900
Spirotropis lithocollata	11	5	55	650-2200	950
Ancistrosyrinx sp.	111	10	1110	750-1150	950
Pleurotomella aff. *bureaui*	6	5	30	800-1700	950
Turridae sp. 5	1	0	-	900-1000	950
Pyramidellidae sp. 3	87	0	-	900-1200	950
Oocorys sulcata	35	45	1575	900-3850	950
Cymatiidae sp. 1	1	0	-	950 only	950
Phymorhynchus sp. 1	1	0	-	950 only	950
Turridae sp. 2	1	0	-	950 only	950
Corinnaeturris sp. 1	2	0	-	950-1400	950
Leucosyrinx verrilli	123	65	7995	300-2750	1000

continued

Table 35 continued

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Mangelia sp.	4	0	-	350-1100	1000
Benthomangelia macra	12	0	-	350-1700	1000
Oocorys sp.	5	5	25	350-2650	1000
"Mangelia" antonia	65	5	325	450-1400	1000
Corinnaeturris leucomata	67	10	670	450-3350	1000
Benthonella fisheri	85	10	850	550-1700	1000
Rissoa xanthias	3	0	-	550-1700	1000
Leucosyrinx cf. *sigsbei*	14	5	70	550-3250	1000
Latiromitra bairdi	22	10	220	750-1350	1000
Heliacus sp.	1	0	-	800-1200	1000
Columbellidae sp. 1	11	0	-	800-1200	1000
Cyclostrematidae sp. 1	1	0	-	800-1200	1000
Cyclostrematidae sp. 2	1	0	-	800-1200	1000
Cyclostrematidae sp. 3	1	0	-	800-1200	1000
Cyclostrematidae sp. 4	1	0	-	800-1200	1000
Aclis sp.	2	0	-	800-1200	1000
Naticidae sp. 2	2	0	-	800-1200	1000
Seguenzia sp. 2	2	0	-	800-1200	1000
Famelica catherinae	3	0	-	800-1200	1000
Famelica mirmidina	2	0	-	800-1200	1000
Pleurotomella aff. *lottae*	4	0	-	800-1200	1000
Teretia aperta	1	0	-	800-1200	1000
Turridae sp. 9	1	0	-	800-1200	1000
Rissoa pyrrhias	17	0	-	800-1200	1000
Seguenzia sp. 3	7	0	-	800-1200	1000
Seguenzia sp. 4	3	0	-	800-1200	1000
Echinogurges clavatus	24	0	-	800-1200	1000
Drilliola loprestiana	4	0	-	800-1200	1000
Micropleurotoma lophoessa	10	0	-	800-1200	1000
Theta sp.	2	5	10	800-1200	1000
Basilissa alta	16	0	-	800-1400	1000
Solariella pourtalisi	64	5	320	800-1400	1000
Acteon sp. 5	3	0	-	800-1500	1000
Seguenzia sp. 5	21	0	-	800-1700	1000
Basilissa sp.	31	0	-	800-1700	1000
Belomitra exsculpta	7	0	-	800-1700	1000
Benthomangelia sp. 2	4	0	-	800-1700	1000
Mangelia exsculpta	3	0	-	900-1300	1000
Mangelia cf. *bandella*	3	0	-	950-1100	1000
Teramachia sp.	1	0	-	950-1100	1000
Pleurotomella cf. *edgarianum*	1	0	-	950-1100	1000
Natica sp.	1	0	-	950-1100	1000
Mitra sp.	10	0	-	950-1250	1000
Lischkeia sp.	10	0	-	950-1450	1000

continued

Table 35 continued

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Ringicula nitida	24	0	-	1000-1400	1000
Leucosyrinx tenoceras	375	60	22500	400-2100	1050
Volutomitra cf. *bairdii*	41	0	-	550-1100	1050
Benthobia tryoni	2	5	10	700-1400	1050
Trophon aculeatus	43	5	215	750-3250	1050
Pleurotomella cf. *chariessa*	16	0	-	1050 only	1050
Columbellidae sp. 3	2	0	-	1100-1200	1150
Epitoneum nitidum	1	0	-	1100-1200	1150
Aclis mizon	1	0	-	1100-1200	1150
Eulimidae & Aclidae n. genera	1	0	-	1100-1200	1150
Bulla cf. *eburnea*	1	0	-	1100-1200	1150
Turridae sp. 1	1	0	-	1100-1200	1150
Corinnaeturris sp. 2	13	0	-	550-1200	1150
Seguenzia sp. 6	7	0	-	550-1700	1150
Scissurella alba	16	0	-	800-1200	1150
Solariella tiara	30	0	-	800-1200	1150
Leucosyrinx cf. *subgrundifera*	4	5	20	1150 only	1150
Theta pandionis	51	20	1020	700-1500	1200
Terebra nassula	6	0	-	800-1600	1200
Phymorhynchus sulcifera	31	5	155	950-1400	1200
Retusa sp.	4	5	20	950-1450	1200
Cerithiella sp.	2	0	-	1000-1500	1250
Columbarium bermudezi	3	0	-	1200-1400	1300
Theta jeffreysi	112	0	-	450-3250	1400
Calliotropis calatha	28	20	560	800-3250	1400
Drilliola sp.	2	0	-	950-1450	1400
Coralliophila dalli	1	0	-	1350-1450	1400
Solariella sp. A	4	5	20	1350-1450	1400
Aclis cf. *egregia*	1	0	-	1400 only	1400
Solariella obscura	2	0	-	1400 only	1400
Eudolium crosseanum	5	5	25	200-2650	1450
Pleurotomella agassizii	50	10	500	550-1500	1450
Gymnobela ipara	261	25	6525	550-1700	1450
Solariella sp. 2	2	0	-	1400-1500	1450
Epitonium sp.	1	0	-	1500 only	1500
Pyramidellidae sp. 2	1	0	-	1500 only	1500
Epitonium formosissimum	2	0	-	1500-1700	1600
Columbellidae sp. 2	2	0	-	1600 only	1600
Nassarius sp.	8	5	40	1600 only	1600
Naticidae sp. 1	5	0	-	1600 only	1600
Turridae sp. 4	1	0	-	1600 only	1600
Benthomangelia sp. 1	9	0	-	550-1700	1700
Colus sp.	12	5	60	750-2650	1700
Acteon sp. 3	2	0	-	1700 only	1700

continued

Table 35 continued

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Pleurotomella benedicti	1	0	-	1700 only	1700
Retusa cf. *domitus*	4	0	-	1850 only	1850
Spirotropis centimata	2	5	10	1850-2100	2000
Gymnobela homeostata	1	0	-	2100 only	2100
Oocorys abyssorum	3	5	15	2100-2200	2150
Scaphander nobilis	1	0	-	2250 only	2250
Epitoneum sp. 1	2	5	10	2350-2550	2450
Gymnobela blakeana	5	0	-	800-2750	2750
Gymnobela bairdi	77	5	385	1050-2750	2750
Turridae sp. 6	9	5	45	2100-3250	2750
unidentified Buccinidae	4	0	-	2750 only	2750
Phymorhynchus sp. 2	4	0	-	2750 only	2750
Pleurotomella cf. *bairdii*	8	0	-	2750 only	2750
Solariella infundibulum	34	5	170	3100 only	3100
Seguenzia sp. 1	1	0	-	3200 only	3200
Fusinus sp.	17	10	170	900-3350	3250
Acteon sp. 1	7	0	-	3250 only	3250
Acteon sp. 4	1	5	5	3250 only	3250
Relichna simplex	1	5	5	3250 only	3250
Relichna sp.	1	5	5	3250 only	3250
Acteon sp. 2	8	5	40	3250 only	3250
Crenilabium exilis	1	5	5	3350 only	3350
Turridae sp. 8	1	5	5	3400-3500	3450

(II) Dominant gastropods presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Gemmula periscelida	450
Leucosyrinx tenoceras	1050
Gymnobela ipara	1450
Leucosyrinx verrilli	1000
Gaza superba	600
Murex beauii	200
Scaphander watsoni	300
Scaphander cf. *clavus*	700
Scaphander mundus	900
Oocorys bartschi	650
Ancistrosyrinx sp.	950
Theta pandionis	1200

Table 36. Distribution of species of Gastropoda among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	41	14	55
Archibenthal Zone (475-950 m)	43	79	122
Upper Abyssal (975-2250 m)	95	22	117
Mesoabyssal (2275-3200 m)	9	12	21
Lower Abyssal (3225-3850)	8	7	15

Table 37. (I) Cephalopoda found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of cephalopods in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Loligo pealei	9	20	180	150-200	200
Abralia veranyi	17	10	170	300 only	300
Pteroctopus tetracirrhus	2	5	10	500-550	500
Semirossia equalis	2	0	-	150-900	550
Semirossia tenera	2	5	10	150-900	550
Rossia bullisi	2	5	10	550 only	550
Rossia tortugaensis	2	5	10	550 only	550
Benthoctopus januari	52	30	1560	450-2100	700
Alloposus mollis	1	5	5	700 only	700
Japatella diaphana	7	35	245	150-1750	950
Histioteuthis dofleini	3	15	45	850-2100	950
Vampyroteuthis infernalis	5	20	100	950-2150	1000
Ornithoteuthis antillarum	2	5	10	1000 only	1000
Semirossia sp.	1	5	5	1050 only	1050
Bathothauma lyromma	3	10	30	1050-1750	1050
Neorossia sp. A	2	10	20	950-1200	1100
Opisthoteuthis agassizi	1	5	5	1100 only	1100
unidentified Argonautidae	3	5	15	1300-2100	1300
Argonauta hians	1	0	-	1350 only	1350
Cranchia scabra	3	0	-	1350 only	1350
Mastigoteuthis grimaldi	3	5	15	1350 only	1350
Neorossia sp.	1	5	5	1400 only	1400
Helicocranchia pfefferi	1	5	5	1450 only	1450
Pholidoteuthis adami	6	10	60	1050-2000	1500
Eledonella pygmaea	2	5	10	1200-1750	1500
Grimalditeuthis bomplandii	1	5	5	2100 only	2100
Brachioteuthis sp.	1	5	5	2650 only	2650
Tremoctopus violaceus	2	5	10	3200 only	3200
Octopoteuthis megaptera	2	0	-	3250 only	3250
Grimpoteuthis sp. A	8	10	80	3250-3750	3250
Onychoteuthis banksii	28	35	980	950-3700	3300
Histioteuthis corona corona	2	5	10	3500 only	3500

(II) Dominant cephalopods presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Benthoctopus januari	700
Onychoteuthis banksii	3300
Japatella diaphana	950
Vampyroteuthis infernalis	1000

Table 38. Confirmed benthic and benthopelagic cephalopods among those collected from the Gulf of Mexico by the R/V ALAMINOS.

Species	Depth Range (m)
OCTOPODA	
Pteroctopus tetracirrhus	500- 550
Benthoctopus januari	450-2100
Opisthoteuthis agassizi	1100 only
Grimpoteuthis sp. A	3250-3750
SEPIOIDEA	
Semirossia equalis	150- 900
Semirossia tenera	150- 900
Rossia bullisi	550 only
Rossia tortugaensis	550 only
Semirossia sp.	1050 only
Neorossia sp. A	950-1200
Neorossia sp.	1400 only

Table 39. Distribution of species of Cephalopoda among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	2	4	6
Archibenthal Zone (475-950 m)	9	2	11
Upper Abyssal (975-2250 m)	15	4	19
Mesoabyssal (2275-3200 m)	2	1	3
Lower Abyssal (3225-3850)	4	0	4

Porifera

Table 40 lists 38 sponge identifications with most of the species (21) being recorded from only one station. The most abundant species, according to the number of stations where they occurred, are listed below with their total depth range and the ranges over which they are most common.

Species	Depth Range (m)	
	Total	Effective
Radiella sol	850-3850	850-1500
Thenea fenestrata	50-3750	900-3750
Euplectella sp.	900-3800	900-1400
Radiella sp.	1350-3850	3250-3850
Hyalonema sp.	200-1000	900-1000

Radiella sol and *Radiella* sp. are small hemispherical sponges that occurred abundantly throughout the Gulf. Sponges of the genus *Radiella* are evident in many deep-Gulf photographs as small individual domes covered with sediment. *Radiella* sp. was distributed similarly to its sister species *R. sol*, however it is more common at deeper depths than was *R. sol*.

Thenea fenestrata is also hemispherical in shape although it is somewhat more domed and larger than *Radiella*. This species was evenly distributed throughout the Gulf at depths of 900 m and deeper. The two glass sponges (Hexactinellida), *Euplectella* sp. and *Hyalonema* sp. are the most common in the lower Archibenthal and Upper Abyssal Zones. However, *Euplectella* sp. ranges much deeper than *Hyalonema* sp. The distribution of numbers of sponge species among zones is shown in Table 41. The *in situ* photograph of a cup sponge is shown in its natural habitat in Plate 8 B. It is evident that sponges are rather evenly distributed among zones and thus do not exhibit the parabolic pattern of distribution characteristic of most other groups.

Table 41. Distribution of sponge species among zones.

Zone	No. of Species
Shelf/Slope Transition (150-450 m)	16
Archibenthal Zone (475-950 m)	19
Upper Abyssal (975-2250 m)	18
Mesoabyssal (2275-3200 m)	12
Lower Abyssal (3225-3850)	14

Table 40. (I) Porifera found in the deep Gulf of Mexico.

(I) Inventory of sponges in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Sum of Stations Where Species Occur	Depth Range (m)
Pachastrella sp.	1	400 only
Sphinctrella horrida	1	400 only
Raspailia sp.	1	400 only
Pleroma sp.	1	400 only
Theonella sp.	1	400 only
unidentified Lithisdidae	1	400 only
Latrunculia sp.	1	400 only
unidentified Hexasterophora	1	400 only
Acanthascus sp.	1	400 only
Hyalonema sp.	13	200-1000
Aaptos sp.	1	600 only
Eurete sp.	2	200-1150
Aphrocallistes bocagei	1	800 only
Aphrocallistes cf. *beatrix*	1	800 only
Chondrocladia sp.	1	900 only
Geodia sp. C	2	950 only
Geodia sp. A	1	950 only
Farrea sp.	3	400-1650
Tethycordyla thyris	10	650-1500
Plakortis sp.	1	1400 only
Tetilla sp.	1	1450 only
Dragmatyle topsenti	10	600-2450
Tisiphonia sp.	2	950-2250
Tylodesma sp.	3	400-2950
unidentified Dictyonina	6	150-3450
Thenea fenestrata	38	50-3750
Dactylocalyx sp.	2	600-3300
Thenea sp.	8	400-3850
Radiella sol	46	850-3850
Euplectella sp.	24	900-3800
Hyalonema sp. B	7	1000-3750
Hyalonema sp. A	3	1050-3850
Radiella sp.	16	1350-3850
Tethyopsilla lens	1	2700 only
Desmacidon sp.	2	3250 only
Geodia sp. B	1	3300 only
Holoxea sp.	1	3300 only
unidentified Suberitidae	1	3550 only
Fangophilina sp.	1	3550 only

Epifaunal Groups of Lesser Importance

Coelenterata

The coelenterata are represented in the deep Gulf by 23 species of stony corals (Scleractinea) as listed in Table 42 ranging in depth between 100 and 1650 m; 14 species of sea pens (Pennatulacea) as listed in Table 43 ranging in depth between 100 and 3700 m; 10 species of soft corals (Alcyonacea) as listed in Table 44 ranging in depth between 500 and 1650 m; and 8 species of Hydrozoa (Table 45) ranging in depth between 400 and 1850 m. Sea anemones (Actiniaria) were also present in the deep Gulf samplings, but the specimens were not identified by the taxonomic specialist in time for this report. Table 46 shows the distribution of the numbers of coelenterate species among the bathymetric zones, with the Archibenthal and Upper Abyssal accounting for most of the coelenterate species. *In situ* bottom photographs of a sea pen and the gorgonian soft coral, *Chrysogorgia elegans*, are shown in their natural habitat in Plate 8 C and D.

Bryozoa

Bryozoans from the ALAMINOS collections are represented by 22 species (Table 47), most of which occur on the continental shelf at depths of 100 m or less. Only two species range into the Shelf/Slope Transition and Upper Archibenthal Zones (Table 48), and one species, *Nellia oculata*, was found in the Mesoabyssal Zone at 3000 m.

Brachiopoda

Four species of Brachiopoda were taken in the deep Gulf samplings (Table 49), ranging in depth between 150 and 3850 m. *Chlidonophora incerta* is the dominant brachipod species in the Gulf, occurring between 2150 and 3850 m. Table 50 shows the distribution of brachipods by bathymetric zones.

Sipuncula

Eight species of sipunculan worms are found in the deep Gulf (Table 51) ranging between 150 and 3750 m. *Sipunculus* sp. 1 (cf. *norvegicus*), occurring in the Archibenthal Zone between 500 and 900 m, is the dominant sipunculan in the deep Gulf followed by *Golfingia flagrifera*, a deeper living species which has its depth of maximum population in the Upper Abyssal Zone at 1850 m. The distribution of Sipuncula by bathymetric zones is shown in Table 52.

Table 42. (I) Zoantharia: Scleractinea and Antipatharia found in the deep Gulf of Mexico.

(I) Inventory of stony corals (Scleractinea) and black corals (Antipatharia) in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Stations	Depth Range
Scleractinea		
Asterosmilia prolifera	1	100 only
Madracis asperula	1	100 only
Paracyathus pulchellus	3	100-800
Madrepora carolina	1	150 only
Thallamophyllia riisei	1	150 only
Balanophyllia sp.	1	150 only
Madracis myriaster	1	150 only
Deltocyathus italicus	14	200-2650
Deltocyathus hexagonus	1	250-350
Schizocyathus fissilis	1	400 only
unidentified Zoanthidae	1	400 only
Anomocora fecunda	2	400-800
Deltocyathus calcar	1	600 only
Trocyathus rawsoni	7	600 only
Caryophyllia berteriana	1	800 only
Pepanocyathus stimpsonii	1	800 only
Madrepora oculata	3	800-1200
Stephanocyathus (s.) *diadema*	5	800-1500
Caryophyllia ambrosia	15	800-1500
Stephanocyathus (o.) *coronatus*	2	1050 only
Enallopsammia profunda	2	1050-1200
Desmophyllum cristigalli	1	1100-1200
Solenosmilia variablis	1	1100-1200
Caryophyllia polygona	1	1650 only
Antipatharia		
unidentified Antipatharia	2	100-1000

Table 43. (I) Alcyonaria: Pennatulacea found in the deep Gulf of Mexico.

(I) Inventory of sea pens in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Stations	Depth Range
Pennatula sp.	1	100-200
Funiculina quadrangularis	12	150-1450
Protoptilum carpenteri	5	500-1200
Funiculina sp.	1	650-850
Umbellula sp. C	2	700-900
Umbellula sp. F	3	800-950
Umbellula sp. D	1	950 only
Umbellula sp. 3	1	950 only
unidentified Pennatulacea	2	950-1150
Stylatula antillarum	1	1100 only
? *Anthoptilum* sp.	5	1100-1450
Umbellula sp.	1	2100 only
Umbellula sp. B	1	2350 only
Umbellula lindahlii	1	2650 only
Umbellula sp. A	3	2650-3700

Table 44. (I) Alcyonaria: Alcyonacea found in the deep Gulf of Mexico.

(I) Inventory of soft corals in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Stations	Depth Range
Swiftia koreni	1	900-1000
Calyptrophora josephinae	1	900-1000
Chrysogorgiidae (axis)	1	950 only
Chrysogorgia elegans	8	500-1750
? *Keratoisis* (axis)	4	500-2250
Acanella eburnea	4	600-1300
? *Acanella* (basal disk)	10	600-2050
Acanella sp.	4	900-1250
Isididae	3	950-1300
Corallium	1	1650 only
axis of *Acanella* or *Lepidisis* sp.	1	1000-1100

Table 45. (I) Hydrozoa found in the deep Gulf of Mexico.

(I) Inventory of hydroids in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Stations	Depth Range
unidentified Hydrozoa	1	400 only
Acryptolaria conferta	1	400 only
Opercularella sp. B	1	750 only
? *Opercularella* sp. A	1	600 only
Thecocarpus bispinosus	1	400 only
Halecium sp.	1	600 only
Eudendrium sp.	2	600-750
Tubularidae	1	600 only
Cladocarpus flexuosus	4	800-1850

Table 46. Distribution of coelenterate species among zones.

Zone	No. of Species
Shelf/Slope Transition (150-450 m)	16
Archibenthal Zone (475-950 m)	34
Upper Abyssal (975-2250 m)	27
Mesoabyssal (2275-3200 m)	4
Lower Abyssal (3225-3850)	1

Table 47. (I) Bryozoa found in the deep Gulf of Mexico.

(I) Inventory of bryozoans in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Colonies at all Stations	B. Sum of Stations Where Species Occur	Depth Range (m)
Bugula sp.	1	1	50 only
Bracebridgia subsulcata	1	1	100 only
Reptadeonella violacea	2	1	100 only
Tremogasterina mucronata	3	1	100 only
Tremogasterina sp.	1	1	100 only
Copidozoum tenuirostre	1	1	100 only
Celleporaria albirostris	2	1	100 only
Celleporaria sp.	17	1	100 only
Celletosia radiata	1	1	100 only
Cupuladria biporosa	30	1	100 only
Cleidochasma porcellanum	1	1	100 only
Cleidochasma contractum	1	1	100 only
Trypostega venusta	1	1	100 only
Mamillopora cupula	17	1	100 only
Hippopetraliella bisinuata	3	1	100 only
Stylopoma spongites	3	1	100 only
Parasmittina trispinosa	1	1	100 only
Steganoporella magnilabris	8	1	100 only
Hippoporidra edax	2	1	100 only
Cupuladria doma	97	4	50-750
Discoporella umbellata	2	1	100-750
Nellia oculata	1	1	3000 only

Table 48. Distribution of bryozoan species among zones.

Zone	No. of Species
Shelf/Slope Transition (150-450 m)	2
Archibenthal Zone (475-950 m)	2
Upper Abyssal (975-2250 m)	0
Mesoabyssal (2275-3200 m)	1
Lower Abyssal (3225-3850)	0

Table 49. (I) Brachiopoda found in the deep Gulf of Mexico.

(I) Inventory of brachiopods in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Terebratulina cailleti	1	0	-	150 only	150
Argyrotheca barretti	4	5	20	150 only	150
Platidia anomioides	3	5	15	750 only	750
Pelagodiscus atlanticus	8	5	40	2100-3850	3000
Chlidonophora incerta	114	22	2508	2150-3850	3700

Table 50. Distribution of species of Brachiopoda among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	1	0	1
Archibenthal Zone (475-950 m)	1	0	1
Upper Abyssal (975-2250 m)	0	2	2
Mesoabyssal (2275-3200 m)	1	1	2
Lower Abyssal (3225-3850)	1	1	2

Table 51. (I) Sipuncula found in the deep Gulf of Mexico.

(I) Inventory of sipunculids in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Golfingia sp. 4 (cf. *misakiana*)	1	5	5	150 only	150
Golfingia sp. 3	3	0	-	700 only	700
Sipunculus sp. 1 (cf. *norvegicus*)	63	45	2835	500-900	750
Golfingia catharinae	3	5	15	1100 only	1100
Golfingia flagrifera	23	10	230	1850-2750	1850
Golfingia sp. 2 (cf. *flagrifera*)	2	10	20	2750-3700	3200
Golfingia sp. 1	pieces	0	-	3750 only	3750
Phascolosoma sp. 1	1	5	5	3750 only	3750

Table 52. Distribution of species of Sipuncula among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	1	0	1
Archibenthal Zone (475-950 m)	2	0	2
Upper Abyssal (975-2250 m)	2	0	2
Mesoabyssal (2275-3200 m)	1	1	2
Lower Abyssal (3225-3850)	2	1	3

THE INFAUNA

Polychaeta

One hundred thirty-seven species of polychaete annelid worms were collected by the ALAMINOS from the shelf break to the abyss in the Northern Gulf of Mexico (Table 53). These species were distributed among 11 orders and 28 families of which the Maldanidae, Ampharetidae, Sigalionidae, Onuphidae, Eunicidae, and Polyodontidae were the most speciose (Table 54). It is interesting to note that the leading four families belong to different orders (Table 55).

The maldanids are all tubicolous, with mud-walled tubes and are usually large enough to appear in bottom photographs. They are common from the shelf to the abyss but generally are more abundant in depths less than 1000 m (Table 54). Ampharetids generally bear relatively long tentacles and thus resemble terebellids. They are common in the deep Gulf, having a vertical distribution paralleling that of the maldanids. Both groups are most common in the Archibenthal Zone. Sigalionids are scale worms that prefer muddy bottoms, particularly on the outer shelf and in the Shelf/Slope Transition Zone. The onuphids are tubicolous and in such genera as Hyalinoecia and Nothria* carry their tubes around as they plow through soft bottoms. So far as is known, onuphids are scavengers. Like the maldanids and ampharetids, they are most abundant in the Archibenthal Zone but do occur on the Abyssal Plain. The eunicids are generally considered to be carnivores, and this is probably true of those species that live on hard substrata, but those that live in the deep sea are more likely omnivores that are able to scavenge upon detritus, as is evidenced from underwater, in situ photographs (see Plate 9A). Like the sigalionids, the polyodontids are scale worms that are more abundant in the Shelf/Slope Transition Zone and are not represented on the Abyssal Plain. It is interesting to note that suspension-feeding polychaetes such as serpulids and sabellids are represented in abyssal depths, but all are very small unlike the deposit-feeding or scavenging types such as the maldanids. The distribution of polychaete species by bathymetric zones is shown in Figure 56. Polychaetes of the families Onuphidae, Oweniidae,and Polyodontidae are shown in their typical habitats in Plate 9, A, B, and C.

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* These polychaetes live on very soft bottoms through which they plow in search of food, often being almost completely buried. Because they obtain their food beneath the water-sediment interface, it seems appropriate to regard them as infaunal.

Table 53. (I) Polychaeta found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of polychaetes in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Nereis succinea	?	0	-	shelf only	*
Nephtys verrilli ?	1	5	5	shelf only	*
Lepidonotus sublevis	?	0	-	shelf only	*
Sthenelais picta	11	5	55	shelf only	*
Sthenelanella uniformis	2	5	10	shelf only	*
Sthenolepsis sp. A	2	0	-	shelf only	*
Acoetes sp.	3	5	15	shelf-150	150
Polyodontes frons	1	0	-	150 only	150
Euarche tubifex	777	40	31080	150-200	150
Acoetes pacifica	8	5	40	shelf-200	200
Sthenolepis incisa ?	4	10	40	shelf-200	200
Polyodontes lupinus	9	10	90	shelf-400	200
Polyodontes sp. B	1	5	5	200 only	200
Chloeia viridis ?	1	5	5	200 only	200
Diplocirrus capensis	1	5	5	200 only	200
Protula tubularia	3	5	15	200 only	200
Sthenolepis sp.	1	5	5	200 only	200
Psammolyce flava	1	5	5	200 only	200
Ehlersileanira incisa	53	20	1060	150-600	250
Goniada norvegica	1	0	-	250 only	250
Asychis sp. C	1	0	-	250 only	250
Johnstonia sp.	2	0	-	250 only	250
Onuphis sp. B	1	0	-	250 only	250
Leanira alba	17	5	85	250 only	250
unidentified Serpulidae	2	5	10	250-300	300
Pherusa sp.	1	5	5	300 only	300
Salmacina sp. A	1	5	5	300 only	300
Vermiliopsis sp. A	1	5	5	300 only	300
Sthenelais sp.	1	0	-	350 only	350
Scoloplos rubra	5	5	25	350-900	350
Panthalis pacifica	21	10	210	250-600	400
unidentified Syllidae	12	5	60	300-400	400
Lumbrineris cf. *latreilli*	6	0	-	350-750	400
Eunice norvegica	22	0	-	400 only	400
Goniada sp. B	1	5	5	400 only	400
Orbinia sp.	1	5	5	400 only	400
Ophelina sp. A	11	5	55	400 only	400
Sabellastarte sp.	3	0	-	400 only	400

continued

Table 53 continued

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Syllis sp.	2	0	-	400 only	400
Harmothoe sp. A	5	5	25	400-600	400
Maldane sarsi	24	10	240	400-750	400
Eunice floridana	49	5	245	400-900	400
Scoloplos sp. A	19	5	95	450 only	450
Melinna sp.	?	0	-	450 only	450
Diplocirrus sp.	4	0	-	450-1150	450
Goniada sp. A	5	10	50	350-700	500
Panthalis sp. A	50	10	500	350-750	500
Ophelina cylindricaudata ?	2	5	10	400-650	500
Spiophanes cf. *soederstromi*	1	0	-	550 only	550
Rhamphobrachium agassizi	36	5	180	200-3250	600
Pista sp.	2	5	10	250-950	600
Nothria sp. A	52	40	2080	450-3250	600
unidentified Acoetidae	7	5	35	500-900	600
Myriochele sp. B	63	10	630	500-2750	600
Anobothrus sp.	1	0	-	600 only	600
Samythella elongata	6	0	-	600 only	600
Eunice sp.	2	0	-	600 only	600
Marphysa sp.	3	5	15	600 only	600
new genus *Thelepinae*	?	0	-	600 only	600
Nothria conchylega	12	0	-	600 only	600
Eusamytha sp. ?	1	0	-	600 only	600
Amage tumida	16	5	80	600-900	600
Harmothoinae sp. 2	3	0	-	600-950	600
Nereis sp. A	3	5	15	400-900	650
Melinna maculata ?	1	0	-	650 only	650
Marphysa sanguinea	1	0	-	650 only	650
Orbinia riseri	3	0	-	450-950	700
Loimia sp.	?	0	-	550-800	700
Sosane sp.	5	10	50	600-950	700
Ninoe nigripes	2	0	-	650-750	700
Polydora websteri	3	5	15	500-700	700
Capitellidae sp. B	1	5	5	700 only	700
Goniada teres	1	0	-	700 only	700
Spiochaetopterus sp.	10	15	150	700-3100	700
Marphysa cf. *bellii*	5	10	50	600-750	750
Amphicteis gunneri	1	0	-	750 only	750
? *Sabellides* sp.	1	0	-	750 only	750
Liphonerus ambigua	1	0	-	750 only	750
Aphrodita sp.	1	0	-	750 only	750
near *Notomastus*	1	5	5	750 only	750
unidentified Lumbriclymeninae	8	5	40	750 only	750
Onuphis microcephala	5	10	50	400-3100	800
Phyllampharete longicirrata	3	5	15	750-900	800

continued

Table 53 continued

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Hyalinoecia cf. *stricta*	110	55	6050	400-1050	850
Asychis cf. *gotoi*	38	5	190	700-900	850
unidentified Chaetopteridae	149	25	3725	350-2750	900
Asychis byceps ?	2	5	10	750-900	900
Maldane sp. B	25	15	375	750-3250	900
Myriochele sp. A, n. species	68	50	3400	300-3550	950
Onuphis sp. A	44	15	660	350-950	950
Terebellides sp.	7	0	-	400-1150	950
unidentified Sigalionidae	3	10	30	550-1350	950
Notomastus latericeus	10	30	300	600-950	950
Lumbrineris sp. A	38	5	190	750-950	950
Lanice/Eupolymnia sp.	10	20	200	900-3100	950
Ampharetidae, n. genus	1	5	5	950 only	950
Eunice cf. *schemacephala*	1	0	-	950 only	950
Lysidice cf. *ninetta*	171	5	855	950 only	950
Asychis sp. (*sensu stricta*)	2	5	10	950 only	950
Paradiopatra cf. *solenotecton*	18	30	540	950-3850	950
Nephtys hombergi ?	5	5	25	200-1850	1000
Chloeia viridis	1	5	5	1050 only	1050
Hermodice carunculata	1	5	5	1050 only	1050
Drilonereis sp. A	2	0	-	700-1500	1100
Hyalinoecia tubicola	152	45	6840	600-3250	1150
Phyllodoce sp.	1	0	-	1150 only	1150
Spionidae sp. A	1	5	5	1150 only	1150
Glycera oxycephala	26	0	-	350-1200	1200
Nephtys phyllocirra	23	10	230	350-1200	1200
Nephtys paradoxa	26	10	260	950-1200	1200
Eunice pennata ?	2	5	10	750-1850	1300
Leanira n.	10	15	150	450-1500	1350
Leanira hystricis	18	15	270	750-2100	1400
Harmothoinae sp. 1	4	10	40	950-1400	1400
unidentified Ampharetidae	4	0	-	600-1450	1450
unidentified Terebellidae	2	5	10	1450 only	1450
Phalacrostemma cidariophilum ?	2	5	10	950-2250	1600
Asychis n. species	32	10	320	1450-1700	1700
Capitellidae sp. A	1	0	-	1700 only	1700
Spionidae sp. B	1	0	-	1700 only	1700
Onuphis sp.	4	0	-	500-3250	1850
Glycera tessellata	1	5	5	1850 only	1850
unidentified Oweniidae	2	0	-	700-3250	1950
unidentified Opheliidae	2	5	10	750-3400	2050
Travisia sp. ?	2	0	-	2150 only	2150
Maldane sp.	2	0	-	950-3450	2200
Travisia forbesii ?	3	5	15	950-3450	2200
Eunice pennata	14	10	140	800-2750	2750

continued

Table 53 continued

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
unidentified Lumbrineridae	6	5	30	2950 only	2950
unidentified Sabellidae	6	5	30	500-3100	3100
unidentified Maldaninae	1	0	-	3100 only	3100
unidentified Ampharetinae	?	0	-	3200 only	3200
unidentified Onuphidae	11	10	110	1100-3350	3250
Phyllochaetopterus sp.	1	5	5	3250 only	3250
Maldanella sp.	5	5	25	3250 only	3250
Eunoe sp. ?	1	0	-	3250 only	3250
Hyalopomatus langerhansi	1	5	5	3400 only	3400
Amelinna sp.	3	10	30	700-3650	3650

(II) Dominant polychaetes presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Euarche tubifex	150
Hyalinoecia tubicola	1150
Hyalinoecia cf. *stricta*	850
Myriochele sp. A, n. species	950
Nothria sp. A	600
Ehlersileanira incisa	250

* Unknown

Table 54. Survey of polychaete families found in the deep Gulf with a tabulation of their species in vertical zones.

Family	Total Species	Number of Species in Zone				
		Shelf/ Slope	Archibenthal	Upper Abyssal	Mesoabyssal	Lower Abyssal
Maldanidae	13	3	6	2	1	1
Ampharetidae	12	1	7	2	1	1
Sigalionidae	12	9	1	2	-	-
Onuphidae	11	1	7	2	-	-
Eunicidae	10	2	6	1	1	-
Polyodontidae	9	7	2	-	-	-
Terebellidae	6	-	6	-	-	-
Opheliidae	5	1	1	3	-	-
Serpulidae	5	4	-	-	-	1
Polynoidae	5	2	1	1	-	1
Spionidae	4	-	2	2	-	-
Goniadidae	4	2	2	-	-	-
Lumbrinereidae	4	1	2	-	1	-
Flabelligeridae	4	3	1	-	-	-
Nephtyidae	4	1	-	3	-	-
Orbiniidae	3	2	1	-	-	-
Chaetopteridae	3	-	2	-	-	1
Capitellidae	3	-	2	1	-	-
Amphinomidae	3	1	-	2	-	-
Sabellidae	3	1	1	-	1	-
Syllidae	2	2	-	-	-	-
Glyceridae	2	-	-	2	-	-
Nereidae	2	1	1	-	-	-
Phyllodocidae	1	-	-	1	-	-
Aphroditidae	1	-	1	-	-	-
Arabellidae	1	-	-	1	-	-
Sabellariidae	1	-	-	1	-	-
Trichobranchidae	1	-	1	-	-	-
Totals		44	52	26	5	6

Table 55. The distribution of polychaete families among orders. The most speciose families in the deep Gulf of Mexico are ranked and underlined.

Phyllodocida	Sabellida
3. Sigalionidae	Sabellidae
6. Polyodontidae	Serpulidae
Syllidae	Capitellida
Nereidae	1. Maldanidae
Glyceridae	Capitellidae
Nephtyidae	Spionida
Phyllodicidae	Spionidae
Aphroditidae	Chaetopteridae
Polynoidae	Amphinomida
Eunicida	Amphinomidae
4. Onuphidae	Flabelligerida
5. Eunicidae	Flabelligeridae
Lumbrinereidae	Orbiniida
Arabellidae	Orbiniidae
Terebellida	Opheliida
2. Ampharetidae	Ophellidae
Sabellariidae	Oweniida
Terebellidae	Oweniidae
Trichobranchidae	

Table 56. Distribution of species of polychaetes among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	39	24	63
Archibenthal Zone (475-950 m)	55	28	83
Upper Abyssal (975-2250 m)	26	3	29
Mesoabyssal (2275-3200 m)	5	18	23
Lower Abyssal (3225-3850)	6	11	17

Mollusca

Bivalvia

The list of deep Gulf of Mexico bivalves collected by the R/V ALAMINOS (Table 57) is somewhat incomplete due to an unfortunate loss of specimens during shipment to the taxonomic specialist. A total of 73 species among 18 families are listed. Among these, the palaeotaxodont families Malletiidae, Nuculanidae, and Nuculidae, and the family Propeamussiidae are complete. The ensuing discussion will therefore be biased toward data from these four families. Such a restricted discussion is partly justified since the palaeotaxodontids, at least, are the most abundant bivalve group in the deep Gulf below 500 m. The distribution of the bivalves according to depth zones is shown in Table 58.

The glass scallops, *Propeamussium* sp. A and *Propeamussium* sp. C were the two most abundant bivalves collected. The *Propeamussium* species apparently form aggregations. *Propeamussium* sp. A was collected at 13 stations and an average of 54 specimens per hectare were taken at stations where the species was found, and the other members of the genus were collected in similarly high densities. The benthic skimmer and 20-m trawl were the most efficient gear in sampling the Propeamussiidae, probably because these animals are excellent swimmers and could avoid the slower grabs and dredges. Glass scallops are carnivorous and probably feed while swimming by sucking water and small crustaceans and other small prey into the mantle. Other *Propeamussium* species identified from the Gulf with their entire depth ranges and including records from outside the Gulf (Thomas Waller, pers. comm., 1982)* are:

Propeamussium sp. A	677-1766 m
Propeamussium sp. B	475-1005 m
Propeamussium sp. C	715-1256 m
Propeamussium sp. D	364- 864 m
P. dalli (Smith, 1885)	183-1097 m

Dr. Waller is presently preparing a monograph of the Propeamussiidae and the Pectinidae.

The palaeotaxodont species are small, and unlike the glass scallops, were sampled poorly by the skimmer since many specimens could easily pass through the 6.4 mm mesh. Most stations with high recorded densities of palaeotaxodonts were sampled with the canvas-lined dredges.

Twenty-six species but relatively few live individuals (192 total) of Nuculanidae were collected. The Malletiidae was represented by 18 species and the Nuculidae by 10, and two species from each of these families were dominant bivalves of the deep-Gulf fauna. The malletiid *Tindaria amabilis* was widespread throughout the Gulf although it seemed to be confined to a band between 100-1500 m. Stomach content analysis (James, 1972) suggested that *T. amabilis* individuals less than 10 mm long fed rather selectively on foraminifera while larger individuals were detritus feeders.

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* U.S. National Museum of Natural History, Washington, D.C.

The malletiid *Neilo* sp. A and the nuculids *Brevinucula verrilli* and *Nucula callicredemna* were all dominant species having similar depth distributions. *Neilo* sp. A was a very common medium-sized (4.8-13.0 mm) bivalve in the Meso- and Lower Abyssal Zones. Large numbers of dead valves were often collected, particularly in areas where ironstone occurred. The small nuculid *Brevinucula verrilli* (2.4-4.9 mm) was the most abundant of the family and had a broad geographic and bathymetric distribution in the Gulf. Live individuals were collected from 1000 m depth and Knudsen (1970) recorded *B. verrilli* from as shallow as 44 m depth, but these shallow records are probably "abnormal" and possibly result from transport of the species upward by upwelling (Knudsen, 1979). *B. verrilli* in this study was certainly most common in the Meso- and Lower Abyssal Zones. *Nucula callicredemna*, a larger nuculid (3.1-18.9 mm) had a bathymetric distribution very similar to both *Neilo* sp. A and *B. verrilli*. *Neilo* sp. A and *N. callicredemna* were often collected together.

Figure 92 from James (1972) summarizes the vertical distribution of the live palaeotaxodonts collected in the Gulf of Mexico. Five of these species were recognized from other ocean basins as abyssal: *Neilo bermudensis*, *Nucula callicredemna*, *Brevinucula verrilli*, *Neilonella guineensis*, and *Pristigloma nitens* which supports the idea that the Gulf does indeed have an abyssal zone, regardless of the higher bottom temperatures in the Gulf than in the other basins (James, 1972).

The palaeotaxodonts which are the dominant bivalves below 1000 m, are all infaunal deposit feeders. *Propeamussium* is carnivorous and its distribution is confined to the Archibenthal and Upper Abyssal Zones. These observations reflect the importance of feeding strategies among bivalves in relation to food sources and abundance in the deep Gulf.

Table 57. (I) Bivalves found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of bivalves in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Yoldia solenoides	8 live	0	-	150-400	200
	42 valves			150-750	
Nuculana acuta	45 live	15	675	150-250	200
	187 valves			150-2450	
Anadara cf. *baughmani*	1 live	5	5	200 only	200
Cardiomya striata	2 live	0	-	200 only	200
Nemocardium peramabile	21 live	5	105	200 only	200
	25 valves			200 only	
Aequipecten glyptus	26 live	25	650	200-250	200
	many valves			200-250	
Nuculana carpenteri	no live	-	-	-	-
	42 valves			200-3300	
Astarte cf. *nana*	19 live	10	190	300-350	300
Anodontia cf. *endentula*	6 live	5	30	300-350	300
Cuspidaria rostrata	1 live	0	-	350 only	350
Nuculana hebes	3 live	0	-	350 only	350
	17 valves			350 only	
Phacoides filosus	5 live	5	25	350 only	350
Venericardia armilla	1 live	5	5	350 only	350
Nucula sp. A	3 live	5	15	350 only	350
	5 valves			350-1700	
Cardiomya sp. C	10 live	5	50	400 only	400
Amygdalum politum	44 live	20	880	400-750	400
	24 valves			400 only	
Nuculana platessa	2 live	5	10	400 only	400
	3 valves			400-2450	
Anodontia sp.	46 live	5	230	200-450	450
Verticordia cf. *fischeriana*	44 live	5	220	450 only	450
Propeamussium sp. D	44 live	10	440	550-750	550
	14 valves			550-750	
Nuculana solidifacta	14 live	5	70	600 only	600
Vesicomya sp.	4 live	5	20	600 only	600
Abra longicalis americana	82 live	20	1640	200-3350	700
	375 valves			400-1450	
Nuculana bipennis	no live	-	-	-	-
	7 valves			200-750	
Nuculana concentrica	no live	-	-	-	-
	10 valves			750 only	

continued

Table 57 continued

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Nucula culebrensis	no live	-	-	-	-
	96 valves			400-2450	
Capulus cf. *galena*	5 live	0	-	750-900	750
Propeamussium sp. B	1 live	0	-	900 only	900
	fragments			700 only	
Astarte nana	2 live	0	-	1000 only	1000
Nuculana sp. B	no live	-	-	-	-
	11 valves			750-1150	
Malletia sp. B	2 live	0	-	1000 only	1000
Limopsis sp.	24 live	0	-	1000-1450	1000
	3 valves			1400 only	
Neilonella sp. B	1 live	0	-	1000 only	1000
	107 valves			750-2450	
Yoldiella pachia	1 live	0	-	1000 only	1000
	18 valves			1000-2450	
Propeamussium sp. C	782 live	25	19550	800-1450	1050
	65 valves			800-1050	
Nuculana solidula	no live	-	-	-	-
	27 valves			1000-1150	
Nucula pernambucensis	8 live	10	80	1000-1500	1150
	11 valves			750-1700	
Yoldiella quandrangularis	7 live	0	-	1000-1400	1150
	144 valves			750-1700	
Nuculana sp. A	no live	-	-	-	-
	51 valves			750-2450	
Tindariopsis agathida	10 live	15	150	1000-1850	1150
	301 valves			750-3100	
Astarte cf. *globula*	4 live	0	-	1000-1250	1150
Nucula sp. B	2 live	0	-	1150 only	1150
	10 valves			1000-1700	
Nuculana semen	no live	-	-	-	-
	2 valves			1150 only	
Limopsis galatheae	1 live	0	-	1250 only	1250
Nucula obliterata	1 live	0	-	1250 only	1250
	3 valves			1000 only	
Arca orbiculata	8 live	5	40	1000-2650	1250
Propeamussium dalli	69 live	5	345	350-1350	1350
Propeamussium spp.	517 live	45	23265	640-2100	1350
Cardiomya sp. B	3 live	0	-	1350 only	1350
Pteriidae	1 live	5	5	1350 only	1350
Limopsis pelagica	115 live	35	4025	700-2000	1400
Abra sp.	4 live	0	-	1400 only	1400
	15 valves			200-650	
Tindaria amabilis	111 live	35	3885	1000-1500	1400
	803 valves			750-1850	
Pectinidae	6 live	5	30	1400 only	1400

continued

Table 57 continued

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Cetoconcha sp. ?	6 live	0	-	200-2650	1450
Propeamussium sp. A	648 live	45	29160	700-1500	1450
	23 valves			700-1500	
Limopsis aurita paucidentata	3 live	0	-	1450 only	1450
Neilonella sp. A	2 live	5	10	1000-2450	1750
	27 valves			1000-3250	
Poromya sp.	5 live	5	25	1850-2100	1850
Neilo sp.	2 live	5	10	2000 only	2000
Thyasira sp.	1 live	5	5	2100 only	2100
Neilo bermudensis	3 live	5	15	2300 only	2300
	5 valves			2300 only	
Nucula fernandinae	no live	-	-	-	-
	1 valve			2450 only	
Nuculana sp. C	no live	-	-	-	-
	2 valves			2450 only	
Yoldiella mirmidina	1 live	5	5	2450 only	2450
	2 valves			2450 only	
Cyclopecten cf. *hadalis*	7 live	5	35	2450-2650	2450
Cardiomya sp. A	2 live	0	-	2650 only	2650
Neilo sp. B	no live	-	-	-	-
	179 valves			2750 only	
Poromya tornata	23 live	5	115	2450-3350	3100
	19 valves			3250 only	
Brevinucula verrilli	110 live	40	4400	950-3500	3200
	370 valves			950-3500	
Tindariopsis aeolata	4 live	5	20	2800-3250	3200
	10 valves			3100-3450	
Pristigloma nitens	3 live	5	15	3200 only	3200
Yoldiella sp. A	1 live	0	-	3200 only	3200
Bathyarca asperula	63 live	15	945	1000-3350	3250
Nucula callicredemna	254 live	25	6350	2450-3750	3250
	212 valves			2100-3750	
Neilo sp. A	215 live	25	5375	2650-3750	3250
	1796 valves			2650-3800	
Cetoconcha bulla	105 live	5	525	3000-3250	3250
	15 valves			3250 only	
Neilonella guineensis	13 live	10	130	3200-3550	3250
	100 valves			3100-3650	
Cardiomya sp.	20 live	0	-	1000-3300	3300
Malletia sp. A	27 live	10	270	2100-3700	3300
	105 valves			1100-3700	
Cuspidaria glacialis	20 live	0	-	3300-3350	3300
Tindaria sp. A	no live	-	-	-	-
	13 valves			2550-3450	

continued

Table 57 continued

(II) Dominant bivalves presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Propeamussium sp. A	1450
Propeamussium spp.	1350
Propeamussium sp. C	1050
Nucula callicredemna	3250
Neilo sp. A	3250
Brevinucula verrilli	3200
Limopsis pelagica	1400
Tindaria amabilis	1400
Abra longicalis americana	700

Table 58. Distribution of species of bivalves among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	18	3	21
Archibenthal Zone (475-950 m)	6	8	14
Upper Abyssal (975-2250 m)	29	5	34
Mesoabyssal (2275-3200 m)	9	11	20
Lower Abyssal (3225-3850)	8	4	12

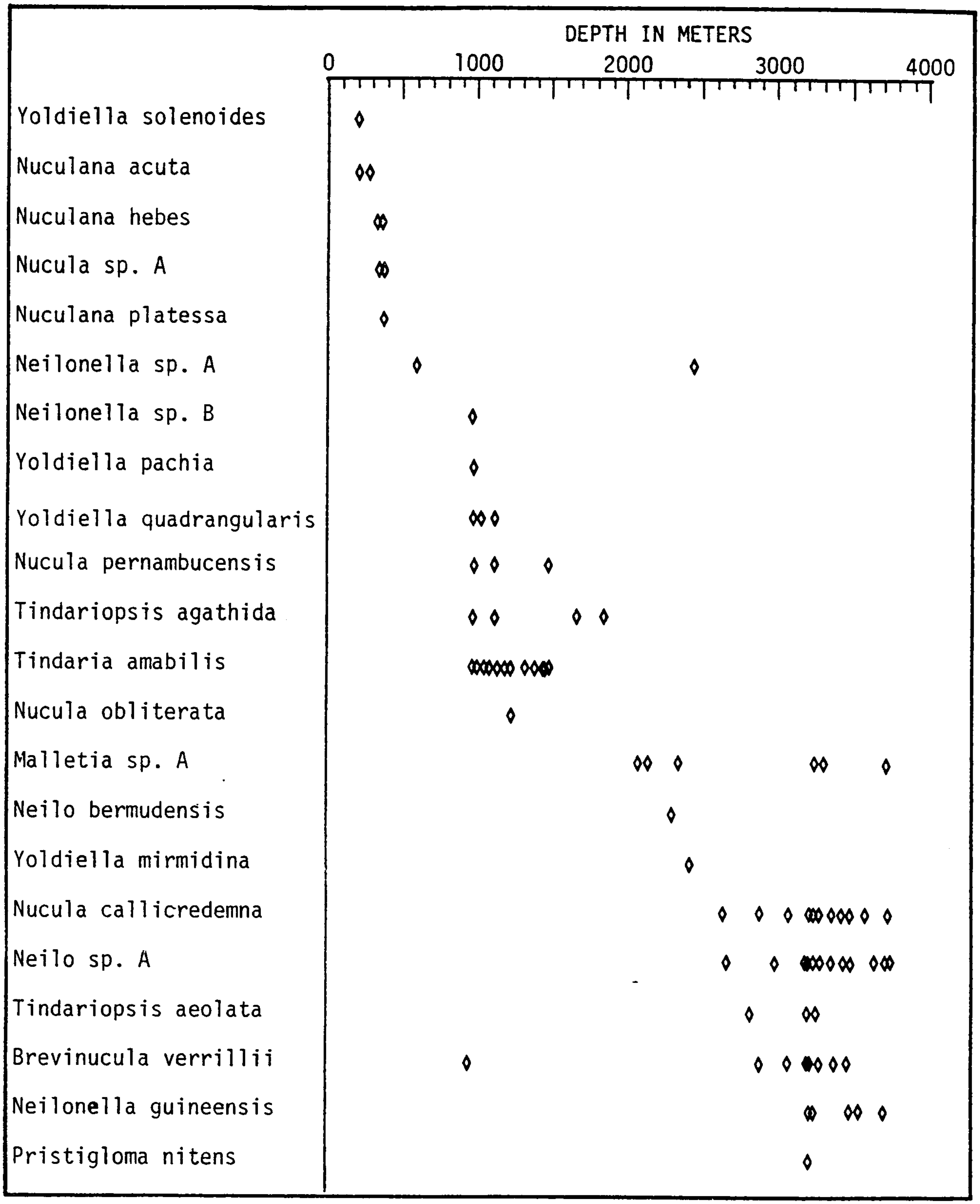


Figure 92. Vertical distribution of live palaeotaxodont specimens from the Gulf of Mexico. (From James, 1972).

Scaphopoda (Tusk Shells)

Seventeen species of scaphopods are listed in Table 59, although live individuals of only 10 species were actually collected. Nine of these 10 species are of the genus *Dentalium*. Some of these scaphopods, particularly the deeper occurring species, cover quite a bathymetric span. Among the dominant species, *Dentalium perlongum* (live) had the greatest depth range of of 2400 m, while *D. meridionale* and *D. callithrix* had ranges of 1600 m and 1100 m, respectively. These three species were the only scaphopods of which numerous live individuals were taken. All three are upper- and mesoabyssal species, and have broad geographic ranges as well. The distribution of scaphopod species by bathymetric zones is shown in Table 60.

Scaphopods are actually infaunal burrowers. They burrow head first into the sediment and feed on microscopic organisms, usually forams, from the surrounding water and sediment. Few specifics are known of the ecology of deep-sea scaphopods (e.g. their predators or reproductive patterns), but their shells were often collected in great numbers from much shallower and deeper than the ranges of the live individuals. Hence it would be helpful to have better knowledge of the live scaphopod distribution, in order to discern whether the abundant scaphopod shells are relicts of past populations or displaced deposits by currents, slumping, turbidity currents, and other transport processes.

Table 59. (I) Scaphopoda found in the deep Gulf of Mexico.
(II) Dominant species in rank order.

(I) Inventory of tusk shells in the Gulf of Mexico arranged by depth of maximum population.

SPECIES	A. Total Individuals at all Stations	B. Sum of Stations Where Species is Dominant (x5)	C. Product A x B	Depth Range (m)	Depth of Max. Pop. (m)
Fessidentalium floridense	1 live?	5	5	100 only	100
Dentalium stenoschizum	4 live	10	40	150-200	200
	1 shell			200 only	
Dentalium semistriolatum	no live	-	-	-	-
	1 shell			200 only	
Dentalium ceratum	1 live	0	-	300 only	300
	4 shells			100-300	
Laevidentalium callipeplum	no live	-	-	-	-
	3 shells			650 only	
Cadulus sp.	no live	-	-	-	-
	365 shells			200-1150	
Dentalium circumcinctum	1 live	5	5	950 only	950
	278 shells			350-2200	
Entalina platamodes ?	no live	-	-	-	-
	10 shells			950-1150	
Entalina sp.	no live	-	-	-	-
	8 shells			950-1150	
Pulsellum pressum	6 live	0	-	1000 only	1000
	203 shells			200-1400	
Dentalium perlongum	162 live	105	17010	900-3300	1000
	716 shells			200-3500	
Dentalium obscurum ?	no live	-	-	-	-
	4 shells			750-1350	
Dentalium laqueatum	3 live	5	15	100-1400	1400
	33 shells			100-3700	
Dentalium carduum	no live	-	-	-	-
	1 shell			1750 only	
Dentalium callithrix	18 live	25	450	1350-2450	2000
	688 shells			950-3500	
Dentalium ensiculus	5 live	15	75	2100-3300	3200
	47 shells			1000-3300	
Dentalium meridionale	174 live	25	4350	1750-3350	3250
	305 shells			1650-3350	

(II) Dominant tusk shells presented in rank order.

SPECIES	Depth of Peak Pop. (m)
Dentalium perlongum	1000
Dentalium meridionale	3250
Dentalium callithrix	2000

Table 60. Distribution of species of Scaphopoda among zones.

Zone	No. of Species With Max. Pop. in Zone	No. of Other Species That Live in Zones	Total
Shelf/Slope Transition (150-450 m)	3	6	9
Archibenthal Zone (475-950 m)	6	4	10
Upper Abyssal (975-2250 m)	4	8	12
Mesoabyssal (2275-3200 m)	0	5	5
Lower Abyssal (3225-3850)	3	2	5

PLATE 1

ASTEROIDEA
(Starfish)

The asteroids typically do not have arms that are sharply demarcated from the central disk. That is true of some deep-sea species but not of two shown on this plate (viz., "B" and "D"). Starfish commonly feed on molluscs, usually either gastropods or bivalves.

A. *Dipsacaster antillensis*. Shown is the feeding impression made by this typical asteroid. Belonging to the family Astropectinidae, this species burrows easily into the sediments in search for bivalves. The depth is 3678 m in the Lower Abyssal Zone of the central Gulf.
Scale 0.6 x 0.8 m.

B. *Midgardia xandaros*. In at least three ways this brisingid is an atypical starfish. First, it is the largest known. Second, it has the form of an ophiuroid, i.e., its arms are slender and sharply marked off from the central disk. Third, as this photo indicates, it is a suspension-feeder; feeding much as do some crinoids. The depth is 549 m in the Archibenthal Zone of the western Gulf.
Scale 0.6 x 0.8 m.

C. *Dipsacaster antillensis*. This photo shows the starfish embedded in sediments. The depth is 2697 m in the Upper Abyssal Zone of the western Gulf.
Scale 0.6 x 0.8 m.

D. *Zoroaster fulgens*. This starfish belongs to the family Zoroasteridae all of which occur in deep water. They also prefer muddy bottoms, such as shown here. The depth is 2213 m in the Upper Abyssal Zone of the western Gulf.
Scale 0.7 x 0.8 m.

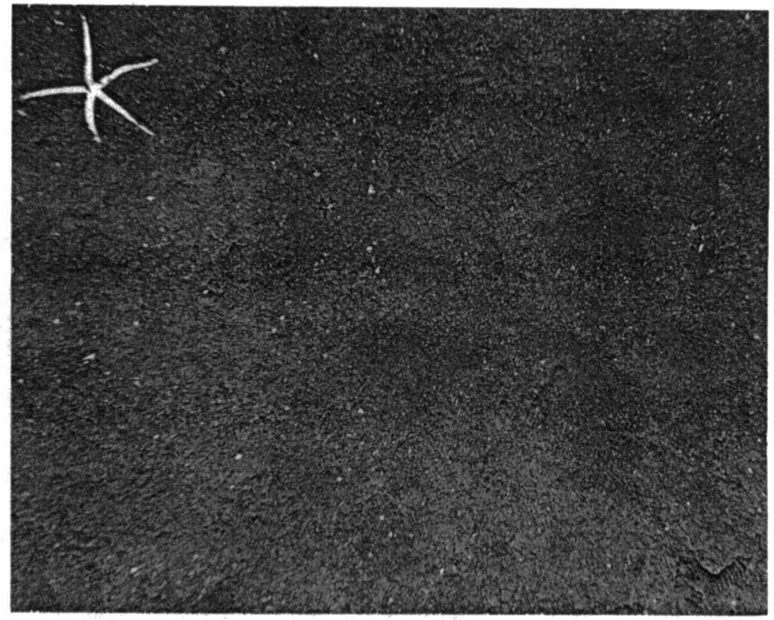



PLATE 2

ECHINOIDEA
(Sea-urchins)

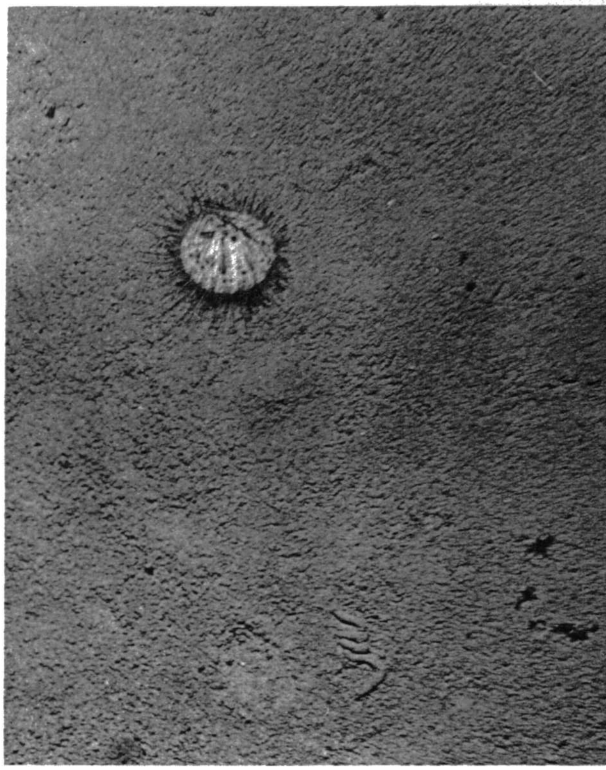
The sea-urchins of the deep sea differ from those in shallow water primarily in the degree of calcification of the body. They tend either to be leathery or with very thin-walled tests. Otherwise they have typical movable spines and tube feet.

A. *Phormosoma placenta*. This is one of the most common off-shelf sea-urchins in the Gulf of Mexico. Its test is leathery. As is true of many echinoids it travels in loosely organized groups or herds. Note the stippling of sediments by the tube feet. The depth is 800 m in the Archibenthal Zone of the western Gulf. Scale 0.5 x 0.7 m.

B. *Hygrosoma petersi*. This leathery sea-urchin is far less common in the Gulf than *Phormosoma*. It is large and dark purple. The depth is 2122 m in the Upper Abyssal Zone of the eastern Gulf. Scale 1.6 x 2.0 m.

C. Unidentified echinoid. This sea-urchin is found primarily on carbonate sediments where plant debris has settled on the bottom. The depth is 752 m in the Archibenthal Zone of the eastern Gulf in the DeSoto Canyon. Scale 0.9 x 1.1 m.

D. *Plesiodiadema antillarum*. This sea-urchin is abundantly represented in the benthic fauna of the deep Gulf. It is one of the smallest of the group although it has relatively long spines. The depth is 1353 m in the Upper Abyssal Zone of the western Gulf. This species is usually common where pteropod shells and plant debris gather on the bottom. Scale 1.0 x 1.2 m.



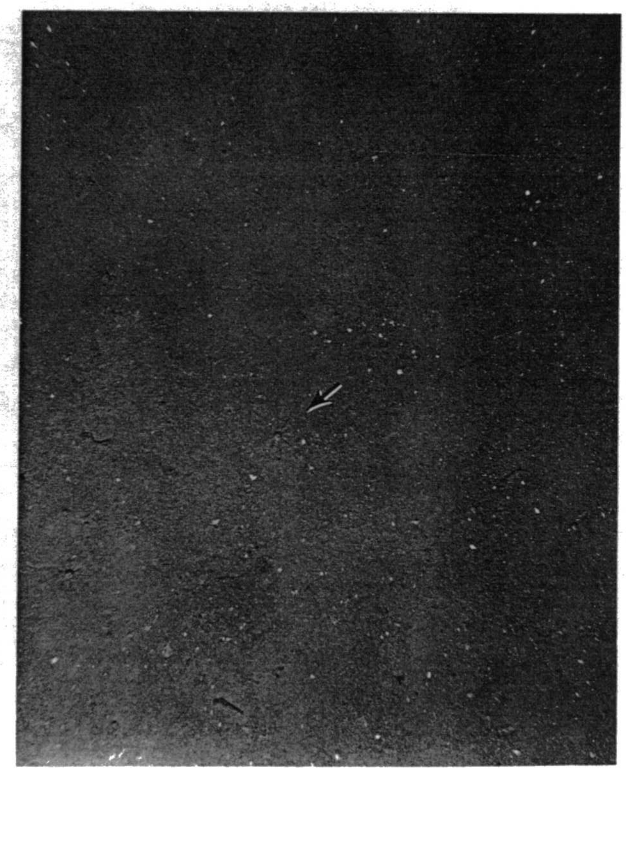



PLATE 3

OPHIUROIDEA
(Brittle and Serpent Stars)

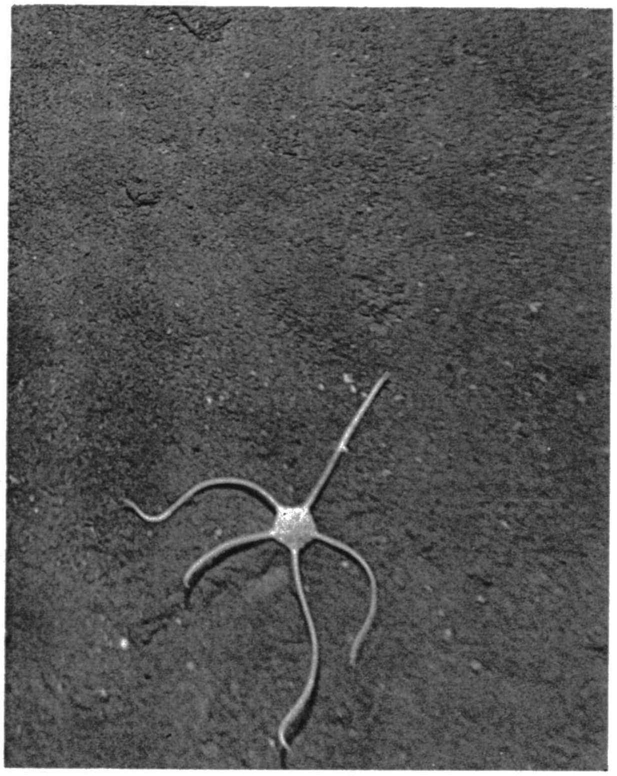
The serpent stars in these photographs depict well the typical morphology of the Class Ophiuroidea of the Phylum Echinodermata in that the arms are sharply demarcated from the central disk.

A. *Ophiomusium planum*. This serpent star was photographed in the act of searching for food. Note the tips of three arms are buried in the sediments. The depth is 2214 m in the Upper Abyssal Zone of the western Gulf. Scale 0.5 x 0.7 m.

B. *Ophiomusium planum*. This serpent star was photographed in a stance characteristic of this genus. Note the fecal casting of a holothurian in the upper right. The depth is 3248 m in the Mesoabyssal Zone of the eastern Gulf. Scale 0.5 x 0.7 m.

C. *Ophiomusium planum*. Having located its prey, this serpent star is apparently in the process of engulfing it. It is known to feed on crustaceans and bivalves, some valves of which are scattered in the sediment. The depth is 2214 m in the Upper Abyssal Zone of the western Gulf. Scale 1.0 x 1.2 m.

D. *Ophiernus* sp. Very little is known about the feeding habits of this species. The depth is 549 m in the Archibenthal Zone of the western Gulf. Scale 0.7 x 0.9 m.



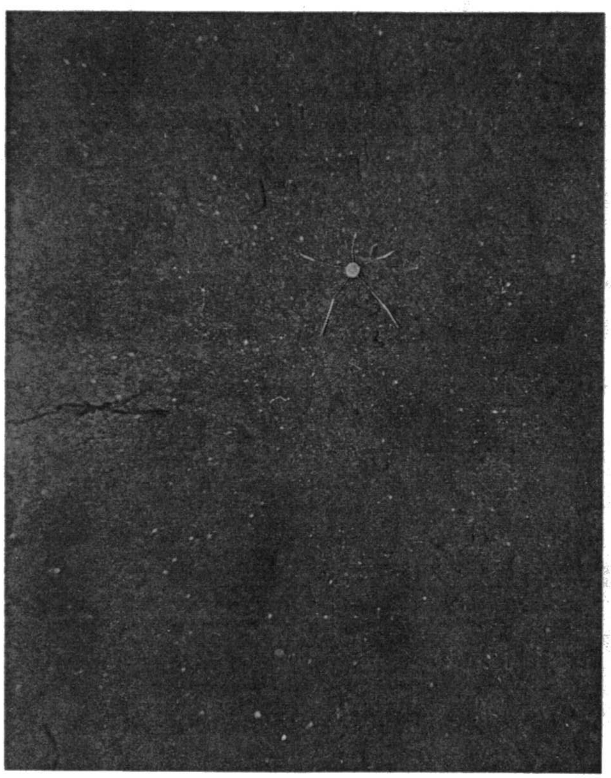
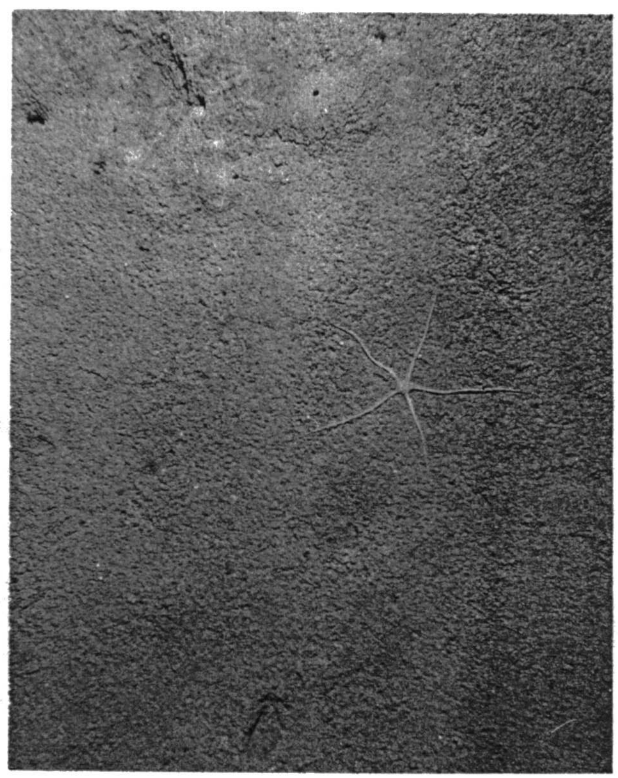



PLATE 4

HOLOTHUROIDEA
(Sea Cucumbers)

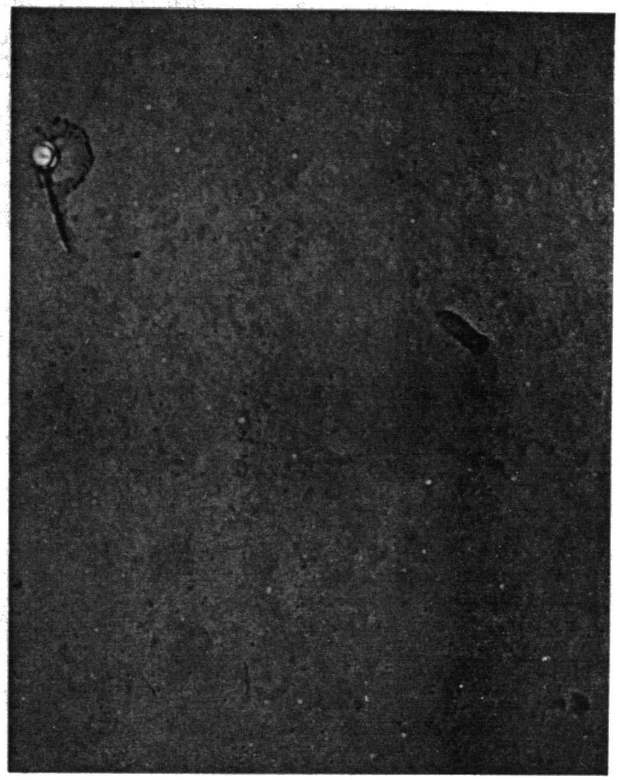
If any group of animals can be said to be typical of the deep sea, the Holothuroidea would have to be a first choice. In part this is because their endoskeleton has been reduced to microscopic spicules or plates embedded in the body wall or are absent entirely. Thus, they do not have to face the problem of calcification in cold water. Both benthic and pelagic sea cucumbers are found in the Gulf.

A. *Psychropotes semperiana*. This elasipod has a moderately well-developed tail-like appendage. As is true of all elasipod holothurians this species is only found very deep. The depth is 3676 m in the Lower Abyssal Zone of the western Gulf, actually on the Sigsbee Abyssal Plain. Scale 0.8 x 1.0 m.

B. *Psychropotes depressa*. This elasipod has only a small caudoid appendage. It is confined to deep water. The depth is 3667 m in the Lower Abyssal Zone of the western Gulf. Scale 1.8 x 2.3 m.

C. *Psychropotes* cf. *longicauda*. As its name implies this elasipod species has a very long caudoid appendage. One can see by the change of color of the sediments where it has been feeding. The depth is 3750 m in the Lower Abyssal Zone of the western Gulf. Scale 0.8 x 1.0 m.

D. *Deima validum*. This elasipod differs from most others by having a hard encrusted surface of thin plates. The depth is 1000 m in the Upper Abyssal Zone of the western Gulf. Scale 2.2 x 2.8 m.



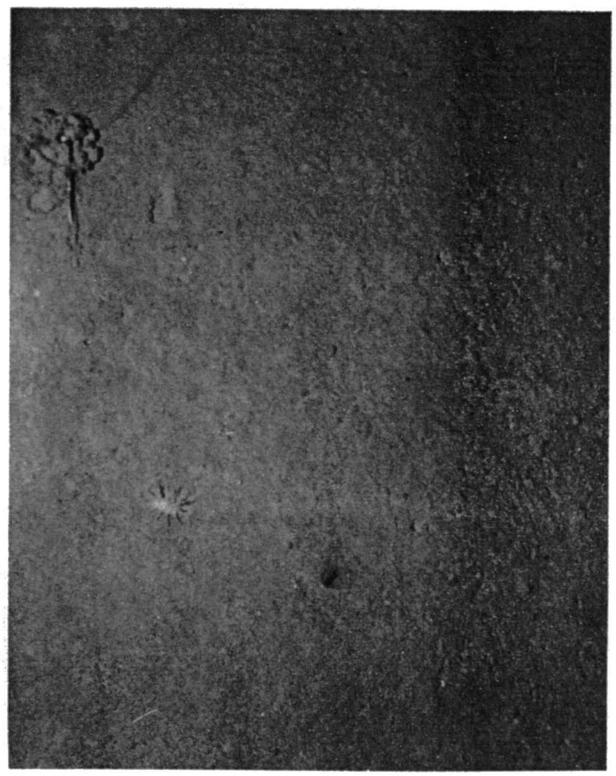


PLATE 5

HOLOTHUROIDEA continued
(Sea Cucumbers)

A. Bathyplotes pourtalesi. This sea cucumber is not an elasipod. Rather it belongs to the order Aspidochirota that contains many of the shallow-water species. However, the family Synallactidae to which Bathyplotes belongs contains several other genera found in the Gulf, e.g., Paelopatides, Pseudostichopus, and Mesothuria. The depth is 925 m in the Archibenthal Zone of the western Gulf.
Scale 2.2 x 2.8 m.

B. Benthodytes typica. This elasipod is the most common sea cucumber in the deep water of the Gulf. The depth is 2213 m in the Upper Abyssal Zone of the western Gulf.
Scale 0.7 x 0.9 m.

C. Pelagothuria sp. This is a pelagic elasipod. Many of the individuals of this genus previously taken were netted at the surface. Its body is completely devoid of spicules or plates. The depth is 2200 m in the western Gulf.
Scale 0.7 x 0.9 m.

D. Pseudostichopus sp. An arched organism incrusted with shells and foraminiferans, which is a synallactid sea cucumber. Note its trail. The spheroid object by it from which lines are radiating is a large protozoan (Protista) with trails made by its pseudopods. It is in the order Xenophytophoria and the family Cerelasmidae. The depth is 2213 m in the Upper Abyssal Zone of the western Gulf.
Scale 0.7 x 0.9 m.

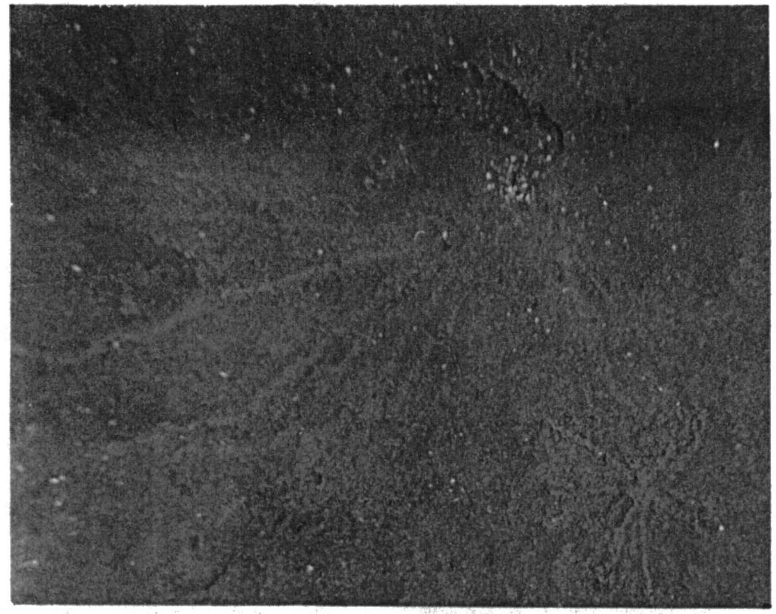
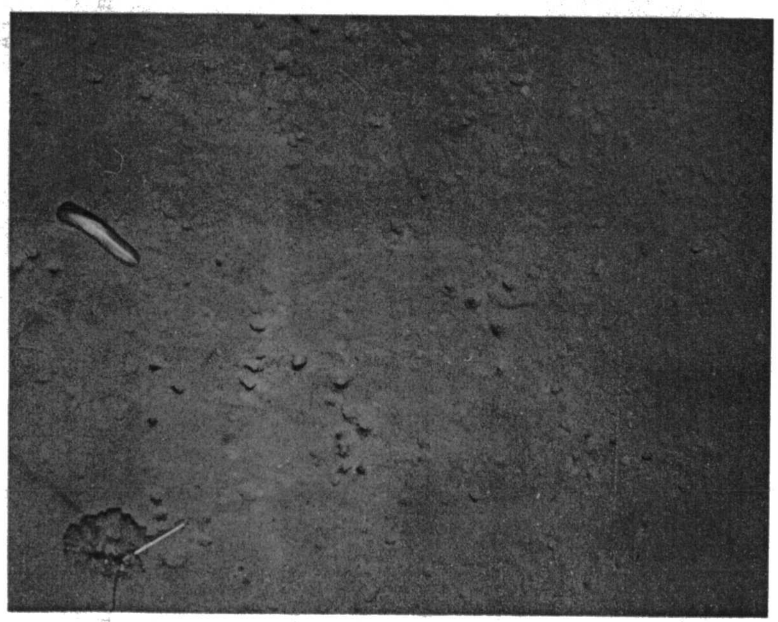
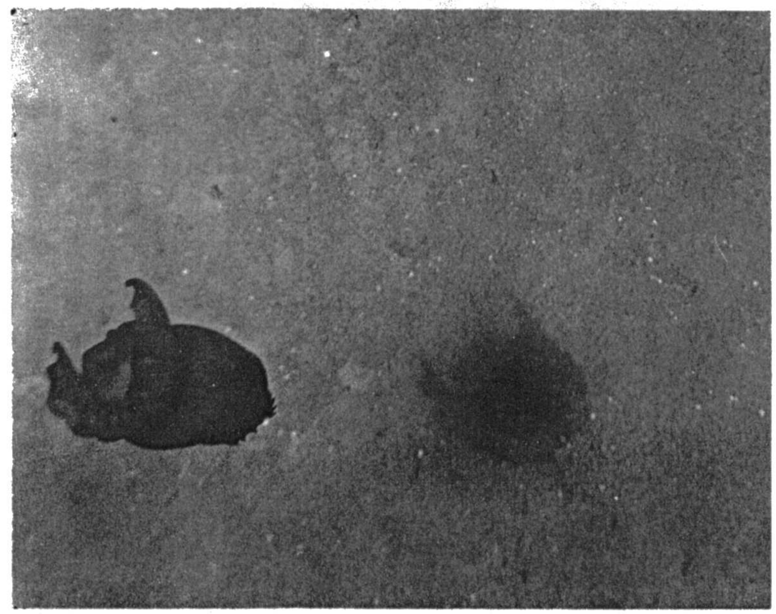





PLATE 6

CRUSTACEA

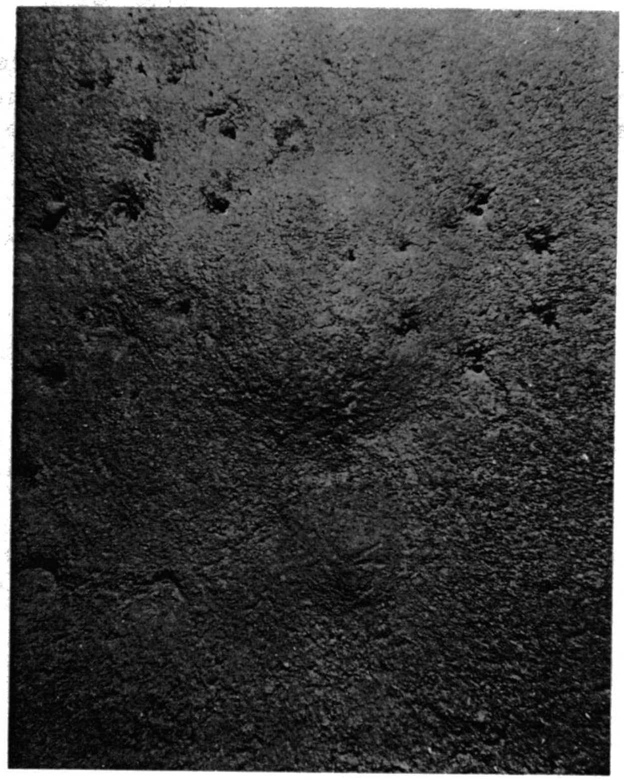
The Crustacea play a very important role in the deep-sea ecosystem. The natantians shown here in "A" and "C" are carideans. These forms feed on bivalves, polychaetes, and other crustaceans and in turn are fed on by fishes.

A. Glyphocrangon nobilis. Before taking this photo, it was assumed that these heavy-bodied carideans never left their burrows. In this photo, however, we see that they are capable of rapid movement. The clues in this photo indicate that they bound along making slash marks in the bottom. The depth is 1234 m in the Upper Abyssal Zone of the western Gulf.
Scale 0.4 x 0.5 m.

B. Glyphocrangon nobilis. The burrow system of this species is shown in this photo. Here we see the characteristic circlet of burrows of this caridean. It is likely that they are colonial. The depth, as in "A", is 1234 m in the Upper Abyssal Zone of the western Gulf.
Scale 0.7 x 0.9 m.

C. Nematocarcinus rotundus. This species is the most abundant caridean in the deep Gulf. The source of the burrow systems seen here is unknown, but it is suspected that they were made by eels. The depth is 1110 m in the Upper Abyssal Zone of the western Gulf.
Scale 0.5 x 0.7 m.

D. Nephropsis aculeata. This deep-sea lobster belongs in the family Nephropidae. It burrows but the system is not shown in this photo. The fish to the left is a macrourid or rat-tail. The depth is 549 m in the Archibenthal Zone of the western Gulf.
Scale 0.4 x 0.6 m.

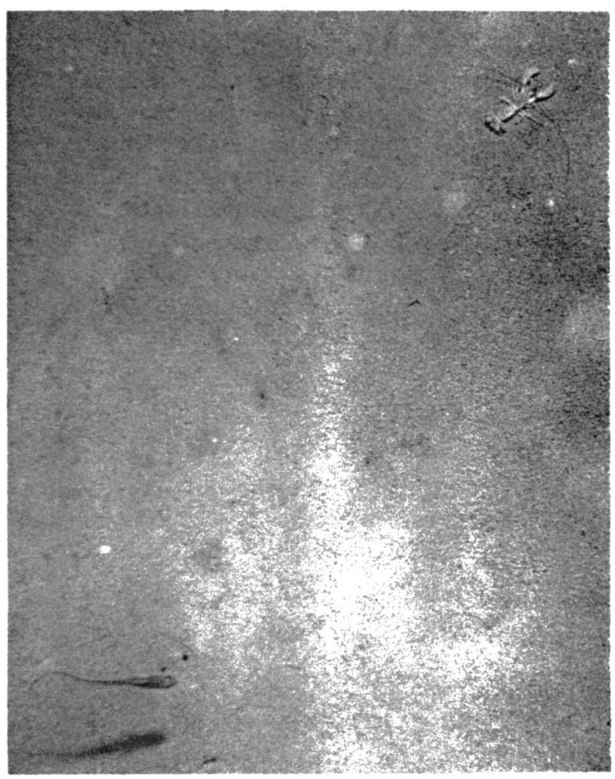


PLATE 7

CHARACTERISTIC FISHES

The fishes shown in these photos represent several important types in ecosystems of the Gulf of Mexico. The abundance of fishes in an area is perhaps the most significant indication of the benthic production at the site. The fishes in these photos are demersal types.

A. Gadidae. This gadid apparently feeds on benthic infaunal organisms which it uncovers with its modified fins. Movies taken of these fishes in the Gulf show them stirring up large clouds of sediment. The depth is 549 m in the Archibenthal Zone of the western Gulf.
Scale 0.3 x 0.4 m.

B. Chaemeridae. Although the chaemerids are not as abundant in the Gulf as gadids, they do play a significant trophic role in the benthic ecosystem. The depth is 549 m in the Archibenthal Zone of the western Gulf. Scale 0.3 x 0.4 m.

C. Synaphobranchidae. The synaphobranchid eels play a very important ecological role in the Upper Abyssal Zone of the Gulf. They feed upon crustaceans. The depth is 1300 m in the eastern Gulf below DeSoto Canyon.
Scale 1.5 x 1.9 m.

D. Macrouridae. The rat-tails are among the most abundant and characteristic fishes in the Upper Abyssal Zone of the Gulf. This one is living at a depth of 1569 m in the eastern Gulf below DeSoto Canyon.
Scale 1.5 x 1.9 m.

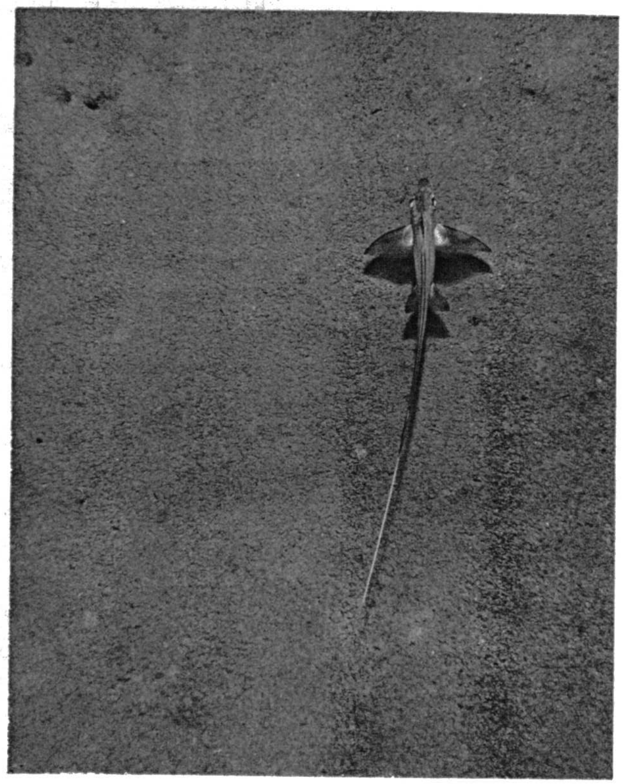
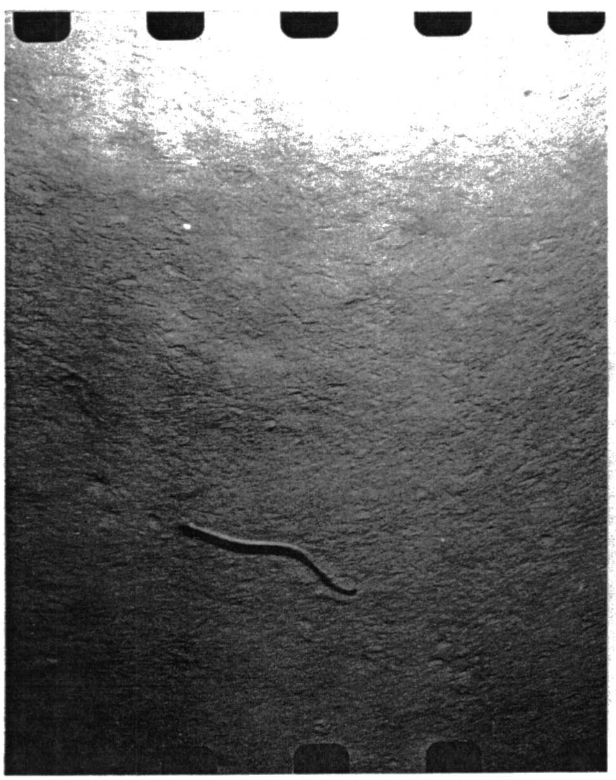





PLATE 8

PROTOZOA, SPONGES, COELENTERATES

A. A giant protozoan in the order Xenophytophoria and family Cerelasmidae. They are common on soft bottoms in deep water. The radiating marks are traces made by feeding pseudopods. The depth is 1569 m in the eastern Gulf below DeSoto Canyon. Scale 1.5 x 1.9 m.

B. A cup sponge taken at a depth of 2213 m in the Upper Abyssal Zone of the western Gulf. Scale 0.5 x 0.7 m.

C. A sea pen taken at a depth of 1234 m in the Upper Abyssal Zone in the western Gulf. Scale 0.7 x 0.9 m.

D. *Chrysogorgia elegans*. This gorgonian coral is the exclusive home of the uroptychid crustacean *Uroptychus nitidus*. The depth is 824 m in the Archibenthal Zone of the western Gulf. Scale 0.5 x 0.7 m.

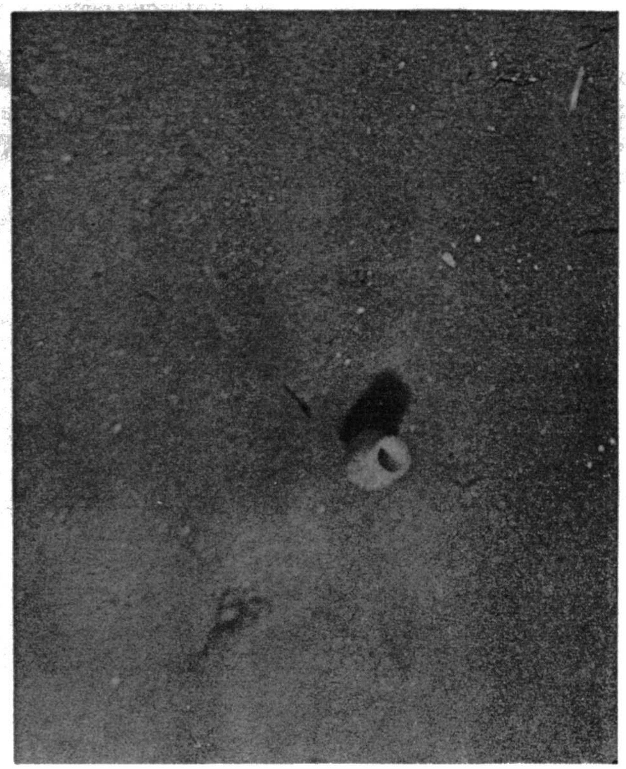
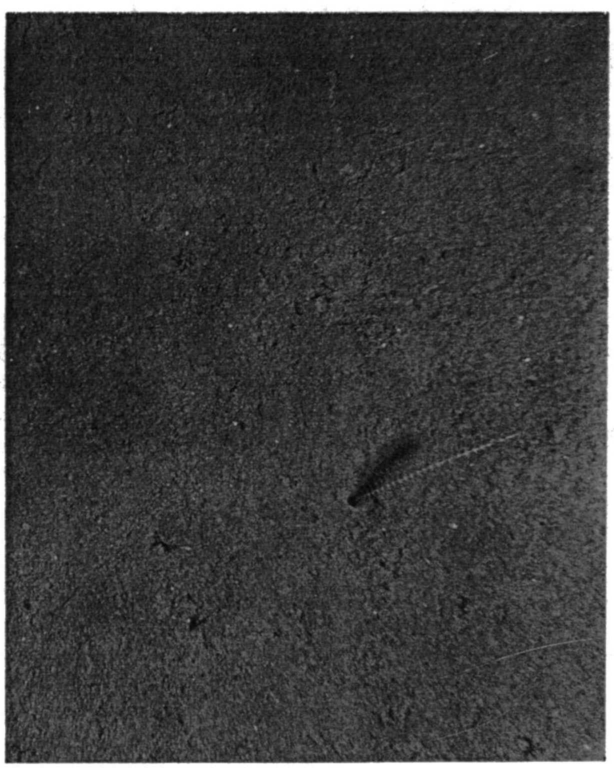
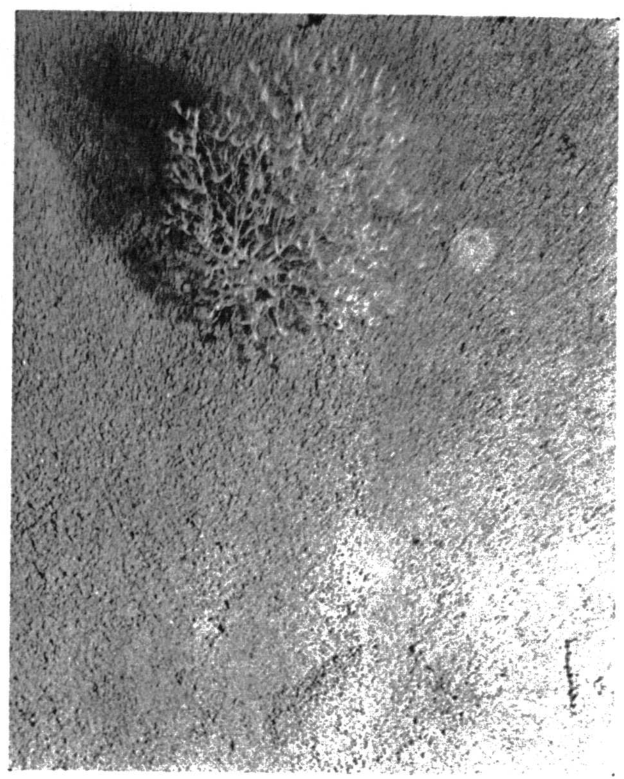





PLATE 9

POLYCHAETES AND AN OCTOPUS

Polychaete annelids are of crucial importance to deep-sea ecosystems. They are primarily deposit-feeders and carnivores. They are among the most important macrofauna on the Sigsbee Abyssal Plain, as indeed, they are on the continental shelf.

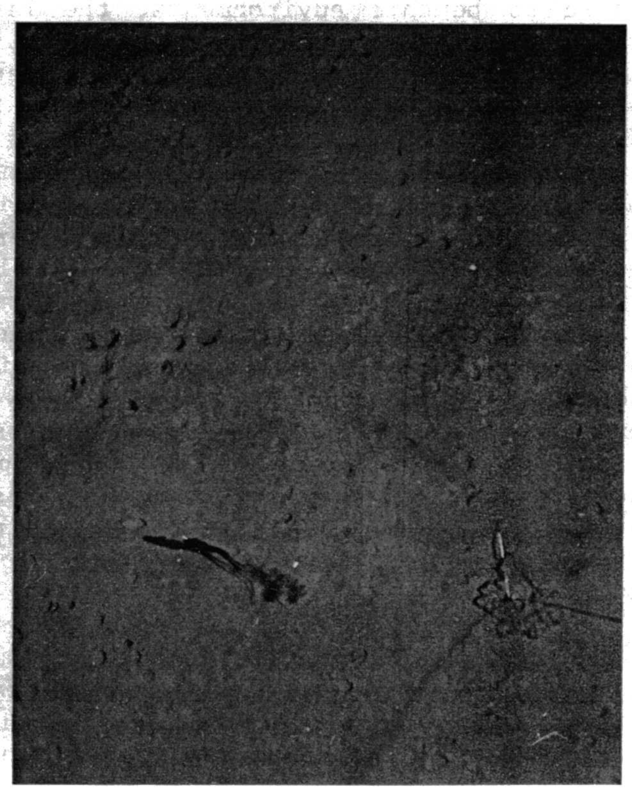
A. Onuphidae. This onuphid polychaete is believed to belong to the genus Nothria. It lives in a mud tube that often resembles the fecal deposits of sea cucumbers. The depth is 3722 m in the Lower Abyssal Zone of the Sigsbee Abyssal Plain's eastern extension at 91°04'W longitude. Scale 0.7 x 0.9 m.

B. Oweniidae. This oweniid polychaete is very common on the Sigsbee Abyssal Plain. They are very active worms foraging over relatively large areas of the seabed. The depth is 3722 m in the Lower Abyssal Zone of the central Gulf. Scale 0.5 x 0.7 m.

C. Polyodontidae. In this photo we see the tube, burrow, and foraging trails of a polychaete belonging to the family Polyodontidae. The depth is 3678 m in the Lower Abyssal Zone of the central Gulf. Scale 1.5 x 1.9 m.

D. Octopus. Octopi are generally strict carnivores, usually feeding on shellfish. Deep-sea octopi are fed upon by fishes, particularly eels. The individual in this photo has just released a shot of ink. As is well known in the case of shallow-water octopi the ink presumably narcotizes the olfactory sense of the eels. Since eels generally have poor eyesight, the octopi can escape. The depth is 925 m in the Archibenthal Zone of the western Gulf. Scale 2.4 x 3.0 m.



5. DEEP BENTHIC ECOSYSTEMS: ZONATION AND FAUNAL ASSEMBLAGES

DEFINITIONS: COMMUNITIES VERSUS FAUNAL ASSEMBLAGES

Although it is acceptable to use the terms community and faunal assemblage interchangeably, it has been the practice in this study to use assemblage as the word of choice. Upon its application to ecology the word "community" carried with it the implication of integration of species actions, involving interdependencies beyond the predator-prey relationship. In a later time, Krebs (1972) joined the two words in an operational definition saying simply that a community may be thought of as "any assemblage of populations of living organisms in a prescribed area or habitat." Fager (1963) anticipated the problem of proving interdependencies and felt it best to state, "a community is any group of species which are often found living together." The essential point to keep in mind is that in a community one is dealing with populations of organisms that together make up the faunal assemblages of coincidental species that exhibit a high enough degree of recurrence in similar habitats as to preclude the conclusion that they are simply randomly assembled collections of species. Accepting these guidelines, we agree with Menzies et al., (1973) when they say "Obviously we accept the existence of communities of organisms in the sea as a reality ----."

At the present level of development of deep-sea biology, the acceptability of the above definitions is heightened by the fact that neither one of them puts any limit on the size of communities nor does either one require that attempts be made to include every species that lives in the habitat. This is important to marine benthic studies where species richness can be high and the availability of species-level taxonomic expertise may be low. Moreover, the shift from pelagic to benthic environments, the large range of size from meiofauna to megafauna, extreme differences in mobility of the constituent species, and changes in the texture of the seabed demand that several sampling techniques be employed if any reasonable approximation of a "complete" representation of the constituents of a marine community is to be achieved. The descriptions of the faunal assemblages in the following pages is limited to macro- and megafaunal components that for the most part were captured by means of dredges or trawls. Even so, sampling problems in deep water could easily dissuade one from attempting to discuss deep-benthic assemblages except for the fact that after gaining experience one cannot but be impressed by the observation that when the catch of a trawl or dredge from a particular isobath or habitat is laid out on the deck it is similar to but not identical with recurrent groups of species taken previously by the same gear. Rowe and Haedrich (1979) recognize this fact when they say referring to faunal assemblages of the slope ----." Despite their restricted vertical range, these populations usually extend great distances along isobaths. This means that slight changes in depth across continental slopes result in radical changes in what lives there, but over extensive distances along a depth contour the composition of a community is altered very little."

In the present study we have found, as have others elsewhere, that animal taxa are congregated in such a way that the fauna can be subdivided by statistical criteria into assemblages arranged in vertical depth zones. In fact, we have established five faunal zones from the shelf to the abyss in the northern Gulf

(Table 61, right-hand column). These conform reasonably closely to those established by Menzies et al., (1973) for the Northwest Atlantic Ocean, as shown in the left-hand column of Table 61. The principal difference is seen to be in the depth of the shelf break, some 246 m in the Atlantic and 125 to 150 m in the Gulf. Thus, we have established a Shelf/Slope Transition Zone above the Archibenthal Zone. Note also in Table 61 that there are reasonably distinctive subdivisions of the Archibenthal and Mesoabyssal Zones that we refer to as horizons.

Table 61. Comparison of Northwest Atlantic and Gulf of Mexico faunal zones.

Northwest Atlantic Zones (Menzies et al., 1973)	Gulf Physiography	Gulf of Mexico Zones
Shelf (0-246 m)	Continental Shelf (0-125 m)	Shelf (0-125 m)
		Shelf/Slope Transition (150-450 m)
Archibenthal Zone (445-940 m)		Archibenthal Zone Horizon A (475-750 m) Horizon B (775-950 m)
	Continental Slope (150-2700 m)	
Upper Abyssal (940-2635 m)		Upper Abyssal (975-2250 m)
Mesoabyssal (2635-3330 m)		Mesoabyssal Horizon C (2275-2700 m) Horizon D (2725-3200 m)
	Continental Rise (2700-3400 m)	
Lower Active Abyssal (3330-4800 m)	Abyssal Plain (3400-3840 m)	Lower Abyssal Active East (3225-3850 m) Tranquil West

DENDROGRAM CONSTRUCTION

BASIS

The dendrogram (Figure 93) was based on a clustering technique applied to faunal similarity between isobaths. Because of the bias in sampling toward the megafauna and macrofauna, only data on these larger groups (fishes, crustaceans, and echinoderms except Crinoidea) were used in the calculations.

This dendrogram is based upon the index of similarity I, which is calculated by using the value

$$\frac{2j}{2ab-(a+b)j}$$

where a and b are the respective number of species in two samples and j is the number of species common to both samples. Mountford (1962) derived the index, based on logarithmic-series distribution, and showed it to be less dependent on sample size than earlier ones. This method tends to classify stations into groups of similar stations on the basis of the fauna collected at each and makes use not only of the index of similarity between a pair of single stations, but also of an index of similarity between two groups of stations. The index between a station B and a group composed of A_1 and A_2 is defined as

$$I(A_1A_2;B) = \frac{I(A_1B) + I(A_2B)}{2}$$

where $I(A_1B)$ is the index of similarity between the pair of stations A_1 and B; and, in general, the index of similarity between a Station B and a group composed of m stations is defined as

$$I(A_1,A_2\ldots A_m;B) = \frac{I(A_1B) + I(A_2B)\ldots + I(A_mB)}{m}$$

The index between a group composed of stations A_1 and A_2 and a second group composed of stations B_1 and B_2 is

$$I(A_1A_2;B_1B_2) = \frac{I(A_1B_1) + I(A_1B_2) + I(A_2B_1) + I(A_2B_2)}{4}$$

In general the index between groups A_1, A_2,...A_m and B_1, B_2,...B_m is defined as

$$\frac{1}{mn} \sum_{i=1}^{m} \sum_{j=1}^{n} I(A_iB_j)$$

A table of the indices (Figure 94) shows the similarity of the designated fauna between the various isobaths. The highest index of similarity was between the two deepest isobaths, 3800 m and 3850 m. The indices of similarity naturally become progressively lower between isobaths that are further and further apart.

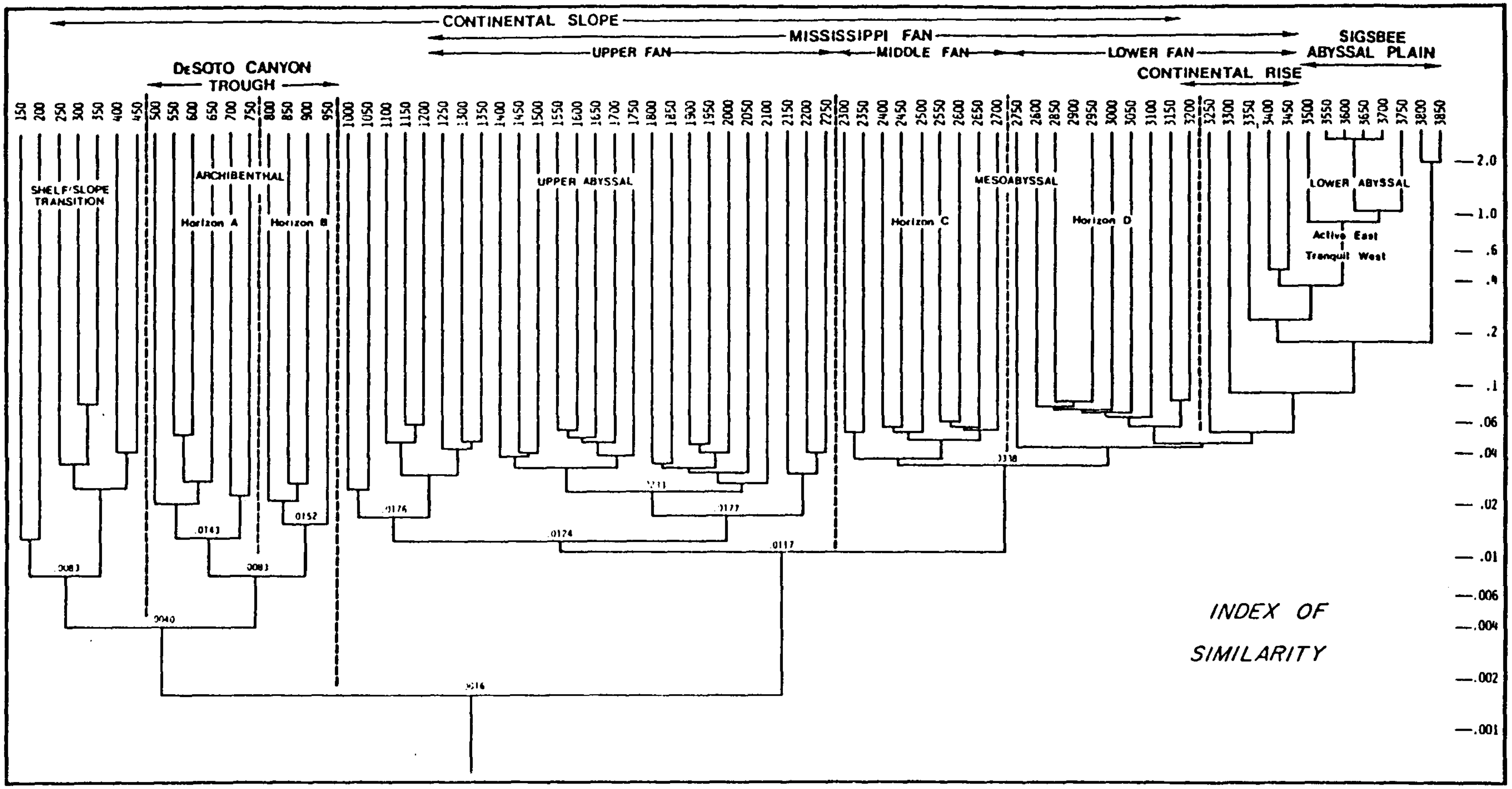


Figure 93. Dendrogram derived from calculated indices of similarity for each 50m depth interval. Faunal zones and various physiographic features of the Gulf of Mexico are indicated. The index is dimensionless and in the above example is based on all collections taken at a given isobath.

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Figure 94. Table of similarity indices of Gulf of Mexico deep fauna by depth.

LEGEND

Similarity Indices are $X10^{-4}$

- 0 - 9
- 10 - 99
- 100 - 999
- 1000 - 9999
- ≥10,000

DEPTHS meters	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000	2050	2100	2150	2200	2250	2300	2350	2400	2450	2500	2550	2600	2650	2700	2750	2800	2850	2900	2950	3000	3050	3100	3150	3200	3250	3300	3350	3400	3450	3500	3550	3600	3650	3700	3750	3800	3850
150																																																																												
200	125																																																																										
250	105	191																																																																								
300	80	129	434																																																																						
350	56	97	264	780																																																																				
400	36	60	159	311	464																																																																		
450	28	51	138	209	291	393																																																																
500	19	31	68	109	142	156	302																																																														
550	13	22	48	73	90	98	167	273																																																												
600	10	16	34	55	67	70	115	189	522																																																										
650	10	16	32	47	59	62	96	161	249	301																																																									
700	7	9	18	27	35	40	63	101	146	181	231																																																							
750	5	8	15	23	31	33	52	80	104	134	166	229																																																						
800	5	8	14	21	28	28	41	56	73	86	99	142	159																																																					
850	3	6	11	15	20	20	30	47	63	75	86	132	154	232																																																				
900	3	5	10	14	19	19	30	44	58	69	79	111	128	193	281																																																		
950	2	5	9	12	17	16	24	32	43	48	54	73	83	117	153	186																																																	
1000	2	4	8	12	17	16	24	30	38	43	47	61	69	97	127	161	165																																																
1050	2	4	7	10	15	14	20	27	35	39	43	57	62	85	109	125	143	254																																															
1100	2	4	7	8	11	12	17	23	32	33	36	39	46	80	98	114	127	194	258																																														
1150	2	5	7	8	13	12	18	24	29	30	33	46	51	73	89	113	118	187	237	462																																													
1200	2	5	7	8	10	11	17	22	28	29	31	45	49	70	84	96	101	157	195	477	591																																												
1250	2	4	6	7	9	11	16	19	25	27	29	36	41	61	73	85	91	140	167	282	325	355																																											
1300	2	4	6	7	9	11	16	19	25	27	29	36	41	59	70	85	91	140	160	268	307	335	449																																										
1350	2	4	6	7	9	11	16	19	26	26	28	37	42	57	68	80	83	127	145	237	269	292	381	465																																									
1400	1	3	4	4	5	7	12	16	20	22	24	34	39	52	61	70	72	109	119	180	200	216	269	317	326																																								
1450	1	3	4	4	5	7	10	16	20	21	22	32	34	49	58	66	68	96	104	154	171	184	225	262	268	376																																							
1500		2	3	3	3	7	10	14	20	20	22	32	34	51	60	70	69	99	108	154	169	183	223	261	282	373	414																																						
1550		2	3	3	4	7	10	16	21	22	24	35	38	50	58	65	66	91	99	141	154	166	191	223	240	311	343	432																																					
1600		2	3	3	4	7	10	16	21	22	24	35	38	50	58	65	66	91	99	141	154	166	191	223	240	311	343	432	535																																				
1650		2	3	4	4	7	11	16	21	22	24	36	38	50	59	61	62	86	93	131	143	155	177	206	221	285	313	389	474	474																																			
1700		2	3	4	4	7	11	16	21	22	24	36	36	48	57	61	62	86	93	131	143	155	177	206	221	285	313	389	474	474	455																																		
1750		2	3	3	3	7	10	15	20	20	22	33	33	40	47	55	55	76	83	116	126	136	154	178	190	241	263	322	387	387	374	374																																	
1800		2	3	3	4	7	10	16	20	20	22	32	32	41	48	52	53	74	80	112	122	126	142	173	176	222	242	291	345	345	355	355	201																																
1850		2	3	3	3	7	10	15	19	19	21	30	30	38	45	49	50	66	71	99	107	111	125	150	153	191	207	247	289	289	298	298	301	349																															
1900		2	3	4	4	7	9	13	18	18	20	30	31	40	46	51	53	64	70	93	100	104	116	134	144	189	195	230	265	265	272	272	280	342	348																														
1950		2	3	4	4	7	9	13	18	18	20	30	31	40	46	51	53	64	70	93	100	104	116	134	144	189	195	230	265	265	272	272	280	342	348	449																													
2000		2	3	4	4	7	9	13	17	17	19	29	29	38	44	48	50	61	66	87	94	97	109	126	134	175	181	213	245	245	251	251	258	312	317	405	405																												
2050		2	3	3	3	3	6	11	15	15	16	25	26	33	39	44	44	53	58	76	82	85	94	109	116	149	154	180	205	205	211	211	215	257	260	326	326	317																											
2100		1	1	2	2	4	4	9	12	13	14	22	23	29	34	39	39	47	51	67	72	74	83	95	101	129	133	154	176	176	180	180	183	217	218	270	270	248	257																										
2150		1	1	2	2	4	5	8	12	13	14	21	21	27	32	35	37	46	50	62	67	69	77	89	100	111	120	138	156	156	159	160	164	193	196	238	238	233	207	242																									
2200		1	2	2	2	5	6	8	12	13	14	22	21	29	34	36	39	48	52	66	71	74	82	95	102	120	125	143	160	160	163	163	162	190	195	234	234	231	219	221	312																								
2250		1	2	2	2	5	6	8	11	12	13	20	19	27	31	35	36	44	49	61	66	68	76	89	95	118	116	132	148	148	151	151	150	175	170	215	215	212	201	215	284	392																							
2300		1	2	2	2	4	5	10	13	14	15	16	15	21	25	25	30	38	43	50	57	57	62	76	81	97	102	115	127	127	138	138	150	174	183	215	215	215	194	213	262	346	363																						
2350		1	2	2	2	4	4	8	12	13	14	15	14	20	23	24	28	36	40	47	50	53	58	70	76	90	94	106	118	118	127	127	137	160	157	196	196	196	177	193	236	310	324	514																					
2400		1	2	3	3	2	2	7	12	13	14	13	13	19	22	22	28	36	40	47	50	53	58	67	73	87	92	103	114	114	124	124	127	148	156	182	182	183	166	184	224	288	303	459	448																				
2450		1	2	2	3	2	2	7	11	13	14	13	12	18	21	22	27	35	39	46	49	52	57	65	71	85	89	100	111	111	120	120	123	143	152	176	176	177	161	178	216	278	271	403	394	550																			
2500		1	2	3	3	2	2	7	12	13	14	13	13	19	22	23	29	37	41	48	51	54	60	69	75	90	94	106	117	117	127	127	131	152	142	164	164	155	142	158	190	241	253	368	361	496	523																		
2550		2	2	3	3	2	3	8	13	14	15	14	14	20	24	25	24	31	35	41	44	47	51	60	65	80	84	94	104	104	113	113	118	137	128	147	147	139	128	144	173	216	227	323	319	427	451	489																	
2600		2	2	3	3	2	3	8	13	14	16	14	14	21	24	25	24	32	36	42	45	48	53	62	67	82	87	97	107	107	116	116	121	141	132	152	152	144	132	149	179	224	236	336	332	447	472	513	590																
2650		2	2	3	3	2	3	7	12	14	15	14	13	20	23	24	23	30	34	40	43	46	50	59	64	77	82	92	101	101	110	110	114	133	124	143	143	135	124	139	167	209	219	310	307	409	431	467	535	562															
2700		2	2	3	3	2	3	8	13	15	16	15	15	20	23	24	23	31	35	41	43	43	47	56	61	75	80	89	98	98	107	107	113	131	123	141	141	133	123	140	168	208	220	308	306	406	430	464	528	553	505														
2750		1	2	3	3	2	3	7	12	13	14	13	13	17	19	20	20	26	29	34	37	36	40	47	51	62	66	74	81	81	88	88	92	106	100	114	114	108	180	112	134	165	161	222	220	308	322	346	390	407	374	446													
2800		2	2	3	3	2	3	6	11	13	14	13	13	17	20	19	19	25	29	34	36	36	39	51	56	64	69	77	84	84	92	92	97	113	106	121	121	115	106	114	136	167	176	240	240	339	358	384	431	450	414	492	492												
2850		2	3	3	3	2	3	6	12	13	14	13	13	18	21	19	19	26	30	35	37	37	40	48	53	66	71	79	86	86	95	95	101	117	110	125	125	119	110	118	141	173	182	249	249	354	374	402	452	471	434	516	518	728											
2900		2	3	3	3	2	3	6	12	13	14	13	13	18	21	19	19	26	30	35	37	37	40	48	53	66	71	79	86	86	95	95	101	117	110	125	125	119	110	118	141	173	182	249	249	354	374	402	452	471	434	516	518	728	773										
2950		2	3	3	3	2	3	6	12	13	14	13	13	18	21	19	19	26	30	35	37	37	40	48	53	66	71	79	86	86	95	95	101	117	110	125	125	119	110	118	141	173	182	249	249	354	374	402	452	471	434	516	518	728	773	773									
3000		2	2	3	3	2	3	6	11	12	13	12	12	16	19	18	17	24	27	31	34	33	36	44	48	59	63	70	77	77	84	84	89	104	97	111	111	105	97	103	123	151	159	216	215	301	317	339	380	396	365	431	427	587	620	620	620								
3050		2	2	3	3	2	3	6	11	13	14	13	12	17	20	18	18	25	28	33	35	35	38	46	51	63	67	74	81	81	89	89	94	110	103	118	118	112	103	110	132	161	170	231	231	325	343	368	413	430	397	470	468	650	688	688	688	622							
3100		2	2	3	3	2	3	6	11	12	13	12	12	17	19	18	18	24	28	32	34	34	37	45	49	61	65	72	79	79	87	87	92	107	100	114	114	108	100	107	127	156	164	224	223	313	329	353	396	412	380	450	447	617	653	653	653	590	655						
3150		2	3	3	3	2	3	6	10	12	12	12	11	16	18	17	17	24	28	32	34	34	37	45	50	63	67	75	82	82	90	90	96	112	105	120	120	114	105	113	126	154	163	219	220	309	327	349	390	405	375	440	406	543	570	570	570	526	578	551					
3200		2	3	3	3	2	3	6	10	12	12	12	11	16	18	17	17	24	28	32	34	34	37	45	50	63	67	75	82	82	90	90	96	112	105	120	120	114	105	113	126	154	163	219	220	309	327	349	390	405	375	440	406	543	570	570	570	526	578	551	767				
3250		2	2	3	3	2	3	6	9	10	11	10	10	14	16	15	15	21	24	28	30	29	32	39	43	53	57	63	69	69	76	76	81	94	88	100	100	95	88	94	104	127	134	179	179	247	259	276	307	318	296	344	316	414	434	434	434	400	436	417	504	560			
3300		2	3	4	4	3	3	5	7	9	9	9	8	14	16	15	13	17	20	24	25	25	27	35	40	53	57	64	69	69	78	78	78	92	86	98	98	93	86	81	89	107	105	136	139	193	207	218	238	245	231	261	255	319	330	330	330	288	308	298	380	380	339		
3350		3	4	5	5	4	4	6	9	12	13	12	11	15	17	16	14	19	20	23	25	24	26	37	44	60	66	73	80	80	91	91	93	111	105	118	118	113	105	98	108	129	127	163	171	245	266	280	305	315	297	335	305	377	391	391	391	342	365	353	458	458	423	797	
3400		3	5	5	6	4	5	8	7	10	11	10	10	14	16	19	17	23	24	28	29	29	32	38	45	64	72	79	86	86	100	100	103	125	117	133	133	126	117	110	121	144	142	183	193	319	352	371	406	419	394	448	410	513	532	532	532	463	495	478	552	552	513	848	2200											
3450		3	5	5	6	4	5	8	7	10	11	10	10	14	16	19	17	23	24	28	29	29	32	38	45	64	72	79	86	86	100	100	103	125	117	133	123	126	117	110	121	144	142	183	193	319	352	371	406	419	394	448	410	513	532	532	532	463	495	478	552	552	513	848	2200	4583									
3500		3	5	6	6	5	6	4	4	7	8	7	7	11	13	17	15	20	21	25	26	26	28	35	43	62	70	78	85	85	99	99	103	126	119	134	124	128	119	111	122	145	143	183	196	330	367	387	423	436	410	465	431	537	557	557	557	486	519	502	578	578	543	893	2308	4667	4667								
3550		3	5	6	6	5	6	4	4	7	8	7	7	11	13	17	15	20	21	25	26	26	28	35	43	62	70	78	85	85	99	99	103	126	119	134	124	128	119	111	122	145	143	183	196	330	367	387	423	436	419	465	431	537	557	557	557	486	519	502	578	578	543	893	2308	4667	4667	9545							
3600		3	5	6	6	5	6	4	4	7	8	7	7	11	13	17	15	20	21	25	26	26	28	35	43	62	70	78	85	85	99	99	103	126	119	134	124	128	119	111	122	145	143	183	196	330	367	387	423	436	410	465	431	537	557	557	557	486	519	502	578	578	543	893	2308	4667	4667	9545	9545						
3650		3	5	6	6	5	6	4	4	7	8	7	7	11	13	17	15	20	21	25	26	26	28	35	43	62	70	78	85	85	99	99	103	126	119	134	124	128	119	111	122	145	143	183	196	330	367	387	423	436	410	465	431	537	557	557	557	486	519	502	578	578	543	893	2308	4667	4667	9545	9545	9545					
3700										4	4	4	4	8	9	13	12	18	18	21	22	22	24	31	39	60	69	76	83	83	98	98	103	127	120	135	125	129	120	112	123	147	144	185	199	345	387	408	445	459	432	489	459	571	592	592	592	517	552	534	614	727	690	1176	2500	5000	5000	10,000	10,000	10,000	10,000				
3750										4	5	4	4	4	5	10	8	14	15	17	18	18	20	27	36	57	67	74	81	81	97	97	103	129	122	137	127	131	122	114	126	149	146	187	204	365	415	437	476	491	462	523	499	619	642	642	642	561	599	579	665	665	645	1053	2000	3333	3333	5000	5000	5000	5000	10,000			
3800																7	6	23	23	27	29	28	31	44	44	78	97	107	116	116	94	94	108	116	110	123	123	118	110	103	113	133	131	165	155	329	322	337	362	372	353	392	329	392	403	403	403	362	382	372	415	415	436	630	1250	1667	1667	2000	2000	2000	2000	2500	3333		
3850																7	6	21	21	25	26	26	28	40	40	71	86	95	103	103	84	84	97	103	98	110	110	105	98	92	101	118	117	147	138	285	279	292	313	322	306	339	285	339	348	348	348	313	330	322	358	358	372	534	1017	1333	1333	1579	1579	1579	1579	1935	2500	20,000	

For example, absolutely no faunal similarity exists between the 150 m and 1500 m isobaths, or between the 850 and 3800 m isobaths. Further examination of the table reveals that faunal similarity between consecutive isobaths increases with depth; that is, there is a slower rate of change in the fauna with increasing depth. This point is more dramatically reflected by construction of a dendrogram.

The indices of similarity between the various isobaths and/or groups of isobaths that provided the data for construction of the dendrogram are presented in rank order in Table 62.

INTERPRETATION

The dendrogram (Figure 93) assists one in discerning those "critical" depths along the slope, rise, and abyssal plain where apparent changes in the fauna occur. Two pronounced faunal breaks seem to occur within the upper 1000 m, one between 450 and 500 m and another at the 950-1000 m line. A less pronounced break also occurs between 750 and 800 m, the point of separation between Horizons A and B. The closely spaced separations reflect the rapid changes in fauna on the upper slope as compared to the deeper aspects of the Gulf. The dendrogram and the distribution of similarity index values appear to support the conclusion that there are four faunal assemblages on the continental slope and that two of them, viz., the Archibenthal and Mesoabyssal Zones, have less closely linked horizons. We note also that the Lower Abyssal Zone appears to incorporate most of the continental rise as well as the abyssal plain. The separation of the latter zone into Active East and Tranquil West subdivisions is based in part on the demonstrated strong bottom currents in the east and their apparent absence in the west. As has been pointed out by Rowe and Haedrich (1979) a universal feature in the distribution patterns of the slope fauna is the tight zonation, as suggested by the relatively large number of subsets in the slope cluster of Figure 93. In TerEco's earlier report on the upper slope fauna (Pequegnat et al., 1976) it seemed likely from examination of the dendrogram in that report that at least one additional true slope assemblage occurs at depths below 1050 m. This prediction is clearly borne out by the construction of the present dendrogram. Note also that the subsets coinciding with the rise are more closely spaced than those on the Sigsbee Abyssal Plain, which is an area of considerable monotony.

The composition of the fauna on the continental slope is not wholly unique, sharing species on its upper reach with the continental shelf and on its lower part with the continental rise. Nevertheless, as a whole the slope clearly represents a distinctive biological province. Its base, however, may vary in depth from ocean to ocean. Rowe and Haedrich (1979) as well as Rex (1981) mark it at around 2000 m in the North Atlantic. In the Gulf, however, our work as well as that of Uchupi (1967) puts its lower limit at between 2900 and 3200 m (Figure 93). In either event the boundary marks a change in gradient and, proceeding seaward, by a gradual shift to greater and greater pelagic contributions to the sediments. Whereas Sanders and Hessler at one time (1969) believed there was a uniform and gradual replacement of species without distinct boundaries down the slope and across the rise, our work in 1976 and the present report, as well as the work of Mills (1972) and Menzies et al., (1973) show that even the mobile megafauna of the slope conform to a statistically created zonal pattern. In this connection we note also that Rowe and Haedrich (1979) present clear evidence for tight zonation of the megafauna on the continental

Table 62. **Isobaths and their indices of similarity, in rank order, which provided data for construction of the dendrogram.**

RANK	ISOBATHS	INDEX OF SIMILARITY
1	3800 3850	2.0
2	3500-3600-3650-3700 3750	1.0
3	3500 3550-3750	.8727
4	3400 3450	.4583
5	3400-3450 3500-3750	.3722
6	3350 3400-3750	.2267
7	3350-3750 3800-3850	.1825
8	3300 3350-3850	.0860
9	300 350	.0780
10	2850 2900 2950	.0773
11	3150 3200	.0767
12	2800 2850-2950	.0728
13	2800-2950 3000	.0679
14	2800-3000 3050	.0674
15	2800-3050 3100	.0637
16	1150 1200	.0591
17	2550 2600	.0590
18	2800-3100 3150-3200	.0558
19	2400 2450	.0550
20	2550-2600 2650	.0549
21	1550 1600	.0535
22	2550-2650 2700	.0529
23	550 600	.0522
24	2300 2350	.0514
25	2400-2450 2500	.0510
26	1550-1600 1650	.0474
27	1100 1150-1200	.0470
28	1550-1650 1700	.0468
29	1300 1350	.0465
30	2400-2500 2550-2700	.0451
31	1900 1950	.0449
32	2800-3200 3250-3850	.0438
33	2750 2800-3850	.0418
34	1250 1300-1350	.0415
35	1450 1500	.0414
36	1900-1950 2000	.0405
37	400 450	.0393
38	2200 2250	.0392
39	1550-1700 1750	.0381
40	1400 1450-1500	.0375
41	2300-2350 2400-2700	.0355
42	250 300-350	.03491
43	1800 1850	.03488
44	2300-2700 2750-3850	.03380
45	1800-1850 1900-2000	.0335
46	1400-1500 1550-1750	.0331
47	2150 2200-2250	.0298
48	1800-2000 2050	.02972
49	1100-1200 1250-1350	.02967
50	850 900	.0281

Table 62 continued

RANK	ISOBATHS	INDEX OF SIMILARITY
51	550-600 650	.0275
52	250-350 400-450	.0262
53	1000 1050	.0254
54	1800-2050 2100	.0247
55	1400-1750 1800-2100	.0233
56	700 750	.0229
57	800 850-900	.0213
58	500 550-650	.0208
59	1400-2100 2150-2250	.0177
60	1000-1050 1100-1350	.0176
61	800-900 950	.0152
62	500-650 700-750	.0143
63	150 200	.0125
64	1000-1350 1400-2250	.0124
65	1000-2250 2300-3850	.0117
66	150-200 250-450	.00833
67	500-750 800-950	.00831
68	150-450 500-950	.0040
69	150-950 1000-3850	.0016

slope. Gardiner and Haedrich (1978) also found and designated zonation in the total megafauna above 3000 m, but below that depth the boundaries were indistinct if present at all. We find very much the same situation in the Gulf below about 3200 m. This, however, is to be expected because gradients of all physical parameters, including pressure, have leveled off drastically as compared with any part of the slope but especially with regard to the escarpments.

SPECIES COMPOSITION OF THE FAUNAL ASSEMBLAGES

As noted earlier, the present study deals with faunal assemblages, occurring in offshelf waters, but some attention must be given to their relationships with the continental shelf if for no other reason than to gain perspective on the importance of similarities and differences between shelf and offshelf assemblages. Since, however, a detailed description of the shelf assemblages was given in Pequegnat et al., (1976), only a brief mention will be made of them here.

SHELF ASSEMBLAGES

The continental shelf of the northern Gulf appears to provide ecological niches for three major groupings of organisms, some of which change habitats while completing their life-cycles or when as adults they respond by migration to very evident seasonal changes of temperature. Seaward of the estuary, we recognized three assemblages:

1) Inner Shelf Assemblage (Intertidal to 50-70 m depth).

   All of the fishes (except the shoal flounder) and the penaeid shrimps are intimately associated with the estuaries of the Gulf. Many of the fishes move into deeper waters offshore in winter and then return to the inner shelf area in summer. This is clearly a response to some direct and indirect effects (food supply) of temperature.

2) Outer Shelf Assemblage (from 50-70 m to 118 m or so).

   The fishes characteristic of this assemblage are never associated with the estuaries, and they tend to have less seasonality in their abundance.

3) Shelf/Slope Transition (from 118 m to as much as 450 m).

   This zone's assemblage appears to be easily separable into two groups, but they are not sufficiently distinctive as to warrant separate names. Nor do we deem it advisable to tag the differences as horizons. Rather in the earlier report Pequegnat et al., (1976) we discussed the more shelf-oriented subset assemblage, whereas in the present report we shall deal exclusively with the deeper group as noted below. The fishes of the shallower groups are caught in commercial quantities on the shelf but they also range down some distance on the slope. Even these species are not associated with the estuaries.

SLOPE, RISE, AND ABYSSAL PLAIN ASSEMBLAGES

Shelf/Slope Transition Zone (150-450 m)

Demersal fishes are certainly the hallmark of this zone. Coupling this with the rich group of asteroids and brachyurans, the majority of which are predatory, it appears that this is a very productive part of the benthic environment. Note that 90 species of demersal fishes were collected here and perhaps even of greater interest is that over two-thirds of them reach their maximum populations in the zone. Gastropod mollusks and polychaete annelids are also well represented in this zone. Noteworthy for their paucity are the sea cucumbers; contrariwise the Brissopsis group of sea-urchins are extremely abundant.

Demersal Fishes

Species with Maximum Population in Zone
(first 10 species in rank order)

1. Poecilopsetta beani
2. Hymenocephalus italicus
3. Pontinus longispinus
4. Pristipomoides aquilonaris
5. Bembrops gobioides
6. Monolene sp.
7. Bembrops anatirostris
8. Coelorinchus caribbaeus
9. Urophycis cirrata
10. Trichopsetta ventralis

11. Ancylopsetta dilecta
12. Argentina striata
13. Bellator militaris
14. Callionymus agassizi
15. Chlorophthalmus chalybeius
16. Citharichythys cornutus
17. Citharichthys gymnorhinus
18. Congridae sp.
19. Gnathagnus egregius
20. Gonioplectrus hispanus
21. Halieutichthys aculeatus
22. Hemanthias leptus
23. Hemanthias vivanus
24. Hildebrandia flava
25. Hollardia hollardia
26. Hoplostethus mediterraneus
27. Hoplunnis macrurus
28. Hoplunnis schmitti
29. Hoplunnis tenuis
30. Laemonema sp.
31. Lepophidium brevibarbe
32. Lepophidium sp.
33. Mistriophis sp.
34. Monolene sessilicauda
35. Muraenesox sp.
36. Mustelis canis
37. Myrophis punctatus
38. Neobythites gilli
39. Neomerinthe beanorum
40. Neoraja sp.
41. Nettenchelys pygmaeus
42. Ogcocephalus vespertilio
43. Ophichthus sp.
44. Parahollardia lineata
45. Parasudis truculenta
46. Paraxenomystax bidentatus
47. Physiculus fulvus
48. Polymixia lowei
49. Prionotus beani
50. Prionotus rubio
51. Prionotus stearnsi
52. Raja garmani
53. Saccogaster maculatus
54. Scorpaena agassizi
55. Scorpaena plumieri
56. Scytalichthys cf. miuris
57. Setarches guentheri
58. Squalus cubensis
59. Steindachneria argentea
60. Syacium papillosum
61. Symphurus piger
62. Synodus poeyi
63. Trachyscorpia cristulata
64. Uroconger syringinus
65. Urophycis floridana
66. Urophycis regia

Shelf/Slope Transition Zone (150-450 m) - continued

Other Species that Live in the Zone

67. Breviraja sinusmexicanus
68. Bythites sp.
69. Caulolatilus sp.
70. Centropristis philadelphica
71. Chaunax pictus
72. Chlorophthalmus agassizi
73. Coelorinchus coelorhinchus carminatus
74. Decodon puellaris
75. Dibranchus atlanticus
76. Echiophis mordax
77. Epigonus pandionus
78. Gadella maraldi
79. Lophius sp.
80. Merluccius albidus
81. Merluccius bilinearis
82. Neomerinthe hemingwayi
83. Peristedion greyae
84. Pseudophichthys laterodorsalis
85. Saurida brasiliensis
86. Symphurus marginatus
87. Synodus foetens
88. Urophycis tenuis
89. Ventrifossa occidentalis
90. Zalieutes mcgyntyi

Asteroidea

Species with Maximum Population in Zone
(species in rank order)

1. Anthenoides piercei
2. Astropecten nitidus
3. Cheiraster echinulatus
4. Luidia elegans
5. Tethyaster grandis
6. Rosaster alexandri
7. Astropecten alligator
8. Astropecten duplicatus
9. Luidia barbadensis
10. Luidia clathrata
11. Coronatus briareus
12. Astropecten nitidus forcipatus
13. Luidia barimae

Other Species that Live in the Zone

14. Astropecten americanus
15. Doraster constellatus
16. Ceramaster grenadensis
17. Nymphaster arenatus
18. Astropecten sp.

Holothuroidea

Species with Maximum Population in Zone

1. Holothuria imperator

Other Species that Live in the Zone

2. Molpadia cubana
3. unidentified Holothuroidea
4. Molpadia barbouri

Shelf/Slope Transition Zone (150-450 m) - continued

Echinoidea

Species with Maximum Population in Zone
(species in rank order)

1. Brissopsis atlantica
2. Brissopsis sp.
3. Brissopsis alta
4. Brissopsis alta-elongata
5. Brissopsis elongata-atlantica
6. Hypselaster limicolus
7. Stylocidaris affinis
8. Echinolampus depressa
9. Brissopsis elongata
10. Agassizia excentrica
11. Araesoma fenestratum
12. Palaeobrissus hilgardi
13. Podocidaris sculpta

Other Species that Live in the Zone

14. Coelopleurus floridanus
15. Lytechinus euerces
16. Echinocardium cordatus
17. Conolampas sigsbei
18. Genocidarus maculata
19. Stylocidaris sp.

Ophiuroidea

Species with Maximum Population in Zone
(species in rank order)

1. Ophiolepis sp.
2. Amphiura semiermis
3. Ophiostigma isacanthum
4. Amphichilus dalous
5. Ophioderma sp.
6. Amphichilus sp.
7. Amphioplus tumidus

Other Species that Live in the Zone

8. Ophiernus adspersum
9. unidentified Ophiuroid

Crinoidea

Species with Maximum Population in Zone
(species in rank order)

1. Neocomatella pulchella
2. Comactinea meridionalis
3. Leptonemaster venustus
4. Comactinea echinoptera
5. Crinometra brevipinna
6. Crinometra sp.
7. Stylometra spinifera
8. Neocomatella sp.

Penaeidae

Species with Maximum Population in Zone
(species in rank order)

1. Penaeopsis serrata
4. Hymenopenaeus tropicalis

Shelf/Slope Transition Zone (150-450 m) - continued

2. Parapenaeus longirostris
3. Solenocera vioscai
5. Solenocera necopina

Other Species that Live in the Zone

6. Hymenopenaeus robustus
7. Hymenopenaeus debilis

Caridea

Species with Maximum Population in Zone
(species in rank order)

1. Parapandalus willisi
2. Systellaspis pellucida
3. Plesionika tenuipes
4. Heterocarpus ensifer
5. Sabinea tridentata
6. Pontocaris caribbaeus
7. Plesionika edwardsii

Other Species that Live in the Zone

8. Pasiphaea merriami
9. Pontophilus gracilis

Anomura - Galatheidae

Species with Maximum Population in Zone
(species in rank order)

1. Munida longipes
2. Munida forceps
3. Munida flinti
4. Munida irrasa
5. Munida sculpta

Other Species that Live in the Zone

6. Munidopsis longimanus
7. Munidopsis polita
8. Munidopsis robusta
9. Munidopsis tridentata
10. Munida valida

Anomura except Galatheidae
Paguridae

Species with Maximum Population in Zone
(species in rank order)

1. Pagurus rotundimanus
2. Paguristes oxyophthalmus
3. Pagurus bullisi
4. Dardanus insignis
5. Pylocheles scutata
6. Paguristes sp. A
7. Paguristes sp. B

Other Species that Live in the Zone

8. Agaricochirus boletifer
9. Anisopagurus bartletti
10. Cancellus ornatus
11. Paguristes spinipes
12. Pylopagurus sp.
13. Rhodochirus rosaceus
14. Solenopagurus lineatus
15. Parapagurus spp.

Porcellanidae

Species with Maximum Population in Zone

1. Porcellana sigsbeiana	shelf-950 m	max. pop. 200 m

Uroptychidae & Lithodidae

(no species collected in this zone)

Brachyura

Species with Maximum Population in Zone
(species in rank order)

1. Lyreidus bairdii
2. Acanthocarpus alexandri
3. Benthochascon schmitti
4. Thalassoplax angusta
5. Raninoides louisianensis
6. Ethusa microphthalma
7. Myropsis quinquespinosa
8. Parthenope agona
9. Osachila tuberosa
10. Cylodorrippe antennaria

11. Callapa angusta
12. Chasmocarcinus cylindricus
13. Collodes leptocheles
14. Dicranodromia ovata
15. Ethusa microphthalma
16. Eucratodes agassizii
17. Euphrosynoplax clausa
18. Iliacantha subglobosa
19. Palicus dentatus
20. Palicus gracilis
21. Palicus obesus
22. Palicus sicus
23. Parthenope pourtelesii
24. Podochela sidneyi
25. Podochela sp.
26. Pyromaia arachna
27. Pyromaia cuspidata
28. Solenolambrus typicus
29. Stenocionops spinimana
30. Stenocionops spinosissima
31. Tetraxanthus rathbuni

Other Species that Live in the Zone

32. Anasimus latus
33. Bathyplax typhla
34. Rochinia crassa
35. Geryon quinquedens

Macrura
Polychelidae

Other Species that Live in the Zone

1. Polycheles typhlops

Shelf/Slope Transition Zone (150-450 m) - continued

Nephropidae

Other Species that Live in the Zone

1. Nephropsis aculeata

Callianassidae, Arciidae, & Scyllaridae

Species with Maximum Population in Zone
(species in rank order)

1. Callianassa marginata
2. Arciidae
3. Scyllarus depressus
4. Callianassa latispina

Cirripedia

Species with Maximum Population in Zone
(species in rank order)

1. Arcoscalpellum portoricanum
2. Scalpellum portoricanum

Other Species that Live in the Zone

3. Arcoscalpellum regina
4. Balanus sp. aff. calidus

Isopoda

Other Species that Live in the Zone
(actual number captured in zone = 1)

1. Bathynomus giganteus

Stomatopoda

Species with Maximum Population in Zone
(species in rank order)

1. Heterosquilloides armata
2. Squilla edentata

Pycnogonida

(no species collected in this zone)

Miscellaneous Crustacea

Gammaridea

Species with Maximum Population in Zone

1. Elasmopus sp.

Tanaidacea

(no species collected in this zone)

Gastropoda

Species with Maximum Population in Zone
(first 14 species in rank order)

1. Gemmula periscelida
2. Murex beauii
3. Scaphander watsoni
4. Conus mazei
5. Polystira tellea
6. Leucosyrinx sp.
7. Polystira albida
8. Gymnobela tanneri
9. Buccinidae sp. 1
10. Sconsia striata
11. Inodrillia (?)
12. unidentified Turridae
13. Suavotrochus iridea
14. Cerithium sp.

15. Antillophos sp.
16. Acamptochetus sp.
17. Niso aeglees (?)
18. unidentified Muricidae
19. Natica sp. ?
20. Sinum maculatum
21. Calliostoma bairdi oregon
22. Calliostoma rosewateri
23. Calthodrilla haliostriphis
24. Phalium granulatum
25. Scaphella sp.
26. Hindsiclava alesidota
27. Scaphella dubia
28. Euchelus carbis
29. Compsodrillia halistrephis
30. Astyris diaphana
31. Niso sp.
32. Mathilda sp.
33. Scaphander sp.
34. Homalopoma linnei
35. Gymnobela sp.
36. Turrid sp. 7
37. Glyphostoma sp.
38. Solariella sp. C
39. Tugurium longleyi
40. Compsodrillia acestra
41. Turrid sp. 3

Other Species that Live in the Zone

42. Antillophos candaei
43. Oocorys bartschi
44. Amerstroryrinz elegans
45. Pyrunculus ovatus
46. Drilleea horrenda
47. Leucosyrinx verrilli
48. Mangelia sp.
49. Benthomangelia macra
50. Oocorys sp.
51. "Mangelia" antonia
52. Corinnaeturris leucomata
53. Leucosyrinx tenoceras
54. Theta jeffreysi
55. Eudolium crosseanum

Shelf/Slope Transition Zone (150-450 m) - continued

Bivalvia

Species with Maximum Population in the Zone
(first 10 species in rank order)

1. Amygdalum politum
2. Nuculana acuta
3. Aequipecten glyptus
4. Anodontia sp.
5. Verticordia cf. fischeriana
6. Astarte cf. nana
7. Nemocardium peramabile
8. Cardiomya sp. C
9. Phacoides filosus
10. Anodontia cf. endentula

11. Yoldia solenoides
12. Anadara cf. baughmani
13. Cardiomya striata
14. Cuspidaria rostrata
15. Nuculana hebes
16. Propeamussium dalli
17. Venericardia armilla
18. Nucula sp. A
19. Nuculana platessa

Other Species that Live in the Zone

20. Abra longicalis americana
21. Cetoconcha sp. ?

Scaphopoda

Species with Maximum Population in Zone
(species in rank order)

1. Dentalium stenoschizum
2. Dentalium ceratum
3. Dentalium semistriolatum

Other Species that Live in the Zone

4. Cadulus sp.
5. Pulsellum pressum
6. Dentalium circumcinctum
7. Dentalium laqueatum
8. Dentalium perlongum

Cephalopoda

Species with Maximum Population in Zone
(species in rank order)

1. Loligo pealei
2. Abralia veranyi

Other Species that Live in the Zone

3. Semirossia equalis
4. Semirossia tenera
5. Benthoctopus januari
6. Japatella diaphana

Shelf/Slope Transition Zone (150-450 m) - continued

Polychaeta

Species with Maximum Population in Zone
(first 10 species in rank order)

1. Eupanthalis tubifex
2. Ehlersileanira incisa
3. Eunice floridana
4. Maldane sarsi
5. Panthalis pacifica
6. Scoloplos sp. A
7. Polyodontes lupinus
8. Leanira alba
9. unidentified Syllidae
10. Ophelina sp. A

11. Polyodontes pacifica
12. Sthenolepis incisa ?
13. Scoloplos rubra
14. Harmothoe sp. A
15. Polyodontes sp.
16. Protula tubularia
17. unidentified Serpulidae
18. Polyodontes frons
19. Polyodontes sp. B
20. Chloeia viridis ?
21. Diplocirrus capensis
22. Sthenolepis sp.
23. Psammolyce flava
24. Goniada norvegica
25. Asychis sp. C
26. Johnstonia sp.
27. Onuphis sp. B
28. Pherusa sp.
29. Salmacina sp. A
30. Vermiliopsis sp. A
31. Sthenelais sp.
32. Lumbrineris cf. latreilli
33. Eunice norvegica
34. Goniada sp. B
35. Orbinia sp.
36. Sabellastarte sp.
37. Syllis sp.
38. Mellina sp.
39. Diplocirrus sp.

Other Species that Live in the Zone

40. Goniada sp. A
41. Panthalis sp. A
42. Ophelina cylindricaudata
43. Rhamphobrachium agassizi
44. Pista sp.
45. Nothria sp. A
46. Orbinia riseri
47. Onuphis microcephala
48. Hyalinoecia cf. stricta
49. unidentified Chaetopteridae
50. Myriochele sp. A (n. sp.)
51. Onuphis sp. A
52. Terebellides sp.
53. Nephtys hombergi ?
54. Glycera oxycephala
55. Nephtys phyllocirra
56. Leanira n. sp.

Porifera

Species that Live in the Zone

1. Pachastrella sp.
2. Sphinctrella horrida
3. Raspailia sp.
4. Pleroma sp.
5. Theonella sp.
6. unidentified Lithisdidae
7. Latrunculia sp.
8. unidentified Hexasterophora
9. Acanthascus sp.
10. Hyalonema sp.
11. Eurete sp.
12. Farrea sp.
13. Tylodesma sp.
14. unidentified Dictyonina
15. Thenea fenestrata
16. Thenea sp.

Shelf/Slope Transition Zone (150-450 m) - continued

Hydrozoa

Species that Live in the Zone

1. unidentified Hydrozoa
2. Acryptolaria conferta
3. Thecocarpus bispinosus

Alcyonacea

(no species collected in this zone)

Pennatulacea

Species that Live in the Zone

1. Pennatula sp.
2. Funiculina quadrangularis

Scleractinea

Species that Live in the Zone

1. Paracyathus pulchellus
2. Madrepora carolina
3. Thallamophyllia riisei
4. Balanophyllia sp.
5. Madracis myriaster
6. Deltocyathus italicus
7. Deltocyathus hexagonus
8. Schizocyathus fissilis
9. unidentified Zoanthidae
10. Anomocora fecunda

Antipatharia

Species that Live in the Zone

1. unidentified Antipatharia

Sipuncula

Species with Maximum Population in Zone

1. Golfingia sp. 4 (cf. misakiana)

Bryozoa

Species that Live in the Zone

1. Cupuladria doma
2. Discoporella umbellata

Shelf/Slope Transition Zone (150-450 m) - continued

Brachiopoda

Species with Maximum Population in Zone
(species in rank order)

1. Argyrotheca barretti
2. Terebratulina cailleli

Archibenthal Zone - Horizon A (475-750 m)

Demersal fishes are abundantly represented here, but there is a reduction in total from 90 to 79 species and those with maximum population from 66 to 45. Asteroids are very well represented and the sea cucumbers have doubled in number. The *Brissopsis* echinoids are almost absent, but their place has been taken by the appearance of *Phormosoma placenta* and *Plesiodiadema antillarum*. Caridean shrimp species have doubled in number here, and among the galatheids the genus *Munidopsis* is beginning to replace *Munida* which predominates in the shelf areas. Gastropods and polychaetes are still very abundant.

Demersal Fishes

Species with Maximum Population in Zone
(first 10 species in rank order)

1. Dibranchus atlanticus
2. Symphurus marginatus
3. Bathygadus macrops
4. Pseudophichthys laterodorsalis
5. Ventrifossa atlantica
6. Coelorinchus coelorhinchus carminatus
7. Etmopterus pusillus
8. Diplacanthopoma brachysoma
9. Etmopterus spinax
10. Urophycis tenuis

11. Bathygadus sp.
12. Breviraja sinuxmexicanus
13. Brosmiculus imberbis
14. Bythites sp.
15. Chaunax nuttingi
16. Chaunax pictus
17. Chimaera monstrosa
18. Chlorophthalmus agassizi
19. Conger oceanicus
20. Epigonus occidentalis
21. Epigonus pandionus
22. Etmopterus schultzi
23. Gadella maraldi
24. Gadomus sp.
25. Hydrolagus alberti
26. Hydrolagus mirabilis
27. Hydrolagus sp. (cf. media)
28. Laemonema barbatulum
29. Leptoderma macrops
30. unidentified Lophiiformes
31. Lophius sp.
32. Luciobrotula sp.
33. Merluccius albidus
34. Merluccius bilinearis
35. Neobythites marginatus
36. Nezumia cf. sclerorhynchus
37. unidentified Ophidiidae
38. Peristedion greyae
39. Phycis chesteri
40. Physiculus kaupi
41. Polymetme corythaeola
42. Raja clarki
43. Raja sp.
44. Ventrifossa occidentalis
45. Yarrella blackfordi

Archibenthal Zone - Horizon A (475-750 m) - continued

Other Species that Live in the Zone

46. Apristurus profundorum
47. Barathronus bicolor
48. Bathygadus melanobranchus
49. Bathypterois longipes
50. Bathytroctes sp.
51. Bathyuroconger vicinus
52. Bembrops anatirostris
53. Bembrops gobioides
54. Coelorinchus caribbaeus
55. Coelorinchus occa
56. unidentified Congridae
57. Coryphaenoides colon
58. Coryphaenoides sp.
59. Dicrolene intronigra
60. Gadomus arcuatus
61. Gadomus longifilis
62. Gnathagnus egregius
63. Halosaurus guentheri
64. Monomitopus agassizi
65. Myrophis punctatus
66. Neoscopelus macrolepidotus
67. Nettastoma melanura
68. Nezumia aequalis
69. Parasudis truculentus
70. Physiculus fulvus
71. Poecilopsetta beani
72. Polymixia lowei
73. Symphurus piger
74. unidentified Synaphobranchidae
75. Synaphobranchus oregoni-brevidorsalis
76. Trachonurus villosus
77. Urophycis cirrata
78. Urophycis regia
79. Venefica procera

Asteroidea

Species with Maximum Population in Zone
(species in rank order)

1. Astropecten americanus
2. Cheiraster mirabilis
3. Cheiraster enoplus
4. Persephonaster echinulatus
5. Midgardia xandaros
6. Doraster constellatus
7. Brisingella verticellata
8. Cheiraster sp.
9. Benthopecten sp.
10. Pseudarchaster gracilis
11. Pteraster militaroides
12. Ceramaster grenadensis
13. Psilaster cassiope

Other Species that Live in the Zone

14. Cheiraster echinulatus
15. Goniopecten demonstrans
16. Pseudarchaster sp.
17. Plinthaster dentatus
18. Nymphaster arenatus
19. Astropecten sp.
20. Brisinga costata
21. Plutonaster intermedius
22. Dipsacaster antillensis

Holothuroidea

Species with Maximum Population in Zone
(species in rank order)

1. Hedingia albicans
2. Bathyplotes natans
5. Molpadia oolitica
6. Paracaudina sp.

Archibenthal Zone - Horizon A (475-750 m) - continued

3. Molpadia cubana
4. Ypsilothuria talismani
7. Bathyplotes pourtalesi
8. Protankyra sluiteri

Other Species that Live in the Zone

9. Molpadia barbouri
10. Molpadia musculus
11. Benthodytes sanguinolenta
12. Mesothuria lactea
13. Scotoanassa sp.
14. Molpadia blakei

Echinoidea

Species with Maximum Population in Zone
(species in rank order)

1. Phormosoma placenta
2. Homolampas fragilis
3. Echinocyamus sp.
4. Hemiaster expergitus

Other Species that Live in the Zone

5. Echinolampas depressa
6. Brissopsis sp.
7. Agassizia excentrica
8. Plesiodiadema antillarum

Ophiuroidea

Species with Maximum Population in Zone
(species in rank order)

1. Ophiernus adspersum
2. Bathypectinura heros
3. Ophiura lepida
4. Ophiochiton grandis
5. Ophiocamax fasciculata
6. Amphitarsus nike
7. Ophioplax ljungmani
8. Ophioleptoplax sp.
9. Ophiopyren sp.
10. Bathypectinura lacertosa
11. Ophiomusium monoplax

Other Species that Live in the Zone

12. Amphiura semiermis
13. unidentified Ophiuroid
14. Amphiophiura sp.
15. Amphioplus sp.
16. Ophiomusium eburneum

Crinoidea

Species with Maximum Population in Zone
(species in rank order)

1. Caryometra cf. alope
2. Atelecrinus balanoides
3. Antedonidae

Archibenthal Zone - Horizon A (475-750 m) - continued

Other Species that Live in the Zone

4. Democrinus sp.

Penaeidae

Species with Maximum Population in Zone
(species in rank order)

1. Hymenopenaeus debilis
2. Hymenopenaeus robustus
3. Aristaemorpha foliacea
4. Aristeus antillensis

Other Species that Live in the Zone

5. Penaeopsis serrata
6. Plesiopenaeus edwardsianus
7. Benthesicymus bartletti

Caridea

Species with Maximum Population in Zone
(species in rank order)

1. Glyphocrangon alispina
2. Plesionika holthuisi
3. Pasiphaea merriami
4. Glyphocrangon longleyi
5. Plesionika acanthonotus
6. Plesionika polyacanthomerus
7. Psathyrocaris infirma
8. Plesionika sp. (cf. acanthonotus)
9. Psalidopus barbouri
10. Plesionika martia

Other Species that Live in the Zone

11. Systellaspis pellucida
12. Pontophilus gracilis
13. Acanthephyra armata
14. Heterocarpus oryx
15. Glyphocrangon nobilis
16. Nematocarcinus rotundus

Anomura - Galatheidae

Species with Maximum Population in Zone
(species in rank order)

1. Munida valida
2. Munidopsis longimanus
3. Munidopsis robusta
4. Munidopsis erinaceus
5. Munidopsis tridentata
6. Munidopsis n. sp. (cf. abreviata)
7. Munidopsis polita
8. Munida iris
9. Munidopsis serratifrons

Other Species that Live in the Zone

10. Munidopsis alaminos
11. Munida forceps
12. Munida longipes
13. Munidopsis sigsbei

Anomura except Galatheidae

Paguridae

Species with Maximum Population in Zone
(species in rank order)

1. Sympagurus pictus
2. Sympagurus pilimanus
3. Paguristes planatus
4. Xylopagurus

Other Species that Live in the Zone

5. Dardanus insignis
6. Paguristes oxyophthalmus
7. Parapagurus spp.

Porcellanidae

Other Species that Live in the Zone

1. Porcellana sigsbei

Uroptychidae

Species with Maximum Population in Zone

1. Gastroptychus spinifer

Other Species that Live in the Zone

2. Uroptychus nitidus

Lithodidae

(no species collected in this zone)

Brachyura

Species with Maximum Population in Zone
(species in rank order)

1. Bathyplax typhla
2. Trichopeltarion nobile
3. Rochinia crassa
4. Ranilia constricta

Other Species that Live in the Zone

5. Pyromaia arachna
6. Ethusa microphthalma
7. Palicus gracilis
8. Lyreidus bairdii
9. Benthochascon schmitti
10. Geryon quinquedens

Archibenthal Zone - Horizon A (475-750 m) - continued

Macrura
Polychelidae

Species with Maximum Population in Zone
(species in rank order)

1. Polycheles typhlops

Other Species that Live in the Zone

2. Stereomastis s. sculpta

Nephropidae

Species with Maximum Population in Zone
(species in rank order)

1. Nephropsis aculeata
2. Nephropsis rosea
3. Acathacaris caeca

Callianassidae, Arciidae, & Scyllaridae

Other Species that Live in the Zone

1. Callianassa marginata

Cirripedia

Species with Maximum Population in Zone
(species in rank order)

1. Verruca sp. 3
2. Megalasma gracile gracilius
3. Arcoscalpellum semisculptum
4. Verruca sp. 2

Other Species that Live in the Zone

5. Scalpellum portoricanum
6. Arcoscalpellum regina

Isopoda

Other Species that Live in the Zone

(actual number captured in zone = 12)

1. Bathynomus giganteus

Stomatopoda

(no species collected in this zone)

Archibenthal Zone - Horizon A (475-750 m) - continued

Pycnogonida

(no species collected in this zone)

Miscellaneous Crustacea

Gammaridea

Species with Maximum Population in Zone

1. Urothoides sp.

Other Species that Live in the Zone

2. Epimera sp. A (n. sp.)

Tanaidacea

(no species collected in this zone)

Gastropoda

Species with Maximum Population in Zone
(species in rank order)

1. Gaza superba
2. Scaphander cf. clavus
3. Oocorys bartschi
4. Scaphella cf. gouldiana
5. Hyalorissia galeus
6. Solariella lamellosa
7. Leucosyrinx cf. subgrundifera
8. Amerstroryinz elegans
9. Drilleea horrenda
10. Homalopoma sp.
11. Pyrunculus ovatus
12. Corrinnaeturris incilis
13. Eulima sp.
14. Pyramidellidae sp. 1
15. Gymnobela edgariana
16. Lusitanops sp.

Other Species that Live in the Zone

17. Polystira albida
18. Conus mazei
19. unidentified Turridae
20. Scaphander watsoni
21. Inodrillia (?)
22. Glyphostoma sp.
23. Buccinidae sp.
24. Gemmula periscelida
25. Leucosyrinx sp.
26. Tugurium longleyi
27. Turrid sp. 3
28. Gymnobela tanneri
29. "Bulla" abyssicola
30. Scaphander mundus
31. Spirotropis lithocollata
37. "Mangelia" antonia
38. Corinnaeturris leucomata
39. Benthonella fisheri
40. Rissoa xanthias
41. Leucosyrinx cf. sigsbei
42. Latiromitra bairdi
43. Leucosyrinx tenoceras
44. Volutomitra cf. bairdi
45. Benthobia tryoni
46. Trophon aculeatus
47. Corinnaeturris sp. 2
48. Seguenzia sp. 6
49. Theta pandionis
50. Theta jeffreysi
51. Eudolium crosseanum

Archibenthal Zone - Horizon A (475-750 m) - continued

32. Ancistrosyrinx sp.
33. Leucosyrinx verrilli
34. Mangelia sp.
35. Benthomangelia macra
36. Oocorys sp.
52. Pleurotomella agassizii
53. Gymnobela ipara
54. Benthomangelia sp. 1
55. Colus sp.

Bivalvia

Species with Maximum Population in the Zone
(species in rank order)

1. Abra longicalis americana
2. Propeamussium sp. D
3. Nuculana solidifacta
4. Vesicomya sp.
5. Capulus cf. galena

Other Species that Live in the Zone

6. Amygdalum politum
7. Propeamussium dalli
8. Propeamussium spp.
9. Limopsis pelagica
10. Cetoconcha sp. ?
11. Propeamussium sp. A

Scaphopoda

Species with Maximum Population in Zone

1. Laevidentalium callipeplum

Other Species that Live in the Zone

2. Cadulus sp.
3. Pulsellum pressum
4. Dentalium circumcinctum
5. Dentalium obscurum ?
6. Dentalium laqueatum
7. Dentalium perlongum

Cephalopoda

Species with Maximum Population in Zone
(species in rank order)

1. Benthoctopus januari
2. Pteroctopus tetracirrhus
3. Semirossia tenera
4. Rossia bullisi
5. Rossia tortugaensis
6. Alloposus mollis
7. Semirossia equalis

Other Species that Live in the Zone

8. Japatella diaphana

Polychaeta

Species with Maximum Population in Zone (species in rank order)

1. Nothria sp. A
2. Myriochele sp. B
3. Panthalis sp. A
4. Rhamphobrachium agassizi
5. Spiochaetopterus sp.
6. Amage tumida
7. Goniada sp. A
8. Sosane sp.
9. Marphysa cf. bellii
10. unidentified Lumbriclymeninae
11. unidentified Polyodontidae
12. Marphysa sp.
13. Nereis sp. A
14. Polydora websteri
15. Ophelina cylindricaudata ?
16. Pista sp.
17. Capitellidae sp. B
18. near Notomastus
19. Spiophanes cf. soederstromi
20. Anobothrus sp.
21. Samythella elongata
22. Eunice sp.
23. Thelepinae (n. genus)
24. Nothria conchylega
25. Eusamytha sp. ?
26. Melinna maculata ?
27. Marphysa sanguinea
28. Orbinia riseri
29. Loimia sp.
30. Ninoe nigripes
31. Goniada teres
32. Amphicteis gunneri
33. ? Sabellides sp.
34. Linopherus ambigua
35. Aphrodita sp.

Other Species that Live in the Zone

36. Ehlersileanira incisa
37. Scoloplos rubra
38. Panthalis pacifica
39. Lumbrineris cf. latreilli
40. Harmothoe sp. A
41. Maldane sarsi
42. Eunice floridana
43. Onuphis microcephala
44. Phyllampharete longicirrata
45. Hyalinoecia cf. stricta
46. Asychis cf. gotoi
47. unidentified Chaetopteridae
48. Asychis byceps ?
49. Maldane sp. B
50. Myriochele sp. A., n. sp.
51. Onuphis sp. A
52. Terebellides sp.
53. unidentified Sigalionidae
54. Notomastus latericeus
55. Lumbrinereis sp. A
56. Nephtys hombergi
57. Drilonereis sp. A
58. Hyalinoecia tubicola
59. Glycera oxycephala
60. Nephtys phyllocirra
61. Eunice pennata ?
62. Leanira n. sp.
63. Leanira hystricis
64. unidentified Ampharetidae
65. Onuphis sp.
66. unidentified Oweniidae
67. unidentified Opheliidae
68. unidentified Sabellidae
69. Amelinna sp.

Porifera

Species that Live in the Zone

1. Hyalonema sp.
2. Aaptos sp.
3. Eurete sp.
7. Tylodesma sp.
8. unidentified Dictyonina
9. Thenea fenestrata

4. Farrea sp.
5. Tethycordyla thyris
6. Dragmatyle topsenti
10. Dactylocalyx sp.
11. Thenea sp.

Hydrozoa

Species that Live in the Zone

1. Opercularella sp. B
2. ? Opercularella sp. A
3. Halecium sp.
4. Eudendrium sp.
5. Tubularidae

Alcyonacea

Species that Live in the Zone

1. Chrysogorgia elegans
2. ? Keratoisis (axis)
3. Acanella eburnea
4. ? Acanella (basal disk)

Pennatulacea

Species that Live in the Zone

1. Funiculina quadrangularis
2. Protoptilum carpenteri
3. Funiculina sp.
4. Umbellula sp. C

Scleractinea

Species that Live in the Zone

1. Paracyathus pulchellus
2. Deltocyathus italicus
3. Anomocora fecunda
4. Deltocyathus calcar
5. Trocyathus rawsoni

Antipatharia

Species that Live in the Zone

1. unidentified Antipatharia

Sipuncula

Species with Maximum Population in Zone
(species in rank order)

1. Sipunculus sp. 1 (cf. norvegicus)
2. Golfingia sp. 3

Archibenthal Zone - Horizon A (475-750 m) - continued

Bryozoa

Species that Live in the Zone

1. Cupuladria doma
2. Discoporella umbellata

Brachiopoda

Species with Maximum Population in Zone

1. Platidia anomioides

Archibenthal Zone - Horizon B (775-950 m)

Although the total number of demersal fishes has reduced only moderately, the number of those species that reach maximum populations here is less than half that in Horizon A. This presages a major zonal change. The same is true of asteroids and echinoids. Another remarkable change is the drastic reduction in brachyuran crabs. Gastropod mollusks and polychaetes are still extremely well represented.

Demersal Fishes

Species with Maximum Population in Zone
(first 10 species in rank order)

1. Nezumia aequalis
2. Bathygadus melanobranchus
3. Halosaurus guentheri
4. Nezumia cyrano
5. Coryphaenoides colon
6. Gadomus arcuatus
7. Myxine sp.
8. Nettastoma melanura
9. Neoscopelus macrolepidotus
10. Coelorinchus occa

11. Bathypterois viridensis
12. Bathytroctes antillarum
13. Bathyuroconger vicinus
14. Cynomacrurus sp.
15. Diplacanthopoma sp.
16. Histiobranchus bathybius
17. Howella sp.
18. Lamprogrammas niger (?)
19. Nezumia bairdii
20. Penopus macdonaldi
21. Pseudoxenomystax dubius
22. Raja bigelowi
23. Trachonurus villosus

Other Species that Live in the Zone

24. Aldrovandia affinis
25. Aldrovandia gracilis
26. Alepocephalus agassizii
27. Apristurus profundorum
28. Barathronus bicolor
29. Barathronus sp.
30. Bathygadus favosus
31. Bathygadus macrops
47. Gadomus longifilis
48. Gadomus sp.
49. Hydrolagus alberti
50. Hydrolagus mirabilis
51. Ilyophis brunneus
52. Luciobrotula sp.
53. Merluccius bilinearis
54. Monomitopus agassizi

Archibenthal Zone - Horizon B (775-950 m) - continued

32. Bathypterois longipes
33. Bathypterois quadrifilis
34. Bathytroctes sp.
35. Cetonurus globiceps
36. Chaunax pictus
37. Chimaera monstrosa
38. unidentified Congridae
39. Coryphaenoides mexicanus
40. Coryphaenoides sp.
41. Dibranchus atlanticus
42. Dicrolene intronigra
43. Dicrolene sp.
44. Diplacanthopoma brachysoma
45. Epigonus occidentalis
46. Etmopterus spinax
55. Monomitopus sp.
56. unidentified Ophidiidae
57. Poecilopsetta beani
58. Pseudophichthys laterodorsalis
59. Raja fuliginea
60. Sphagemacrurus grenadae
61. Squalogadus modificatus
62. Stephanoberyx monae
63. unidentified Synaphobranchidae
64. Synaphobranchus oregoni-brevidorsalis
65. Venefica procera
66. Ventrifossa occidentalis
67. Yarrella blackfordi

Asteroidea

Species with Maximum Population in Zone
(species in rank order)

1. Nymphaster arenatus
2. Astropecten sp.
3. Goniopecten demonstrans
4. Plinthaster dentatus
5. Zoroaster fulgens
6. Psilaster patagiatus
7. Pseudarchaster sp.

Other Species that Live in the Zone

8. Cheiraster echinulatus
9. Astropecten americanus
10. Midgardia xandaros
11. Persephonaster echinulatus
12. Doraster constellatus
13. Ceramaster grenadensis
14. Psilaster cassiope
15. Cheiraster mirabilis
16. Brisinga costata
17. Plutonaster intermedius
18. Dytaster insignis

Holothuroidea

Species with Maximum Population in Zone
(species in rank order)

1. Molpadia musculus
2. Molpadia barbouri
3. unidentified Holothuroidea
4. Protankyra abyssicola
5. Molpadia sp.

Other Species that Live in the Zone

6. Bathyplotes natans
7. Molpadia cubana
8. Benthodytes sanguinolenta
9. Echinocucumis hispida
10. Mesothuria lactea
11. Scotoanassa sp.
12. Enypniastes ecalcarea
13. Molpadia blakei
14. Benthodytes lingua

Archibenthal Zone - Horizon B (775-950 m) - continued

Echinoidea

Species with Maximum Population in Zone
(species in rank order)

1. Plesiodiadema antillarum
2. Hypselaster brachypetalus

Other Species that Live in the Zone

3. Echinolampas depressa
4. Brissopsis sp.
5. Phormosoma placenta

Ophiuroidea

Species with Maximum Population in Zone
(species in rank order)

1. Ophioplinthaca dipsacos
2. Ophiomusium sp.
3. Amphiophiura sp.
4. Ophiodictys sp.

Other Species that Live in the Zone

5. Ophiernus adspersum
6. Ophiochiton grandis
7. Bathypectinura heros
8. Amphiura spp.
9. Bathypectinura sp.
10. Ophiomusium sp.
11. Amphioplus sp.
12. Ophiomusium eburneum

Crinoidea

Species with Maximum Population in Zone

1. Democrinus sp.

Other Species that Live in the Zone

2. Atelecrinus balanoides

Penaeidae

Species with Maximum Population in Zone

1. Plesiopenaeus edwardsianus

Other Species that Live in the Zone

2. Hymenopenaeus debilis
3. Aristaeus antillensis
4. Benthesicymus bartletti

Caridea

Species with Maximum Population in Zone
(species in rank order)

1. Heterocarpus oryx
2. Pontophilus gracilis
3. Acanthephyra armata
4. Nematocarcinus cursor

Other Species that Live in the Zone

5. Systellaspis pellucida
6. Aristaeus antillensis
7. Psalidopus barbouri
8. Plesionika holthuisi
9. Plesionika polyacanthomerus
10. Glyphocrangon alispina
11. Glyphocrangon nobilis
12. Nematocarcinus rotundus
13. Glyphocrangon aculeata
14. Bathypalaemonella serratipalma

Anomura - Galatheidae

Species with Maximum Population in Zone
(species in rank order)

1. Munidopsis sigsbei
2. Munidopsis alaminos
3. Munidopsis subspinoculata

Other Species that Live in the Zone

4. Munidopsis tridentata
5. Munidopsis longimanus
6. Munidopsis abreviata
7. Munidopsis robusta
8. Munidopsis spinoculata
9. Munidopsis spinosa

Anomura except Galatheidae

Paguridae

Other Species that Live in the Zone

1. Sympagurus pilimanus
2. Parapagurus spp.

Porcellanidae

Other Species that Live in the Zone

1. Porcellana sigsbeiana

Uroptychidae

Species with Maximum Population in Zone

1. Uroptychus nitidus

Archibenthal Zone - Horizon B (775-950 m) - continued

Lithodidae

(no species collected in this zone)

Brachyura

Species with Maximum Population in Zone
(species in rank order)

1. Geryon quinquedens
2. Cymonomus sp. cf. quadratus
3. Rochinia umbonata

Other Species that Live in the Zone

5. Lyreidus bairdii
6. Bathyplax typhla
7. Ethusina abyssicola

Macrura

Polychelidae

Other Species that Live in the Zone

1. Polycheles typhlops
2. Stereomastis s. sculpta

Nephropidae

Species with Maximum Population in Zone

1. Nephropsis agassizii

Other Species that Live in the Zone

2. Nephropsis aculeata
3. Acathacaris caeca

Callianassidae, Arciidae, & Scyllaridae

(no species collected in this zone)

Cirripedia

Species with Maximum Population in Zone
(species in rank order)

1. Arcoscalpellum regina
2. Verruca sp. 1
3. Scalpellum gracilius
4. Arcoscalpellum idioplax

Other Species that Live in the Zone

5. Arcoscalpellum albatrossianum

Isopoda

Other Species that Live in the Zone

(actual number captured in zone = 4)

1. Bathynomus giganteus

Stomatopoda

(no species collected in this zone)

Pycnogonida

(no species collected in this zone)

Miscellaneous Crustacea

Gammaridea

Other Species that Live in the Zone

1. Epimera sp. A (n. sp.)

Tanaidacea

(no species collected in this zone)

Gastropoda

Species with Maximum Population in Zone
(first 9 species in rank order)

1. Oocorys sulcata
2. Scaphander mundus
3. Ancistrosyrinx sp.
4. Spirotropis lithocollata
5. Gaza fisheri
6. Latirus aff. varai
7. Pleurotomella aff. bureaui
8. "Bulla" abyssicola
9. Epitoneum pyrrhias

10. Nassarina columbellata
11. Distorsio macgintyi
12. Fusinus eucosmius
13. Hipponicidae sp. n. ?
14. Coralliophila sp.
15. Murex recurvirostris
16. Murex sp.
17. Trivia sp.
18. Homalopoma albida
19. Cocculina sp.
20. Gymnobela agassizi
21. Cylichnium spatha
22. Turrid sp. 5
23. Pyramidellidae sp. 3
24. Cymatiidae sp. 1
25. Phymorhynchus sp. 1
26. Turrid sp. 2
27. Corinnaeturris sp. 1

Archibenthal Zone - Horizon B (775-950 m) - continued

Other Species that Live in the Zone

28. Polystira albida
29. Conus mazei
30. unidentified Turridae
31. Inodrillia (?)
32. Glyphostoma sp.
33. Gemmula periscelida
34. Turrid sp. 3
35. Gymnobela tanneri
36. Gaza superba
37. Oocorys bartschi
38. Amerstroryrinz elegans
39. Gymnobela edgariana
40. Scaphander cf. clavus
41. Leucosyrinx cf. subgrundifera
42. Pyrunculus ovatus
43. Drilleea horrenda
44. Homalopoma sp.
45. Corinnaeturris incilis
46. Leucosyrinx verrilli
47. Mangelia sp.
48. Benthomangelia macra
49. Oocorys sp.
50. "Mangelia" antonia
51. Corinnaeturris leucomata
52. Benthonella fisheri
53. Rissoa xanthias
54. Leucosyrinx cf. sigsbei
55. Latiromitra bairdi
56. Heliacus sp.
57. Columbellidae sp. 1
58. Cyclostrematidae sp. 1
59. Cyclostrematidae sp. 2
60. Cyclostrematidae sp. 3
61. Cyclostrematidae sp. 4
62. Aclis sp.
63. Naticidae sp. 2
64. Seguenzia sp. 2
65. Famelica catherinae
66. Famelica mirmidina
67. Pleurotomella aff. lottae
68. Teretia aperta
69. Turrid sp. 9
70. Rissoa pyrrhias
71. Seguenzia sp. 3
72. Seguenzia sp. 4
73. Echinogurges clavatus
74. Drilliola loprestiana
75. Micropleurotoma lophoessa
76. Theta sp.
77. Basilissa alta
78. Solariella pourtalisi
79. Acteon sp. 5
80. Seguenzia sp. 5
81. Basilissa sp.
82. Belomitra exsculpta
83. Benthomangelia sp. 2
84. Mangelia exsculpta
85. Mangelia cf. bandella
86. Teramachia sp.
87. Pleurotomella cf. edgarianum
88. Natica sp.
89. Mitra sp.
90. Lischkeia sp.
91. Leucosyrinx tenoceras
92. Volutomitra cf. bairdii
93. Benthobia tryoni
94. Trophon aculeatus
95. Corinnaeturris sp. 2
96. Seguenzia sp. 6
97. Scissurella alba
98. Solariella tiara
99. Theta pandionis
100. Terebra nassula
101. Phymorhynchus sulcifera
102. Retusa sp.
103. Theta jeffreysi
104. Calliotropis calatha
105. Drilliola sp.
106. Eudolium crosseanum
107. Pleurotomella agassizi
108. Gymnobela ipara
109. Benthomangelia sp. 1
110. Colus sp.
111. Pleurotoma smirna
112. Gymnobela blakeana
113. Fusinus sp.

Bivalvia

Species with Maximum Population in the Zone

1. Propeamussium sp. B

Archibenthal Zone - Horizon B (775-950 m) - continued

Other Species that Live in the Zone

2. Abra longicalis americana
3. Propeamussium sp. C
4. Propeamussium dalli
5. Propeamussium spp.
6. Limopsis pelagica
7. Cetoconcha sp. ?
8. Propeamussium sp. A
9. Brevinucula verrilli

Scaphopoda

Species with Maximum Population in Zone
(species in rank order)

1. Dentalium circumcinctum
2. Cadulus sp.
3. Pulsellum pressum
4. Entalina platamodes ?
5. Entalina sp.

Other Species that Live in the Zone

6. Dentalium obscurum ?
7. Dentalium laqueatum
8. Heteroschismoides callithrix
9. Dentalium perlongum

Cephalopoda

Species with Maximum Population in Zone
(species in rank order)

1. Japatella diaphana
2. Histioteuthis dofleini

Other Species that Live in the Zone

3. Semirossia equalis
4. Semirossia tenera
5. Benthoctopus januari
6. Vampyroteuthis infernalis
7. Neorossia sp. A
8. Onychoteuthis banksii

Polychaeta

Species with Maximum Population in Zone
(species in rank order)

1. Hyalinoecia cf. stricta
2. unidentified Chaetopteridae
3. Myriochele sp. A., n. sp.
4. Lysidice cf. ninetta
5. Onuphis sp. A
6. Paradiopatra cf. solenotecton
7. Maldane sp. B
8. Notomastus latericeus
9. Asychis cf. gotoi
10. Lumbrinereis sp. A
11. Onuphis microcephala
12. unidentified Sigalionidae
13. Phyllampharete longicirrata
14. Asychus byceps ?
15. Asychus sp. (sensu stricta)
16. Ampharetidae, n. genus
17. Terebellides sp.
18. Eunice cf. schemacephala
19. Lanice/Eupolymnia sp.

Archibenthal Zone - Horizon B (775-950 m) - continued

Other Species that Live in the Zone

20. Scoloplos rubra
21. Eunice floridana
22. Diplocirrus sp.
23. Rhamphobrachium agassizi
24. Pista sp.
25. Nothria sp. A
26. unidentified Polyodontidae
27. Myriochele sp. B
28. Amage tumida
29. Harmothoinae sp. 2
30. Nereis sp. A
31. Orbinia riseri
32. Loimia sp.
33. Sosane sp.
34. Spiochaetopterus sp.
35. Nephtys hombergi ?
36. Drilonereis sp. A
37. Hyalinoecea tubicola
38. Glycera oxycephala
39. Nephtys phyllocirra
40. Nephtys paradoxa
41. Eunice pennata
42. Leanira n. sp.
43. Leanira hystricis
44. Harmothoinae sp. 1
45. unidentified Ampharetidae
46. Phalacrostemma cidariophilum
47. Onuphis sp.
48. unidentified Oweniidae
49. unidentified Opheliidae
50. Maldane sp.
51. Travisia forbesii ?
52. Eunice pennata
53. unidentified Sabellidae
54. Amelinna sp.

Porifera

Species that Live in the Zone

1. Hyalonema sp.
2. Eurete sp.
3. Aphrocallistes bocagei
4. Aphrocallistes cf. beatrix
5. Chondrocladia sp.
6. Geodia sp. C
7. Geodia sp. A
8. Farrea sp.
9. Tethycordyla thyris
10. Dragmatyle topsenti
11. Tisiphonia sp.
12. Tylodesma sp.
13. unidentified Dictyonina
14. Thenea fenestrata
15. Dactylocalyx sp.
16. Thenea sp.
17. Radiella sol
18. Euplectella sp.

Hydrozoa

Species that Live in the Zone

1. Cladocarpus flexuosus

Alcyonacea

Species that Live in the Zone

1. Swiftia koreni
2. Calyptrophora josephinae
3. Chrysogorgiidae (axis)
4. Chrysogorgia elegans
5. ? Keratoisis (axis)
6. Acanella eburnea
7. ? Acanella (basal disk)
8. Acanella sp.
9. Isididae

Archibenthal Zone - Horizon B (775-950 m) - continued

Pennatulacea

Species that Live in the Zone

1. Funiculina quadrangularis
2. Protoptilum carpenteri
3. Funiculina sp.
4. Umbellula sp. C
5. Umbellula sp. F
6. Umbellula sp. D
7. Umbellula sp. 3
8. unidentified Pennatulacea

Scleractinea

Species that Live in the Zone

1. Paracyathus pulchellus
2. Deltocyathus italicus
3. Anomocora fecunda
4. Caryophyllia berteriana
5. Pepanocyathus stimpsonii
6. Madrepora oculata
7. Stephanocyathus (s.) diadema
8. Caryophyllia ambrosia

Antipatharia

Species that Live in the Zone

1. unidentified Antipatharia

Sipuncula

Species that Live in the Zone

1. Sipunculus sp. 1 (cf. norvegicus)

Bryozoa

(no species collected in this zone)

Brachiopoda

(no species collected in this zone)

Upper Abyssal Zone (975-2250 m)

Even though the Upper Abyssal Zone's bathymetric range is nearly three times that of the Archibenthal Zone, its demersal ichthyofauna is only half that of the latter zone. This exponential drop in species accelerates more rapidly as one moves into the Mesoabyssal. One should note, however, that the number of demersal fishes attaining maximum populations in the Upper Abyssal is over twice that of Horizon B. This is indicative of a group uniquely adapted to this environment above the slope's escarpment. Another noteworthy point is the major increase in the number of species of large sea cucumbers. The galatheids are here represented by 11 species of the genus Munidopsis and only one of Munida. The number of brachyuran crab species continues to drop with only four present here compared with the 35 in the Shelf/Slope Transition. It is perhaps most significant to observe that gastropod and sponge species reach peak numbers here, and polychaete numbers are still at high levels.

Demersal Fishes

Species with Maximum Populations in Zone
(first 10 species in rank order)

1. Gadomus longifilis
2. Dicrolene intronigra
3. Synaphobranchus oregoni-brevidorsalis
4. Aldrovandia gracilis
5. Stephanoberyx monae
6. Monomitopus agassizi
7. Aldrovandia affinis
8. Coryphaenoides mexicanus
9. unidentified Synaphobranchidae
10. Ipnops murrayi

11. Alepocephalus agassizii
12. Alepocephalus sp.
13. Apristurus profundorum
14. Barathronus sp.
15. Barbantus curvifrons
16. Bassozetus catena
17. Bathygadus favosus
18. Bathylagus cf. longirostris
19. Bathypterois longipes
20. Bathypterois phenax
21. Bathypterois quadrifilis
22. Bathypterois sp.
23. Bathytroctes melanocephalus
24. Bathytroctes sp.
25. Benthosaurus grallator
26. Cataetyx sp.
27. Cetonurus globiceps
28. Chalinura carapina
29. Conocara macdonaldi
30. Conocara cf. macroptera
31. Coryphaenoides macrocephalus
32. Coryphaenoides sp.
33. Dicrolene sp.
34. Diplolychnus sp.
35. Epigonus sp.
36. Ilyophis brunneus
37. Leptochilochthys agassizi
38. Monomitopus sp.
39. Narcetes stomias
40. Platytroctes apus
41. Polyacanthonotus africanus
42. Porogadus catena
43. Raja fuliginea
44. Raja oregoni
45. Raja purpuriventralis
46. Sphagemacrurus grenadae
47. Squalogadus modificatus
48. Venefica procera
49. Xyelacyba myersi

Other Species that Live in the Zone

50. Barathronus bicolor
51. Bassozetus normalis
52. Bassozetus sp.
53. Bathygadus melanobranchus
54. Bathytroctes macrolepis
55. Coelorinchus occa
56. unidentified Congridae
57. Coryphaenoides colon
58. Dibranchus atlanticus
59. Epigonus occidentalis
62. Halosaurus guentheri
63. Hemipterois sp.
64. Hydrolagus alberti
65. Luciobrotula sp.
66. Nezumia aequalis
67. Nezumia bairdii
68. Nezumia cyrano
69. unidentified Ophidiidae
70. Poecilopsetta beani
71. Trachonurus villosus

Upper Abyssal Zone (975-2250 m) - continued

60. Etmopterus spinax
61. Gadomus arcuatus
72. Ventrifossa occidentalis
73. Yarrella blackfordi

Asteroidea

Species with Maximum Population in Zone
(species in rank order)

1. Plutonaster intermedius
2. Pteraster acicula
3. Brisinga costata
4. Astropecten antillensis
5. Pteraster abyssorum
6. Mammaster sigsbeei
7. Odontaster hispidus
8. Poranisca lepida
9. Hymenaster anomalus
10. Evoplosoma n. sp.
11. Pteraster personatus
12. Ceramaster sp.
13. Drachmaster sp.
14. Hymenaster rex
15. Marsipaster sp.
16. near Marsipaster
17. Hymenaster modestus
18. Calyptraster coa

Other Species that Live in the Zone

19. Astropecten americanus
20. Midgardia xandaros
21. Doraster constellatus
22. Goniopecten demonstrans
23. Pseudarchaster sp.
24. Plinthaster dentatus
25. Nymphaster arenatus
26. Astropecten sp.
27. Zoroaster fulgens
28. Dipsacaster antillensis
29. Dytaster insignis
30. Benthopecten simplex
31. Litonotaster intermedius

Holothuroidea

Species with Maximum Population in Zone
(species in rank order)

1. Mesothuria lactea
2. Echinocucumis hispida
3. Benthodytes sanguinolenta
4. Molpadia blakei
5. Paelopatides cf. gigantea
6. Deima v. validum
7. Paroriza prouhoi
8. Bathyplotes sp.
9. Scotoanassa sp.
10. Enypniastes ecalcarea
11. Peniagone cf. islandica

Other Species that Live in the Zone

12. Molpadia cubana
13. Molpadia oolitica
14. Molpadia barbouri
15. Molpadia musculus
16. Benthodytes lingua
17. Psychropotes depressa
18. Mesothuria verrilli
19. Benthodytes typica
20. Pseudostichopus sp.
21. Protankyra brychia

Upper Abyssal Zone (975-2250 m) - continued

Echinoidea

Species with Maximum Population in Zone
(species in rank order)

1. Echinocyamus grandiporus
2. Echinus alexandri
3. Hygrosoma petersi
4. Phormosoma placenta sigsbei

Other Species that Live in the Zone

5. Phormosoma placenta
6. Plesiodiadema antillarum

Ophiuroidea

Species with Maximum Population in Zone
(species in rank order)

1. Ophiura spp.
2. Homalophiura sp.
3. Amphiura spp.
4. Ophiomusium sp.
5. Amphioplus sp.
6. Ophiopyren cf. longispinus
7. Ophiomusium spinigerum
8. Amphichilus incisus
9. Amphiura otteri
10. Bathypectinura sp.
11. Ophiomusium eburneum

Other Species that Live in the Zone

12. Ophiernus adspersum
13. Ophiochiton grandis
14. Bathypectinura heros
15. Amphiophiura sp.

Crinoidea

Species with Maximum Population in Zone
(species in rank order)

1. Monachocrinus caribbeus ?
2. Bathycrinidae

Other Species that Live in the Zone

3. Atelecrinus balanoides
4. Democrinus sp.

Penaeidae

Species with Maximum Population in Zone
(species in rank order)

1. Benthesicymus bartletti
2. Hymenopenaeus aphoticus
3. Plesiopenaeus coruscans
4. Benthesicymus carinatus
5. Funchalia taaningi
6. Funchalia cf. villosa
7. Benthonectes filipes

Other Species that Live in the Zone

8. Hymenopenaeus debilis
9. Plesiopenaeus edwardsianus
10. Hepomadus tener
11. Plesiopenaeus armatus
12. Benthesicymus cereus/iridescens
13. Hemipenaeus carpenteri
14. Hepomadus ? glacialis

Caridea

Species with Maximum Population in Zone
(species in rank order)

1. Nematocarcinus rotundus
2. Glyphocrangon nobilis
3. Glyphocrangon aculeata
4. Nematocarcinus ensifer
5. Bathypalaemonella serratipalma
6. Glyphocrangon longirostris
7. Glyphocrangon sculptus
8. Bathypalaemonella texana

Other Species that Live in the Zone

9. Systellaspis pellucida
10. Glyphocrangon alispina
11. Pontophilus gracilis
12. Acanthephyra armata
13. Heterocarpus oryx
14. Nematocarcinus acanthitelsonis

Anomura - Galatheidae

Species with Maximum Population in Zone
(species in rank order)

1. Munidopsis simplex
2. Munidopsis nitida
3. Munidopsis abreviata
4. Munidopsis spinosa
5. Munidopsis spinoculata
6. Munida microphthalma
7. Munidopsis rostrata
8. Munidopsis riveroi
9. Munidopsis gulfensis

Other Species that Live in the Zone

10. Munidopsis longimanus
11. Munidopsis robusta
12. Munidopsis sigsbei

Anomura except Galatheidae

Paguridae

Species with Maximum Population in Zone
(species in rank order)

1. Parapagurus spp.
2. Catapaguroides microps

Porcellanidae

(no species collected in this zone)

Upper Abyssal Zone (975-2250 m) - continued

Uroptychidae

Other Species that Live in the Zone

1. Uroptychus nitidus

Lithodidae

Species with Maximum Population in Zone

1. Lithodes agassizii

Brachyura

Species with Maximum Population in Zone
(species in rank order)

1. Homologenus rostratus
2. Homolodromia paradoxa

Other Species that Live in the Zone

3. Geryon quinquedens
4. Ethusina abyssicola

Macrura

Polychelidae

Species with Maximum Population in Zone
(species in rank order)

1. Stereomastis s. sculpta
2. Polycheles validus
3. Polycheles crucifer

Nephropidae

Other Species that Live in the Zone

1. Nephropsis aculeata
2. Nephropsis agassizii

Callianassidae, Arciidae, & Scyllaridae

(no species collected in this zone)

Cirripedia

Species with Maximum Population in Zone
(species in rank order)

1. Trilasmis kaempferi inaequilaterale
2. Acroscalpellum albatrossianum
3. Verruca sp.
4. Scalpellum svetlanae
5. Arcoscalpellum antillarum

Upper Abyssal Zone (975-2250 m) - continued

Other Species that Live in the Zone

6. Arcoscalpellum regina

Isopoda

Species with Maximum Population in Zone

1. Bathynomus giganteus
2. Ianirella caribbica

Stomatopoda

(no species collected in this zone)

Pycnogonida

Species with Maximum Population in Zone

1. Paranymphon spinosum

Miscellaneous Crustacea

Gammaridea

Species with Maximum Population in Zone
(species in rank order)

1. Epimera sp. A (n. sp.)
2. Trischizostoma longirostre
3. Rhachotropis (n. sp. ?)
4. cf. Cyclocaris sp.
5. Cyphocarid genus
6. Halicreion sp.
7. Valettiopsis cf. dentatus
8. Lysianassidae n. genus
9. Oediceroides cf. rostratus

Tanaidacea

Species with Maximum Population in Zone

1. Apseudes sp. A
2. Apseudes sp. B
3. Apseudes sp. C
   (A. propinquus complex)
4. Paranarthrura ? sp. A
5. Neotanais sp. A

7. Neotanais armiger

Gastropoda

Species with Maximum Population in Zone
(first 25 species in rank order)

1. Leucosyrinx tenoceras
2. Leucosyrinx verrilli

14. Leucosyrinx cf. sigsbei
15. Colus sp.

Upper Abyssal Zone (975-2250 m) - continued

3. Gymnobela ipara
4. Theta pandionis
5. Benthonella fisheri
6. Corinnaeturris leucomata
7. Calliotropis calatha
8. Pleurotomella agassizii
9. "Mangelia" antonia
10. Solariella pourtalisi
11. Latiromitra bairdi
12. Trophon aculeatus
13. Phymorhynchus sulcifera
16. Nassarius sp.
17. Oocorys sp.
18. Eudolium crosseanum
19. Leucosyrinx cf. subgrundifera
20. Retusa sp.
21. Solariella sp. A
22. Oocorys abyssorum
23. Theta sp.
24. Benthobia tryoni
25. Spirotorpis centimata

26. Mangelia sp.
27. Benthomangelia macra
28. Rissoa xanthias
29. Heliacus sp.
30. Columbellidae sp. 1
31. Cyclostrematidae sp. 1
32. Cyclostrematidae sp. 2
33. Cyclostrematidae sp. 3
34. Cyclostrematidae sp. 4
35. Aclis sp.
36. Naticidae sp. 2
37. Seguenzia sp. 2
38. Famelica catherinae
39. Famelica mirmidina
40. Pleurotomella aff. lottae
41. Teretia aperta
42. Turridae sp. 9
43. Rissoa pyrrhias
44. Seguenzia sp. 3
45. Seguenzia sp. 4
46. Echinogurges clavatus
47. Drilliola loprestiana
48. Micropleurotoma lophoessa
49. Basilissa alta
50. Acteon sp. 5
51. Seguenzia sp. 5
52. Basilissa sp.
53. Belomitra exsculpta
54. Benthomangelia sp. 2
55. Mangelia exsculpta
56. Mangelia cf. bandella
57. Teramachia sp.
58. Pleurotomella cf. edgarianum
59. Natica sp.
60. Mitra sp.
61. Lischkeia sp.
62. Ringicula nitida
63. Volutomitra cf. bairdii
64. Pleurotomella cf. chariessa
65. Columbellidae sp. 3
66. Epitoneum nitidum
67. Aclis mizon
68. Eulimidae & Aclidae n. genera
69. Bulla cf. eburnea
70. Turridae sp. 1
71. Corinnaeturris sp. 2
72. Seguenzia sp. 6
73. Scissurella alba
74. Solariella tiara
75. Terebra nassula
76. Cerithiella sp.
77. Columbarium bermudezi
78. Theta jeffreysi
79. Aclis cf. egregia
80. Solariella obscura
81. Drilliola sp.
82. Coralliophila dalli
83. Solariella sp. 2
84. Epitonium sp.
85. Pyramidellidae sp. 2
86. Epitoneum formosissimum
87. Columbellidae sp. 2
88. Naticidae sp. 1
89. Turridae sp. 4
90. Benthomangelia sp. 1
91. Aceton sp. 3
92. Pleurotomella benedicti
93. Retusa cf. domitus
94. Gymnobela homeostata
95. Scaphander nobilis

Other Species that Live in the Zone

96. unidentified Turridae
97. Inodrillia (?)
107. Ancistrosyrinx sp.
108. Pleurotomella aff. bureaui

Upper Abyssal Zone (975-2250 m) - continued

98. Glyphostoma sp.
99. Gemmula periscelida
100. Gymnobela tanneri
101. Oocorys bartschi
102. Scaphander cf. clavus
103. Pyrunculus ovatus
104. Scaphander mundus
105. Cylichnium spatha
106. Spirotropis lithocollata
109. Turridae sp. 5
110. Pyramidellidae sp. 3
111. Oocorys sulcata
112. Corinnaeturris sp. 1
113. Gymnobela blakeana
114. Gymnobela bairdi
115. Turridae sp. 6
116. Fusinus sp.

Bivalvia

Species with Maximum Population in Zone (first 15 species in rank order)

1. Propeamussium sp. A
2. Propeamussium spp.
3. Propeamussium sp. C
4. Limopsis pelagica
5. Tindaria amabilis
6. Propeamussium dalli
7. Tindariopsis agathida
8. Nucula pernambucensis
9. Arca orbiculata
10. Pectinidae
11. Poromya sp.
12. Neilonella sp. A
13. Neilo sp.
14. Thyasira sp.
15. Pteriidae

16. Astarte nana
17. Malletia sp. B
18. Limopsis sp.
19. Neilonella sp. B
20. Yoldiella pachia
21. Yoldiella quadrangularis
22. Astarte cf. globula
23 Nucula sp. B
24. Nucula obliterata
25. Cardiomya sp. B
26. Abra sp.
27. Cetoconcha sp. ?
28. Limopsis aurita paucidentata
29. Limopsis galatheae

Other Species that Live in the Zone

30. Abra longicalis americana
31. Brevinucula verrilli
32. Bathyarca asperula
33. Cardiomya sp.
34. Malletia sp. A

Scaphopoda

Species with Maximum Population in Zone (species in rank order)

1. Dentalium perlongum
2. Dentalium callithrix
3. Dentalium laqueatum
4. Pulsellum pressum

Other Species that Live in the Zone

5. Dentalium ensiculus
6. Dentalium meriodionale

Upper Abyssal Zone (975-2250 m) - continued

Cephalopoda

Species with Maximum Population in Zone
(species in rank order)

1. Vampyroteuthis infernalis
2. Pholidoteuthis adami
3. Bathothauma lyromma
4. Neorossia sp. A
5. unidentified Argonautidae
6. Mastigoteuthis grimaldi
7. Ornithoteuthis antillarum
8. Eledonella pygmaea
9. Semirossia sp.
10. Opisthoteuthis agassizi
11. Neorossia sp.
12. Helicocranchia pfefferi
13. Grimalditeuthis bomplandii
14. Cranchia scabra
15. Argonauta hians

Other Species that Live in the Zone

16. Benthoctopus januari
17. Japatella diaphana
18. Histioteuthis dofleini
19. Onychoteuthis banksii

Polychaeta

Species with Maximum Populations in Zone
(species in rank order)

1. Hyalinoecia tubicola
2. Asychis n. sp.
3. Leanira hystricis
4. Nephtys paradoxa
5. Nephtys phyllocirra
6. Leanira n. sp.
7. Harmothoinae sp. 1 ?
8. Nephtys hombergi ?
9. Travisia forbesii
10. Eunice pennata ?
11. unidentified Terebellidae
12. Phalacrostemma cidariophilum
13. unidentified Opheliidae
14. Chloeia viridis
15. Hermodice carunculata
16. Spionidae sp. A
17. Glycera tessellata
18. Drilonereis sp. A
19. Phyllodoce sp.
20. Glycera oxycephala
21. unidentified Ampharetidae
22. Capitellidae sp. A
23. Spionidae sp. B
24. Onuphis sp.
25. unidentified Oweniidae
26. Travisia sp. ?
27. Maldane sp.

Other Species that Live in the Zone

28. Diplocirrus sp.
29. Rhamphobrachium agassizi
30. Nothria sp. A
31. Myriochele sp. B
32. Spiochaetopterus sp.
33. Onuphis microcephala
34. Hyalinoecia cf. stricta
35. unidentified Chaetopteridae
36. Maldane sp. B
37. Terebellides sp.
38. unidentified Sigalionidae
39. Lanice/Eupolymnia sp.
40. Paradiopatra cf. solenotecton
41. Eunice pennata
42. unidentified Sabellidae
43. Amelinna sp.
44. Myriochele sp. A, n. sp.
45. unidentified Onuphidae

Upper Abyssal Zone (975-2250 m) - continued

Porifera

Species that Live in the Zone

1. Hyalonema sp.
2. Eurete sp.
3. Farrea sp.
4. Tethycordyla thyris
5. Plakortis sp.
6. Tetilla sp.
7. Dragmatyle topsenti
8. Tisiphonia sp.
9. Tylodesma sp.
10. unidentified Dictyonina
11. Thenea fenestrata
12. Dactylocalyx sp.
13. Thenea sp.
14. Radiella sol
15. Euplectella sp.
16. Hyalonema sp. B
17. Hyalonema sp. A
18. Radiella sp.

Hydrozoa

Species that Live in the Zone

1. Cladocarpus flexuosus

Alcyonacea

Species that Live in the Zone

1. Swiftia koreni
2. Calyptrophora josephinae
3. Chrysogorgia elegans
4. ? Keratoisis (axis)
5. Acanella eburnea
6. ? Acanella (basal disk)
7. Acanella sp.
8. Isididae
9. Corallium
10. Acanella or Lepidisis sp. (axis)

Pennatulacea

Species that Live in the Zone

1. Funiculina quadrangularis
2. Protoptilum carpenteri
3. unidentified Pennatulacea
4. Stylatula antillarum
5. ? Anthoptilum sp.
6. Umbellula sp.

Scleractinea

Species that Live in the Zone

1. Deltocyathus italicus
2. Madrepora oculata
3. Stephanocyathus (s.) diadema
4. Caryophyllia ambrosia
5. Stephanocyathus (o.) coronatus
6. Enallopsammia profunda
7. Desmophyllum cristigalli
8. Solenosmilia variablis
9. Caryophllia polygona

Upper Abyssal Zone (975-2250 m) - continued

Antipatharia

Species that Live in the Zone

1. unidentified Antipatharia

Sipuncula

Species with Maximum Population in Zone
(species in rank order)

1. Golfingia flagrifera
2. Golfingia catherinae

Bryozoa

(no species collected in this zone)

Brachiopoda

Species that Live in the Zone

1. Pelagodiscus atlanticus
2. Chlidonophora incerta

Mesoabyssal Zone - Horizon C (2275-2700 m)

A very sharp faunal break occurs here between the Upper Abyssal Zone and Horizon C of the Mesoabyssal Zone. For instance, the number of demersal fish species having maximum populations in the zone drops from 49 in the Upper Abyssal to 3 in Horizon C. Even if both horizons of the Mesoabyssal are included the total is only 5. Similar reductions of species are noted in other groups (maximum population species only).

	Upper Abyssal	Mesoabyssal
Asteroids	18	3
Holothuroids	11	7
Echinoids	4	2
Ophiuroids	11	4
Penaeids	7	2
Carideans	8	2
Galatheids	9	1
Gastropods	95	10
Bivalves	28	9
Scaphopods	4	1
Polychaeta	27	5

Mesoabyssal Zone - Horizon C (2275-2700 m) - continued

Demersal Fishes

Species with Maximum Population in Zone
(species in rank order)

1. Chlorophthalmus sp.
2. Dicrolene kanazawai
3. Lamprogrammus sp.

Other Species that Live in the Zone

4. Aldrovandia gracilis
5. Barathronus bicolor
6. Bassozetus normalis
7. Bassozetus sp.
8. Bathyonus pectoralis
9. Bathypterois quadrifilis
10. Bathytroctes macrolepis
11. Bathytroctes sp.
12. Coryphaenoides sp.
13. Hemipterois sp.
14. Ilyophis brunneus
15. Ipnops murrayi
16. unidentified Ophidiidae
17. Porogadus catena
18. unidentified Synaphobranchidae

Asteroidea

Other Species that Live in the Zone

1. Plinthaster dentatus
2. Nymphaster arenatus
3. Zoroaster fulgens
4. Benthopecten simplex
5. Dipsacaster antillensis
6. Dyaster insignis
7. Litonotaster intermedius

Holothuroidea

Species with Maximum Population in Zone
(species in rank order)

1. Protankyra brychia
2. Peniagone sp.
3. Synallactidae
4. Peniagone cf. azorica

Other Species that Live in the Zone

5. Molpadia oolitica
6. Scotoanassa sp.
7. Enypniastes ecalcarea
8. Molpadia blakei
9. Paelopatides cf. gigantea
10. Psychropotes depressa
11. Mesothuria verrilli
12. Benthodytes lingua
13. Benthodytes typica
14. Pseudostichopus sp.

Echinoidea

Other Species that Live in the Zone

1. Phormosoma placenta

Mesoabyssal Zone - Horizon C (2275-2700 m) - continued

Ophiuroidea

Other Species that Live in the Zone

1. Bathypectinura heros
2. Ophiomusium sp.
3. Amphioplus sp.
4. Ophiomusium eburneum

Crinoidea

(no species collected in this zone)

Penaeidae

Species with Maximum Population in Zone

1. Hepomadus tener

Other Species that Live in the Zone

2. Hymenopenaeus aphoticus
3. Plesiopenaeus coruscans
4. Plesiopenaeus armatus
5. Benthesicymus cereus/iridescens
6. Hemipenaeus carpenteri
7. Hepomadus ? glacialis

Caridea

Species with Maximum Population in Zone

1. Pontophilus talismani

Other Species that Live in the Zone

2. Glyphocrangon longirostris
3. Nematocarcinus ensifer
4. Nematocarcinus acanthitelsonis

Anomura - Galatheidae

Species that Live in the Zone

1. Munidopsis bermudezi
2. Munidopsis geyeri
3. Munidopsis sundi
4. Munidopsis columbiana

Anomura except Galatheidae
Paguridae

Species that Live in the Zone

1. Parapagurus spp.

Porcellanidae, Uroptychidae, & Lithodidae

(no species collected in this zone)

Brachyura

Other Species that Live in the Zone

1. Ethusina abyssicola

Macrura

Polychelidae

Other Species that Live in the Zone

1. Stereomastis s. sculpta
2. Polycheles validus

Nephropidae & Callianassidae, Arciidae, & Scyllaridae

(no species collected in this zone)

Cirripedia

(no species collected in this zone)

Isopoda

(no species collected in this zone)

Stomatopoda

(no species collected in this zone)

Pycnogonida

(no species collected in this zone)

Miscellaneous Crustacea

(no species collected in this zone)

Gastropoda

Species with Maximum Population in Zone

1. Epitoneum sp. 1

Mesoabyssal Zone - Horizon C (2275-2700 m) - continued

Other Species that Live in the Zone

2. unidentified Turridae
3. Oocorys sulcata
4. Leucosyrinx verrilli
5. Oocorys sp.
6. Corinnaeturris leucomata
7. Leucosyrinx cf. sigsbei
8. Trophon aculeatus
9. Theta jeffreysi
10. Calliotropis calatha
11. Eudolium crosseanum
12. Colus sp.
13. Gymnobela blakeana
14. Gymnobela bairdi
15. Turrid sp. 6
16. Fusinus sp.

Bivalvia

Species with Maximum Population in the Zone
(species in rank order)

1. Cyclopecten cf. hadalis
2. Neilo bermudensis
3. Yoldiella mirmidina
4. Cardiomya sp. A

Other Species that Live in the Zone

5. Abra longicalis americana
6. Arca orbiculata
7. Cetoconcha sp. ?
8. Neilonella sp. A
9. Poromya tornata
10. Brevinucula verrilli
11. Bathyarca asperula
12. Nucula callicredemna
13. Neilo sp. A
14. Cardiomya sp.
15. Malletia sp. A

Scaphopoda

Species that Live in the Zone

1. Dentalium perlongum
2. Dentalium callithrix
3. Dentalium ensiculus
4. Dentalium meridionale

Cephalopoda

Species with Maximum Population in Zone

1. Brachioteuthis sp.

Other Species that Live in the Zone

2. Onychoteuthis banksii

Mesoabyssal Zone - Horizon C (2275-2700 m) - continued

Polychaeta

Other Species that Live in the Zone

1. Rhamphobrachium agassizi
2. Nothria sp. A
3. Myriochele sp. B
4. Spiochaetopterus sp.
5. Onuphis microcephala
6. unidentified Chaetopteridae
7. Maldane sp. B
8. Myriochele sp. A, n. sp.
9. Lanice/Eupolymnia sp.
10. Paradiopatra cf. solenotecton
11. Hyalinoecia tubicola
12. Onuphis sp.
13. unidentified Oweniidae
14. unidentified Opheliidae
15. Maldane sp.
16. Travisia forbesii ?
17. Eunice pennata
18. unidentified Sabellidae
19. unidentified Onuphidae
20. Amelinna sp.

Porifera

Species that Live in the Zone

1. Dragmatyle topsenti
2. Tylodesma sp.
3. unidentified Dictyonina
4. Thenea fenestrata
5. Dactylocalyx sp.
6. Thenea sp.
7. Radiella sol
8. Euplectella sp.
9. Hyalonema sp. B
10. Hyalonema sp. A
11. Radiella sp.
12. Tethyopsilla lens

Hydrozoa

(no species collected in this zone)

Alcyonacea

(no species collected in this zone)

Pennatulacea

Species that Live in the Zone

1. Umbellula sp. B
2. Umbellula lindahlii
3. Umbellula sp. A

Scleractinea

Species that Live in the Zone

1. Deltocyathus italicus

Mesoabyssal Zone - Horizon C (2275-2700 m) - continued

Antipatharia

(no species collected in this zone)

Sipuncula

Species that Live in the Zone

1. Golfingia flagrifera

Bryozoa

(no species collected in this zone)

Brachiopoda

Species that Live in the Zone

1. Pelagodiscus atlanticus
2. Chlidonophora incerta

Mesoabyssal Zone - Horizon D (2725-3200 m)

This horizon coincides with the lower and steep part of the continental slope in the western Gulf. There it encompasses the Sigsbee Escarpment, the lower part of which intersects with the continental rise. In the northeastern Gulf such an escarpment does not exist. Rather, it is dominated by the Mississippi Trough and the Mississippi Fan. Thus, there is a more definitive separation of faunal assemblages between Horizons C and D in the western Gulf than in the east. This seems to indicate that the degree of slope may play a significant role in species richness, possibly not directly so much as through its contribution to instability of the seabed and the frequency of slumping and related causes of turbidity flows. There are some differences in assemblage constitution between the horizons. For instance, there are nearly twice as many species of demersal fishes in C than in D and four of the species in the former are not found in D. On the other hand, among the Asteroidea there are four species that reach maximum populations in D, whereas none do in C. Other differences are readily apparent in the following analyses of the assemblages.

Demersal Fishes

Species with Maximum Population in Zone
(species in rank order)

1. Bassozetus normalis
2. Bathyonus pectoralis

Other Species that Live in the Zone

3. Bathytroctes sp.
8. Hemipterois sp.

Mesoabyssal Zone - Horizon D (2725-3200 m) - continued

4. Coryphaenoides sp.
5. Ilyophis brunneus
6. Barathronus bicolor
7. Bathytroctes macrolepis
9. Bassozetus sp.
10. unidentified Ophidiidae
11. unidentified Synaphobranchidae

Asteroidea

Species with Maximum Population in Zone
(species in rank order)

1. Benthopecten simplex
2. Dipsacaster antillensis
3. Psilaster sp.

Other Species that Live in the Zone

4. Plinthaster dentatus
5. Nymphaster arenatus
6. Litonotaster intermedius
7. Zoroaster fulgens
8. Dytaster insignis
9. Paragonaster subtilis

Holothuroidea

Species with Maximum Population in Zone
(species in rank order)

1. Psychropotes depressa
2. Mesothuria verrilli
3. Mesothuria candelabri

Other Species that Live in the Zone

4. Molpadia oolitica
5. Molpadia blakei
6. Paelopatides cf. gigantea
7. Benthodytes typica
8. Pseudostichopus sp. A
9. Synallactidae
10. Benthodytes lingua
11. Pseudostichopus sp.

Echinoidea

Species with Maximum Population in Zone
(species in rank order)

1. Sarsiaster griegii

Ophiuroidea

Species with Maximum Population in Zone
(species in rank order)

1. Homalophiura cf. inornata
2. Homalophiura abyssorum
3. Silax verrilli
4. Amphilepis norvegica

Mesoabyssal Zone - Horizon D (2725-3200 m) - continued

Other Species that Live in the Zone

5. Bathypectinura heros
6. Amphioplus sp.
7. Ophiomusium eburneum
8. Ophiomusium planum

Crinoidea

(no species collected in this zone)

Penaeidae

Species with Maximum Population in Zone

1. Plesiopenaeus armatus

Other Species that Live in the Zone

2. Hymenopenaeus aphoticus
3. Benthesicymus cereus/iridescens
4. Hepomadus ? glacialis
5. Hepomadus tener
6. Hemipenaeus carpenteri

Caridea

Species with Maximum Population in Zone

1. Nematocarcinus acanthitelsonis

Other Species that Live in the Zone

2. Nematocarcinus ensifer
3. Pontophilus talismani

Anomura - Galatheidae

Species with Maximum Population in Zone
(species in rank order)

1. Munidopsis geyeri

Anomura except Galatheidae
Paguridae

Species that Live in the Zone

1. Parapagurus spp.

Mesoabyssal Zone - Horizon D (2725-3200 m) - continued

Porcellanidae, Uroptychidae, & Lithodidae

(no species collected in this zone)

Brachyura

Species that Live in the Zone

1. Ethusina abyssicola

Macrura

Polychelidae

Species that Live in the Zone

1. Polycheles validus
2. Stereomastis s. sculpta

Nephropidae & Callianassidae, Arciidae, & Scyllaridae

(no species collected in this zone)

Cirripedia

Species with Maximum Population in Zone
(species in rank order)

1. Scalpellum sp.

Isopoda

(no species collected in this zone)

Stomatopoda

(no species collected in this zone)

Pycnogonida

(no species collected in this zone)

Miscellaneous Crustacea

(no species collected in this zone)

Mesoabyssal Zone - Horizon D (2725-3200 m) - continued

Gastropoda

Species with Maximum Population in Zone
(species in rank order)

1. Gymnobela bairdi
2. Solariella infundibulum
3. Turrid sp. 6
4. Pleurotomella cf. bairdii
5. Acteon sp. 1
6. Gymnobela blakeana
7. unidentified Buccinidae
8. Phymorhynchus sp. 2
9. Sequenzia sp. 1

Other Species that Live in the Zone

10. Oocorys sulcata
11. Leucosyrinx verrilli
12. Corinnaeturris leucomata
13. Leucosyrinx cf. sigsbei
14. Trophon aculeatus
15. Theta jeffreysi
16. Calliotropis calatha
17. Fusinus sp.

Bivalvia

Species with Maximum Population in Zone
(species in rank order)

1 Brevinucula verrilli
2. Poromya tornata
3. Tindariopsis aeolata
4. Pristigloma nitens
5. Yoldiella sp. A

Other Species that Live in the Zone

6. Abra longicalis americana
7. Nucula callicredemna
8. Cetoconcha bulla
9. Cardiomya sp.
10. Bathyarca asperulla
11. Neilo sp. A
12. Neilonella guineensis
13. Malletia sp. A

Scaphopoda

Species with Maximum Population in Zone
(species in rank order)

1. Dentalium ensiculus

Other Species that Live in the Zone

2. Dentalium perlongum
3. Dentalium meridionale

Mesoabyssal Zone - Horizon D (2725-3200 m) - continued

Cephalopoda

Species with Maximum Population in Zone

1. Tremoctopus violaceus

Other Species that Live in the Zone

2. Onychoteuthis banksii

Polychaeta

Species with Maximum Populations in Zone
(species in rank order)

1. Eunice pennata
2. unidentified Lumbrineridae
3. unidentified Sabellidae
4. unidentified Maldaninae
5. unidentified Ampharetinae

Other Species that Live in the Zone

6. Rhamphobrachium agassizi
7. Nothria sp. A
8. unidentified Oweniidae
9. unidentified Opheliidae
10. Myriochele sp. B
11. Spiochaetopterus sp.
12. Onuphis microcephala
13. unidentified Chaetopteridae
14. Maldane sp. B
15. Myriochele sp. A, n. sp.
16. Lanice/Eupolymnia sp.
17. Paradiopatra solenotecton
18. Hyalinoecia tubicola
19. Onuphis sp.
20. Maldane sp.
21. Travisia forbesii
22. Amelinna sp.
23. unidentified Onuphidae

Porifera

Species that Live in the Zone

1. Tylodesma sp.
2. unidentified Dictyonina
3. Thenea fenestrata
4. Dactylocalyx sp.
5. Thenea sp.
6. Radiella sol
7. Euplectella sp.
8. Hyalonema sp. B
9. Hyalonema sp. A
10. Radiella sp.

Mesoabyssal Zone - Horizon D (2725-3200 m) - continued

Hydrozoa

(no species collected in this zone)

Alcyonacea

(no species collected in this zone)

Pennatulacea

Species that Live in the Zone

1. Umbellula sp. A

Scleractinea

(no species collected in this zone)

Sipuncula

Species with Maximum Population in Zone

1. Golfingia sp. 2 (cf. flagrifera)

Other Species that Live in the Zone

2. Golfingia flagrifera

Bryozoa

Species that Live in the Zone

1. Nellia oculata

Brachiopoda

Species with Maximum Population in Zone

1. Pelagodiscus atlanticus

Other Species that Live in the Zone

2. Chlidonophora incerta

Lower Abyssal Zone (3225-3850 m)

If we assume that the Lower Abyssal Zone begins near the bottom of the slope's escarpments, i.e., at the intersection with the continental rise, its megafauna is depauperate but not to the degree expected by the drop in diversity observed between the Upper Abyssal and Mesoabyssal Zones. Furthermore, this zone has an interesting assemblage of benthic species that do not occur elsewhere.

Demersal Fishes

Acanthonus armatus
Tauredophidium hextii
Bassogigas sp.
Haptenchelys texis

Asteroidea

Ampheraster alaminos
Hydrasterias ophidion

Holothuroidea

Psychropotes semperiana
Psychropotes cf. longicauda

Echinoidea

Aceste bellidifera

Ophiuroidea

Amphilepis sp.

Caridea

Acanthephyra microphthalma
Acanthephyra acutifrons

Galatheidae

Munidopsis bermudezi
Munidopsis sundi
Munidopsis columbiana

Macrura (Polychelidae)

Willemoesia forceps

Cirripedia

Scalpellum spicatum
Arcoscalpellum vitreum

Tanaidacea

Apseudes (Leiopus) sp. D (cf. S. sibogae)

Gastropoda

Acteon sp. 2
Acteon sp. 4
Acteon sp. 1
Relichna simplex
Relichna sp.
Crenilabium exilis
Turrid sp. 8

Bivalvia

Cuspidaria glacialis

Cephalopoda

Histioteuthis corona corona
Grimpoteuthis sp. A
Octopoteuthis megaptera

Polychaeta

Maldanella sp.
Hyalopomatus langerhousi
Phyllochaetopterus sp.
Eunoe sp. ?

Sipuncula

Phascolosoma sp. 1
Golfingia sp. 1

We have separated the Lower Abyssal Zone into the Active East and Tranquil West subdivisions. This is intended to reflect the fact that bottom currents have been detected in the east but not in the west. Also, there is a marked difference in the sediments between the two subdivisions. Menzies et al., (1973) recognized a Lower Abyssal Tranquil Zone in the southeast Pacific Ocean (Peru). It was established at depths ranging between 5000 and 6280 m. Interestingly enough, however, the megafaunal species that they list as characteristic of this zone have counterparts in the Gulf of Mexico, to wit:

Southeast Pacific	Gulf of Mexico
Ophiomusium lymani	Ophiomusium planum
Pseudostichopus sp.	Pseudostichopus sp.
Psychropotes longicauda	Psychropotes cf. longicauda
Peniagone sp.	(Peniagone sp. present but not so deep)

It should also be pointed out that the Psychropotes longicauda and related sea cucumbers are not found in the Active East subdivisions where they could not maintain their position in moving water. In such active areas the very flat and streamlined Benthodytes typica is found.

Demersal Fishes

Species with Maximum Population in Zone

1. Bassozetus sp.
2. Barathronus bicolor
3. Bathytroctes macrolepis
4. Hemipterois sp.
5. Acanthonus armatus
6. Tauredophidium hextii
7. Bassogigas sp.
8. Haptenchelys texis

Other Species that Live in the Zone

9. Bassozetus normalis
10. Bathytroctes sp.
11. Ilyophis brunneus
12. unidentified Ophidiidae
13. Bathyonus pectoralis
14. Coryphaenoides sp.
15. unidentified Synaphobranchidae

Asteroidea

Species with Maximum Population in Zone

1. Dytaster insignis
2. Ampheraster alaminos
3. Litonotaster intermedius
4. Paragonaster subtilis
5. Hydrasterias ophidion

Other Species that Live in the Zone

6. Dipsacaster antillensis

Holothuroidea

Species with Maximum Population in Zone
(species in rank order)

1. Benthodytes typica
4. Pseudostichopus sp.

Lower Abyssal Zone (3225-3850 m) - continued

2. Psychropotes semperiana
3. Benthodytes lingua
5. Pseudostichopus sp. A

Other Species that Live in the Zone

6. Molpadia oolitica
7. Psychropotes depressa
8. Paelopatides cf. gigantea
9. Molpadia blakei

Echinoidea

Species with Maximum Population in Zone

1. Aceste bellidifera

Ophiuroidea

Species with Maximum Population in Zone

1. Ophiomusium planum
2. Amphilepis sp.

Other Species that Live in the Zone

3. Bathypectinura heros
4. Amphilepis norvegica
5. Ophiomusium eburneum

Crinoidea

(no species collected in this zone)

Penaeidae

Species with Maximum Population in Zone

1. Benthesicymus cereus/iridescens
2. Hemipenaeus carpenteri
3. Hepomadus ? glacialis

Other Species that Live in the Zone

4. Hymenopenaeus aphoticus
5. Hepomadus tener
6. Plesiopenaeus armatus

Caridea

Species with Maximum Population in Zone

1. Acanthephyra microphthalma
2. Acanthephyra acutifrons

Lower Abyssal Zone (3225-3850 m) - continued

Other Species that Live in the Zone

3. Nematocarcinus acanthitelsonis
4. Pontophilus talismani
5. Nematocarcinus ensifer

Anomura - Galatheidae

Species with Maximum Population in Zone
(species in rank order)

1. Munidopsis bermudezi
2. Munidopsis columbiana
3. Munidopsis sundi

Anomura except Galatheidae
Paguridae

Species with Maximum Population in Zone

1. Parapagurus spp.

Uroptychidae, Porcellanidae, & Lithodidae

(no species collected in this zone)

Brachyura

Species with Maximum Population in Zone

1. Ethusina abyssicola

Macrura
Polychelidae

Species with Maximum Population in Zone

1. Willemoesia forceps

Other Species that Live in the Zone

2. Polycheles validus

Cirripedia

Species with Maximum Population in Zone

1. Scalpellum spicatum
2. Arcoscalpellum vitreum

Lower Abyssal Zone (3225-3850 m) - continued

Isopoda

(no species collected in this zone)

Stomatopoda

(no species collected in this zone)

Pycnogonida

(no species collected in this zone)

Miscellaneous Crustacea

Tanaidacea

Species with Maximum Population in Zone

1. Apseudes (Leiopus) sp. D (cf. S. sibogae)

Gammaridea

(no species collected in this zone)

Gastropoda

Species with Maximum Population in Zone

1. Fusinus sp.
2. Acteon sp. 2
3. Acteon sp. 4
4. Relichna simplex
5. Relichna sp.
6. Crenilabium exilis
7. Turrid sp. 8
8. Acteon sp. 1

Other Species that Live in the Zone

9. Oocorys sulcata
10. Corinnaeturris leucomata
11. Leucosyrinx cf. sigsbei
12. Trophon aculeatus
13. Theta jeffreysi
14. Calliotropis calatha
15. Turrid sp. 6

Bivalvia

Species with Maximum Population in Zone

1. Nucula callidredemna
2. Neilo sp. A
3. Bathyarca asperula
4. Cetoconcha bulla
5. Malletia sp. A
6. Neilonella guineensis
7. Cardiomya sp.
8. Cuspidaria glacialis

Lower Abyssal Zone (3225-3850 m) - continued

Other Species that Live in the Zone

9. Poromya tornata
10. Brevinucula verrilli
11. Tindariopsis aeolata

Scaphopoda

Species with Maximum Population in Zone

1. Dentalium meriodionale

Other Species that Live in the Zone

2. Dentalium ensiculus
3. Dentalium perlongum

Cephalopoda

Species with Maximum Population in Zone

1. Onychoteuthis banksii
2. Grimpoteuthis sp. A
3. Histioteuthis corona corona
4. Octopoteuthis megaptera

Polychaeta

Species with Maximum Populations in Zone
(species in rank order)

1. unidentified Onuphidae
2. Amelinna sp.
3. Maldanella sp.
4. Phyllochaetopterus sp.
5. Hyalopomatus langerhansi
6. Eunoe sp. ?

Other Species that Live in the Zone

7. Myriochele sp. A, n. sp.
8. Paradiopatra cf. solenotecton
9. unidentified Opheliidae
10. Nothria sp. A
11. Onuphis sp.
12. Maldane sp. B
13. Maldane sp.
14. Travisia forbesii ?
15. Rhamphobrachium agassizi
16. Hyalinoecia tubicola
17. unidentified Oweniidae

Porifera

Species that Live in the Zone

1. unidentified Dictyonina
2. Thenea fenestrata
3. Thenea sp.
4. Radiella sol
8. Radiella sp.
9. unidentified Suberitidae
10. Fangophilina sp.
11. Dactylocalyx sp.

Lower Abyssal Zone (3225-3850 m) - continued

5. Euplectella sp.
6. Hyalonema sp. B
7. Hyalonema sp. A
12. Desmacidon sp.
13. Geodia sp. B
14. Holoxea sp.

Hydrozoa

(no species collected in this zone)

Alcyonacea

(no species collected in this zone)

Pennatulacea

Species that Live in the Zone

1. Umbellula sp. A

Scleractinea

(no species collected in this zone)

Antipatharia

(no species collected in this zone)

Sipuncula

Species with Maximum Population in Zone
(species in rank order)

1. Phascolosoma sp. 1
2. Golfingia sp. 1

Other Species that Live in the Zone

3. Golfingia sp. 2 (cf. flagrifera)

Bryozoa

(no species collected in this zone)

Lower Abyssal Zone (3225-3850 m) - continued

Brachiopoda

Species with Maximum Population in Zone

1. Chlidonophora incerta

Other Species that Live in the Zone

2. Pelagodiscus atlanticus

SPECIES DIVERSITY

A useful paramter of ecological assemblages or communities is species richness or diversity. As all communities do not contain equivalent numbers of species, the species diversity index can be an important device for comparing such groups. The simplest method would seem to be to compare the number of species occurring in each group being examined. Unfortunately this approach has two serious shortcomings which are amplified by application to deep-water studies. First, it is often difficult to obtain benthonic, deep water samples which are reliably representative of the species in a community. This emphasizes the point that we are constrained to deal with samples rather than whole assemblages. Moreover, species counts are dependent upon sample size which, in turn, is often dependent upon the type or types of sampling gear used. Further, a particular sampling device can be expected to vary in efficiency when sampling in various substrata. Second, the number of individuals is not necessarily related to the number of species. That is, simple counts do not include the quality of equitability in the estimate of species diversity. Equitability measures the evenness of distribution of individuals among the species. Thus, species diversity, conversely to dominance diversity, is greater when the individuals are more evenly distributed among the species.

The present study uses the Shannon-Wiener function to calculate species diversity indices for each collecting station as well as for data pooled by 50-meter depth ranges (i.e., 1200 m values would contain data from stations from 1175 m to 1225 m depths). This function is somewhat dependent upon sample size, but is affected primarily by the number of species and equitability. Thus, in comparing two stations the one with the larger number of species will have the larger index but the magnitude of the difference will depend on the evenness of distribution of individuals. Maximal diversity for a given number of species occurs when each species is represented by an equal number of individuals. This situation usually only occurs in very small samples which typically have a single individual for each of two or three species.

From the Shannon-Wiener function,

$$H' = - \sum_{i=1}^{S} P_i \log_2 P_i$$

where, H' = index of species diversity
S = number of species in the sample, and
P_i = proportion of total sample belonging to the ith species,

one can calculate equitability. First, one determines Hmax, the maximal diversity obtainable by every species being represented by an equal number of individuals; Hmax being determined by $\log_2 S$. The ratio of H'/Hmax is defined as equitability (HR).

Species diversity indices (H'), maximal diversity values (Hmax), and equitability (HR) are shown in Table 63 and 64 for each depth interval. Table 64 values were determined after correcting for patchiness in sample distributions. Following procedures used by Rex (in press) species represented by an inordinately large number of individuals in a given sample were removed from determinations of diversity for that sample. Table 65 shows diversity indices and maximal diversity for each deep Gulf of Mexico station with comments pertinent to the possible causes of any substantial difference between H' and Hmax for each.

Values of H' and Hmax are plotted by depth in Figure 95 with values determined after samples had been corrected for patchiness given in Figure 96.

The difference between H' and Hmax may be attributed to any one or more of various factors:

(1) A certain sampling gear may not be appropriate for sampling a particular habitat (e.g., difference between 69A11-12 taken by a dredge and 69A11-13 taken by a skimmer).

(2) The sampling gear may not be adequate for sampling most species equally effectively.

(3) One or more species may tend to congregate in large numbers (e.g., station 69A11-13 with a disproportionately large number of carideans).

When corrected for patchy distribution and those stations with samples insufficient for analysis are eliminated, the species diversity indices show a general tendency to decrease with depth. Closer inspection, however indicates an initial increase of H' with depth to about 950 meters, where the highest calculated diversity (H'=5.25) occurs, followed by a gradual decrease with depth.

Analysis of variance indicates a significant difference at the 95% confidence level between diversity indices of the Shelf/Slope Transition, the Archibenthal Horizon A and Horizon B, and the Upper Abyssal and the Mesoabyssal Horizon C. No significant difference at the 95% level appears between the Archibenthal Horizon A and Horizon B, nor between the Mesoabyssal Horizon C, Horizon D, and the Lower Abyssal. Thus, based upon the distribution of species diversity, the zones appear to be divided into four distinct groups: 1) Shelf/Slope Transition, 2) Archibenthal Horizons A and B, 3) Upper Abyssal, and 4) Mesoabyssal Horizons C and D combined with the Lower Abyssal. Mean values of species diversity indices for each of these groups are 4.35, 4.81, 3.97, and 3.09 respectively.

Table 63. Species diversity indices by depth interval. Asterisk (*) indicates no sample was taken at this depth.

Depth Interval (m)	Diversity (H')	Maximal Diversity (Hmax)	Equitability (HR)	Number of Species (S)	Number of Individuals (N)
50	2.84	4.58	0.62	24	193
100	4.79	6.09	0.79	68	424
150	4.96	6.46	0.77	88	1083
200	2.23	6.77	0.33	109	18580
250	4.34	5.93	0.73	61	687
300	3.50	4.95	0.71	31	355
350	2.57	4.81	0.53	28	428
400	3.46	6.09	0.57	68	1583
450	4.12	4.64	0.89	25	77
500	4.08	6.38	0.64	83	1756
550	4.08	6.46	0.63	88	1994
600	3.49	6.41	0.54	85	2172
650	4.69	6.02	0.78	65	408
700	3.89	6.51	0.60	91	1551
750	4.88	6.71	0.73	105	992
800	4.31	6.07	0.71	67	715
850	4.16	4.75	0.88	27	91
900	4.25	6.19	0.69	73	1580
950	0.95	6.89	0.14	119	23200
1000	2.17	6.46	0.34	88	6139
1050	4.60	6.28	0.73	78	1608
1100	4.18	5.93	0.71	61	2037
1150	4.04	5.52	0.73	46	731
1200	3.78	5.81	0.65	56	1327
1250	1.21	4.64	0.26	25	1636
1300	2.90	4.91	0.59	30	672
1350	2.32	5.70	0.41	52	2967
1400	3.53	5.61	0.63	49	769
1450	4.19	5.39	0.78	42	232
1500	3.59	3.81	0.94	14	23
1550*				0	0
1600*				0	0
1650	1.38	1.58	0.87	3	7
1700	1.00	1.00	1.00	2	2
1750	4.32	4.95	0.87	31	110
1800*				0	0
1850	3.85	4.64	0.83	25	60
1900*				0	0
1950*				0	0
2000	3.26	3.70	0.88	13	30
2050	4.13	4.75	0.87	27	80
2100	2.76	5.64	0.49	50	1066
2150	3.02	5.00	0.60	32	278
2200	2.42	3.70	0.65	13	106
2250	3.94	4.91	0.80	30	123

Table 63 continued

Depth Interval (m)	Diversity (H')	Maximal Diversity (Hmax)	Equitability (HR)	Number of Species (S)	Number of Individuals (N)
2300	0.81	1.00	0.81	2	4
2350	3.26	4.25	0.77	19	90
2400*				0	0
2450	3.57	4.25	0.84	19	72
2500	2.64	2.81	0.94	7	9
2550	0	0	?	1	1
2600*				0	0
2650	3.84	4.25	0.90	19	54
2700*				0	0
2750	3.59	4.39	0.82	21	119
2800	2.93	3.17	0.92	9	18
2850*				0	0
2900*				0	0
2950	0.88	2.32	0.38	5	34
3000	3.21	3.81	0.84	14	52
3050*				0	0
3100	2.51	3.46	0.73	11	33
3150*				0	0
3200	0.81	1.00	0.81	2	4
3250	2.21	5.32	0.41	40	1035
3300	3.01	4.39	0.68	21	84
3350	1.82	3.58	0.51	12	116
3400	0.92	1.00	0.92	2	3
3450	2.25	2.32	0.97	5	6
3500	0	0	?	1	1
3550	0.92	1.00	0.92	2	3
3600*				0	0
3650	2.59	2.81	0.92	7	11
3700	2.84	3.81	0.75	14	68
3750	3.10	3.70	0.84	13	36
3800*				0	0
3850	3.77	3.81	0.99	14	15

Table 64. Species diversity indices (corrected for patchiness; eliminating stations with samples insufficient for diversity analysis). One asterisk (*) indicates no sample was taken at this depth, two asterisks (**) indicates the sample was insufficient for diversity analysis.

Depth Interval (m)	Diversity (H')	Maximal Diversity (Hmax)	Equitability (HR)	Number of Species (S)	Number of Individuals (N)
50	3.99	4.46	0.90	22	61
100	4.79	6.09	0.79	68	424
150	4.96	6.46	0.77	88	1083
200	5.06	6.70	0.76	104	2065
250	4.34	5.93	0.73	61	687
300	3.50	4.95	0.71	31	355
350	3.96	4.64	0.85	25	82
400	4.46	6.04	0.74	66	723
450	4.12	4.64	0.89	25	77
500	4.85	6.32	0.77	80	825
550	4.99	6.44	0.77	87	1248
600	4.84	6.38	0.76	83	984
650	4.69	6.02	0.78	65	408
700	5.14	6.49	0.79	90	878
750	4.88	6.71	0.73	105	992
800	4.42	6.04	0.73	66	588
850	4.16	4.75	0.88	27	91
900	4.88	6.15	0.79	71	941
950	5.25	6.88	0.76	118	2196
1000	4.53	6.46	0.70	87	1772
1050	4.60	6.28	0.73	78	1608
1100	4.18	5.93	0.71	61	2037
1150	4.04	5.52	0.73	46	731
1200	4.27	5.75	0.74	54	740
1250	3.51	4.58	0.77	24	265
1300	3.49	4.75	0.73	27	173
1350	4.27	5.52	0.77	46	267
1400	3.99	5.58	0.71	48	502
1450	4.19	5.39	0.78	42	232
1500	3.59	3.81	0.94	14	23
1550*				0	0
1600*				0	0
1650**				3	7
1700**				2	2
1750	4.32	4.95	0.87	31	110
1800*				0	0
1850	3.85	4.64	0.83	25	60
1900*				0	0
1950*				0	0
2000	3.26	3.70	0.88	13	30
2050	4.13	4.75	0.87	27	80
2100	4.14	5.58	0.74	48	331
2150	4.17	4.95	0.84	31	135

Table 64 continued

Depth Interval (m)	Diversity (H')	Maximal Diversity (Hmax)	Equitability (HR)	Number of Species (S)	Number of Individuals (N)
2200	2.90	3.58	0.81	12	52
2250	3.94	4.91	0.80	30	123
2300**				2	4
2350	3.26	4.25	0.77	19	90
2400*				0	0
2450	3.57	4.25	0.84	19	72
2500	2.64	2.81	0.94	7	9
2550**				1	1
2600*				0	0
2650	3.84	4.25	0.90	19	54
2700*				0	0
2750	3.59	4.39	0.82	21	119
2800	2.93	3.17	0.91	9	18
2850*				0	0
2900*				0	0
2950	1.92	2.00	0.96	4	5
3000	3.21	3.81	0.84	14	52
3050*				0	0
3100	2.51	3.46	0.73	11	33
3150*				0	0
3200**				2	4
3250	4.26	5.25	0.81	38	197
3300	3.22	4.32	0.74	20	54
3350	2.99	3.46	0.86	11	36
3400**				2	3
3450	2.25	2.32	0.97	5	6
3500**				1	1
3550**				2	3
3600*				0	0
3650	2.59	2.81	0.92	7	11
3700	2.84	3.81	0.75	14	68
3750	3.10	3.70	0.84	13	36
3800*				0	0
3850	3.77	3.81	0.99	14	15

Table 65. Shannon-Wiener diversity functions (H') and maximal indices (Hmax) for the stations. Some explanatory statements are provided where appropriate under Comments.

	Station	Depth (m)	Gear*	H'	Hmax	Comments
1.	64A10-3	789	D	0.00	0.00	Very small sample; single crab
2.	64A10-13C	151	D	2.60	3.32	Small sample
3.	64A13-1	210	D&G	2.07	2.81	Small sample
4.	64A13-2C	549	D	0.41	1.00	Very small sample; two crab species
5.	65A3-2	2321	D	0.81	1.00	Very small sample; two fish species
6.	65A3-4	3563	D	0.92	1.00	Very small sample; two species
7.	65A3-6	240	D	1.00	1.00	Very small sample; two specimens
8.	65A9-25	797	D	2.16	2.58	Small sample
9.	65A9-26	81	G	1.50	1.58	Very small sample; three species
10.	66A5-3#2	3109	D	0.00	0.00	Very small sample; single barnacle
11.	66A5-3#3	3212	D	0.00	0.00	Very small sample; single species holothuroid
12.	66A5-3#4	3214	D	0.00	0.00	Very small sample; single holothuroid
13.	66A5-4	1143	D	0.86	1.00	Very small sample; two species echinoderms
14.	66A5-5	1682	D	1.00	1.00	Very small sample; two species echinoderms
15.	66A5-6	793	D	0.00	0.00	Very small sample; single barnacle species
16.	66A5-7	350	D	0.00	0.00	Very small sample; single macruran
17.	66A9-15	1000	T	2.97	4.64	Disproportionate number of ophiuroids and holothuroids
18.	66A9-17	589	G	0.00	0.00	Very small sample; single echinoid
19.	66A16-1	329	D	0.00	0.00	Very small sample; single barnacle
20.	67A5-1A	1020	SK	1.00	1.00	Very small sample; two echinoderms
21.	67A5-2H	1829	SK	3.02	3.91	Small sample; disproportionate number of ophiuroids
22.	67A5-4G	2651	SK	2.69	2.81	Very small sample; seven species

* D - Dredge
G - Grab
T - Trawl
SK - Skimmer
CD - Canvas Dredge
OT - Otter Trawl
QD - Quant. Dredge

Table 65 continued

Station		Depth (m)	Gear*	H'	Hmax	Comments
23.	67A5-5D	1454	SK	2.98	3.17	Small sample
24.	67A5-6B	788	SK	3.07	4.00	Small sample; disproportionate number of carideans
25.	67A5-6E	788	D	0.00	0.00	Very small sample; single species barnacle
26.	67A5-7C	853	SK	3.34	3.91	Small sample
27.	67A5-7E	752	D	1.84	2.00	Very small sample; four species echinoderms
28.	67A5-8B	1494	SK	3.32	3.46	Small sample
29.	67A5-8B	1494	D	2.11	2.32	Very small sample; five species
30.	67A5-9A	752	SK	4.23	5.13	Good sample
31.	67A5-9E	640	D	0.00	0.00	Very small sample; single holothuroid
32.	67A5-10B	95	SK	0.82	1.58	Very small sample; three species
33.	67A5-11C	190	D	2.63	2.81	Small sample
34.	67A5-13B	379	D	1.58	1.58	Very small sample; three species
35.	67A5-13E	379	SK	2.77	3.58	Small sample; disproportionate number of crabs
36.	67A5-14A	2434	D	0.00	0.00	Very small sample; single holothuroid
37.	67A5-14E	2367	SK	3.26	4.25	Small sample; disproportionate number of ophiuroids
38.	67A5-15F	3092	SK	2.26	3.17	Very small sample; nine species; disproportionate number of holothuroids
39.	67A5-15G	3080	D	0.00	0.00	Very small sample; single ophiuroid
40.	67A5-16E	3255	SK	2.51	3.00	Small sample
41.	68A3-3B	3658	SK	2.59	2.81	Small sample
42.	68A3-10B	988	Sk	1.24	3.00	Disproportionate number of echinoids
43.	68A7-1A	696	SK	4.56	5.52	Good sample
44.	68A7-2A	408	SK	2.01	2.81	Small sample; disproportionate number of penaeids
45.	68A7-2B	595	SK	1.82	2.32	Very small sample; five species
46.	68A7-2C	696	SK	2.81	3.70	Small sample
47.	68A7-3C	2743	SK	3.12	4.00	Small sample
48.	68A7-4A	3237	SK	2.32	4.00	Small sample; disproportionate number of ophiuroids and holothuroids
49.	68A7-4E	3255	SK	2.50	3.91	Small sample; disproportionate number of ophiuroids and holothuroids
50.	68A7-7A	2809	SK	0.72	1.00	Very small sample; two species
51.	68A7-7B	1097	SK	2.86	3.00	Small sample
52.	68A7-8A	190	CD	0.70	1.58	Very small sample; three species
53.	68A7-8C	199	SK	3.97	4.58	Good sample

Table 65 continued

	Station	Depth (m)	Gear*	H'	Hmax	Comments
54.	68A7-9A	384	SK	1.88	4.09	Disproportionate number of penaeids and carideans
55.	68A7-10A	566	SK	3.58	4.91	Disproportionate number of ophiuroids
56.	68A7-12A	585	D	0.00	0.00	Very small sample; single species
57.	68A7-12B	900	SK	3.97	4.95	Disproportionate number of carideans, macrourid fish, and holothuroids
58.	68A7-13A	1061	SK	4.08	4.86	Slightly disproportionate number of crabs
59.	68A7-13B	1399	SK	3.28	3.81	Small sample
60.	68A7-13D	1463	SK	3.56	4.09	Good sample
61.	68A7-14B	1829	SK	3.82	4.00	Small sample
62.	68A7-14C	2103	SK	1.43	4.46	Disproportionate number of echinoids
63.	68A7-15D	1097	SK	3.78	4.39	Good sample
64.	68A7-15H	914	SK	3.96	4.52	Disproportionate number of macrurans, asteroids, carideans, and fish
65.	68A7-16C	2140	SK	1.60	3.32	Disproportionate number of echinoids
66.	68A7-17B	900	SK	3.56	4.25	Disproportionate number of ophiuroids, carideans, and penaeids
67.	68A13-1	878	SK	2.97	5.09	Disproportionate number of echinoids and barnacles
68.	68A13-3	713	D	3.26	3.70	Small sample
69.	68A13-4	512	SK	3.19	5.17	Disproportionate number of crabs
70.	68A13-5	274	SK	2.55	4.39	Disproportionate number of penaeids and echinoids
71.	68A13-7	274	SK	2.99	4.46	Disproportionate number of penaeids and echinoids
72.	68A13-8	732	SK	3.65	4.86	Disproportionate number of carideans and echinoids
73.	68A13-9	3365	SK	1.82	3.58	Disproportionate number of holothuroids
74.	68A13-10	3438	D	2.25	2.32	Very small sample; five species
75.	68A13-11	1216	SK	3.50	4.25	Small sample
76.	68A13-12A	1189	SK	2.88	5.25	Disproportionate number of ophiuroids, echinoids, crabs, and carideans
77.	68A13-14	969	D	0.94	4.64	Disproportionate number of echinoids
78.	68A13-15	759	SK	3.12	4.58	Disproportionate number of ophiuroids
79.	68A13-16	713	D	2.00	2.00	Very small sample; four specimens
80.	68A13-17	183	SK	3.07	3.32	Good sample

Table 65 continued

Station		Depth (m)	Gear*	H'	Hmax	Comments
81.	68A13-18	439	D	3.16	3.46	Small sample
82.	68A13-19	361	SK	2.94	3.58	Small sample
83.	68A13-21	576	SK	3.43	5.13	Disproportionate number of crabs and ophiuroids
84.	68A13-22	476	D	1.56	3.00	Small sample; disproportionate number of crabs
85.	68A13-23	732	SK	3.33	5.00	Disproportionate number of ophiuroids and echinoids
86.	68A13-24	878	SK	2.84	4.86	Disproportionate number of crabs and macrurans
87.	68A13-26	1404	SK	3.28	4.58	Disproportionate number of crabs and carideans
88.	68A13-27	1134	SK	2.85	4.52	Disproportionate number of ophiuroids and carideans
89.	69A11-2	942	SK	2.56	2.81	Small sample
90.	69A11-4	1006	SK	3.37	4.39	Disproportionate number of carideans
91.	69A11-7	1399	SK	3.23	4.09	Disproportionate number of carideans
92.	69A11-12	1463	D	1.52	1.58	Very small sample; three species
93.	69A11-13	1463	SK	3.21	4.25	Disproportionate number of carideans
94.	69A11-14	2432	SK	1.30	1.58	Very small sample; three species
95.	69A11-17	3292	SK	2.32	2.32	Very small sample; five species
96.	69A13-4	1984	SK	0.99	1.58	Very small sample; three species
97.	69A13-28	3239	SK	2.29	2.58	Small sample
98.	69A13-29	3230	SK	1.93	3.58	Small sample; disproportionate number of ophiuroids and holothuroids
99.	69A13-37	3001	SK	3.21	3.81	Small sample
100.	69A13-38	2736	SK	2.88	3.17	Very small sample; nine species
101.	69A13-39	2105	SK	2.32	2.32	Very small sample; five species
102.	69A13-40	476	SK	3.32	4.00	Small sample
103.	69A13-41	311	SK	2.39	3.81	Small sample; disproportionate number of penaeids
104.	69A13-42	183	OT	3.53	4.46	Disproportionate number of echinoids and penaeids
105.	69A13-43	210	SK	3.14	3.91	Small sample
106.	69A13-44	752	OT	3.76	5.28	Disproportionate number of macrurans and carideans
107.	69A13-45	82	SK	1.38	2.81	Small sample; disproportionate number of penaeids
108.	70A10-58	3248	T	0.95	3.46	Disproportionate number of ophiuroids
109.	71A7-4	576	SK	1.00	1.00	Very small sample; two specimens
110.	71A7-7	874	SK	2.53	3.17	Small sample

Table 65 continued

	Station	Depth (m)	Gear*	H'	Hmax	Comments
111.	71A7-9	906	T	3.23	4.86	Disproportionate number of crabs and holothuroids
112.	71A7-10	937	T	3.34	5.17	Disproportionate number of crabs, holothuroids, and fish
113.	71A7-11	636	T	4.56	5.85	Disproportionate number of fish and carideans
114.	71A7-16	939	QD	0.00	0.00	Very small sample; single specimen
115.	71A7-17	204	QD	0.54	1.00	Very small sample; two species
116.	71A7-18	229	T	4.17	4.75	Good sample
117.	71A7-20	229	SK	0.92	1.00	Very small sample; two species
118.	71A7-23	210	SK	0.00	0.00	Very small sample; single individual
119.	71A7-32	192	SK	1.58	1.58	Very small sample; three species
120.	71A7-34	192	T	4.39	5.58	Many fish
121.	71A7-38	534	T	4.11	4.64	Good sample
122.	71A7-41	732	SK	0.00	0.00	Very small sample; single species
123.	71A7-42	936	SK	2.72	2.81	Very small sample; six species
124.	71A7-43	992	T	4.27	5.39	Disproportionate number of crabs, carideans, and fish
125.	71A7-47	878	SK	0.92	1.00	Very small sample; two species
126.	71A7-49	937	T	4.10	5.09	Disproportionate number of fish, macrurans, and carideans
127.	71A7-56	538	T	3.90	5.32	Disproportionate number of crabs, asteroids, and fish
128.	71A7-57	1225	T	3.97	4.75	Disproportionate number of carideans and macrurans
129.	71A7-62	1198	SK	1.00	1.00	Very small sample; two species
130.	71A7-65	237	SK	3.66	3.91	Small sample
131.	71A8-3	1196	SK	1.37	1.58	Very small sample; three species
132.	71A8-4	1364	SK	1.50	1.58	Very small sample; three species
133.	71A8-8	2057	T	4.13	4.75	Good sample
134.	71A8-10	2077	T	3.43	4.09	Small sample
135.	71A8-11	3287	T	1.90	2.81	Small sample; disproportionate number of holothuroids and asteroids
136.	71A8-13	3267	T	2.10	4.00	Disproportionate number of holothuroids and ophiuroids
137.	72A13-32	1774	T	2.93	3.32	Small sample
138.	72A13-39	1061	T	4.03	5.64	Disproportionate number of crabs, carideans, asteroids, and fish
139.	72A13-45	412	T	3.41	4.95	Disproportionate number of penaeids, macrurans, and carideans
140.	72A13-49	585	T	2.92	5.64	Disproportionate number of crabs, ophiuroids, and echinoids

Table 65 continued

Station		Depth (m)	Gear*	H'	Hmax	Comments
141.	72A13-51	1376	T	2.87	4.86	Disproportionate number of crabs, carideans, and macrurans
142.	72A13-53	1161	T	3.43	4.95	Disproportionate number of carideans and macrurans
143.	73A2-8	869	T	3.21	3.32	Very small sample; ten species
144.	73A10-20	970	OT	3.36	5.32	Disproportionate number of crabs, and carideans

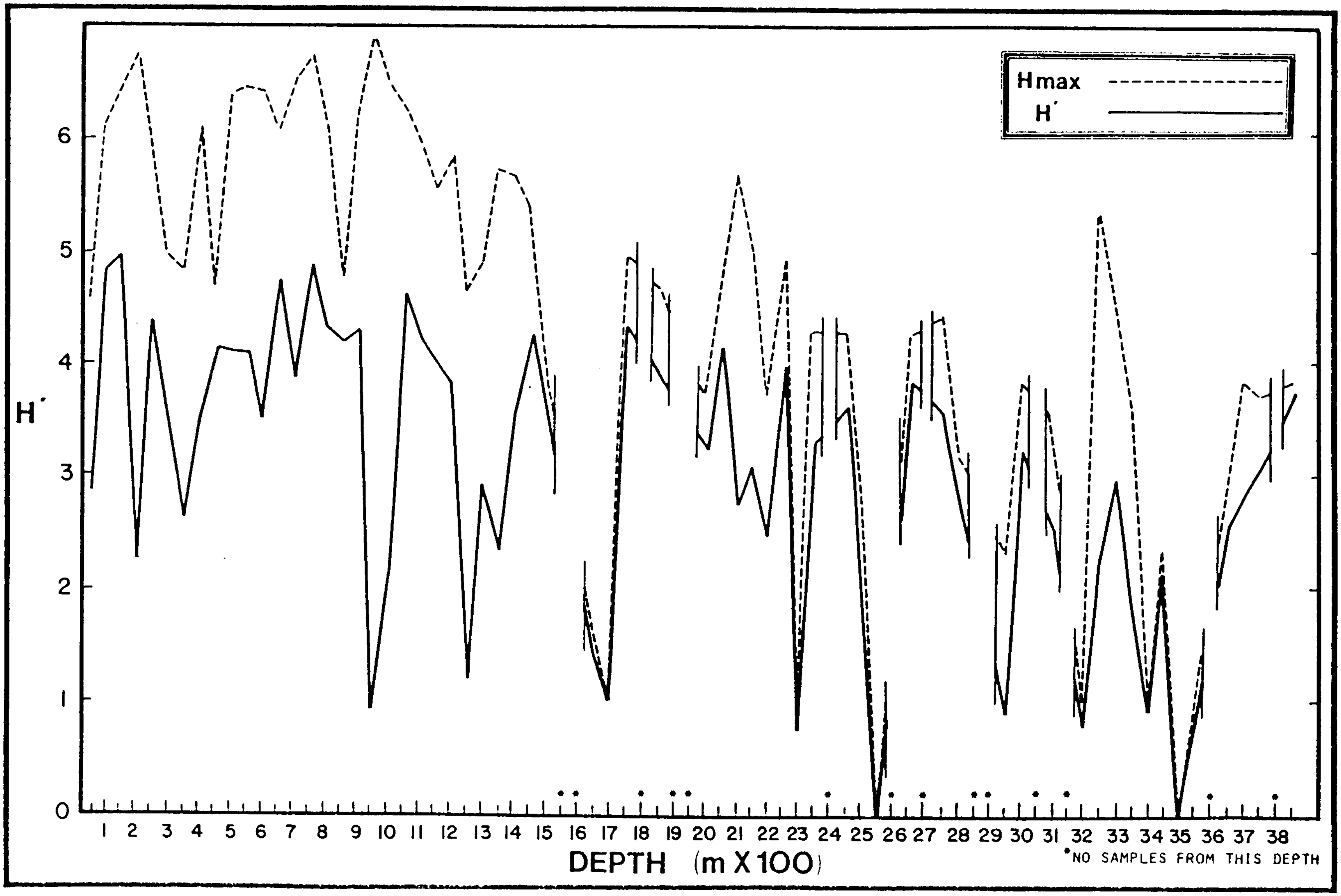


Figure 95. Species diversity index (H') and maximal diversity (Hmax) by depth.

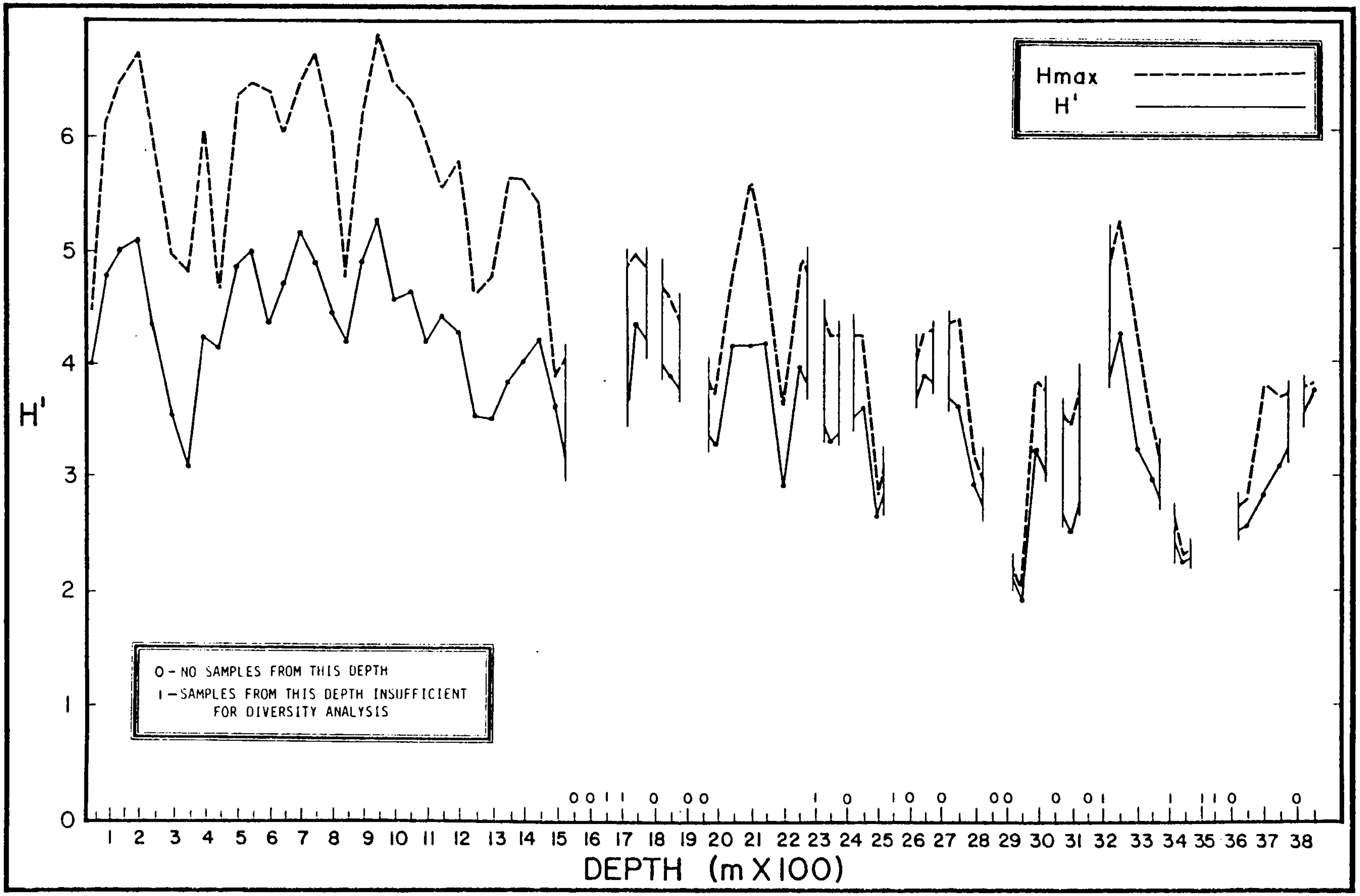


Figure 96. Species diversity index (H') and maximal diversity (Hmax) by depth corrected for patchiness and eliminating samples insufficient for diversity analysis.

KEY SPECIES OF THE FAUNAL ASSEMBLAGES

Unfortunately we know as yet very little about the food habits of individual components of deep-sea faunal assemblages. It follows, therefore, that we have even more cursory knowledge of important food chains or webs beyond the shelf. Nevertheless, some information as to these matters has been gained for what it seems appropriate to call key species. Essentially they have been selected as key species on the basis of frequency of appearance in samples and numbers taken per trawl.

PHYSICAL CHARACTERISTICS OF KEY SPECIES

Some conception of the sizes of the megafaunal organisms that exist in the deep Gulf will assist one in visualizing the distribution of biomass and the nature of the extant food chains.

Fishes

The species in the following list are arranged in relation to the depth at which they attain peak populations (Pequegnat et al., 1976).

	Average Length (mm)	Average Width (mm)	Average Volume (ml)	Depth (m)
Pontinus longispinus	153	19	19	200
Ancylopsetta dilecta	125	6.3	36	250
Poecilopsetta beani	138	7	52	200
Bembrops gobioides	203	19	19	400
Hymenocephalus italicus	124	11	15	450
Coelorinchus carminatus	267	24	38	550
Dibranchus atlanticus	100	40	14	650
Bathygadus macrops	261	20	32	700
Bathygadus melanobranchus	382	28	36	900
Nezumia aequalis	205	15	27	900
Monomitopus agassizi	165	12	24	1050
Gadomus longifilis	157	10	16	1050
Dicrolene intronigra	200	13	24	1200
Coryphaenoides mexicanus	293	26	47	1200
Stephanoberyx monae	91	11	15	1200
Aldrovandia affinis	349	14	17	1400
Aldrovandia gracilis	418	11	15	1450

Rayburn (1975) found that on the average each milliliter of fish volume was equal to 1 gram of ash-free dry weight (r=0.95). On this basis the following distribution of fish biomass was calculated:

Depth (m)	Fish Biomass (mg ash-free organisms/m^2)	Zone
192	16.15	Shelf/Slope Transition
538	12.12	Archibenthal
636	5.68	Archibenthal
920	1.15	Archibenthal
1000	2.15	Upper Abyssal
1220	.60	Upper Abyssal
1350	.20	Upper Abyssal

It is interesting to compare the key species designated in the 1976 report, which dealt primarily with depths to 1000 m, with those selected in the present report dealing with the entire vertical range.

A rank ordering of the 20 most abundant fish species in the northern Gulf and their depth of peak populations in the 1976 and present study (see Table 32).

1976 Study	Depth (m)	1983 Study	Depth (m)
1. Dicrolene intronigra	1050	1. Gadomus longifilis	1050
2. Gadomus longifilis	1050	2. Dicrolene intronigra	1200
3. Synaphobranchus oregoni-brevidorsalis	1100	3. Synaphobranchus oregoni-brevidorsalis	1000
4. Poecilopsetta beani	250	4. Dibranchus atlanticus	650
5. Bathygadus melanobranchus	900	5. Nezumia aequalis	900
6. Nezumia aequalis	1050	6. Poecilopsetta beani	250
7. Dibranchus atlanticus	500	7. Hymenocephalus italicus	450
8. Hymenocephalus italicus	550	8. Aldrovandia gracilis	1450
9. Stephanoberyx monae	1100	9. Pontinus longispinus	200
10. Bembrops gobioides	450	10. Stephanoberyx monae	1200
11. Pontinus longispinus	200	11. Bathygadus melanobranchus	900
12. Aldrovandia gracilis	1450	12. Pristipomoides aquilonaris	200
13. Coryphaenoides mexicanus	1450	13. Bembrops gobioides	400
14. Coelorinchus caribbaeus	250	14. Monolene sp.	200
15. Coelorinchus c. carminatus	550	15. Monomitopus agassizi	1050
16. Aldrovandia affinis	1400	16. Aldrovandia affinis	1400
17. Bathygadus macrops	700	17. Halosaurus guentheri	900
18. Ancylopsetta dilecta	150	18. Bembrops anatirostris	200
19. Haliuetichthys aculeatus	100	19. Coryphaenoides mexicanus	1200
20. Monomitopus agassizi	1050	20. Coelorinchus caribbaeus	300

Even though the lower depth limit of the present study exceeded that of 1976 by about 2800 m, the lists are remarkably similar. In fact out of lists of 20 each only four are different in each list. Calculating the depth at which each species reached peak abundance, it is interesting to note that the average depth in the 1976 study was 800 m and about 760 m in the present study. This depth marks the boundary between the horizons of the Archibenthal Zone. These facts serve to emphasize the substantial drop in biomass with increases of depth. We see that demersal fish attaining significant numerical dominance do not do so deeper than 1500 or so meters, which is in the Upper Abyssal Zone. The steepest decline in species diversity, however, does not occur until the Mesoabyssal Zone around the 2300-m isobath. Since many of these fishes operate at high trophic levels, foraging both on the bottom and to a certain extent on the pelagial, the above facts seem to indicate a drop in benthic prey production. Moreover, since as one moves down the slope the distance from land is also increasing, it is to be expected that production in the pelagial will also drop and the energy output required to move vertically to feed upon it may be too costly.

Invertebrates

Starfish

Comparing the top 10 numerically dominant starfish species between 1976 and the present study we find 7 species common to both lists. The three unmatched species in the present list (see Table 3) all reach peak populations very deep (2750-3250 m), either at the boundary between the horizons of the Mesoabyssal Zone or at the boundary of that zone with the Lower Abyssal Zone. Thus, unlike the situation in the fishes, the average depth of the numerical dominants increased from 625 to 1270 m. We note also that these starfish increase in numbers within the zones where the fishes begin to occur in markedly smaller numbers. Furthermore, two of the three species involved, viz., *Dytaster insignis* and *Benthopecten simplex*, are not of small size.

	Major Radius (mm)	Depth of Peak Population (m)
Astropecten nitidus	30	150
Anthenoides piercei	50	200
Astropecten americanus	56	600
Persephonaster echinulatus	33	650
Doraster constellatus	149	700
Goniopecten demonstrans	94	800
Nymphaster arenatus	60	900
Plutonaster intermedius	51	1050
Benthopecten simplex	48	2750
Ampheraster alaminos	50	3250
Dytaster insignis	47	3250
Litonotaster intermedius	19	3250

In the above tabulation we note a general similarity in size of the dominant asteroids from the Shelf/Slope Transition to the Lower Abyssal Zone. Because these species are predators on bivalve and gastropod mollusks and their populations are of equivalent size, it seems reasonable to conclude that the productivity of these prey types is reasonably high in the abyss. It should be noted, however, that demersal fishes are markedly reduced in the abyss so that asteroids and, perhaps, ophiuroids are the principal predators that the mollusks must sustain.

Sea-urchins

The numerically dominant species of sea-urchins in the Gulf occur at an average depth of only 400 m (see Table 5). They reach peak populations either in the Shelf/Slope Transition or Archibenthal Zones. Various species of the genus *Brissopsis* predominate in the former, while *Phormosoma placenta* leads in Horizon A and *Plesiodiadema antillarum* in Horizon B of the Archibenthal. Moreover, there is a remarkable reduction in either the degree of skeletal calcification or size or both. Although *Plesiodidema* occurs in huge numbers (Table 5), it is less than one tenth the mass of *Phormosoma*. Only one urchin was collected in the Lower Abyssal Zone (*Aceste bellidifera*) and it is even smaller and more delicate than *Plesiodiadema*.

Species and Depth of Collection (m)		Horizontal Diameter (mm) Max.	Min.	Ave.
Brissopsis alta-elongata				
170- 180		64	20	30
190- 210	Peak population	48	31	43
230- 240		62	43	54
270- 285		61	34	43
Phormosoma placenta				
360- 730		103	13	62
730-1100	Peak population	89	13	62
1100-1470		68	7	28
1470-1840		70	22	40
1840-2210		78	18	67
2210-2580		74	53	67

Plesiodiadema antillarum

Ranges in diameter between 8 and 12 mm. and reaches peak populations at 900 m.

These three species account for 90% of the urchins collected by the ALAMINOS in the offshelf waters of the Gulf.

Sea Cucumbers

Increasing the depth parameter in the present study produced some significant changes in the numerically dominant sea cucumbers (see Table 9). For one thing, the average depth of the peak populations of all dominants doubled from 950 to 1900 m. For another, three of the 11 dominants reached peak populations in the Lower Abyssal Zone. Also, a higher percentage of all species of holothurians occur in the Lower Abyssal Zone than of any other invertebrate or vertebrate group. Benthodytes typica, which is the most abundant megafaunal holothurian in the Gulf, is, as are Psychropotes semperiana and Benthodytes lingua, truly deep-sea in that it generally occurs far from any observed influence of organic material derived from the land.

Species	Lengths (mm) Max.	Min.	Ave.	Depth of Peak Population (m)
Molpadia musculus	46	18	33	950
Molpadia barbouri	67	21	43	950
Echinocucumis hispida	24	5	18	1000
Mesothuria lactea	370	30	250	1050
Deima validum	110	17	66	1850
Molpadia blakei	38	25	31	2100
Benthodytes lingua	356	150	240	3250

Some of the largest holothurians in the Gulf occur from the Upper Abyssal into the Lower Abyssal Zone. This is coherent with the fact that they are deposit-feeders. It seems likely that they utilize whatever organic material is found in the surficial sediments, including small macroinfauna and meiofauna.

Penaeid Shrimps

The key species of penaeid shrimps are easily divisable into three groups on the basis of dominance diversity and depth, viz.,

Species	Carapace Length (mm) Max.	Min.	Ave.	Depth of Max. Population (m)
I				
Parapenaeus longirostris	47	7	19	250
Penaeopsis serrata	52	15	33	300
II				
Hymenopenaeus robustus	88	11	56	500
Hymenopenaeus debilis	21	10	15	600
III				
Benthesicymus bartletti	30	10	19	1050
Plesiopenaeus armatus	81	15	44	3100

The average depth of occurrence of the four most abundant penaeids is 1000 m.

Caridean Shrimps

The key species of caridean shrimps reach maximum populations only in the uppermost three faunal zones. Although they do occur in the Mesoabyssal and Lower Abyssal Zones, they exist there only in very small numbers.

Species	Carapace Length (mm) Max.	Min.	Ave.	Depth of Max. Population (m)
Plesionika tenuipes	13	8	10	250
Systellaspis pellucida	17	10	14	300
Parapandalus willisi	15	8	10	400
Heterocarpus ensifer	10	9	9	450
Glyphocrangon longleyi	33	11	21	550
Pasiphaea merriami	36	10	22	600
Plesionika holthuisi	18	6	11	650
Glyphocrangon alispina	20	5	14	750
Nematocarcinus rotundus	27	9	17	1050
Glyphocrangon aculeata	30	5	15	1150
Glyphocrangon nobilis	20	5	14	1400
Nematocarcinus ensifer	26	4	17	2100
Acanthephyra microphthalma	20	11	16	3550

The two genera of carideans with the most species in the Gulf are Glyphocrangon, with six species, and Nematocarcinus with four. They reach peak populations at well-spaced depth invertals. Interestingly, the average depth of occurrence of the four most abundant carideans is the same as that of the penaeids, viz., 1000 m, which is just in the shallow boundary of the Upper Abyssal Zone. If, however, we tabulate the distribution of all species among zones, it is clear that the carideans tend to prefer waters less than 1000 m deep, whereas penaeids display greater species richness below that isobath.

	Zone of Maximum Population (% of total spp.) Shelf/Slope	Archibenthal	Upper Abyssal	Mesoabyssal	Lower Abyssal
Penaeids	5 (23)	5 (23)	7 (32)	2 (9)	3 (14)
Carideans	7 (21)	14 (42)	8 (24)	2 (6)	2 (6)

Galatheid Crabs

The two most important genera of galatheids, namely, Munida and Munidopsis, are spaced so that competition among them is reduced. For instance, the most populous species of Munida do not occur below Horizon A of the Archibenthal Zone (750 m), whereas the most abundantly represented species of Munidopsis do not occur shallower than 750 m.

Species	Carapace Length (mm) Max.	Min.	Ave.	Depth of Max. Population (m)
Munida forceps	27	6	19	200
Munida longipes	20	4	13	400
Munida valida	39	9	21	650
Munidopsis longimanus	12	6	9	750
Munidopsis alaminos	13	7	10	800
Munidopsis sigsbei	24	3	14	950
Munidopsis simplex	12	6	94	1350
Munidopsis nitida	22	9	6	1350

In addition to the above, we note that four species of Munidopsis are found only at depths over 3000 m (see Table 24).

Brachyuran Crabs

In sharp contrast with the galatheid crabs, the brachyurans are clearly shallow water forms. Only three species reach their maximum populations below 950 m (lower limit of the Archibenthal Zone) and all of these occur in exceedingly small numbers (see Table 29). With the exception of the Giant Red Crab (Geryon quinquedens), the brachyurans tend to decrease in size with increasing depth.

Species	Carapace Width (mm) Max.	Min.	Ave.	Depth of Max. Population (m)
Portunus spinicarpus	42	27	34	100
Acanthocarpus alexandri	43	6	24	200
Lyreidus bairdii	21	5	12	300
Bathyplax typhla	32	6	17	550
Ethusina abyssicola	14	5	10	3250
Geryon quinquedens	20	11	16	3550
Polychelid lobsters				
Polycheles typhlops	45	30	34	500
Stereomastis s. sculpta	63	17	36	1050
Polycheles crucifer	39	13	26	1200
Polycheles validus	80	17	49	2100
Nephropid lobsters				
Nephropsis aculeata	47	12	38	500
Nephropsis rosea	53	12	30	600
Acanthacaris caeca	58	41	47	700
Nephropsis agassizii	37	14	25	950

FOOD HABITS OF SELECTED KEY SPECIES

Fishes

There is currently a very limited amount of available information on the food habits of any deep-sea fish fauna. But it is typical of demersal fishes in shallower depths that their feeding habits are quite flexible. That is to say that they will devour a wide range of organisms, provided the prey are of appropriate size and consistency (Raymont, 1963). It is interesting that evidence is mounting that this applies to several deep-sea species in the Gulf as well (Bright, 1968, 1970; Rayburn, 1975). Also, Pearcy and Ambler (1974) describe some abyssal macrourid fishes off the Oregon coast as generalized feeders, utilizing mainly epifauna or pelagic animals for food. Those species that make forays from the bottom to feed upon truly pelagic prey are better called benthopelagic than demersal. Whether a fish feeds on the bottom, just above the bottom, or well up in the water column may depend upon age. For instance, young of the the macrourid *Coryphaenoides armatus* depend mostly on benthonic species, whereas upon attaining mature size pelagic sources predominate (Smith, 1978). Rayburn (1975) found that the principal components of the diet of some deep-sea fishes change with depth, which is another expression of opportunistic feeding. Marshall (1966) concluded that the species of fish living near the deep-sea floor feed largely on invertebrates. Rayburn (1975) examined the stomach contents of 378 individuals of seven species of deep-sea fishes that occur in the Gulf. His findings, as summarized in Table 66 support Marshall's conclusions.

Table 66. Principal food types of selected deep-sea fishes in the Gulf of Mexico. Numbers in columns equal percent of total fish examined with the item in the stomach. Fish species are in order *D. atlanticus*, *N. aequalis*, *B. melanobranchus*, *H. guentheri*, *M. agassizii*, *D. intronigra*, and *C. mexicanus*.

Depth of Max. Population (m)	*Dibranchus* (Ogcocephalidae) 650	*Nezumia* (Macrouridae) 900	*Bathygadus* (Macrouridae) 900	*Halosaurus* (Halosauridae) 900	*Monomitopus* (Ophidiidae) 1050	*Dicrolene* (Ophidiidae) 1200	*Coryphaenoides* (Macrouridae) 1200
Food Organism							
Polychaeta	20	90	15	90	15	80	90
Gammaridea	25	60	30	60	50	65	85
Tanaidacea	10	40	10	20	35	20	35
Ostracoda	20	35	20	15	65	45	10
Cumacea	0	30	10	30	20	20	60
Cyclopoida	5	30	5	15	10	20	10
Forams	15	30	5	35	10	40	25
Calanoida	25	25	40	35	45	25	0
Unidentified Crustacea	45	25	25	25	40	15	15
Bivalvia	45	20	0	25	0	5	0
Isopoda	5	18	10	20	15	30	45
Harpacticoida	5	15	0	5	5	5	0
Fish	0	0	15	0	0	0	8
Caridea	0	5	5	5	0	10	0
Stomatopoda	0	0	0	0	0	5	10
Squids	0	5	10	5	5	5	0
Brachyura	15	0	0	0	0	0	0
Gastropoda	15	0	0	0	0	0	0

Some of the salient points displayed in this table are that four of the seven species (in three different families) are about equally dependent upon polychaetes and gammaridean amphipods. *Nezumia aequalis* and *Halosaurus guentheri*, though in separate families, have their maximum populations at the same depth and have very similar patterns of food organism preferences.

The food preferences of these two species contrast sharply with those of the benthopelagic macrourid *Bathygadus melanobranchus*, which depends to a large extent on calanoid copepods and is one of few species to have fish remains in its stomach, and the predatory *Dibranchus atlanticus* which feeds to a large extent on bivalves and crustaceans, and is the only one of the seven known to prey upon brachyurans and gastropods. The only species other than *Bathygadus* to have fish remains in their stomachs were individuals of *Coryphaenoides mexicanus*. Although these two species are both macrourids, their feeding habits are otherwise quite different (Table 66).

The shift of diet with depth change is very well displayed by *Dibranchus* in Table 67. The principal shifts are underlined. It is apparent that at its deep bathymetric limit in the Upper Abyssal Zone, *Dibranchus* has an exclusively crustacean diet, possibly because of keen competition from macrourid and halosaurid better adapted to these increased depths.

Table 67. The relative abundance of food items in the fish, *Dibranchus atlanticus*, expressed as percentage frequency of occurrence in relation to zones.

Item	Archibenthal Zone		Upper Abyssal Zone
	Horizon A	Horizon B	
Polychaeta	10	86	0
Gammaridea	24	57	50
Tanaidacea	7	29	50
Ostracoda	19	29	0
Cyclopoida	5	0	0
Forams	19	0	0
Unidentified Crustacea	43	43	0
Bivalvia	45	14	0
Isopoda	0	15	50
Harpacticoida	2	0	0
Gastropoda	15	0	0
Porifera	10	0	0
Ophiuroidea	10	0	0
Brachyura	15	0	0
Natantia	2	0	0
Heteropoda	5	0	0
Anomura	2	0	0

Bright (1970) found 631 specimens of food organisms in the guts of the 81 deep-sea fish from the Gulf of Mexico that he examined. The 81 fish represented 36 different species that wre captured at depths between 366 and 3175 m with the majority between 500 and 100 m. Small crustaceans were the most numerous food items encountered. In descending order of abundance, they were gammarids, calanoid copepods, cumaceans, tanaidaceans, and others. The preponderance of organisms listed as unidentified crustacea undoubtedly belonged to these groups but were not recognizable because of their digested or fragmentary condition. Because of their larger size, polychaetes probably provide at least a third of the diet of most of these fishes even though their frequency of ingestion may be less than that of crustaceans. Bright (1970) found that mollusks comprised an insignificant portion of the diet of the majority of the fishes. The few small echinoids encountered were ingested whole. Fish were poorly represented as diet components in the fishes studied by Bright, possibly because he examined only one specimen of one of the species (Coryphaenoides mexicanus) and none of the second species that Rayburn found to have eaten fish.

The placement and size of unpaired fins in benthopelagic fish seem also to have an influence on their feeding habits. An example of this is found in the family Macrouridae in which the subfamily Bathygadinae has the second dorsal fin rays longer than the anal fin rays. This fin positioning imposes a slight head-upward inclination while the fish is swimming. In this study Bathygadus melanobranchus exemplifies this type of fin structure and swimming attitude. It is interesting to note that this species had (1) a high percentage of calanoid copepods and some fish in its diet and (2) low percentages of polychaetes and bottom-dwelling crustaceans. Macrourids of the subfamily Macrourinae, on the contrary, are characterized by long anal fin rays with short second dorsal fin rays. This placement imposes a head-down mode of swimming. Nezumia aequalis is a representative of this subfamily. Halosaurs, although in a different family, also have a long anal fin equipped with long rays and as a consequence swim tail high. It is interesting to note that both Nezumia and Halosaurus have very high percentages of polychaetes and gammarideans in their diets.

To summarize, it appears that there are three basic modes of feeding utilized by deep-sea bottom fish ordinarily captured in trawls and dredges. They are (1) predation upon small, benthonic organisms involving ingestion of considerable amounts of sediment, (2) predation upon small benthopelagic, pelagic, or planktonic organisms, and (3) active predation upon large macrobenthonic, planktonic, or nektonic organisms. A fourth option that may be utilized by any of the above is a fall-back mode of scavenging upon plant material or deadfalls of animal carcasses. Apparently selective sediment ingestion, which is resorted to by numerous shallow water fishes, is not performed by abyssal fishes.

The first group above ingests small macrobenthonic and meiobenthonic organisms found by rooting in the sediments, and possibly by feeling for them with long tactile fin rays. These fishes, mostly non-bathygadine macrourids, morids of the family Gadidae, and halosaurids may have well-developed gustatory receptors on the lips and surrounding skin, as well as on barbels and possibly fins, with which to sense the presence of prey (Marshall, 1965). They also tend to ingest a moderate amount of sediment which may be a limited source of nutriment for them (Bright, 1968). Members of the second group, particularly the bathygadine macrourids and some ophidiids, appear to feed extensively upon benthopelagic organisms and tend not to ingest a significant amount of sediment with their diet. The thrid group, very active predators and anglerfishes, feeds upon the larger macrobenthos and is largely confined to the upper continental slope. Many species of this group belong to assemblages that have affinities with the continental shelf ichthyofauna. Bembrops gobioides is an excellent example of this group. This is not to say that there are not large and relatively active predators in the abyss. A number of reports of sharks of formidable size occurring on the bottom, in depths greater than 2000 m, have been made in recent years (Isaacs, 1969).

The partitioning of food resources between pairs of closely related species without competitive exclusion is illustrated by the macrourids *Nezumia aequalis* and *Coryphaenoides mexicanus* and the ophidiids *Dicrolene intronigra* and *Monomitopus agassizii*.

Nezumia and *Coryphaenoides* have similar structures, i.e., an inferior mouth, elongated anal fin and stiff snout, and they have similar overall geographical and vertical distributions in the Gulf, although *Nezumia* attains maximum populations at 900 m, whereas *Coryphaenoides* does at 1200 m. Moreover, *Nezumia* is generally more populous than *Coryphaenoides*. As shown in Table 66, the primary food for both species is polychaetes, but it is also evident that *Nezumia* is a much more generalized feeder. Whereas after polychaetes *Coryphaenoides* depends primarily upon crustaceans (especially gammarids, cumaceans, and isopods), *Nezumia* not only feeds on those types but also upon calanoids, squids, bivalves, gastropods, harpacticoids, and caridean crustaceans - none of which were found in the *Coryphaenoides*. Interestingly, where *Nezumia* reaches peak populations, its diet is most varied and *Coryphaenoides* is most restricted, while where the latter is most abundant it depends heavily upon benthopelagic fishes to supplement a reduced intake of polychaetes and gammarids.

The relationship between *Dicrolene* and *Monomitopus* also involves similar morphological characteristics, the same geographical distribution, and overlapping vertical ranges although *Dicrolene* attains maximum populations around 1200 m and *Monomitopus* at 1050 m depth. Generally *Dicrolene* is more populous than the latter. In this case where an average of 78% of *Dicrolene* examined had ingested polychaetes, only 14% of the *Monomitopus* taken at the same station had polychaetes in their stomachs. Again where *Dicrolene* reached peak populations individuals had as many as 18 different food items in their stomachs, *Monomitopus* never had more than 10. These observations on the two related pairs seem to support the conclusion that the most populous species are the more generalized feeders.

Invertebrates

Most of the original data in our possession relating to the food of benthic invertebrates in the Gulf is derived from crustaceans and echinoderms. The list of these with food in their stomachs is not long, to wit:

Bathynomus giganteus (Isopoda) *Synaphobranchus* (eel)
Glyphocrangon nobilis (Caridea) *Yoldiella quadrangularis* (bivalve)
Benthochascon schmitti (Brachyura) Fish
Dytaster insignis (Asteroidea) *Neilonella guineensis* (bivalve)
sponge and forams
Sargassum
Astropecten nitidus (Asteroidea) gastropods and bivalves
Astropecten americanus (Asteroidea) gastropods
Nymphaster arenatus (Asteroidea) sponge and forams
Athenoides piercei (Asteroidea) small sponge
Tethyaster grandis (Asteroidea) *Brissopsis alta* (echinoid)

Goniopecten demonstrans (Asteroidea) gastropods, forams, radiolarians
Persephonaster echinulatus (Asteroidea) bivalves, gastropods, cumaceans
Phormosoma placenta (Echinoidea) sediment and plants
Mesothuria lactea (Holothuroidea) sediment

Pequegnat (1979) reported collecting five asteroids (Persephonaster echinulatus) that were in the process of solubilizing tar within gastric fimbriae. That this choice was not the result of the absence of natural foods is demonstrated by the fact that these same individuals had mollusks in their stomachs as well.

Food Chains Involving Some Key Species

In the previous sections on fishes and invertebrates we have presented some data on food habits that comprise links in a food chain. We shall attempt to summarize and extend that information in this section.

Crustacea - crustacea - fish - crustacea - (?) fish

1. Meiofauna into small crustacea
2. Crustacean eaten by larger crustacean Polycheles
3. Polycheles validus eaten by Synaphobranchus (eel)
4. Synaphobranchus eaten by large isopod Bathynomus
5. Bathynomus giganteus - top carnivore ? or eaten by fish ?

Detritus - bivalve - crustacean - fish - (?) fish

1. Detritus eaten by Yoldiella (bivalve)
2. Yoldiella quadrangularis eaten by Glyphocrangon (caridean)
3. Glyphocrangon nobilis eaten by Bembrops (fish)
4. Bembrops gobioides - top carnivore ?

Detritus - echinoid - asteroid

1. Detritus eaten by Brissopsis (sea-urchin)
2. Brissopsis atlantica eaten by Tethyaster (starfish)
3. Tethyaster grandis - top carnivore ? very likely

Plankton - squid - fish

1. Planktonic crustacea eaten by squid
2. Squid eaten by Etmopterus (shark)
3. Etmopterus schultzi - top carnivore ? very likely

Detritus - bivalve - caridean - fish

1. Detritus eaten by Tindaria (bivalve)
2. Tindaria amabilis eaten by Glyphocrangon (caridean)
3. Glyphocrangon longleyi eaten by Bembrops (fish)
4. Bembrops anatirostris - top carnivore ?

Fish - crab - fish

1. Copepods eaten by fish
2. Fish eaten by Benthochascon (brachyura)
3. Benthochascon schmitti eaten by Dibranchus (fish)
4. Dibranchus atlanticus - top carnivore

6. DEEP BENTHIC ECOSYSTEMS: CONTROLLING FACTORS OF ZONATION

INTRODUCTION

It is customary in an ecological treatise of this type to describe the physical environment of the study area before delving into biological findings. It is easy to see that this has been reversed in the present study. Throughout the study our interests have been to delineate the epibenthic assemblages and relate these to larger vertical units, the faunal zones. Having done this, our search for those environmental factors that exert important controls over these clusterings of organisms and that account for their existence can be more discriminating. Obviously, there are critical limitations on the number of different ways by which organisms can respond to the effects of environmental factors. Thus, it is not surprising that the organisms of one assemblage must be responding in essentially the same way to the critical environmental controls. And although the boundaries between two assemblages may not be sharp, there is nevertheless a sufficient shift of species to justify establishing lines of demarcation between zones. Accordingly, it is proposed to begin this section by examining possible environmental controls and then at the end to evaluate their possible roles in accounting for the assemblages noted earlier.

PHYSIOGRAPHIC AND GEOLOGIC FACTORS

The Gulf of Mexico has been described as a mediterranean-type sea (Garrison and Martin, 1973; Watkins et al., 1978) or as a small ocean basin (Antoine et al., 1974; Uchupi, 1975) surrounded by continental masses. It covers an area of more than 1.5 million square kilometers and has many of the geomorphic features of large oceans; its continental margins are structurally complex and in some cases rather unique. Maximum water depth over the Sigsbee Abyssal Plain (about 3840 meters) greatly exceeds the sill depths of those two passageways that connect the Gulf of Mexico with the adjacent Caribbean Sea and Atlantic Ocean.

Sedimentologically, the Gulf can be divided into two major provinces, a terrigenous one to the west and a carbonate one to the east, with a variety of physiographic provinces, subprovinces, and individual features contained within each of these realms. Because of its mineral richness (Martin and Bouma, 1978) and topographic complexity (Uchupi, 1975), the Gulf of Mexico has attracted the attention of numerous investigators with seismic research efforts having contributed to the bulk of recent literature related to its geologic aspects (Martin and Case, 1975). Our literature survey abetted with personal communications (e.g., R. Rezak, Department of Oceanography, TAMU, College Station, Texas and L. E. Garrison, USGS, Corpus Christi, Texas - November 1982) revealed that very little information had been published concerning deep-Gulf surficial sediments since the work of Bouma (1972). A general discussion concerning the physiography of the Gulf of Mexico, with major emphasis and/or attention being given to details of topography and sedimentology on the northern Gulf's outer continental shelf and upper slope, can be found in Pequegnat et al. (1976). The lower bathymetric limit for that investigation was at a depth of 1000 meters, intersecting about the upper one-third of the continental slope's extension.

The present study area lies primarily within the confines of the terrigenous province north of the 25th parallel. Its scope extends over the remaining lower two-thirds of the slope down to the Sigsbee Abyssal Plain. Intermediate between these relief features, landforms (Figure 97) such as Alaminos and De-Soto Canyons, the Sigsbee Escarpment, the Mississippi Fan and Trough, and in

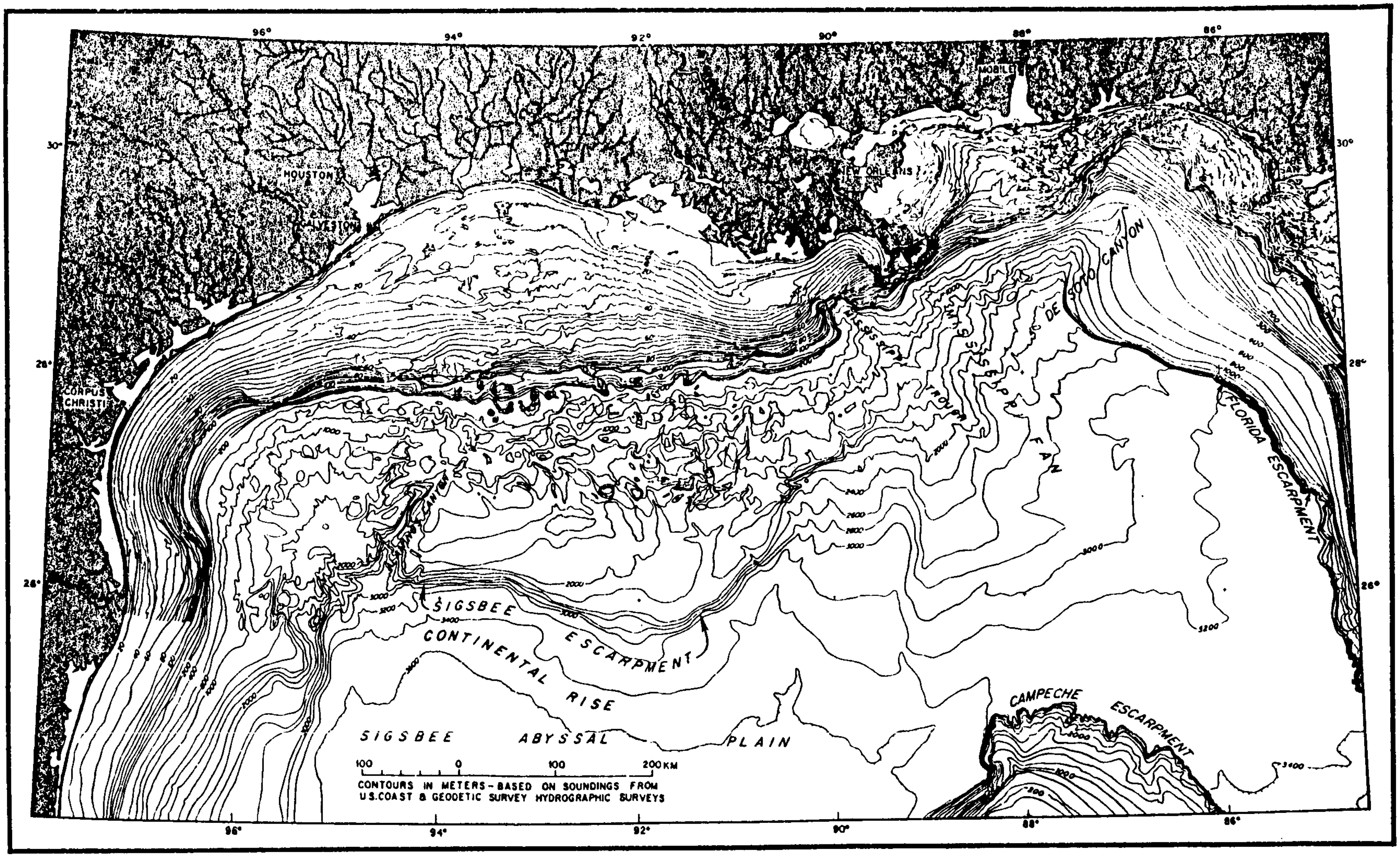


Figure 97. Topography of the northern Gulf of Mexico (adapted from Ballard and Uchupi, 1970).

places a typical continental rise will be taken into consideration. Portions of the Mexican ridge system (Bryant et al., 1968) south of the Texas continental terrace will be given attention since it could represent a continuation of features, both structural and faunal, on the Texas-Louisiana continental slope.

SUBMARINE TOPOGRAPHY

Major physiographic provinces in the Gulf of Mexico include the continental shelf, the continental slope, the continental rise, and the abyssal plain (Martin and Bouma, 1978). Their division of these provinces into subprovinces was deemed to be warranted by either variations in morphologic characteristics or on the basis of geographic location.

Continental Slope - Northern Gulf of Mexico

The continental slope is a region of relatively steeply sloping seafloor that extends from the shelf edge to the upper limit of the continental rise, or locally to the abyssal plain (Bergantino, 1971). It contains a variety of submarine landforms and generally possesses steep, irregular topography but can sometimes have rather large, smooth areas. The steeper portion of a slope, an escarpment in particular, can be considered as the margin or edge of the continental platform even though it is generally treated as part of the slope. In the northern Gulf, the continental slope is believed to be the southern and growing edge of the Gulf Coast geosyncline (Uchupi, 1975), the primary structural element within that region (Wilhelm and Ewing, 1972; Antoine et al., 1974). This geosyncline is principally a Cenozoic basin where a great thickness of sediment has accumulated since late in the Cretaceous (Moody, 1967).

Texas-Louisiana Slope

West of the Mississippi Fan, the continental slope is characterized by a hummocky topography that consists of various shaped and sized hillocks and depressions (Bouma et al., 1980). Seismic-reflection data reveal complicated underlying structures such as diapirs (salt and shale), slides, slumps, and growth faults. Bergantino (1971) describes the gross shape of the Texas-Louisiana slope as being step-like with steep upper and lower gradients that enclose an intermediate gently sloping plateau. Steep-sided knolls, enclosed basins, and digitate canyons characterize the eastern two-thirds of the slope, whereas, the western sector off south Texas is essentially featureless with only occasional small hills and noses. The hill-and-basin seafloor (Martin and Bouma, 1978) of the slope covers an area of about 120,000 square kilometers; its entire frontal edge abuts the continental rise by a pronounced steepening of gradient known as the Sigsbee Escarpment.

The upper limits of this declivity is at a depth of about 2100 meters and its overall elevation ranges from between 730 and 1100 meters. Its base (between 3000 and 3200 meters) abuts the continental rise, which slopes gently seaward to the abyssal plain that commences at a depth of about 3650 meters. This scarp constitutes the foot of the Texas-Louisiana Slope from the Alaminos Canyon area to the Mississippi Fan where it continues across the fan region as a buried feature (Shih and Watkins, 1974; Amery, 1978). The most prominent reentrants in the scarp are Alaminos Canyon (Bouma et al., 1968; 1972), Keathley Canyon (Martin and Bouma, 1978), and a northeast-southwest trending valley which intersects the escarpment toward the east end at about 92°W longitude (Bergantino, 1971; Uchupi, 1975).

In contrast to its upper hummocky counterpart which is underlain by salt stocks and steep-sided massifs, the lower slope appears to be underlain by a single ridge of salt at least 500 kilometers long (Garrison and Martin, 1973). The upper surface of this salt mass is unevenly pillowed and in places thinly veneered by sediment. According to Uchupi (1975), such smoothness could be due to salt diapirs having risen to a common elevation. Humphris (1978) finds a close relation between salt movement and sediment disposition; he hypothesizes that salt features on the outer slope are not as well developed (i.e., no individual salt diapirs) as those near the shelf because sedimentation has been much less on the slope. In addition, that investigator states that salt generated structures near the delta are more mature than those in the western Gulf because of higher rates of sedimentation. Intraslope basins such as those reported by Martin and Bouma (1978) on the northern slope are directly related to diapiric growth of adjacent salt structures which block submarine canyon systems or coalesce to create seafloor depressions in noncanyon areas. Gyre Basin (Bouma et al., 1975) is an example of the blocked canyon type while Orca Basin (Trabant and Presley, 1978) is an example of the noncanyon type.

Off south Texas (i.e., south from Alaminos Canyon), the slope has been previously mentioned as having subdued topography and being somewhat featureless. This sector appears to be different in salt structures when compared to regions on either side (Watkins et al., 1978). Martin and Bouma (1978) refer to a region of linear and irregular hills between that area and the ridge and valley seafloor of the ridge system (Bryant et al., 1968) off eastern Mexico. This part of the slope is underlain by large massifs, interspersed by deep basins and troughs containing thick sections of clastic sediments. Bruce (1973) reports that diapiric structures off southernmost Texas and northeastern Mexico probably result from the mobility of undercompacted shale. The potential for such an occurrence is revealed in Watkins and Kraft's (1978) findings related to stress in connection with slope stability.

Mississippi Fan

This fan-shaped seafloor covers bathyl and abyssal depth zones while dominating the topography of the east-central Gulf. The fan's apex is on the uppermost part of the slope (at a depth of 1200 meters) near the mouth of the Mississippi Trough, a scour feature (Stewart and Caughey, 1976) in the continental slope that marks an earlier watercourse of the ancestral Mississippi River. Surface area of the fan has been reported to range from about 160,000 square kilometers (Garrison and Martin, 1973; Moore et al., 1978) to an excess of 300,000 square kilometers (Huang and Goodell, 1970; Stewart and Caughey, 1976). The surface gradient over most of the fan is less than 0.25°, varying from about 1° in the upper part to being virtually horizontal on the abyssal plain. For the purpose of this study the Mississippi Fan will be divided into three parts (upper, middle, lower) even though various investigators (Huang and Goodell, 1970; Bergantino, 1971; Martin and Bouma, 1978) have reported only upper and lower sectors. Subdivision for this report follows the scheme of Stewart and Caughey (1976) which was based on surface gradient, relative smoothness, distribution of salt diapirs, and seismic character.

The upper fan is deformed by salt diapirs, thus similar in structure and surface morphology to adjacent slope regions. It contains a partly leveed erosional channel cut into older fan sediments (Moore et al., 1978) and is filled with late Pleistocene fine clastic sediments. Bergantino (1971) reports that local relief on the upper fan varies up to 100 fathoms (183 meters) but generally averages about 20 fathoms (37 meters). The boundary between the upper and middle fan occurs at a water depth of about 2300 meters (Stewart and Caughey, 1976). Absence of diapirs within the middle part gives rise to a moderately smooth surface of lower gradient than noted for the upper fan. The lower fan has a smooth low gradient, about 0°4' (Huang and Goodell, 1970), surface that transitionally extends into the Florida and Sigsbee Abyssal Plains. The upper and lower portions of the fan are confined on the north and west by the Texas-Louisiana slope whereas the Florida Escarpment bounds the middle and lower fan on the east (Moore et al., 1978). In the south, portions of the middle and lower fans abut the Campeche Escarpment (Martin and Bouma, 1978).

DeSoto Slope

The DeSoto Canyon (Bergantino, 1971) lies off the Mississippi-Alabama coast between the eastern limits of the upper Mississippi Fan and the west Florida continental terrace. Martin and Bouma (1978) report this slope to be comparatively smooth, marked locally by low-relief hillocks that express underlying salt structures and by small erosional channels. Deformation of the underlying conformably bedded sediment consist of minor folds and diapiric disturbances.

DeSoto Canyon, a trough which heads near the 440-m contour and terminates near the 950-m isobath, is the most significant surface feature of the upper slope in this area (Jordan, 1951). Harbison (1968) attributes its formation to a combination of erosion, deposition, and structural control by diapirs clustered in that vicinity. Diapirs within the eastern extremity of the terrigenous embankment are not uncommon, but their occurrence is sparse as compared with their distribution in the northwestern Gulf (Garrison and Martin, 1973). Unlike most submarine canyons, DeSoto Canyon has a comparatively gentle gradient, is somewhat S-shaped, and has a closed bathymetric low near its southern boundary. Martin (1972) refers to a broad structural valley on the lower portion of the slope that merges westward into the Mississippi Fan. This reentrant is reported by Garrison and Martin (1973) to be composed of a great thickness of mostly unconsolidated sediment.

Continental Rise

The Western Gulf Rise is a broad expanse of gently sloping seafloor that onlaps the Sigsbee Escarpment and merges with the Sigsbee Plain generally along the 3500-m isobath (Emery and Uchupi, 1972). Bergantino (1971) reports that gradients on the surface of the rise vary from 1:100 to 3:100. The Sigsbee wedge (Wilhelm and Ewing, 1972) possesses a thickness of about 760 meters along the northern Sigsbee Escarpment and thins basinward to a pinchout beneath near horizontal beds of the abyssal plain. It is characterized by zones of unstratified material interpreted as gravitational flows originating on the unstable continental slope (Garrison and Martin, 1973). The wedge is probably composed of many flows. Common topographic irregularities reported by Martin and Bouma (1978) on the rise include depositional aprons at the mouths of canyons, small knolls related to underlying salt diapirs, and areas of roughened seafloor resulting from mass sediment movement. As it progresses southward along eastern Mexico, topographic definition of the continental rise diminishes until it is little more than a continuation of the gradient of the slope.

Sigsbee Abyssal Plain

The abyssal plain of the Gulf of Mexico covers more than 350,000 square kilometers of seafloor (Martin and Case, 1975) that includes the Sigsbee Plain in the west and the area of seafloor between the Campeche and Florida Escarpments in the east. It is bounded by these two steep escarpments on the east and south and by the less abrupt slopes of the Sigsbee and Rio Grande scarps on the north and northwest. Elsewhere the abyssal floor merges gently with the varied topographies of the Mississippi Fan and the continental slope of the western and southwestern Gulf.

The Sigsbee Plain occupies the deepest part of the Gulf basin and is essentially flat (slope of less than 1:8000) or featureless except for the prominence of the Sigsbee Knolls. These knolls are clustered near the center of the plain and stand 100-200 meters above its level (Garrison and Martin, 1973). They are the surface expressions of but a few of the large diapirs that pierce and uplift many thousands of meters of abyssal strata (Watkins et al., 1978). In the vicinity of the knolls, a maximum thickness (nearly 400 meter) of the well-stratified section of horizontally layered turbidites and interbedded pelagic oozes is revealed (Martin and Bouma, 1978). These range in age from Pliocene to Holocene (Burk et al., 1969).

SEDIMENTOLOGY

The geology of the northern Gulf's offshore area is better known at the subsurface level than at the surface due to the vast amount of work with precision echo sounding and in refraction seismic, gravity, and magnetic surveying (Pequegnat et al., 1976). In addition, multichannel seismic reflection techniques now permit recognition of stratigraphic units throughout very large oceanic regions (Worzel and Burk, 1979). Comprehensive sedimentological studies in the northwestern Gulf have been restricted largely to the continental shelf and abyssal plain (Appelbaum, 1972), with limited study on the continental slope.

The major source of sediment for the northwestern Gulf is Mississippi River discharge with lesser amounts of weathered products being supplied by the Rio Grande and the many rivers and streams positioned between these two. During transport to and within the Gulf basin, sedimentary materials are mixed and sorted by a variety of agents before deposition. The fact that detrital sediments are being deposited on the inner continental shelf is substantiated by the nature of the material, the presence of pure indigenous faunas, and foraminifera population ratios. Phleger (1967) speculates that some detritus from land is also being deposited on the continental slope and in the basin. This suggests that sediment being supplied to the Gulf does not reach the outer shelf, or if it does, it is being deposited seaward of the shelf.

Bouma et al. (1980) stress that sea level fluctuations strongly determine the amount and type of sediment being transported to the continental slope. During the period of lowest sea-level stand, sediments from all rivers were carried directly across the exposed continental shelf where currents and longshore drift dispersed them throughout the present deeper aspects of the Gulf. Only during low stands of sea level were significant volumes of sand moved to the shelf break (Bouma et al., 1980). Near the break, these sands collected in submarine canyons; however, further transport by sliding, gravity flow, and turbidity current mechanisms resulted in ultimate deposition on the lower slope or deeper water submarine fans.

The Mississippi River sediment load accounts for about two-thirds of the total sediment delivered to the Gulf which Trefry (1977) suggests is eventually deposited over a large area comparable to that described in this section as the Mississippi Fan. Wilhelm and Ewing (1972) infer that deposition of the last major volume of clastic sediment on the Mississippi Fan took place during early Holocene time. Later deposits from the Mississippi and other rivers that reached the abyssal plain were, at least in part, turbidity-current controlled (Davies, 1972).

Heavy Mineral Studies

Work on heavy minerals of the northwest Gulf began with Bullard's examination of the heavy mineral suites of Texas river and beach sands in order to determine their source areas (Bullard, 1942). He concluded that each of the principal Texas rivers carries a distinct heavy mineral suite dependent upon the nature of the source rock of the various drainage basins. Goldstein (1942) divided the northern Gulf of Mexico into four distinct sedimentary provinces on the basis of heavy mineral suites. These divisions are the East Gulf province, the Mississippi province, the Western province, and the Rio Grande province. In the northwest Gulf, the Mississippi and Western provinces are differentiated by a lower percentage of pyroxene and a higher percentage of leucoxene in the Western province. The Rio Grande province is distinguished from the Western by a higher percentage of pyroxene and the presence of basaltic hornblende.

van Andel (1960) pointed out that with the exception of the Colorado River sedimentary suite, the sediments of rivers emptying into the northwest Gulf are orthoquartzitic and are derived mainly from the Cretaceous and Tertiary margins of the Gulf Coast basin. He found modification of the sand in the basin only slight except for the removal of pyroxenes from Rio Grande and Mississippi sands exposed during the Pleistocene. van Andel and Poole (1960) examined the heavy minerals shoreward of the 110-meter contour in order to determine sand sources. In addition to Goldstein's provinces, these authors added a Texas coast province characterized by abundant tourmaline with zircon and some epidote. They attributed the Western province assemblage to mixing during the early Holocene transgression.

Major emphasis in sedimentologic research in the Gulf has been concentrated on the continental shelf because of the accessibility and availability of samples from shallow water. Davies (1972) recognizes five distinct heavy-mineral provinces on the shelf and traces each province from the shelf to the abyssal plain. His provinces include those four of Goldstein (1942) with addition of a Northeast Mexico province. He found no significant modification of his heavy mineral assemblages over extended travel paths. In fact, he reports the assemblage at Cairo, Illinois (on the Mississippi River) is indistinguishable from the assemblage in the Gulf of Mexico abyssal plain. Figure 98 depicts the approximate areal extent of Davies' provinces that are included in the overall area encompassed by this study.

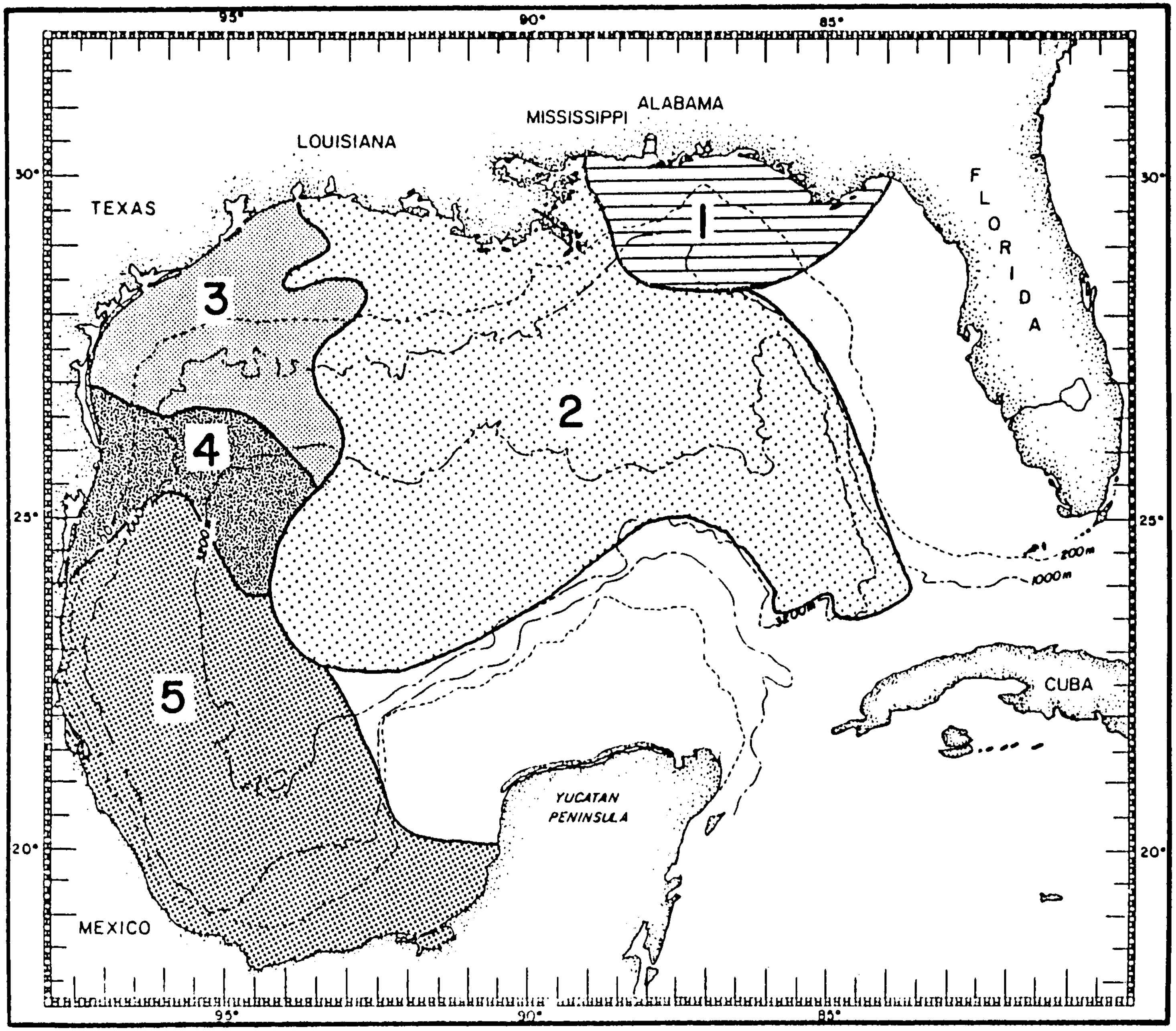


Figure 98. Distribution of heavy mineral provinces in the Gulf of Mexico. (Modified from Davies, 1972). 1. Eastern Gulf province; 2. Mississippi province; 3. Western Gulf province; 4. Rio Grande province; 5. Northeast Mexico province.

Clay Mineral Studies

As pointed out by van Andel and Poole (1960), the distribution patterns for different size fractions of sediment are not necessarily the same. Modern clay mineral examination of the western Gulf began with Grim and Johns (1954) who worked with samples from Texas coastal waters. They identified montmorillonite, chlorite, illite, and kaolinite and suggested alteration of clay minerals in response to changing chemical environments as accountable for the variation in mineral quantities. Samples from the Sigsbee Deep were examined by Murray and Harrison (1956) and were found to containe approximately twice as much montmorillonite as chlorite and illite.

Johns and Grim (1958) discovered that the bulk of the material being deposited by the Mississippi River is montmorillonitic in nature and undergoes no diagenesis upon introduction into the Gulf. Its original source, the Missouri River system, differs from the Ohio River system in that material from the latter alters to chlorite and illite. Pinsak and Murray (1960) reported on regional clay mineral patterns in the Gulf, giving concentration areas and possible sources for montmorillonite, illite, kaolinite, and chlorite. McAllister (1964) worked on the clay minerals of the west Mississippi Delta whereas Harlan (1966) investigated those of the Sigsbee Deep. Scafe and Kunze (1971) determined that the complex of conditions during and since the Pleistocene had little effect on the relative abundance of clay minerals in their core samples from the western Gulf.

Griffin (1962) reported that montmorillonite is the dominant clay mineral of the Western Mississippi River Basin and that illite is found throughout the Mississippi drainage basin. Kaolinite is the prevalent clay mineral of southern and southeastern U.S. areas (Trefry, 1977). Lower Mississippi River sediments are found to have a clay mineral distribution of 50-80% montmorillonite, 10-30% illite, 10-20% kaolinite, and trace chlorite (Johns and Grim, 1958; Griffin, 1962). Similar clay mineral distribution is found in the Mississippi Delta and Fan sediments which show 46-56% montmorillonite, 21-38% illite, 13-19% kaolinite, and $<$ 5% chlorite (Johns and Grim, 1958; McAllister, 1964; Scafe and Kunze, 1971). In summary, the Mississippi River delivers very fine grained, montmorillonite-rich sediment that contains hornblende and epidote as the most abundant heavy minerals.

Sediment Character and Distribution

One of the deeper-water studies was that of Curray's investigation of Holocene sediments of the northwest Gulf as a part of American Petroleum Institute Project 51 (Curray, 1960). While utilizing samples from depths shallower than 190 meters, he compiled most of what was known of the surficial sediments and history of Holocene deposition. Bouma (1972) has updated the subject of sediment distribution in the Gulf; however, his data were obtained from average content within the upper 7 m of the sediment column. He describes the sediments from the outer shelf and deeper environments as primarily clay with variable amounts of silt (i.e., pelite - a combination of all size fractions in the clay and silt range). To show variation in sediment types, a clayey pelite is defined as a pelite containing 75% or more clay and a silty pelite as one with 25% or more silt.

As stated earlier, the Mississippi River accounts for about two-thirds of the sediment being delivered to the Gulf of Mexico at the present time. Trefry (1977) reports that the suspended sediment is typically fine-grained with no material greater than 104 um, 1-2% between 104 um and 74 um, 30-60% between 74 um and 4 um, 20-30% between 4 um and 1 um, and 20-30% less than 1 um. The bed load (estimated from about 10-20% of total load) is characterized as 10-30% fine and very fine sand (250-62 um), 40-80% silt (62-4 um), and less than 10-50% clay. It follows that delta and associated fan sediments are also fine-grained with reported particle-size distribution of less than 1-10% sand (> 62 m), 25-45% silt (62-2 um) and 50-75% clay (Scafe, 1968; Tieh et al., 1973; Hottman, 1975).

The upper 10 meters of sediment on the slope, rise, plain, and Mississippi Fan of the Gulf is reported by Davies (1972) to be capped by a 20-50 cm layer of Globigerina ooze. Below the ooze the sediments are predominantly argillaceous lutite interstratified with terrigenous and carbonate sand and silt interbeds 1 mm-150 cm thick. Other sediment varieties include locally developed conglomerates and calcilutites (Rezak and Edwards, 1972). Bouma (1972) shows agreement with these findings except for his reporting that the northwestern abyssal plain-continental rise-Alaminos Canyon area has little or no real ooze as top sediment. The material in that area is reported as "... mainly clayey pelite with a high percentage of scattered Globigerina tests, but not enough to call the deposit an ooze."

The Mississippi Fan is the primary reservoir for Quaternary sediments in the open Gulf (Garrison and Martin, 1973). The upper portion of the fan is characterized by Mississippi gray clay containing less than 10% calcium carbonate (Scafe and Kunze, 1971; Hottman, 1975). Lower fan sediments are characterized by a 20-50 cm layer of Globigerina ooze overlying Mississippi gray lutite indicating a recent decrease in terrigenous flux to the area (Trefry, 1977).

The upper slope on the continental margin off Texas has been receiving fine-grained sediment during the past several thousand years and Booth (1979) reports that episodes of mass movement have taken place throughout the region. Clay-sized particles make up 60-85% of the sediment (Scafe and Kunze, 1971) being deposited with sedimentation rates being variable. Off the Rio Grande, rates of deposition have slowed considerably since the last sea-level rise. Slumps, slides, or other related events periodically interrupt the steady accumulation of sediments on the upper slope off Texas and mass moves them toward the lower reaches of the slope, the rise, and/or onto the Sigsbee Plain (Booth, 1979). Sediments on the gently sloping continental rise and the flat abyssal plain are very similar (i.e., high in clay content with variable amounts of calcium carbonate) and reveal turbidities of both slope and pelagic origin.

Analyses of the sediment from core stations in the study region (Figure 99) yielded data concerning grain size and percentage composition for the upper 5-7 cm of core section. These determinations were obtained by means of wet sieve and settling velocity procedures. Sand was considered to be any material greater than 0.062 mm in size, regardless of being terrestrial or biogenous (i.e., foraminifera tests, mollusk shells or coral debris) in origin. Later microscopic examination revealed the presence of carbonate sand and almost complete absence of quartz sand in the coarse fraction obtained from the core samples. No authigenic grains, that is, deposited on the seafloor as a result

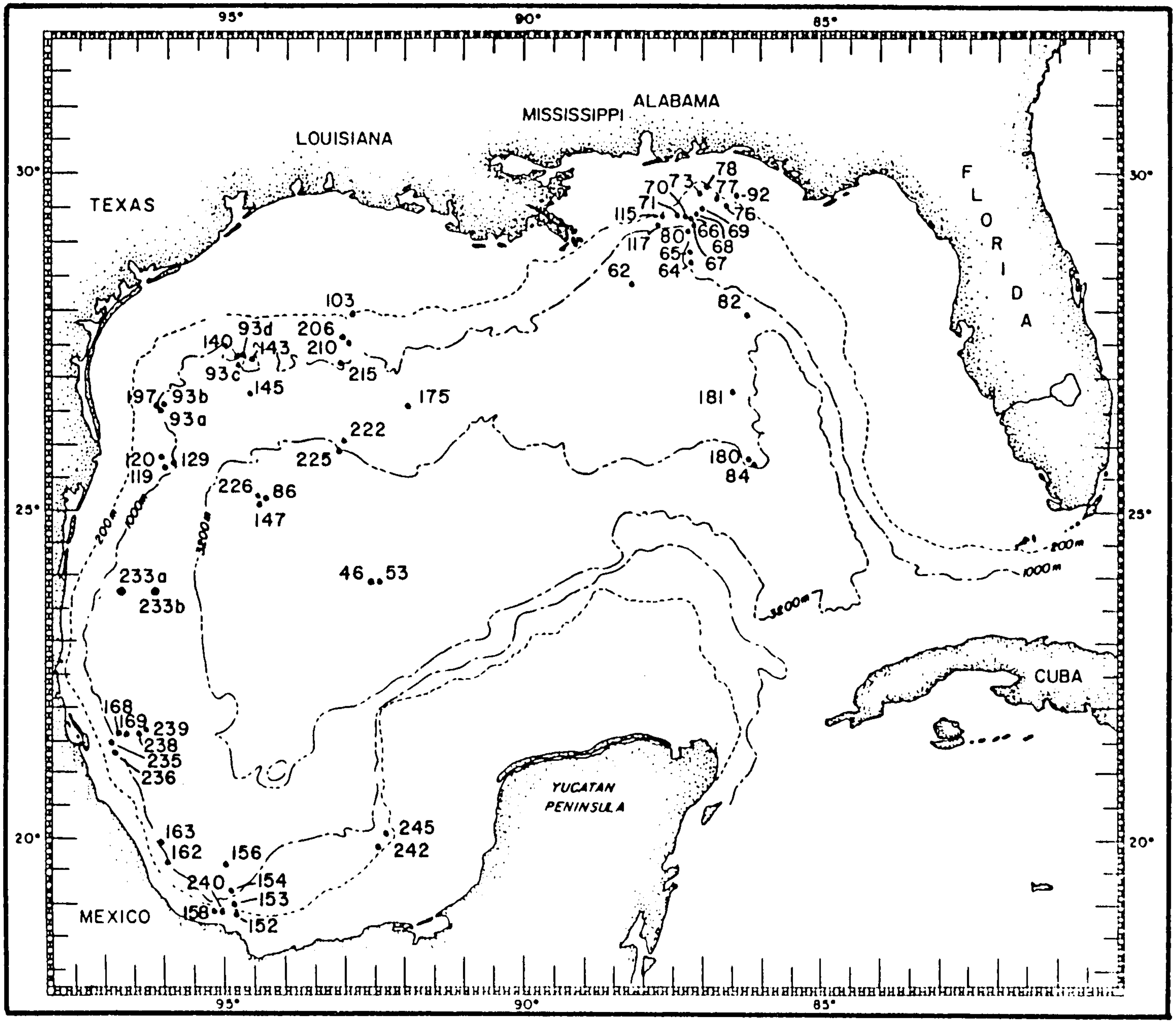


Figure 99. Location of core stations used for in-house grain size analysis.

of chemical reactions (e.g. glauconite), were noted in any of the samples. Table 68 shows the actual data obtained.

Table 68. Sediment data from laboratory analyses of TerEco samples.

Station	BLM	Sampler	% Sand	% Silt	% Clay
66A5-1	46	Grab	13	13	74
66A9-6	55	Dredge	17	24	59
67A5-2F	62	Dredge	4	18	78
67A5-4H	64	Dredge	12	12	76
67A5-4G	64	Skimmer	1	92	7
67A5-5D	65	Skimmer	26	15	59
67A5-6B	66	Skimmer	12	15	73
67A5-6E	67	Dredge	9	15	76
67A5-7C	68	Skimmer	7	25	68
67A5-7E	69	Dredge	2	42	56
67A5-8B	70	Skimmer	3	96	1
67A5-8B	71	Dredge	7	15	78
67A5-9E	73	Dredge	32	17	51
67A5-11C	76	Dredge	26	41	33
67A5-12A	77	Dredge	27	40	33
67A5-13B	78	Dredge	41	34	25
67A5-14A	80	Dredge	8	14	78
67A5-15C	82	Dredge	39	15	46
67A5-16E	84	Skimmer	35	63	2
68A3-3D	86	Core	3	16	81
68A3-14B	93a	Core	0	38	62
68A3-15C	93b	Core	11	88	1
68A3-16C	93c	Core	5	88	7
68A3-17A	93d	Core	3	12	85
68A7-15D	115	Skimmer	3	14	83
68A7-16C	117	Skimmer	5	14	81
68A13-1	119	Skimmer	2	21	77
68A13-3	120	Dredge	2	47	51
68A13-14	129	Dredge	2	38	60
68A13-27	140	Skimmer	5	38	57
69A11-8	143	Core	0	80	20
69A11-15	145	Core	0	39	61
69A11-20	147	Core	8	28	64
69A11-33	152	Core	1	48	51
69A11-36	153	Core	0	66	34
69A11-42	154	Core	1	50	49
69A11-48	156	Core	9	52	39
69A11-54	158	Core	0	60	40
69A11-62	162	Core	0	58	42
69A11-65	163	Core	6	45	49
69A11-80	168	Core	5	40	55
69A11-82	169	Core	17	45	38
69A13-1	175	Core	6	37	57
69A13-31	180	Core	11	34	55
69A13-32	181	Core	0	61	39

Table 68 continued

71A7-16	197	Dredge	38	49	13
71A7-26	203	Core	5	52	43
71A7-37	206	Core	7	32	61
71A7-45	210	Core	4	23	73
71A7-60	215	Core	16	61	23
71A8-7	222	Core	35	22	43
71A8-12	225	Core	8	30	62
71A8-14	226	Core	8	29	63
71A8-33	233a	Core	86	5	9
71A8-38	233b	Core	2	32	66
71A8-42	235	Core	1	69	30
71A8-44	236	Core	2	42	56
71A8-52	238	Core	10	33	57
71A8-55	239	Core	8	36	56
71A8-61	240	Core	4	38	58
71A8-68	242	Core	6	34	60
71A8-76	245	Core	1	32	67

A map of sediment distribution in the northern Gulf was constructed by Grady (1970) for the National Marine Fisheries Service. In general, his chart shows sediment types from the shoreline to depths ranging between 100 and 1000 meters for that area north of the 24th parallel. It is notable that several of the above core stations are located within the limits of his map and that comparisons reveal almost total agreement with his general sediment type for that locale. With this in mind and using Grady's work as a base, a map of predominant sediment types has been constructed by means of interpolation from his control area seaward to the cited core stations. This compilation is designated as Figure 100. One should be aware that some extrapolation of data was required between 89° and 92°W longitudes; however, literature related to the Mississippi Cone (Huang and Goodell, 1970; Wilhelm and Ewing, 1972) indicate the predominant sediment of that area to be foraminiferal clay. Other primary data used in construction and/or verification of the map were those of SUSIO (1977); Bouma (1972); Davies (1972); Rezak and Edwards (1972); Ludwick (1964); and Ewing et al. (1958).

PHYSICO-CHEMICAL FACTORS

WATER MASSES (from Pequegnat et al., 1976)

The principal inflow of marine water into the Gulf of Mexico is from the Caribbean Sea through the Yucatan Strait whose sill depth is estimated to be between 1650- 1900 m. Under normal circumstances this sill determines the greatest depth from which Caribbean water is allowed to enter the Gulf. Most of the outflowing water passes through the Florida Straits into the North Atlantic. This latter passage has a sill depth of some 800 m.

The waters entering the Gulf through the Yucatan Strait are a mixture of South Atlantic water (transported northwestward by the Guiana and Equatorial current systems) with North Atlantic water (from the west Sargasso Sea). The ratio of South Atlantic to North Atlantic water has been estimated to be between 1:4 and 1:2 (Harding and Nowlin, 1966).

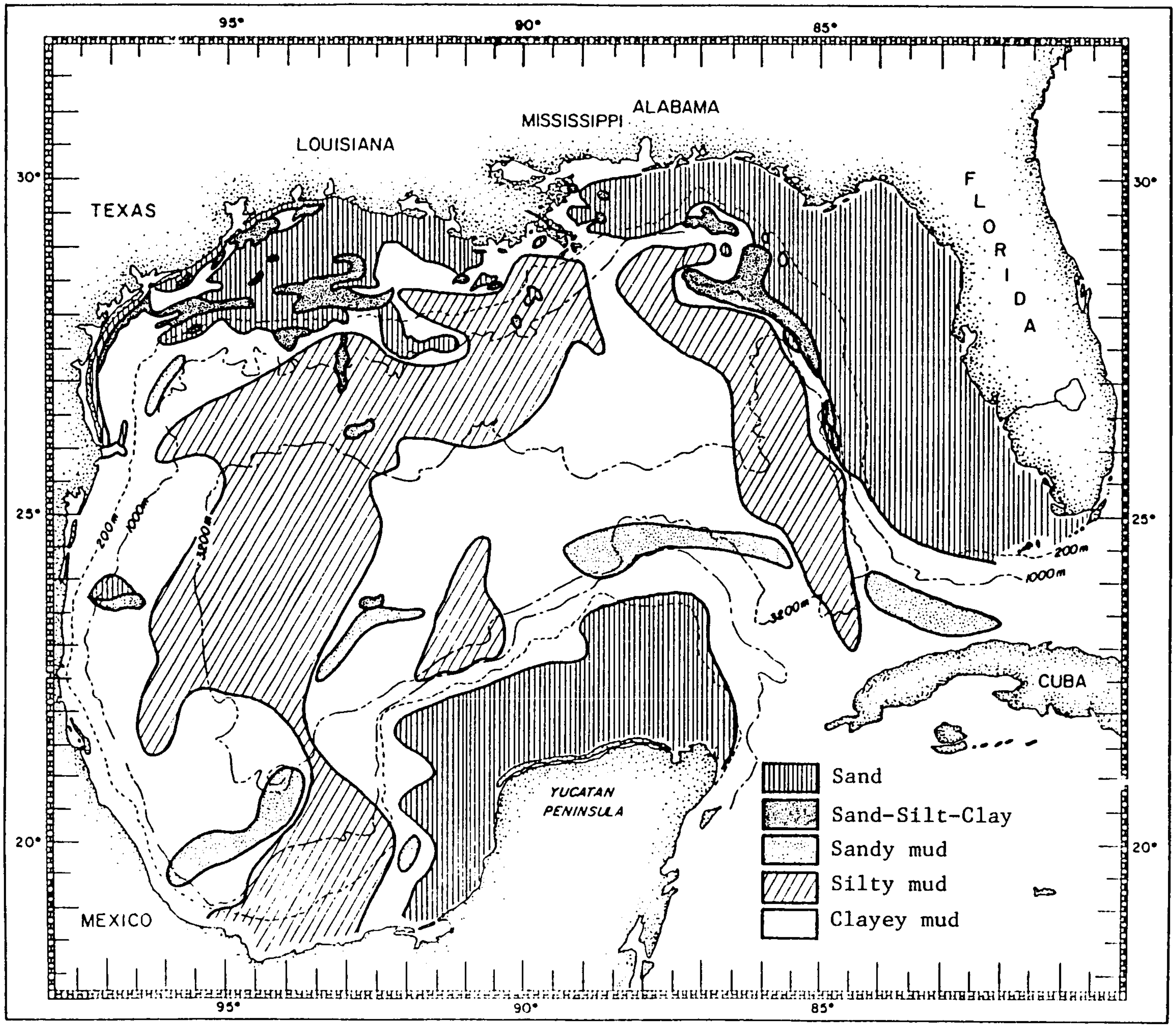


Figure 100. Predominant sediment types.

The Gulf may be classified as tropical in the south and warm temperate in the north; the Tropic of Cancer, 23°27'N, passes through the western Gulf about 150 miles south of Brownsville, Texas, and through the eastern Gulf between Florida and Cuba. Characteristic open Gulf surface temperatures are 28-30°C in the summer and 20-25°C in the winter. Over the central Gulf basin, surface salinities are generally in the range of 36.0-36.3 ppt.

Five water masses are recognized in the Gulf. These water masses are vertically layered as follows: (1) Surface Mixed Layer, (2) Subtropical Underwater, (3) Oxygen Minimum Layer, (4) Subantarctic Intermediate Water, and (5) Gulf Basin Water. Each of these water masses can be distinguished in the Gulf by distinct values, gradients, or relative maxima or minima in specific parameters. In Figure 101 are plotted temperature, salinity, and oxygen as functions of depth for a March hydrographic station taken in the west-central Gulf; also approximate water mass depth ranges are shown for the five water masses. The distinguishing characteristics given below for each water mass were taken from various sources - Harding and Nowlin, 1966; Nowlin, 1971, 1972; Wust, 1964.

(1) Surface Mixed Layer (SML) - generally characterized as the upper isothermal layer with temperature depending on the heat budget and by a salinity distribution depending on evaporation minus precipitation, runoff, and the horizontal advection of currents. The thickness of the SML may vary from a fraction of a meter to over 125 meters, depending on location, time of the year, and local influences. Depth of SML, shown in Figure 101 is approximately 75 m.

(2) Subtropical Underwater (SU) - characterized by an intermediate maximum of salinity in depths between 50-200 m. This water mass is present throughout the Caribbean, but its salinity maximum becomes eroded in the Gulf outside the Loop Current. The region of Campeche Bank appears to be a focal point for this modification in the Gulf. Figure 102 gives horizontal distribution of the salinity maximum in the core of the SU; Figure 102 gives the depth distribution of the core of the SU. The source of the SU in the Caribbean and Gulf is probably from the tropical North Atlantic at 20-25° N, 30-50° W.

(3) Oxygen Minimum Layer (OML) - characterized by minimum oxygen values within depths of approximately 300-600 m. The OML is not associated with salinity or temperature extremes. The Gulf OML is clearly continuous with that of the Caribbean. In the eastern Gulf a secondary OML is present throughout the water bounded by the Loop Current, but is almost completely suppressed in the western Gulf. Figure 103 shows representative dissolved oxygen curves for various sections of the Gulf.

(4) Subantarctic Intermediate Water (SIW) - characterized in the Gulf by a salinity minimum of 34.86-34.89 ppt at depths between 550-900 m. This water mass has its origin at the Antarctic Convergence where cold, low salinity water sinks and spreads to the north. This core of minimum salinity enters the Caribbean with salinities of slightly less than 34.7 ppt but mixing that accompanies horizontal spreading raises the salinity to approximately 34.8 ppt by the time it reaches the Yucatan Strait and is further raised to 34.88-34.89 ppt in the western Gulf. Calculations show the percentage composition of Subantarctic water in the core to be less than 5% at the Yucatan Strait and only some 1-2% in the western Gulf. A suggestion has been made to label this portion of

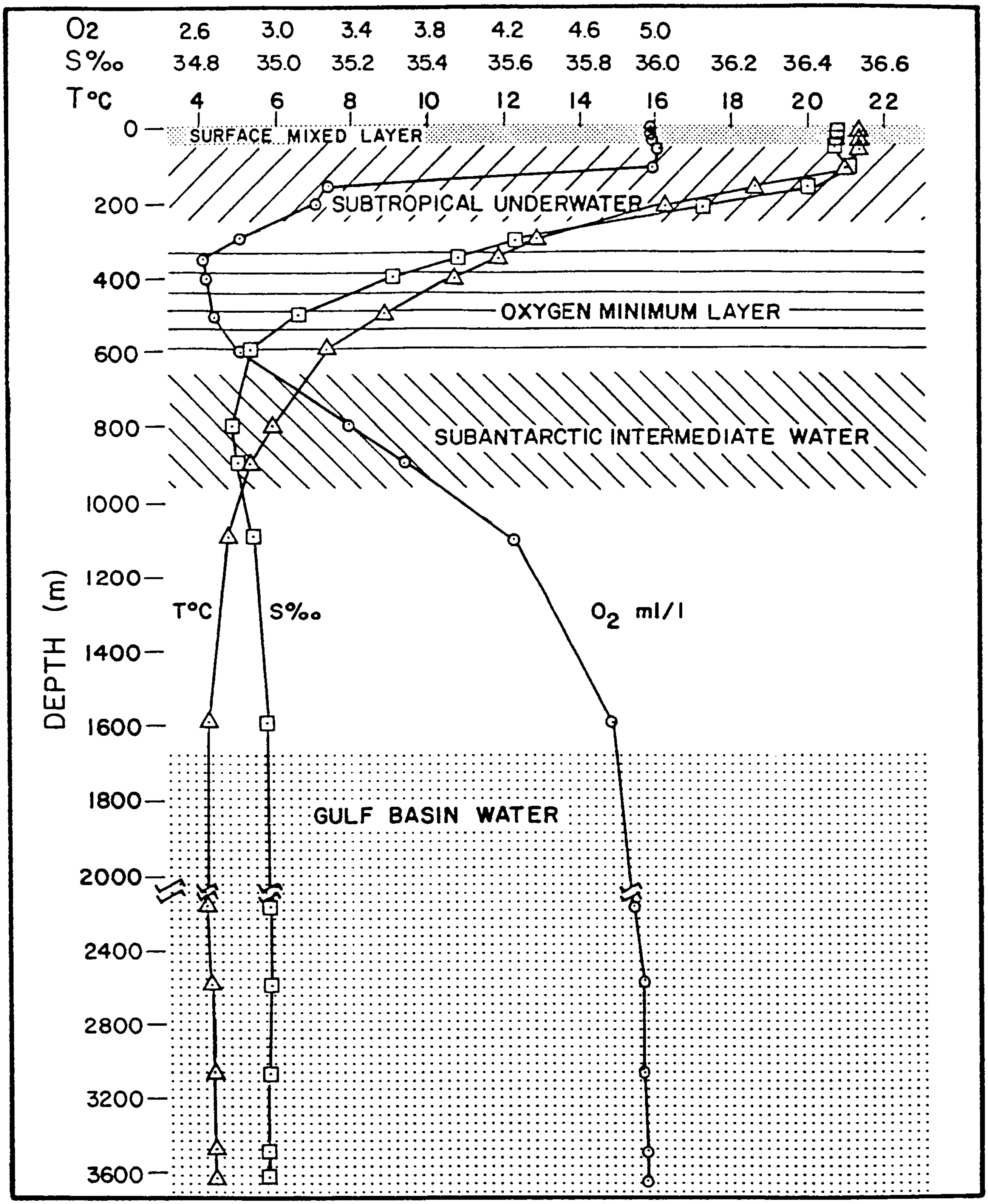


Figure 101. Physical characteristics and water mass designations from a west-central Gulf hydrographic station (25°09'N, 94°11'W; 15 March 1968). Deepest sample taken four meters above the bottom.

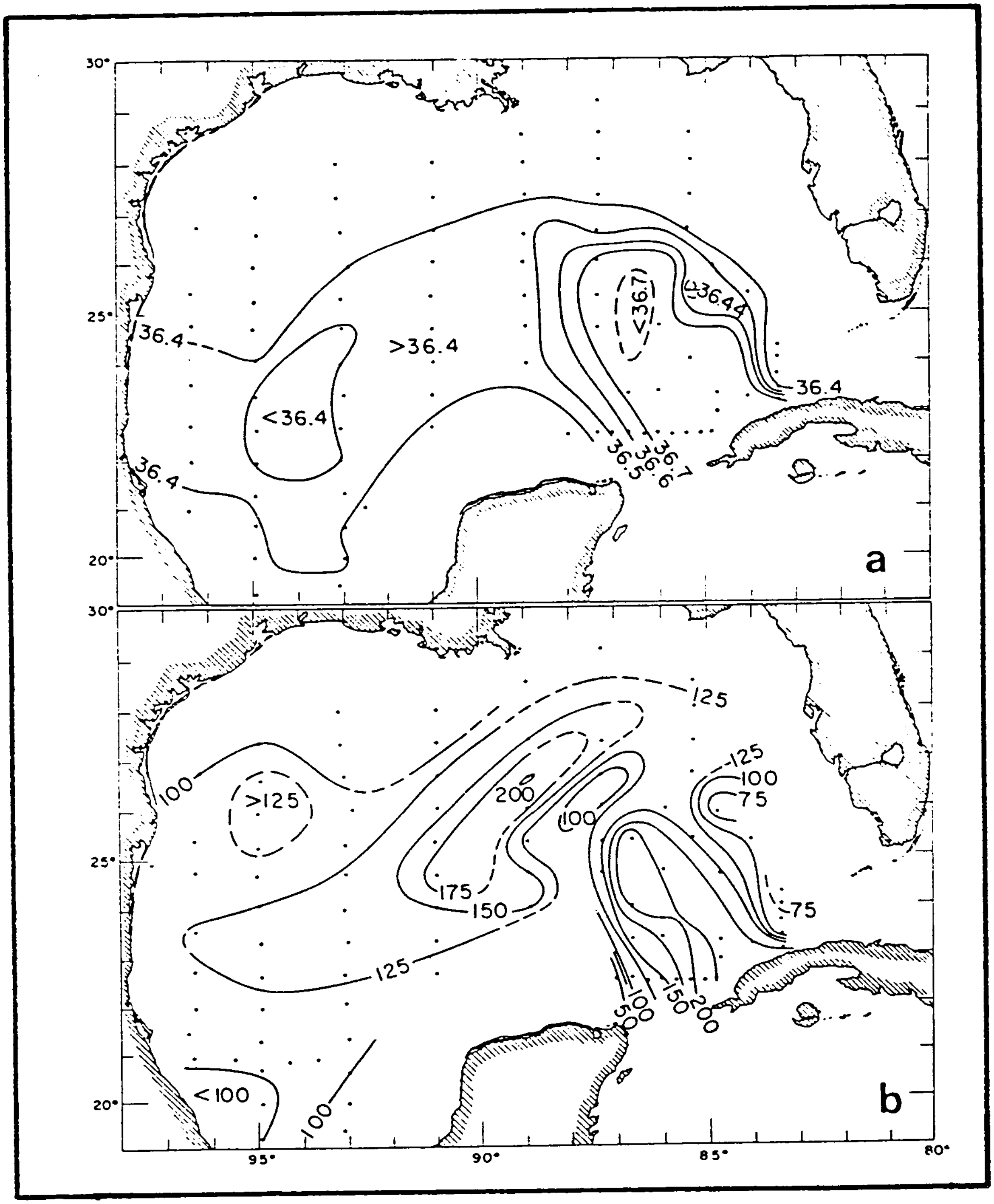


Figure 102. Core of salinity maximum of the Subtropical Underwater: (a) core salinity at 0.1 ppt intervals, (b) core depth in 25 m intervals (from Nowlin, 1972).

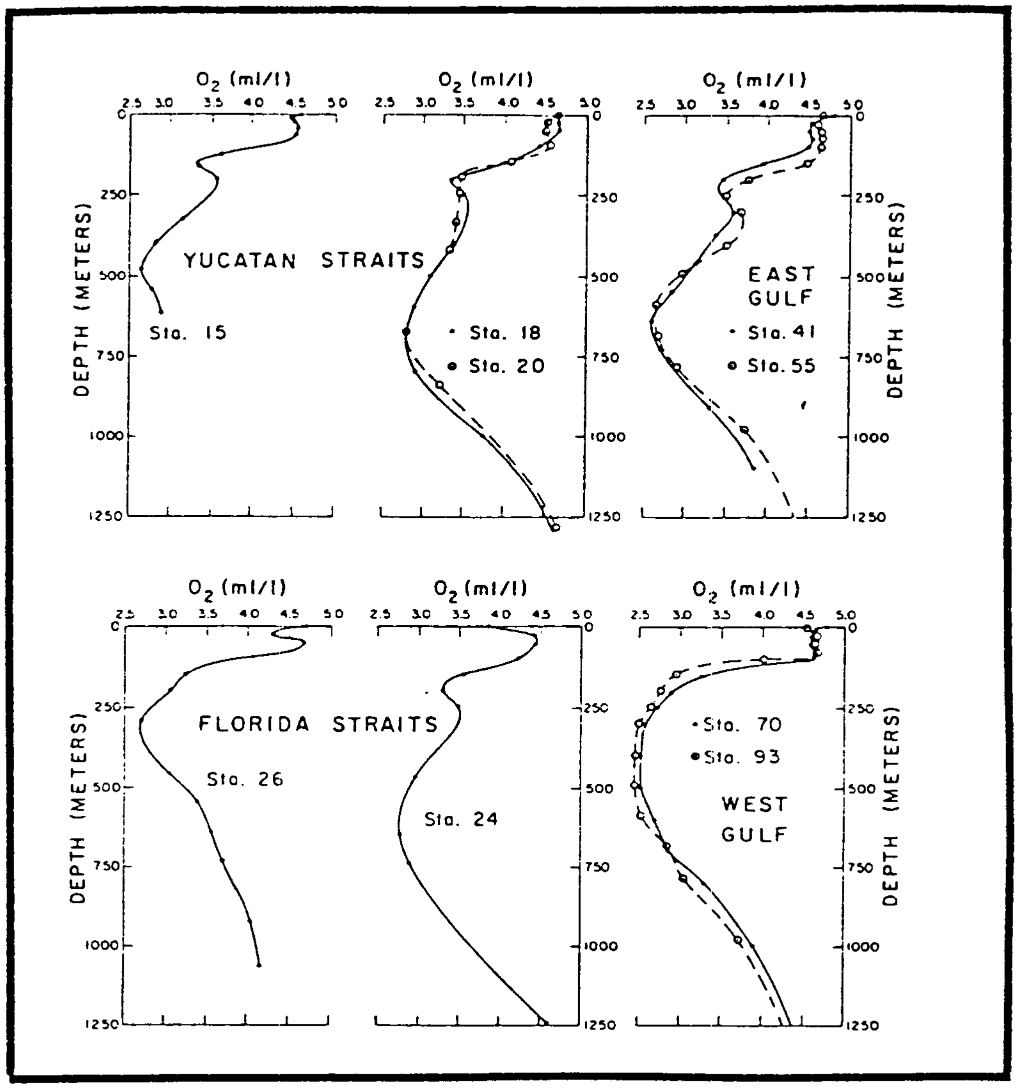


Figure 103. Dissolved oxygen concentration versus depth for various sections of the Gulf (from Nowlin, 1972; station numbers refer to Hidalgo Cruise 62-H-3).

the Gulf water mass "Remnant of the Subantarctic Intermediate Water." The Gulf depth distribuiton of the SIW core layer is given in Figure 104.

(5) Gulf Basin Water (GBW) - defined as those waters below 1650-1900 m (estimate of Yucatan sill depth). At approximately 2000 m the mean temperature and salinity are 4.23°C and 34.97 ppt respectively. Below 2000 m in situ temperature increases approximately 0.1°C per 1000 m (adiabatic warming) and salinity increases approximately 0.002 ppt per 1000 m. The stability of the GBW is reported to be near neutral (slightly positive) as calculated from the present state-of-the-art parameter determinations. Relationships of potential temperature versus salinity on both sides of the Yucatan sill are quite similar and thus are consistent with the idea of present day displacement of GBW by Caribbean waters.

NEAR BOTTOM TEMPERATURE, SALINITY, AND DISSOLVED OXYGEN

There is a paucity of Gulf of Mexico temperature, salinity, and dissolved oxygen data that have been collected near the bottom in depths below 200 m. The bottom hydrocast collection bottle of ALAMINOS data presented herein was lowered to within 10 m of the bottom with most being within 3 m and some being within 1 m regardless of depth. Location of hydrographic stations are shown in Figure 105 and Table 69.

Three methods of collection were employed: (1) an acoustical pinger was attached to the bottom of the hydrographic wire and its location relative to the bottom was monitored with an oscilloscope which was connected to the ship's transducer. Niskin or Nansen bottles were attached above the pinger, (2) Niskin or Nansen bottles were attached to a device which upon bottom contact mechanically actuated the bottle tripping mechanism, and (3) Niskin bottles were attached to a frame suspended from a tetrapod. The entire device was lowered to the bottom and 10 minutes later the bottles were electronically tripped.

This report examines the benthos below 200 m. The general trends of bottom temperature, salinity, and dissolved oxygen in the northern Gulf above 200 m are adequately covered by Pequegnat et al., (1976) and are not repeated herein. The data that are to be discussed were collected by the ALAMINOS. Comparisons, however, are made between ALAMINOS data and those near bottom data found in the literature. For each of the 45 near bottom hydrocasts, parameter (temperature, salinity, dissolved oxygen) values for the lower 200 m of the cast were plotted against depth. A composite of these 45 individual graphs, irrespective of seasonality, was constructed for each parameter. The temperature and salinity data presented herein are the narrowest "envelopes" that would contain all individual data points. Depth distribution of the 45 hydrographic stations are shown in Figure 105.

The temperature composite is shown in Figure 106. Note the "envelope" is narrow and very confining. The difference in isobathic temperature extremes is approximately ± 2°C at 200 m, ± 1°C at 400 m, ± 0.5°C at 700 m, and < 0.3 below 1000 m. These data agree relatively well with near-bottom, long-term, continuous records taken by Molinari et al. (1979) from 970 m in the northeastern Gulf and those by Brooks and Eble (1982) from 700 m in the northwestern Gulf.

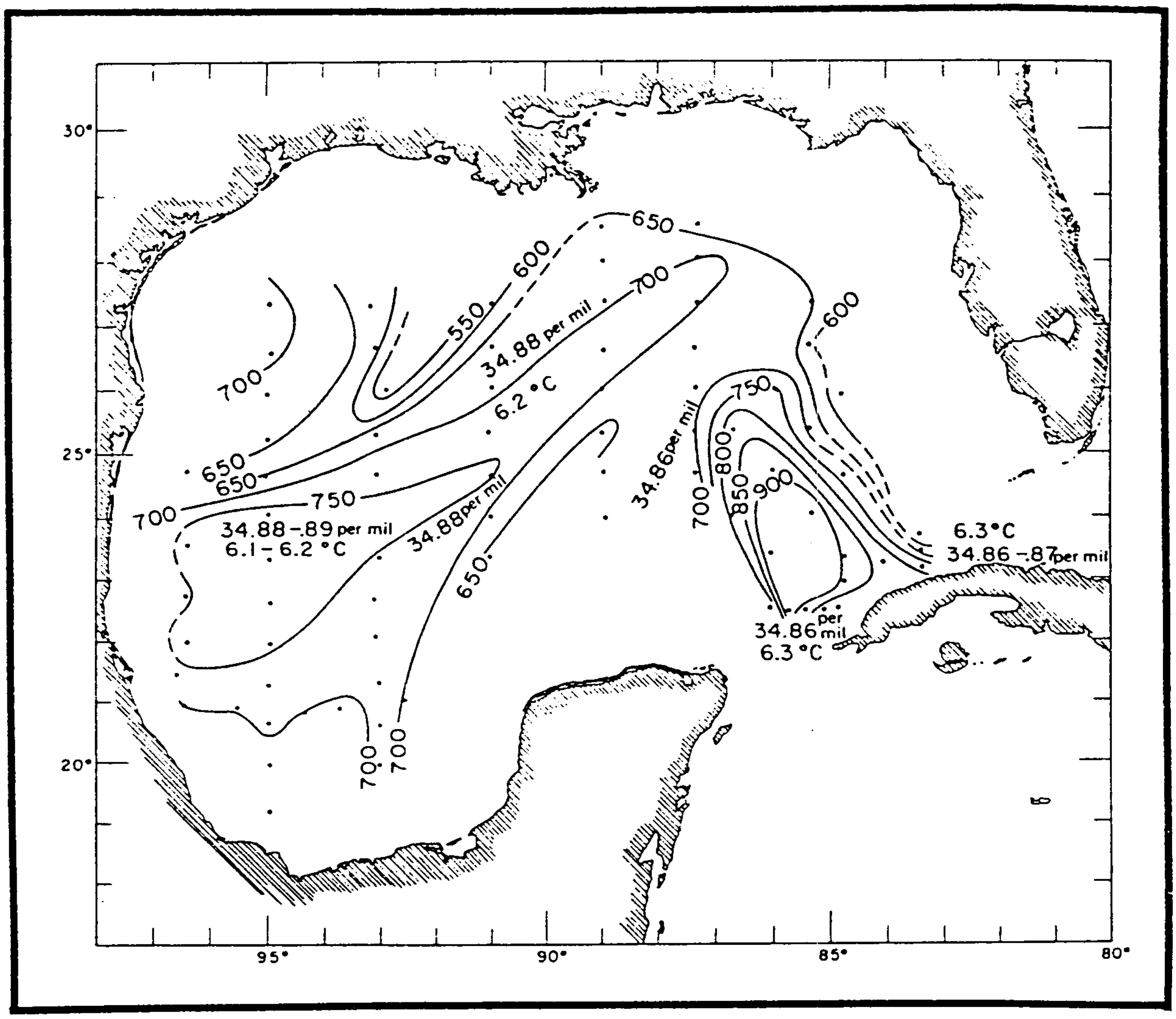


Figure 104. Depth of core layer of the Subantarctic Intermediate Water (in 50 m intervals). Selected values of salinity and temperature at core depth are shown (from Nowlin, 1972).

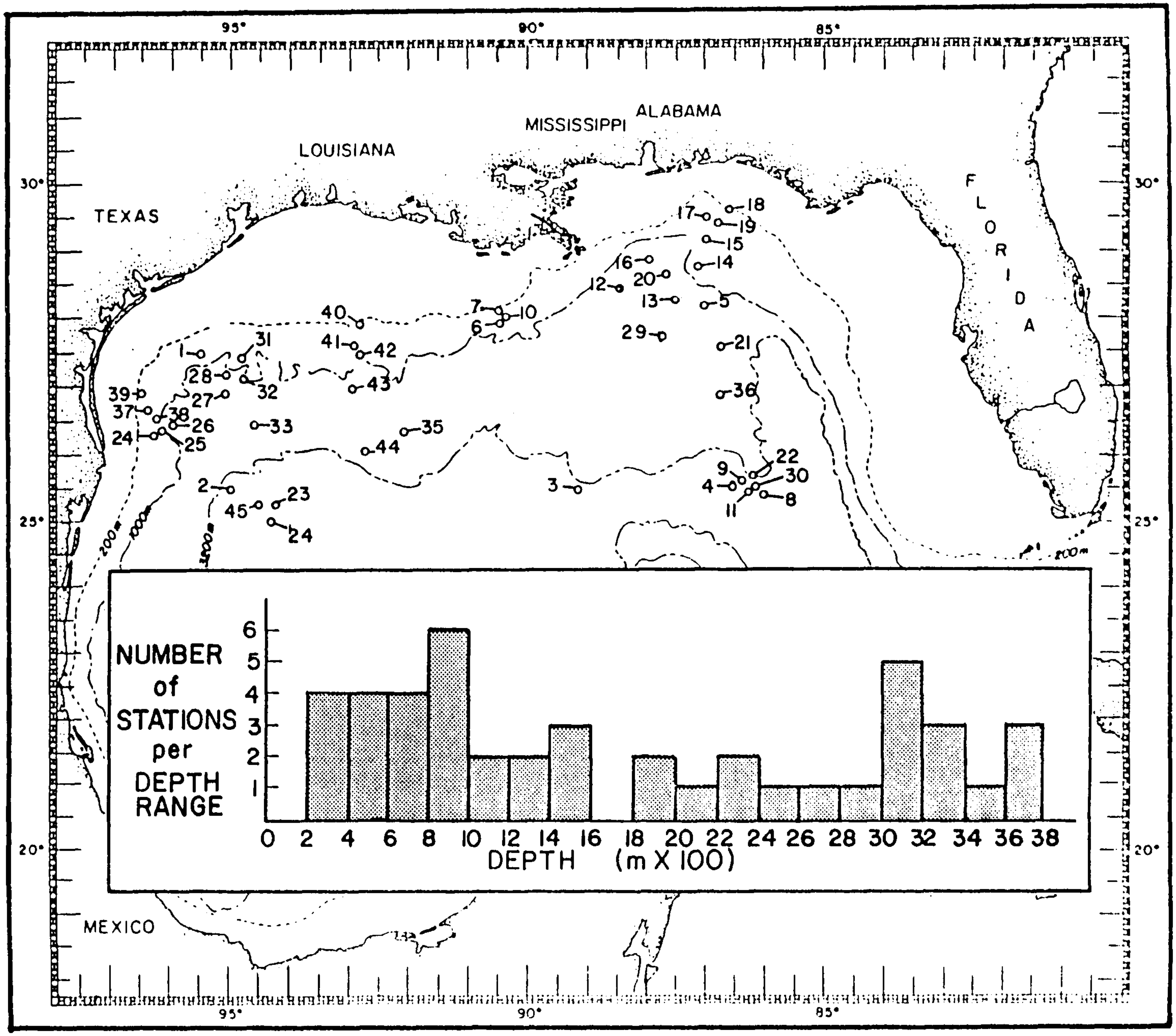


Figure 105. Location and depth distribution of hydrographic stations. Station identification numbers correspond to those on Table 69.

Table 69. Location of hydrographic stations. Map number corresponds to those in Figure 105.

Map No.	Station	Date	Bottom Depth	Depth of Bottom Bottle	N Latitude	W Longitude
1.	65A3-1	03/65	846	813	27°31'	95°30'
2.	65A3-3	03/65	3422	3418	25°29'	94°55'
3.	66A5-2	03/66	3365	3360	25°32.5'	89°02'
4.	66A5-3	03/66	3210	3204	25°25'	86°13'
5.	66A5-4	04/66	1481	1474	28°14'	87°00'
6.	66A5-6	04/66	801	785	27°52.5'	90°22'
7.	66A5-7	04/66	350	340	28°01'	90°26'
8.	66A9-13	07/66	3190	3162	25°19'	85°59'
9.	66A9-14	07/66	3197	3233	25°28'	86°17'
10.	66A9-17	07/66	600	575	27°55'	90°20'
11.	66A16-1	11/66	3238	3230	25°24'	86°07'
12.	67A5-2EC	07/67	1875	1874	28°24.2'	88°20.3'
13.	67A5-4AC	07/67	2520	2500	28°20.4'	87°26.3'
14.	67A5-6FG	07/67	751	750	28°47.3'	87°02'.8
15.	67A5-7FG	07/67	868	867	29°15.5'	86°59'
16.	67A5-8AD	07/67	1580	1578	28°57'7	87°24.5'
17.	67A5-9B	07/67	730	675	29°27'	86°51.1'
18.	67A5-12C	07/67	191	190	29°35.5'	86°36'
19.	67A5-13C	07/67	378	350	29°30'	86°52.5'
20.	67A5-14AF	07/67	2375	2370	28°40.3'	87°39.2'
21.	67A5-15BE	07/67	3170	3169	27°39'	86°35.1'
22.	67A5-16C	07/67	3169	3165	25°29.2'	86°07'
23.	68A3-3C	03/68	3637	3633	25°09'	94°11'
24.	68A3-12A	03/68	725	719	26°21'	96°08.5'
25.	68A3-14A	03/68	949	945	26°25'	96°03.8'
26.	68A3-15B	03/68	1090	1086	26°28.8'	95°59'
27.	68A3-16B	03/68	1522	1518	26°55.6'	95°06.2'
28.	68A3-17A	03/68	1310	1306	27°11.5'	95°03.9
29.	68A7-3AB	07/68	2690	2685	27°42.4'	87°43.5'
30.	68A7-4C	07/68	3255	3252	25°25.3'	86°05.3'
31.	69A11-6	08/69	940	937	27°25'	94°45.6'
32.	69A11-8	08/69	1292	1289	27°03.7'	94°43.4'
33.	69A11-16	08/69	2351	2348	26°18.7'	94°38'
34.	69A11-22	08/69	3720	3717	24°52'	94°20'
35.	69A13-3	10/69	2005	2004	26°12.5'	92°00'
36.	69A13-34	10/69	3083	3082	26°50.5'	86°40'
37.	71A7-5	07/71	585	582	26°38'	96°15.1'
38.	71A7-8	07/71	960	957	26°31.2'	96°05.5'
39.	71A7-21	07/71	229	227	26°43.5'	96°25.5'
40.	71A7-25	07/71	190	187	27°54.6'	92°49.5'
41.	71A7-36	07/71	566	563	27°36.5'	92°58.4'
42.	71A7-44	07/71	927	924	27°30.4'	92°49.3'
43.	71A7-59	07/71	1196	1193	26°59.1'	92°58.5'
44.	71A8-9	07/71	2081	2078	26°07.5'	92°42'
45.	71A8-15	07/71	3668	3665	25°05.5'	94°23.1'

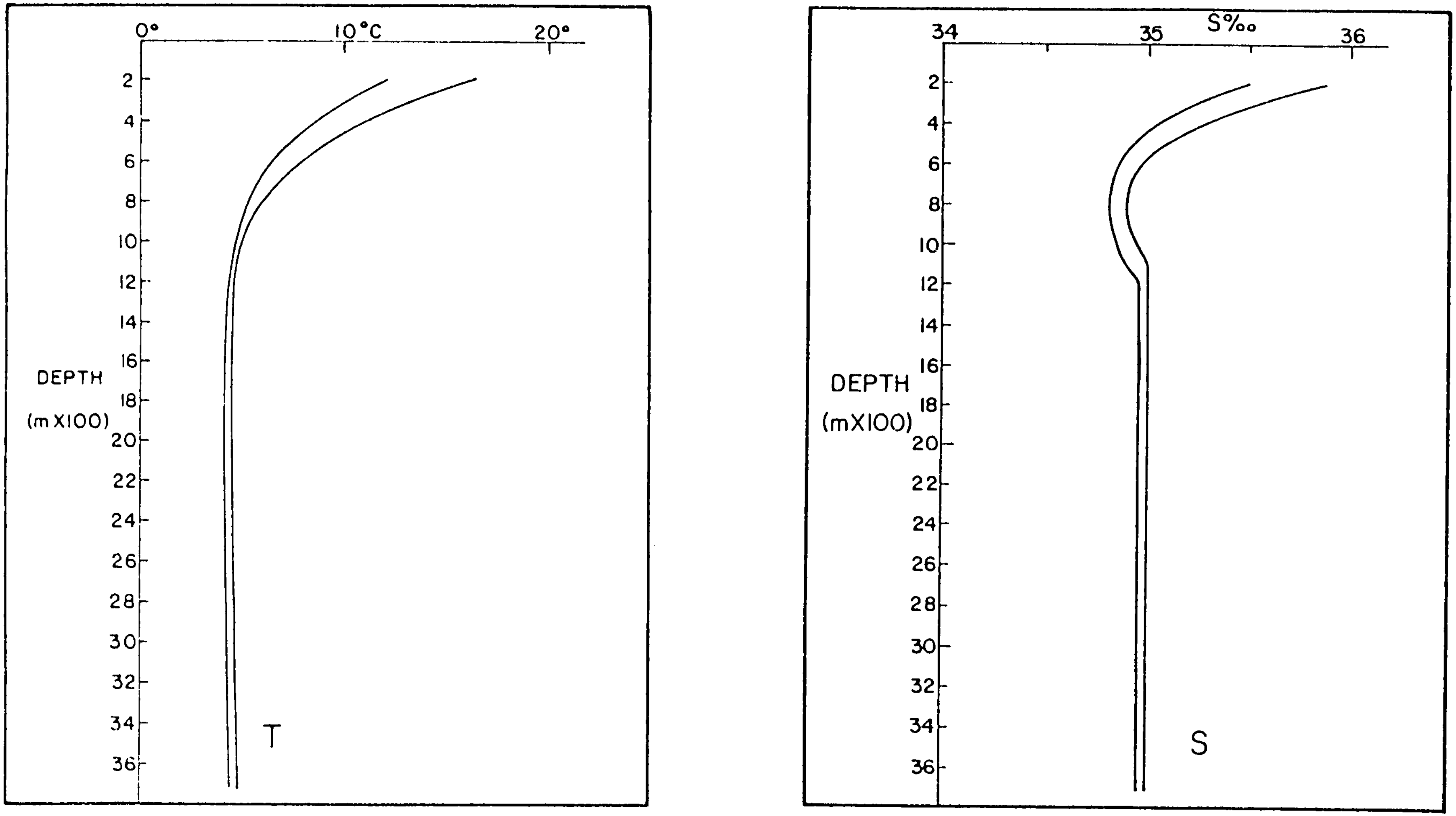


Figure 106. Isobathic temperature and salinity "envelopes" of composite data.

The salinity composite is shown in Figure 106. Salinity decreases from about 35.7 ppt at 200 m to a minimum of 34.84-34.89 ppt at 700-900 m then increases slightly to 34.97 ppt at 1200 m where it remains rather isohaline ($\pm$ 0.03 ppt) down to the deeper aspects of the study area (approximately 3800 m). The salinity minimum at 700-900 m is characteristic of the subantarctic intermediate water mass previously discussed. Molinari et al. (1979) did not collect long-term salinity data in conjunction with their temperature-current meter array. Salinity data given by Brooks and Eble (1982) are not compared herein because their instrumentation seems to be out of calibration, viz., the values from the three relatively closely spaced arrays differ suspiciously from each other as well as from historical data.

A dissolved oxygen "envelope" was not constructed; instead, data points distinguishable from east and west are presented (Figure 107). The dividing line between east and west was arbitrarily taken as 90°W longitude. The number of data points used in constructing this figure were essentially the same for east and west (east - 20 hydrocasts, west - 25 hydrocasts). In the western Gulf the oxygen-minimum layer is thicker and has lower extreme values. This agrees well with Nowlin's (1972) assessment of the open-water column. Note that in the eastern Gulf between 3000 and 3400 m dissolved oxygen values are above 5 ml/l; whereas, in the western Gulf values below 5 ml/l were predominant from 3400-3800 m. No data were collected in the western Gulf in depths of 2600 to 3400 m; thus an "envelope" was not constructed because of the chance of data misinterpretation. If an "envelope" were constructed it would indicate a decrease in dissolved oxygen from 3100 to 3800 m which instead may be an east-west difference in this nonconservative parameter. In addition, because of its possible lower dissolved oxygen values, one may wish to infer a much longer residence time for the waters of the western Gulf.

CIRCULATION AND CURRENTS

Surface and Upper Layer

The surface circulation in the Gulf of Mexico has been studied by oceanographers throughout the twentieth century using observations from ships, hydrographic stations, driftbottles and drogues, current meters, experimental laboratory modeling, and one of our latest technologies — satellite imagery. These efforts have established a rather well defined circulation pattern for at least the eastern Gulf.

The Gulf of Mexico may be divided into two major circulatory provinces, East and West, each distinguished by different flow regimes. Water enters the Gulf via the Yucatan Channel and leaves via the Florida Straits. The salient flow pattern in the Eastern Gulf is the Loop Current (Figure 108) which flows in a clockwise (anticyclonic) direction. This is in essence an extension of the Yucatan Current which penetrates into the Gulf and then turns to the right to flow out the Florida Straits. Prior to about 1975 it was believed that on a seasonal basis the Loop Current extended far to the north in the spring and summer and receded during the fall and winter. Molinari and Festa (1978) find the average position of the northern edge of the Loop to be 26°N and that penetrations north and south of this mean can occur during <u>any</u> season. According to Molinari et al. (1979) when the Loop is far to the south in the Gulf, the circulation to the north is characterized by a series of gyres of alternating rotational flow. The number and size of the gyres are reduced as the Loop

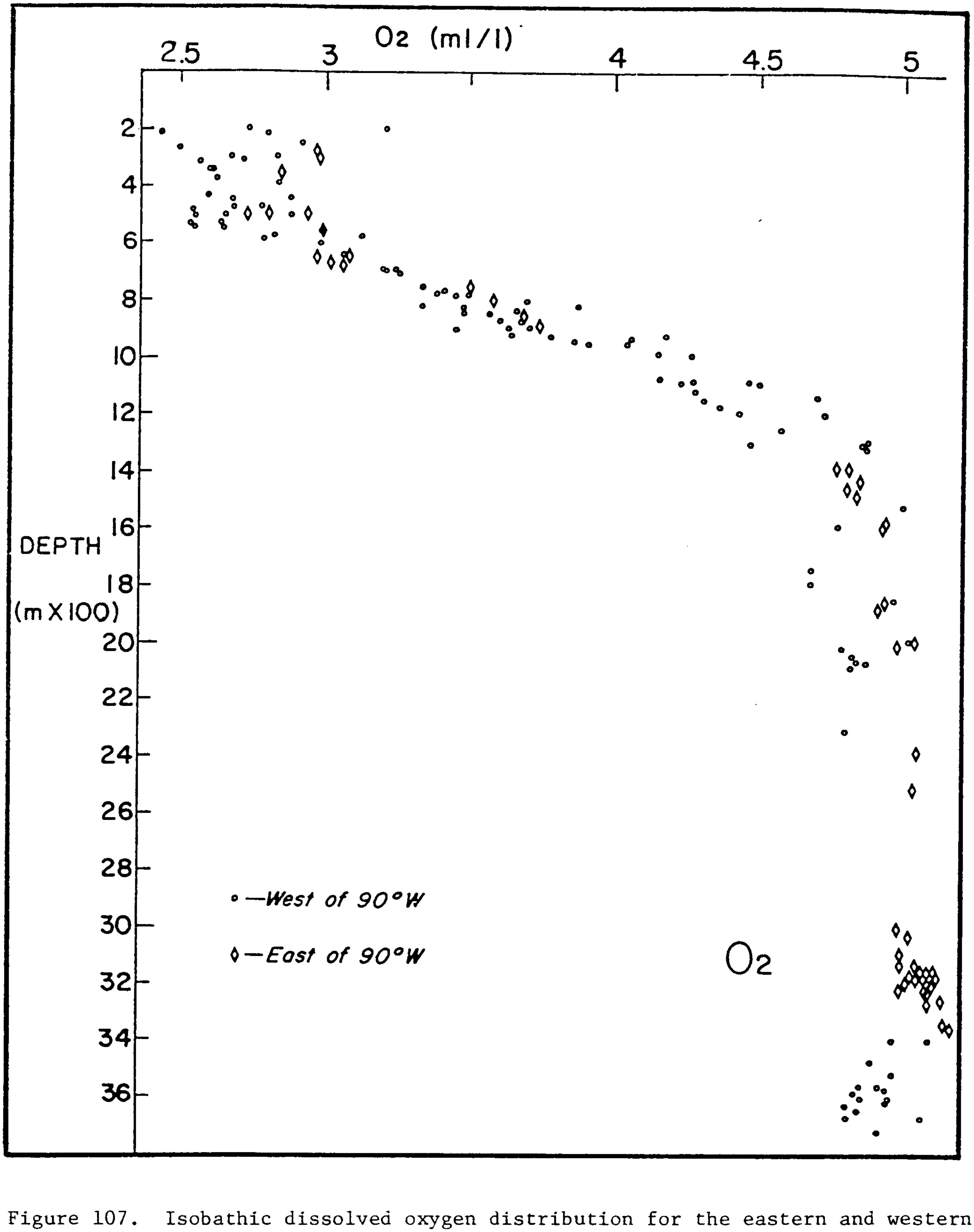


Figure 107. Isobathic dissolved oxygen distribution for the eastern and western parts of the study area.

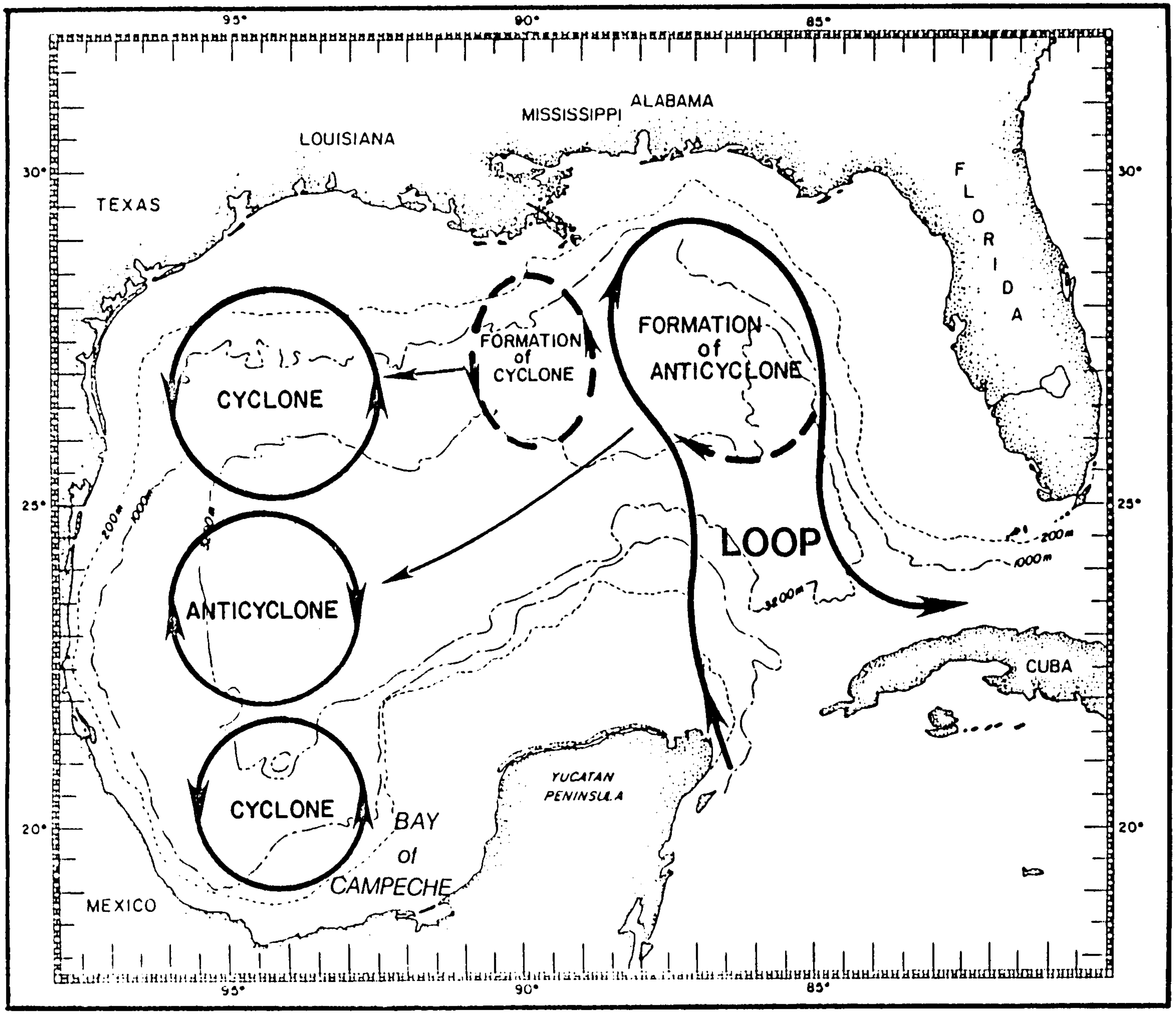


Figure 108. Diagrammatic representation of the large scale circulation processes of the Gulf of Mexico.

intrudes to the north. When the Loop fills the entire eastern Gulf basin, the flow in the northeastern Gulf is predominately to the east. In other cases, the flow is a function of the type of gyre, cyclonic or anticyclonic, located in the northern Gulf at the time.

Although data are insufficient to obtain a clear picture of the surface circulation over the northeastern Gulf Slope, two features are relevant. First, only rarely does the Loop seem to penetrate as far north as shown in Figure 108. Secondly, the flow along the western flank of the DeSoto Canyon is frequently to the north (Molinari et al., 1979).

Currents in the western Gulf of Mexico are relatively unexplored compared to the eastern Gulf where numerous observations of the Loop Current have been made (Merrell and Morrison, 1981). Interest in the study of circulation processes of the western Gulf, however has increased noticeably in the past few years (Sturges and Blaha, 1976; Molinari et al., 1978; Clemente-Colon, 1980; Blaha and Sturges, 1981; Merrell and Morrison, 1981; Elliott, 1982).

Circulation in the northwestern part of the Gulf is dominated by a semi-permanent anticyclonic (clockwise) cell in the region between 22° and 25°N (Figure 108). The southward movement of this cell is prevented by the wind stress maintained cyclonic circulation of the Bay of Campeche. Two hypotheses have been proposed for the driving force of the anticyclonic cell. Sturges and Blaha (1976) and Blaha and Sturges (1978) hypothesize that the circulation is driven by the curl of the wind stress; whereas, Elliott (1982) suggests the dominant factor responsible is the periodic invasion of anticyclonic rings detached from the Loop Current. Elliott carefully documents the migration of several rings to the west and estimates this migration from the eastern Gulf to the western boundary to be about 1.1 years. He also documents the presence of intense cyclonic circulation on the northern shelf-slope (Figure 108). Merrell and Morrison (1981) reviewed a draft of Elliott's paper and they postulate that a combination of wind stress and detached rings is the anticyclonic driving force.

The circulation north of 25°C (over the northeastern slope) is a region of high variability. From time to time this region is occupied by a cyclonic cell (Figure 108). Merrell and Morrison (1981) speculate that when the Loop Current is fully extended, cyclonic cells can form on the western edge and migrate westward (anticyclones can separate from the Loop at any extension but cyclones can only form when the Loop is fully extended and a low pressure trough is present). When there is a cyclonic cell to the north of the semi-permanent anticyclonic cell (Figure 108) there is eastward transport between them. Merrell and Morrison calculate this transport relative to 1500 m to be close to 30 x $10^6 m^3$/sec which is comparable to the flow through the Yucatan Strait. They also contend the circulation in the northwestern region depends on whether a cyclone or anticyclone has migrated into the area. If a cyclone migrates into the area, a three-gyre system such as shown in Figure 108 develops and the cyclone is fed by water from the Texas shelf. If an anticyclone migrates into the area, it may be weakened and perhaps even split by the shelf outflow.

Near Bottom

Pequegnat (1972) was first to document the presence of deep near-bottom currents in the Gulf of Mexico. To date there have been three additional Gulf of Mexico studies that have reported on deep near-bottom currents: Moore, 1973;

Molinari et al., 1979; and Brooks and Eble, 1982. Locations of current meter placement for the above studies are shown in Figure 109. The documentation Pequegnat (1972) presents consists of data from biological evidence obtained by dredging, bottom photography, and in situ current meters. His data were collected in the East Central Gulf at bottom depths of 3046-3286 m. Speed data from six current meter measurements taken 1 m above the bottom ranged from 6 to 19 cm/sec. Near-bottom current measurements from the Northwestern Gulf continental slope are reported by Moore, 1973. Short term measurements (less than nine hours) were taken at five sites in depths of 240, 370, 542, 687, and 1150 m. Current speeds of 4-8 cm/sec were recorded for the 1150 m station; whereas, the remaining four measurements were 15-29 cm/sec. Molinari et al. (1979) investigated possible OTEC sites in the Northeastern Gulf through a literature review and on-site data collection. Current data were obtained from two locations using moored meters suspended 65 m above the bottom in 1050 m of water. The meters were utilized during July 1977 through August 1978 with one meter collecting 91 days of data and the other collecting for 308 days. The maximum speed observed during each of the 13 collection months ranged from 10 to 30 cm/sec. On the average (a) 10% of the observation were greater than 14 cm/sec, (b) 50% of the observations were greater than 7 cm/sec, and (c) 90% were greater than 2 cm/sec. Brooks and Eble (1982) present a data report on current meter output from the deployment of three arrays along the 730 m isobath in the Northwestern Gulf of Mexico. Aside from upper level current meters, conductivity probes, and temperature probes, each of the moorings had a recording current meter 30 m off the bottom. The instruments recorded current speed and direction for about 6.5 months, from 18 July 1980 to 4 February 1981. Current data are presented as stick plots for each mooring. These data have not been fully reduced so at this time the only inferences to be drawn are that currents were present and possessed an average speed of about 7-10 cm/sec.

Current direction in the above discussion was intentionally left out because it deserves separate treatment. The long-term data collected by Molinari et al. (1979) clearly show the water movement near the bottom closely parallels the isobath or as they state "the flow is very channelized by the bathymetry." The steeper the topograhic gradient the more influence it has in directing flow. In those regions where there is little topographic gradient, the direction of flow will be more erratic since boundary influences are lessened and direction becomes more of a resultant of upcurrent flow direction, downcurrent resistance, density discontinuity, and the Coriolis effect.

Current directions given by Pequegnat (1972) would be classified with those having little topographic gradient. Data of Moore (1973) and Brooks and Eble (1982) were taken in regions of moderate topographic relief and thus should be under the influences of boundary conditions. Both studies, however, were conducted in the region described by Gealy (1955) as the "hummocky" zone. The region is characterized by localized systems of diapiric structures thus apparent flow direction (that of Moore, 1973; Brooks and Eble, 1982) will be localized and any discernment of possible large scale circulation trends must await further reduction of Brooks and Eble's (1982) data.

CHEMICAL FACTORS - DISTRIBUTION OF HEAVY METALS

Trefry (1981) reviews and summarizes the existing knowledge on trace metals in the Gulf. Much that follows was taken from this review. Water column dissolved and particulate metals were his primary interests; however, riverine input and depositional sediments were addressed.

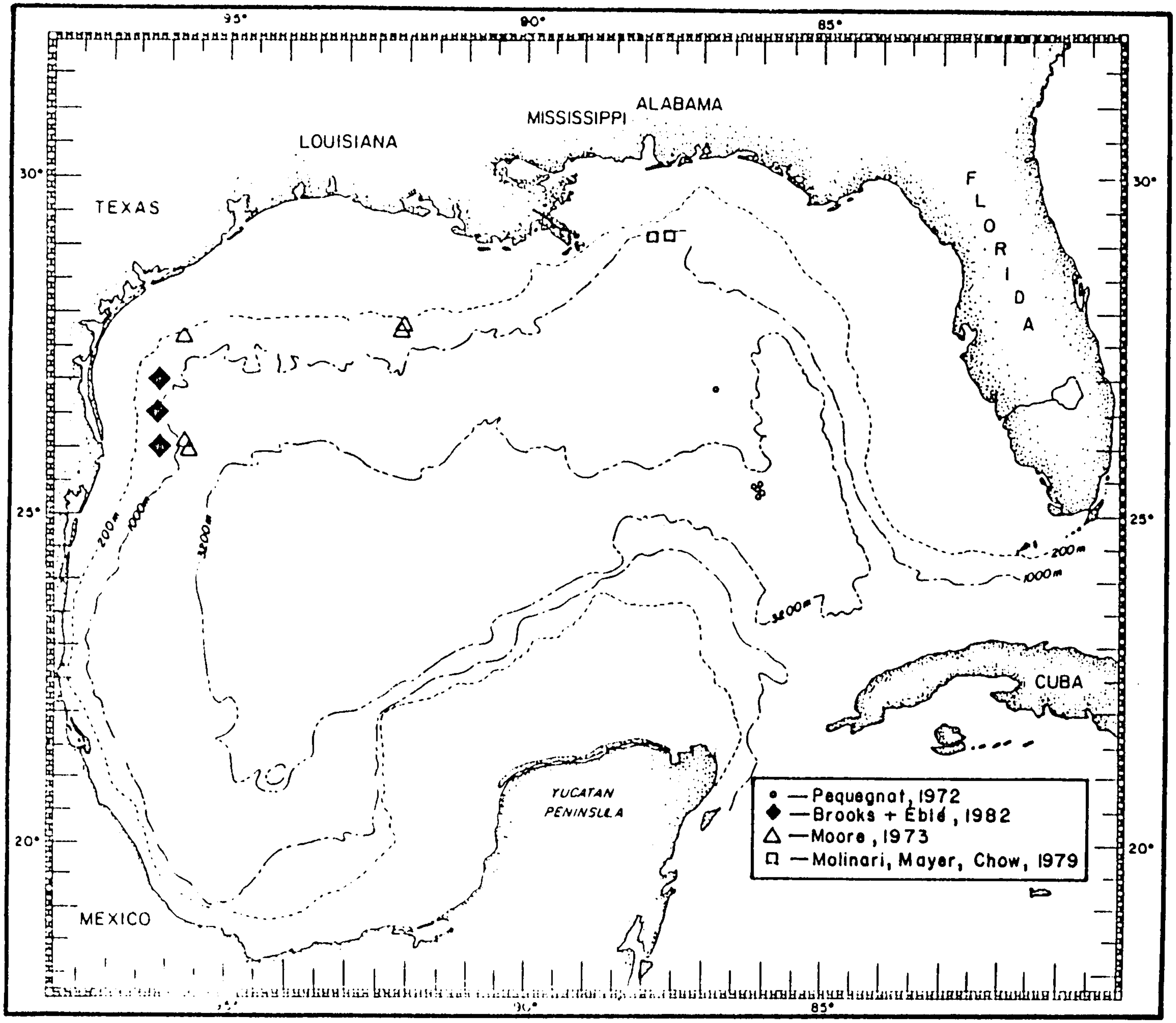


Figure 109. Location of near-bottom current meter placements for the deep Gulf of Mexico.

The two major inputs of dissolved and particulate chemicals into the Gulf are the Mississippi River and waters entering through the Yucatan Strait. In perspective, the volume of water entering the Gulf via the Yucatan Strait is some 785 times the volume of riverine input. Slowey and Hood (1971) suggest that inflow through the Yucatan Strait may be a much greater source of metals than is the Mississippi River. Even though a major portion of the Yucatan Strait water quickly moves through the Gulf via the Loop Current, its magnitude gives it the potential to significantly influence the Gulf's chemical distribution. As discussed in the section on water masses, large volumes of upper layer Yucatan water are transported to the western Gulf by anticyclonic rings that separate from the Loop Current and migrate westward.

Table 70 and 71 present respectively the dissolved and particulate trace metal concentrations for the Gulf of Mexico. These tables also include metal concentration for average sea water and the Mississippi River. Dissolved trace metal concentration in the central Gulf compare closely to estimates for average sea water. As one approaches the coastal zone, concentrations tend to increase, e.g., note especially manganese and iron.

Data on particulate trace metal concentrations from coastal waters are highly variable. This variability may result from problems associated with sample collection and analysis. When suspended loads are low, they are generally nonhomogenous. This nonhomogeneity makes it difficult to obtain a representative sample using the relatively small volume of a Niskin bottle. In the central Gulf, data on suspended particulate metal chemistry is limited to the major elements, notably, aluminum and iron. Betzer and Pilson (1971) show near bottom particulate iron concentrations in the eastern Gulf are significantly higher (340 ng/l) than those found above this layer (102 ng/l). Their data support the existence of a near bottom nepheloid layer in the eastern Gulf. Feely (1975) documents the highly variable near bottom nephloid layer in the deep Gulf. In general his data show the deep water nepheloid layer to be discernible in the eastern Gulf and at one station in the northwestern Gulf. The amount of suspended matter in the nephloid layer is very small (54 ug/l), but it is twice that amount (24 ug/l) found in waters above.

Sediments serve as the "ultimate sink" for the ocean's trace metals. Holmes has overseen massive sampling and analytical efforts for sediment trace metals along the continental shelf and slope (Holmes, 1973) and the central Gulf (Holmes, 1976). In general, very low concentrations are found on the Florida shelf and higher values occur along the outer shelf and slope of the northwestern Gulf, west of the Mississippi Delta. With some exceptions, the trend reflects the metal-poor values of the carbonate-rich Florida shelf and the metal-rich fine-grained clay sediments west of the Mississippi Delta. The exceptions to these trends are magnesium and strontium which are present in relatively higher concentrations on the Florida shelf. The higher concentration of strontium is generally attributed to biological activity. Similar calcium/strontium anomalous concentrations are seen in the western Gulf in the Flower Garden region. A similar anomaly occurs in upper DeSoto Canyon and is attributable to a carbonate bank present on the rim of the canyon. Concentrations of magnesium are generally higher in evaporite type carbonate deposits, such as the Florida Peninsula, since magnesium also deposits in a carbonate form. Table 72 presents trace metal concentrations that have been reported for sediments of the Florida shelf, Mississippi Delta, and the slope, rise, and abyssal plain of the Gulf.

Table 70. Dissolved trace metal concentrations in the Gulf of Mexico (GOM) (from Trefry, 1981).

	(All concentrations in ng/l)									
	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sn	Zn
Coastal NW. GOM	≤200[a]	800[a]	<200[b] 900[c]	18000[a]	18[a]	<1000[a] 500[b] 1600[c]	≤2000[a]	<500[a]	-	2500[c]
Coastal Eastern GOM	20 to 1700[d]	200 to 2200[d]	100 to 3200[d]	-	30[e]	300 to >10000[d]	-	90 to 1200[d]	4[f]	200 to >5000[d]
Central GOM	-	-	500[b] <900[c]	500[g]	<30[h]	260[c]	<100[b]	<100[b]	-	2600[c]
Mississippi River	100	500	2000	5000	40	10000	1000	200	-	10000
Average Seawater (Brewer, 1975)	100	300	500	2000	30	300	800	10	-	-

[a] Shokes et al. (1979). [b] Davis (1968). [c] Slowey and Hood (1971). [d] Corcoran (1972).
[e] Andren and Harriss (1975). [f] Braman and Tompkins (1979). [g] Alexander (1964). [h] Custodi (1977).

Table 71. Suspended particulate trace metal concentrations in the Gulf of Mexico (GOM) (from Trefry, 1981).

		(All concentrations in ng/l)									
		Al	Cd	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
Coastal NW. GOM		-	-	(190)[a]	60[a] 45[b]	18000[a] 50000[b]	340[a] 1400[b]	-	(50)[a]	-	(300)[b]
Mississippi Delta (Trefry & Presley, 1976)		88000	(1.5)	84	56	46000	1230	56	(48)	-	-
Coastal Eastern GOM (Betzer, 1978)	W.A.S.	-	2	2	20	340	-	-	40	-	-
	REF.	-	1	20	20	4000	-	-	10	-	-
Central GOM (Feely, 1975)		25000	-	-	-	15000	-	-	-	-	-

[a] Holmes et al. (1977). [b] Shokes et al. (1979).

Table 72. Reported metal concentrations for Gulf of Mexico (GOM) sediments (from Trefry, 1981).

	No. of Samples	Fe (%)	Al (%)	Mn (ppm)	Zn (ppm)	Pb (ppm)	Cu (ppm)	Co (ppm)	Cr (ppm)	Ni (ppm)	V (ppm)	Cd (ppm)	$CaCO_3$ (%)
Mississippi Delta (Trefry & Presley, 1976)	88	4.0	8.1	740	125	34	28	15	84	41	141	1.0	3
Mississippi Delta, outer shelf, NW Gulf (Davis, 1968)	8	-	-	700	110	50	27	-	-	-	-	-	-
Florida shelf (Trefry et al., 1978)	105	2.3 to 0.04	-	-	66 to 0.8	16 to 0.6	8 to 0.3	-	47 to 2	16 to 0.4	42 to 1	0.3 to 0.01	98 to 6
Slope, rise, plain lower Mississippi Fan (Holmes, 1976)	2482	2.46	-	900	-	11	23	20	84	40	133	-	11
Slope, rise, plain knolls (Trefry, 1977)	43	3.25	6.95	1870	94	17	40	19	57	50	146	0.2	22

BIOLOGICAL FACTORS

PRODUCTION AND DISTRIBUTION OF FOOD

Production and distribution of food exert important, indeed, perhaps the most critical of controls over the development and maintenance of megabenthic faunal assemblages on both geographic and bathymetric axes. Because photosynthesizing plants are limited to the thin, surficial photic zone, the deep sea lacks ordinary primary production so that the supply of chemical potential energy available to nourish the benthic fauna decreases both with increasing vertical distance from the photic zone and horizontal distance from the land. As has been noted, the equivalent of net primary production in the deep sea is the transport and sinking of organic debris that originates either as surface production or as land runoff (Rex, 1976). Thus, energy sources that sustain the deep-sea faunal assemblages come in the form of particulate organic debris from surface production, nutrient-rich fecal pellets of large benthopelagic species that may forage as adults on midwater organisms, plant material derived either from land or shallow subtidal environments, benthic organisms that die in the deep sea, and animal carcasses that come from lower mid-water regions. As yet we are unable to discern with certainty the role that the huge supply of dissolved organic matter (DOM) may have in sustaining bacteria or meiofauna or small macroinfauna, but one may intuit DOM to be of substantial importance. In fact, one can speculate as to the nature of a simple food chain involving DOM that is consumed by bacteria that are eaten by meiofaunal nematodes that are in turn preyed upon by penaeid shrimps and finally the latter being eaten by one or more kinds of predatory fishes. However that may be, the quality, rate, and pattern of food input probably exert some of the most powerful selective forces acting on the deep-sea fauna, shaping the pattern of species diversity (Rex, in press), and accounting for animal density and biomass. In fact, the magnitude of the latter seems to be directly proportional to the amount of usable organic matter reaching the bottom.

PLATE 10

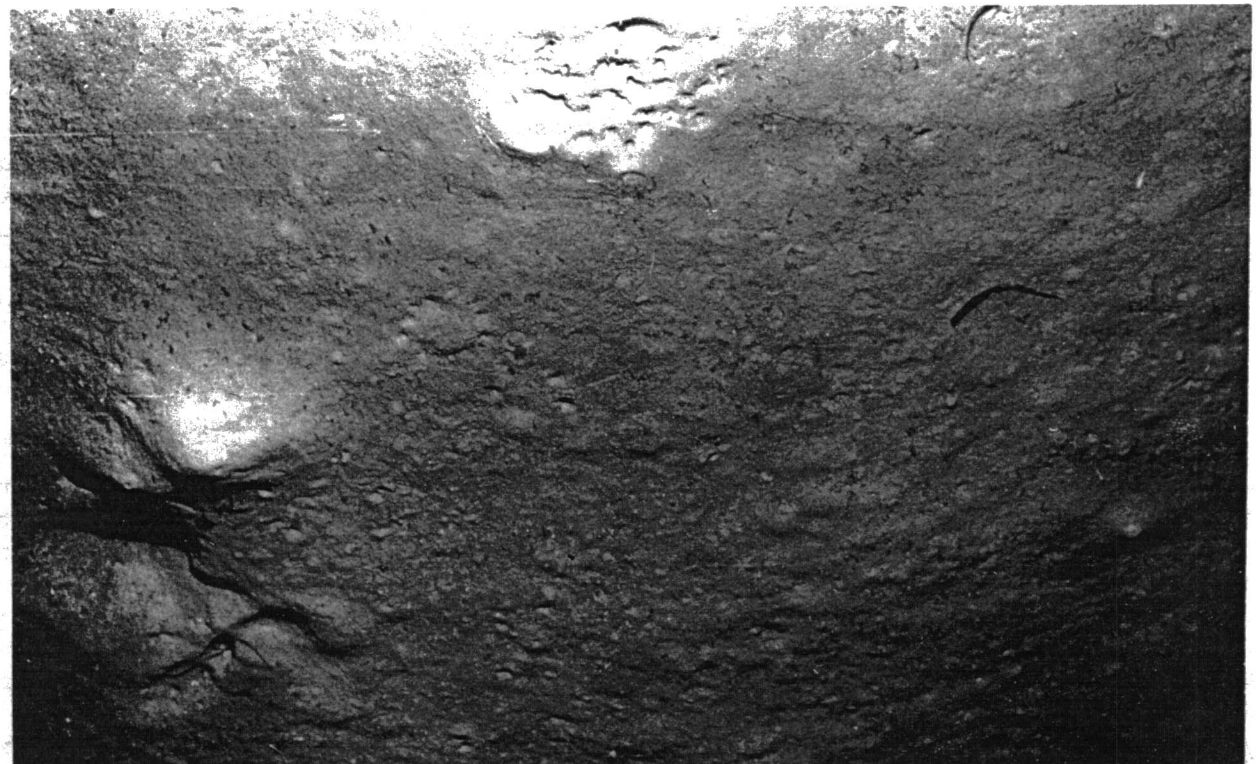
PLANT MATERIAL

There is little doubt but that plant material brought to the deep sea either from the land or shallow marine waters plays an important role in the energetics of the ecosystems of the deep sea.

A. Various types of plant debris at a depth of 1353 m under the Loop Current in the eastern Gulf. Scale 1.5 x 1.9 m.

B. Masses of the leaves of *Thalassia* are collected in the trough by bottom currents. The depth is 1353 m in the eastern Gulf. Scale 1.0 x 1.3 m.

C. *Thalassia* leaves on the bottom at a depth of 752 m in the eastern Gulf. Scale 1.3 x 2.0 m.



As we have indicated above, the energy releasing nutrients are transported to the deep sea in several forms (Hinga et al., 1979) as noted below:

1. Particulate organic material.- This material is generally small and may be made up of copepod and other zooplankter fecal pellets, pseudofeces, zooplankter exoskeletons, phytoplankton cells, and finely triturated debris from land and marine plants. Much of it provides a valuable substratum for colonies of bacteria, but they probably contribute to mineralization of available compounds (Jannasch, 1978). Nevertheless, this material can provide a direct flow of energy to deep-sea detritivores (Rex, in press), especially truly abyssal holothurians (e.g., Psychropotes longicauda), some polychaetes, and such echinoids as Phormosoma placenta. Because currents carry this material considerable distances and because many ocean currents vary in speed and direction with change of season, there can be considerable geographic variation in the season, amount, and kind of material reaching the bottom to sustain benthic assemblages. There is the possibility that this material forms part of the diet of certain suspension feeders such as the brisingid asteroids e.g., Midgardia xandaros (see Plates III, D and IV, A in Appendix A), crinoids, etc.

2. Organic debris.- Sinking plant remains are quite common on the bottom of the deep sea, especially offshore of rivers or under major ocean currents that have nearshore branches. Agassiz (1888) is probably first to have called attention to the existence of land and coastal marine plant remains on the bottom of offshelf regions. Mortensen (1938) found plant remains in the intestine of various echinoids and other invertebrates. Bruun (1957) and our own observations indicate that dredge or trawl hauls that contained substantial amounts of plant debris were also rich in animals.

It is well known that extensive beds of turtle grass (Thalassia testudinum) exist in the shallow coastal waters of the Caribbean and parts of the Gulf of Mexico. Moore (1963) was the first to note that storm waves break blades and/or uproot Thalassia plants and carry them seaward where they are transported by currents. Menzies and Rowe (1969) photographed substantial amounts of turtle grass that had been deposited on the sea bottom off North Carolina. It is quite likely that it came from the coast of Florida many kilometers away. We have evidence that Thalassia as well as Sargassum is carried into the Gulf from the Caribbean. The most substantial inputs of plant debris that we observed in the Gulf were those derived from Rio Papaloapan and Rio Tonala that pour into Bahia Campeche (Figure 110), the South Pass and Pass a Loutre of the Mississippi River, and the East Gulf Loop Current passing through the Yucatan Strait. In all cases the major inputs to the bottom come during summer and fall. In some cases Thalassia leaves are rolled into compact masses by currents after they have settled to the bottom (Plate 10). Wherever this plant debris accumulates on the bottom, including off Rio Magdalena of northern Columbia and Rio Patuca off Honduras, we found maximum faunal densities. It is impossible to give a precise distance of travel for plant debris before it settles on the bottom, but our estimate for both east and west Gulf are essentially the same, i.e., not less than 550 km in water between 1000 and 3300 m deep. This is in agreement with Wolff's (1976) estimates for Thalassia photographed on the bottom by Menzies and Rowe (1969). Assuming a 2-knot current, this would make the maximum sinking rate about 10 m/hr.

Taking data from photographs of Menzies and Rowe (1969), Wolff (1976) calculated the density of blades in an area of 1.25 hectares to be about 0.1 blade/

m^2. The highest concentration off North Carolina, about 0.16 blade/m^2 was found at depths between 2700 and 3200 m.

Considerably higher concentrations of Thalassia leaves were photographed by TerEco personnel in October on the Mississippi Fan under the Loop Current in the eastern Gulf around 25°24'N and 86°04'W in an average depth of 3310 m. (See Plate XXIX, C and Plates L-LVII in Appendix A.) In a total area of 350 m^2 covered by the photographs, a total of 114 Thalassia leaf parts were pictured for an average of 0.33 leaves/m^2. In addition, some photographs depicted land plants or Sargassum. Some indirect evidence is at hand that this plant debris is having a positive influence on faunal density and diversity in the area. First, there appears to be no accumulation of the material on the bottom, i.e., there was no increase in debris on the bottom during a series of several photographing days while at the same time large quantities of leaves were taken in the midwater trawl. Second, wherever Thalassia leaves were photographed on the bottom in this area the density and diversity of detritus/deposit feeders were great involving as many as six species of holothurians and numerous polychaetes and mollusks.

Animal deadfall remains are seldom observed in the deep sea. Rex (in press) reports that the account of a deadfall given by Jannasch (1978) is the only one of which he is aware. The same is true of our experience. In 1969, Dr. Maurice Ewing showed the senior author a picture of the carcass of a very large fish on the seabed in deep water off the northwestern coast of the United States. It was being torn apart by echinoids and fish. This is not surprising in light of pictures taken by Isaacs (1969) of fishes and invertebrates tearing apart bait underneath his free-falling, time-lapse camera.

BIOLOGICAL INTERACTIONS - COMPETITION AND PREDATION

Biological interactions are important in determining and controlling the faunal composition of benthic communities; hence they clearly play a role in forming zones. Menge and Sutherland (1976) point out that although competition and predation are influential in structuring communities, they act upon different faunal components. Predation is considered to be a prime factor in organizing and causing diversification in those prey populations (e.g. herbivores and detritus feeders) that occupy lower trophic levels. On the other hand, competition for prey at higher trophic levels (the carnivores) is an important factor controlling the diversity of prey populations. Terborgh (1971) argues that when predators at upper trophic levels are under greater competitive pressure than members of lower levels, they should show more rapid species changes with depth than the latter. Predation from upper levels should reduce competition among prey species resulting in overlap of vertical ranges and a close relationship with the availability of appropriate food. Very likely the most significant predatory impact in deep-sea benthic communities is generated by the megaepifauna as it feeds upon the macroinfauna and macroepifauna. As might be expected then, the epifauna has lower density, lower species diversity, and is zoned more rapidly and definitively than the infauna (Haedrich et al., 1975; Rex, 1977). Taking gastropods as the predators and polychaetes and bivalves as prey, Rex (1977) provides graphic evidence that the rate of zonation (i.e., rate of species replacement) does appear to be related to trophic position, as noted above. In addition to trophic position other factors that affect the rate of species replacement with depth in different groups are the dispersal ability of larvae and the level of mobility involved in gaining food.

Species diversity of the megafauna and, according to Rex (1981) and others, the macrofauna increases with depth below the continental shelf into the Upper Abyssal Zone (Table 73) and then decreases on the rise and the abyssal plain. There appears to be a more gradual decrease across the plain as distance from land increases. But this factor is not as important in the Gulf as perhaps it is in a major ocean. Moreover, it is dependent upon the source of food and the water circulation that might bring terrestrial and other debris for deposition on the abyssal plain. The major deep-sea macrofaunal taxa, viz., polychaetes, gastropods, cumaceans, and bivalves have parabolic patterns of diversity with peaks at 2300-2800 m and lower values on the shelf and abyssal plain (Rex, 1981). This is essentially what we see in the megafaunal groups in Table 73 (for a breakdown of subgroups within the major taxa in Table 73, see Tables 4-33) except that maximum diversity occurs somewhere between 700 and 2250 m. As we have discussed previously, this pattern is probably controlled by the interaction among food production, predation, and competition. Quite clearly lower diversity on the abyssal plain is related to the fact that suitable food input for the megafauna is so low (productivity) that some species cannot maintain critical densities to sustain viable populations. This would be much more critical for organisms feeding at upper trophic levels than for those such as sea cucumbers that are deposit-feeders.

Table 73. Total number of megafaunal species found in the faunal zones of the northern Gulf of Mexico. Note the sharp break below the Upper Abyssal.

Zone	Echinoderms	Decapods	Demersal Fishes	Totals
Shelf-Slope Transition 150-450 m (slope)	71	78	90	239
Archibenthal 475-950 m (slope)	83	73	108	264
Upper Abyssal 975-2250 m (slope)	81	53	72	206
Mesoabyssal 2275-3200 m (slope)	39	16	18	73
Lower Abyssal 3225-3850 m (rise and abyss)	25	18	15	58

Analysis of megabenthos samples taken by means of the skimmer and otter trawls show not only the increase of species richness with increase of depth on the slope but also suggestions of zonation (Figure 110). The curves shown are for decapod crustaceans, fishes, and echinoderms, which are the three principal megafaunal groups. We see that very few decapod crustaceans are added deeper than about 750 m, which is the junction between the two horizons of the Archibenthal Zone. Few fish species are added below 1000 m, which is the depth of the junction between the Archibenthal and Upper Abyssal Zones. Primarily because of holothurians, the echinoderms level off at about 2200 m. These

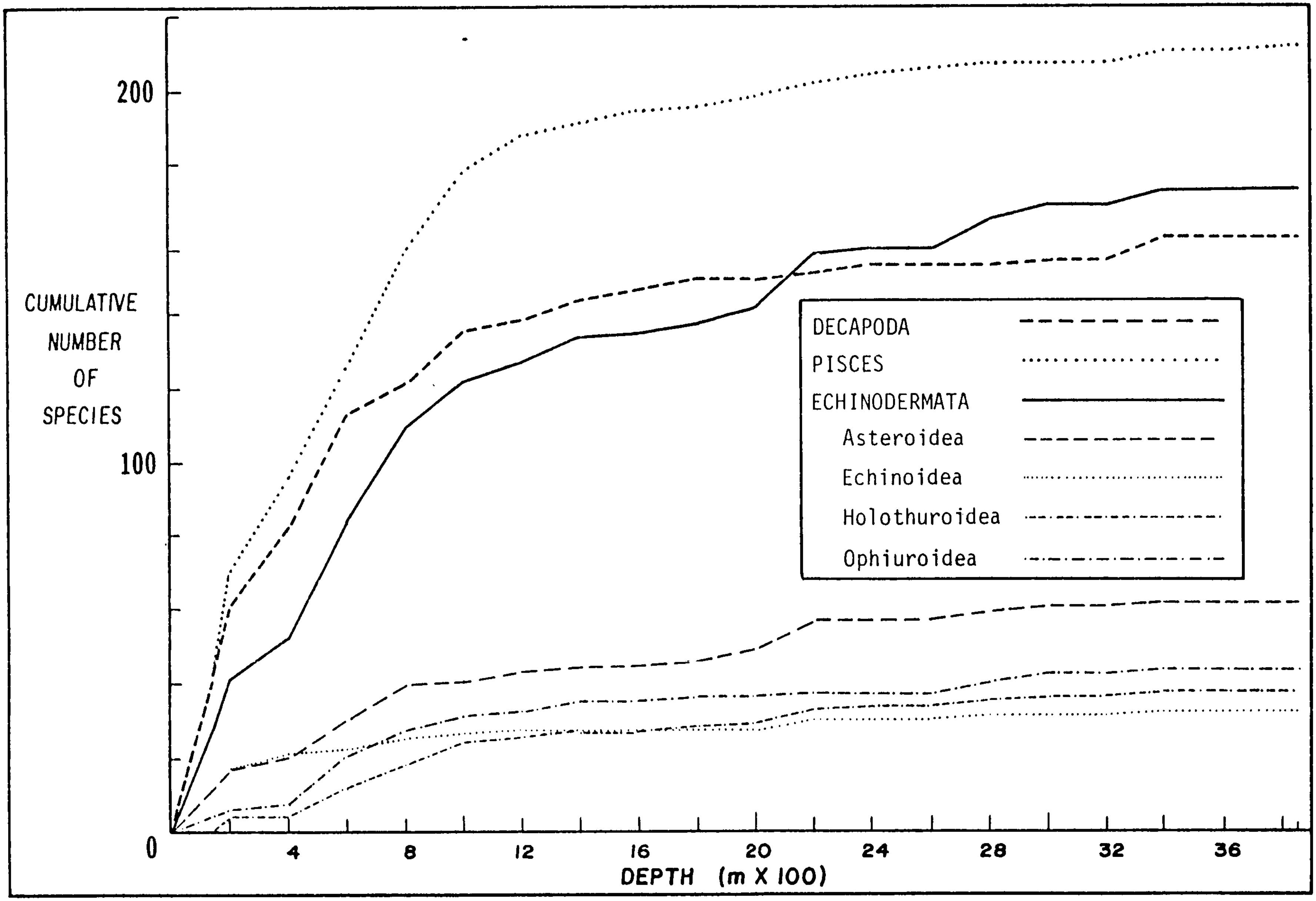


Figure 110. Addition of species of echinoderms (classes shown below), decapod crustaceans, and demersal fishes taken in skimmer and trawl samples from the continental shelf break to the Sigsbee Abyssal Plain in the Gulf of Mexico.

findings are only partially in agreement with the findings of Rowe and Haedrich (1979) where the "most marked changes in fishes occur at 800 and 1600 m separating a homogeneous assemblage, whereas the echinoderm fauna, initially homogeneous, undergoes rapid changes beginning at about 2200 m. Deeper than 800 m, few decapods are added." It should be pointed out that we are dealing with two and one-half times as many fish, three and one-half times as many decapods, and four times as many echinoderm species. Since most of the fish species taken by the ALAMINOS were collected in a very large trawl (20-m gape), chances are high that many of the most mobile species in the zones were captured. If mobile species are less prone to occupy narrow zones on the slope, then their addition could smooth out the abrupt changes noted by Rowe and Haedrich (1979).

One cannot overlook the possibility that hydrostatic pressure exerts a critical control on the vertical distribution of some benthic organisms. We know that several properties of proteins and, indeed, protoplasm itself undergo significant changes under high pressure. This could mean that some metabolic enzymes would cease to function properly at and above a given pressure (Siebenaller and Somero, 1978). This could affect not only somatic but also genetic and reproductive functions.

SUMMARY

Having examined the factors that are considered to be the most important in controlling the distribution and zonation of benthic animals, attempts will be made here to evaluate the relative importance of these factors as determiners of species diversity, the composition of faunal assemblages, and zonation. This triad is linked together by one common factor, the species, so that species diversity is related to the composition of faunal assemblages which is the *sine qua non* of zonation. Because zonal boundaries are generally drawn between different faunal assemblages, we cannot have a change of zone without a significant change in the composition of the faunal assemblages. However, there need not be a change in species diversity between zones.

Attempts to explain zonation of the benthos in shallow water cite as causes temperature and salinity variations, as well as the heterogeneity of surficial sediments or other substratum. Unfortunately the level of our present knowledge will not permit definitive assessment of the importance of these factors as determiners of zonation of the deep-sea benthos. Clearly, though, we cannot rule them out as contributory causes in some parts of the deep sea. Thus, because temperature and salinity variations are small below the permanent thermocline and negligible below depths of about 1000 m, it is difficult to envisage that the gradients in these factors are affecting the distribution of animals at increasing depths. From the data in Figure 101 it is apparent that if temperature, salinity, and dissolved oxygen are to act upon zonation, it would be above the 1000-m isobath (note also information in Table 74). Below 1000 m the difference in isobathic temperature extremes is less than 0.3°C; dissolved oxygen is at or above 4 ml/l and it rises steadily to a high of 5 ml/l in the abyss; and salinity changes less than 0.1 ppt from there to abyssal depths. Nevertheless, it is readily apparent from Figure 93 that in the northern Gulf there are more zones and cluster subsets below than above the 1000-m isobath. For these reasons the above factors cannot be considered to be prime determiners of zonation in the deep sea.

Table 74. Comparisons of some physico-chemical factors and zones above 1000 m depth in the Gulf of Mexico.

Physico-chemical Factor	Depth (m)	Zone Relationship (if any)
Permanent Thermocline	~ 150	Upper limit of Shelf/Slope Transition Zone (Subtropical Underwater)
Oxygen Minimum	~ 450	Boundary between Shelf/Slope and Archibenthal Zones
Salinity Minimum	~ 800	Boundary between Archibenthal horizons (Subantarctic Intermediate Water)
Temperature Minimum	~ 1200-1600	In middle of Upper Abyssal Zone

Because we have seen definite changes in faunal assemblages from the continental shelf to the abyssal plain, it could be assumed that if physico-chemical factors are important causes of these changes they should change in a similar discrete way. Indeed, in some cases they do, but in other cases they do not and it is my thesis that the latter may exert as great or greater influence than the former. For instance, physiography changes abruptly in places on the vertical axis from the shelf to the upper slope and from the lower slope to the steep escarpments and thence to the flat abyssal plain. In places, as seen shortly, there appears to be a relationship between physiographic change and boundaries between zones. However, these physical changes probably do not exert any severe impact on organisms. Rather their effects may be indirect as on sedimentation and possibly the accumulation (or lack of it) of particulate food. In such cases, organisms are attracted to and not impacted by the physical change. On the other hand, there are some physico-chemical factors that even though they change regularly with depth can be strong factors in creating discrete zonation. Hydrostatic pressure, which changes 1 atmosphere for each 10-m change in ocean depth, is one of these. Certain physiologic functions of organisms, such as the action of particular metabolic enzymes, are known to be pressure sensitive; hence species having similar pressure thresholds will arrive at similar tolerance depths. In such cases, organisms are repelled by the impact of an inimical factor. Thus, we have the rudiments of assemblage formation either by attraction or repulsion or both.

The roles played by pressure and bottom currents are ill-defined at present, but it is difficult to believe that the metabolic effects of pressure do not affect the vertical distribution of some species. The fact that the tendency for bottom currents to follow contours is proportional to the steepness of the slope provides some relationship between them and isobathic zones. Their effect could be mediated by delivery of food and larvae in a zonal manner, but as yet documentation is lacking.

The role of physiography in determining zonation is also impossible to define; yet there are some interesting correlations. For instance, the shelf break in the northern Gulf ranges between 118 and 150 m, the latter of which marks the upper limit of the Shelf/Slope Transition Zone. The 2200-m isobath marks the beginning of the Sigsbee Escarpment and the upper limit of the Mesoabyssal Zone whose lower boundary at 3200 m also marks the intersection of the escarpment with the continental rise. Physiographic effects on zonation may be quite indirect through their effects on currents and thus on the distribution of food and larvae. Physiography, especially the steepness of slope may be disruptive of zones but beneficial to the deep-sea benthos by facilitating slumping that can transport food to the rise and abyssal plain.

Sediment grain size can affect the distribution of specific types of benthos (Gray, 1974) but there is little evidence that sediment texture is arranged in zonal patterns. This simply emphasizes the point that both geological and biological sampling in the deep ocean have not been done in sufficient density to ascertain in a specific way the influence of sediment type on faunal composition.

The distribution of particular types of food is clearly a prime determiner of the faunal composition of benthic communities and zones and to a certain extent of species diversity. The latter is a matter of contention. Although species diversity of the megaepifauna increases down the slope to intermediate depths and then decreases across the rise onto the abyssal plain, animal density and biomass, which are measures of production, decrease markedly along this same depth gradient. The effect of this on diversity is quite straightforward, i.e., diversity drops on the plain in part because food inputs are often so low that some species cannot maintain densities sufficient to support viable populations.

Even though experimental proof or even direct observations are lacking, it is not difficult to accept the possibility that competition and predation, particularly when coupled with the rate of production and patterns of distribution of food, play critical roles in determining species diversity and contributory roles in determining assemblage composition and zonation. Thus, the diversity of faunal assemblages is determined by predators that tend to feed upon the numerically dominant prey species. This reduces interspecific competition at lower trophic levels which could permit higher diversity among prey species. Competition among predators can then lead to feeding predilections and specializations that would allow more predators to coexist in a physical environment that appears, outwardly at least, to be homogeneous.

PART III. GENERAL ECOSYSTEM ANALYSIS

7. THE SLOPE AND ABYSSAL ENVIRONMENTS

PHYSICO-CHEMICAL CHARACTERISTICS

The benthic environment of the deep Gulf with its overlying water column presents some distinctive contrasts. For instance, we see a relatively flat, broad and very productive continental shelf joined along a hummocky intersection to a very flat and apparently barren abyssal plain through a moderately rich, two-angled and very active continental slope and rise. Throughout this sweep of seabed there are some active and changing environments but whereas a decade ago one would have described the whole of the deep end of the benthic in the Gulf as stable, serene, and almost unchanging, we now know that some parts of it have strong bottom currents and much of it is regularly receiving substantial inputs of sediment. This constrast is recognized by our designating the eastern part of the Lower Abyssal Zone as the "Active" subdivision and the western part as the "Tranquil" subdivision. Although the slope system can be thought of as a transition environment broadly influenced by processes occurring to either side, it has several unique characteristics that impact upon both its benthos and pelagial. The concept of transition applies equally as much if not more to the pelagic than to the benthic environments on and over the slope.

HORIZONTAL GRADIENTS IN THE SURFACE WATER

Hydrographically, the surface water of the upper slope may be derived from either the neritic or the oceanic areas. The resident surface water here generally constitutes a mixture of shelf and open Gulf water, but at any moment one or the other water mass may predominate. As noted in an earlier section, the temperature of the shelf water, which is located between 28° and 30°N latitude, closely parallels the daily and seasonal temperature regimes of the air. This becomes less obviously the case southward where the water over the lower slope, rise, and abyss is less influenced by continental than tropical conditions between 23° and 28°N latitude. Here daily variations and seasonal extremes are dampened.

Under the influence of river discharge, shelf water displays salinity patterns that are both lower and more variable than offshore surface waters. Throughout most of the year the Mississippi River controls the shelf salinity for considerable distances west of the Delta. In the summer, generally during July and early August, its principal flow is eastward at least as far as the region over DeSoto Canyon. The high salinities of the offshore waters are influenced and maintained high by the Loop Current. As noted in an earlier section, although this current per se does not penetrate into the western Gulf, anticyclonic rings detached from the Loop migrate westward on a regular basis. These rings transport not only Caribbean water but also pelagic larvae and other plankters as well. So far as surface waters are concerned, the gradients in temperature and salinity between shelf and offshelf waters are not observed to the same degree in the case of dissolved oxygen. Since dissolved oxygen is derived through diffusion from the atmosphere and photosynthetic activity of phytoplankton, the dissolved oxygen of the surface waters is, in all cases, near saturation.

VERTICAL GRADIENTS IN THE WATER COLUMN

In the previous section we have noted the horizontal variations in the Surface Mixed Layer of the Gulf. The thickness of this layer varies from place to place but has a maximum of about 125-150 m. Below this depth four other layers or water masses are noted. But only two of them are widespread, viz., the Oxygen Minimum Layer, which typically extends from 300 to 700 m in depth, and the Gulf Basin water which is found most typically from 2000 m on down to the bottom.

Seasonal temperature variation is suppressed with depth, and it has been noted that the depth of the 18°C isotherm is relatively constant, ranging only between 125 and 150 m. Below this depth very little seasonal change in temperature occurs. Whereas the surface water temperature seasonally varies at least 8-9°C, the variation at 150 m is rarely 3°C and at 750 m is only 1.0°C. As in the case of temperature, seasonal variation in salinity also decreases with depth.

Although variations in temperature and salinity are greatest in shallow waters over the continental shelf, there are gradients in these parameters as well as dissolved oxygen that are reached in depths over the slope. For temperature the gradient extends from values of 30°C or so at the surface to about 4.23°C at 2000 m (in the Gulf Basin water); for salinity it extends from as much as 36.7 ppt at 50-200 m below the surface to a salinity minimum of 34.86 ppt between 550 and 900 m depth and then rises to about 34.9 ppt at the bottom; and for oxygen it extends from 5.0 ml/l at the surface to about 2.5 ml/l in the oxygen minimum layer and then increases again to 5.0 ml/l toward the bottom. Since, as noted above, several layered water masses are traversed in the vertical profile, the gradients undoubtedly have discontinuities at the layer interfaces. One point that probably has additional ecological significance is the fact that the Oxygen Minimum Layer extends from 150 to 750 m depth in the northeastern Gulf and only from 250 to 650 depth in the northwestern Gulf.

Another major vertical gradient is, of course, related to the quantity and quality of light penetrating to various depths in the shelf and slope waters. One percent of the incident solar radiation marks the limit below which little useful photosynthetic activity is carried on in the sea. In the turbid waters of the shelf this value may be reached at a depth of scarcely more than one meter. But on an offshore line this limit may be extended to depths of 50 to 60 m. Since available light energy controls the ability of phytoplankton to carry on photosynthesis, this depth may be taken as the lower boundary of the euphotic zone. Thus, the entire slope and abyssal environments are in the perpetual darkness of the aphotic zone except, of course, for bioluminescence. A final vertical gradient is that of pressure. Increasing at the rate of one atmosphere per 10 m increase in depth, it ranges from 15 atmospheres at the shelf break to about 380 atmospheres in the Abyssal Zone. As yet, however, we are unable to state with certainty how this 25-fold increase in pressure may control the vertical distribution of animals in the slope-abyss environments.

BOTTOM TOPOGRAPHY AND SURFACE SEDIMENTOLOGY

The Gulf of Mexico is a subsided oceanic area that contains a thick sedimentary sequence and is underlain by oceanic crust (Antoine, 1972). The shelf and slope area of the northeastern Gulf is a carbonate bank which has been subsiding since Cretaceous time. The mesozoic salt deposits of the northern Gulf thin toward the east in this province. The major feature of the northwestern Gulf is the Gulf Coast Geosyncline where salt diapirism has modified the sedimentary pattern extensively (Antoine, 1972). The central basin of the Gulf is divided into three parts: the continental rise, the Sigsbee Abyssal Plain, and the Mississippi Fan. The continental rise resulted from a build-up of sediments transported from the north toward and into the basin. The principal features of the Sigsbee Abyssal Plain are its extreme flatness (1:8000, Ewing et al., 1958), the diapiric structures called the Sigsbee Knolls which rise as much as 375 m above the plain, and the fact that the sediments of the basin are about as thick as the present greatest depth of the Gulf (3850 m). The Mississippi Fan (or Mississippi Cone) extends from the Mississippi Trough to the southeast. The sediments of the fan merge with the basin sediments.

One of the principal features at slope depths of the northeastern Gulf is DeSoto Canyon. There are many salt diapirs in the canyon but they scarcely reach the sediment surface. Antoine (1972) found it difficult to account for the continuing presence of the canyon with the encroachment onto its western edge of prograding sediments from the Mississippi. There is no river drainage system from the north that can be associated with the canyon. It seems likely that it owes its origin and its persistence to the action of oceanic currents.

One of the most interesting topographic features of the northwestern Gulf is a complex submarine canyon-fan valley located about 200 km south of Galveston, Texas. It begins at the 180-m isobath and terminates after receiving other systems in the abyssal plain. Bouma (1972) indicates that this complex, referred to as Alaminos Canyon, was very likely connected with the Rio Grande and Brazos-Trinity Rivers.

The largest area covered by one mineral suite is the central Gulf, including the Mississippi Fan and the shelf-slope-rise-abyssal plain area south of Louisiana. The sediments are detrital and come from the Mississippi Delta (Bouma, 1972). On the fan and abyssal plain turbidity currents were important agents of transport and deposition. Also, it is now known that bottom currents strong enough to scour the bottom and winnow out sands exist on the fan, and, indeed, extend up into DeSoto Canyon. So far as we know now, such currents do not exist on the western extension of the rise and plain. In areas where sediment is actively accumulating from Mississippi River deposition, the bottom becomes structurally unstable and slumping is common. Moreover, slumping may occur on the upper slope in the western Gulf as a result of the seaward prograding of the shelf break as the sediment overload causes the deep salt beds to flow under steady pressure.

BOTTOM HABITAT DIFFERENTIATION

From the above discussions and descriptions, it is evident that there can be considerable habitat differentiation on the botton and in the near-bottom waters. Depth related factors acting singly or in combination tend to control the distribution of offshelf organisms. This is complicated by the fact that the vertically layered water masses intersect the slope at various depths creating slight changes in the physics and chemistry of the bottom itself and the near-bottom waters. On the northern slope where the Oxygen Minimum Layer bathes the bottom there is a zone of organic-rich sediments. Thus, although the concentration of dissolved oxygen may not be low enough to seriously affect many marine animals, it may not be sufficient to oxidize organics as rapidly as elsewhere. Habitat differentiation may also be brought about by bottom currents that flow along the contours, perhaps bringing with them fine sediments, larvae, and organic detrital material from the surface. Another factor, of course, is produced by topographic irregularities on both small and large scales. The physical devastation which accompanies slumping will locally denude some areas and bury others, but at the same time it may bring food materials. A change of sediments may also produce important albeit patchy habitat differentiation. Even surface and intermediate water currents can produce bottom differentiation, since all basic food materials and in some cases pelagic larvae of the benthos must be imported from above. Where they come to rest depends on sinking rate and transport speeds, directions, and persistence. In addition to creating bottom habitat differentiation these latter factors may account for periodicity or seasonality in the offshelf environment.

SEASONALITY IN THE DEEP GULF

Seasonal changes in temperature, salinity, and light that are substantial in surface waters are moderated with depth. Still, their effects are felt in the deeper areas of the Gulf. It is evident also that changes in surface currents can result in effects that are felt in deeper layers, perhaps even at abyssal depth. Those surface currents that are generated by winds can change in speed, in volume of flow, and direction, even to the extent of reversal with time of year. Such changes are known to occur regularly along the Texas coast, and their perturbations affect conditions on the outer continental shelf and down the slope. Seasonal changes in production of organic matter in the surface waters should be reflected in seasonal variation in the benthic deposition of organic matter. Moreover, in the rainy season on continental masses, rivers in flood stage bring masses of land vegetation, including that from wetlands, into the Gulf where some of it is carried long distances before being deposited on the bottom. Storms at sea during summer and fall often dislodge marine growth from the bottom and carry it into currents that travel for hundreds of miles dropping vegetation to the bottom along the way. In this study we have documented photographically (see Plate 10) and by bottom sampling that such inputs do occur. Moreover, they occur on a regular basis so that they may produce what can be called quasi seasonal responses of the benthos. In an otherwise relatively constant environment, these slight changes may be picked up by benthic organisms as coordinating cues for feeding, breeding, and other activities.

BIOLOGICAL DISTRIBUTION PATTERNS

DISTRIBUTION OF PLANKTON AND MICRONEKTON IN THE WATER COLUMN

As in the case of benthic organisms, a common distributional pattern of plankton describes a change in species composition and abundance as one proceeds from the shelf to the offshore waters. Change in species composition has been noted for diatoms and dinoflagellates among the phytoplankters, and for copepods, euphausiids, and chaetognaths among the zooplankters. Early work and the more recent investigations of Hopkins (1982) reveal that although an onshore-offshore gradient of reduction of plankton populations occurs in the northern Gulf, there is still a substantial abundance in deep water as, for example, over the Mississippi Fan at 27°N latitude and 86°W longitude.

Shelf populations of phytoplankton organisms tend to run about 0.2-9.0 x 10^6 cells/l, and open Gulf populations average about 1.0 x 10^2 cells/l. Those of the waters over the slope run around 1.3-12.0 x 10^2 cells/l, which is only slightly greater than the open Gulf values. As might be expected, zooplankton abundance shows similar patterns. The standing crop in shelf waters averages around 0.1 ml/m^3; that of the slope averages about 0.06 ml/m^3; and that of the open Gulf averages about 0.05 ml/m^3. The shelf plankton is frequently dominated by meroplankters, whereas holoplankton tends to predominate in the open Gulf. However, it should be noted that meroplanktonic stages of various decapod crustaceans, e.g., megalops larvae of true crabs, have been noted to be extremely abundant in surface waters over the abyssal depths, especially in summer.

The vertical distribution of zooplankton over the deep Gulf was studied by Hopkins (1982). Both grazers and carnivores reach maximum numbers during the day in the upper 50 m, and, at night, in the top 15 m.

Copepods are the principal contributors to biomass, constituting 49% of the day and 60% of the night standing stock. Euphausiids ranked second and chaetognaths third, the combined total being 75% of the day and 80% of the night standing stock. Hence we see that abundance decreases exponentially with depth, and over half of the biomass occurs in the upper 200 m. Hopkins' (1982) data show that the night biomass of zooplankton over the Mississippi Fan (22°N 86°W) at a depth of 15 m was 1193.6 mg/100 m^3 (div) and 26.4 mg/100 m^3 at a depth of 1000 m.

Just as zooplankton genera, especially of copepods, tend to change along an onshore-offshore axis, the dominant taxa change from one depth zone to the next. An interesting observation on the micronektonic mid-water fish, particularly the myctophids, shows that their zone of abundance does not always coincide with that of their food species. Thus, whereas copepods that are the principal source of food for myctophids reach maxima in water shallower than 50 m, the fish concentrate in the 50 to 150 m zone. This argues for the point of view that other factors than food availability may regulate the vertical distribution of micronekton.

DISTRIBUTION OF BENTHIC ANIMALS OF THE SLOPE AND ABYSS

Most of benthic inhabitants of the slope are not found elsewhere, and the same is true of the abyssal plain. Some of the benthic species of the outer shelf do spill over onto the upper slope, but most of these have disappeared by a depth of no more than 250 m. Likewise, species that have their maximum population on the upper slope but move onto the shelf do not penetrate far shoreward and do not depend upon estuaries for completion of their life cycle. Beyond the 250-m isobath the fauna becomes truly deep sea in character.

The obvious features of the benthic fauna are the depth-related limitations of individual species and the breaks in the faunal assemblages. Although technically we recognize four faunal zones on the slope, only three are descriptive of a true slope fauna. Several faunal breaks have been noted at the following depth ranges on the slope, rise, and abyss:

150- 450 m	Shelf/Slope Transition Zone
450- 500 m	Break between Shelf/Slope Transition and Archibenthal Zones
750- 800 m	Break between Horizons A and B of the Archibenthal Zone
950-1000 m	Break between the Archibenthal and Upper Abyssal Zones
2250-2300 m	Break between the Upper Abyssal and Mesoabyssal Zones
2700-2750 m	Break between Horizons C and D of the Mesoabyssal Zone
3200-3250 m	Break between the Mesoabyssal and Lower Abyssal Zones

On this basis it appears that seven more or less distinct depth-related faunal assemblages characterize the benthic slope-rise-abyss faunae of the northern Gulf. The observed faunal breaks clearly reflect, in part, discontinuities in physical and chemical factors of the benthic environment. These include known current patterns and the upper and lower limits of the Oxygen Minimum Layer. However, not all the faunal breaks can be accounted for on the basis of physical and chemical factors, and it is not unlikely that biological factors as well as physiographic factors are also involved, as discussed elsewhere.

EXCHANGE PROCESSES

Potentially the surface waters of the continental slope and rise are in continuity with those of the shelf and the open Gulf over the abyss. But in actuality they are not, at least not in all parts of the Gulf. In some places the surface waters of the slope constitute a zone of mixing between shelf and open Gulf and thus reflect intermediate physical and chemical properties. But in other places they are separated from shelf and abyssal surface waters by strong shears that are so marked as to be perceived visually. This is not to deny that tidal, wind-generated, and other currents may from time to time cause fairly extensive mixing. For instance, during the passage of polar fronts, waters in the northern Gulf can be affected profoundly to depths of 150 m. As surface waters are pushed southward by winds having velocities of 40 kt or more, they are replaced by bottom water flowing shoreward from the upper slope isobaths. Today we know that even the deepest parts of the Gulf are not static nor comprise a closed system. Note, for example, the vertical structure of the dissolved oxygen concentrations in the eastern Gulf, remembering that dissolved oxygen can only be added at the surface and carried to depths by downwelling water masses (Table 75, A). Here we see that dissolved oxygen concentrations rise steadily to a level of over 5 ml/l at 3170 m depth from the oxygen minimum at 500 m depth (Table 75, B). In order to maintain this relatively high dissolved oxygen concentration in the deep Gulf, there must be periodic inputs of oxygen-rich water from the deeper aspects of the Caribbean that is forced over the sill into the Yucatan Straits from which it courses into the abyssal basin by virtue of its high density. The high dissolved oxygen concentrations on the bottom indicate that this water is regularly replaced as it rises slowly and eventually exits the Gulf. So far as we are aware this outflow is primarily into the Caribbean at intermediate depths. This flow should not be confused with the East Gulf Loop Current which also enters the Gulf via the Yucatan Straits but at shallow depths. Most but not all of this water eventually leaves the Gulf via the Florida Strait; some returns to the Caribbean via the Yucatan.

Clearly these surface and deep water movements carry not only physico-chemical constituents but also plankton, including larval stages, and particulate and dissolved food materials.

Table 75. (A) Physico-chemical characteristics of the water column 15 cm above the bottom on the Mississippi Fan. Samples taken by a special time-activated water bottle between July 12 and 24, 1967 in the eastern Gulf in and below DeSoto Canyon. (B) Samples collected during the same period and in the same area but by conventional gear and hydrocast techniques.

Depth (m)	Temperature (°C)	Salinity (ppt)	Oxygen (ml/l)	
(A)				
750	5.73	34.881	3.495	
868	5.32	34.899	3.696	
1875	4.17	34.994	4.883	
2320	4.18	34.973	5.087	
3170	4.28	34.966	5.115	
(B)				
1	29.30	36.254	4.474	
10	29.30	36.253	4.510	Surface oxygen minimum
50	23.44	36.677	4.338	Salinity minimum
500	8.76	35.049	2.731	Oxygen minimum
700	6.20	34.876	3.272	Salinity minimum
1600	4.15	34.967	4.930	Temperature minimum

RESIDENCE VS. TRANSIENCE OF SPECIES

Given any particular shallow part of the Gulf of Mexico, one would expect to find both permanent resident and transient species comprising the faunal assemblages at one time of year or another. The percentage of true resident species certainly increases with depth, reaching its maximum in the benthic inhabitants. Because planktonic organisms are by definition carried passively by water currents, one might expect to find only transient species as they are swept into and out of an area with the water masses. But two characteristics of some plankters, including larval plankters (meroplankton), permit many species to remain as quasi residents of an area. Planktonic species typically exhibit rapid reproductive response to favorable environmental conditions. Second, many plankters undergo diel vertical migrations. When we couple these traits with the observation that current direction may differ dramatically with depth in the water column, we have conditions that favor establishment of resident status for some planktonic species. Moreover, it is known that even the direction of flow of surface currents far at sea may reverse on an as yet unknown time scale. These phenomena could account for maintenance of both pelagic and benthic species in an area in spite of their inability to move against current flow. Clearly we have more than hypothetical evidence that these things occur.

It is known, for example, that bottom currents at depths of 120 or so meters at the shelf break off Texas in the vicinity of the Flower Garden Banks generally flow toward the southwest. Surface currents in the same area on the other hand are observed to flow in varying directions, including toward the northeast. Moore (1973) has demonstrated that subsurface currents ranging in speed from 0.1 to 0.6 kt move along or obliquely across the upper continental slope of the northwest Gulf. He found that deep currents separated by a sharp shear were flowing to the northeast at 200 m and to the southwest at 450 m depth. In the same region some 160 nm south of Galveston, TerEco personnel tracked surface currents in July 1982 for as much as 12 nm during which time the current moved at an average speed of 1.4 kts. The direction of flow was generally to the east-northeast often in face of an opposing wind. In August 1982 at the same location the current was moving to the west-southwest at speeds up to 1.5 kt, again often counter winds were blowing. The water depths in this area range up to 1800 m over the slope. Previous field studies carried out by TerEco in the same area indicate that various pelagic species and benthic meroplankters undergo vertical migration here.

Nektonic species are free-swimming and are capable of maintaining themselves in an area, despite the water currents, or of migrating to favorable areas. A great deal of information points to the fact that many of the nektonic predators are seasonal transients in the area, primarily during the warmer months of the year. These include the billfishes, tunas, dolphin, wahoo, jackfishes, mackerels, and other highly mobile forms.

Ordinarily we expect that deep-sea species of benthos practice lecithotrophic development. For instance, among the deep-sea species of bivalves, 60-70 percent have lecithotrophic development (i.e., large, yolky eggs and a short nonfeeding pelagic stage) and between 15-30 percent have direct development (Knudsen, 1979). Peracarid crustaceans (e.g. amphipods and isopods) have nonfeeding larval development also. On the other hand, Rex and Waren (1982) point out that many deep-sea prosobranch snail species have planktotrophic development. Interestingly enough, 76% of these are predatory species. Only 31% of the lecithotrophic prosobranchs are predatory. Rex and Waren (1982) think that the dispersal afforded by planktotrophic development may "better able predators to track changes in prey availability." This relationship appears to be highly tenuous, particularly since even a two-day lecithotrophic larval stage could disperse eggs or nonfeeding larvae for about 17 km with a 10 cm/sec current (0.19 kt).

INTERNAL DYNAMICS - PRODUCTION, CONSUMPTION, DECOMPOSITION

Biological production involves the creation of living organic matter, either through photosynthesis (primary production) or through consumption of other organic matter (secondary production). In a vertical section of the deep-ocean environment, as elsewhere in the world oceans, primary production is limited to the euphotic zone. Such material may then be consumed locally, transported out of the area horizontally, or transported to deeper layers of the ocean system. In addition, organic matter produced on the land, estuaries, or the shelf may be imported into the deep ocean system.

Consumer species are found at all levels of the water column and depths of the bottom. Whereas those species inhabiting the euphotic zone may utilize locally-produced or imported food sources, those that inhabit the aphotic zone are dependent entirely upon production which comes from the upper layers or from outside the system. Such food arrives in several forms. The conventional concept is that of a drizzle of fine organic particles from above that sustains the meiofauna and macroinfauna. For years the notion that deadfalls of fishes, whales, squids, etc. formed a significant part of the food supply of the deep sea was not popular. But in the 1970s, especially when the significance of the films showing a wide variety of vertebrates and invertebrates voraciously devouring dead bait was realized, the idea began to gain wider acceptance (see, for example, Haedrich and Rowe, 1977). Certainly plant material of marine or terrestrial origin serves as a basis for a food chain. Then, too, in parts of the deep system, large predators, such as some demersal fishes, do not wait for the rain down of material from above. Rather they move up in the water column to forage upon mid-water life and then return to the bottom to breed. Finally, cognizance must be taken of the contribution that dissolved organic matter makes either directly or indirectly to the support of deep benthic assemblages. This material is known to leak from rapidly photosynthesizing phytoplankters, from the bodies of dying organisms, and from those that are torn apart by predators. This dissolved material (DOC) is anywhere from 10 to 20 times as abundant as organic carbon in small particulate form (POC). Water samples taken by TerEco Corporation personnel just 15 cm above the bottom at various depths down DeSoto Canyon and onto the Mississippi Fan demonstrate this very well, as follows:

Depth (m)	DOC (mg C/l)	POC (mg C/l)
750	0.46	0.046
868	0.44	0.028
1875	0.47	0.029
2320	0.47	0.028
3170	0.58	0.028

The significance of these figures becomes clearer when we note that one year's production of organic carbon in photic waters over the slope of the northern Gulf of Mexico is only 2.28 mg C/l. It is therefore inconceivable that this huge storehouse of potential chemical energy (0.5 g C/m^3) is not extremely important to the nutrition of the deep sea, since we know that bacteria and various invertebrates (both meiofauna and macroinfauna) can absorb and oxidize DOC.

INTERNAL DYNAMICS: VERTICAL AND HORIZONTAL TRANSPORT

Transport of nutrients and organisms involves the displacement of materials from one area to another. It may take place by a variety of means. Horizontal transport may involve the passive movement of dissolved and suspended matter by wind-driven or geostrophic currents or it may entail active swimming by nektonic species.

Horizontal transport is particularly important adjacent to and at various more distant points from mouths of major rivers. The Mississippi is of course such a river. For much of any given year most of the outflow from the Mississippi courses westward after reaching the Gulf. Because it carries nutrients in dissolved and particulate form, including vegetation, it is not surprising that very productive fisheries exist in the area west of the delta. But in our early pelagic and benthic sampling we found very rich zooplankton and benthos on a line from the eastern exit of the river (Pass a Loutre) over the upper part of DeSoto Canyon. In August of 1968, we traced Mississippi River water as far eastward as Panama City, Florida some 120 nm distant from the delta. On

August 9 a long "river" of very green water was noted in the vicinity of DeSoto Canyon. Using an STD it was found that the green was of low salinity and temperature (Table 76). Furthermore along the contact between green and blue water dense masses of marine (Sargassum) and terrestrial vegetation were accumulating. It was obvious that the thin layer of low-salinity water (31.38 ppt) was flowing over the marine water (35-36 ppt) causing floating vegetation to accumulate along the shear as the high-salinity water turned downward. Fish also appeared in large numbers along the shear. In fact, swordfish were taken in commercial quantities along this contact later in the summer.

Table 76. Temperature and salinity data taken in the vicinity of DeSoto Canyon on August 9 and 10, 1968. Note the thin layer of Mississippi River water flowing over the normal marine waters of the region.

Date	Depth (m)	Salinity (ppt)	Temperature (°C)	Location and Comments
9 Aug.	Surface	31.38	29.7	29°11.3'N, 87°30.5'W
	9	31.90	28.0	DeSoto Canyon
	15	35.60	25.0	green water, much floating
	60	36.35	19.5	vegetation, pycno-thermocline
9 Aug.	Surface	31.48	30.0	29°10.3'N, 87°31.5'W
	12	35.00	26.0	green water, floating
	15	35.40	24.5	vegetation, pycno-thermocline
	60	36.30	19.5	
9 Aug.	Surface	31.62	30.3	29°10.9'N, 87°22.5'W
	15	36.00	25.0	green water, floating
	60	36.25	19.8	vegetation, near contact
				of green and blue water
10 Aug.	Surface	34.1	31.0	28°46.3'N, 87°36.2'W
				blue water

Benthic samples taken in the vicinity of the westernmost part of the low-salinity water contained a great deal of plant material of terrestrial origin and the samples were rich in holothurians, demersal fishes, galatheids, and carideans. As we sampled eastward the vegetation on the bottom was primarily of marine origin and the benthic faunal samples were less rich.

After tracing the water to positions offshore from Panama City, Florida we found that mixing had caused the salinity to rise to 34 ppt and that very little floating vegetation was present.

Vertical water currents may transport dissolved and suspended materials upward (through upwelling) or downward (through water mass sinking). Materials may also be transported upward by gravitational floating (if particles become less dense than water, as through the incorporation of gas bubbles in the carcasses of dead organisms) or by gravitational sinking of dense particles and dead organisms. In addition, vertical migrations of animals in the water column are known to occur on daily and seasonal bases, and large amounts of organic matter may be transported in this way, as was noted above. Finally, it should be noted that some benthic animals may pass portions of their life cycles close to the surface of the water column. Typical of this is the _Leptocephalus_ larval stage of the deep-sea eels that as adults live on or in the bottom. The _Leptocephalus_ of one of the numerical dominant fishes, _Synaphobranchus oregoni_, lives and grows in the euphotic zone. When it metamorphoses and sinks to the bottom, it takes up demersal life at depths between 500 and 2000 m on the slope.

SYSTEM COORDINATION AND REGULATION

Ecosystem processes cannot be based upon random events. Environmental signals, however subtle, must serve as cues to initiate biological activities, insuring simultaneous response of different members of the same species, and coordinating simultaneous and sequential activities of different species within the system. In all ecosystems so far studied, the general signals are provided by the physical environment, and specific recognition cues are provided by individuals within each species. The former often relate to seasonal and daily weather phenomena, and the latter may be based upon visual display, behavior patterns, sound or light production, release of specific chemical cues, and the like.

Very little is known about the signals and communication devices important in the life histories of most slope organisms. Within the euphotic zone light and other well known weather factors undoubtedly supply the primary information required. Although such factors become subdued with depth, at least some of the seasonally induced changes of the surface waters must reach the bottom in "coded" form. Slight modifications of currents, nutrients or sediments from above, or of temperature or salinity may supply the information necessary to trigger breeding, spawning, release of larvae, feeding, etc. Individual species recognition may be accomplished through photophores, specific chemicals (taste and odor), sound and other vibrations, and touch. These modifications or adaptations are only hints at what must be a very complex and sensitive communication system in the deeper waters of the slope.

8. THE DEEP GULF ECOSYSTEM

INTRODUCTION

In view of the limited amount of critical data at hand, it may seem presumptuous to attempt to describe the deep Gulf ecosystem and analyze how it works. It is admitted that many gaps exist in our knowledge of the offshelf ecosystems, but it is felt that enough information is now available to permit development of rough conceptual models of the composition and dynamics of this complex system. But before launching into this topic, it may be well to define the term ecosystem and say something about its components.

In principle the concept ecosystem is dimensionless; hence one is justified in discussing the ecosystem of an estuary or of the continental shelf or of the continental slope, or indeed, of all of the area from the outer shelf to and including the abyssal plain, which is what we propose to do here. A marine ecosystem then is the community of organisms in a given area, including both pelagic and benthic species that are interacting with the physico-chemical environment in such manner that energy flows through trophic levels of varying diversity and in which mineralization of materials occurs to produce a true cycle from primary producers to top consumer and return.

COMPONENTS OF MARINE ECOSYSTEMS

From the trophic point of view an ecosystem has two principal components, viz., the autotrophic component and the heterotrophic component (Odum, 1972). The autotrophs or producers, largely green plants ranging from diatoms to sea grasses and kelps, photosynthesize organic compounds. These compounds form a strong yoke between biotic and abiotic components (e.g. CO_2, H_2O, N, etc.). The heterotrophs or consumers are divisable into predators that feed on other living organisms, and saprophages (bacteria, fungi, and some protozoa) that feed on dead organic matter and return to the abiotic sphere the nutrients needed by the autotrophs.

ENERGY FLOW

The energy stored in net primary production by the green plants is available to the array of species populations in the ecosystem which are unable to derive energy from other sources. These populations include the animals, fungi, and certain bacteria. In a typical oceanic community we observe free-floating phytoplankton in the surface layer that are the primary producers and that support, directly or indirectly, a complicated food web of herbivores, carnivores, and scavengers which extends from surface to and into the bottom. The rate of primary production is of course affected by radiation and temperature but the most critical parameter is the storehouse of nutrients in deeper layers and the rate at which they are delivered to the photic zone by vertical circulation (Riley, 1972).

Obviously the depth of water will have a significant influence in shaping the trophic levels in the ecosystem (Riley, 1972). In shallow water not much deeper than the photic zone the autotrophs will be concentrated and their production is sufficient to support a substantial population of zooplankton copepods and a large benthic biomass. But in deep water the phytoplankton is thinly dispersed and there is only the weakest of direct links with the benthos; hence we must look for indirect links between phytoplankton production and benthic consumers. Also, we must designate other sources of food. Steele (1974) has indicated that the most likely main link from primary producers to pelagic fish and the benthos is through the ingestion of phytoplankton and excretion of fecal material by zooplankton. Moreover, it is generally assumed that the zooplankton eat all the phytoplankton produced and excrete about a third of their food as fecal material that falls to the bottom (Steele and Baird, 1972). Only at the beginning of a bloom or in an area of intense upwelling can it be imagined that the growth of phytoplankter populations is substantially greater than the grazing rate of herbivores.

NATURE OF THE DEEP GULF ECOSYSTEM

So far as the geographic emphasis in this study is concerned, the deep Gulf ecosystem is a complex of water and bottom extending from the Mexican border to and including DeSoto Canyon off the Florida panhandle. With the exception of the vicinity of hard banks at the edge of the continental shelf, the sediments are of terrigenous origin. Actually DeSoto Canyon marks the northern contact of clastic sediments with carbonate sediments to the east just as to the south Campeche Canyon runs along a similar contact of clastics with the great carbonaceous Campeche Bank which runs from Campeche Bay to Yucatan Channel.

Although it might appear that the deep ecosystem of the Gulf in the area of this study is quite uniform, in truth there are some remarkable biotal differences. In fact, the biotal differences (Table 77) justify referring to the western Gulf as the "true" Gulf and the eastern part as a divergence of the Atlantic Ocean via the Caribbean Sea.

Table 77. Enumeration of species of fish, decapod crustaceans, and echinoderms that are apparently limited to the eastern or western parts of the Gulf of Mexico (the division line is the 90th meridian of west longitude).

	Western Gulf	Eastern Gulf
Fishes	103	12
Decapods		
Penaeidea	7	0
Caridea	7	1
Galatheidea	19	3
Brachyura	9	4
Macrura	4	0
	46	8
Echinoderms		
Asteroidea	30	5
Echinoidea	2	2
Holothuroidea	6	4
	38	11
Totals	187	31

It is not clear just where a line separating east from west should be drawn. In the present study the 90th meridian of west longitude was chosen as a reasonable compromise. Perhaps a more realistic line would not follow a meridian but would cut obliquely from the easternmost extension of Yucatan Peninsula north-northwestward to the delta of the Mississippi River. The differences between the east and west Gulf are both physico-chemical and biological. We see in Table 77 that whereas some 187 species among demersal fishes, decapods, and some echinoderms are limited in their distribution to the western Gulf, only 31 species among these same groups occur only in the eastern Gulf. Some of this discrepancy may be due to sampling artifacts but the separation might well be even greater had more of the less mobile species been included in the tally. Before attempting to offer a tentative explanation of the existence of this endemism, it will be useful to list some of the physico-chemical differences between the eastern and western parts of the Gulf (Table 78).

Table 78. Some of the physical and chemical differences between the eastern and western parts of the deep Gulf ecosystem (division line is the 90th meridian of west longitude).

Western Gulf	Eastern Gulf
Three more or less permanent offshelf gyres from Campeche Bay to the northwest Gulf off Brownsville, Texas.	No permanent offshelf gyres. Occasional rings separated from East Gulf Loop Current are not permanent. They usually drift westward.
Absence of a fast-moving loop current.	Loop Current from Caribbean moves rapidly into eastern Gulf before exiting through Florida Straits.
Bottom currents of any magnitude an uncommon feature. Photographic evidence indicates absence of bottom currents over large areas.	Strong bottom currents over much of the eastern portion of the Mississippi Fan.
Substantial inputs of nutrient-rich water from rivers of Mexico and the Mississippi.	Minimal inputs of riverine water.
Due to the above there are major inputs of terrestrial vegetation.	Limited inputs of terrestrial vegetation.
Location of the deepest parts of the Gulf.	Deepest part some 225 m shallower than on Sigsbee Abyssal Plain.
Bottom sediments principally muddy and quite flocculent.	Surficial sands common on the Mississippi Fan where bottom current exist.

It is not difficult to suggest possible reasons for the relatively high level of endemism among the benthos in the western Gulf as compared with the eastern part. For one thing, residence time of water is greater in the west than in the east. Some of the water entering the Gulf through Yucatan Channel turns westward and becomes incorporated in the southern cyclonic gyre shown in Figure 108. Moreover, the northern two of the three gyres of the western Gulf are formed by water spinning off from the Loop Current. This water remains sufficiently long here for the development, metamorphosis, and sinking to the bottom of any meroplankters of benthos introduced from the Caribbean. In general this is not so true of the eastern Gulf. Here the Yucatan water often flowing at the rate of 2-4 kts sweeps in and out of the Gulf rather rapidly. Accordingly, holoplankters, meroplankters, and some nekton come into and pass out of the Gulf in a matter of days (note that a 3-knot current travels 72 n miles per day). Assuming an average transit distance of 576 n miles, water in the Loop Current would remain in the Gulf a maximum of 8 days. Actually the effective time for recruitment would be about half of this, simply because in order to reach the bottom before being carried out of the Gulf, pelagic larvae would have to begin their descent during their travel in the ascending (northward) limit of the Loop.

DEEP ECOSYSTEM MODEL

In order to simplify the model we shall ignore details of the various water masses depicted in Figure 101 and consider that any area of the deep ecosystem is comprised of three functionally distinct but interrelated layers (Figure 111).

The uppermost layer, extending from the surface to a depth of about 60 m, is referred to as the euphotic zone, because it receives sufficient sunlight to generate photosynthesis among phytoplankters and fixed plants. Beneath the euphotic zone, and extending to within a meter or so of the bottom, is a huge mass of water which beyond the shelf is largely devoid of sunlight. This is the aphotic zone where photosynthesis cannot occur and where the processes of food consumption, biological decomposition and nutrient regeneration take place in the cold and dark waters. The lowermost layer is the bottom itself together with the contiguous water a meter or so in thickness. This is the benthic zone, repository of sediments from above, where nutrient storage and regeneration take place in association with the solid and semi-solid substrate. Each of these zones has much in common with the others, but each is sufficiently distinct to merit individual separation and analysis. It is a marvel of the ocean that a surface layer of water whose thickness is only about 2 percent of the average depth of the world ocean can support the huge biomass living in the largest mass of water on earth as well as in the largest expanse of soil on the globe. The basis for this is a phenomenon of the geometry of small size; the combined surface area of phytoplankters far exceeds the area of the marine environment. This factilitates the rates of internal reactions and effective use of the sunlight that penetrates the sea surface. Marine plants as large as trees could not produce food as efficiently, a fact that is reflected by the limited development and minor productivity of the giant kelps (e.g. Macrocystis or Nereocystis).

Development of a model of nutrient and energy flow within the deep Gulf ecosystem must start with primary productivity of phytoplankters and identify the reservoirs wherein nutrients and energy are temporarily stored. Then the principal pathways must be designated via which the nutrients and energy are imported, exported, or transferred (Figure 111). As shown in Figure 111 each of the three functional zones of the ecosystem is conceived as a five-reservoir

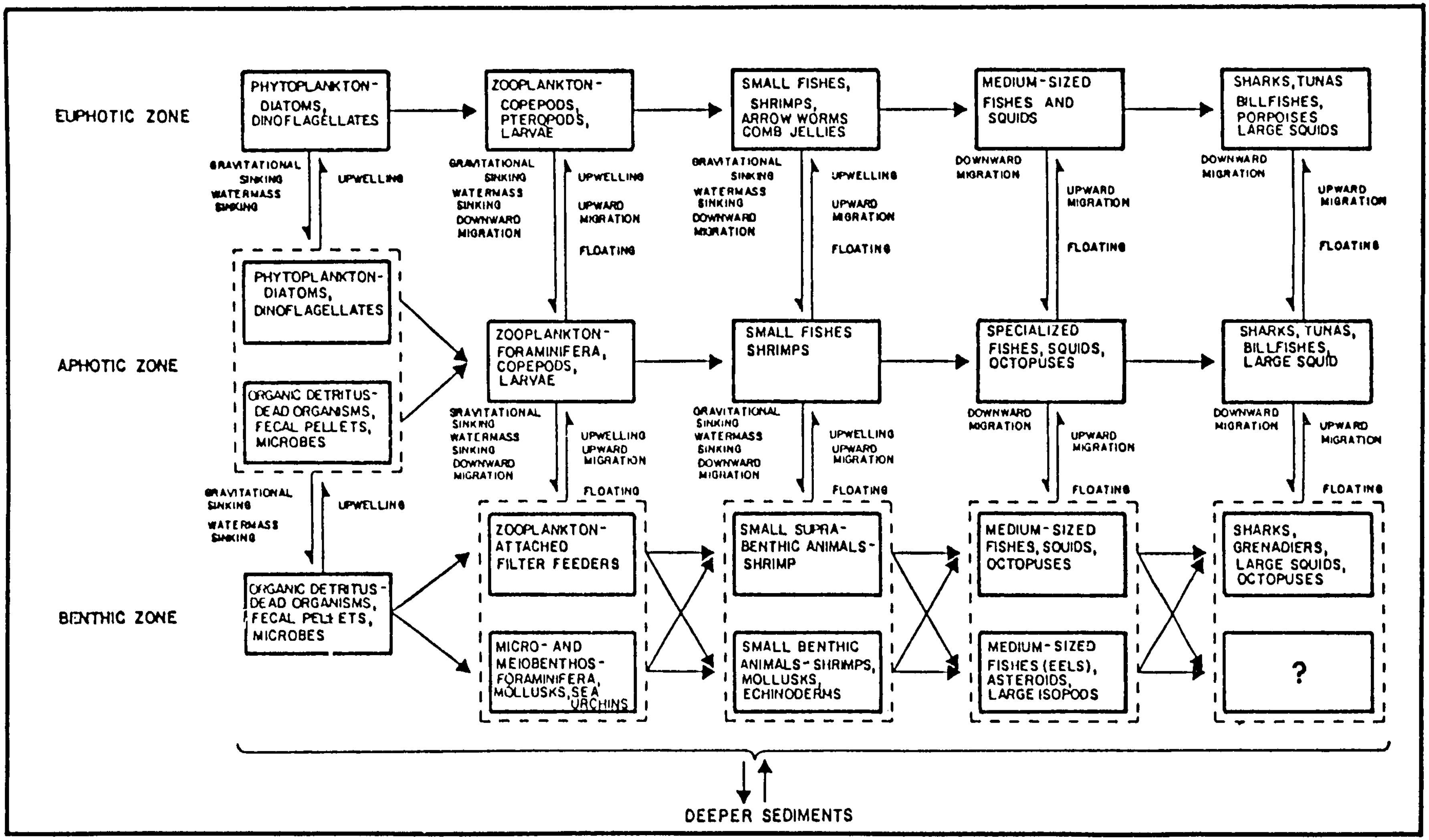


Figure 111. Model of nutrient and energy flow within the continental slope ecosystem elaborating on the chief components of the energy reservoirs.

food chain. Each reservoir provides nutrients and energy to the next reservoir within a given food chain, and each exchanges with its comparable reservoir of the adjacent zones. Furthermore, each reservoir gains (imports) energy and nutrients from outside the system, and each loses (exports) energy and nutrients to the outside.

In operation, sunlight and nutrients enter the system through photosynthetic activity of the phytoplankton (principally diatoms and dinoflagellates) of the euphotic zone. By various mechanisms the energy and nutrients of the phytoplankton become transferred through the three interlocking food chains. In reality, however, each food chain is a complex food web, rather than a simple chain, and each group of consumer organisms more often than not feeds from several of the reservoirs rather than only from the single reservoir below. Lacking from the diagram are reservoirs for dissolved and nonliving particulate organic matter, sediments, and inputs of plant material from the land and shallow marine waters. As mentioned in an earlier section, this plant material and the dissolved organic matter appear to be essential for satisfying the energy budget of the deep sea.

In order to move closer to reality and to quantify some of the reservoirs in Figure 111, estimates will be given for the production of primary producers and consumers of several trophic levels. First it is instructive to note that comparisons of primary productivity in the Gulf of Mexico with other marine environments demonstrate that the Gulf on average is not very productive (Table 79).

Table 79. Rates of average primary productivity, without correction for extracellular material, estimated for various marine environments (g C/m^2/yr). Sources: Gulf of Mexico (El-Sayed, 1972); Sargasso Sea (Menzel and Ryther, 1960); North Sea (Steele, 1974); Northwestern Atlantic (Rowe, 1972); Gulf of Guinea (Corcoran and Mahnken, 1969); and Long Island Sound (S. Conover, 1956).

	Gulf of Mexico	Sargasso Sea	North Sea	Northwest Atlantic	Gulf of Guinea	Long Island Sound
Productivity	55	73	80	145	365	475

Tentative Quantification of Production and Energy Flow

Data from ^{14}C measurements (El-Sayed, 1972) of production of particulate organic carbon by phytoplankton in the Gulf appear to average about 55 g C/m^2/yr (Table 79). The highest values appear to be found in the upwelling area north of Yucatan Channel and in the region around DeSoto Canyon. In the oceanic region the western Gulf is apparently more productive than the region east of the 90th meridian. The above average does not include the production of soluble organic carbon by the phytoplankton. Estimates as to the magnitude of this parameter range widely, as noted above; however, it appears reasonable to assume that it is equivalent to an additional 15 g C/m^2 of particulate carbon production, giving a total for a year of about 70 g C/m^2/yr or 700 kcalories/m^2 in a year.

It is generally assumed that except for brief periods during major plankton blooms the zooplankton consume all the phytoplankton produced. In turn they excrete a high percentage (up to 30%) of their food intake as nutrient-rich feces that sink to the bottom. Most of the herbivorous zooplankters are copepods with calanoids leading all others in the oceanic waters of interest to us. Extrapolating from the copepod dry weight values and assuming three generations of major species per calendar year, it is estimated that the herbivore production is on the order of 14 g $C/m^2/yr$ or 140 $kcal/m^2/yr$. A high percentage of this production is consumed by euphausiids, ctenophores, and chaetognaths within the zooplankton, and most of the remainder is taken up by pelagic fishes. Thus, much of the organic material transported to the bottom from this source takes the form of feces.

Since the herbivores eat most or all of the phytoplankton and may assimilate 70 percent of what they take in, then about 210 $kcal/m^2/yr$ (21 g $C/m^2/yr$) is the energy available to the benthos.

The energy transfers and transformations in the benthic environment are poorly understood. The roles played by the microbenthos (e.g., bacteria and fungi), meiobenthos (e.g., nematodes and harpacticoid copepods), macrobenthos (e.g., polychaetes and bivalves), epifauna (e.g., decapods and holothurians), and demersal fishes (e.g., rattails and cusk eels) must be accounted for. And although we have already pointed out that benthic biomass values drop exponentially with depth, it is almost inconceivable that this array of organisms can be sustained by an input of only 210 $kcal/m^2/yr$, particularly if as seems likely the feces supply metazoan needs only after being acted upon by bacteria and/or fungi. We are unaware of any reliable figures on the efficiency of this transfer but judging from bacterial roles in another depauperate environment, viz., salt marshes, little more than 35-40 percent can be expected. Hence not much more than 75 $kcal/m^2/yr$ are likely available to the rest of the benthos. As touched on previously, other sources of energy must be involved in more than a happenstance manner.

On the basis of a few samples taken by Rowe and Menzel (1971) in the deep Gulf and a reworking of the data by Rowe et al. (1974), we can estimate that the production of the macrobenthos is on the order of 3 $kcal/m^2/yr$ (0.3 g $C/m^2/yr$) in the western Gulf and only 1 $kcal/m^2/yr$ over the deep part of the eastern Gulf.

The role of the meiobenthos in sustaining any part of the macrobenthos and megabenthos has not been demonstrated satisfactorily. It is known that their biomass is small but it is also estimated that their biomass may turn over as much as 10 times per year. Hence their production is biomass/m^2 x 10/yr. Among the group there are carnivores, herbivores, and detritivores, leading some investigators to speculate that this is a self-contained compartment of the ecosystem that provides no energy to other reservoirs. This, however, seems highly unlikely in view of the fact that most of the meiobenthos live in the uppermost part of the surficial sedimentary system. Consequently many of them would be consumed, incidentally or not, by sediment ingesting decapods, echinoderms, and fishes. In any event it seems unlikely that their production is greater than 0.5 g $C/m^2/yr$ (= 5 $kcal/m^2/yr$), assuming that they depend exclusively on the rain of organic matter from the primary producers. This would mean energy usurpation of 25 to 50 $kcal/m^2$ by this group alone.

Two groups are left to be accounted for, viz., the invertebrate megaepifauna and the demersal fishes. Based on the conversion factor of 1 g wet weight = 0.1 g C = 1 kcal, it is assumed that demersal fish production in the deep Gulf is on the order of 2 $kcal/m^2/yr$. This is probably somewhat greater than that of the epifauna, which is estimated to be about 1.5 $kcal/m^2/yr$. Obviously the usurpation of energy by these two groups is considerably greater than the percentage of assimilation. Clearly the invertebrate epifauna alone cannot support the demersal fish fauna.

Other Sources of Matter and Energy for the Deep Sea

It appears from the above estimates that the energy budget of the deep Gulf cannot be balanced unless the assimilative efficiencies of bacteria and meiofauna are extraordinarily high, which is an unlikely prospect. We are left, therefore, with the conclusions that other sources of organic matter for importation to the deep sea must be found. We believe that there are at least five such sources:

1) dissolved organic matter

2) deadfalls of animal carcasses

3) fallout of terrestrial and shallow marine plants

4) transport of animals and organically rich sediments in slumps and turbidity flows

5) active foraging of demersal fish and large benthic crustaceans in the midwater region from which they return to the bottom.

As mentioned earlier, we have no evidence that dissolved organic matter is utilized as a source of energy by the bacteria, meiofauna, or any components of the macroinfauna of the deep sea, but it is a good possibility. This could ease the shortfall of energy in the deep-sea system. It must be pointed out, however, that there must be some limitations upon its availability else the deep-sea biomass should be considerably greater. Two possibilities present themselves as explanations. First, it is quite likely that the compounds involved are available as food primarily to certain bacteria and even then that considerable energy must be expended to convert them to usable materials. It is also possible that for the most part the bacteria-meiofauna link is pretty much a closed cycle; hence the energy advantage of uptake of dissolved organic matter by bacteria would not benefit higher trophic levels to a very large extent.

It is still a matter of conjecture as to the importance of large animal carcasses as a source of food for the megafauna. Very few sightings or photographs of deadfalls have ever been made. This, however, is not particularly surprising. Movies taken by baited camera systems have revealed that large fishes and amphipods can dispatch dead fish in a few hours at most. Moreover, when the larger scavengers are finished, bits and pieces are consumed by ophiuroids, echinoids, and various smaller crustaceans. Bruun (1957) suggested that deadfalls, including whales, could sustain the deep-sea fauna for substantial periods of time. Some twenty years later (1977) Haedrich and Rowe suggest

"... the megafaunal biomass cannot be supported by the macrofauna. The megafauna must therefore depend to a considerable extent on food arriving from pelagic regions in the form of large, fast-falling packets, that is, the bodies of fishes, whales, squids, and decapods." The apparent ease with which mobile species are rallied around baited cameras suggests that attraction to the odors of dead bodies is a normal event. It is to be noted further that these scavengers themselves die and thus serve as a further link between deadfalls and the infauna of all sizes.

The importation of large packets of plant material to the deep benthic region is another source of organic matter of as yet undetermined significance. Areas in the Gulf where we have dredged or trawled substantial amounts of decaying plants are shown in Figure 112. Invariably a rich benthic fauna is found in conjunction with these deposits. In some cases this must result from the refuge for the epifauna formed by the plant mass. All of the evidence that we have collected indicates that if this material is not consumed in its original form, it must be rather quickly transformed into components that are utilized by the infauna. Thus, in spite of large inputs from surface rafts no large accumulations were ever photographed by us on the bottom.

The transport of the infauna from the shelf break and upper slope into much deeper zones continues to take place in the Gulf of Mexico. The tracers that we have used to demonstrate the occurrence of this phenomenon are the shells of paleotaxodont bivalves (see Ds in Figure 112). In Figure 112 three regions where we obtained definite evidence of slumping are shown. One is in and below DeSoto Canyon. Another is west of the Mississippi Delta. The third is off Brownsville, Texas. The bivalve species involved, their vertical transport, and the location of the cache of dead shells are presented in Table 80. Undoubtedly numerous other organisms, particularly polychaetes, small crustaceans, and gastropods would be carried in the slides and turbidity currents that would result from the initial slumping. Some of the valves were carried from lower DeSoto Canyon considerable distances south on the Mississippi Fan (see Nuculana acuta at 27°42.2°N, 87°44.5'W and Tindariopsis agathida at 25°31'N, 86°10'W in Table 80). It is likely that many of the displaced organisms would die during transport and their bodies would provide food.

Another phenomenon that undoubtedly assists in supporting parts of the benthic fauna, at least at depths in the Upper Abyssal Zone, is the active foraging upon midwater pelagic life carried out by some demersal fishes. Actually it is not known what the depth limitations of this mode of feeding are, but for the rattail Coryphaenoides armatus it appears to be around 2000 m (Pearcy and Ambler, 1974; Haedrich and Henderson, 1974). Obviously to occur much deeper than that could require such a large expenditure of energy in the vertical transit as to yield a negative energy flow for the individual.

SUMMING UP

Some of the principal processes which provide matter and energy that sustain the deep-sea ecosystem of the Gulf of Mexico are portrayed in Figure 113. The entire Gulf is shown in order to map those surface currents (open arrows) that were found to transport most of the plant debris that was observed during the field study. Noting previously that there is a positive correlation between the density of the deep benthic fauna (>1000 m) and the occurrence of plant debris from Thalassia, Sargassum, freshwater aquatic plants, and tree limbs, we

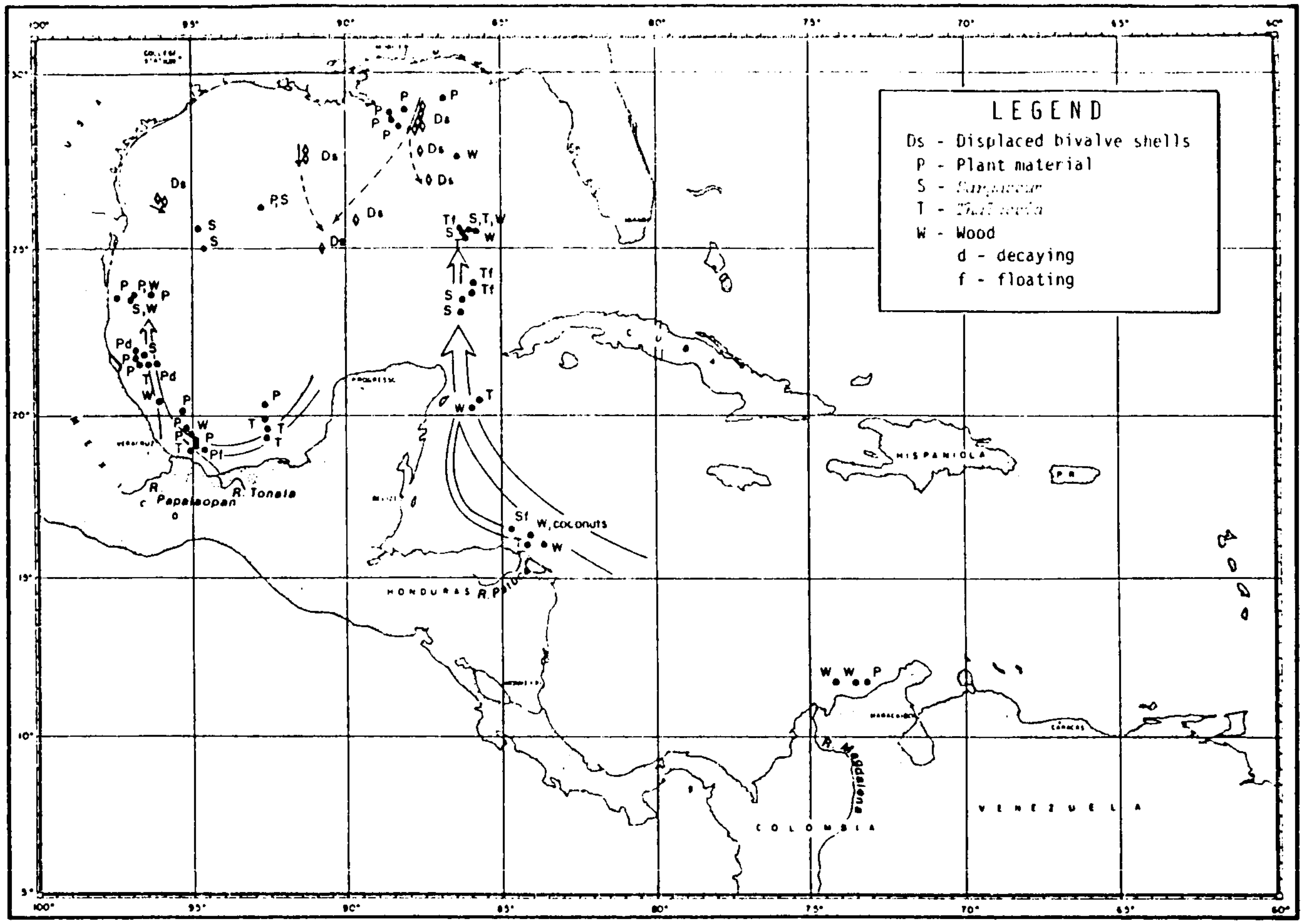


Figure 112. Location of ALAMINOS stations where various types of plant debris were observed either floating (f) or dredged from the bottom. Note also the locations of stations where displaced paleotaxodont bivalve shells (Table 80) were collected. The open arrows depict surface currents; the broken arrows the presumed path of the slumping that transported the shells from shallow to deep water.

have placed shaded ovals where the densest bottom faunas were found. Although the cube has been placed in the western Gulf, the processes that it depicts are gulfwide in occurrence.

Table 80. Paleotaxodont bivalve species that provide evidence of slumping and turbidity flows at three locations in the northern Gulf of Mexico. Note that 87°W longitude is along DeSoto Canyon; 91° and 92°W longitude are just west of the Mississippi Delta; and 96°W longitude is east of Brownsville, Texas.

Species	Living Depth Range (m)	Depths and Locations of Dead Valves		
Nuculana acuta	150-250 m	329 m	27°47'N,	91°25'W
		732 m	26°22'N,	96°08'W
		1494 m	28°55'N,	87°24'W
		2400 m	28°39.9'N,	87°38.7'W
		2700 m	27°42.2'N,	87°44.5'W
Nuculana carpenteri	200 m	2400 m	28°39.9'N,	87°38.7'W
		3292 m	23°46'N,	92°29'W
Nuculana platessa	400 m	2400 m	28°39.9'N,	87°38.7'W
Nucula sp. A	750-1700 m	2400 m	28°39.9'N,	87°38.7'W
Nucula sp. B	1100-1200 m	1700 m	29°00'N,	87°29'W
Nucula culebrensis	500-600 m	2400 m	28°39.9'N,	87°38.7'W
Tindariopsis agathida	1000-1850 m	2400 m	28°39.9'N,	87°38.7'W
		3109 m	25°31'N,	86°10'W
Yoldiella pachia	1000-1500 m	2400 m	28°39.9'N,	87°38.7'W
Yoldiella quadrangularis	1000-1500 m	1638 m	29°00'N,	87°29'W

POTENTIAL HAZARDS FOR THE DEEP GULF ECOSYSTEM

In the preceding sections it has become clear that although the deep Gulf ecosystem has many unique features, it is vitally dependent upon surface currents and the functions of the euphotic zone for its continuing health and future existence. It is, therefore, in double jeopardy in that it will be affected indirectly by agents that are inimical to surface life and directly by pollution emanating from man's activities in the benthic region.

Chemical pollution or other modification of the euphotic zone should have only temporary adverse effects upon the euphotic zone itself because mixing and dilution should occur and because surface water currents should sweep the contaminated water away. However, the deeper layers are nutritionally dependent upon the surface layers in very complex and subtle ways. Therefore, any interference with production in the surface layers or with vertical biological

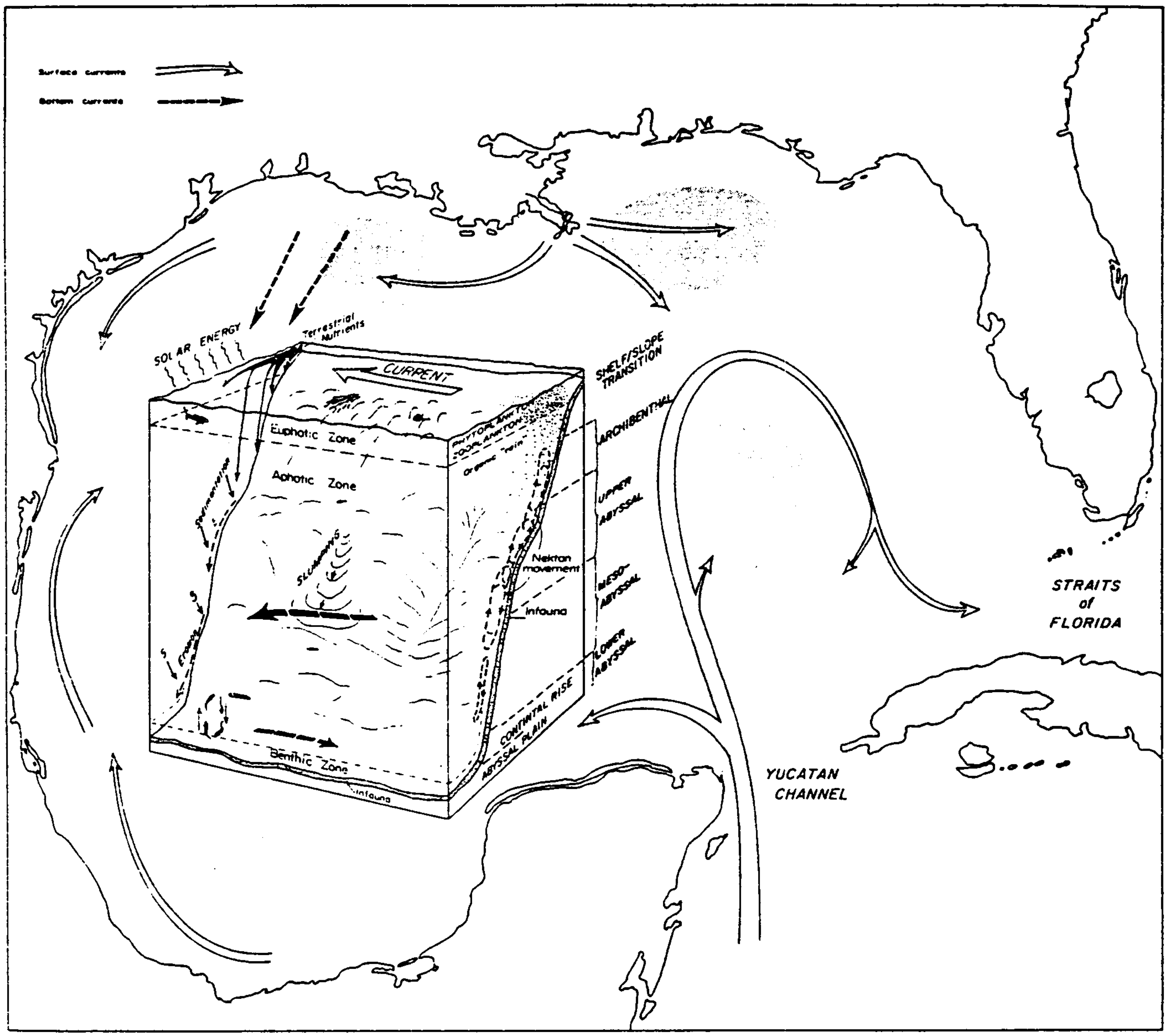


Figure 113. Processes and phenomena involved in the functioning of the deep Gulf ecosystem. Open arrows represent the general track of those surface current systems that carry plant material into the Gulf and from which it drops to the bottom. The shaded ovals indicate where most of the plant material touches down and also where the densest development of the deep benthos occurs. Both the faunal zonation system and the ecosystem zones are depicted. Note also the "rain" of particulate organic matter, sedimentation, and slumping (erosion) processes. Finally, the feeding of demersal fishes upon pelagic species is shown by the arrowed dashed ovals.

and physical transport mechanisms should have adverse effects at some point downstream of the site of contamination upon the aphotic and benthic portions of the system. For example, oil pollution of the surface or intermediate waters might be expected to interfere with feeding and vertical migrations of the zooplankton. This, in turn, would reduce the standing crops of zooplankton and decrease food availability to those animals of the aphotic and benthic zones which depend upon the zooplankton or their fecal pellets for food.

Direct chemical contamination of the aphotic and benthic zones is likely to occasion several serious consequences. The fauna of these zones tends to be more unique and more especially adapted to the prevailing local conditions than those of the surface waters. Physiologists have concluded that deep-water animals have very narrow ranges of tolerance to most environmental factors studies. In this respect they are not like estuarine and other hardy coastal animals which are adapted to survive in highly variable environments. Deep-sea animals are sensitive to even minor shifts in environmental factors. This generalization, based primarily upon studies of benthic animals, undoubtedly applies to the pelagic species of the aphotic zone, as well. Just in terms of maintaining life, the fauna of the aphotic and benthic zones must be considered very vulnerable to chemical pollution.

A great many of the species of the aphotic and benthic zones are filter-feeders and must strain their food from the water. Suspended oily materials would be expected to gum up and heavy concentrations of suspended silt would be expected to clog up the delicate feeding mechanisms. The planktonic larvae of the benthic species should be especially vulnerable to such action. Many other species are deposit feeders which glean organic particles by sorting through the surface sediments. Deposition of heavy silt layers or of petroleum products upon the bottom surface should be devasting, especially to those benthic species which possess limited powers of locomotion.

Finally, there is the major suite of problems associated with underwater "blowout" and slumping. A major underwater "gusher" would send enormous quantities of petroleum into the aphotic and benthic environments of the slope. Without question, such an event would wreak widespread havoc throughout theses delicate systems because of the quantities of petroleum and because of the diversity of petroleum fractions involved. Such an event would also likely be accompanied by significant slumping, and this would result in faunal devastation in a wide path down-slope from the primary event.

Unfortunately, little solid information is available upon which definite prediction can be based. Therefore, a major vulnerability is a lack of knowledge and understanding. One likely would not be in a position to diagnose trouble when it began or to demonstrate the cause if many of the aphotic and benthic populations were suddenly eradicated. Some knowledge of the directions and velocities of the deep current patterns would at least permit prediction of the directions and rates of spread from point-source contamination. However, absolutely nothing is known about ways of ameliorating the effects of deep-water petroleum contamination or of slumping or widespread siltation of the aphotic or benthic zones. Therefore, predictability would not appear to serve any useful purpose in protecting the deep-water ecosystem. The technology of prediction and protection lag far behind the technology of exploitation. However, as suggested in an earlier section of this report, there are some biologically related techniques that might be used to discern geographic areas of the slope that have a history of slumping. These areas could be designated as hazardous drilling sites, and lease rights would not be offered for sale. In this context, predictability would serve to protect the most vulnerable parts of the slope ecosystem.

EXECUTIVE DECISIONS FOR AVOIDING SIGNIFICANT ECOSYSTEM IMPACTS FROM PETROLEUM EXPLOITATION

It is socially and economically desirable to permit maximum safe exploitation of the petroleum resources of the outer shelf and upper slope while minimizing potential hazards to the slope ecosystem. Guidelines for reducing the ecological hazards are given below.

1. Drilling leases should, at first, be limited to those areas of stable bottom where slumping and underwater blowout are least likely to occur. With advancing technology perhaps some of the less stable bottoms might be tried on an experimental basis.

2. In relatively unstable areas drilling should be limited to those seasons of the year which are considered safest. By and large, this means those seasons when storms are least likely, when bottom currents are most propitious, and when visibility at the drilling head is greatest (i.e., when bottom turbidity is the lowest).

3. In carrying out drilling operations in deep water every effort should be made to employ the safest technology available. Automatic shut-off devices should be employed. Drilling muds and other effluents should be barged to relatively safe disposal sites (presumably in off-slope deep water). Drilling rigs should be exceptionally sturdy and firmly anchored deep into the bottom.

4. Buffer zones should be provided between major areas of drilling activity to provide refuge for fauna which may be needed to repopulate disturbed areas. With such species refuges available recovery will be possible from even major underwater disasters.

5. Ecological monitoring of key drilling sites should be carried out before, during, and after the construction and drilling activities to provide a background of specific information on the ecological effects. Present knowledge is rather general and does not provide the definite information required as the basis for sound and long-term management decisions.

6. General ecological surveys of the slope ecosystem should be initiated immediately to provide a broader base of factual information about the slope ecosystem to provide information required for decision-making as the drilling operations proceed into less-stable bottoms and into deeper waters of the slope and abyss. Specifically needed is knowledge of the deeper current patterns, water mass characteristics, faunal distribution in relation to hydrographic parameters, and tolerances of deep-water fauna to heavy turbidity and high levels of petroleum hydrocarbons.

7. The technology for amelioration of the effects of deep-water blowout and heavy turbidity should be developed as soon as possible. For example, it may be possible to develop vertical sleeves to surround drilling sites. Sediments would, thus, be deposited locally, and any petroleum released would be contained and funneled to the surface where it could be handled mechanically or chemically.

PART IV. FUTURE STUDY NEEDS

GENERAL

Application of the four oceanographic disciplines (biological, chemical, geological, and physical) toward deep Gulf of Mexico studies has been understandably unbalanced. The Gulf is one of the best geologically studied basins in the world, primarily because of its economic value to the petroleum industry; however, the bulk of the studies have been limited to seismic and sonograph investigations of the shelf and upper slope. Knowledge of the chemical and physical processes of the deep Gulf is particularly exiguous. Obtaining such data is difficult and expensive and there has not been an urgency to know the chemistry, current patterns, and exchange processes in the deep Gulf, a zone which has been assumed to be a somewhat static environment. This report provides a sound base of data on the deep Gulf of Mexico biology, but it is certainly not all inclusive as it is limited to the deep Gulf benthic mega- and macrofauna. What we need to know of the deep Gulf is not restricted to one or a few disciplines or even geographic areas. Instead, we need a systematic, multidisciplinary sampling program based on existing knowledge of the deep Gulf but not necessarily designed to "fill the gaps" in the data. When deciding upon what data are to be collected, the primary focus should be directed towards determining the following zonal qualities: (1) standing crop, (2) turn over rate, (3) flushing rate, and (4) concentration of certain chemical fingerprint components in organisms and sediments.

The following statements attempt to summarize the major deficiences in knowledge of the deep Gulf of Mexico for later use in designing a deep benthic study in the Gulf. These data gaps are deterrents in understanding the deep Gulf ecosystem as a whole, yet understanding this ecosystem is becoming increasingly more essential as man encroaches deeper into the ocean with his exploration, mining, and dumping activities.

VOIDS IN PHYSICO-CHEMICAL DATA

CHEMICAL

The major studies conducted on chemistry of the deep-Gulf are summarized below:

INVESTIGATOR	TOPIC
Fredericks and Sackett (1970)	Organic carbon
Holmes (1973, 1976)	30 different elements in shelf, slope, and abyssal sediments
Feely (1975)	Nepheloid layer
Trefry (1977, 1981)	Heavy and trace metals in sediments

Little else has been done in the Gulf of Mexico in the way of deep benthic chemistry.

One very basic gap in deep-Gulf chemistry is that of organic content of the sediments and overlying water. Such data are obviously important in understanding the energy transfer of organic matter in and near sediments to the interstitial bacteria, meiofauna, and other organisms. There is undoubtedly variation in organic carbon content of deep sediments not only between isobaths but between the major geographic features (e.g., Alaminos Canyon, Mississippi Fan, DeSoto Canyon), which likely is reflected in standing stock biomass. There is still debate on the relative importance of various sources of organic material to the deep-sea and very little information is available for the Gulf. This question has been tackled for other ocean basins by using sediment traps (Staresinic et al., 1978; Hinga et al., 1979; Rowe and Staresinic, 1979; and Rowe and Gardner, 1979) to estimate at least one source of organic carbon, particle flux. Marine macrophyte detritus is recognized as an important food source in the deep sea (Menzies et al., 1967; Wolff, 1976; Hinga et al., 1979; and Rowe and Staresinic, 1979) but quantifying its contribution to the organic pool has been limited to visual estimates from bottom photographs (Wolff, 1976; this report). Even more difficult is assessing the value of chemoautotrophic production and sinking carcasses of large nekton to the deep benthic ecosystems, which seems to vary considerably with geographic area (Rowe and Staresinic, 1979). Nevertheless, an understanding of this basic part of the deep- sea food web is needed, since it ultimately depends (nearly solely) on overlying production in the water column and coastal areas. Rowe (1972) was able to infer the degree that surface production affected the deep-sea benthos of the Gulf of Mexico, the Pacific off Peru, and the Atlantic off New England and Brazil. Satellite imagery has been used for estimating surface productivity and may prove to be a useful method of relating littoral and deep-benthic Gulf ecosystems.

Secondly, it is important to know much more about the levels of dissolved oxygen in the first meter of water above the bottom, and this should be correlated with Eh values in the adjacent sediments. These values alone will give us important insights into just how important the slope ecosystem is in the total bioeconomy of the Gulf system.

Benthic respirometers for example have been used to measure the use of organic material by bottom fauna in the North Atlantic (Hinga et al., 1979). Not only can oxygen consumption be measured, but carbon flux as well. A basic knowledge of the oxygen and carbon budgets for these elements of the Gulf benthos would be useful in assessing the vulnerability of the benthic fauna to pollution, particularly in those areas subject to oil and gas exploration.

Another basic question often brought up in the discussion of pollution in the Gulf of Mexico concerns the actual flushing time of the Gulf. Determining the residence time of waters in the Gulf is certainly of first-order importance, yet to our knowledge this has not been done discriminately, as through isotope-dating methods.

We have reached that point in ecological investigation where it is no longer sufficient to simply analyze sediment samples for metals. Too much evidence has accumulated that argues that metals highly bound to sediment particles, especially the clay matrices, are not assimilable by organisms and thus they have essentially zero toxicity potential. Rather it is the dissolved metals and, more particularly, the valence state of dissolved metals, that we need to investigate. Hence, pore water samples should be studied appropriately to achieve these objectives. Those metals of greatest concern are zinc, manganese, copper, cadmium, lead, iron, and mercury. At the same time the presence of various organic pollutants could be determined.

PHYSICAL

Currents

Physical oceanographers were convinced that the deep Gulf was devoid of appreciable currents until 1972 when a bottom current with velocities as high as 19 cm/sec was discovered on the Mississippi Fan between 3000 and 3300 m depth (Pequegnat, 1972). Since then deep bottom currents have been discovered on the northeast and northwest Gulf upper slope (Moore, 1973; Brooks and Eble, 1982; respectively); otherwise few efforts have been concerted toward study of the currents on the Gulf slope and none on the currents of the lower slope and abyssal plain. A primary interest in piecing together the overall deep Gulf ecology is to determine the duration, speeds, and patterns of currents traversing the continental slope. If such currents do exist, they serve as a mode of transport for nutrients and perhaps larvae.

Particularly needed is the development of relatively inexpensive ways of obtaining synoptic data. Such methods are available and should be used. Near bottom current measurements should be long-term. Since topography greatly influences near bottom currents, a detailed bathymetric survey should be required in the area of meter placement.

Slumping and Turbidity Flows

The stability of the sediment layer on the upper slope has become a serious concern, particularly to those involved in site selection and construction of oil production platforms in the slope petroleum province. The last 10 years has seen much progress toward understanding sediment movement on the northern Gulf continental outer shelf and slope, mainly in the form of slumps and mudslides. Most of these studies have understandably been on the Mississippi Fan. The active diapirism and subsequent steepening of the slope has led recent investigators to believe that slumping is more common than previously thought. Mass movements such as these and turbidity flows may have profound effects on the slope fauna. The normally "static" deeper environments are probably periodically inundated with sediment on one hand or supplied with fresh organic material on the other. The turbidity deposits below DeSoto Canyon, for example, are thought to enhance production. However these ideas are merely speculative; the effects of slumping and turbidity flows on the fauna is yet another gap in the knowledge of the deep Gulf.

DEFICIENCIES IN BIOLOGICAL DATA

Up to now the emphasis in respect to deep Gulf biological studies has been on the megafauna and macroepifauna with only a moderate amount of study being devoted to the macroinfauna. Thiel (1975) emphasized how these artificial groupings have little taxonomic or ecologic justification and are merely convenient to sample collection and processing. Thus, those faunal assemblages identified to date and, indeed, the system of zonation proposed by previous workers has to a large extent been based on but a fraction of the total benthos. Obviously, ecological assemblages have other important components, including the bacteria, meiofauna, and benthopelagic components.

Morita (1979) stressed the need for further investigations on microbiology of the deep sea, particularly on bacteria metabolic rates, biochemistry, physiology, and utilization of DOC and POC in the deep environments. He outlined six important factors to be considered in deep-sea microbial studies which have not yet been employed in the deep-Gulf.

Thiel (1979) pointed out how lack of suitable data prevented comparisons of deep-sea macrofauna and meiofauna abundance; that is, no synoptic data is available from both size groups from the same sampling program or region. Meiofauna densities seem to decrease more slowly with depth, and are roughly 1000 times higher than macrofauna densities (Thiel, 1979). Moreover, there is promise of correlating meiofauna densities to C/proteins and N/proteins ratios in the sediment (Dinet, 1979). It is requisite to include meiofauna in future deep-Gulf biological investigations, for several reasons: 1) meiofauna are easily collected quantitatively, 2) smaller sample sizes of benthos adequately represent meiofauna populations, and 3) meiofauna respond quickly to changes in the environment and are basically immobile, rendering them good indicators of pollution and other disturbances. To date, very little is known of meiofaunal populations on the Gulf slope and deeper, but a deep-Gulf survey which includes this important component would certainly allow better evaluation of energy transfers and vulnerabilities in deep-Gulf ecosystems.

The benthopelagic component, a most difficult study component of deep-sea ecosystems, is another deficiently researched aspect of the deep Gulf. Many benthopelagic organisms, e.g., fishes and cephalopods, are capable of transferring considerable amounts of organic matter from the pelagic to benthic environment and vice-versa. Hinga et al. (1979) concluded that near-bottom organisms (which they define as organisms living on or near, but not in the sediment) consume much of the organic carbon that reaches the deep-sea. It is therefore important to attain some idea of the relative importance of the somewhat semitransient benthopelagic component to the benthos as a whole.

The macro- and megafauna and demersal fish taxonomy and surveys have been adequately worked out for the deep Gulf. The remaining data gaps pertaining to these and the aforementioned biological components include quantitative biomass measurements, tropic relationships, reproductive patterns, and seasonal changes.

SUGGESTED FUTURE INVESTIGATION

AREAS AND DEPTHS TO BE SAMPLED: CANYON SYSTEMS AND MISSISSIPPI FAN

There are three significant canyon systems in the northern Gulf of Mexico. These are:

1. DeSoto Canyon in the northeastern Gulf, which lies between the easternmost extension of the clastic sediment system and the western reach of the carbonate sediments of Florida. In truth the "trough" of this canyon is rather short, stretching only from a depth of about 450 m down to between 950 and 1000 m, but there is evidence of considerable sediment movement in the lower extension of the canyon down to its intersection with the Mississippi Fan. Note should be taken that this Fan is the largest of its kind in the world ocean system. It is essentially a large "alluvial fan", and is interesting for among other reasons because a substantial bottom current is

known to course over its midsection and because it contains large quantities of quartz sand of presently unknown origin. It has been studied reasonably well biologically but much more attention should be given to it between the 2250 and 2700 m isobaths.

2. The Mississippi Trough which lies in the north-central Gulf on the outer edge of the prograding delta of the Mississippi River: this canyon like feature is known to have been extremely active as a sediment transporter in the late Pleistocene and, indeed, is still an environmentally active site. It, too, intersects with the Mississippi Fan. It has been little studied and thus deserves considerable attention at all depths from the Shelf/Slope Transition down to and across the Fan.

3. Alaminos Canyon, which lies in the northwestern Gulf is now known to traverse a very active area of slumping and turbidity flows. Although the area around the canyon has been studied moderately well, the canyon walls deserve very special attention down to the point where they contact the Sigsbee Escarpment.

It is suggested herewith that these regions and their environs should be studied by means of Y-shaped transects. Both walls, as well as the central valley, of each canyon would be studied. It is recommended that if at all feasible each canyon should be surveyed initially by means of a deep submersible craft.

SOME NOTES ON THE NATURE OF THE ECOLOGICAL PROJECT

As stated previously, up to now the emphasis in deep biological studies has understandably been on the megafauna with only a moderate amount of attention being devoted to the macroinfauna. Accordingly, it is recommended that at strategic depth stations the proposed study should sample the meiofauna and macrofauna by means of boxcores. Also, insufficient attention has heretofore been paid to the benthopelagic component; hence this, too, should be sampled, primarily be means of an appropriate sled.

Thus, the fauna of the study should be sampled by appropriate gear and state-of-the-art techiniques with reasonable treatment being given to all of the following components:

a) meiofauna
b) macroinfauna
c) macroepifauna
d) megafauna
e) demersal fishes
f) benthopelagic fauna.

It is emphasized that bacteria will not be neglected. Rather they will be studied in another context, viz., that of seabed metabolism.

THE ROLE OF SEABED METABOLISM IN ANAYSIS OF IMPACT ASSESSMENT

It is expected that high-density pollutants, including some components of petroleum, may be capable of deleteriously impacting those living parts of the ecosystem that exist in or are dependent upon the sediment bed. Thus, in order to understand just how pervasive such impacts may be, some attention should be given to what we are calling seabed metabolism. Initial steps in this substudy should comprise the following:

1. Deployment of sophisticated suspended material traps (often referred to as sediment traps). These are designed to effectively collect material "raining down" at important sites. The collectables can be analyzed and the available energy content of the organic constituents can be determined. This permits calculation of the input of potential energy to the seabed that will be available to drive the system. The traps should be equipped to surface upon command.

2. The effective transfer of this potential energy to the cryptic system can be investigated by taking subcores from box cores. A press should be used to obtain samples of the true pore water.

   a) dissolved organic compounds that can be considered to be food materials for bacteria, meiofauna, and, in some cases micro- and macroinfauna, should be analyzed and their potential energy content calculated

   b) sulfides and ammonia should also be determined

   c) as noted below other subcores can be taken and analyzed for quite different components.

3. A bell jar equipped with automatic syringes can be deployed directly on the seabed to measure through oxygen fluxes the direct metabolism of the sedimental system. One syringe would automatically take and sequester a sample of the water in the bell jar after it has settled firmly on the seabed. Then, after a predetermined time interval, another syringe would take a second water sample from the bell jar. Following that, the bell jar would be released from the bottom and would rise to the surface. The water in the closed syringes can then be analyzed for D.O. The oxygen utilization in units of time and volume would permit metabolic calculations.

Other subcores from the box core can be utilized for

a) microbiology
b) meiofauna
c) sediment texture

It may be advisable to employ a method for calibrating or gaining insight into the meaning of the metabolic levels determined by the above techinques. This can be done to a large extent by determination of the adenylate energy pool of the sediment system, utilizing material from a subcore of the above mentioned box core.

A FEW THOUGHTS ON THE SAMPLING DESIGN

It is a common fault among field scientists of all types that they overestimate the value of existing data. This is not to say that such data does not have an important use. It does, but it should not be used to establish "how to fill the gaps". Rather one should work with a statistician in order to make a series of predictions about distributions based upon the existing data. Having accomplished this, one can design a sampling program that will test the predictions as well as produce distributional charts. Thus, the value of existing data is that it allows some degree of prediction. In this way, prediction based upon prior knowledge allows for rigorous design and cost effective sampling. In other words, one should not just fill in the blanks, but should use coarse resolution data to design the best fine-resolution study. This applies both to the geographic and bathymetric sampling plan. It also is very dependent upon the knowledgeable and authoritative selection of sampling gear. In regard to bathymetric sampling in the Gulf, considerable attention in the future should be given to the depth band extending from about 2200 to 2750 m. It is in this region that there appears to be a significant shift in the composition of some aspects of faunal assemblages.

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PHOTOGRAPHIC ATLAS

APPENDIX A

PHOTOGRAPHIC ATLAS OF DEEP-SEA ENVIRONMENTS OF THE GULF OF MEXICO

ABSTRACT

This appendix presents a series of bottom photographs taken aboard the R/V ALAMINOS in the eastern, central, and western subdivisions of the Gulf of Mexico. The pictures were selected to portray similarities and differences existing within bathymetric limits, physiographic provinces, and vertical zones of the Gulf and to document a variety of influences that animals have on sedimentary conditions. For the most part the photographs illustrate the deeper parts of the Gulf from the Shelf/Slope Transition and the Upper Continental Slope to the Sigsbee Abyssal Plain. The authors speculate on the causes of several ichnological phenomena observed in the photographs.

INTRODUCTION

This appendix is devoted to a study of bottom photographs taken in the principal physiographic provinces and vertical zones of the deeper parts of the Gulf of Mexico. Several objectives may be ascribed to this study, but two stand out as being most important. These are, first, to provide a reasonably comprehensive view of the similarities and differences of the bottom existing among several bathymetric and geographic parts of the Gulf; and, second, to portray pictorially a variety of influences that animals have on the water-sediment interface, sedimentary structures, and composition. This latter endeavor, which constitutes the field of ichnology, is limited severely by the lack of time-series in still photography. For the same reason it is also difficult to judge the currency of certain phenomena (e.g., ripples and lineations) observed in the photos. With these constraints in mind, it seemed appropriate to have a group constituted of several biologists and geologists analyze each photograph. For the most part, the figure captions present consensus interpretations.

The principal users of deep-sea still photography in their work have been geologists and biologists, with lesser interest demonstrated by paleontologists, physical oceanographers, and geophysicists. In recent years, various biologists have attempted to use sea-floor photography to obtain quantitative estimates of populations of epibenthic animals in the deep sea (McIntyre, 1956; Menzies, Smith and Emery, 1963; Barham, Ayer and Boyce, 1967; Wigley and Emery, 1967; Wigley and Theroux, 1970). Obviously, such considerations can apply only to the megabenthos, including some demersal fishes. In addition, we feel that this method is handicapped by other conditions, namely, that (1) a large number of megabenthonic species are burrowers and (2) the descent of the camera unit frightens animals out of the viewing area (possibly from vibrations, if not from light). This is evidenced by pictures of sediment clouds and luminous clouds revealing the presence of unknown animals shortly before the picture was taken. We do not consider the situation where the analysis of photographs shows larger populations than dredge results from the same site as evidence of the superiority of photographic census techniques. Careful evaluation must also be made of the particular dredging capability employed as a comparison.

Numerous examples may be elicited to demonstrate that population estimates based on photographs have real limitations. For instance, we have dredged hundreds of such decapod crustaceans as _Stereomastis sculpta sculpta_ and

Polycheles validus, which both measure 15 or more centimeters in length, but we have never photographed a single specimen (Firth and Pequegnat, 1971). In fact the family Polychelidae, to which these species belong, is the principal one whose members are not included in our library of deep-sea photographs. And this group is not wholly unique, since we have very few photographs of benthonic caridean shrimps. As a matter of fact we believe that we are showing the first published in situ photographs of a caridean belonging to the genus Glyphocrangon, previously thought to be burrowers that never leave their tunnels (principally because of their heavily calcified exoskeleton). It is possible that we have linked at least one species of Glyphocrangon to its burrow system.

Still photography has been used also for study of erosion on the deep ocean floor (Laughton, 1968) and for detection of bottom currents (McCoy, 1969). Among the many other uses of this observational technique, two of the most important are for estimating the transport of organic matter (in the form of dead animal and plant parts) into the deep-sea environment (Menzies, Zaneveld and Pratt, 1967) and for evaluating the role played by animals in turning over marine sediments (Hanor and Marshall, 1971). Although such effects of animals have been considered to be limited largely to the upper 10 cm of the sediment blanket, this may be far too conservative an estimate. And in any event, such activities have been going on for long periods of time while sediments have been accumulating; hence the intermixing of the sediments in some places has been very complete, whereas in some azoic areas (Black Sea and certain closed basins off southern California) there has been very little vertical disturbance of sediments by animals.

Certainly one of the most intriguing aspects of deep-sea bottom photography to the biologist is the possible relation of certain disturbances of sediments (tracks, burrows, etc.) to particular kinds or species of animals. Two of the active contributors to this field of ichnology in shallow marine waters are Hantzschel (1966) and Frey (1971).

BRIEF GEOLOGICAL DESCRIPTION OF THE STUDY AREA

The present study is limited to examples drawn from several physiographic provinces of the Gulf of Mexico. For ease of description, the Gulf has been subdivided into three areas: the northwest, northeast, and central regions. The separation of northwest from northeast occurs along the 90th meridian from the shelf break down to the 3400-m isobath. The central Gulf region involves the rise and abyssal plain west of the 88th meridian.

Ewing et al. (1958) presented a detailed description of the geology of the central portion of the Gulf, while Bryant et al. (1968) described the structure of the Mexican continental slope. The eastern portion of the Gulf and its geological evolution is discussed in Bryant et al. (1969).

Figure A-1 presents a map of the major physiographic provinces of the Gulf of Mexico. Certainly one of the dominant features here is the large Mississippi Fan, which is a submarine fan composed of sediments derived from the Mississippi River. This is the largest marine fan known. The Sigsbee Abyssal Plain starts at the base of the western limit of the fan. This plain is approximately 410 km long and 200 km wide and is extremely flat with a gradient less than 1:8000. A series of diapiric structures, called the Sigsbee Knolls, are the only topographic irregularities of the plain (Ewing et al., 1958). The location of the Mississippi Fan, its relation with the abyssal plain and its extremely flat nature, and the characteristics of the abyssal plain sediments suggest that the plain has resulted from turbidity current processes originating at the apex of the fan near the Mississippi Delta. The sediments on the abyssal plain are primarily terrigenous silts and clays. Some carbonate turbidites originating from the Campeche Bank are found at certain sections and depths in the plain.

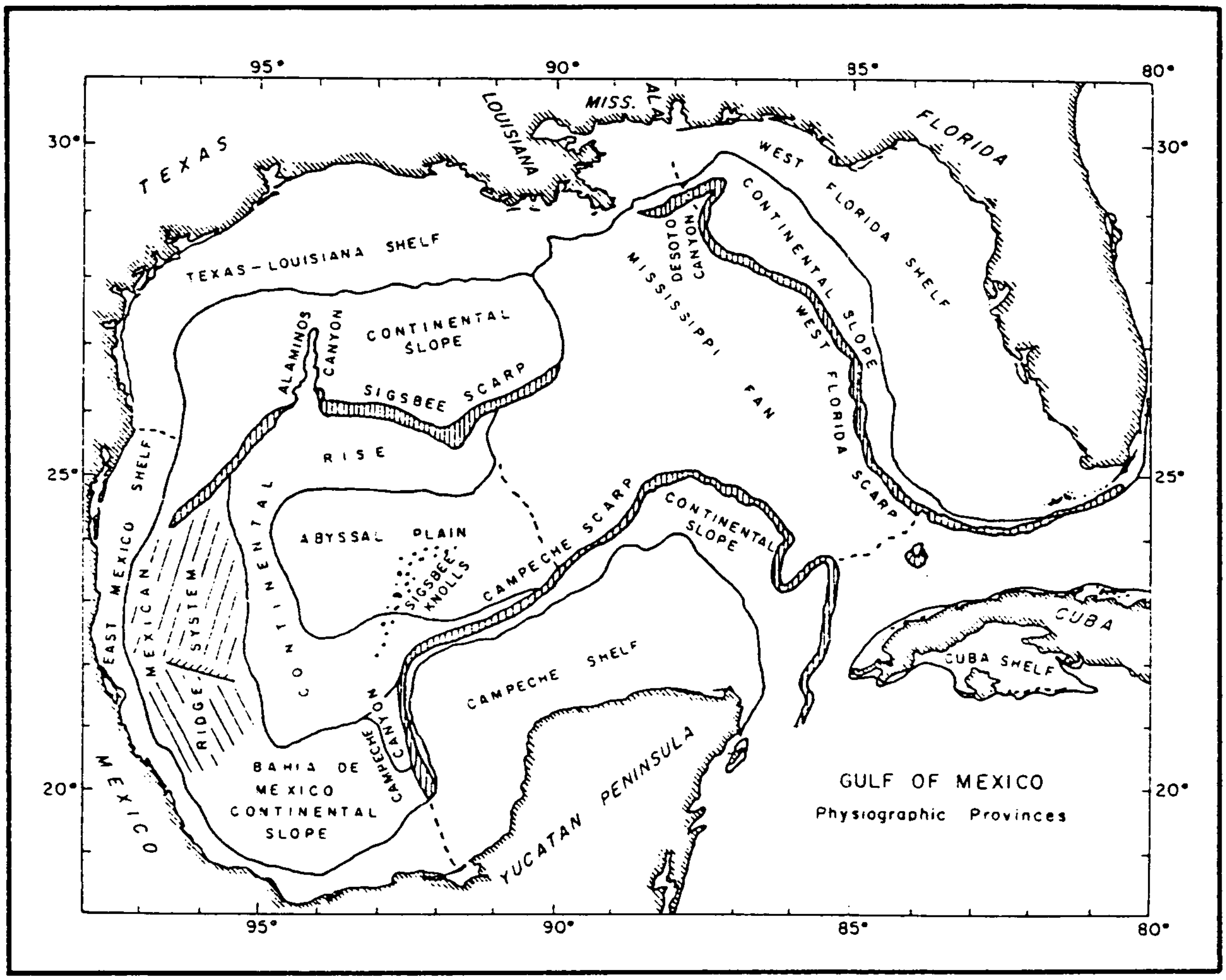

Figure A-1. Map of the Gulf of Mexico depicting its principal physiographic provinces. Note the extensive area covered by the Mississippi Fan.

The Mississippi Fan is a large build-up of detrital material issuing from the Mississippi River. Slumping and current activity are believed to be the main mechanisms of sediment transport in the area during the Holocene-present times. The continental slope off Texas and Louisiana is extremely rugged, being composed of a series of basins and hills resulting from action of salt diapirism. This ends to the south, in water depth of about 2100 m, at the steep Sigsbee Escarpment. The hummocky nature of this region prevents the southward movement of sediments across the continental slope to the deeper portions of the Gulf.

The major structural feature of the Mexican continental slope is a linear fold system that parallels the Mexican coast for a distance of some 600 km between Brownsville, Texas, and Veracruz, Mexico. This fold system, whose origin is suggested to be the result of salt tectonics, is approximately 200 km wide with maximum relief in excess of 600 m. As such, it occupies the major portions of the Mexican continental shelf and slope in this region.

Data from the piston cores have indicated that this fold system has created an effective dike that prevents the movement of sediments from continental Mexico into the deepest parts of the Gulf basin. Sediment cores taken between the folds contain only pelagic sediments with no indication of terrigenous sedimentation. Going landward into the region where the folds are buried by sediments or have little or no topographic relief, the sediments are terrigenous. It is believed that the folds retain those sediments that would normally move from the continent towards the basin until each trough is filled. Consequently, all fold troughs seaward of the first landward-appearing troughs are areas where pelagic sedimentation dominants.

It is not surprising, therefore, that the Mexican continental slope and certain sections of the Texas-Louisiana continental slope that are isolated from terrigenous sedimentation by salt ridges and diapiric structures are the only known areas in the Gulf of Mexico where pelagic sediments predominate.

The Campeche Bank and west Florida continental shelf and slope are the results of up-building and out-building of carbonate sediments. The discovery of early Cretaceous shallow-water sediments in the lower sections (ca. 3000 m) on both the Campeche Bank and Florida Escarpment indicates that a rapid and large subsidence had taken place in these areas during the late Mesozoic Era (Bryant et al., 1969).

Two submarine canyons mark the terminus of the carbonate provinces of the Campeche Bank and Florida continental slope. DeSoto Canyon borders the end of the carbonate province of Florida and the beginning of the diapiric and terrigenous province to the west. The latter province continues around the western extension of the Gulf, runs southward, and again eastward in the region of Veracruz to terminate on the western flank of Campeche Canyon. Both of these canyons are unique in that their origin, although unknown, is probably related to the diapiric activity on the west flank and the up-building of carbonate material on the east flank of each canyon.

EQUIPMENT USED

Two cameras were employed in obtaining the photographs presented in this appendix. Both were originally off-the-shelf models, but each was modified in our laboratories for specific task requirements.

Our initial camera was a 35 mm underwater multi-exposure model (Alpine Geophysical Associates, Model 314) that was triggered by bottom contact. It was equipped with a Wollensak f/11 water corrected lens with a fixed focus of about 3 m. By placing brass shims of appropriate thickness behind the lens we were able to adjust the focus to 1 or 1.5 m. After numerous tests we settled on 1.5 m as being the most effective distance for our purposes. But in order to do this, we had to design and fabricate a closeup frame for the camera, strobes, bottom switch, and pinger. The original camera system was supplied with a single 200 watt-second strobe light, which was adequate for high-speed films. Later a second such strobe was integrated within the system, permitting the use of fine-grain films.

The second camera was a 70 mm Shipek Deep-Sea Camera (Hydro Products Model PC-700) equipped with a single 200 watt-second strobe. The focus of this camera was ordinarily set at 1.6 m.

When the 70 mm camera was set on automatic mode, the distance of the camera from the bottom (critical to focus) was monitored by acoustical means. This was accomplished by attaching a suitable bottom pinger to the camera frame. On the ship the Y axis of an oscilloscope was interconnected with the PDR receiver (the pulse generator being in the "off" position) via the head-set jack connection. Using the Driven Sweep Mode, the oscilloscope screen then displays the outgoing "ping" and incoming "echo" of the pinger as separate peaks. The distance between these peaks is roughly proportional to the distance of the pinger above the bottom. The grid of the oscilloscope can be calibrated in meters or fathoms and the viewer can relay distances to the winch operator controlling the camera.

When employed at the above focus settings, the 35 mm camera views a rectangular area of which the larger dimension is 1.4 m and the 70 mm camera a square with sides measuring about 1.2 m.

THE PHOTOGRAPHS

RELATIONSHIP TO VERTICAL ZONATION

As discussed in the text, we have identified five vertical zones in the northern Gulf of Mexico. These zones and their approximate depth limits are

Shelf/Slope Transition ----- 150 to 450 m
Archibenthal Zone ---------- 475 to 950 m
  Horizon A - 475 to 750 m
  Horizon B - 775 to 950 m
Upper Abyssal Zone --------- 975 to 2250 m
Mesoabyssal Zone ----------- 2275 to 3200 m
  Horizon C - 2275 to 2700 m
  Horizon D - 2725 to 3200 m
Lower Abyssal Zone --------- 3225 to 3850 m

The photographs are very unequally distributed among the zones, primarily because the emphasis in this study is upon the deeper parts of the Gulf. Accordingly the distribution of photographs among zones is as follows (this does not include the in-text photos):

Zone	Number of Plates	Number of Photographs
Shelf/Slope Transition	1.5	6
Archibenthal Zone	21.5	77
Upper Abyssal Zone	17	62
Mesoabyssal Zone	8	30
Lower Abyssal Zone	15	58
Totals	63	233

The above totals are of course augmented by the 10 plates and 39 photographs removed from the atlas and placed in the text, which brings the grand totals to 73 plates and 272 photographs of benthic animals and/or their environments. The present pattern of distribution of photographs among zones with an emphasis on the Archibenthal, Upper Abyssal, and Mesoabyssal Zones tends to coincide with the often parabolic patterns of species diversity among the megabenthos found by Pequegnat et al. (1976) and Rex (1982) with maxima at intermediate depths and smaller values on the upper slope and the abyss (i.e., the Shelf/ Slope Transition and Lower Abyssal Zones).

RELATIONSHIP TO ANIMAL TYPES

The distribution of megabenthic animals as subjects among the photographs in both the text and atlas is very unequal. As might be expected; although there are substantial numbers of photographs depicting fishes, the total is very low when the number is stated in proportion to the number of fish species collected. The reasons for this lack of proportionality are manifold but some of the more important are related to

1. the mobility of the animals;
2. whether or not they burrow;
3. their ability to detect and respond to vibrations emanating from the descending camera;
4. their size and capability of "blending" with the background so that without special enlargement of the picture they will be overlooked.

When applied to the three most significant megafaunal groups in this study, viz., Echinodermata, Arthropoda, and demersal fishes, we gain some insights into their habits (Table A-1).

We note that a much higher proportion of echinoderms were obtained in photographs than either arthropods or fishes. This resulted primarily because echinoderms are slow-moving and burrowing is not particularly common among the group. Interestingly, a higher proportion of sea cucumbers were photographed than other types, primarily because they are slow-moving and are more uniformly represented among the depth zones than any of the other groups. Asteroids had a lower proportion photographed because some species bury into the sediments and in general they are poorly represented in the deepest zones. The very low proportion of galatheid crustaceans photographed as compared with others points to the new possibility that many of them are burrowers. As expected, the fishes have the lowest average proportion because they are generally quite vagile, some species burrow, and others move well up into the pelagic to feed.

RELATIONSHIP TO REGIONS

Any sedimentary structure or other manifestation in the sediments of the sea floor that is directly attributable to the activities of living organisms may be referred to as a Lebensspur (en). Ewing and Davis (1967) discuss some of the problems that arise when trying to seek the cause of a Lebensspur from from still photographs. Burrows tend to be more difficult to account for than tracks and trails because the mere presence of an organism in a burrow entrance is not prima facie evidence that it is a burrower. Nevertheless, when the same genus of animal and the same type of burrow are photographed together many times in diverse geographic areas, the index of suspicion that it is the causal agent rises. Moreover, the tentative relationship can be reinforced by the results of biological dredging along the photographic pathway.

Table A-1. Relationship between the number of photos showing a particular taxon and the number of species in that taxon collected during the study.

Taxa	Number in Photographs	Number of Species Collected		Ratio of Photo to Species
ECHINODERMATA				
Holothuroidea	39	37		1:1
Ophiuroidea	23	40		1:2
Asteroidea	20	60		1:3
Echinoidea	13	25		1:2
TOTAL	95	162	$\bar{x}$	1:2
ARTHROPODA				
Caridea	11	33		1:3.0
Penaeidea	6	22		1:3.7
Brachyura	7	42		1:6.0
Anomura	4	24		1:6.0
Galatheidea	2	30		1:15.0
Macrura	4	13		1:3.3
TOTAL	34	164	$\bar{x}$	1:6
FISH	22	201		1:9

The collection of photographs to follow is discussed under the three geographic regions previously mentioned (for major geologic features and isobaths see Figure A-2).

Northwest Region

The northwest corner of the Gulf of Mexico is characterized by very fine-grained muds, occasionally being silty. Locally, sand occurs in deeper water (Alaminos Canyon complex). Depending upon location, slumps may be encountered. All of the sites represented in these photographs are characterized by much biological activity, obliterating any deposition that at present is primarily

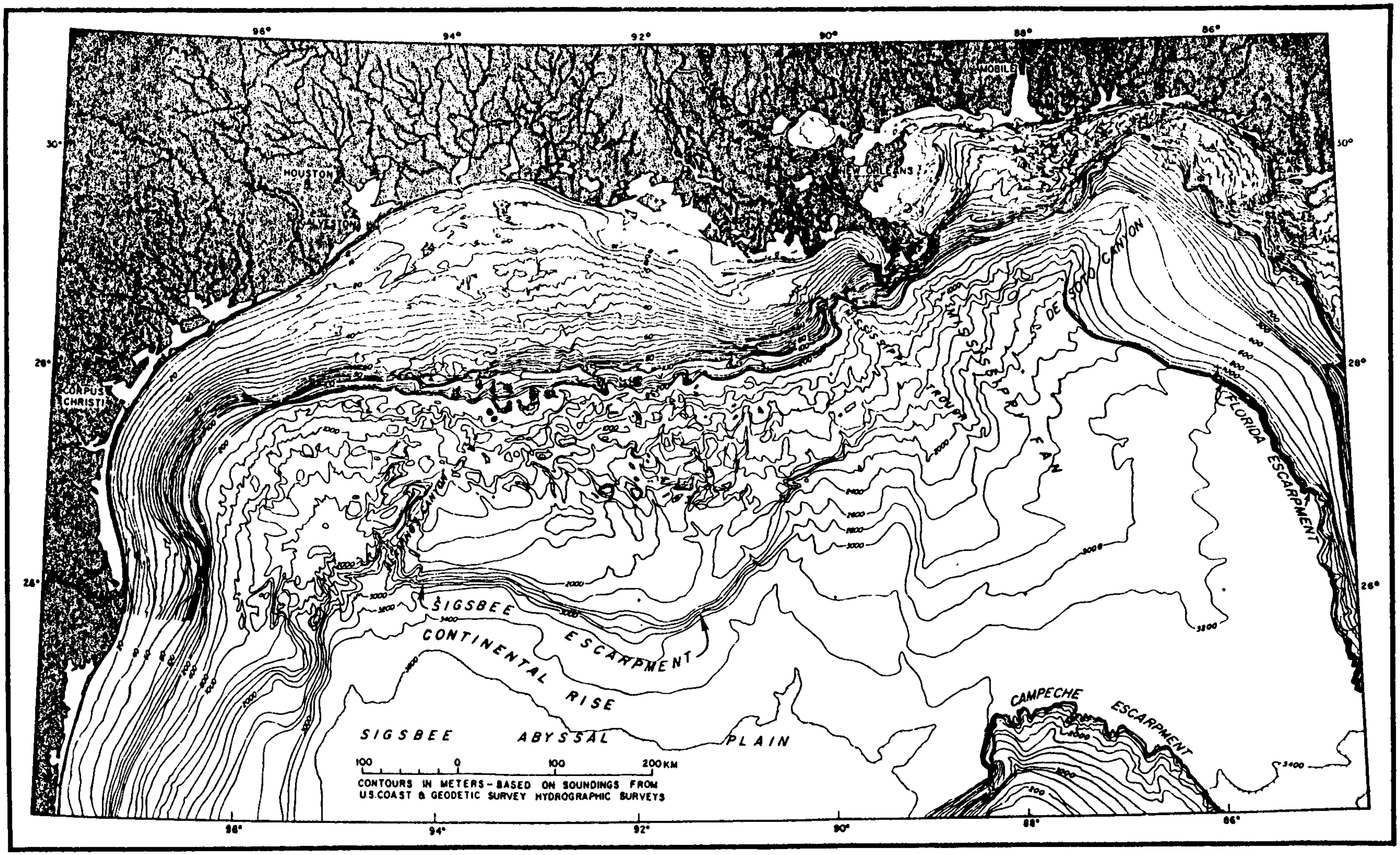

Figure A-2. Topography of the Northern Gulf of Mexico. Note in particular DeSoto Canyon, Mississippi Trough, the Mississippi Fan, and the major escarpments of the lower continental slope. Note also the isobaths that are mentioned in the captions of the photographs.

of pelagic character in the off-shelf areas. Fecal pellets form a high percentage of the water-sediment interface characteristics. The photo series A, B, C, D presents a possible mechanism of disintegration of holothurian fecal pellets, resulting in small pieces that give a grainy texture to the surface sediment.

Northeast Region

This series of photographs of the northeast region constitutes a bottom profile starting in relatively shallow water in the DeSoto Canyon and moving in a SSE direction. The profile shows both the influence of depth and environmental parameters upon the nature of the bottom. In the DeSoto Canyon area a high percentage of irregularities appears to be caused by slumping, whereas in the deeper sections of this profile a near-flat bottom topography is encountered. In this "deep" section, much of which lies under the Loop Current, possibly periodic influences of bottom currents can be observed. It should be pointed out, however, that bottom currents are known to exist in and around DeSoto Canyon (Pequegnat, unpublished data).

The sediments in DeSoto Canyon are a mixture of noncarbonates and carbonates. The former are clays, silts, and other sediments coming primarily from the Mississippi River. Farther south very little carbonate occurs in the sediments except close to the Florida Escarpment where carbonates from the Florida Platform become incorporated.

In general it can be said that one or a combination of activities are present: slumping, currents, animal activity, ironstone crust formation, together with little or no deposition.

The causes of some processes that operate at the sea bottom are unknown. For instance, in the photos Plate XLVI we see ripples and in Plate LVIII we see alignments all of which may be caused by water motion, but the driving forces are not known. Too little study is done on bottom currents in general even though these photographs indicate the need for it. The bottom currents underneath the Loop Current seem to be restricted in time as far as their influences are concerned (see Pequegnat, 1972). Photo C in Plate XLVI shows a film of dark fine-grained sediment that certainly cannot be deposited when currents are active. It is suggested from these photographs that bottom currents here are (1) restricted in width and meander or (2) occur only when the active part of the Loop Current passes over the site.

Photo C in Plate XLVI presents some other unknowns, especially the origin of the steep cliffs off the ripple crest and their preservation after the troughs are covered with a film of coarse-grained sediment.

Ironstone is exposed in areas where bottom currents are active continuously or periodically.

Central Region

All of our photographs from the central Gulf of Mexico reveal a rather smooth bottom comprised of fine-grained sediments. Sedimentological studies indicate that the upper part of the sediment column is clayey and that silts and sands are found as intercalations below the depth of 2-7 m. This means that density currents like turbidity currents are not active anymore in this area and that the top sediments are pelagically derived. The only disturbances at the water-sediment interface are due to animal activity, coring, dredging, and bottom photography.

BOTTOM PHOTOGRAPHS ARRANGED BY FAUNAL ZONE,
ISOBATH, AND LONGITUDE

PLATE I

A. Shelf/Slope Transition Zone.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 380 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.7 x 2.1 m

Photo taken in the eastern Gulf just above the trough of DeSoto Canyon at the intersection of the 380-m isobath and 86°53'W longitude. The sediments are carbonate sands and are apparently smoothed by currents that probably are intermittent. The brachyuran crab is *Benthochascon schmitti*. Note the eel (unidentified) emerging from burrow.

B. Shelf/Slope Transition Zone.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 380 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.7 x 2.1 m

Photo taken in the eastern Gulf just above the trough of DeSoto Canyon at the intersection of the 380-m isobath and 86°53'W longitude. This is about 20 m in depth above the trough of DeSoto Canyon. The crab is the brachyuran *Benthochascon schmitti*. There are many of them in this area. Indications are that this species burrows.

C. Shelf/Slope Transition Zone.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 380 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 2 x 2.6 m

Photo taken in the eastern Gulf just above the trough of DeSoto Canyon at the intersection of the 380-m isobath and 86°53'W longitude. *Benthochascon schmitti* apparently produces many of the depressions seen in this photo. The fish is unidentified.

D. Shelf/Slope Transition Zone.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 380 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 2 x 2.6 m

Photo taken in the eastern Gulf just above the trough of DeSoto Canyon at the intersection of the 380-m isobath and 86°53'W longitude. The smoothed contours of mounds and depressions suggest that the carbonate sands have been reworked by currents. The crab is a *Benthochascon schmitti* individual near its burrow. This species is most abundant on these sands.

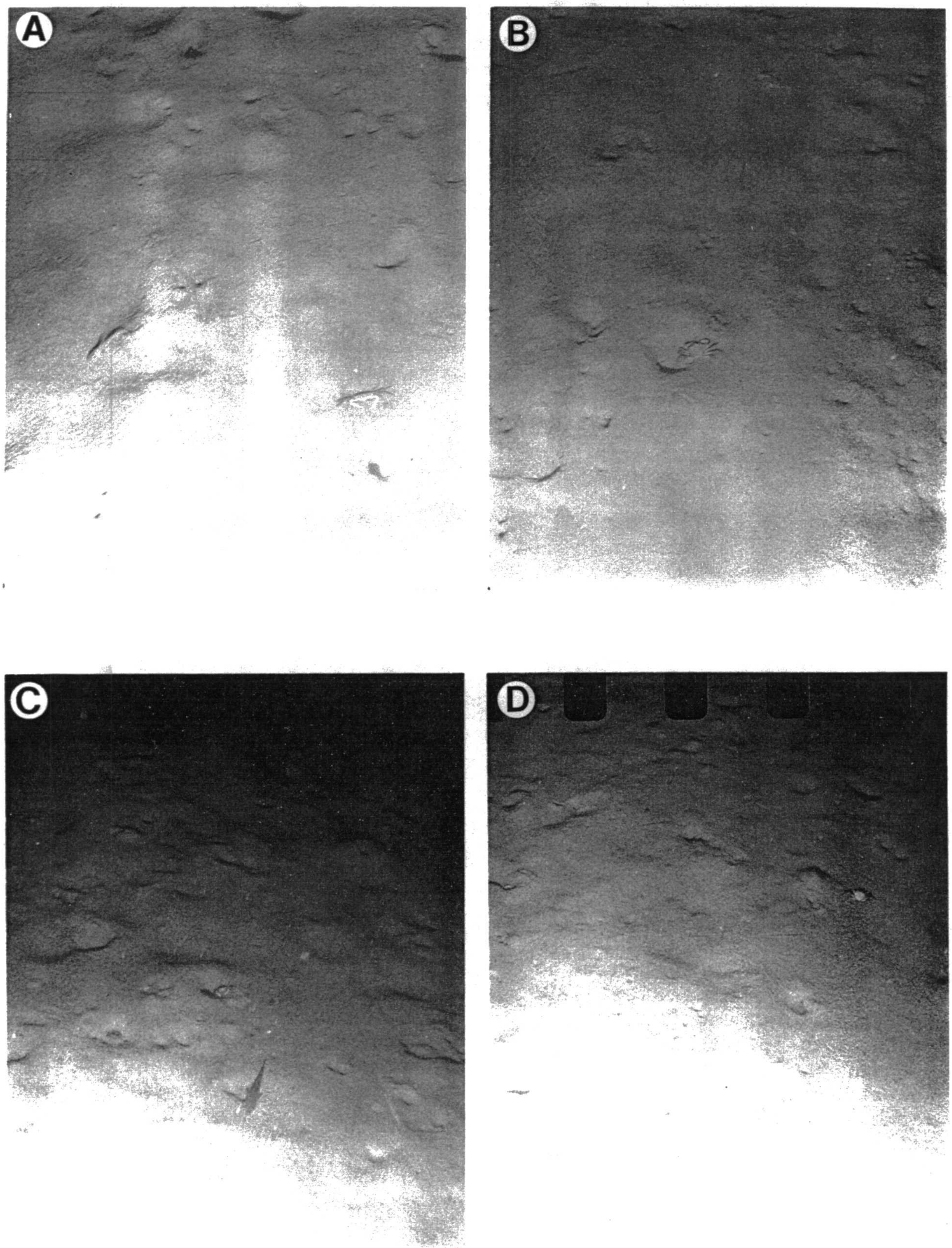
A
B
C
D

PLATE II

A. Shelf/Slope Transition Zone.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 380 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 2 x 2.6 m

Photo taken in the eastern Gulf just 20-m above the trough of DeSoto Canyon at the intersection of the 380-m isobath and 86°53'W longitude. The carbonate sediments here have clearly been reworked by currents. The organisms in the center are suspension-feeding barnacles *Scalpellum portoricanum*.

B. Shelf/Slope Transition Zone.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 380 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 2 x 2.6 m

Photo taken in the eastern Gulf just 20-m above the trough of DeSoto Canyon at the intersection of the 380-m isobath and 86°53'W longitude. The carbonate sediments here are the favored habitat of *Scalpellum portoricanum*.

C. Archibenthal Zone. Horizon A.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 650 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf just above the trough of DeSoto Canyon at the intersection of the 650-m isobath and 86°57'W longitude. The organism that produces the prominent mounds is unknown but may be a bivalve. The structure emerging from the right side of the near mound is believed to be the caudal end of a burrowing holothurian, probably *Molpadia oolitica*, which was taken in large numbers here. The stalked barnacles on the right margin are *Arcoscalpellum regina*.

D. Archibenthal Zone. Horizon A.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 650 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf just above the trough of DeSoto Canyon at the intersection of the 650-m isobath and 86°57'W longitude. This is obviously on a ridge in the bottom of DeSoto Canyon. The organism is a sea pen.

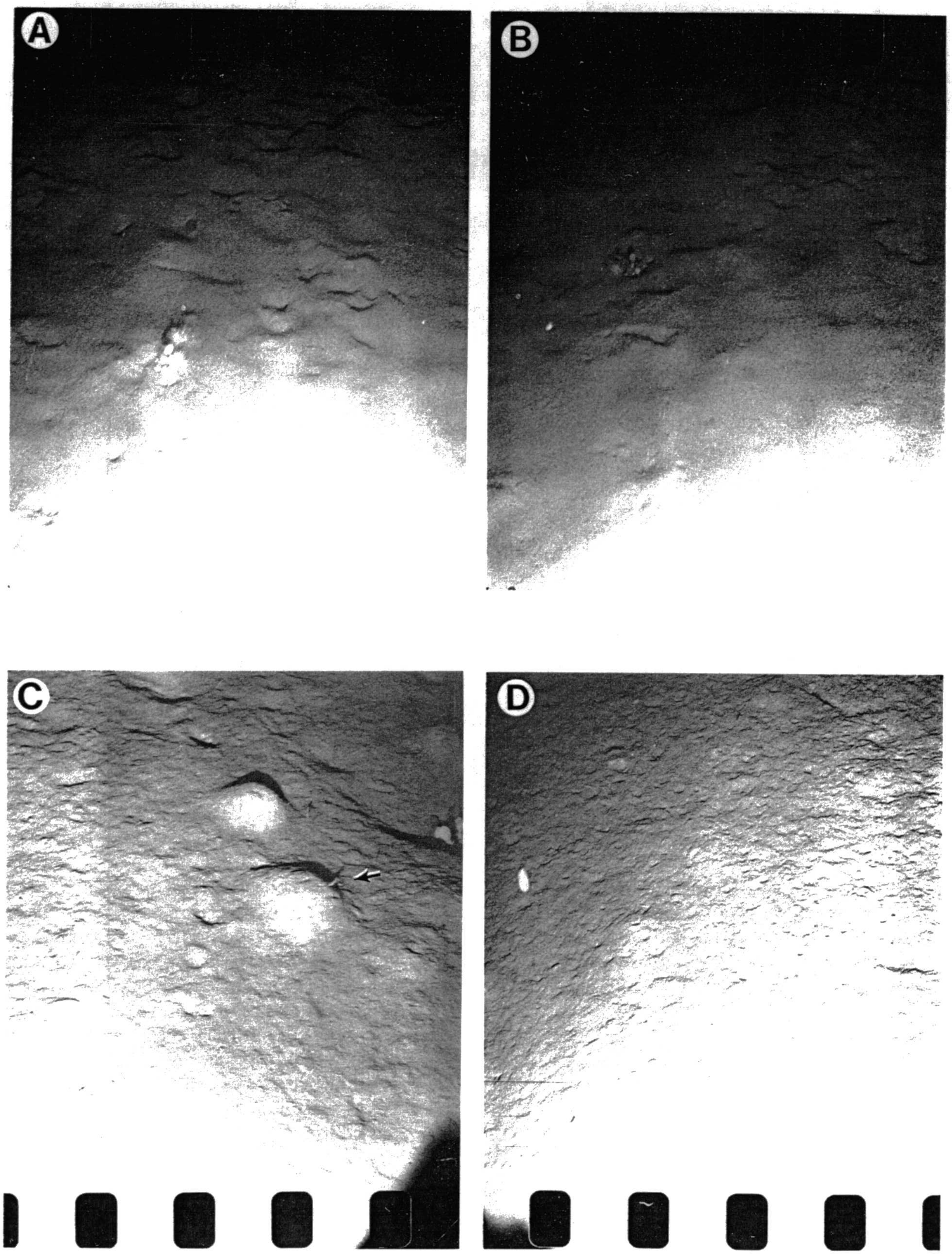
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PLATE III

A. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 550 m
Cruise: 69A11
Preset focus at 1.8 m.
70-mm film. Scale 0.6 x 0.7 m

Photo taken in the western Gulf at the intersection of the 550-m isobath and 95°30.5'W longitude. The sediments here are silty clay. The crustacean is the deep-sea lobster Nephropsis aculeata. The burrow seen in the upper left may belong to this species.

B. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 550 m
Cruise: 69A11
Preset focus at 1.8 m.
70-mm film. Scale 0.6 x 0.7 m

Photo taken in the western Gulf at the intersection of the 550-m isobath and 95°30.5'W longitude. The burrow is probably that of a nephropsid lobster. The stippling of the sediments may be due to the lobster as well.

C. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 550 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.6 x 0.7 m

Photo taken in the western Gulf at the intersection of the 550-m isobath and 95°30.5'W longitude. The burrow system is probably that of an eel.

D. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 550 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.6 x 0.7 m

Photo taken in the western Gulf at the intersection of the 550-m isobath and 95°30.5'W longitude. The brisingid asteroid in the upper right is probably Midgardia xandaros, which is the largest starfish in the world from the standpoint of armspread. The burrow system to the lower left belongs to a species of the caridean Glyphocrangon.

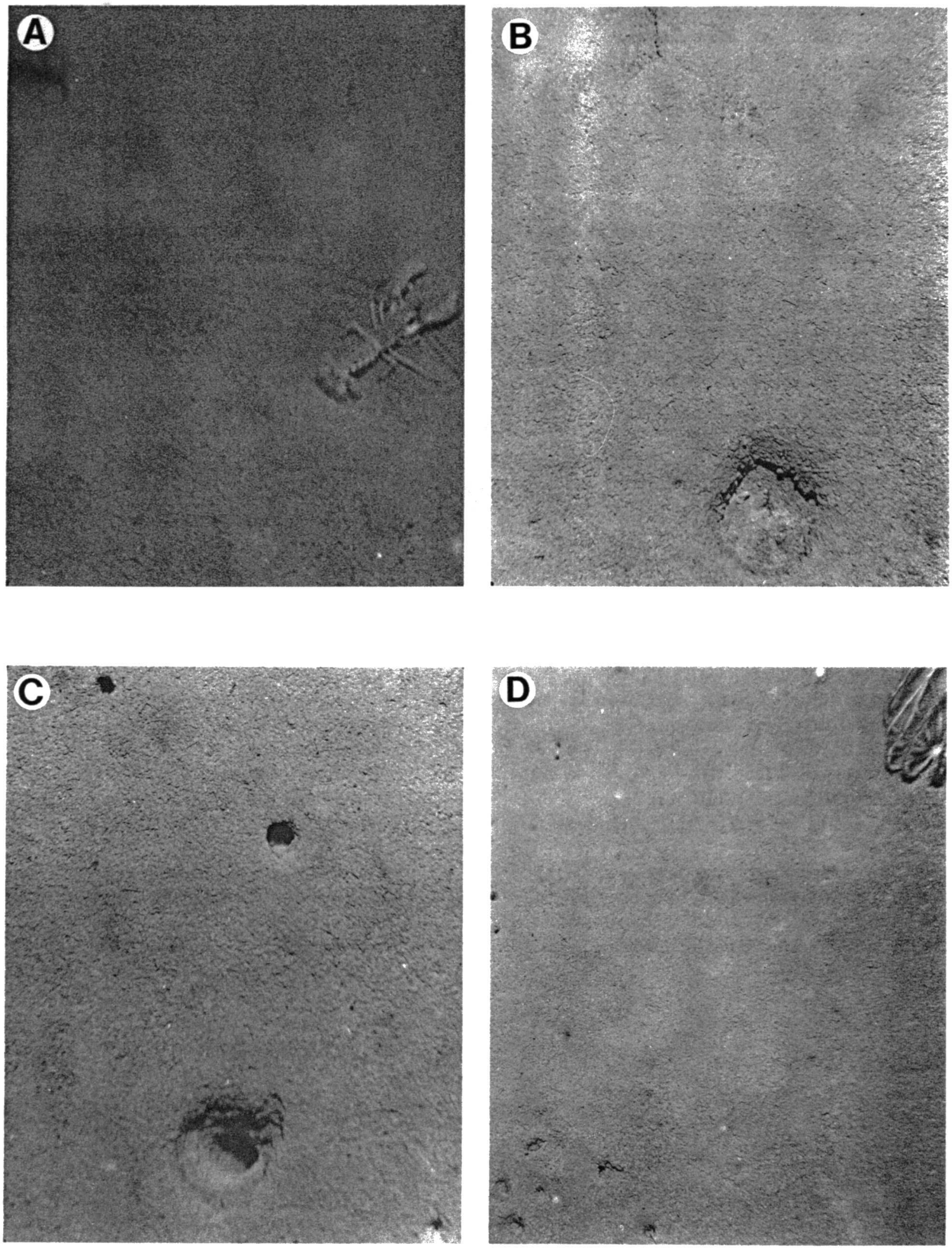
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PLATE IV

A. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 550 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.6 x 0.7 m

Photo taken in the western Gulf at the intersection of the 550-m isobath and 95°30.5'W longitude. The organism on the piece of wood is the brisingid asteroid Midgardia xandaros. It is apparently a suspension-feeder similar in design to an ophiuroid. The central burrow system belongs to Glyphocrangon. The large burrow may belong to the nephropid lobster Nephropsis aculeata.

B. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 550 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.6 x 0.7 m

Photo taken in the western Gulf at the intersection of the 550-m isobath and 95°30.5'W longitude. The ophiuroid echinoderm is probably Ophiernus adspersum.

C. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 550 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.6 x 0.7 m

Photo taken in the western Gulf at the intersection of the 550-m isobath and 95°30.5'W longitude. The demersal fish belongs to the family Gadidae.

D. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 550 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.6 x 0.7 m

Photo taken in the western Gulf at the intersection of the 550-m isobath and 95°30.5'W longitude. The hermit crab is probably Sympagurus pilimanus. The burrows may be a small but characteristic part of a system belonging to Glyphocrangon.

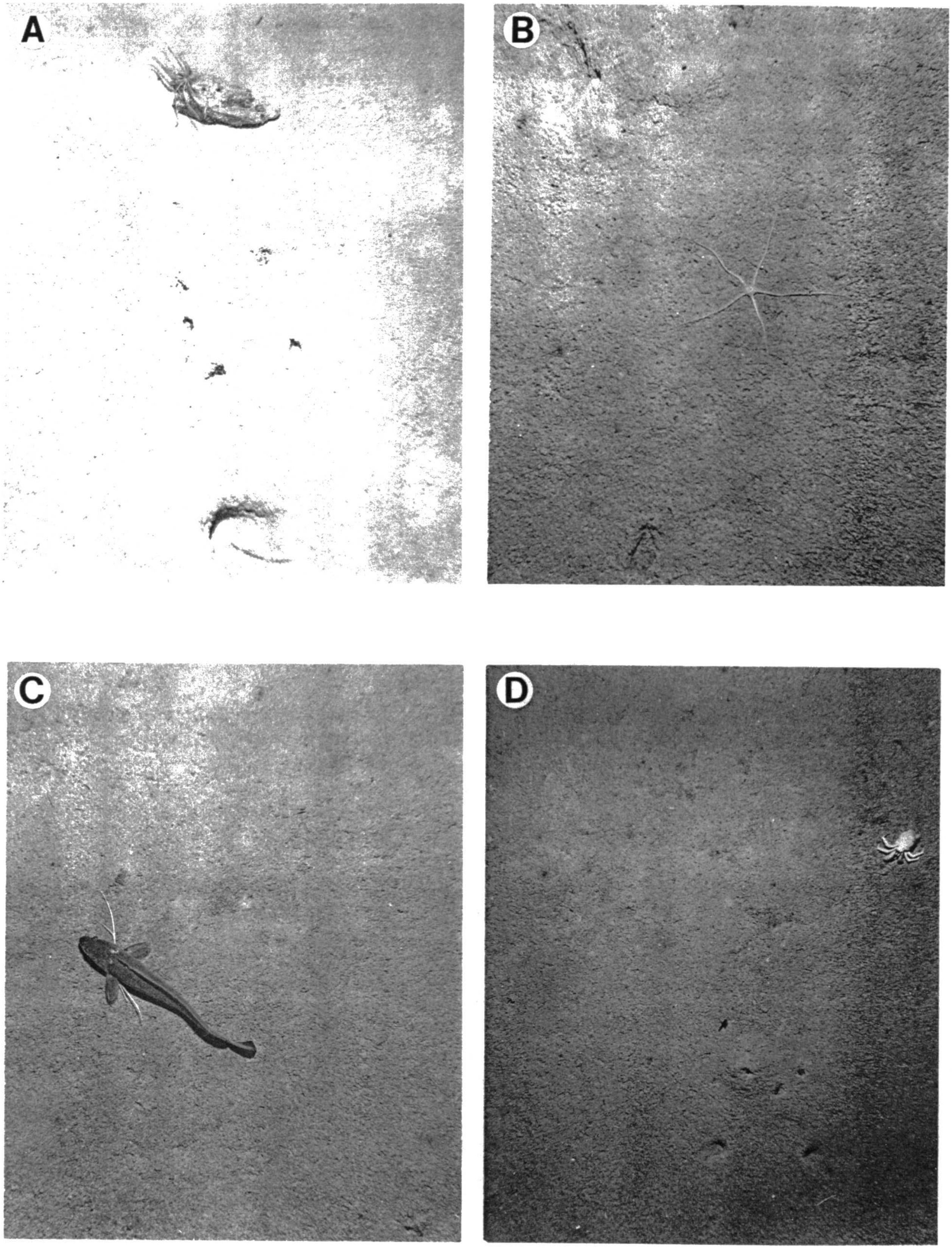
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PLATE V

A. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 570 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.9 x 2.4 m

Photo taken in the western Gulf at the intersection of the 570-m isobath and 92°49.3'W longitude. Unidentified fish and burrow systems.

B. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 570 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.9 x 2.4 m

Photo taken in the western Gulf at the intersection of the 570-m isobath and 92°49.3'W longitude. Fish can be seen feeding making a turbid cloud.

C. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 570 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.9 x 2.4 m

Photo taken in the western Gulf at the intersection of the 570-m isobath and 92°49.3'W longitude. Numerous sea pens can be seen in the left half of the photo.

D. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 570 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.9 x 2.4 m

Photo taken in the western Gulf at the intersection of the 570-m isobath and 92°49.3'W longitude. Note burrowing anemone along left border. Burrows here and photos above probably belong to sea pens, burrowing anemones, caridean shrimps, and nephropid lobsters.

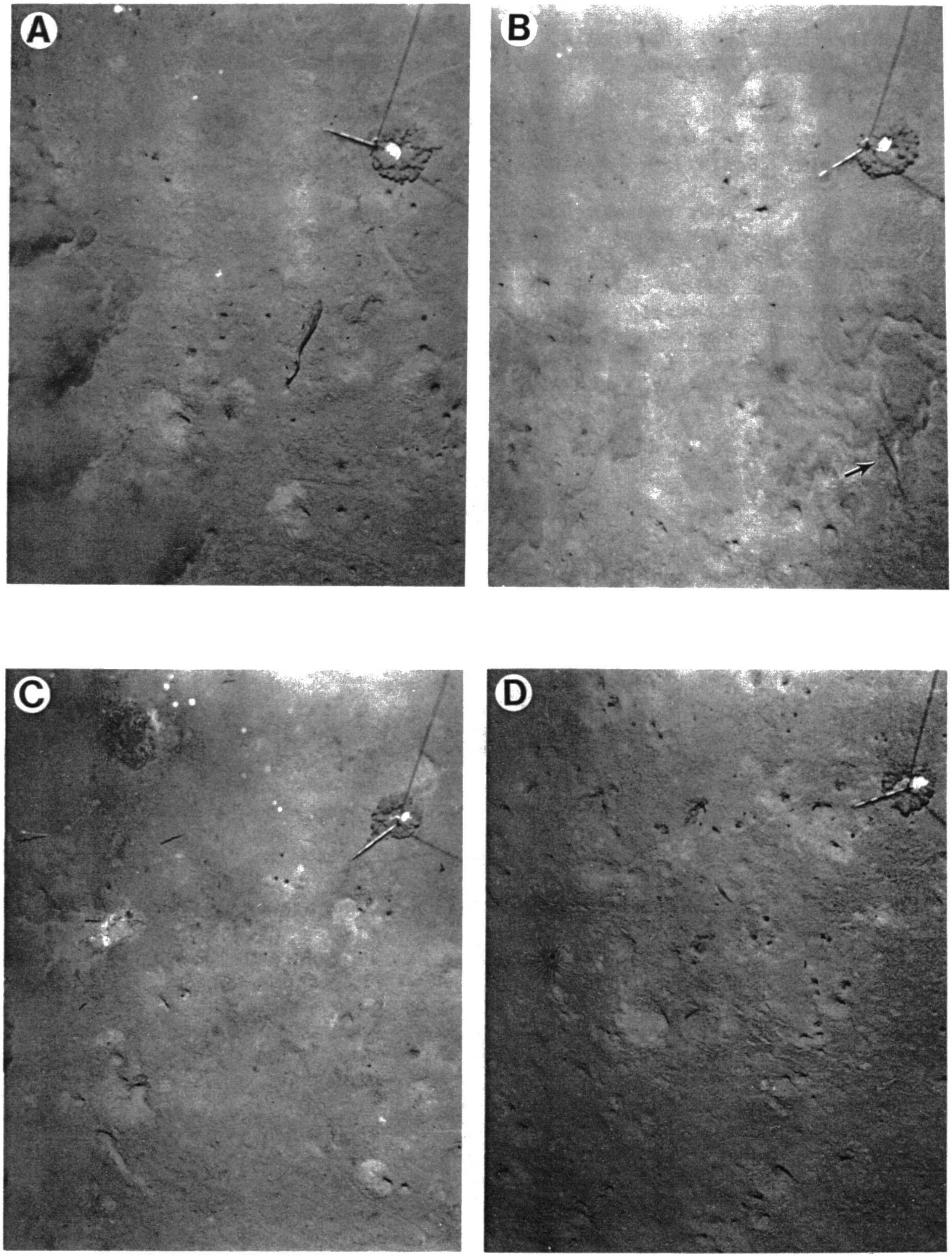
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PLATE VI

A. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 570 m
Cruise: 71A7
Preset focus at 3.0 m.
70-mm film. Scale 1.9 x 2.4 m

Photo taken in the western Gulf at the intersection of the 570-m isobath and 96°15'W longitude. The crustacean below the weight is probably the penaeid shrimp, *Hymenopenaeus robustus*. Part of a burrow system of the caridean shrimp, *Glyphocrangon*, is seen to the right.

B. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 570 m
Cruise: 71A7
Preset focus at 3.0 m.
70-mm film. Scale 1.9 x 2.4 m

Photo taken in the western Gulf at the intersection of the 570-m isobath and 96°15'W longitude. The echinoid at right is *Phormosoma placenta* next to what appears to be a dead fish.

C. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 570 m
Cruise: 71A7
Preset focus at 3.0 m.
70-mm film. Scale 1.9 x 2.4 m

Photo taken in the western Gulf at the intersection of the 570-m isobath and 96°15'W longitude. The fish at left appears to be a species of *Bathygadus*. The small one along the lower right margin is *Peristedion greyae*. The light blotches above this fish may be its feeding marks.

D. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 570 m
Cruise: 71A7
Preset focus at 3.0 m.
70-mm film. Scale 1.9 x 2.4 m

Photo taken in the western Gulf at the intersection of the 570-m isobath and 96°15'W longitude. An unusual concentration of burrows, including a very large one which is believed to belong to the giant isopod *Bathynomus giganteus*.

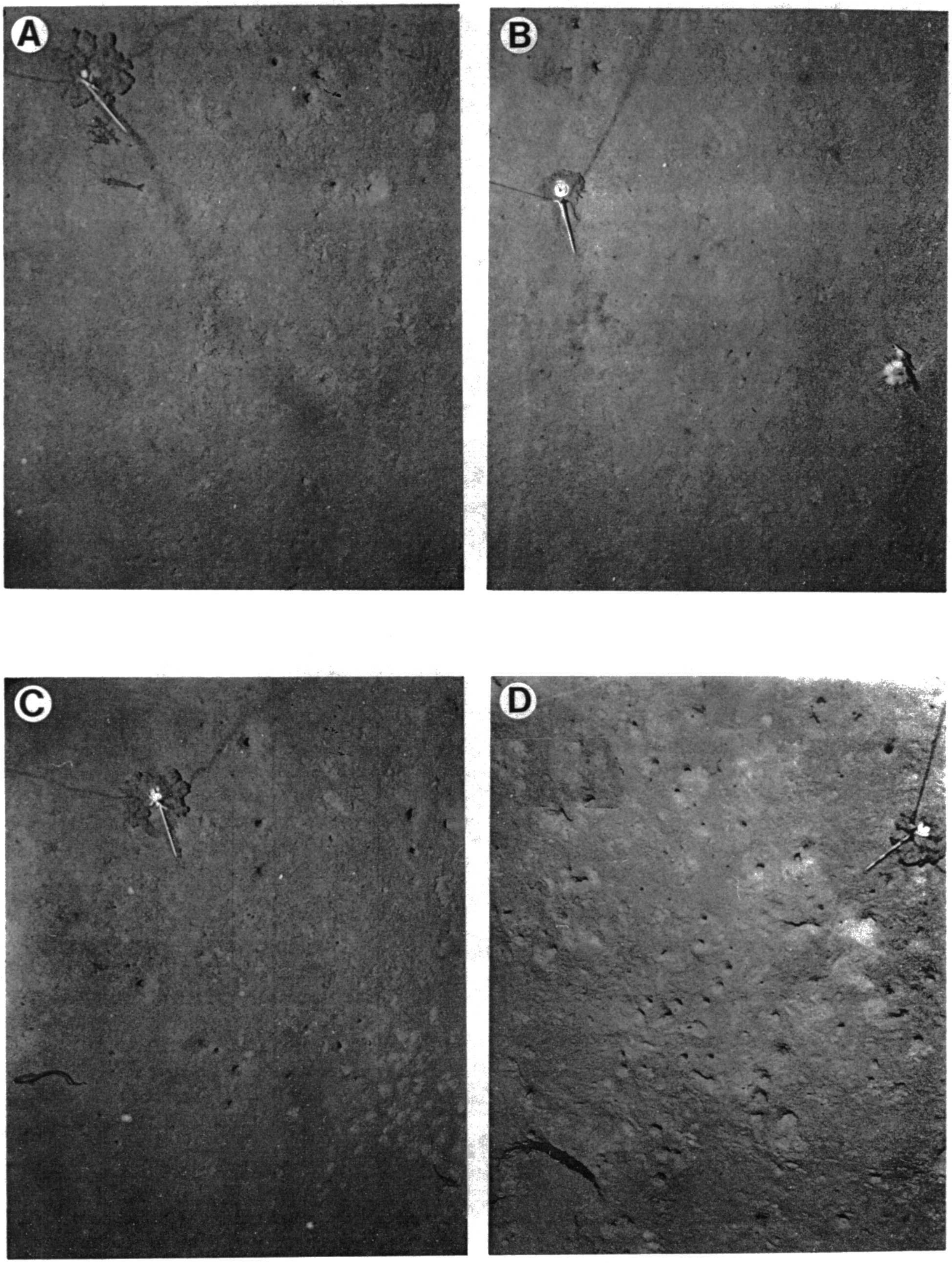

A
B
C
D

PLATE VII

A. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
West edge - Mississippi Trough.
Isobath: 580 m
Cruise: 66A9
Preset focus at 1.5 m.
35-mm film. Scale 1.6 x 1.9 m

Photo taken in the western Gulf at the intersection of the 580-m isobath and 90°20'W longitude. This places the station right on the western rim of the Mississippi Trough. The bottom is very irregular as a result of animal activity. Note burrowing anemone above right. The loaf-shaped masses may be deteriorating fecal deposits of holothurians.

B. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
West edge - Mississippi Trough.
Isobath: 580 m
Cruise: 66A9
Preset focus at 1.5 m.
35-mm film. Scale 1.6 x 1.9 m

Photo taken in the western Gulf at the intersection of the 580-m isobath and 90°20'W longitude. As in all pictures in this group there are signs of intense animal activity. The asteroid and ophiuroid seen here are unidentified.

C. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
West edge - Mississippi Trough.
Isobath: 580 m
Cruise: 66A9
Preset focus at 1.5 m.
35-mm film. Scale 1.6 x 1.9 m

Photo taken in the western Gulf at the intersection of the 580-m isobath and 90°20'W longitude. Another view of large and small burrows.

D. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
West edge - Mississippi Trough.
Isobath: 580 m
Cruise: 66A9
Preset focus at 1.5 m.
35-mm film. Scale 1.6 x 1.9 m

Photo taken in the western Gulf at the intersection of the 580-m isobath and 90°20'W longitude. The smaller burrows here belong to Glyphocrangon, a caridean shrimp. The slash marks in the sediments to the lower right were made by this species as it bounds over the sediments.

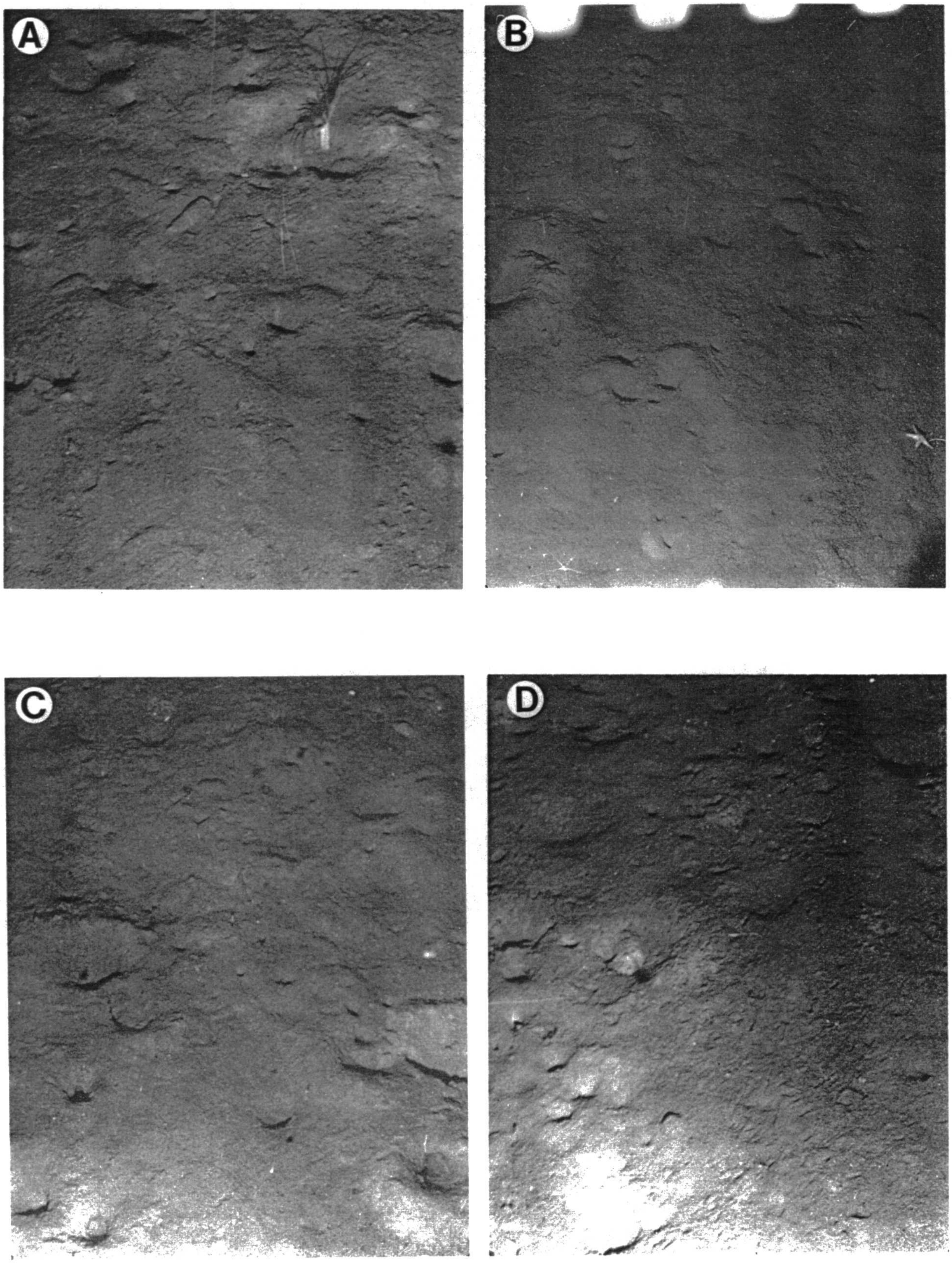

A
B
C
D

PLATE VIII

A. Archibenthal Zone. Horizon A.
Eastern Gulf of Mexico.
Isobath: 600 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.5 x 2.4 m

Photo taken in the eastern Gulf about midway between DeSoto Canyon's trough and the Mississippi Trough at the intersection of the 600-m isobath and 88°43'W longitude. Eel in the background probably is in the family Congridae. Galatheid anomurans at the arrows are probably *Munida valida*. The asteroid depression near bottom margin at left was probably made by *Nymphaster*. All three photos here show a very disturbed bottom, suggesting that it is a very productive benthic environment.

B. Archibenthal Zone. Horizon A.
Eastern Gulf of Mexico.
Isobath: 600 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.2 x 1.5 m

Photo taken in the eastern Gulf about midway between DeSoto Canyon's trough and the Mississippi Trough at the intersection of the 600-m isobath and 88°43'W longitude. Note the eel along the upper right margin. A galatheid, *Munida valida*, is seen at the arrow in the lower left.

C. Archibenthal Zone. Horizon A.
Eastern Gulf of Mexico.
Isobath: 600 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.2 x 1.5 m

Photo taken in the eastern Gulf about midway between DeSoto Canyon's trough and the Mississippi Trough at the intersection of the 600-m isobath and 88°43'W longitude. The asteroid here is probably *Nymphaster arenatus*.

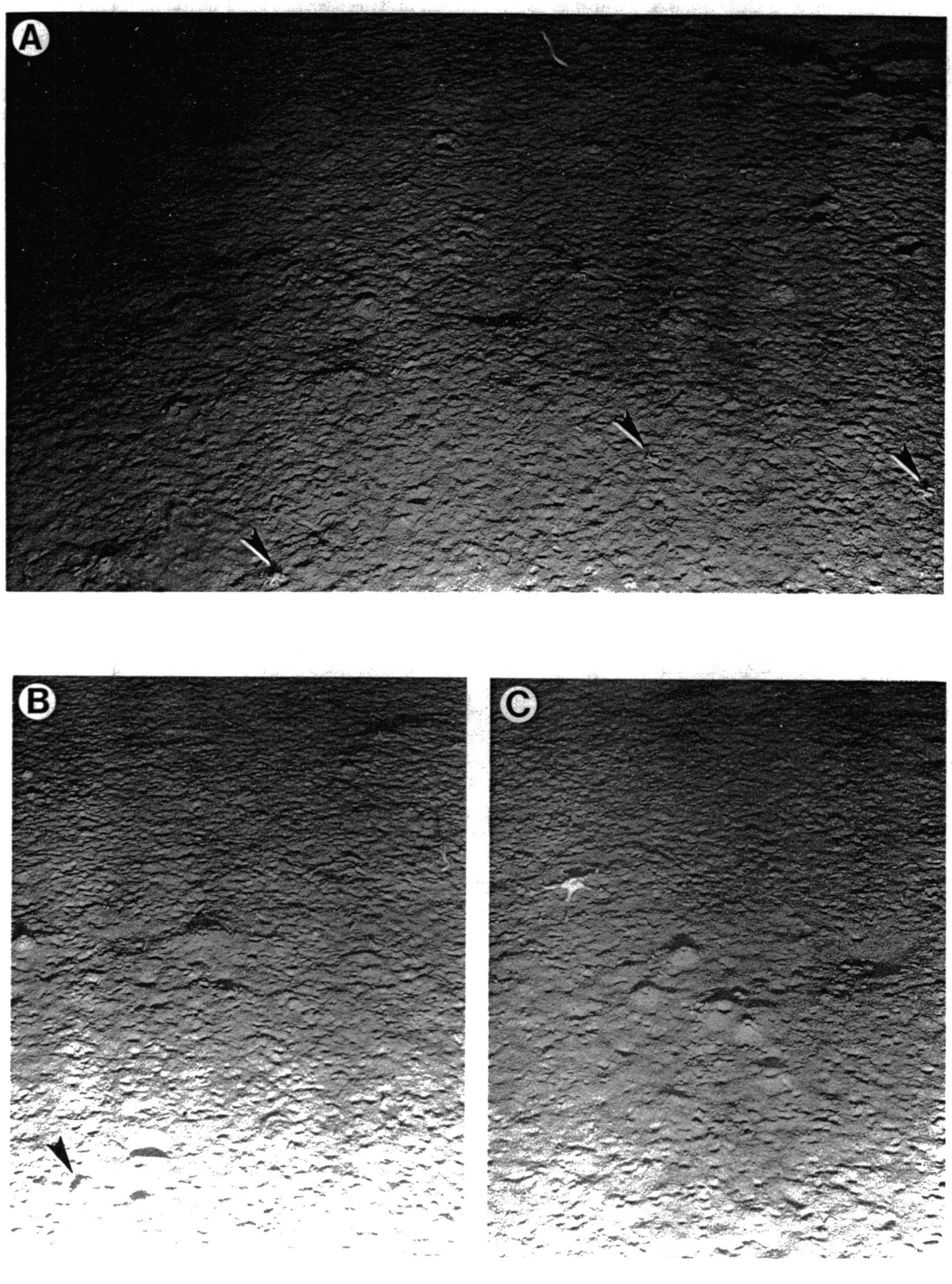

A
B
C

PLATE IX

A. Archibenthal Zone. Horizon A.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 650 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf on the west wall of the trough of DeSoto Canyon at the intersection of the 650-m isobath and 86°57'W longitude. The fish is a macrourid. The white crustacean near the center is probably *Callianassa marginata*. The large burrow and mound are unidentified.

B. Archibenthal Zone. Horizon A.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 650 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf on the west wall of the trough of DeSoto Canyon at the intersection of the 650-m isobath and 86°57'W longitude. Location just to the right of A showing the same *Callianassa* and a complete view of the mounds.

C. Archibenthal Zone. Horizon A.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 650 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf on the west wall of the trough of DeSoto Canyon at the intersection of the 650-m isobath and 86°57'W longitude. Fish is unidentified. The small structures rising vertically from the sea bed may be the caudal extension of the burrowing holothurian *Molpadia cubana*.

D. Archibenthal Zone. Horizon A.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 650 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf on the west wall of the trough of DeSoto Canyon at the intersection of the 650-m isobath and 86°57'W longitude. A large macrourid searching the bottom.

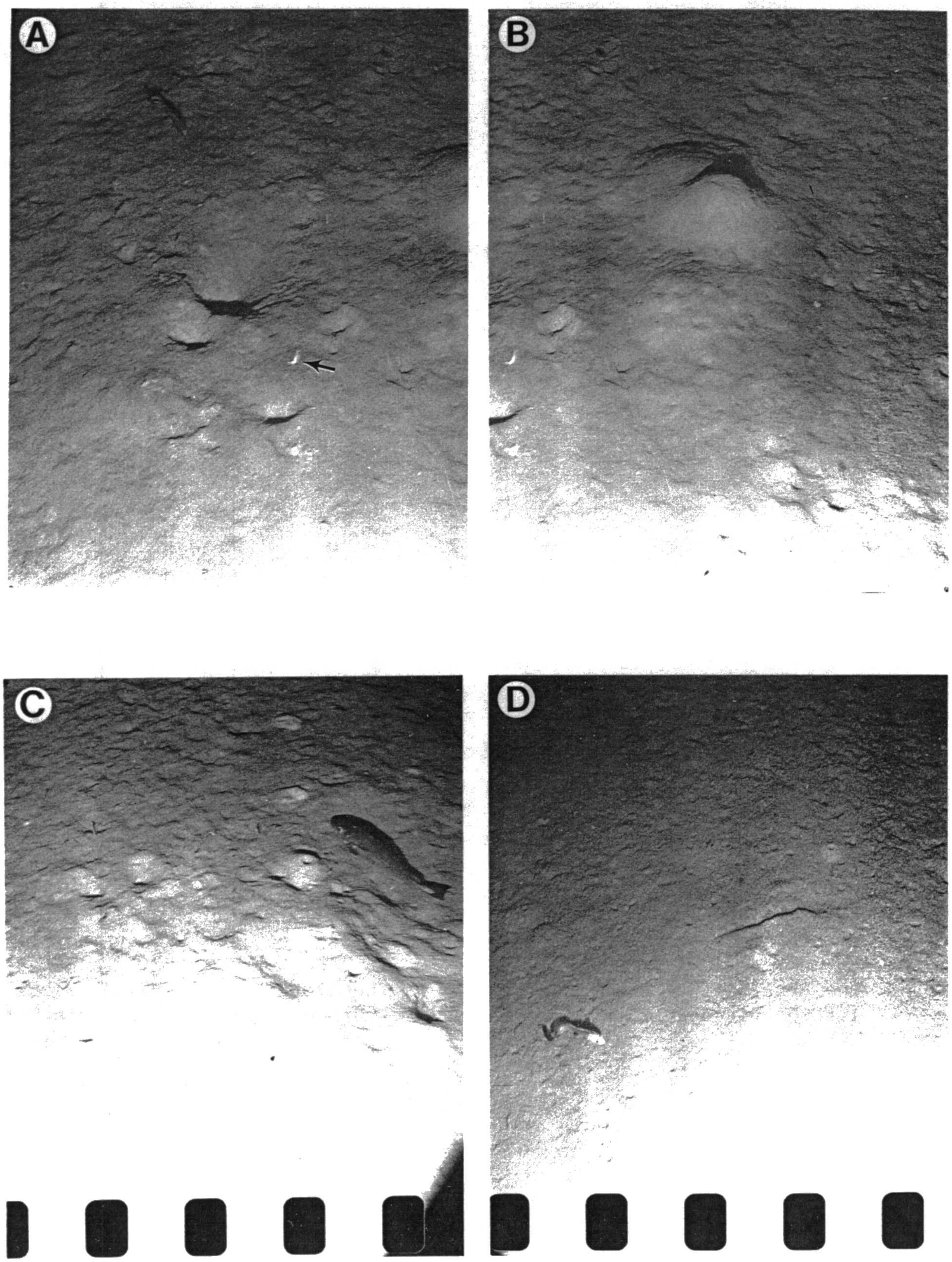

A
B
C
D

PLATE X

A. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 715 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.5 x 0.7 m

Photo taken in the western Gulf at the intersection of the 715-m isobath and 96°10'W longitude. The sediments here are silty clays. Interesting photo showing what appears to be a balloon.

B. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 715 m
Cruise: 68A3
Preset focus at 3.0 m.
35-mm film. Scale 1.0 x 1.2 m

Photo taken in the western Gulf at the intersection of the 715-m isobath and 95°05'W longitude. Top view of a burrowing anemone. Very little evidence of any bioturbation.

C. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
SE of Corpus Christi, Texas
Isobath: 700 m
Cruise: 68A3
Preset focus at 0.9 m.
35-mm film. Scale 0.6 x 0.7 m

Photo taken in the western Gulf at the intersection of the 715-m isobath and 95°06'W longitude. The black object may be a holothurian. If so, it is unidentified.

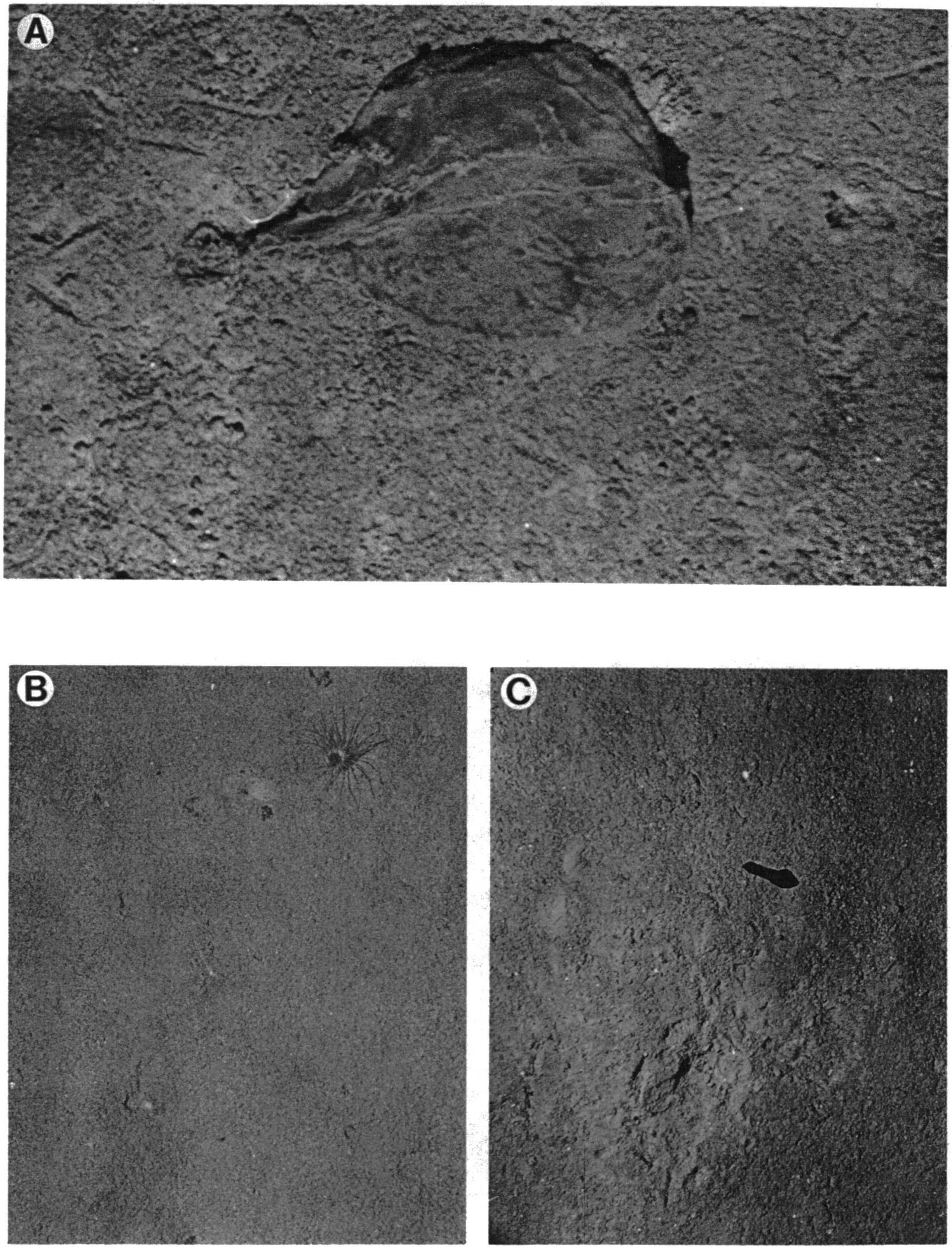

A
B
C

PLATE XI

A. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 715 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.5 x 0.7 m

Photo taken in the western Gulf at the intersection of the 715-m isobath and 96°10'W longitude. The shrimp is the penaeid *Plesiopenaeus edwardsianus*. The sediments here are soft and show very little evidence of bioturbation.

B. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 715 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.5 x 0.7 m

Photo taken in the western Gulf at the intersection of the 715-m isobath and 96°10'W longitude. The ophiuroid is *Bathypectinura heros*. The picture was taken in March 1968. The ophiuroid appears to be gravid. Note small sponges to the right of the ophiuroid's disk.

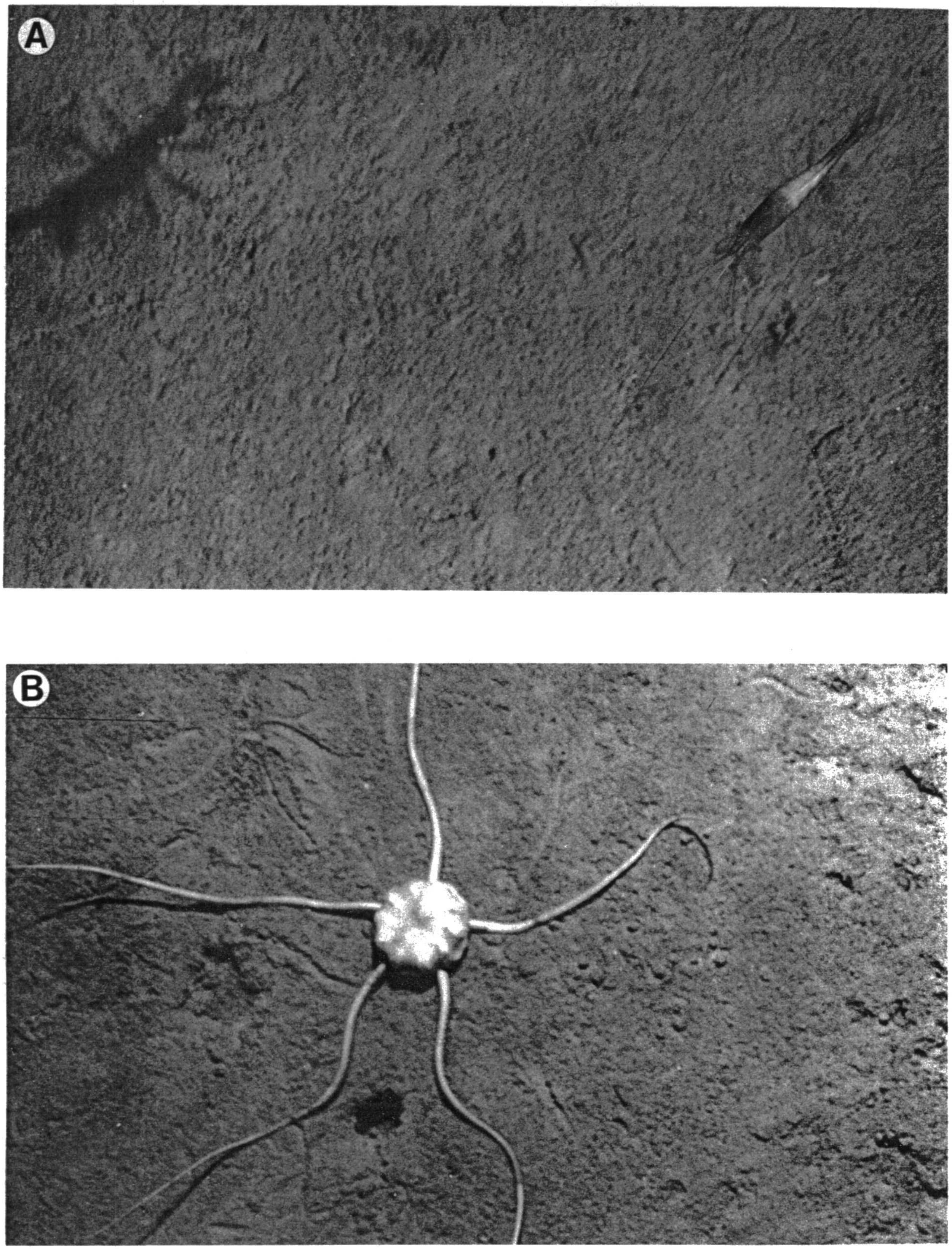

A
B

PLATE XII

A. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 715 m
Cruise: 68A3
Preset focus at 3.0 m.
35-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf south southeast of Galveston, Texas at the intersection of the 715-m isobath and 95°05'W longitude. The echinoderm in the upper left is the brisingid asteroid *Midgardia xandaros*. Little evidence of bioturbation in these photos.

B. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 715 m
Cruise: 68A3
Preset focus at 3.0 m.
35-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf south southeast of Galveston, Texas at the intersection of the 715-m isobath and 95°05'W longitude. The large holothurian near the camera weight (weight is 9 cm in diameter) is *Bathyplotes natans*.

C. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 715 m
Cruise: 68A3
Preset focus at 3.0 m.
35-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf south southeast of Galveston, Texas at the intersection of the 715-m isobath and 95°05'W longitude. The ophiuroid is *Bathypectinura heros*.

D. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 715 m
Cruise: 68A3
Preset focus at 3.0 m.
35-mm film. Scale 1.2 x 1.5 m

Photo taken in the western Gulf south southeast of Galveston, Texas at the intersection of the 715-m isobath and 95°05'W longitude. *Bathypectinura* locomoting.

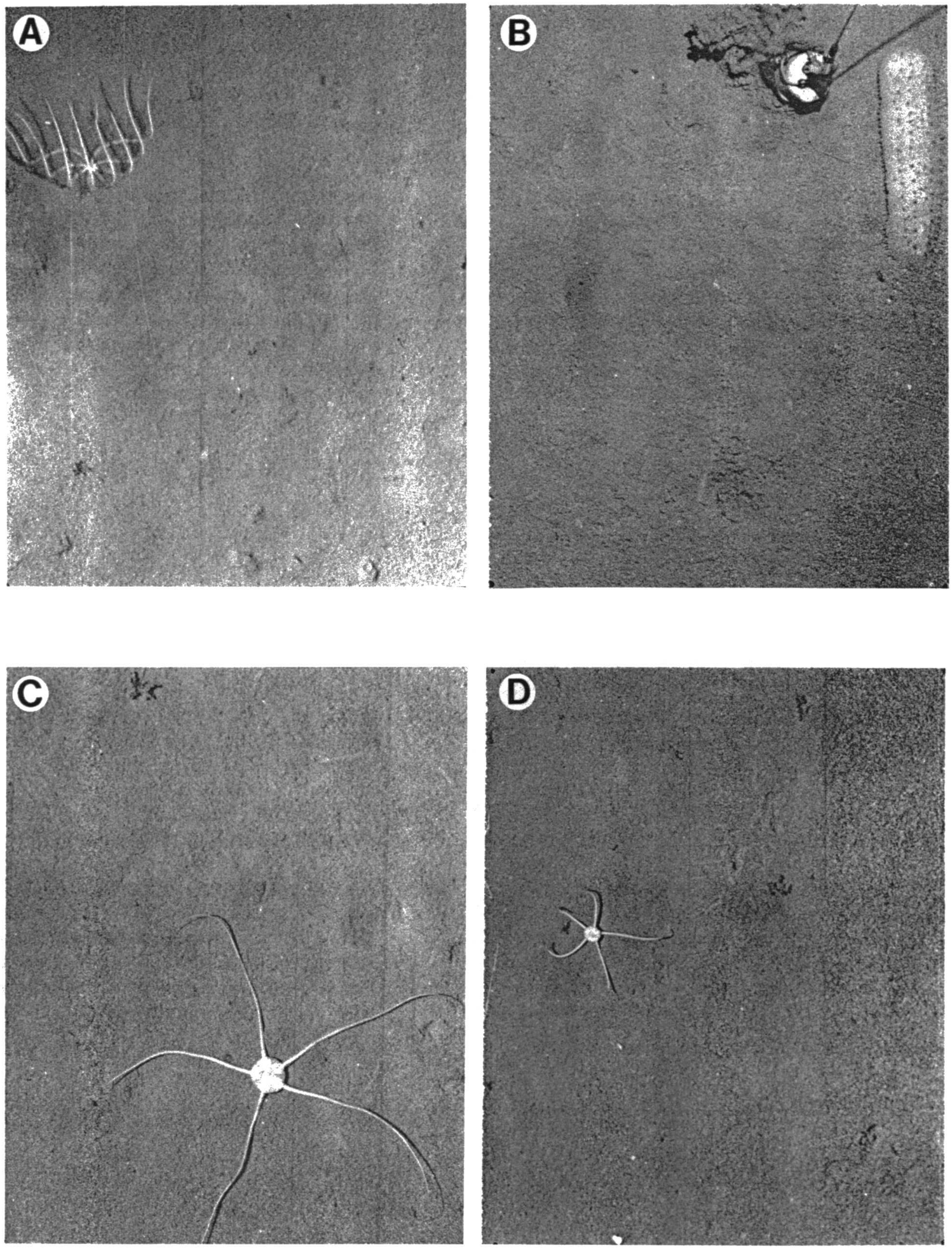

A
B
C
D

PLATE XIII

A. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 715 m
Cruise: 68A3
Preset focus at 3.0 m.
35-mm film. Scale 1.2 x 1.5 m

Photo taken in the western Gulf south southeast of Galveston, Texas at the intersection of the 715-m isobath and 95°05'W longitude. The animal near the top margin and in "B" are an unidentified burrowing anemone. Not much bioturbation nor evidence of currents. Bottom very even and level.

B. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 715 m
Cruise: 68A3
Preset focus at 3.0 m.
35-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf south southeast of Galveston, Texas at the intersection of the 715-m isobath and 95°05'W longitude. The animal in A and B are an unidentified burrowing anemone. Not much bioturbation nor evidence of currents. Bottom very even and level.

C. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 715 m
Cruise: 68A3
Preset focus at 3.0 m.
35-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf south southeast of Galveston, Texas at the intersection of the 715-m isobath and 95°05'W longitude. Organism in the lower left is the echinoid <u>Phormosoma placenta</u>.

D. Archibenthal Zone. Horizon A.
Western Gulf of Mexico.
Isobath: 715 m
Cruise: 68A3
Preset focus at 3.0 m.
35-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf south southeast of Galveston, Texas at the intersection of the 715-m isobath and 95°05'W longitude. Organism in the lower left is the asteroid <u>Doraster constellatus</u>.

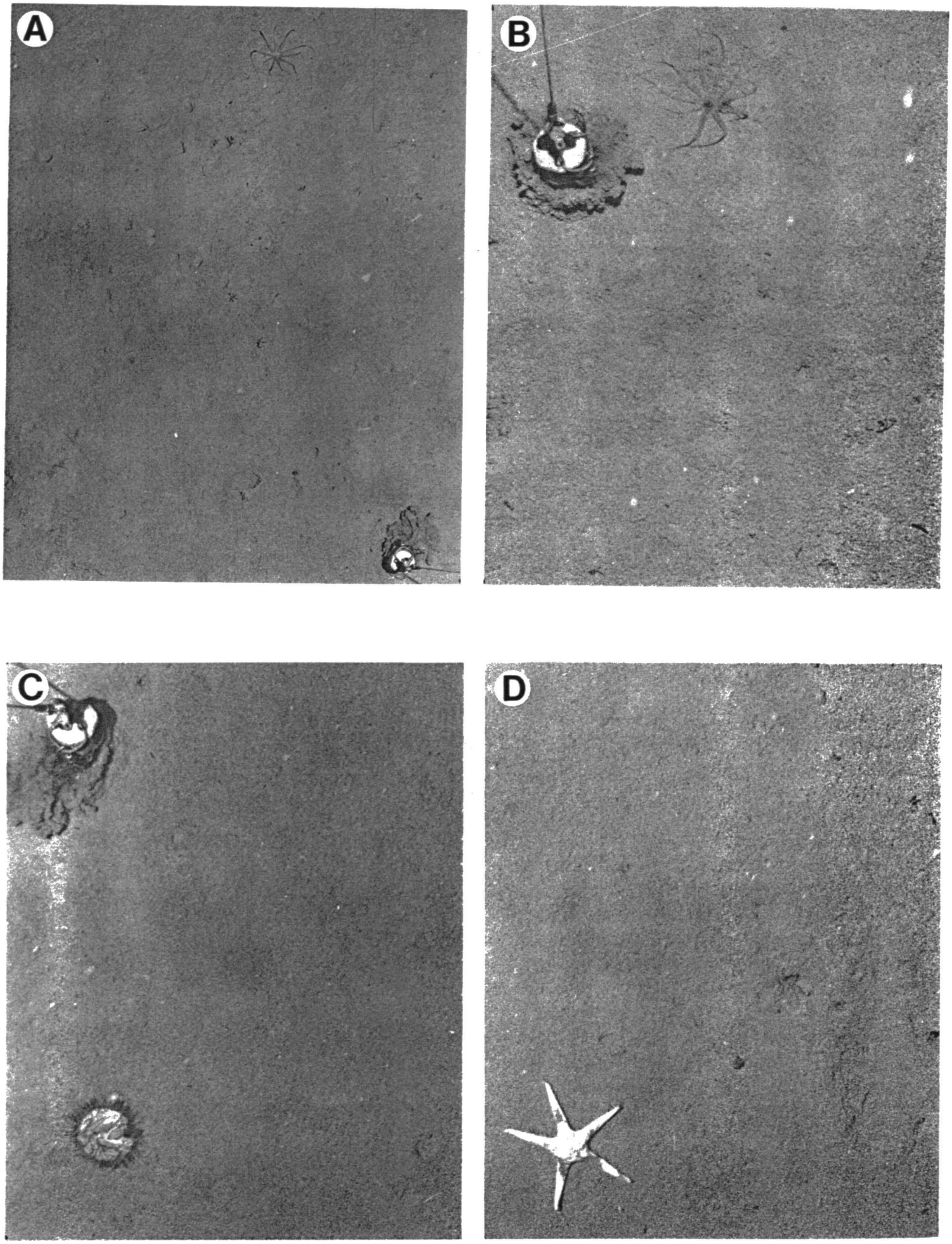

A
B
C
D

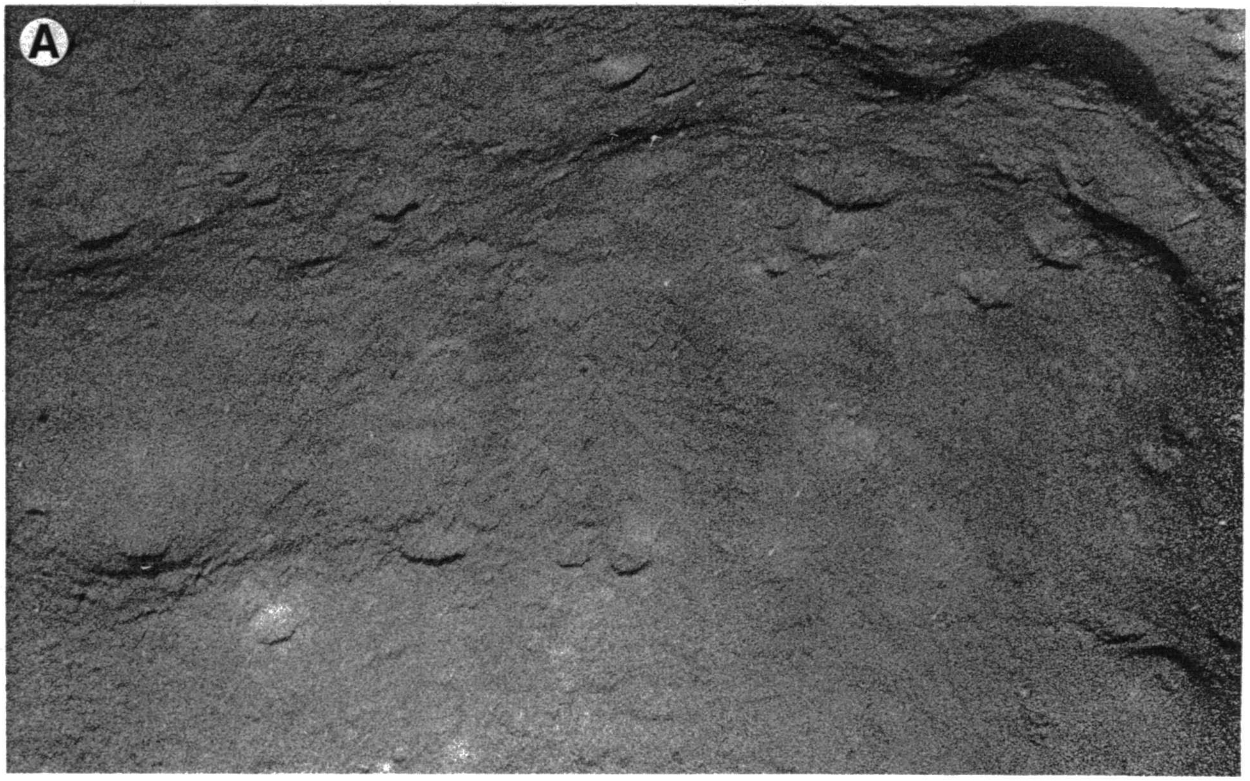
PLATE XIV

A. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 770 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 0.9 x 1.4 m

Photo taken in the eastern Gulf in the trough of DeSoto Canyon proper at the intersection of the 770-m isobath and 87°04'W longitude. The bottom is very irregular in part due to animal activity. In this photo we see the burrows of a "colony" of Glyphocrangon alispina.

B. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 770 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 0.9 x 1.4 m

Photo taken in the eastern Gulf in the trough of DeSoto Canyon proper at the intersection of the 770-m isobath and 87°04'W longitude. The hole and double mound system are as yet unidentified. This system is seen elsewhere in the world ocean.


A


B

PLATE XV

A. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 770 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 0.7 x 0.9 m

Photo taken in the eastern Gulf on the east wall of the trough of DeSoto Canyon, which extends between the depths of 450 and 950 m at the intersection of the 770-m isobath and 87°04'W longitude. The sediments here are silty carbonate sands that appear to be smoothed by bottom currents. Bioturbation is moderate. The fish is probably Hymenocephalus.

B. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 770 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 0.7 x 0.9 m

Photo taken in the eastern Gulf on the east wall of the trough of DeSoto Canyon, which extends between the depths of 450 and 950 m at the intersection of the 770-m isobath and 87°04'W longitude. The sediments here are silty carbonate sands that appear to be smoothed by bottom currents. Bioturbation is moderate. The fish is probably a macrourid but otherwise not identified.

C. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 770 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 0.7 x 0.9 m

Photo taken in the eastern Gulf on the east wall of the trough of DeSoto Canyon, which extends between the depths of 450 and 950 m at the intersection of the 770-m isobath and 87°04'W longitude. The sediments here are silty carbonate sands that appear to be smoothed by bottom currents. Bioturbation is moderate. The fish is an eel belonging to the genus Synaphobranchus.

D. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 770 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 0.7 x 0.9 m

Photo taken in the eastern Gulf on the east wall of the trough of DeSoto Canyon, which extends between the depths of 450 and 950 m at the intersection of the 770-m isobath and 87°04'W longitude. The sediments here are silty carbonate sands that appear to be smoothed by bottom currents. Bioturbation is moderate. The fish is identified as Yarrella blackfordi.

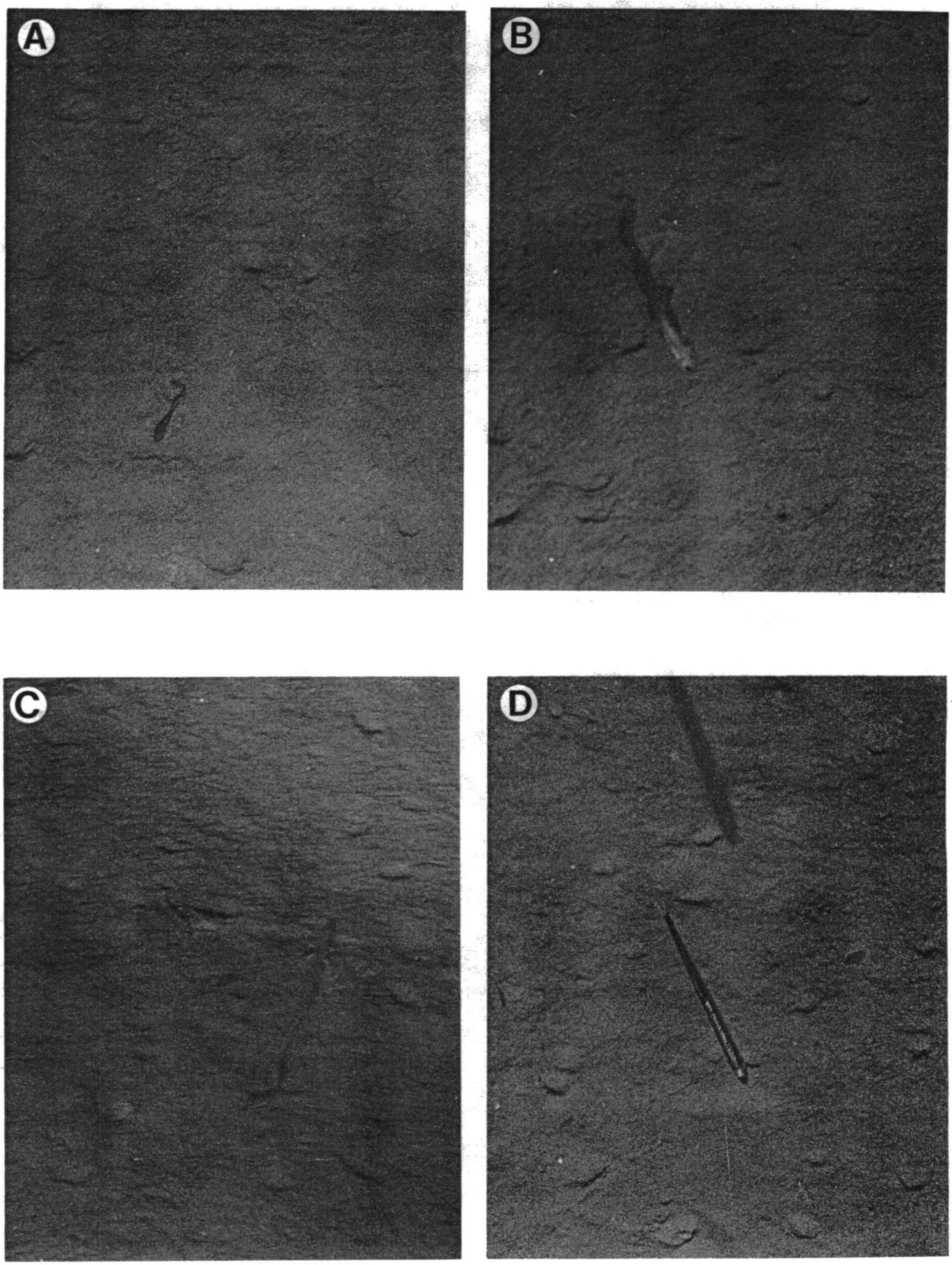

A
B
C
D

PLATE XVI

A. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 800 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.0 x 1.2 m

Photo taken in the eastern Gulf in the trough of DeSoto Canyon at the intersection of the 800-m isobath and 86°59'W longitude. Conglomerate material has apparently been transported down the canyon from the shelf break. Note the absence of sediment cloud around the camera weight (weight is 9 cm diameter). The area was probably swept clean of fine sediment by currents. The small white object above the weight is the swimming bivalve <u>Propeamussium</u> sp. The cause of depressions in the upper half of photo is unknown.

B. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 800 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.1 x 1.3 m

Photo taken on the lower part of the wall of the trough of DeSoto Canyon at the intersection of the 800-m isobath and 86°59'W longitude. Considerable evidence of unstable sediment bed with down canyon slippage.

C. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 825 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.0 x 1.2 m

Photo taken in the eastern Gulf on the west wall of the trough of DeSoto Canyon at the intersection of the 825-m isobath and 86°59'W longitude. Sediments are silty clays. Triangular depressions may be produced by fish feeding on the infauna. Very little evidence of sediment creep here.

D. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 825 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.0 x 1.2 m

Photo taken in the eastern Gulf on the west wall of the trough of DeSoto Canyon at the intersection of the 825-m isobath and 86°59'W longitude. Sediments are silty clays. Ophiuroid is probably <u>Bathypectinura</u> <u>heros</u>. Many pogonophorans were taken in this area.

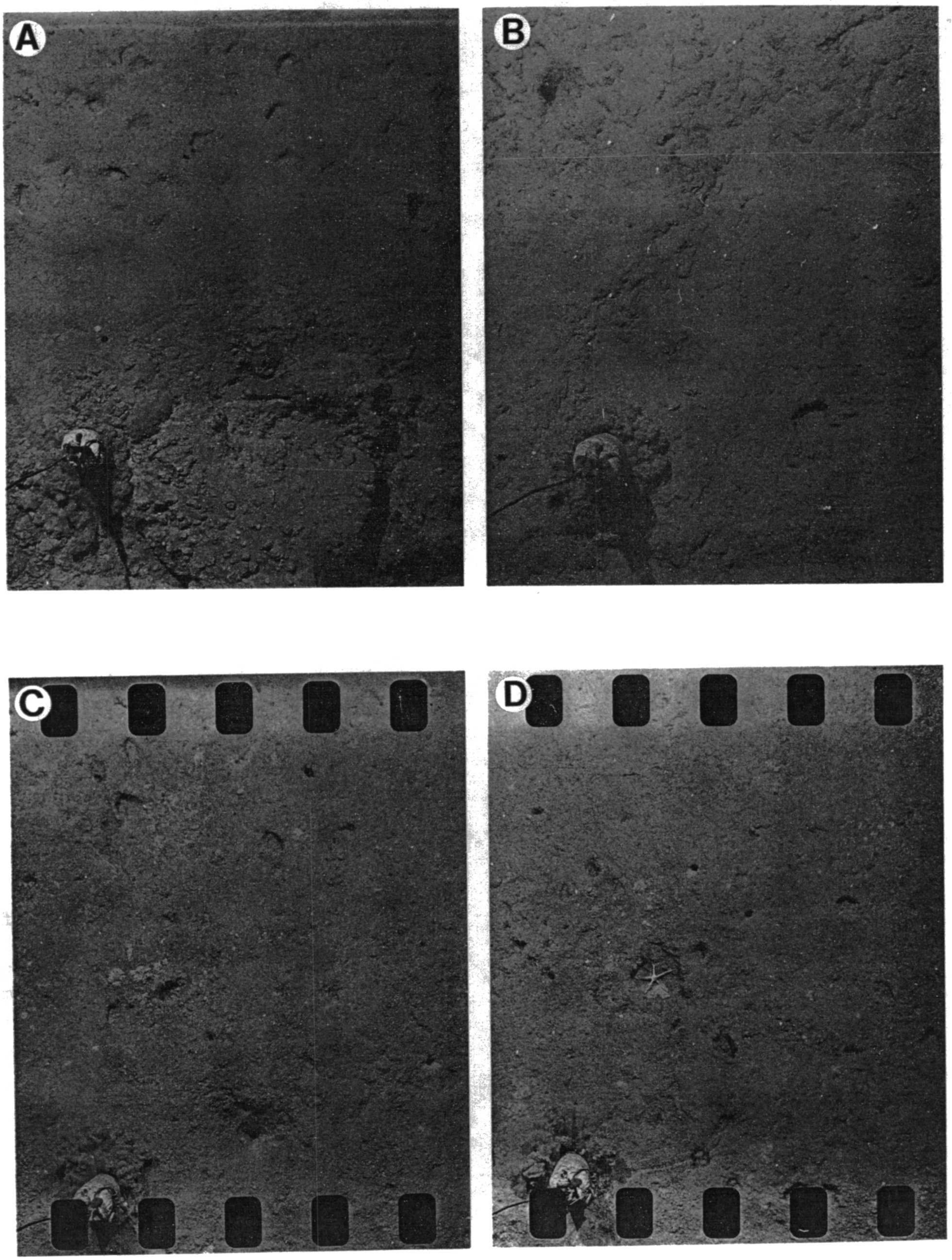

A
B
C
D

PLATE XVII

A. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 850 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf near the bottom of the east wall in the trough of DeSoto Canyon at the intersection of the 850-m isobath and 87°02'W longitude. The sediments are carbonate sands. There is intense bioturbation. Loaf-shaped object apparently is not a holothurian, although Mesothuria lactea is common here.

B. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 850 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf near the bottom of the east wall in the trough of DeSoto Canyon at the intersection of the 850-m isobath and 87°02'W longitude. The sediments are carbonate sands. There is active bioturbation. The eel is not identifiable but appears to be the same as in "D".

C. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 850 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf near the bottom of the east wall in the trough of DeSoto Canyon at the intersection of the 850-m isobath and 87°02'W longitude. The sediments are carbonate sands. There is considerable biological activity. The fish is not identifiable.

D. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 850 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf near the bottom of the east wall in the trough of DeSoto Canyon at the intersection of the 850-m isobath and 87°02'W longitude. The sediments are carbonate sands. There is considerable biological activity. The eel is similar to the one in "B".

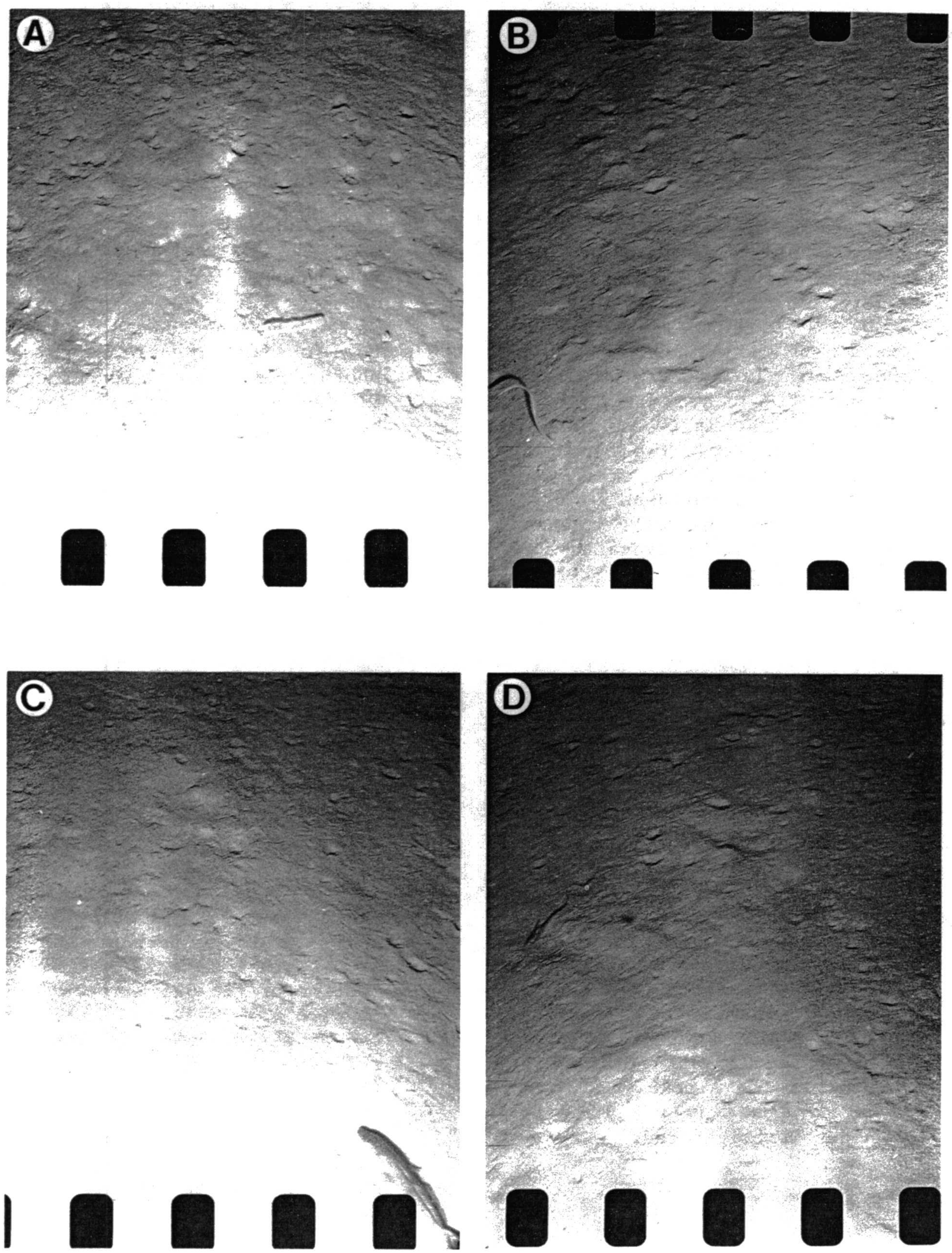

A
B
C
D

PLATE XVIII

A. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken in the western Gulf near the lower boundary of the Archibenthal Zone at the intersection of the 925-m isobath and 96°04.6'W longitude. Note that the fin of the compass weight on the camera is nearly buried in the very fine clayey mud (fin on compass weight is 25 cm long). There are at least two types of burrowers here. The small one belongs to the caridean *Glyphocrangon*, and the larger ones belong to the polychelids - either *Polycheles* or *Stereomastis*.

B. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken in the western Gulf near the lower boundary of the Archibenthal Zone at the intersection of the 925-m isobath and 96°04.6'W longitude. The burrows arranged in circles in this photo belong to *Glyphocrangon*. *Glyphocrangon aculeata* was taken here in large numbers.

C. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken in the western Gulf near the lower boundary of the Archibenthal Zone at the intersection of the 925-m isobath and 96°04.6'W longitude. The crab in this photo is the anomuran *Lithodes agassizii*, which is related to the Alaska King Crab - not a true crab. In life *Lithodes* is bright red.

D. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken in the western Gulf near the lower boundary of the Archibenthal Zone at the intersection of the 925-m isobath and 96°04.6'W longitude. The crustacean at the mouth of its burrow is the deep-sea lobster (Family Nephropidae) *Acanthacaris caeca*. The burrow to the right and above is considerably larger and may belong to the giant isopod *Bathynomus gigantea*.

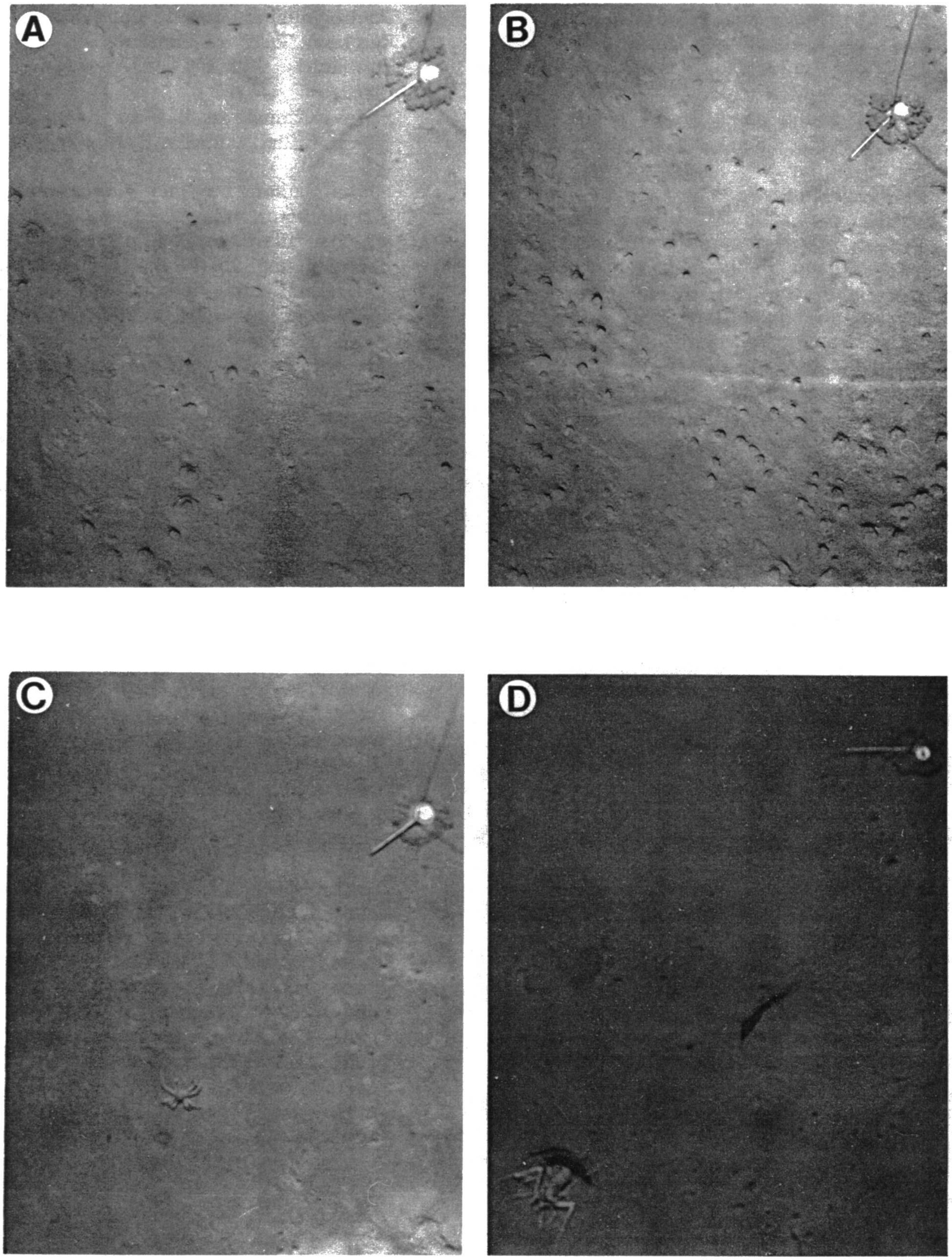

A
B
C
D

PLATE XIX

A. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
Isobath: 925 m
Cruise: 71A7
Preset focus at 1.5 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken on the continental slope west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. Note that the fin of the compass weight on the camera has plunged deep into the seabed (fin on compass weight is 25 cm long). There is a great deal of animal activity here. The fish may be an eel. The closely spaced burrows are those of the caridean Glyphocrangon. Two species were taken here, viz., G. longleyi and G. alispina. The starfish impression to the lower right was probably made by Goniopecten demonstrans.

B. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
Isobath: 925 m
Cruise: 71A7
Preset focus at 1.5 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken on the continental slope west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. Sediments here are very fine and soft clayey muds. The aggregation of burrows near the top of the photo are those of Glyphocrangon. The fish is an eel belonging to the genus Synaphobranchus. The burrow just ahead of the eel may be that of the polychelid crustacean Stereomastis sculpta sculpta which was collected in large numbers here and upon which this eel feeds.

C. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
Isobath: 925 m
Cruise: 71A7
Preset focus at 1.5 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken on the continental slope west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. Sediments here are very fine and soft clayey muds. Many of the burrows here are of Glyphocrangon. The fish in the upper left is the deep-sea shark Etmopterus pusillus.

D. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
Isobath: 925 m
Cruise: 71A7
Preset focus at 1.5 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken on the continental slope west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. Some of the burrows in this photo may belong to the polychelid macruran Stereomastis s. sculpta. The organism in the left lower quadrants is the large gastropod mollusk Gaza superba.

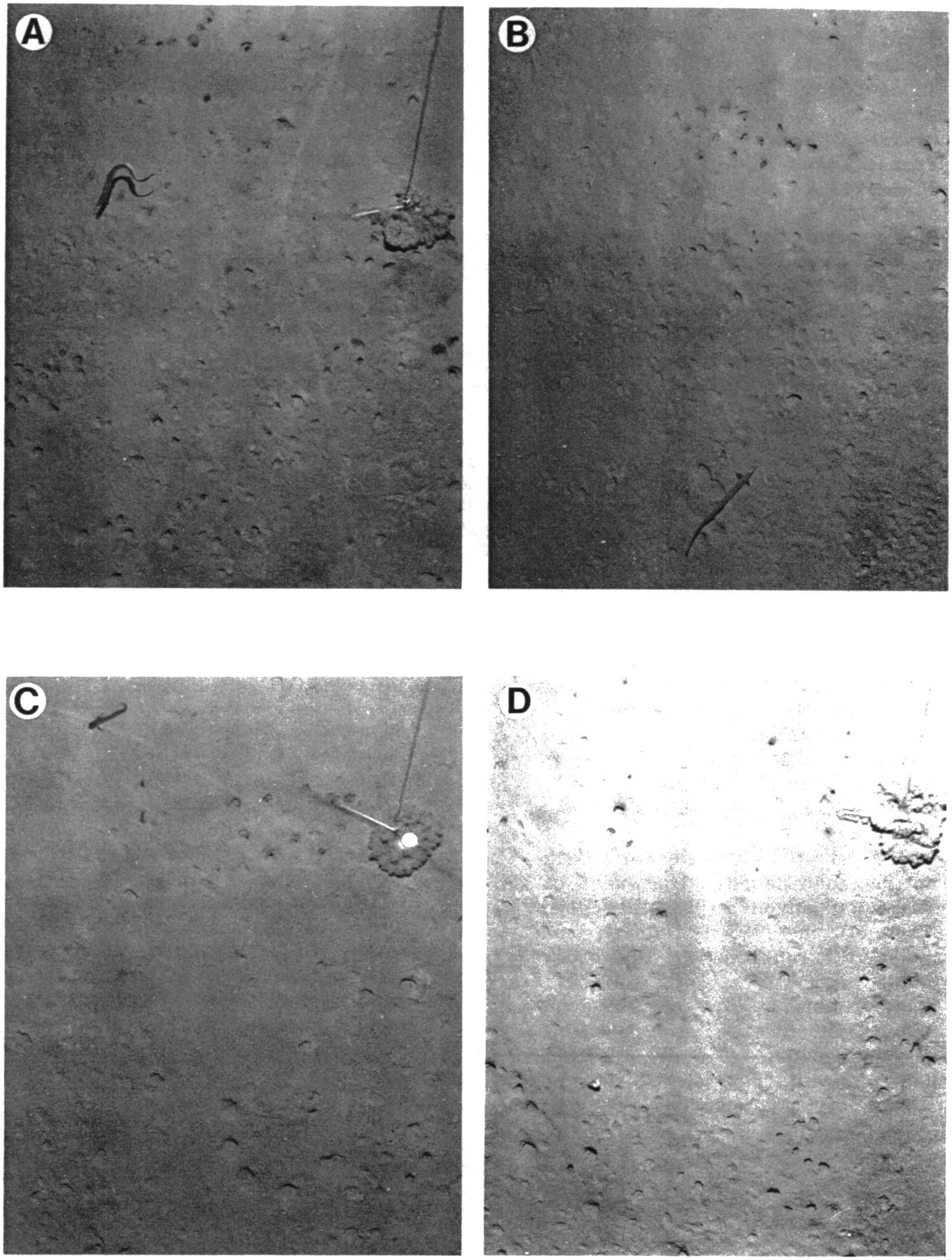

A
B
C
D

PLATE XX

A. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken in the western Gulf on the continental shelf west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. The sediments are very fine and soft clayey muds. There is abundant animal activity. The burrows are of various crustaceans collected in the area, e.g., Glyphocrangon, Nephropsis, and Stereomastis. The octopus Benthoctopus januari has apparently just jetted from the bottom and is travelling just above the bottom as seen in "B".

B. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken in the western Gulf on the continental shelf west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. Benthoctopus januari is to the left and an unidentifable caridean shrimp is to the right.

C. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken in the western Gulf on the continental slope west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. The sediments are very fine and soft clayey muds. The burrows arranged in circles are those of Glyphocrangon. The organism at the top of the photo is the large sea cucumber Benthodytes sanguinolenta.

D. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken in the western Gulf on the continental slope west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. The two organisms near the bottom of the photograph are difficult to identify but may be the brachyuran crab Trichopeltarion nobile.

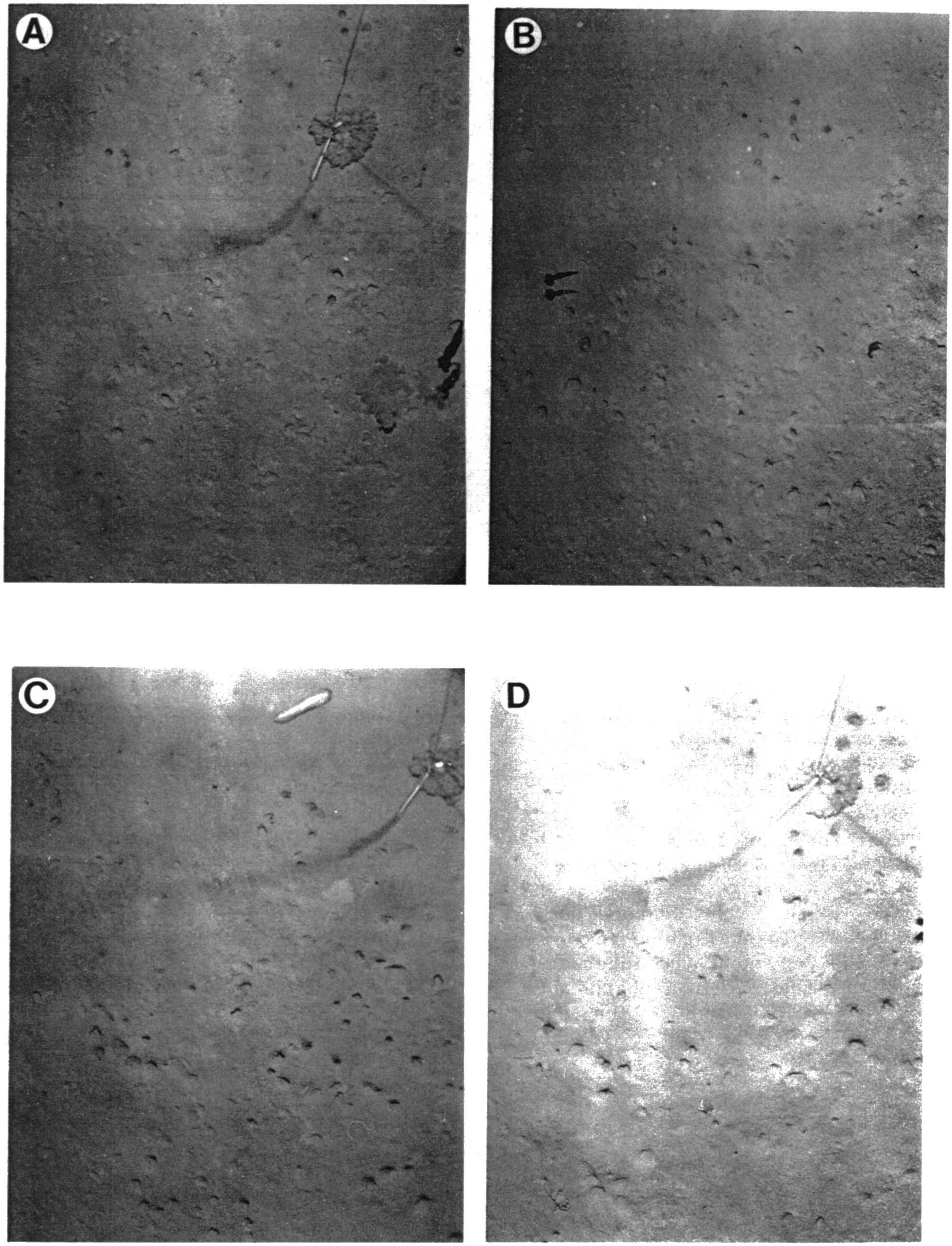

A
B
C
D

PLATE XXI

A. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken in the western Gulf on the continental shelf west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. The sediments here are fine and soft clayey muds. The organism appears to be a goblet or cup sponge.

B. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.3 m

Photo taken in the western Gulf on the continental shelf west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. The organism on the photo's bottom margin is the goblet sponge seen in "A".

C. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.4 m

Photo taken in the western Gulf on the continental slope west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. The sea pen left of the center is unidentified.

D. Archibenthal Zone. Horizon B.
Western Gulf of Mexico.
SE of Corpus Christi, Texas.
Isobath: 925 m
Cruise: 71A7
Preset focus at 2.0 m.
70-mm film. Scale 1.8 x 2.4 m

Photo taken in the western Gulf on the continental slope west of Alaminos Canyon at the intersection of the 925-m isobath and 96°04.6'W longitude. An unusually dense concentration of active *Glyphocrangon* burrows.

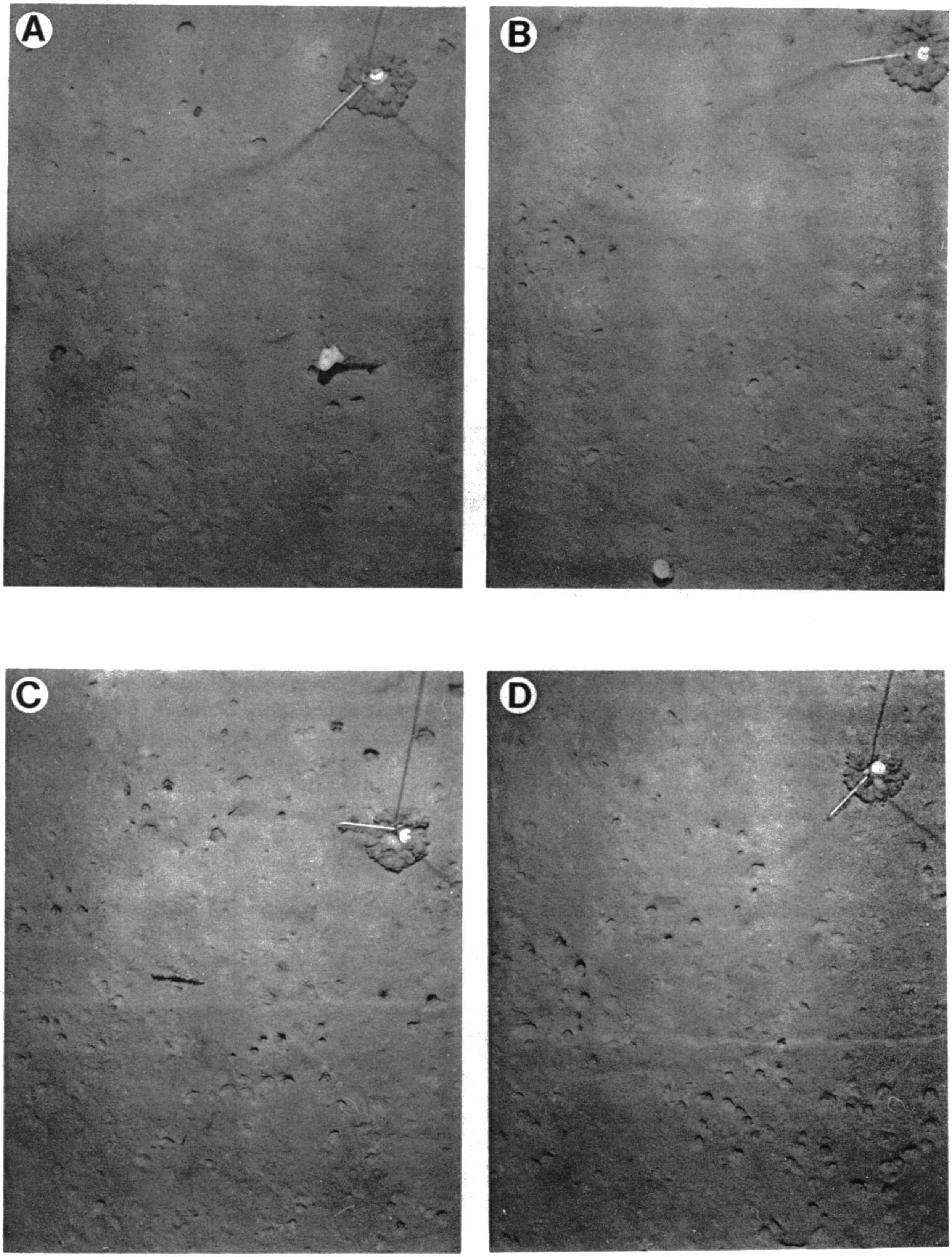

A
B
C
D

PLATE XXII

A. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 930 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.9 x 1.5 m

Photo taken in the eastern Gulf in the bottom of DeSoto Canyon at the intersection of the 930-m isobath and 87°11.7'W longitude. The sediments here are silty clays. Small vertical structures emerging from the seabed at various places are believed to be the "tail" of the burrowing sea cucumber Molpadia musculus that was collected here in substantial numbers. The fish is the synaphobranchid eel Synaphobranchus oregoni. Feeding depressions of fishes are scattered irregularly over the sediment surface.

B. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 930 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.7 x 0.9 m

Photo taken in the eastern Gulf in the bottom of DeSoto Canyon at the intersection of the 930-m isobath and 87°11.7'W longitude. Large hole may be the burrow of the Giant Red Crab, Geryon quinquedens that is common in this area. The source of the mound in the foreground is unknown. It may be related to the hole.

C. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 930 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 1.0 x 1.3 m

Photo taken in the eastern Gulf in the bottom of DeSoto Canyon at the intersection of the 930-m isobath and 87°11.7'W longitude. Holes are probably depressions made by bottom-feeding fish. The fish in the background is a macrourid.

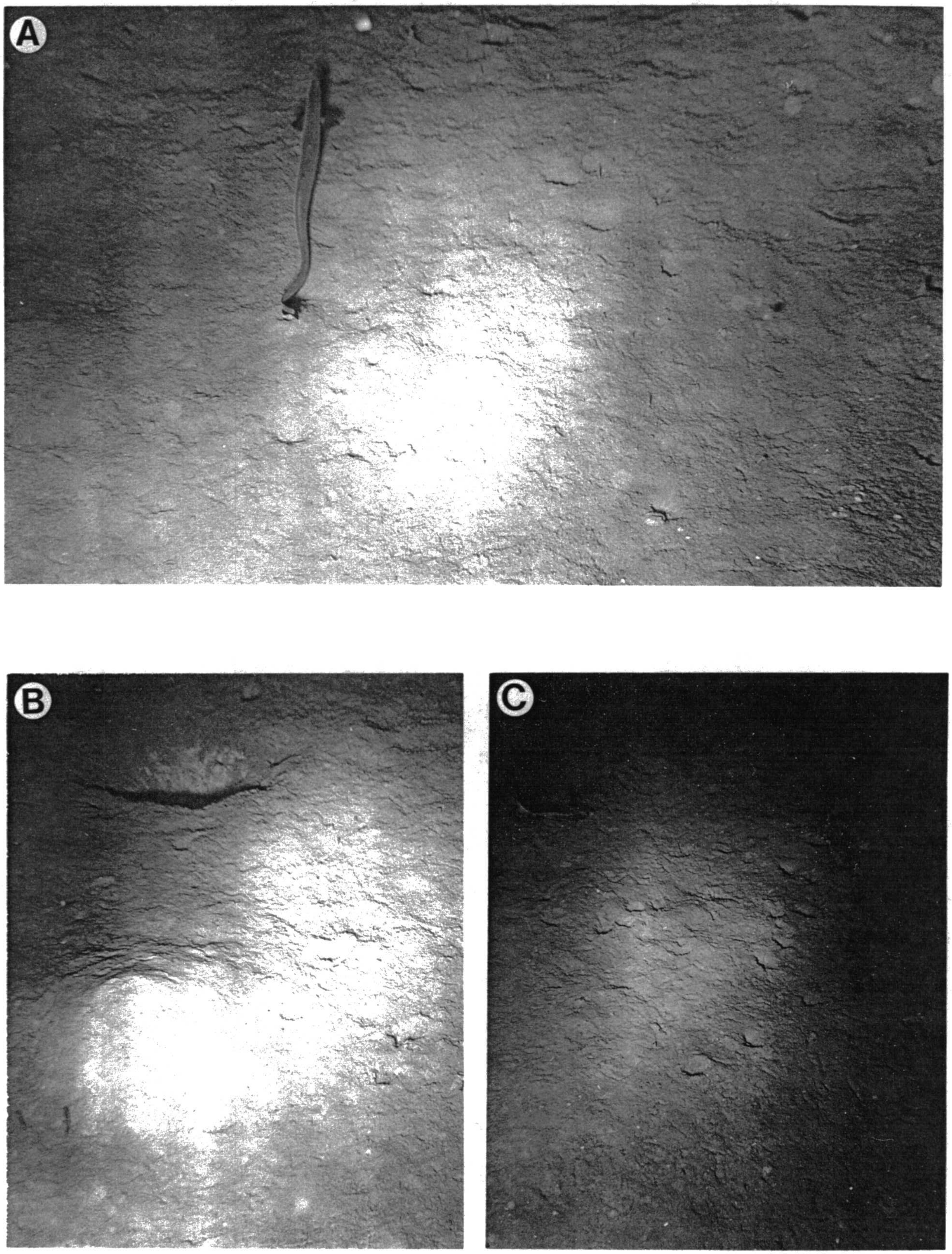

A
B
C

PLATE XXIII

A. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
Isobath: 930 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.9 x 1.5 m

Photo taken in the bottom of DeSoto Canyon at the intersection of the 930-m isobath and 87°11.7'W longitude. The sediments here are soft silty clays. This is an excellent habitat for such burrowing holothurians as <u>Molpadia musculus</u>. The large hole in this and the photo below may be the burrow of <u>Geryon quinquedens</u>, which is common here. Also, the marks of its dactyli, the leg tips can be seen in this photo.

B. Archibenthal Zone. Horizon B.
Eastern Gulf of Mexico.
Isobath: 930 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.9 x 1.5 m

Photo taken in the bottom of DeSoto Canyon at the intersection of the 930-m isobath and 87°11.7'W longitude. Here the canyon floor is filled with very soft, silty-clay sediments. Holes and mounds as seen in "A" above.

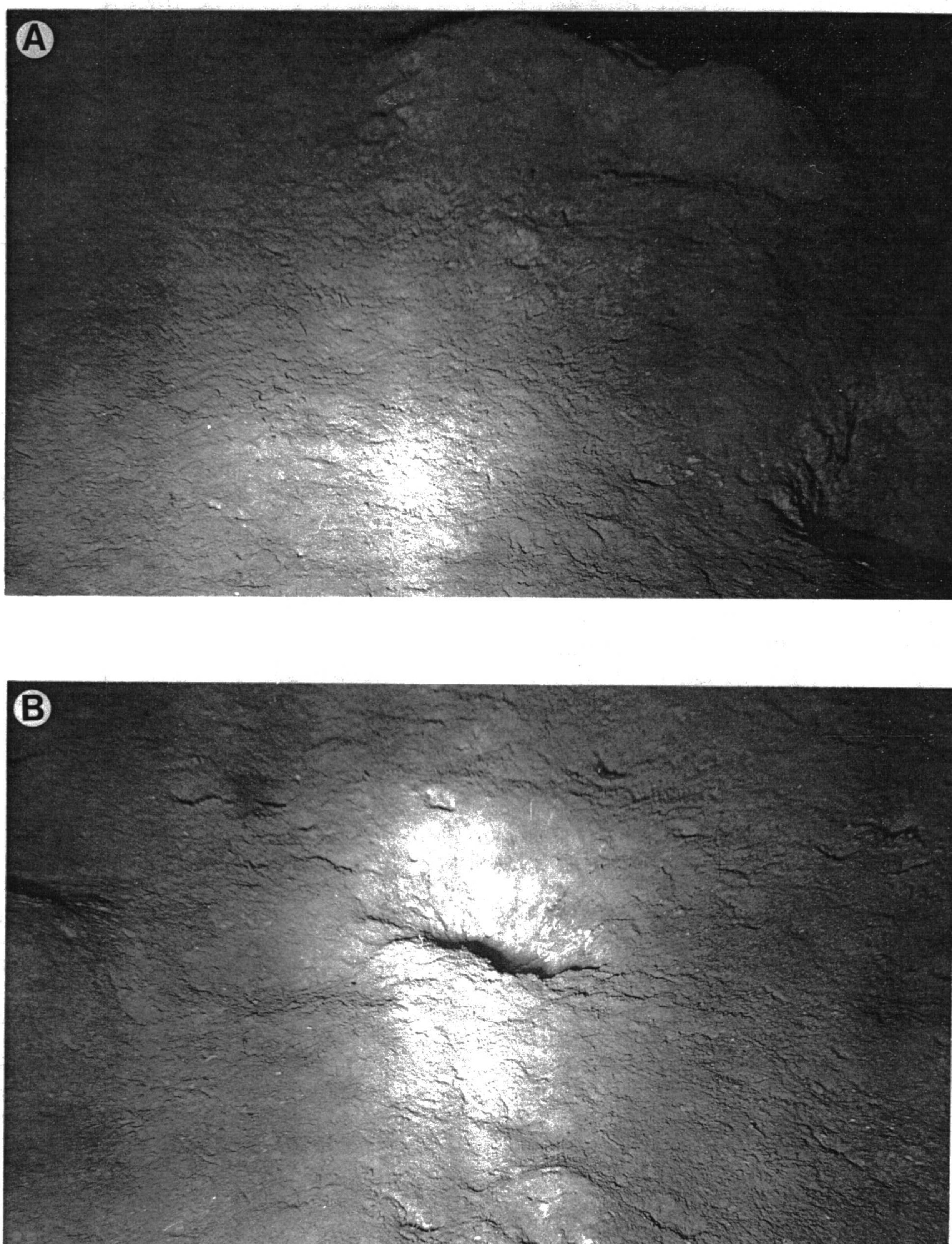

A
B

PLATE XXIV

A. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1025 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 0.6 x 0.8 m

Photo taken in the eastern Gulf below the trough of DeSoto Canyon at the intersection of the 1025-m isobath and 87°16'W longitude. Soft regular bottom consisting of silty mud with various signs of animal activity. The grainy appearance of the surface is due to partly and completely decomposed fecal pellets. Note the fish (Grenadier: Macrouroidea) in the upper left with mud on its snout. Known to be a bottom feeder, this species may make the somewhat triangular impressions seen in the lower right. The short slash marks may be made by the crab _Geryon_.

B. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1025 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 0.5 x 0.7 m

Photo taken in the eastern Gulf below the trough of DeSoto Canyon at the intersection of the 1025-m isobath and 87°16'W longitude. Soft regular bottom consisting of silty mud with feeding depressions of fish, slashes made by dactyli of _Geryon_ and a faint diagonal trail from left to right probably made by a sea cucumber, possibly _Mesothuria lactea_ that is common here. The light-colored round object in the upper right is believed to be the brachiopod _Chlidonophora incerta_.

C. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1025 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 0.5 x 0.7 m

Photo taken in the eastern Gulf below the trough of DeSoto Canyon at the intersection of the 1025-m isobath and 87°16'W longitude. The strange hand-and-arm impression is unexplained. A similar impression was photographed in the western Gulf also.

D. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1025 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 0.5 x 0.7 m

Photo taken in the eastern Gulf below the trough of DeSoto Canyon at the intersection of the 1025-m isobath and 87°16'W longitude. The hole may be the burrow of a retracted sea pen. The slash marks were made by _Geryon_ (Giant Red Crab) and the material in the lower right is decaying gulfweed (_Sargassum_) that has sunk to the bottom.

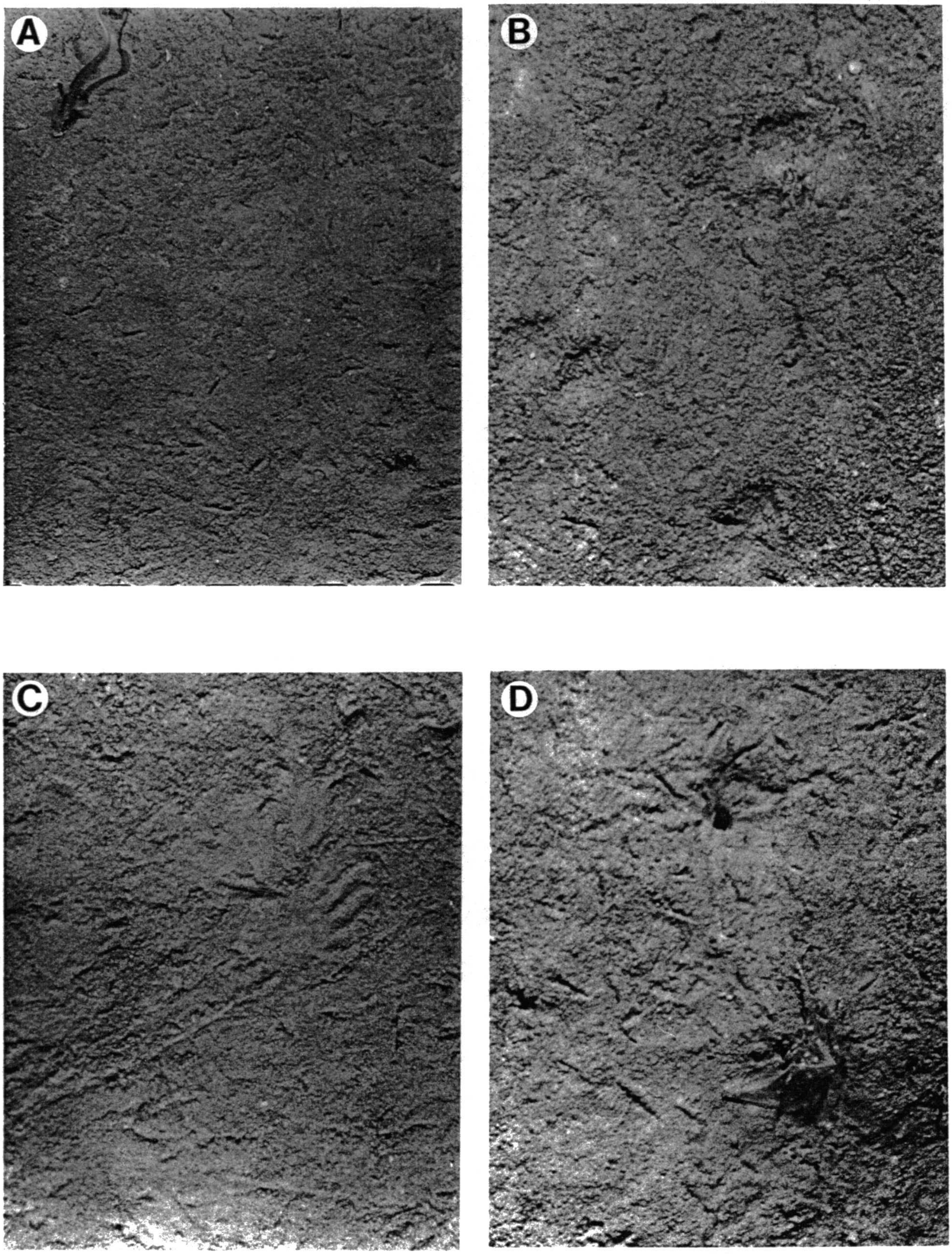

A
B
C
D

PLATE XXV

A. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the eastern Gulf below the east wall of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The large, white sea cucumber is Mesothuria lactea, which is the most abundant large epifaunal holothurian in this area. It engulfs surficial sediments; hence its fecal deposits contribute to the reworked sediments and account in part for its grainy appearance.

B. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the eastern Gulf below the east wall of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. Projecting tubes may be infaunal holothurians or sipunculid worms, both of which are common here.

C. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.6 x 0.8 m

Photo taken in the eastern Gulf below the east wall of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The brachyuran is the Giant Red Crab (Geryon quinquedens). The white objects on the legs are barnacles of the genus Scalpellum. Numerous slash marks in the sediments seen here are made by this crab. The fact that this species is so common here indicates that the area is quite productive, as our sampling also indicates. The leg span on this specimen is about 30 cm. Imprints indicate that the sediment is a very fine clayey mud.

D. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.7 x 0.9 m

Photo taken in the eastern Gulf below the east wall of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The white trail in the water at right appears to be a luminous cloud, possibly made by the shrimp seen in the background. It is impossible to be certain but the shrimp appears to be a caridean belouging to the genus Glyphocrangon. G. nobilis was collected at this site. The fish seen below the shrimp may be pursuing it.

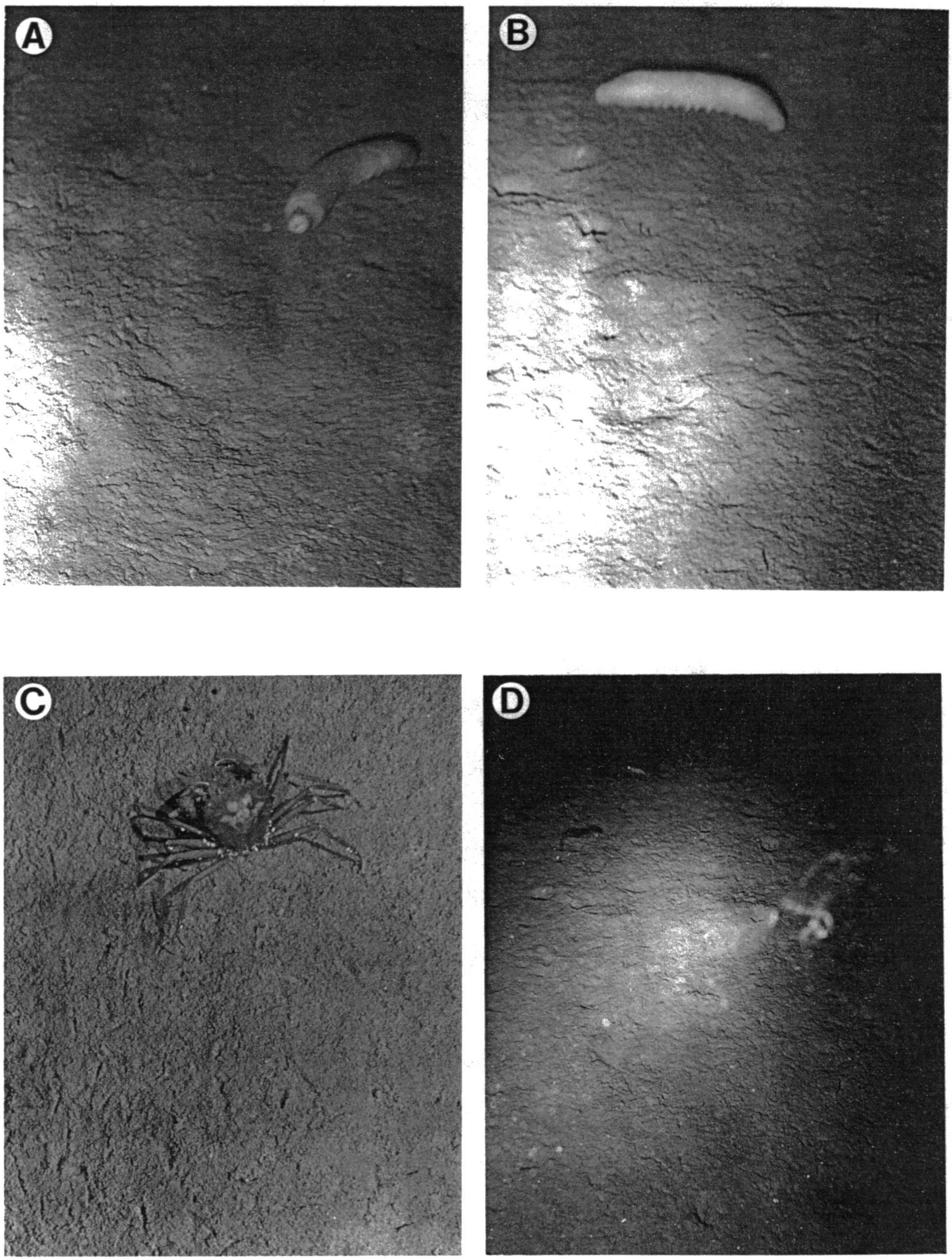

A
B
C
D

PLATE XXVI

A. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The luminous cloud at the right may have been produced by a shrimp - possibly the caridean Glyphocrangon shown at the photo's upper margin and in Plate 25, D. The fish below the shrimp is in a feeding stance. A trail of Geryon can be seen running toward the upper left between the fish and the shrimp.

B. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.4 x 0.6 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. Sediments here are silty clay. They exhibit abundant animal activity. The fish possesses the relatively large eyes characteristic of many demersal fishes.

C. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The grenadier fish appears to be working the soft sediments with the base of its caudal region. Perhaps it uncovers paleotaxodont bivalves that live just below the sediment/water interface.

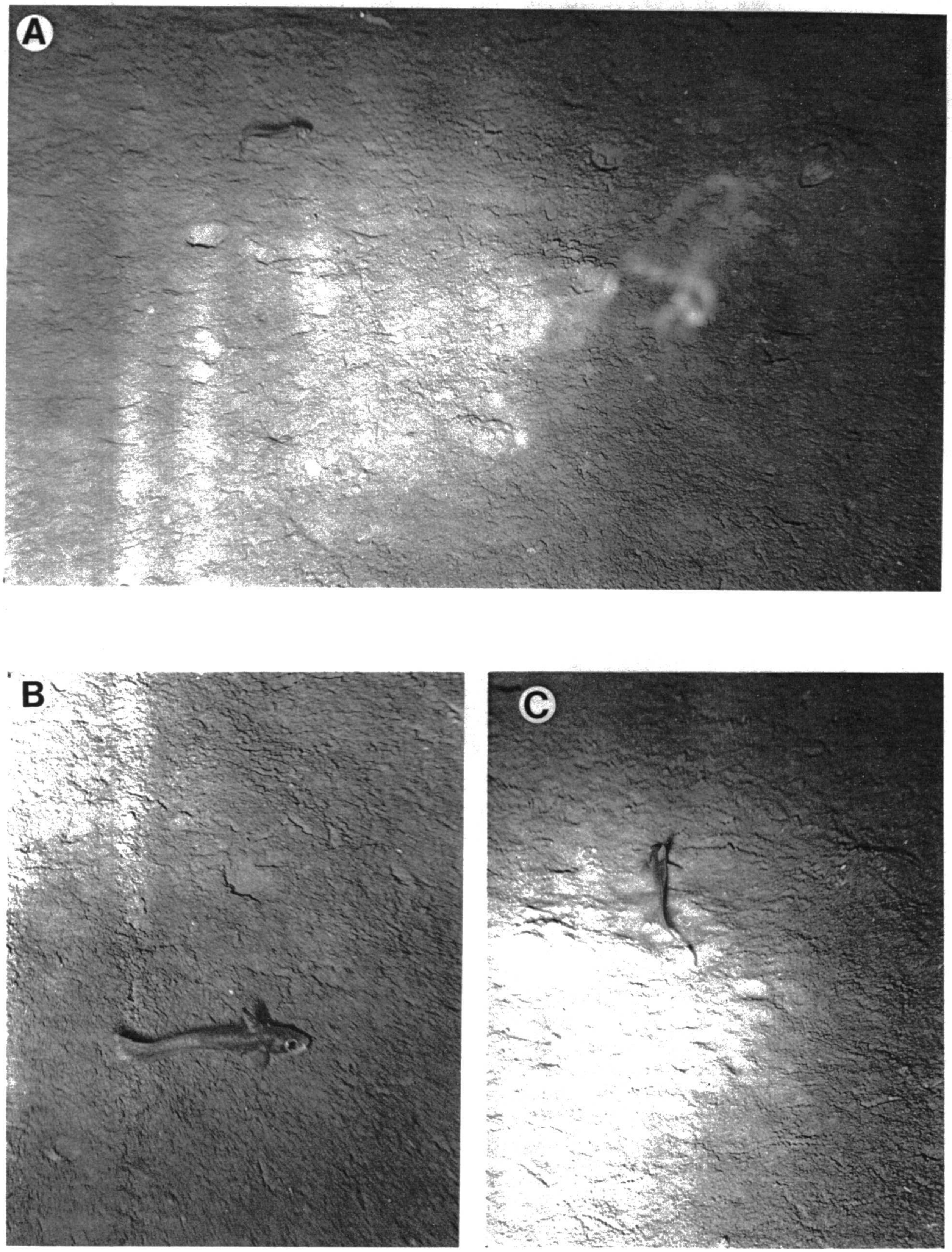

A
B
C

PLATE XXVII

A. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The fish appears to be preparing to use the depression for some unknown purpose (nest for egg deposition?). The silty clay sediments show evidence of considerable animal activity.

B. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The fish appears to be a large synaphobranchid eel. Some of the burrows seen here, especially along the lower right-hand margin, may be of the polychelid crustacean, Stereomastis s. sculpta, upon which this eel feeds.

C. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.6 x 0.8 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The synaphobranchid eel is next to the bottom in a hunting mode.

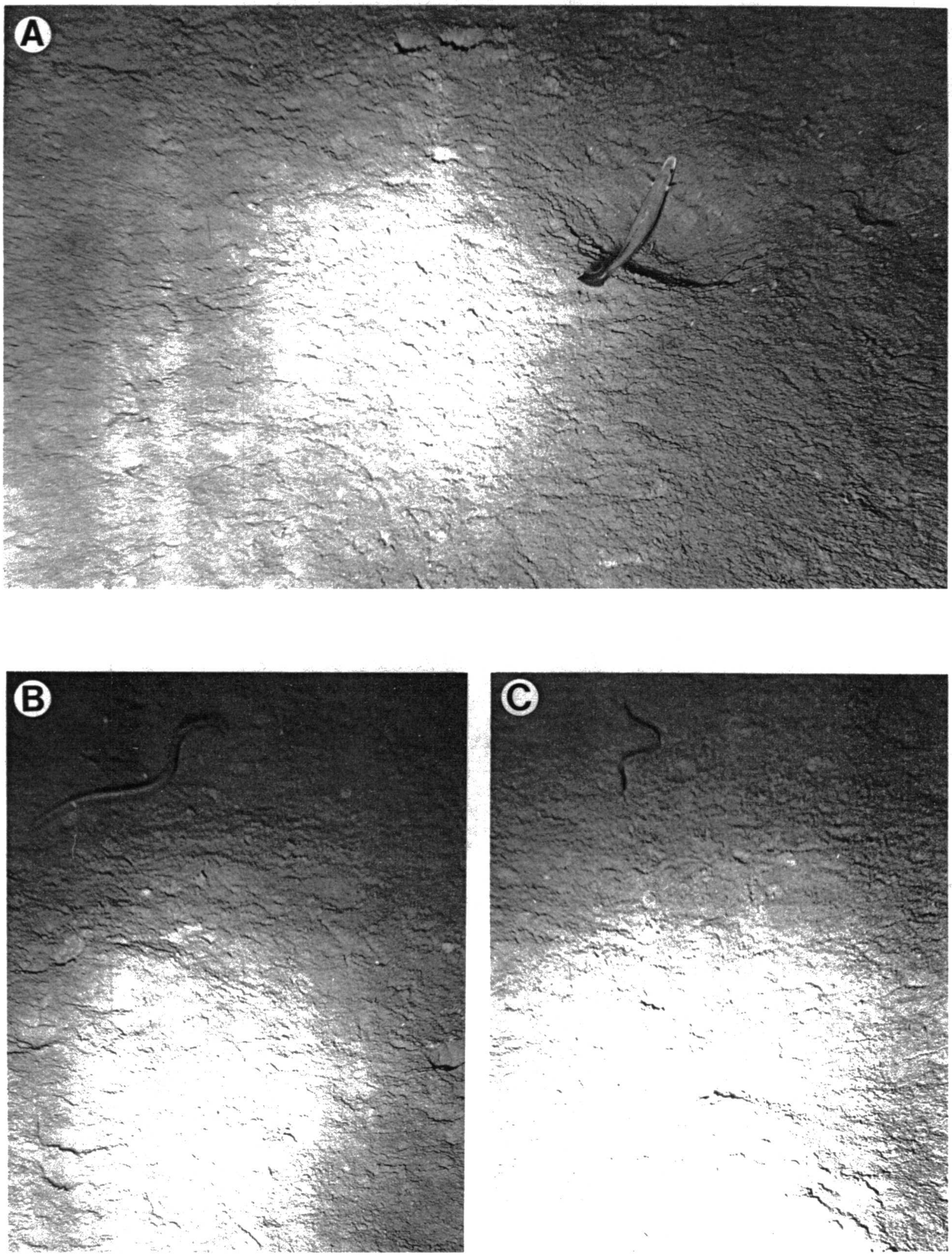

A
B
C

PLATE XXVIII

A. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the eastern Gulf below the east wall of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The organism extending from the seabed may be the sea pen Stylatula antillarum that was collected near this camera station.

B. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf below the east wall of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The seabed here is irregular suggesting past slumping. The depressions may arise in part from past folding. The burrow in the foreground, with its opening facing away from the observer may belong to Geryon the marks of which seem to lead into it.

C. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the eastern Gulf below the east wall of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The fish is a macrourid with the typical high dorsal fin and long rat-like tail, after which the macrourids are often called "rat tails." Macrourids are common in this part of the Upper Abyssal Zone on the continental slope.

D. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.7 x 0.8 m

Photo taken in the eastern Gulf below the east wall of DeSoto Canyon at the intersection of the 1100-m isobath and 87°29.5'W longitude. The starfish is Dipsacaster antillensis.

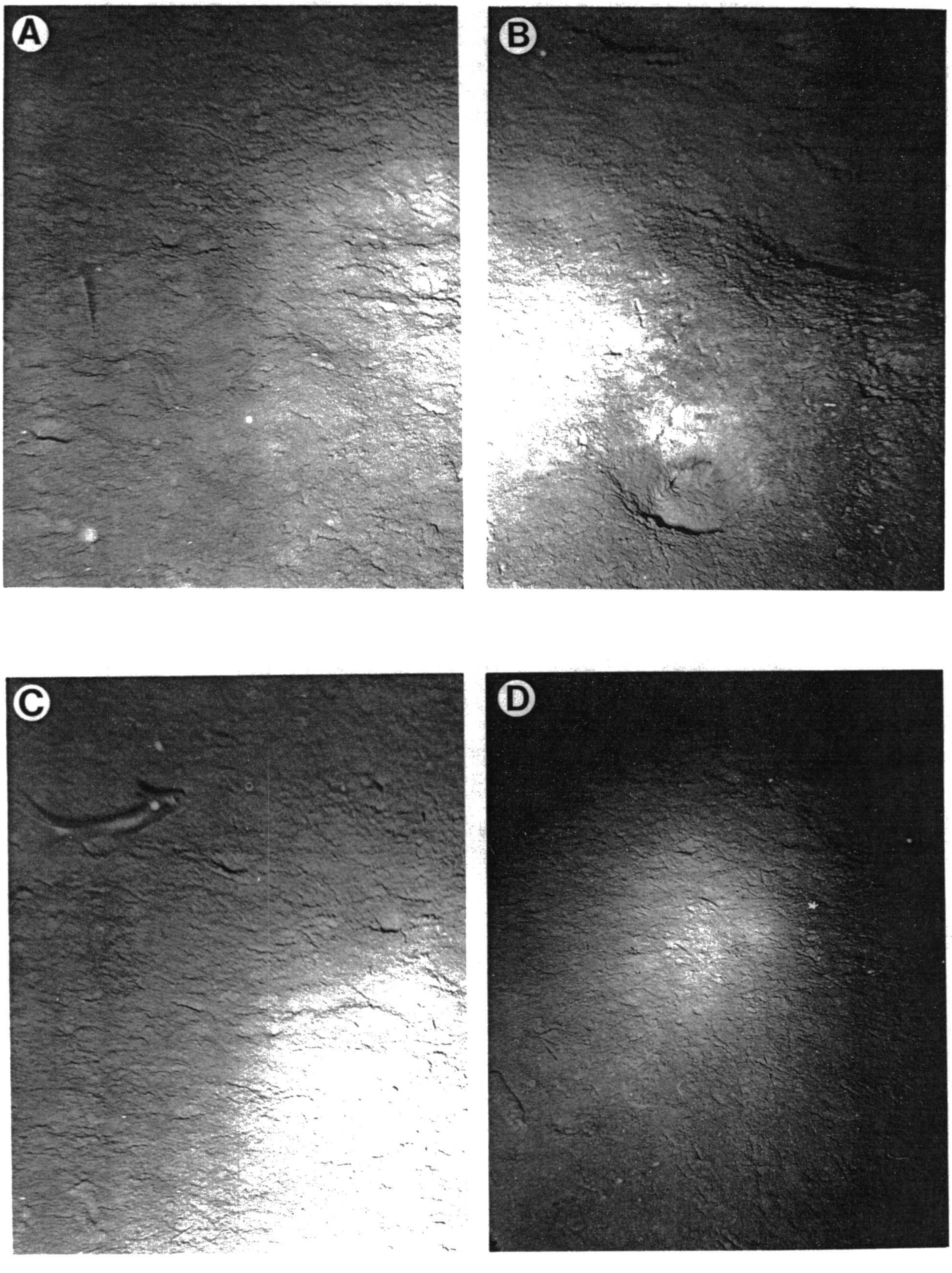

A
B
C
D

PLATE XXIX

A. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A13
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the western Gulf west of Alaminos Canyon at the intersection of the 1100-m isobath and 95°07.5'W longitude. The very irregular bottom suggest past slumping. The burrows probably belong to either the brachyuran crab _Geryon quinquedens_ or the isopod crustacean _Bathynomus giganteus_ or both. The shrimp in the foreground is identified as the caridean _Nematocarcinus rotundus_. The sediments are silty clay.

B. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A13
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the western Gulf west of Alaminos Canyon at the intersection of the 1100-m isobath and 95°07.5'W longitude. The shrimp has been identified as the penaeid _Benthesicymus bartletti_.

C. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A13
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the western Gulf west of Alaminos Canyon at the intersection of the 1100-m isobath and 95°07.5'W longitude. The ridges here suggest that the seabed is creeping downward. The material in the swale appears to be a gulfweed (_Sargassum_) and the fish is probably _Ilyophis brunneus_.

D. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1100 m
Cruise: 68A13
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the western Gulf west of Alaminos Canyon at the intersection of the 1100-m isobath and 95°07.5'W longitude. The turbidity flow caused by the camera frame shows clearly the granular nature of the very superficial sediments.

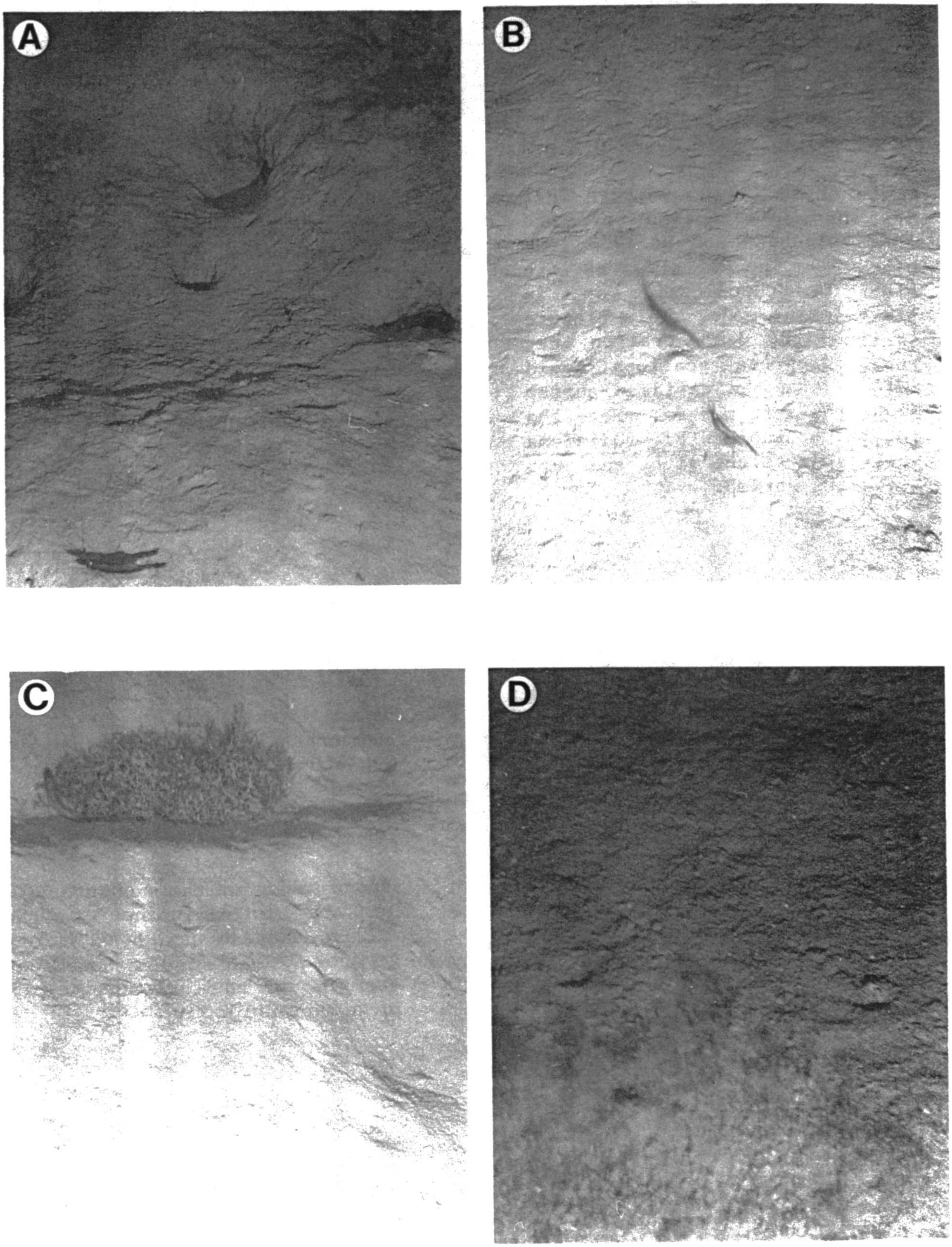

A
B
C
D

PLATE XXX

A. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1225 m
Cruise: 69A11
Preset focus at 1.5 m.
70-mm film. Scale 0.5 x 0.8 m

Photo taken in the western Gulf at the intersection of the 1225-m isobath and 96°47'W longitude. The bivalve at the right is Propeamussium sp. in its swimming mode. This picture is the first demonstration that these deep-sea scallops could swim. Note the caridean shrimp along the left margin. Note the small echinoid Plesiodiadema antillarum to the right and just below the shrimp.

B. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1225 m
Cruise: 68A13
Preset focus at 1.5 m.
70-mm film. Scale 0.4 x 0.5 m

Photo taken in the western Gulf at the intersection of the 1225-m isobath and 96°47'W longitude. This shows a perfect example of the burrow system of Glyphocrangon aculeata.

C. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1225 m
Cruise: 68A13
Preset focus at 1.5 m.
70-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf at the intersection of the 1225-m isobath and 96°47'W longitude. This is an excellent example of the characteristics of a macrourid fish.

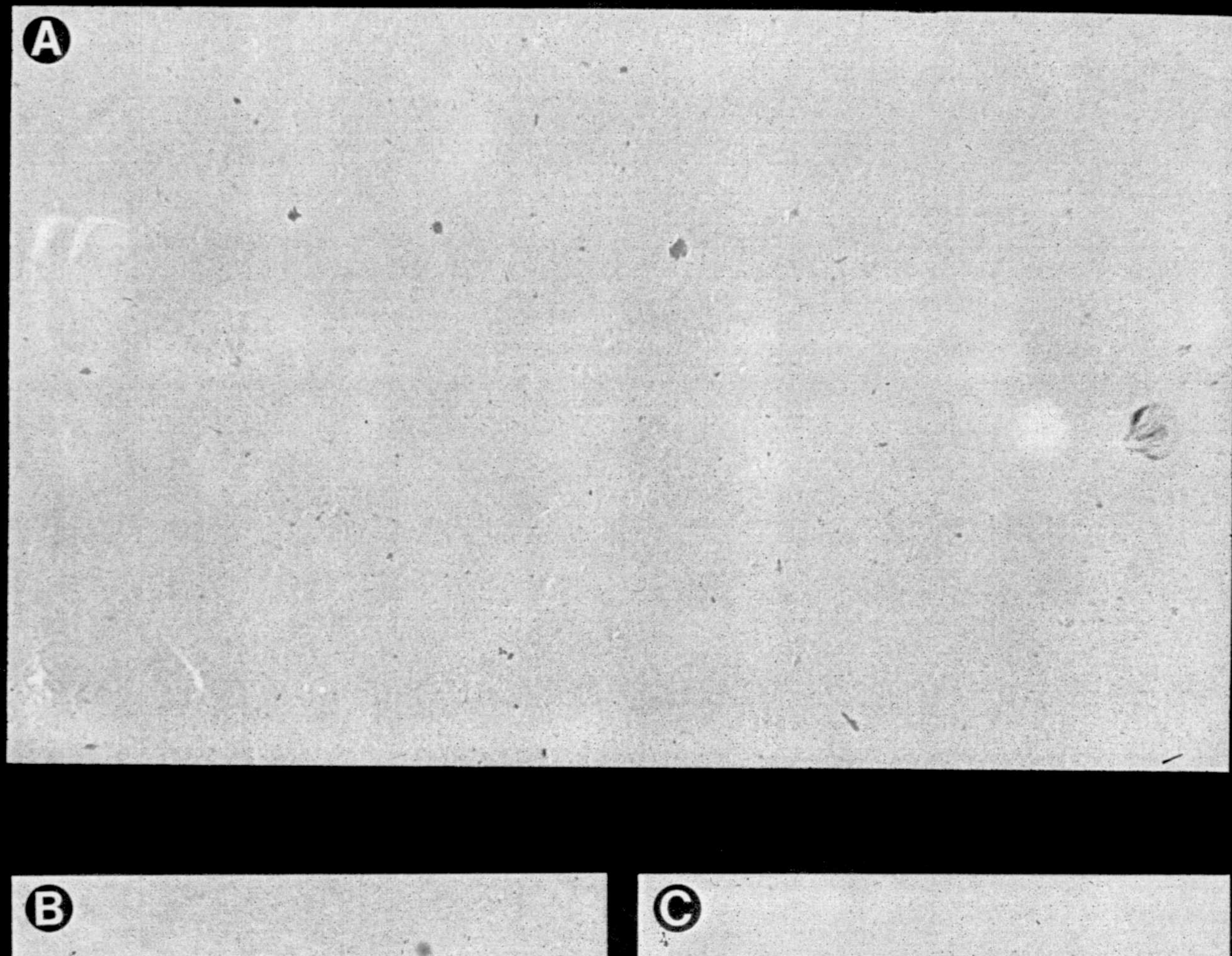

A
B
C

PLATE XXXI

A. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1235 m
Cruise: 69A11
Preset focus at 1.5 m.
70-mm film. Scale 0.4 x 0.5 m

Photo taken in the western Gulf at the intersection of the 1235-m isobath and 95°00'W longitude. The crustacean is the caridean *Glyphocrangon nobilis*. This picture established for the first time that these shrimps leave their burrows. Moreover, it can be seen that they can move quite rapidly. They are known to feed on small bivalves.

B. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1235 m
Cruise: 69A11
Preset focus at 1.5 m.
70-mm film. Scale 0.7 x 0.9 m

Photo taken in the western Gulf at the intersection of the 1235-m isobath and 95°00'W longitude. The sediments are silty clay. The slash marks running diagonally across the photo are believed to have been made by *Glyphocrangon* as it skips across the bottom.

C. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1235 m
Cruise: 68A13
Preset focus at 1.5 m.
70-mm film. Scale 0.7 x 0.9 m

Photo taken in the western Gulf at the intersection of the 1235-m isobath and 95°00'W longitude. The sediments are silty clay. The burrow system in the upper right belongs to *Glyphocrangon nobilis*.

D. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1235 m
Cruise: 68A13
Preset focus at 1.5 m.
70-mm film. Scale 0.7 x 0.9 m

Photo taken in the western Gulf at the intersection of the 1235-m isobath and 95°00'W longitude. The sediments are silty clay. A goblet sponge can be seen in the upper left with another type below it. The latter is probably *Thenea* sp. The gastropod on the lower margin is a turrid.

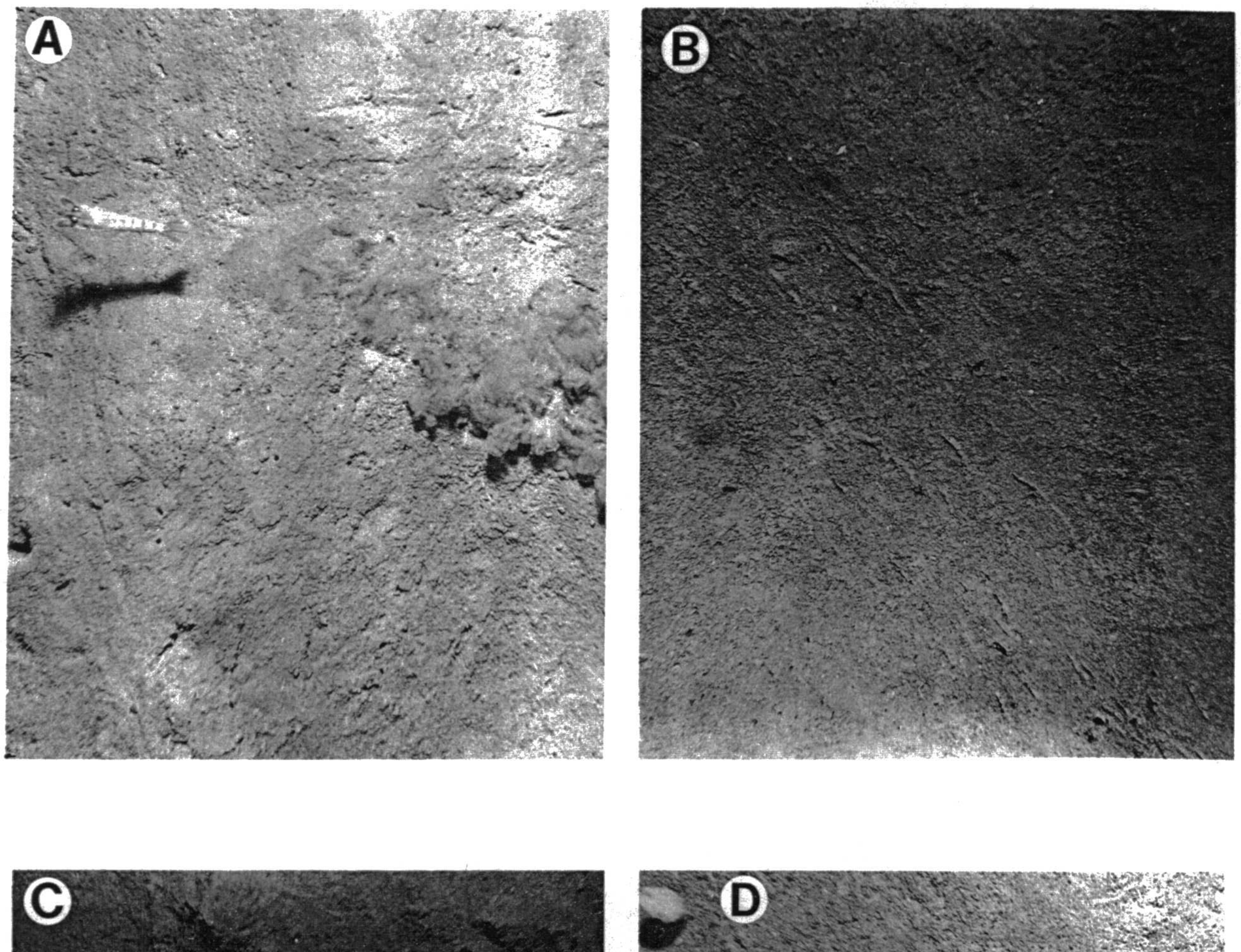


PLATE XXXII

A. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1225 m
Cruise: 69A11
Preset focus at 1.5 m.
70-mm film. Scale 0.7 x 0.9 m

Photo taken in the western Gulf at the intersection of the 1225-m isobath and 95°00'W longitude. The sediments are soft silty clay. The bivalve in the upper left is Propeamussium sp. Several small echinoids (Plesiodiadema antillarum) are present in the picture. The most evident can be seen at the arrow in the lower margin.

B. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1225 m
Cruise: 69A11
Preset focus at 1.5 m.
70-mm film. Scale 0.7 x 0.9 m

Photo taken in the western Gulf at the intersection of the 1225-m isobath and 95°00'W longitude. The sediments are soft silty clay. Note the plant material in the upper right. In the right depth range wherever plant material is found on the bottom the echinoid Plesiodiadema antillarum is present. This is no exception - five can be seen in this photo. Note one at the arrow. The slash marks in this photo and in "A" are believed to have been made by Glyphocrangon.

C. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1225 m
Cruise: 69A11
Preset focus at 1.5 m.
70-mm film. Scale 0.7 x 0.9 m

Photo taken in the western Gulf at the intersection of the 1225-m isobath and 95°00'W longitude. The sediments are soft silty clay. The hexactinellid goblet sponge at the top of the photo is unidentified.

D. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1225 m
Cruise: 69A11
Preset focus at 1.5 m.
70-mm film. Scale 0.7 x 0.9 m

Photo taken in the western Gulf at the intersection of the 1225-m isobath and 95°00'W longitude. The sediments are soft silty clay that appear not to have been worked by bottom currents. The sponge is a hexactinellid cup sponge. Some decaying plant material is present. The holes are probably those of sea pens.

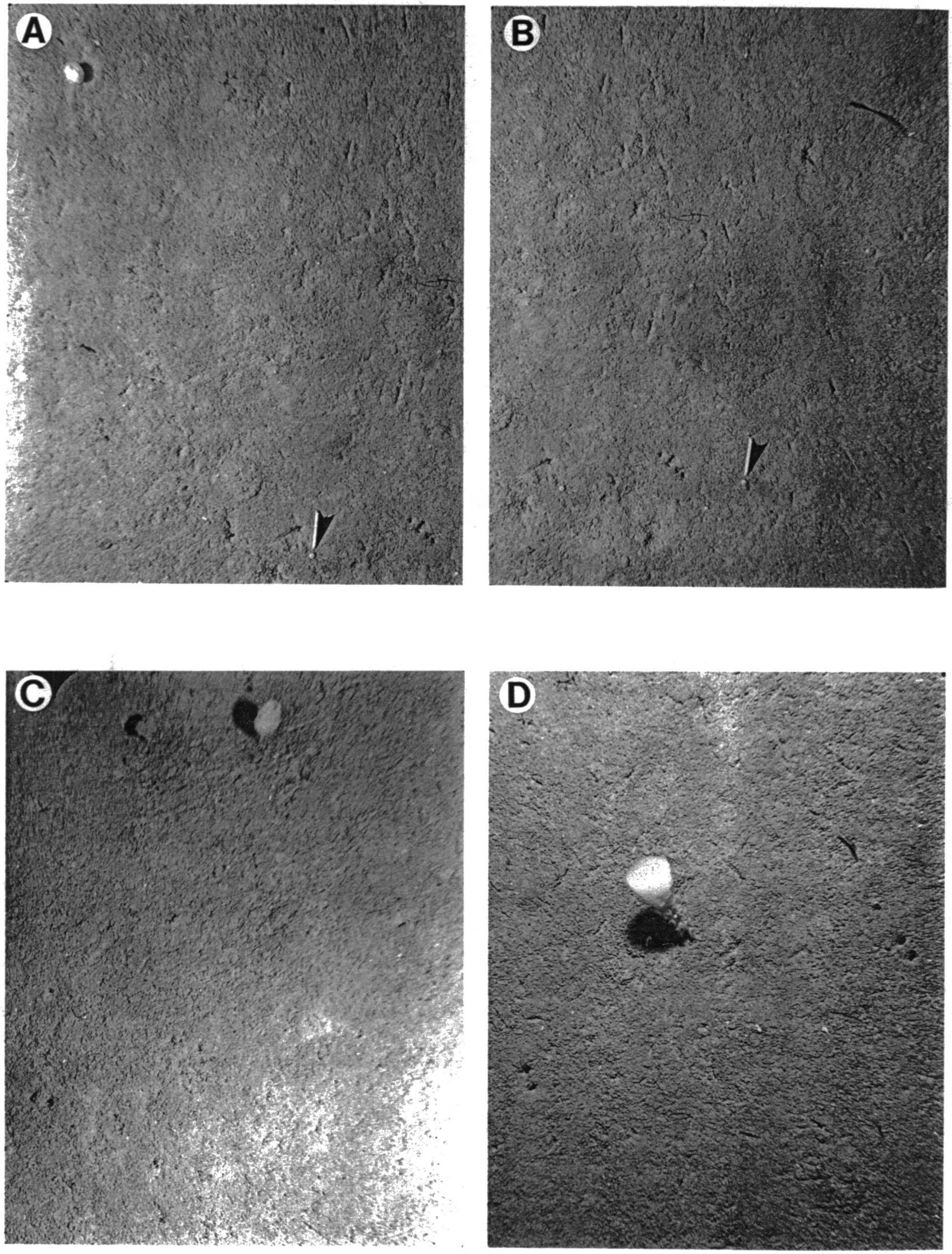

A
B
C
D

PLATE XXXIII

A. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1300 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 1.4 x 1.8 m

Photo taken in the eastern Gulf below DeSoto Canyon at the intersection of the 1300-m isobath and 87°22'W longitude. The sediments are fine silty mud. Dark oxidized clay blanket tops lighter colored fine silty mud. Irregularity of the bottom seems to be the result of slumping. Burrow apparently produced by an animal the size of the Giant Red Crab (Geryon quinquedens) the tracks of which can be seen above and just below the hole.

B. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1300 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 1.4 x 1.8 m

Photo taken in the eastern Gulf below DeSoto Canyon at the intersection of the 1300-m isobath and 87°22'W longitude. Although the bottom is crossed by numerous tracks of large animals, there is very little bioturbation evident in this picture. Possibly this results from instability of the seabed in this down canyon area.

C. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1300 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 1.4 x 1.8 m

Photo taken in the eastern Gulf below DeSoto Canyon at the intersection of the 1300-m isobath and 87°22'W longitude. Presence of the eel in the upper left indicates that its principal food the polychelid Stereomastis s. sculpta is present (collected there by R/V ALAMINOS) which is evidence that the area is fairly productive. Numerous small bivalves were collected here, principally deposit-feeding paleotaxodonts. Perhaps the shallow depressions result from various organisms feeding upon them.

D. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1300 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 1.4 x 1.8 m

Photo taken in the eastern Gulf below DeSoto Canyon at the intersection of the 1300-m isobath and 87°22'W longitude. This picture gives further evidence of the presence of ridges in the seabed that probably are a result of downslope creep.

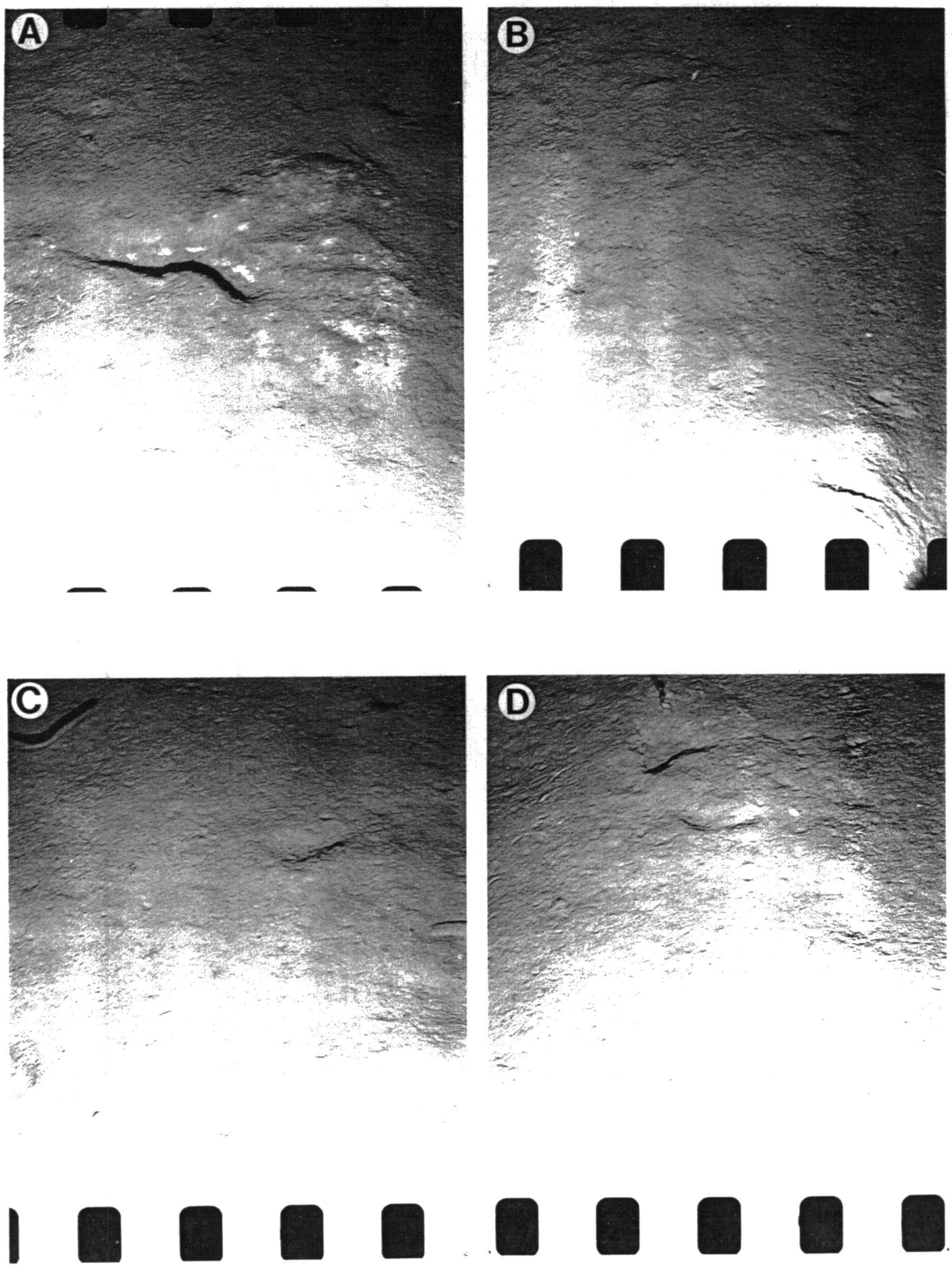

A
B
C
D

PLATE XXXIV

A. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1350 m
Cruise: 69A11
Preset focus at 1.5 m.
70-mm film. Scale 0.4 x 0.7 m

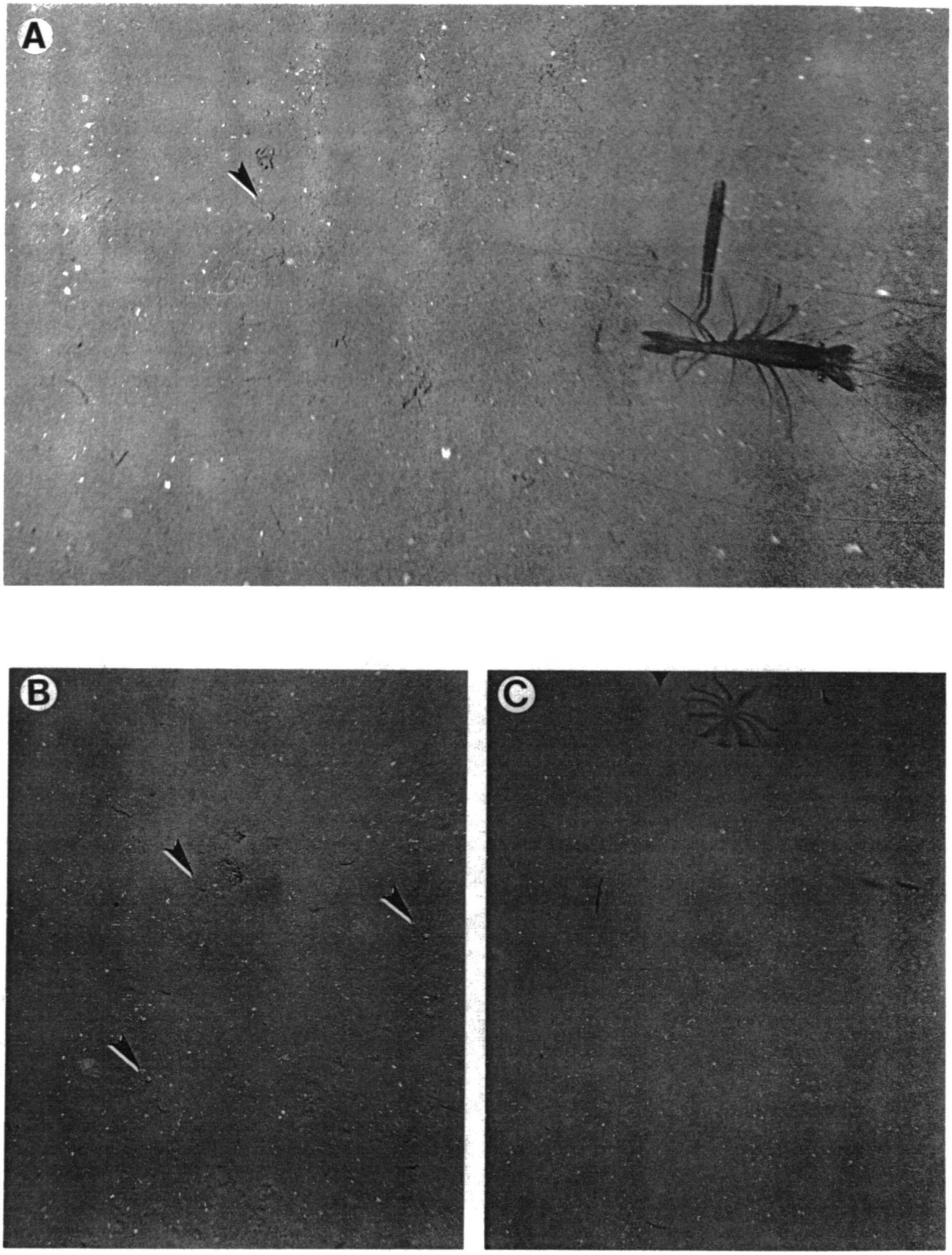
Photo taken in the western Gulf at the intersection of the 1350-m isobath and 96°09.5'W longitude. The sediments are silty clays with a good deal of shell material. The shrimp is the large penaeid *Plesiopenaeus edwardsianus*. This specimen measures about 18 cm. The fish below the shrimp appears to be a halosaur. At the arrow note the small echinoid *Plesiodiadema antillarum*.

B. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1350 m
Cruise: 69A11
Preset focus at 1.5 m.
70-mm film. Scale 1.0 x 1.2 m

Photo taken in the western Gulf at the intersection of the 1350-m isobath and 96°09.5'W longitude. The sediments are silty clays with considerable shell material. The source of the burrow is unknown. A group of small echinoids (*Plesiodiadema antillarum*) is present, as at the arrows.

C. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 1350 m
Cruise: 69A11
Preset focus at 1.5 m.
70-mm film. Scale 1.7 x 2.1 m

Photo taken in the western Gulf at the intersection of the 1350-m isobath and 96°09.5'W longitude. The sediments are silty clays with shell material. There is some wood and other plant material on the bottom. A comatulid crinoid can be seen at the top of the photo. The small black organism casting a shadow at the right is an octopus. Such octopi probably account for many of the bivalve shells seen in the photo.



A
B
C

PLATE XXXV

A. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1470 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 0.6 x 0.8 m

Photo taken in the eastern Gulf below DeSoto Canyon at the intersection of the 1470-m isobath and 87°20'W longitude. Fairly regular silty mud bottom with faint evidence of alignment and low ripples. The fish is a synaphobranchid eel. The group of dark shadows in the upper left are apparently produced by small crustaceans moving just above the bottom (cumaceans or amphipods?). There is a good deal of shell material. Evidently a bottom current is present here.

B. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1470 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 1.4 x 1.8 m

Photo taken in the eastern Gulf below DeSoto Canyon at the intersection of the 1470-m isobath and 87°20'W longitude. The eel is not identified but appears to be a synaphobranchid. The burrow system to the left belongs to _Glyphocrangon_ (probably _nobilis_).

C. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1470 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the eastern Gulf below DeSoto Canyon at the intersection of the 1470-m isobath and 87°20'W longitude. The large burrow may belong to a nephropid lobster.

D. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1470 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 0.6 x 0.8 m

Photo taken in the eastern Gulf below DeSoto Canyon at the intersection of the 1470-m isobath and 87°20'W longitude. The very irregular bottom shows some evidence of current lineations running diagonally across the photo. The cause of the small humps may be sponges.

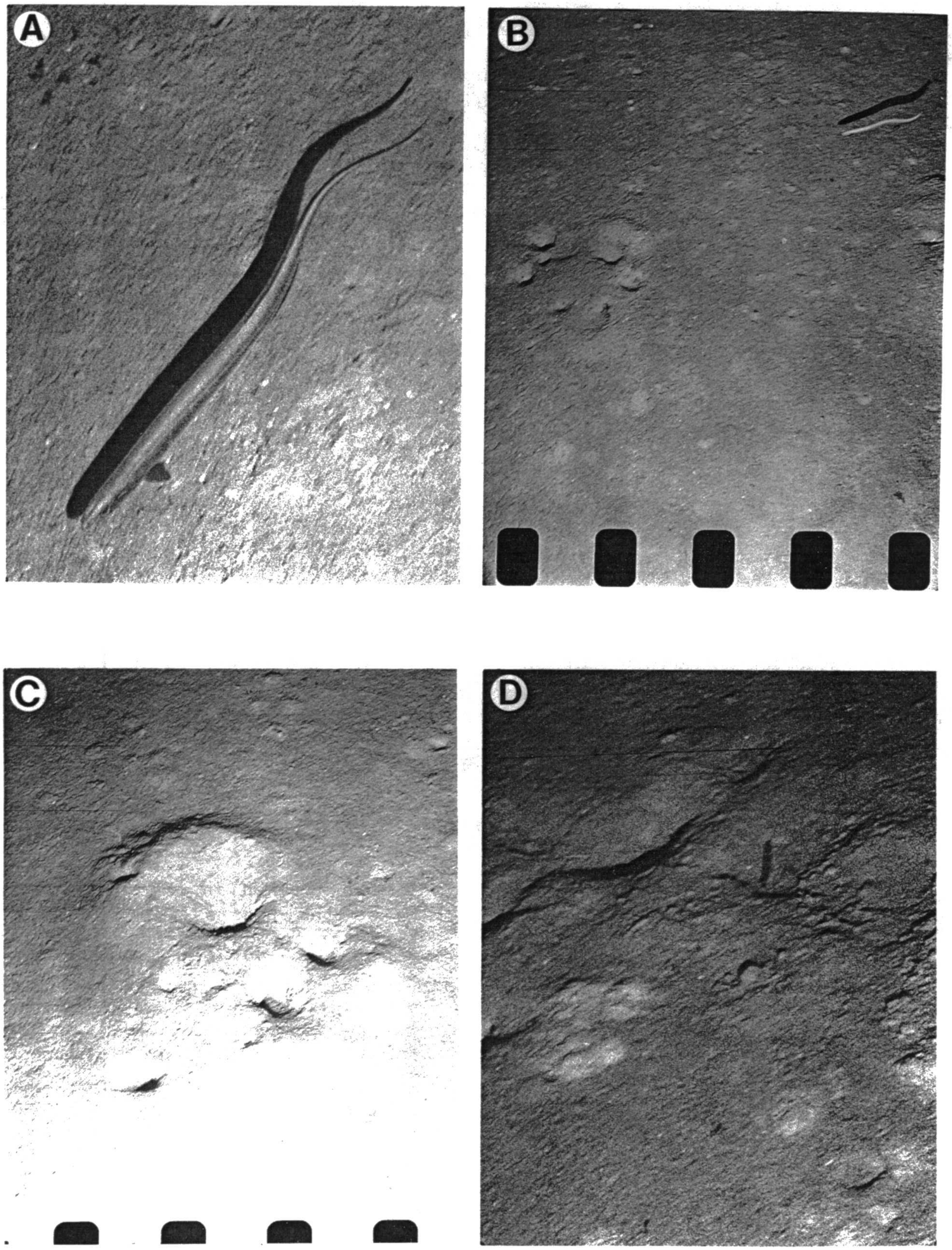

A
B
C
D

PLATE XXXVI

A. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1650 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.3 x 1.6 m

Photo taken in the eastern Gulf below DeSoto Canyon at the intersection of the 1650-m isobath and 87°28'W longitude. The bottom here is covered with large numbers of sponges (Thenea sp.).

B. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1650 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.3 x 1.6 m

Photo taken in the eastern Gulf below DeSoto Canyon at the intersection of the 1650-m isobath and 87°28'W longitude. Statement under Photo A applies here.

C. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1800 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 1.7 x 2.1 m

Photo taken in the eastern Gulf on the Mississippi Fan at the intersection of the 1800-m isobath and 88°21'W longitude. The sea cucumber in the lower left is the largest found in the deep Gulf - Paroriza prouhoi.

D. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 1800 m
Cruise: 67A5
Preset focus at 3.0 m.
35-mm film. Scale 1.7 x 2.1 m

Photo taken in the eastern Gulf on the Mississippi Fan at the intersection of the 1800-m isobath and 88°21'W longitude. The mounds and their sculpturing (trails) have been produced by unknown species. The shrimp on the middle mound is probably the penaeid Hymenopenaeus aphoticus.

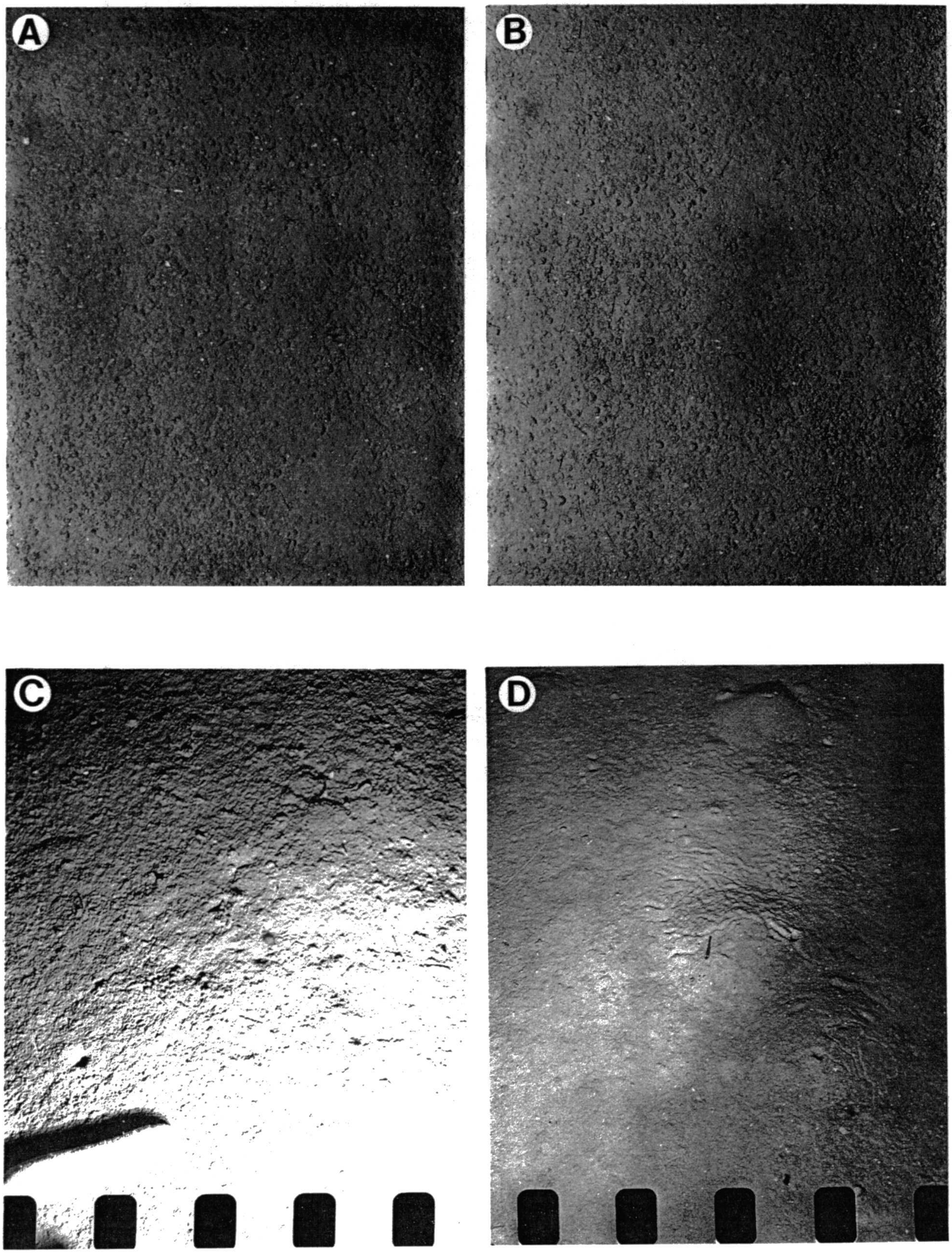

A
B
C
D

PLATE XXXVII

A. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 2025 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the western Gulf at the intersection of the 2025-m isobath and 91°55'W longitude. The series of photographs on the opposite page show two thing well: (1) the distintegration and eventual blending of the fecal deposits of holothurians with the sediment bed, and (2) significant evidence of slow slumping of seabed. In this photo we see a relatively fresh fecal deposit of an unknown holothurian (probably either Benthodytes lingua or B. sanguinolenta). Also, note the faint wavy appearance of the seabed. Note the pteropod shells to the left above.

B. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 2025 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 0.4 x 0.5 m

Photo taken in the western Gulf at the intersection of the 2025-m isobath and 91°55'W longitude. Here we see fragments of old fecal deposits of holothurians as well as one relatively recent or fresh one. There is faint evidence of sediment creep.

C. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 2025 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the western Gulf at the intersection of the 2025-m isobath and 91°55'W longitude. There is quite clear evidence of the wave fronts characteristic of slowly creeping sediments. It is these movements that probably account for the breaking up of the old fecal deposit.

D. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 2025 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 0.4 x 0.5 m

Photo taken in the western Gulf at the intersection of the 2025-m isobath and 91°55'W longitude. Sediment slumping wave fronts are evident. The fecal deposit is relatively old, having in places almost completely blended with the sediments of the seabed.

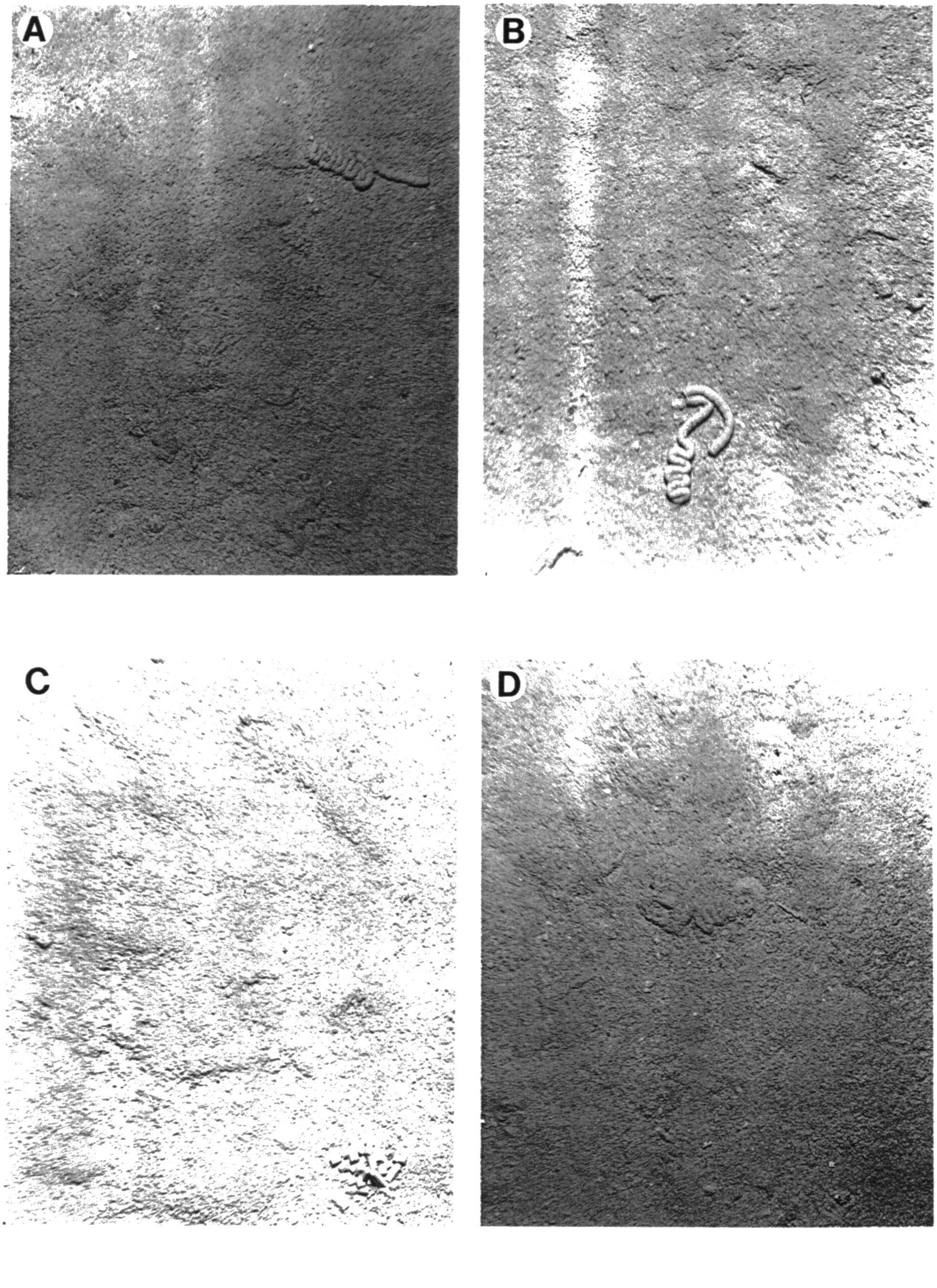

A
B
C
D

PLATE XXXVIII

A. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 2025 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the western Gulf at the intersection of the 2025-m isobath and 91°55'W longitude. The large hole or burrow in the steep sloping area may have been made by the giant isopod Bathynomus giganteus, which was trawled from here. Movies show that this heavy isopod can swim rapidly; hence the apron in front of the hole is probably designed for landing. The sediment is a very fine silty mud.

B. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 2025 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 0.5 x 0.7 m

Photo taken in the western Gulf at the intersection of the 2025-m isobath and 91°55'W longitude. This must be an area of sinking water as noted by the accumulation of vegetation and pteropod shells. The burrow may be that of a small Bathynomus giganteus. The stalked object is probably an octocorallian in the family Isididae, which was collected from near here.

C. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 2025 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 0.4 x 0.5 m

Photo taken in the western Gulf at the intersection of the 2025-m isobath and 91°55'W longitude. There is very strong evidence of slumping with the sediments creeping. The apparent double trail is possibly a loop in a trail made by a single animal (appears to be the trail of the holothurian Pseudostichopus). The top of the loop has been covered by creeping sediments. Note the numerous pteropod shells. The asteroid to the right is apparently Benthopecten simplex.

D. Upper Abyssal Zone.
Western Gulf of Mexico.
Isobath: 2025 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 0.3 x 0.4 m

Photo taken in the western Gulf at the intersection of the 2025-m isobath and 91°55'W longitude. There is considerable evidence of sediment instability. The animal in the upper left is an unidentified anomuran crustacean - possibly a galatheid. The source of the faint trail is unknown.

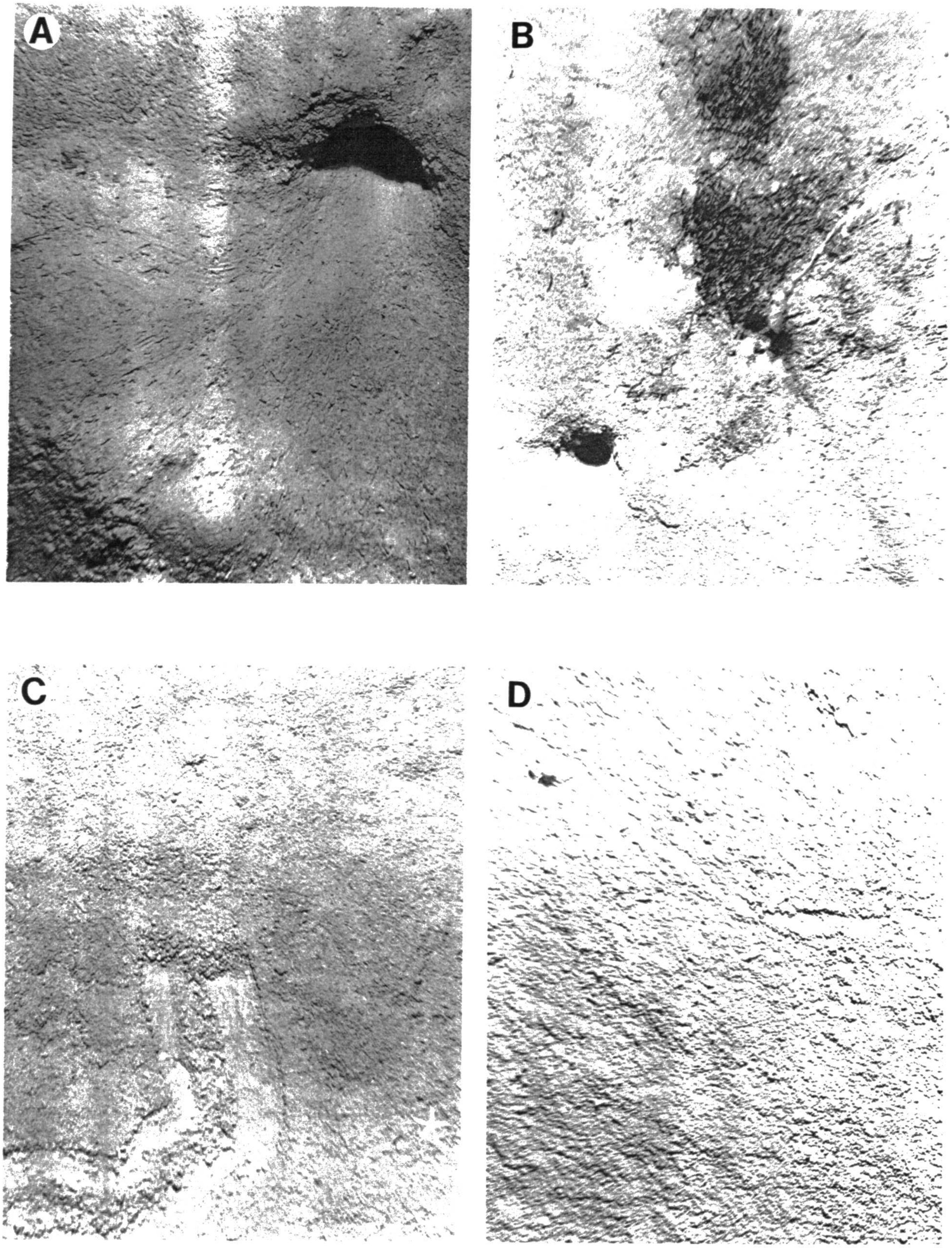

A
B
C
D

PLATE XXXIX

A. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 2120 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 1.5 x 2.4 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 2120-m isobath and 87°34.5'W longitude. The echinoid is the large <u>Phormosoma petersi</u>. The sediments are a very fine silty clay and contain numerous shell fragments.

B. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 2120 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 0.9 x 1.1 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 2120-m isobath and 87°34.5'W longitude. The holothurian is <u>Paelopatides gigantea</u>. Note the small parapodia by means of which it moves.

C. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 2120 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 1.2 x 1.5 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 2120-m isobath and 87°34.5'W longitude. The holothurian is <u>Peniagone</u> cf. <u>islandica</u>. Sediment irregularities here are probably due to animal activities.

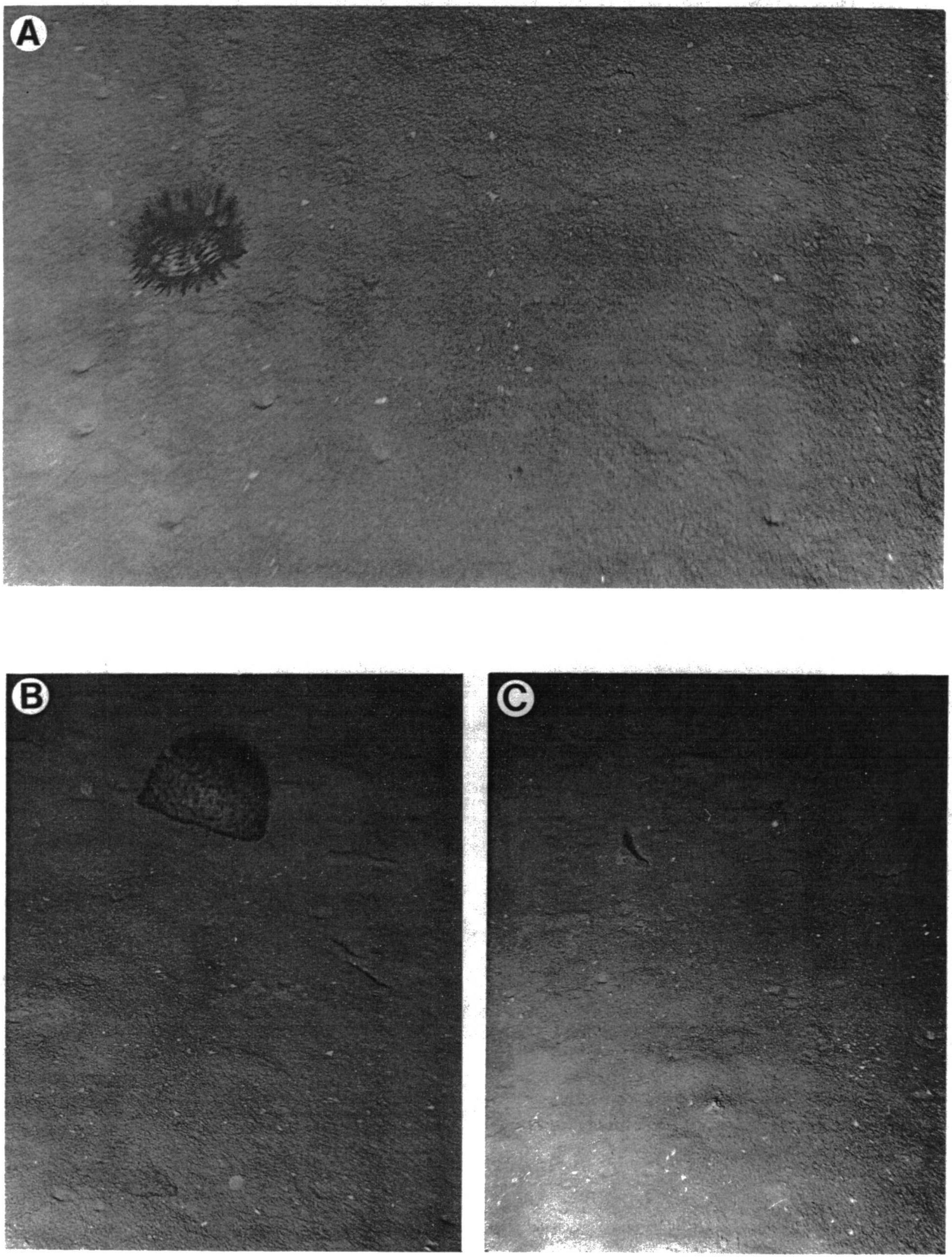

A
B
C

PLATE XL

A. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 2120 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 1.5 x 2.4 m

Photo taken in the eastern Gulf near the lower boundary of the Upper Abyssal Zone at the intersection of the 2120-m isobath and 87°34.5'W longitude. The organisms in the center and along the upper right margin are probably a species of the Pennatulacea, genus Umbellula. The sediments are a very fine silty clay that has accumulated here below the east wall of the trough of DeSoto Canyon. The stippled effect of the sediment surface may be due to the movements of echinoids of the genus Phormosoma.

B. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 2120 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 1.2 x 1.5 m

Photo taken in the eastern Gulf near the lower boundary of the Upper Abyssal Zone at the intersection of the 2120-m isobath and 87°34.5'W longitude. The organism, a burrower, may be Umbellula. The mound in the background probably is a partially broken down fecal deposit of a large holothurian, probably Paelopatides gigantea that was collected here.

C. Upper Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 2120 m
Cruise: 68A7
Preset focus at 1.5 m.
70-mm film. Scale 1.4 x 1.8 m

Photo taken in the eastern Gulf near the lower boundary of the Upper Abyssal Zone at the intersection of the 2120-m isobath and 87°34.5'W longitude. The source of the mound is unknown. The hole and furrows at the lower right were probably produced by a feeding ophiuroid, such as Bathypectinura heros which was collected here.

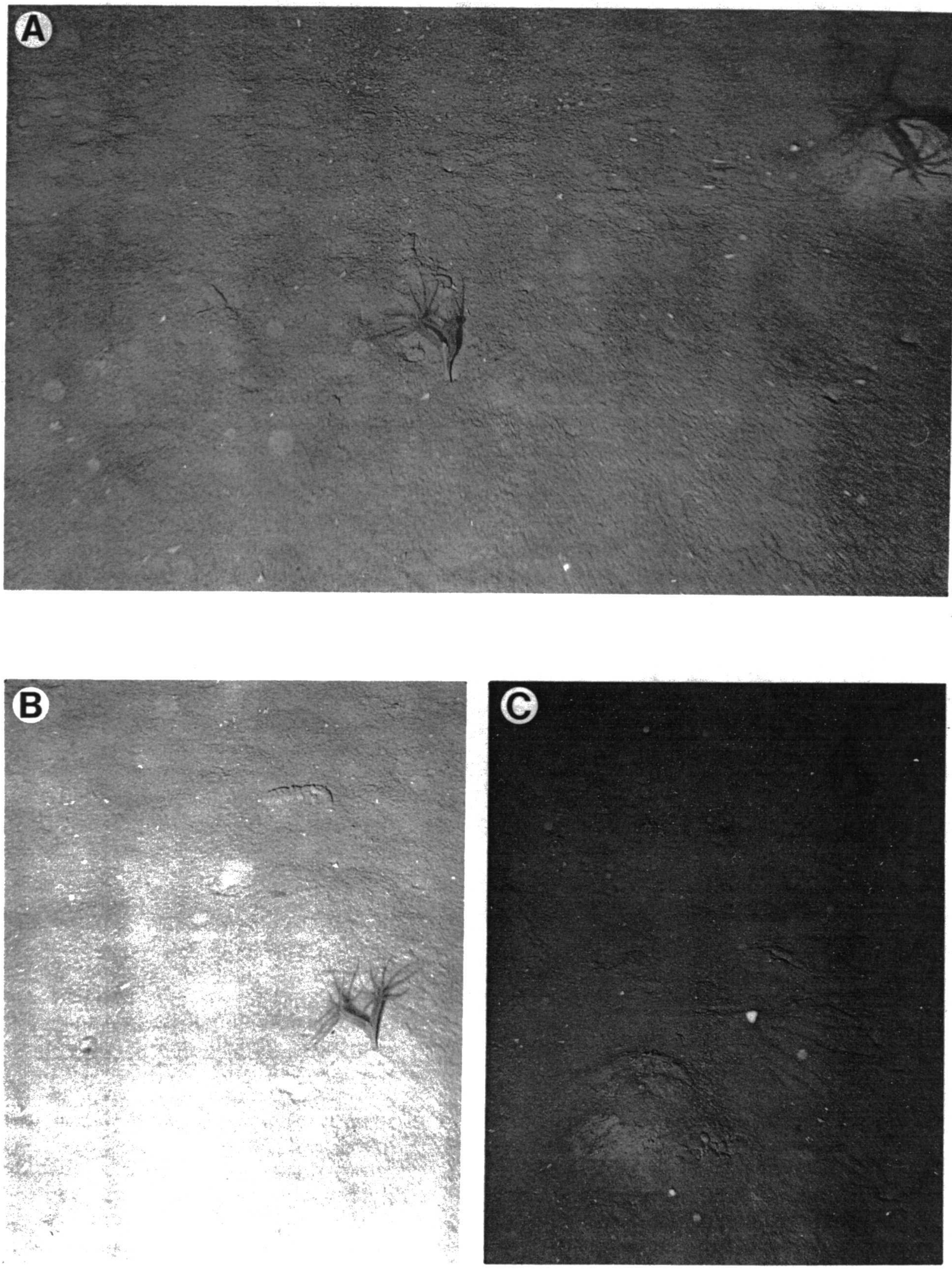

A
B
C

PLATE XLI

A. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2400 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.9 x 2.4 m

Photo taken in the eastern Gulf well below the east wall of the trough of DeSoto Canyon at the intersection of the 2400-m isobath and 87°38'W longitude. The sediments are a very fine silty mud. The organism in the photo center is the holothurian *Peniagone* cf. *islandica*. Much of the irregularity of the sediment cover is due to animal activity. Some of the holes were produced by *Bathypectinura heros*, probably feeding on bivalves that are common here.

B. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2400 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.9 x 2.4 m

Photo taken in the eastern Gulf well below the east wall of the trough of DeSoto Canyon at the intersection of the 2400-m isobath and 87°38'W longitude. Most of the holes here with radiating furrows were produced by ophiuroids. The holothurian is believed to be *Peniagone* cf. *azorica*.

C. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2400 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.7 x 2.1 m

Photo taken in the eastern Gulf well below the east wall of the trough of DeSoto Canyon at the intersection of the 2400-m isobath and 87°38'W longitude. Two echinoids are present. The one to the right is *Hygrosoma petersii*. A small *Peniagone* can be seen to the lower left. Ophiuroid feeding holes are common. The S-shaped cord seen in the lower right and elsewhere is fecal material, probably from the holothurians.

D. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2400 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.9 x 2.4 m

Photo taken in the eastern Gulf well below the east wall of the trough of DeSoto Canyon at the intersection of the 2400-m isobath and 87°38'W longitude. The echinoid *Hygrosoma petersii* can be seen to the left. The cords of fecal material around the light-colored mound have been produced by this species. Two very large ophiuroids, probably *Bathypectinura* can be seen in the background. It appears the photo covers part of a ridge or mound with its trough to the left. Again feeding holes of ophiuroids are common.

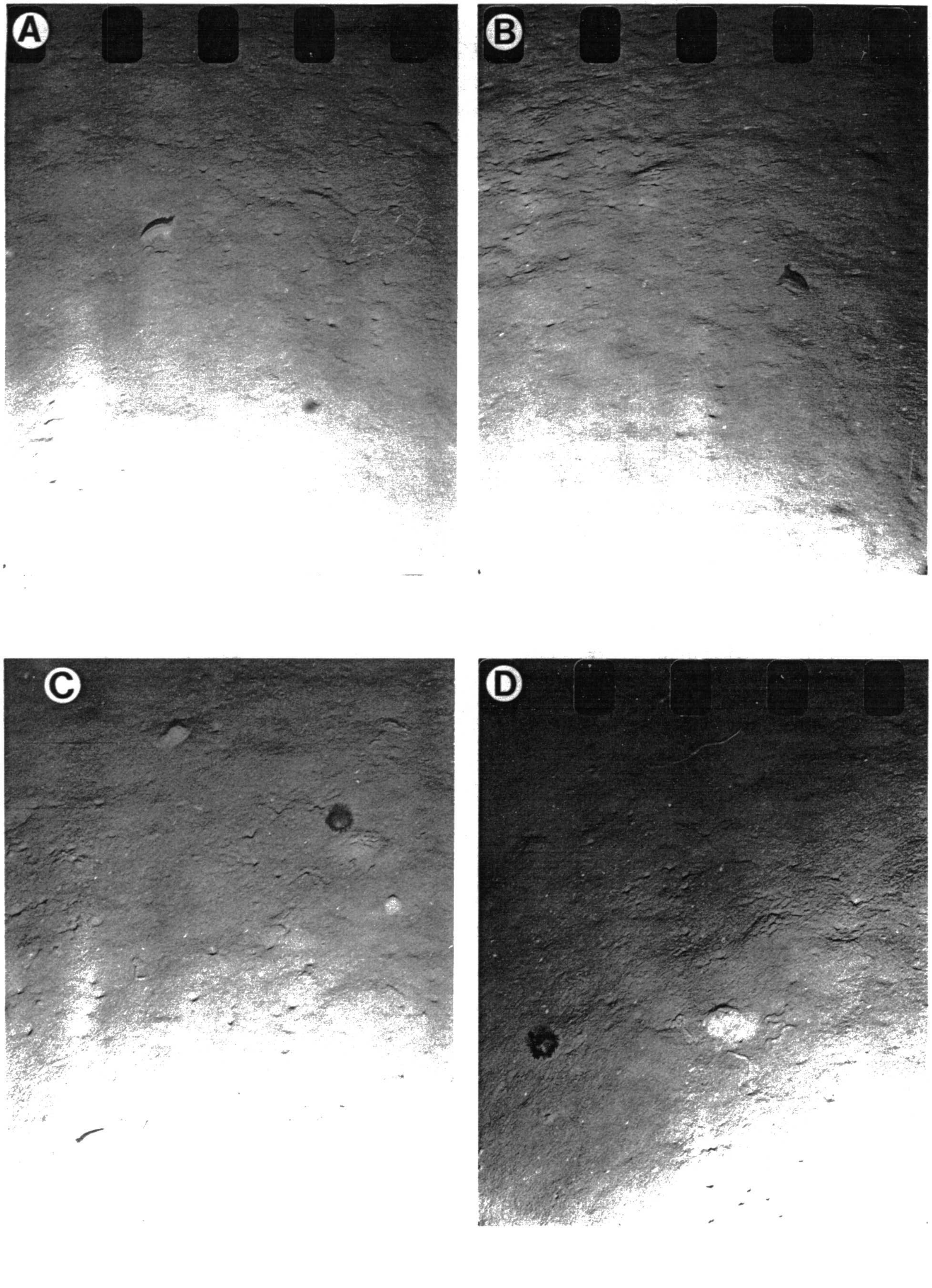

A
B
C
D

PLATE XLII

A. B. C. D.

Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2400 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scales 1.7 x 2.1 m

These four photos were taken in the eastern Gulf below DeSoto Canyon proper toward the Mississippi Fan at the intersection of the 2400-m isobath and 87°38'W longitude. They depict a Bathypectinura heros feeding. In "A" it has apparently located a bivalve (?). Here we can also see marks left by its arms as it locomotes. In "B" it is sending an arm down around its prey. In "C" the arm has penetrated the sediment bed up to the body disk. Here also we see Phormosoma placenta. In "D" the ophiuroid is sinking the disk into the sediments over the extended arm preparatory to feeding on its prey, which may be the bivalve Malletia sp. It is this action that produces the characteristic depressions seen, for example, in the upper right of this photo. Note also that photos "C" and "D" appear to be on opposite walls of a ridge.

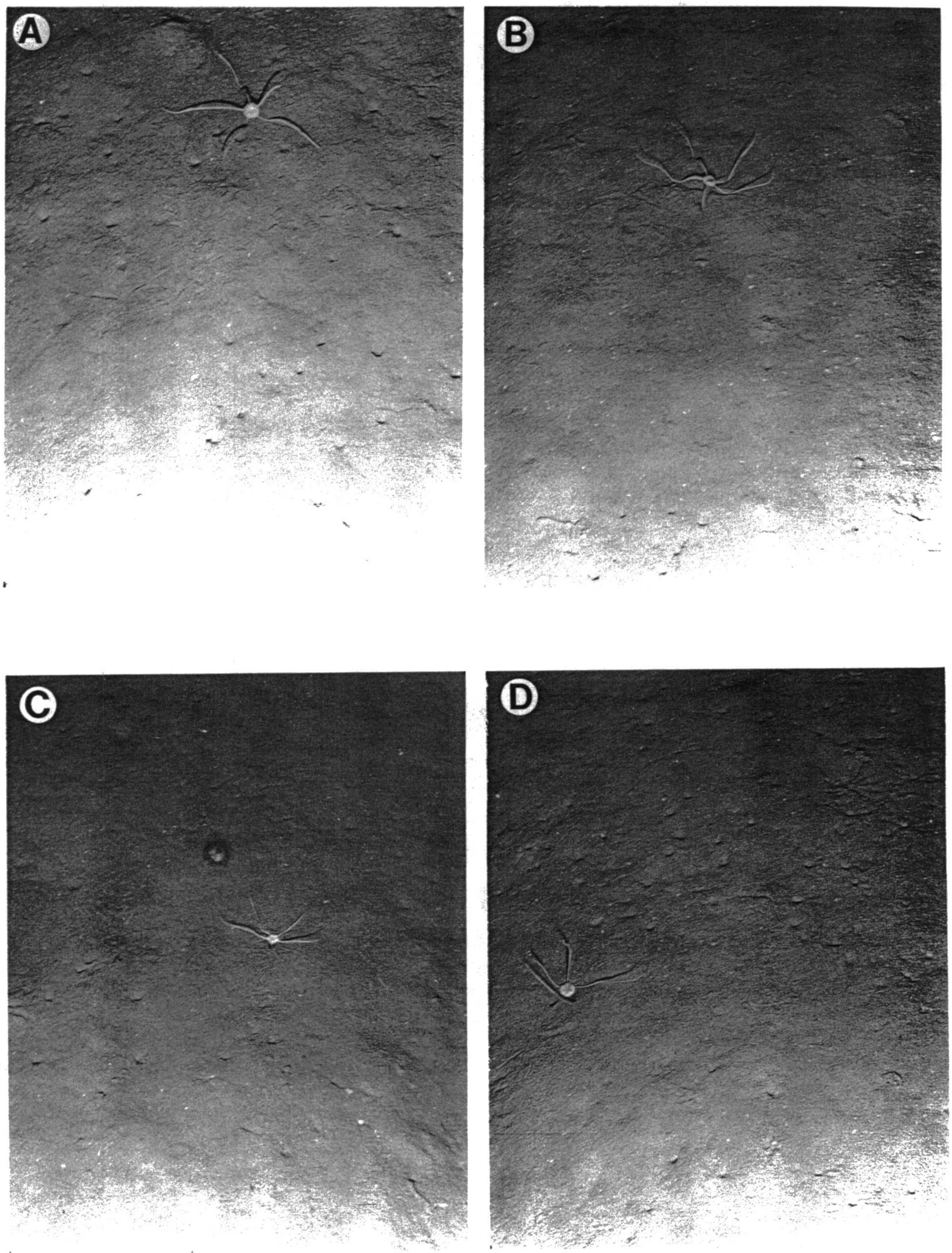

A
B
C
D

PLATE XLIII

A. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2400 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.9 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 2400-m isobath and 87°38'W longitude. Very irregular surface, probably resulting from slumping. The level areas are covered with dark-colored, very fine-grained material. The small depressions on the surface are probably caused by feeding ophiuroids.

B. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2400 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 2400-m isobath and 87°38'W longitude. Note the coiled fecal deposits of the large holothurian *Psychropotes depressa*. The one on the left is very fresh.

C. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2400 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf below the east wall of the trough of DeSoto Canyon at the intersection of the 2400-m isobath and 87°38'W longitude. Note the sea cucumber *Psychropotes depressa* in the upper right. The fecal coil in the lower left has undergone some deterioration.

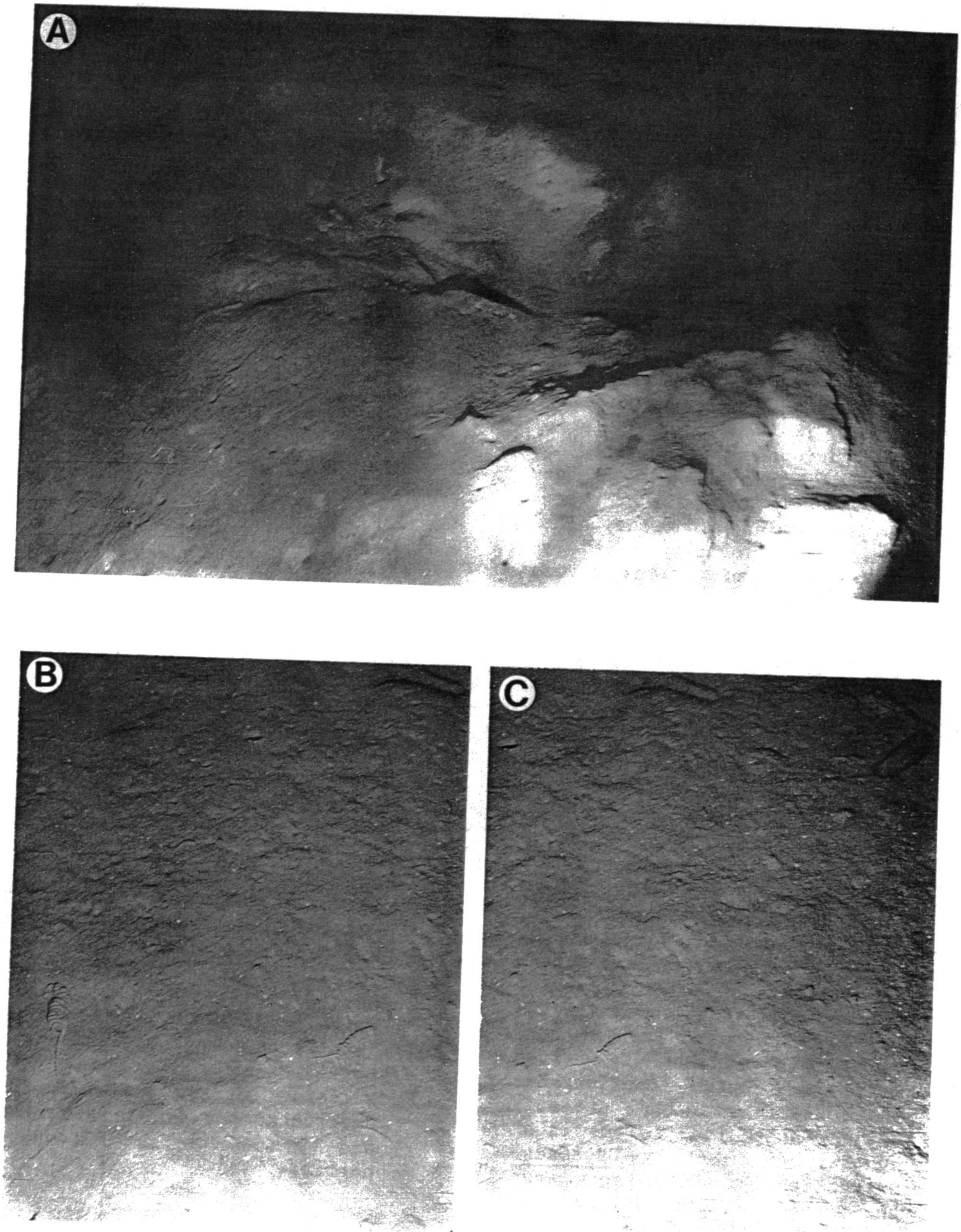

A
B
C

PLATE XLIV

A. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2600 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.6 x 2.0 m

Photo taken in the eastern Gulf near the lower boundary of the Upper Abyssal Zone at the intersection of the 2600-m isobath and 87°26'W longitude. This is well below the east wall of DeSoto Canyon's trough and near the junction with the Mississippi Fan. The source of the large mound surrounded by a ring of holes is unknown. Note the one in the lower left with a starfish depression on the top. The latter was probably made by Dytaster insignis, which was collected here.

B. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2600 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.1 x 1.4 m

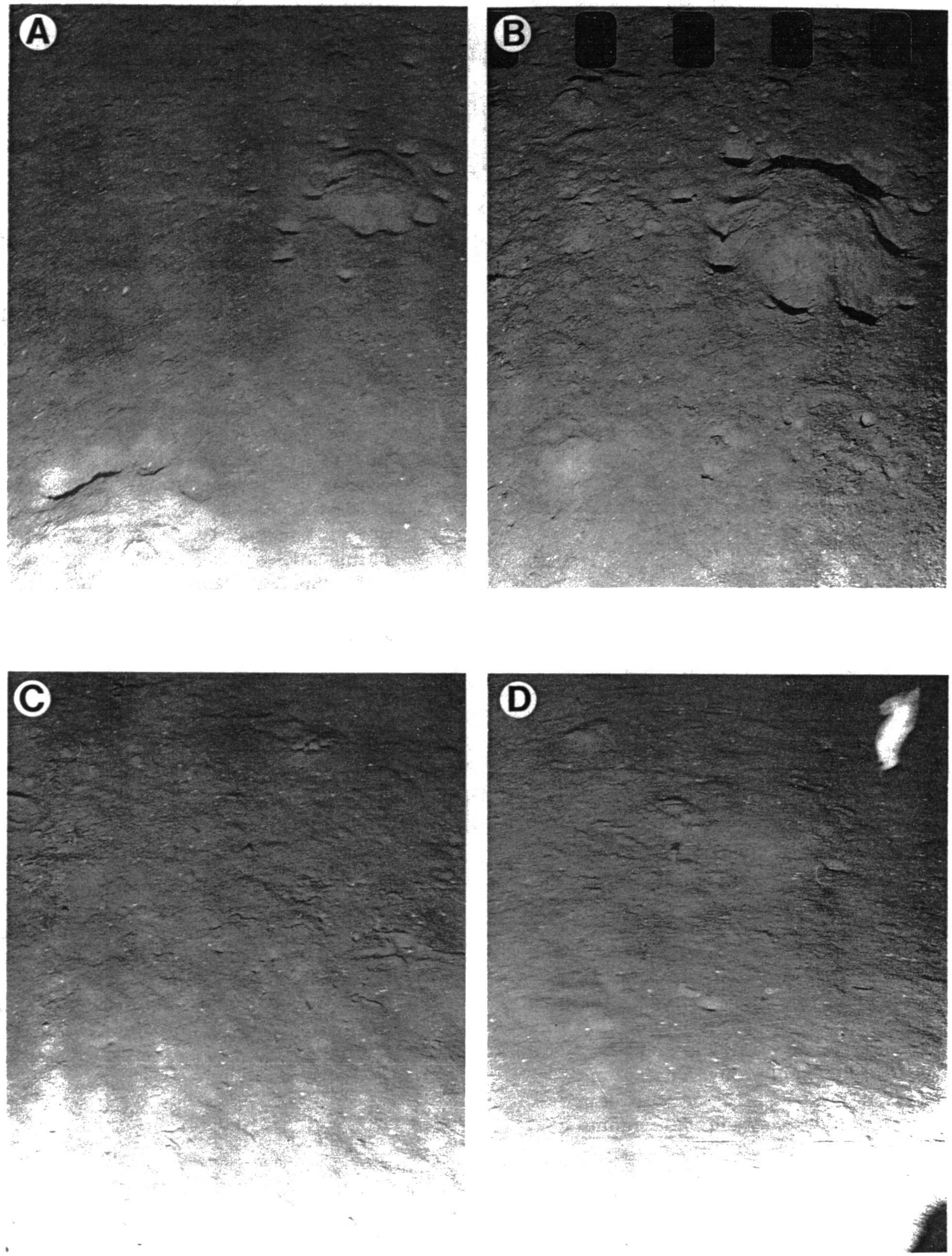
Photo taken in the eastern Gulf near the lower boundary of the Upper Abyssal Zone at the intersection of the 2600-m isobath and 87°26'W longitude. This is another view of the structure shown in "A".

C. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2600 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.6 x 2.0 m

Photo taken in the eastern Gulf near the lower boundary of the Upper Abyssal Zone at the intersection of the 2600-m isobath and 87°26'W longitude. This area appears to be free of currents. The sediment is a fine silty mud with considerable shell debris. The asteroid feeding depression to the right probably was made by Dytaster insignis. The white spots are the sponge Radiella sol and the brachiopod Chlidonophora incerta.

D. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2600 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.6 x 2.0 m

Photo taken in the eastern Gulf near the lower boundary of the Upper Abyssal Zone at the intersection of the 2600-m isobath and 87°26'W longitude. The white organism in the upper right is the benthopelagic holothurian Scotoanassa sp. The radiating furrow system in the foreground appears to have been made by a protistan (Xenophyophoria).


A
B
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D

PLATE XLV

A. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2600 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.6 x 2.0 m

Photo taken in the eastern Gulf near the lower boundary of the Upper Abyssal Zone at the intersection of the 2600-m isobath and 87°26'W longitude. The sediments here are soft, fine sandy clay that show no evidence of currents. There are numerous feeding depressions of ophiuroids. In addition there are several fecal deposits of holothurians. The holothurian is Peniagone cf. islandica.

B. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2600 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.6 x 2.0 m

Photo taken in the eastern Gulf near the lower boundary of the Upper Abyssal Zone at the intersection of the 2600-m isobath and 87°26'W longitude. This photo was below the east wall of the trough of DeSoto Canyon. Note the holothurian along the right margin. It is probably Peniagone cf. azorica. The asteroid depression was most likely made by Dytaster insignis. Note also feeding depressions of ophiuroids. In this and the other photos on this plate there is a great deal of shell material.

C. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2600 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.9 x 2.4 m

Photo taken in the eastern Gulf near the lower boundary of the Upper Abyssal Zone at the intersection of the 2600-m isobath and 87°26'W longitude. The irregularity of the surface is probably caused by animal activity. Note the asteroid depression above and the Peniagone cf. azorica below right.

D. Mesoabyssal Zone. Horizon C.
Eastern Gulf of Mexico.
DeSoto Canyon area.
Isobath: 2600 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.1 x 1.4 m

Photo taken in the eastern Gulf near the lower boundary of the Upper Abyssal Zone at the intersection of the 2600-m isobath and 87°26'W longitude. The holothurian is Paelopatides cf. gigantea.

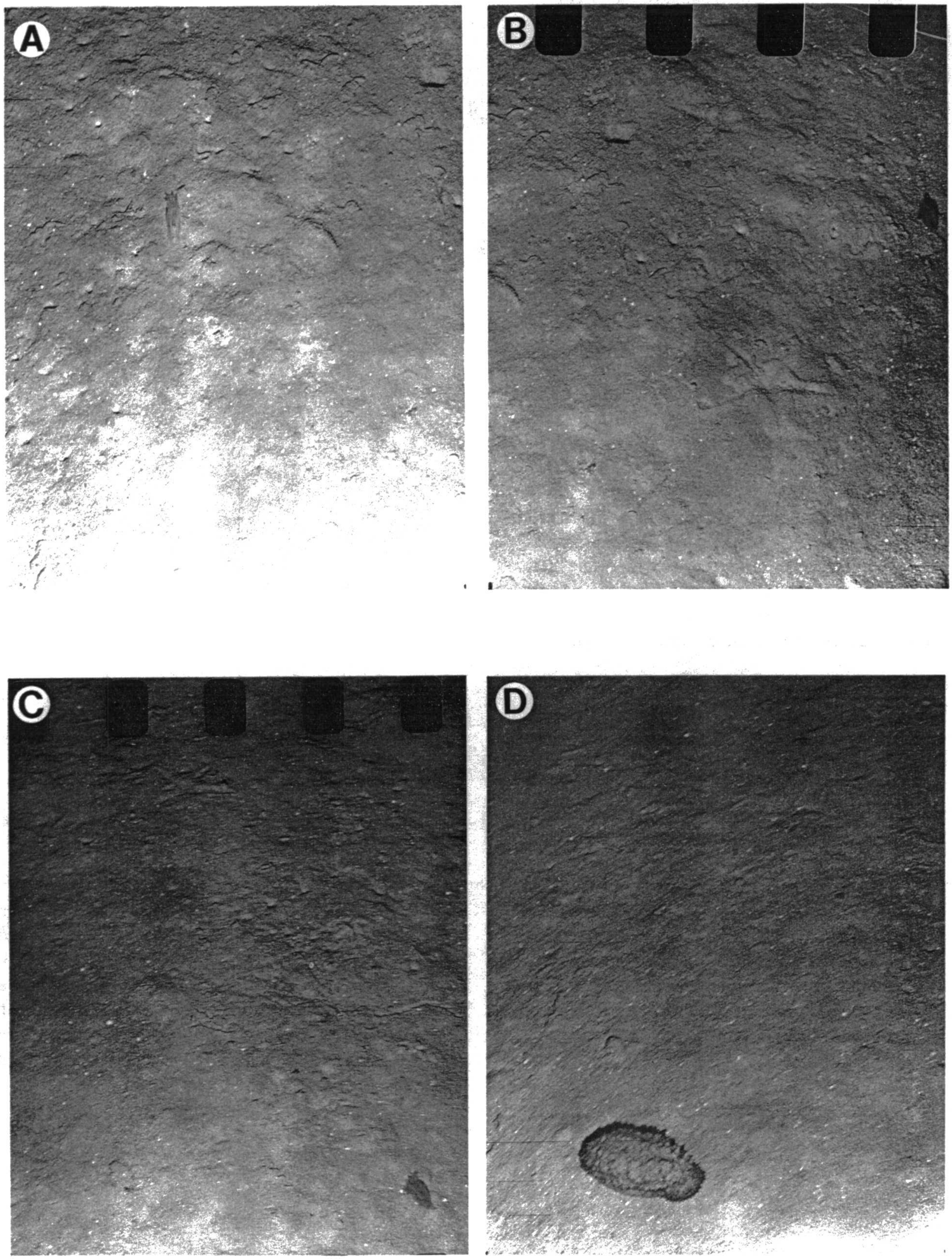
A
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PLATE XLVI

A. Mesoabyssal Zone. Horizon D.
Eastern Gulf of Mexico.
Isobath: 3100 m
Cruise: 69A13
Preset focus at 1.5 m.
35-mm film. Scale 0.7 x 1.1 m

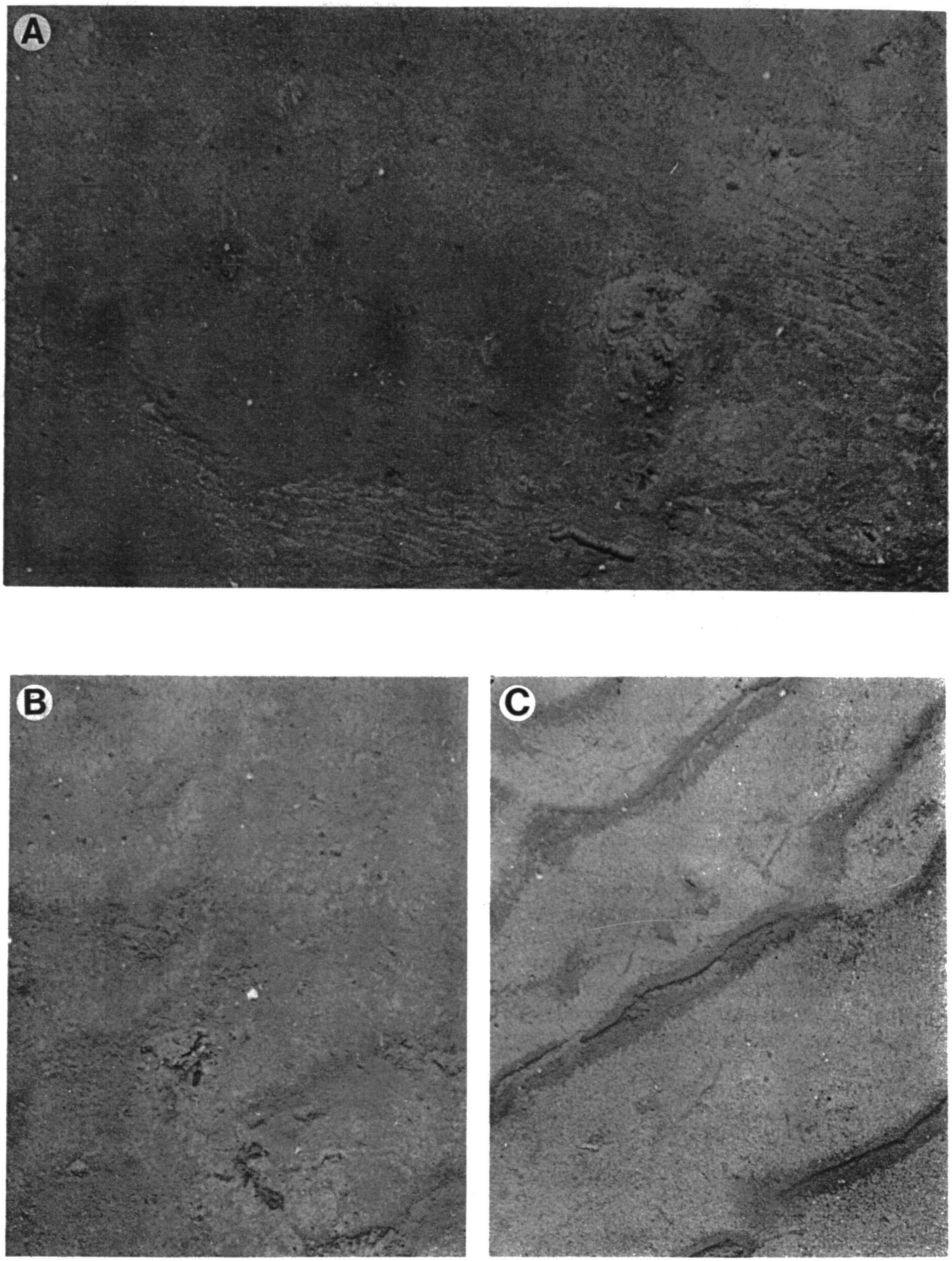
Photo taken in the eastern extension of the Mississippi Fan at the intersection of the 3100-m isobath and 86°42.5'W longitude. There are faint evidences of ripples in the upper part of this photo. There is uncertainty of origin between water movement and slumping. Nevertheless there is stronger evidence for water movement since this photo was taken near "B" and "C". However, the current was absent or very weak at the time of this photograph. The polychaete worm seen in the lower right is in the family Ampharetidae. Its foraging trails can be seen to the lower left and upper right.

B. Mesoabyssal Zone. Horizon D.
Eastern Gulf of Mexico.
Isobath: 3100 m
Cruise: 69A13
Preset focus at 1.5 m.
35-mm film. Scale 0.6 x 0.7 m

Photo taken in the eastern extension of the Mississippi Fan at the intersection of the 3100-m isobath and 86°42.5'W longitude. Faint ripples suggest the presence of an intermittent current.

C. Mesoabyssal Zone. Horizon D.
Eastern Gulf of Mexico.
Isobath: 3100 m
Cruise: 69A13
Preset focus at 1.5 m.
35-mm film. Scale 0.6 x 0.7 m

Photo taken in the eastern extension of the Mississippi Fan at the intersection of the 3100-m isobath and 86°42.5'W longitude. Pronounced ripples with a sandy covering suggest the presence of a strong current. Bottom currents have been recorded in this area.


A
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C

PLATE XLVII

A. Mesoabyssal Zone. Horizon D.
Eastern Gulf of Mexico.
Isobath: 3100 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf on the Mississippi Fan west of the Florida Escarpment at the intersection of the 3100-m isobath and 86°35'W longitude. There is some evidence of a weak current here. The holothurian is _Paelopatides_ cf. _gigantea_ with its feeding trail. The round objects below the holothurian are sponges of the _Radiella sol_ type. The track at above right was probably made by a scaphopod. The mound to the left of center is a deteriorating fecal mound of _Paelopatides_. The asteroid depression was probably made by _Dytaster insignis_.

B. Mesoabyssal Zone. Horizon D.
Eastern Gulf of Mexico.
Isobath: 3100 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

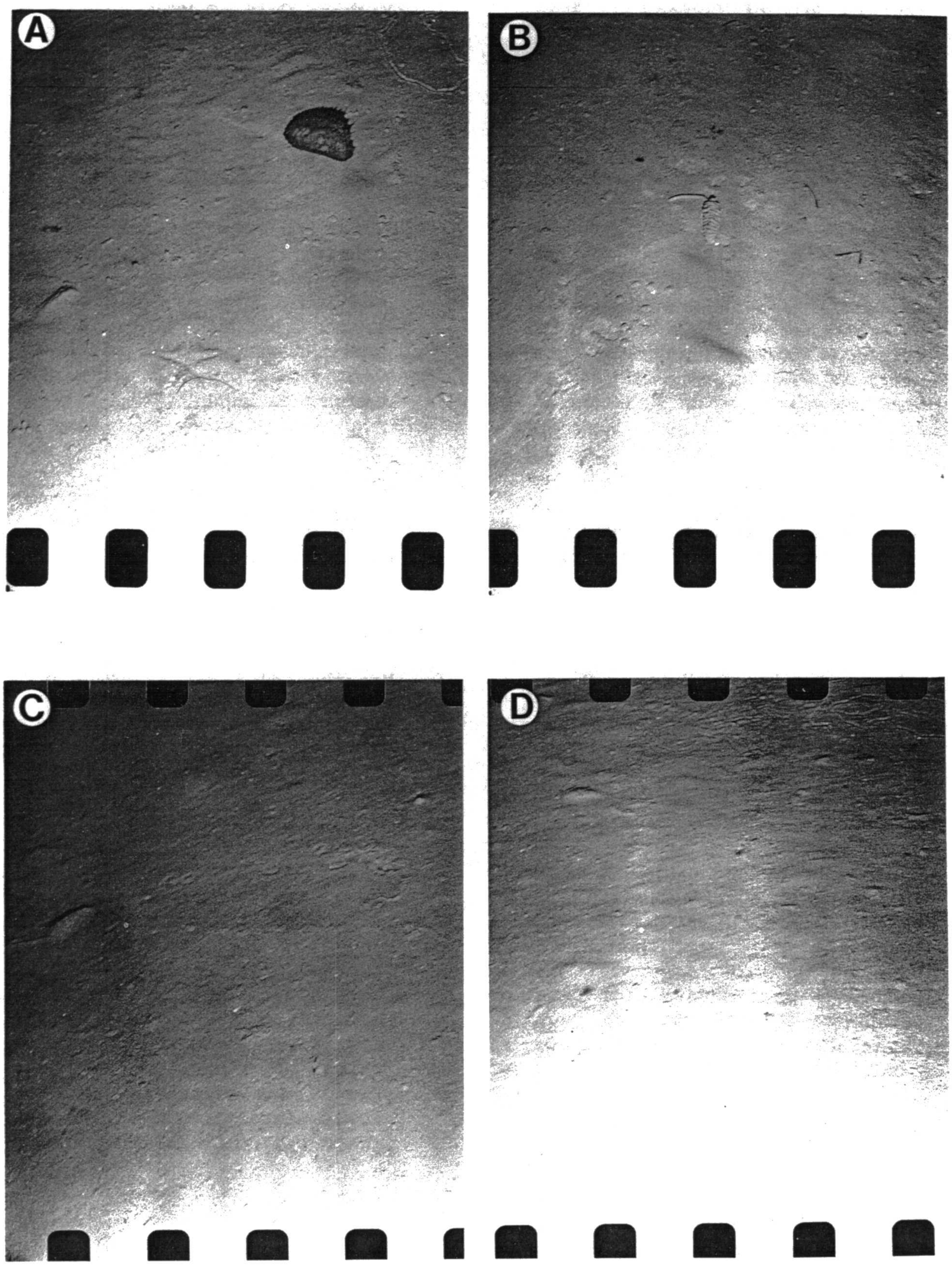
Photo taken in the eastern Gulf on the Mississippi Fan west of the Florida Escarpment at the intersection of the 3100-m isobath and 86°35'W longitude. Note the fresh fecal deposit of _Paelopatides_ with feeding trail leaving it. Note the round sponges and low mound, which is probably a fecal deposit covered by moving sand.

C. Mesoabyssal Zone. Horizon D.
Eastern Gulf of Mexico.
Isobath: 3100 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf on the Mississippi Fan west of the Florida Escarpment at the intersection of the 3100-m isobath and 86°35'W longitude. Note to the left the intermediate stage of reduction of the fecal deposit of _Paelopatides_ and its incorporation into the sediment bed.

D. Mesoabyssal Zone. Horizon D.
Eastern Gulf of Mexico.
Isobath: 3100 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern Gulf on the Mississippi Fan west of the Florida Escarpment at the intersection of the 3100-m isobath and 86°35'W longitude. Several fecal deposits in final stages of reduction and incorporation.


A
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A. Mesoabyssal Zone. Horizon D.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3100 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern extension of the Mississippi Fan below DeSoto Canyon at the intersection of the 3100-m isobath and 86°35'W longitude. The sediments here have a high level of quartz sand (!) of unknown origin - possibly off the west coast of Florida. This is just west of the Florida Escarpment. It is evident that the area is swept by currents from time to time. The trail is made by the scaphopod, Dentalium sp. A dead shell can be seen as the white object along the right border.

B. Mesoabyssal Zone. Horizon D.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3100 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern extension of the Mississippi Fan below DeSoto Canyon at the intersection of the 3100-m isobath and 86°35'W longitude. The sediments here are a mixture of quartz sand and clay. The sea bed has been smoothed by currents. The rounded hills at the top may be produced by a bivalve - the white stem projecting from one mound may be a bivalve siphon. For instance, Poromya tornata was collected here. Again we seen the erratic trails of a scaphopod. The low rounded mounds to the right of the hills are sponges (possibly Radiella sol).

C. Mesoabyssal Zone. Horizon D.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3100 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.8 x 2.3 m

Photo taken in the eastern extension of the Mississippi Fan below DeSoto Canyon at the intersection of the 3100-m isobath and 86°35'W longitude. The sediments here have a high level of quartz sand. This photo is remarkable in that it contains plant material (left and right margins and at bottom). This material was very likely brought in by the East Gulf Loop Current that was running strong at the time of this photograph (25 July 1967). Scaphopod trails are evident. The feeding depression of an asteroid can be seen in the photo's upper left quadrant, probably made by Ampheraster alaminos.

D. Mesoabyssal Zone. Horizon D.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3255 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.0 x 1.3 m

Photo taken at about the southernmost extension of the Mississippi Fan and the lower boundary of the Mesoabyssal Zone at the intersection of the 3255-m isobath and 86°09'W longitude. The holothurian is a truly deep-sea species, Benthodytes typica, which is common in this area. There is a surprising amount of shell debris in this area. Currents are known to exist here.

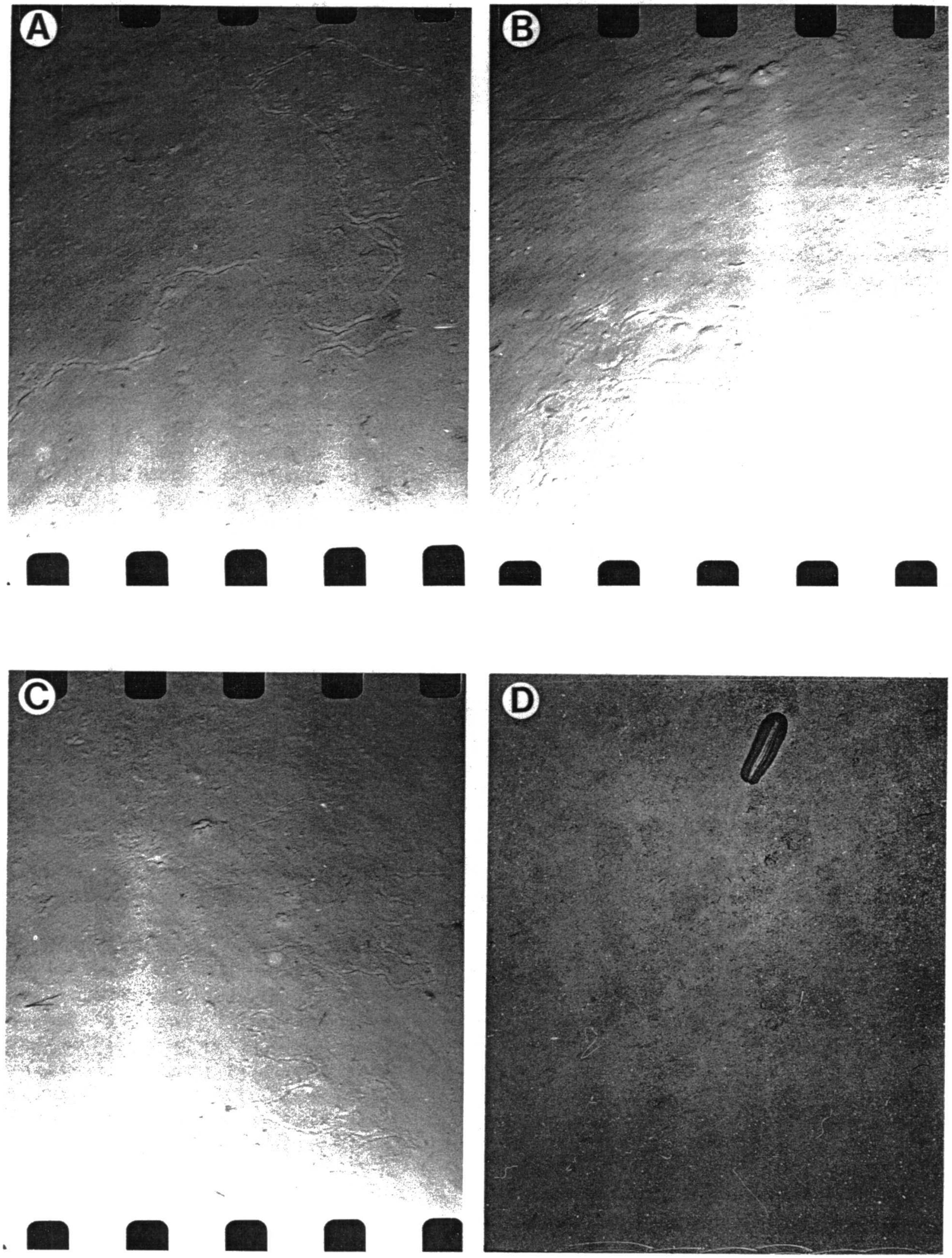
A
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PLATE XLIX

A. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 3240 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.0 x 1.3 m

Photo taken in the eastern Gulf far south on the Mississippi Fan about midway between the Campeche and Florida Escarpments at the intersection of the 3240-m isobath and 86°07'W longitude. Interestingly there appear to be two species of holothurians belonging to the genus Benthodytes in this picture, viz., B. typica above and B. lingua below. The sediment's granular nature is due to small sponges, bivalves, fecal pellets, and worm tubes. There appears to be some weak alignment of mounds, which would indicate water movement in one direction for an appreciable length of time.

B. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 3240 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.0 x 1.3 m

Photo taken in the eastern Gulf far south on the Mississippi Fan about midway between the Campeche and Florida Escarpments at the intersection of the 3240-m isobath and 86°07'W longitude. Note the ophiuroid Ophiomusium planum in the photo center. An asteroid feeding depression can be seen at the top. There are many bivalves and sponges in this photo. The relatively large number of starfish feeding depressions indicates a productive benthic area.

C. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 3240 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.0 x 1.3 m

Photo taken in the eastern Gulf far south of the Mississippi Fan about midway between the Campeche and Florida Escarpments at the intersection of 3240-m isobath and 86°07'W longitude. Note the large asteroid feeding depression along the right border. In the lower left it appears that the starfish is still under the sediments. In all probability it is Dytaster insignis. Sponges, bivalves, fecal deposits of holothurians, and some plant material (upper left quadrant) complete the picture.

D. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 3240 m
Cruise: 68A7
Preset focus at 1.5 m.
35-mm film. Scale 1.0 x 1.3 m

Photo taken in the eastern Gulf far south of the Mississippi Fan about midway between the Campeche and Florida Escarpments at the intersection of 3240-m isobath and 86°07'W longitude. The many asteroid feeding depressions reveal this area to have large populations of bivalves. Note also the plant material (probably a turtle grass leaf) to the right of the center.

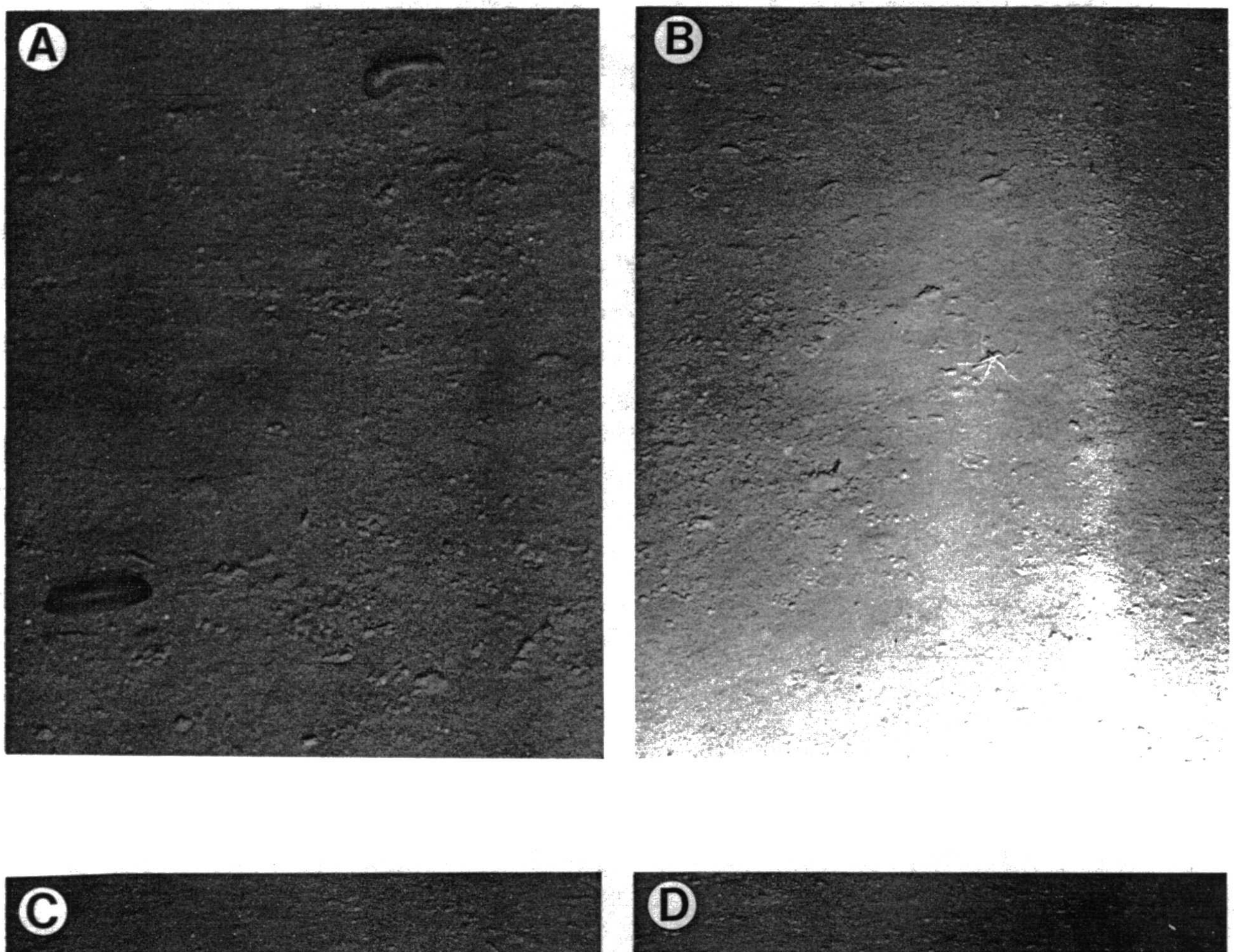
A
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PLATE L

A. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 3255 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 1.0 x 1.3 m

Photo taken in the eastern Gulf along the southernmost extension (25°22.9'N) of the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3255-m isobath and 86°05'W longitude. The 6-rayed starfish is Ampheraster alaminos. Note sponges in the lower right.

B. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 3255 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf along the southernmost extension (25°22.9'N) of the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3255-m isobath and 86°05'W longitude. The ophiuroid is Ophiomusium planum in its typical stance. This species plays the same role in the Gulf ecosystem as Ophiomusium lymani in the western Atlantic off the U.S. East Coast. Note the blade of turtle grass. This position is under the East Gulf Loop Current.

C. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 3255 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 1.0 x 1.3 m

Photo taken in the eastern Gulf along the southernmost extension (25°22.9'N) of the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3255-m isobath and 86°05'W longitude. Here we see a large amount of turtle grass Thalassia brought north out of the Yucatan by the East Gulf Loop Current. This material accounts for the large number of paleotaxodont, deposit-feeding bivalves found in this area.

D. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Isobath: 3255 m
Cruise: 69A13
Preset focus at 2.0 m.
70-mm film. Scale 0.8 x 1.8 m

Photo taken in the eastern Gulf along the southernmost extension (25°22.9'N) of the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3255-m isobath and 86°05'W longitude. The shrimp is the penaeid Hemipenaeus carpenteri. Note the disintegrating fecal deposit that contributes to the granular nature of the sediment here.

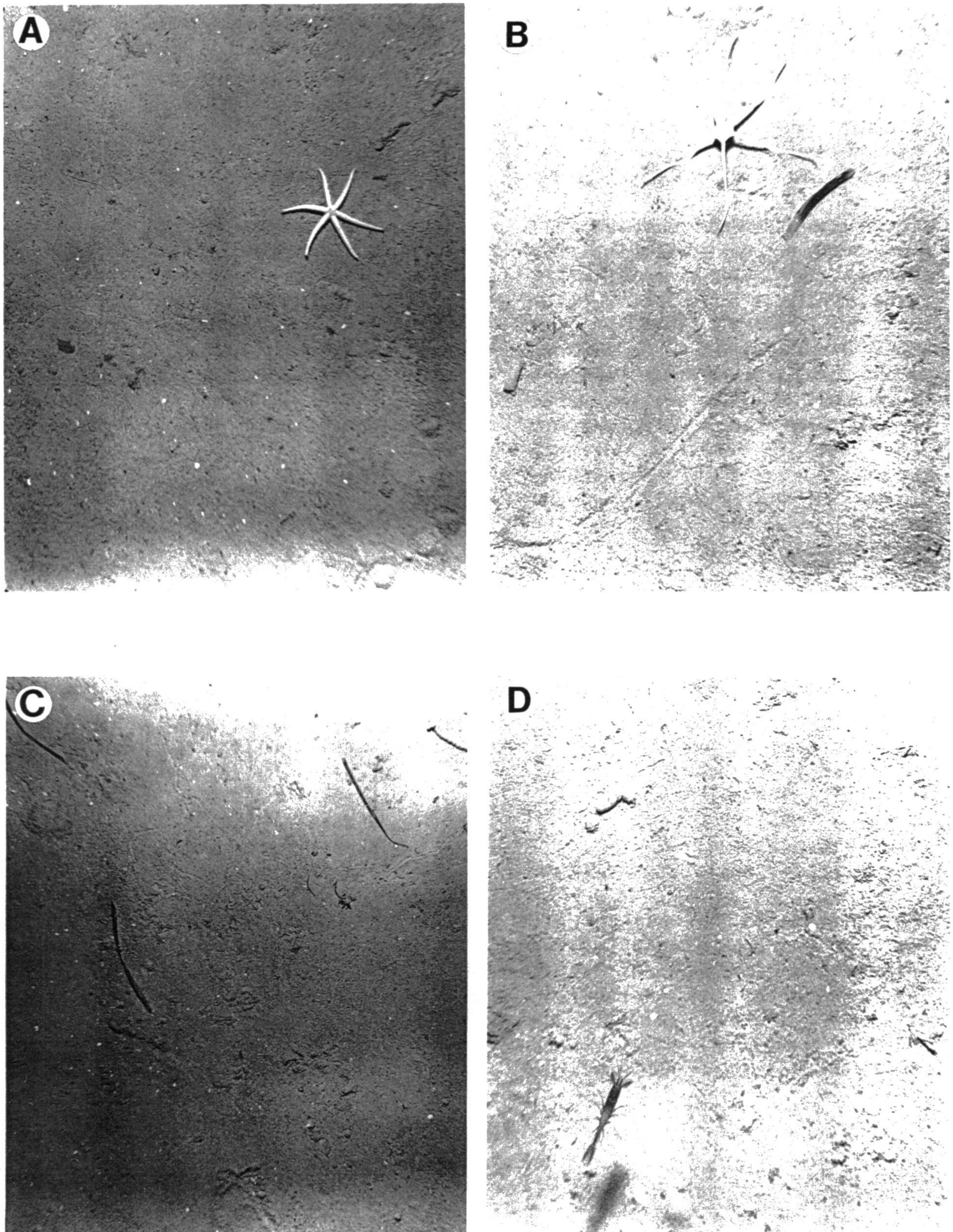
A
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PLATE LI

A. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. This photo shows turtle grass that has been deposited on the bottom after having been brought northward by the Loop Current. Currents probably account for the accumulation of shell material. Low mounds in lower right are the sponge *Radiella sol*.

B. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. This photo shows more turtle grass; shell hash with a large scaphopod shell; and *Radiella sol*.

C. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. This photo shows turtle grass and *Radiella sol*.

D. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. The shell and plant material have collected in a large trough between large ripples.

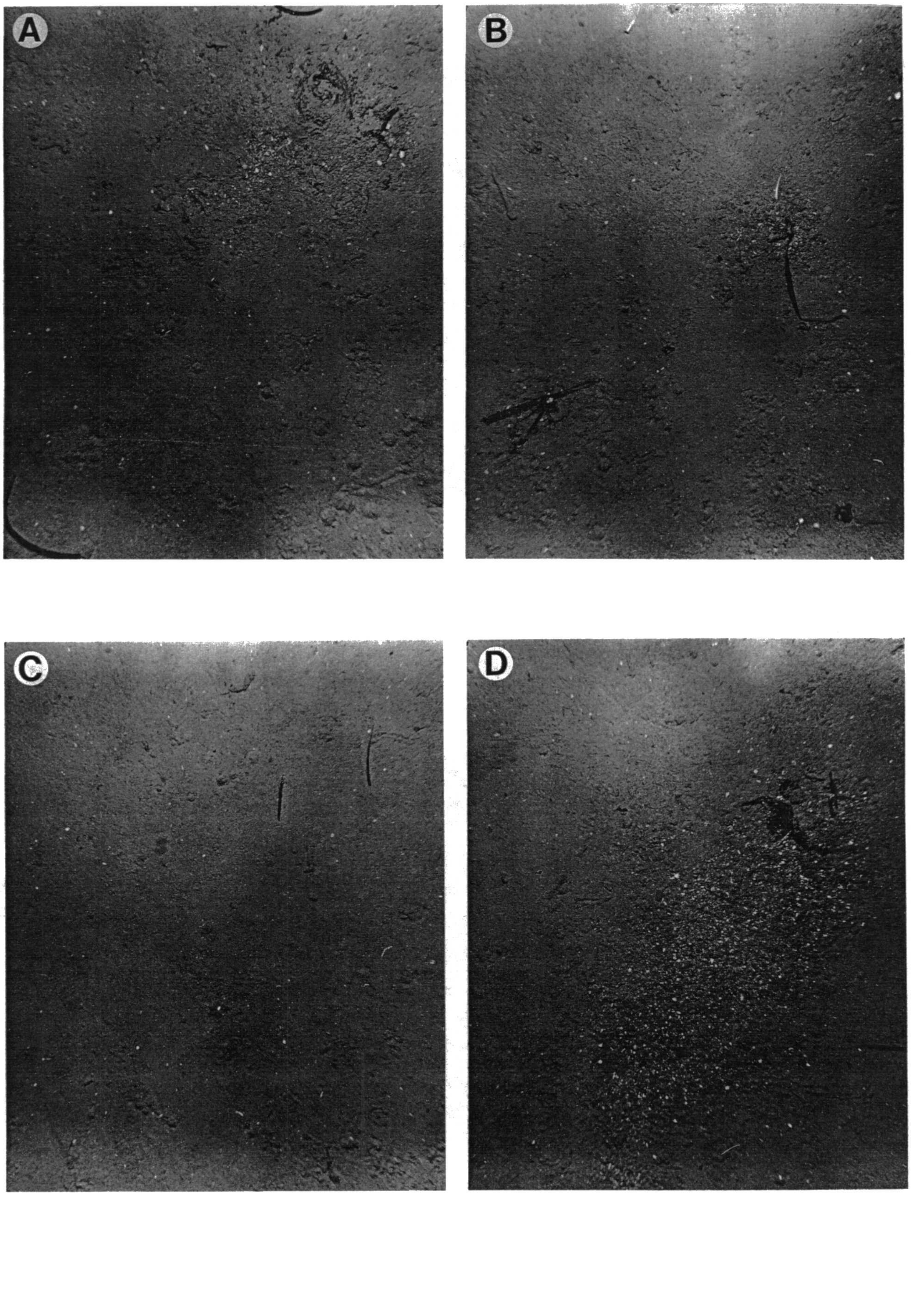
A
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PLATE LII

A. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. The trail running toward the top of the photo is being made by the onuphid polychaete Hyalinoecia tubicola. Decaying Sargassum can be seen at the bottom of the photo and a piece of turtle grass at the top right. There is a great deal of small bioturbation features shown. Sponges are also evident.

B. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. Hyalinoecia tubicola at the lower left. Turtle grass is found at the right.

C. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.4 x 0.5 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. The organism is a tubicolous polychaete belonging to the family Oweniidae (possibly Myriochele sp. A that was collected here).

D. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. The organism in the upper left is a tubicolous polychaete in the family Maldanidae and probably subfamily Eudymerrinae.

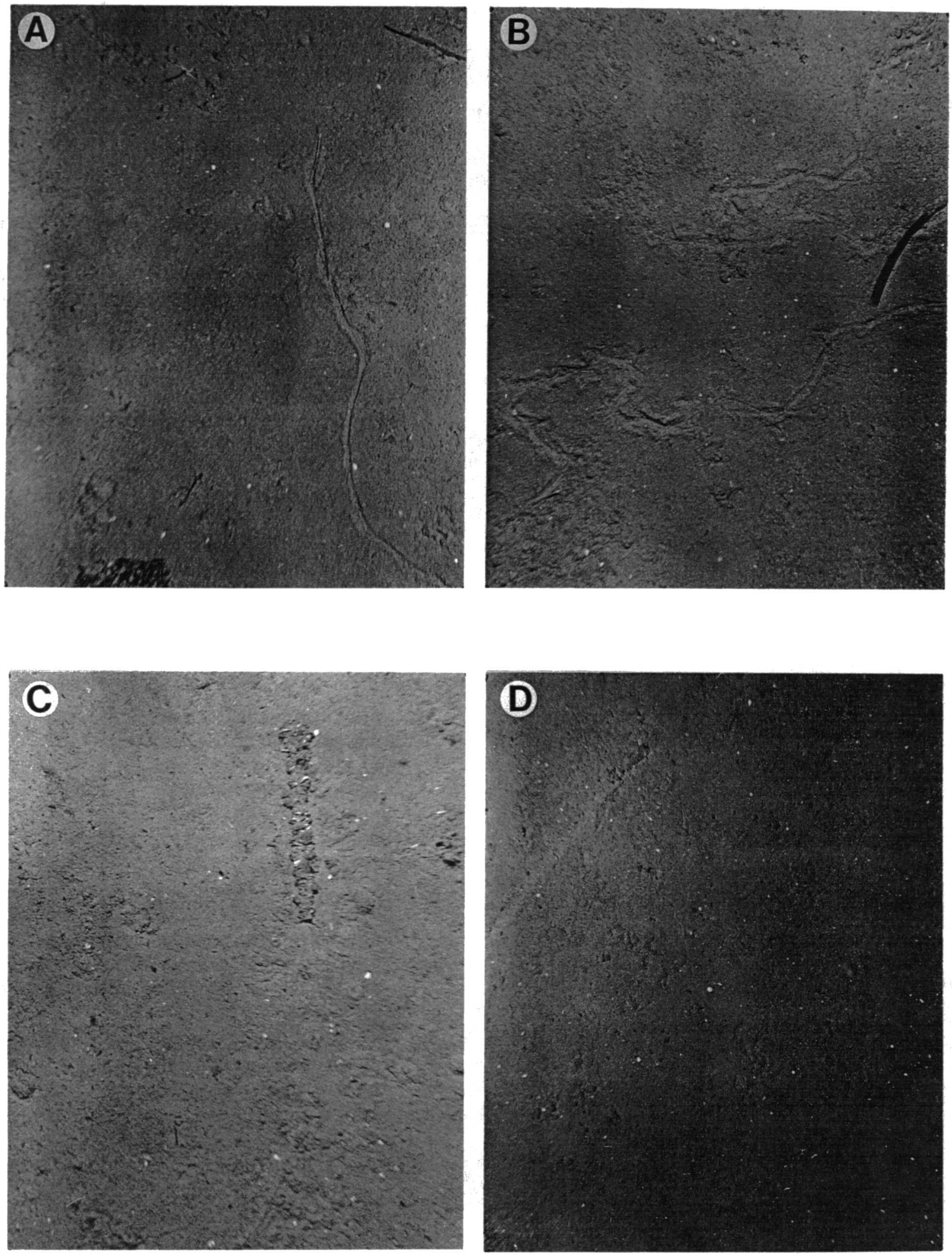
A
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PLATE LIII

A. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. The organism making the trail at the top of the photo is the scaphopod mollusk Dentalium (the species may be meridionale). The trail across the center of the photo was probably made by a polychaete in the family Oweniidae.

B. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. The trails seen here have been made by the scaphopod mollusk, Dentalium meridionale, seen here just left of center.

C. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. The scaphopod mollusk seen along the right margin appears to be Dentalium perlongum. Note the turtle grass near the bottom, which is still semi-bouyant.

D. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.4 x 0.5 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. There is a dead scaphopod shell, probably Dentalium meridionale in the lower left.

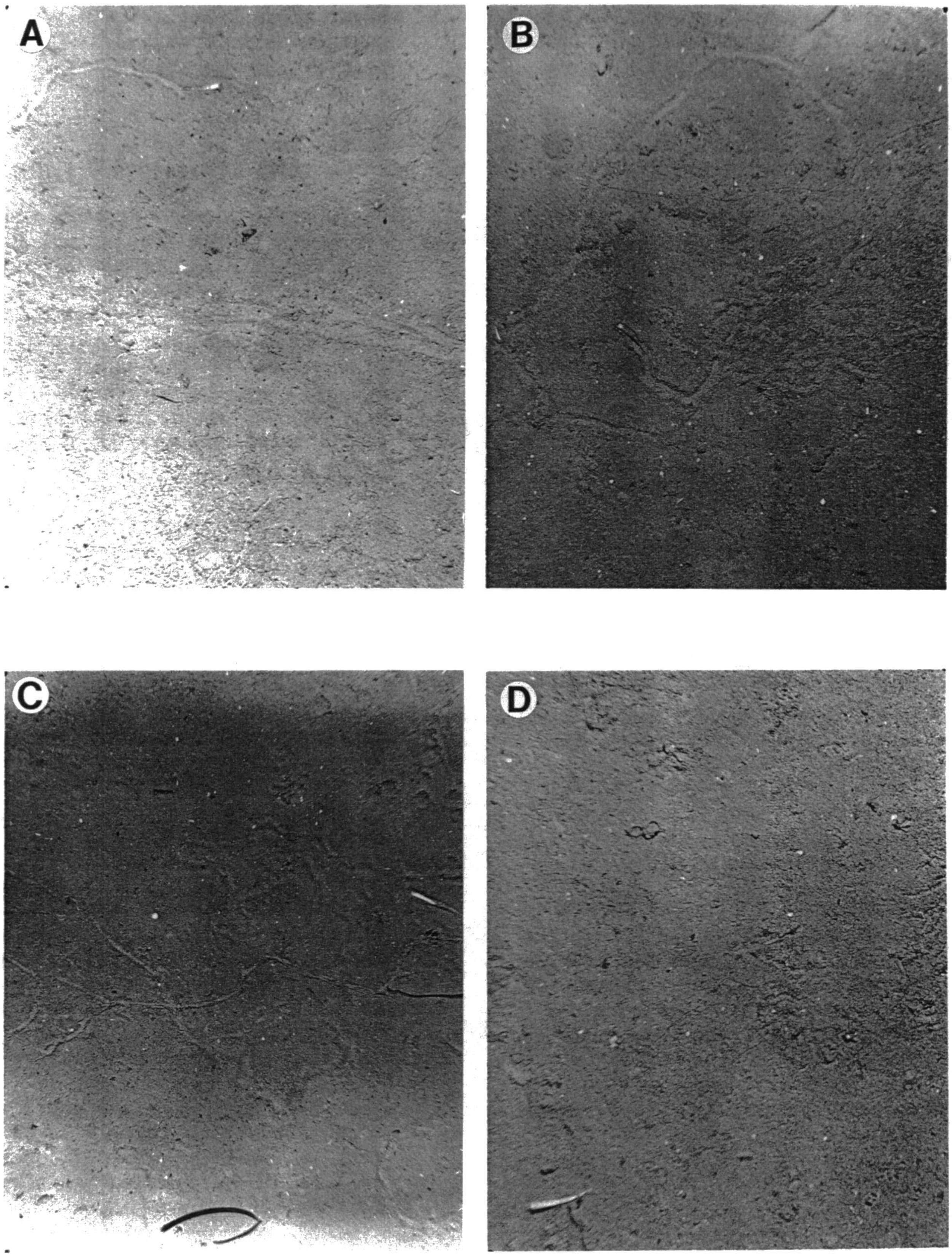
A
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PLATE LIV

A. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. The ophiuroid *Ophiomusium planum* is below. Note its feeding impression above left. In the left upper quadrant there is a disintegrating fecal deposit of *Benthodytes*. Note the *Radiella sol* to the right.

B. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

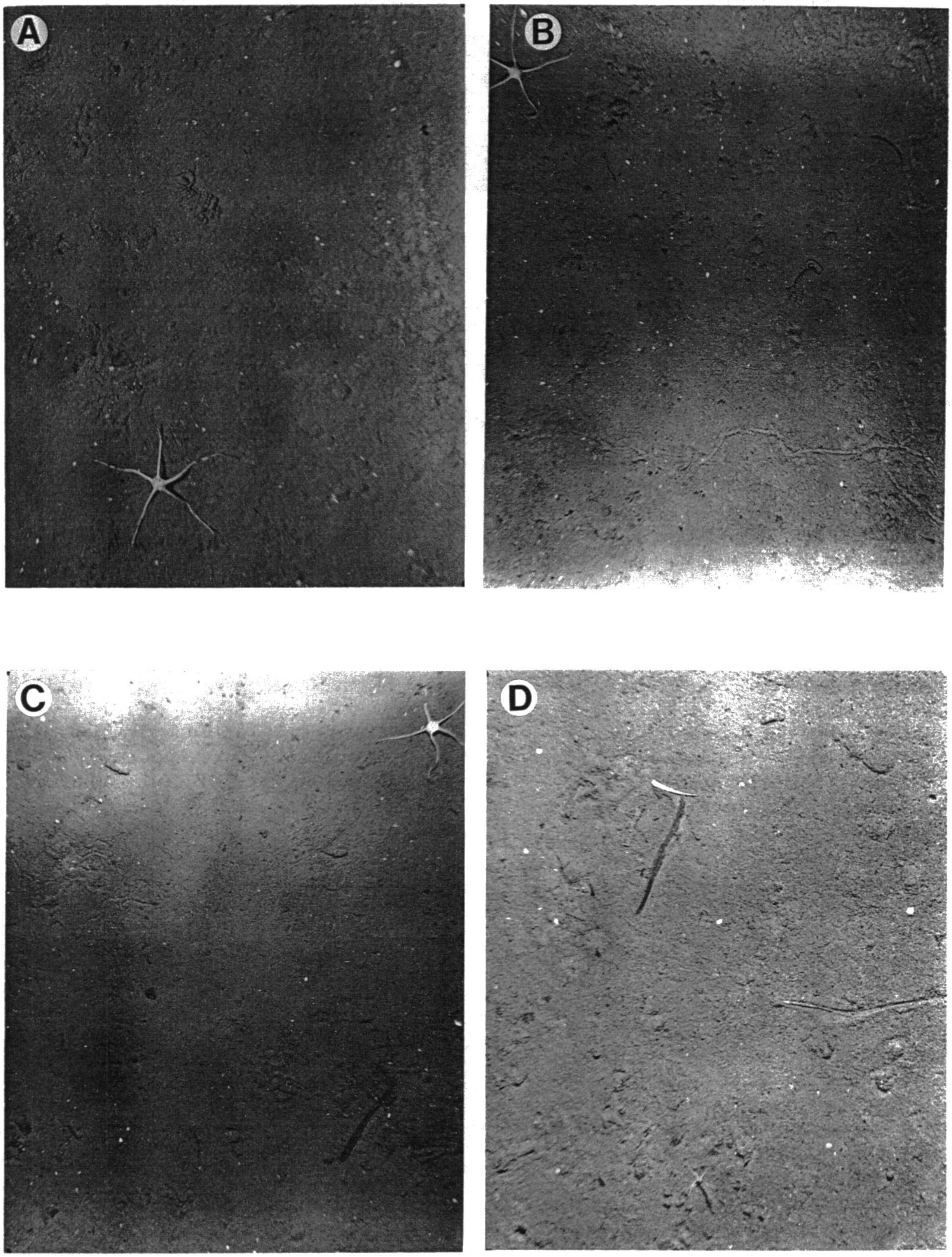
Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. *Ophiomusium planum* are in the upper left. *Radiella sol* are in the central part of the photo. Note also a fresh fecal deposit of *Benthodytes typica*.

C. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.8 x 1.0 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. *Ophiomusium planum* is in the upper right searching for prey. There is turtle grass in the lower right.

D. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.4 x 0.5 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°04'W longitude. The onuphid polychaete *Hyalinoecia tubicola* is making a trail from right to left. A dead scaphopod shell is just above the turtle grass. Note a small ophiuroid which appears to be feeding on plant material at the bottom.


A
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A. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.6 x 0.7 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°06.1'W longitude. Pictures here and in Plate 56 were taken about two nautical miles (roughly 3800 m) west of those in Plates 51-54. Relatively smooth bottom covered with fine-grained mud. A large polychaete annelid worm in the family Maldanidae was moving from right to left and leaving a distinctive banked trail. The worm's hyaline tube differs on the long axis: the anterior 2/3 (visible in photo) is enclosed by a silty cortex encrusted with foraminifera and paleotaxodont shells; the posterior 1/3 is membranous without encrustations.

B. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.6 x 0.7 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°06.1'W longitude. Pictures here and in Plate 56 were taken about two nautical miles (roughly 3800 m) west of those in Plates 51-54. Trail of the maldanid worm seen in "A". The bivalve shell seen in the upper right quadrant is possibly from the paleotaxodont <u>Neilo</u> sp. A.

C. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.5 x 0.6 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°06.1'W longitude. Pictures here and in Plate 56 were taken about two nautical miles (roughly 3800 m) west of those in Plates 51-54. A considerable amount of <u>Thalassia</u> is imported to this region from the south by the Yucatan and Loop Currents.

D. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.5 x 0.6 m

Photo taken in the eastern Gulf far south on the Mississippi Fan between the Campeche and Florida Escarpments at the intersection of the 3250-m isobath and 86°06.1'W longitude. Pictures here and in Plate 56 were taken about two nautical miles (roughly 3800 m) west of those in Plates 51-54. <u>Ophiomusium planum</u> is one of the most common megafaunal species in this area. Its bathymetric range does not overlap to any appreciable extent with that of <u>Bathypectinura heros</u> at shallower depths.

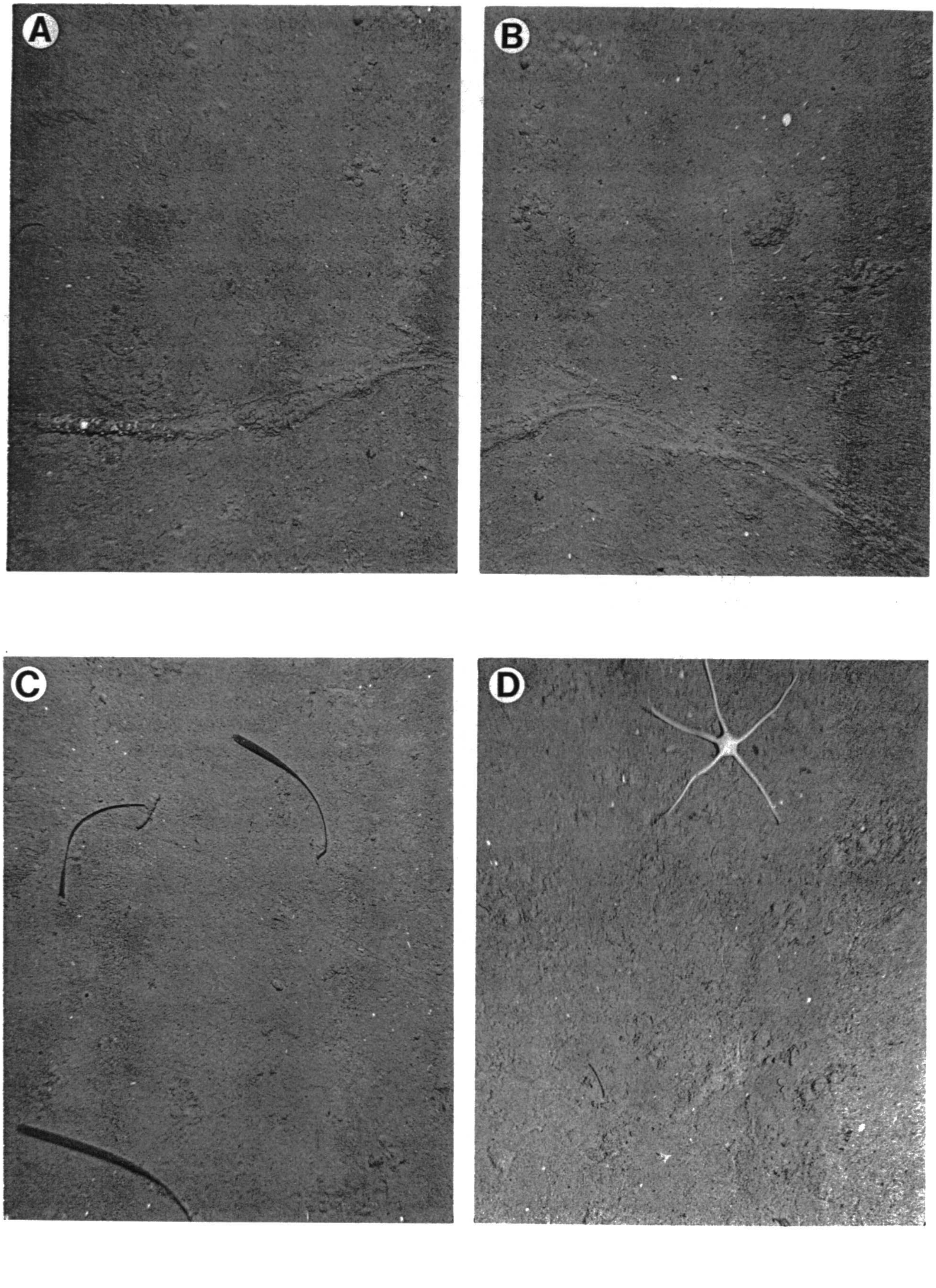

A
B
C
D

PLATE LVI

A. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.5 x 0.6 m

These photos were selected to indicate how abundant Thalassia and other plant materials are in this region. All four of the frames in this plate had one or more blades of turtle grass at the time of the photographing (Oct. 1969). Photo "A" was taken at the intersection of the 3250-m isobath and 86°06.1'W longitude. There is no evidence that a bottom current was flowing at the time the picture was taken. Yet is is known that a strong current exists less than one nautical mile away. We have evidence, however, that the current meanders.

B. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.5 x 0.6 m

Photo "B" was taken at the intersection of the 3250-m isobath and 86°06.1'W longitude. This photo was selected to show turtle grass, sponges along the right margin, and the feeding impression of Dytaster insignis. Note scattered pteropod shells. The benthic fauna is generally rich where pteropod shells and plant material come to rest on the bottom.

C. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.5 x 0.6 m

Photo "C" was taken at the intersection of the 3250-m isobath and 86°06.1'W longitude. This photo shows turtle grass, a dead shell of a paleotaxodont (possibly Neilo sp. A) and to the right of the grass a sponge - perhaps of the genus Thenea (common in deep water).

D. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 69A13
Preset focus at 1.7 m.
70-mm film. Scale 0.5 x 0.6 m

Photo "D" was taken at the intersection of the 3250-m isobath and 86°06.1'W longitude. More turtle grass and moderate bioturbation.

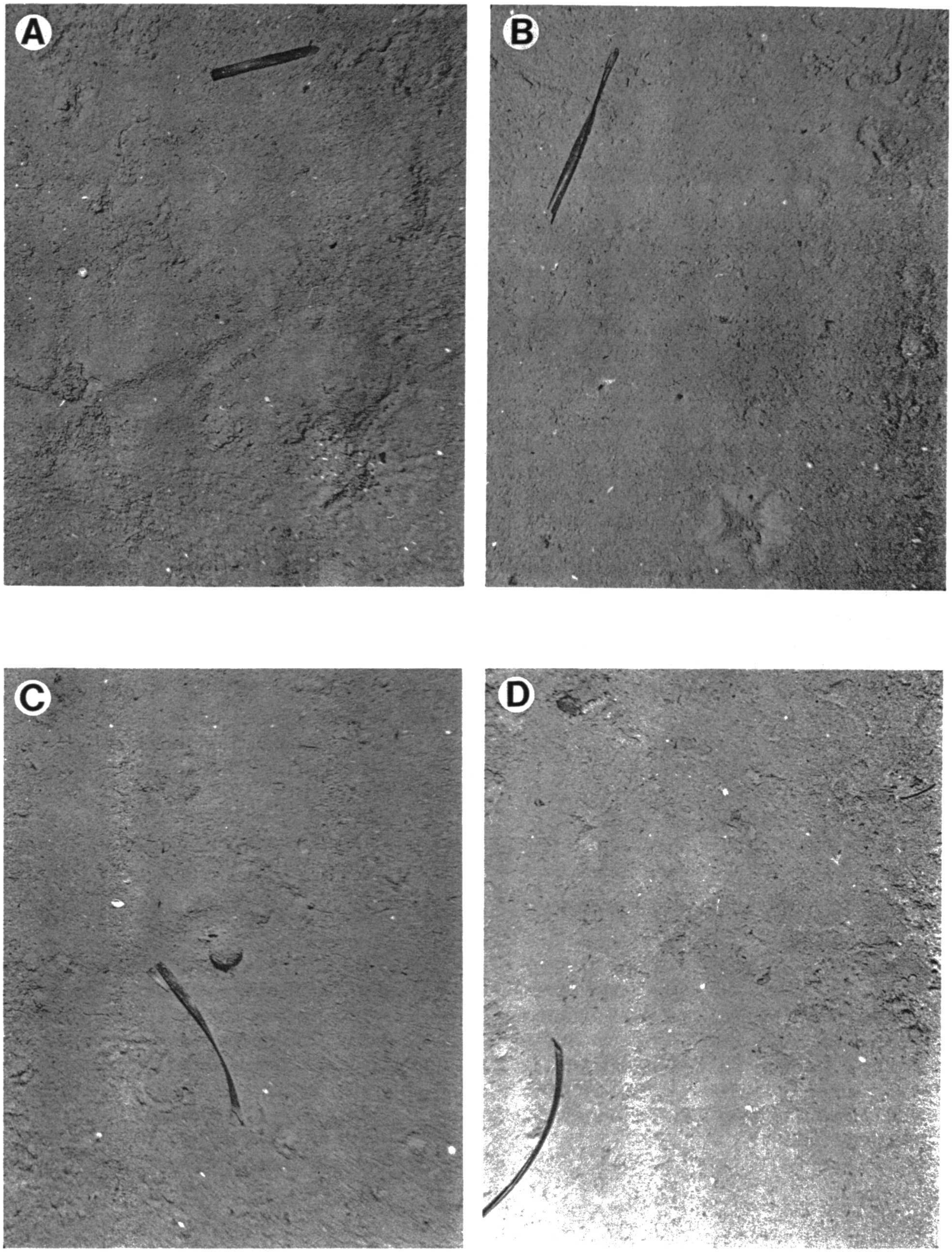

A
B
C
D

PLATE LVII

A. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 70A10
Preset focus at 1.5 m.
70-mm film. Scale 1.0 x 1.2 m

Photo taken in the eastern Gulf in what we refer to as the Ironstone Region at the intersection of the 3250-m isobath and 86°05.3'W longitude. A very irregular sloping area rich in exposed ironstone. Bottom currents up to 0.19 cm/sec (0.32 kt) are known to exist here. It appears to have been flowing at the time of photograph from the lower left to the upper right. Six-rayed starfish in the sandy channel is the new species Ampheraster alaminos. A clump of decaying Sargassum appears in the upper right quadrant. The current has winnowed out a large number of dead shells.

B. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 70A10
Preset focus at 1.5 m.
70-mm film. Scale 1.0 x 1.2 m

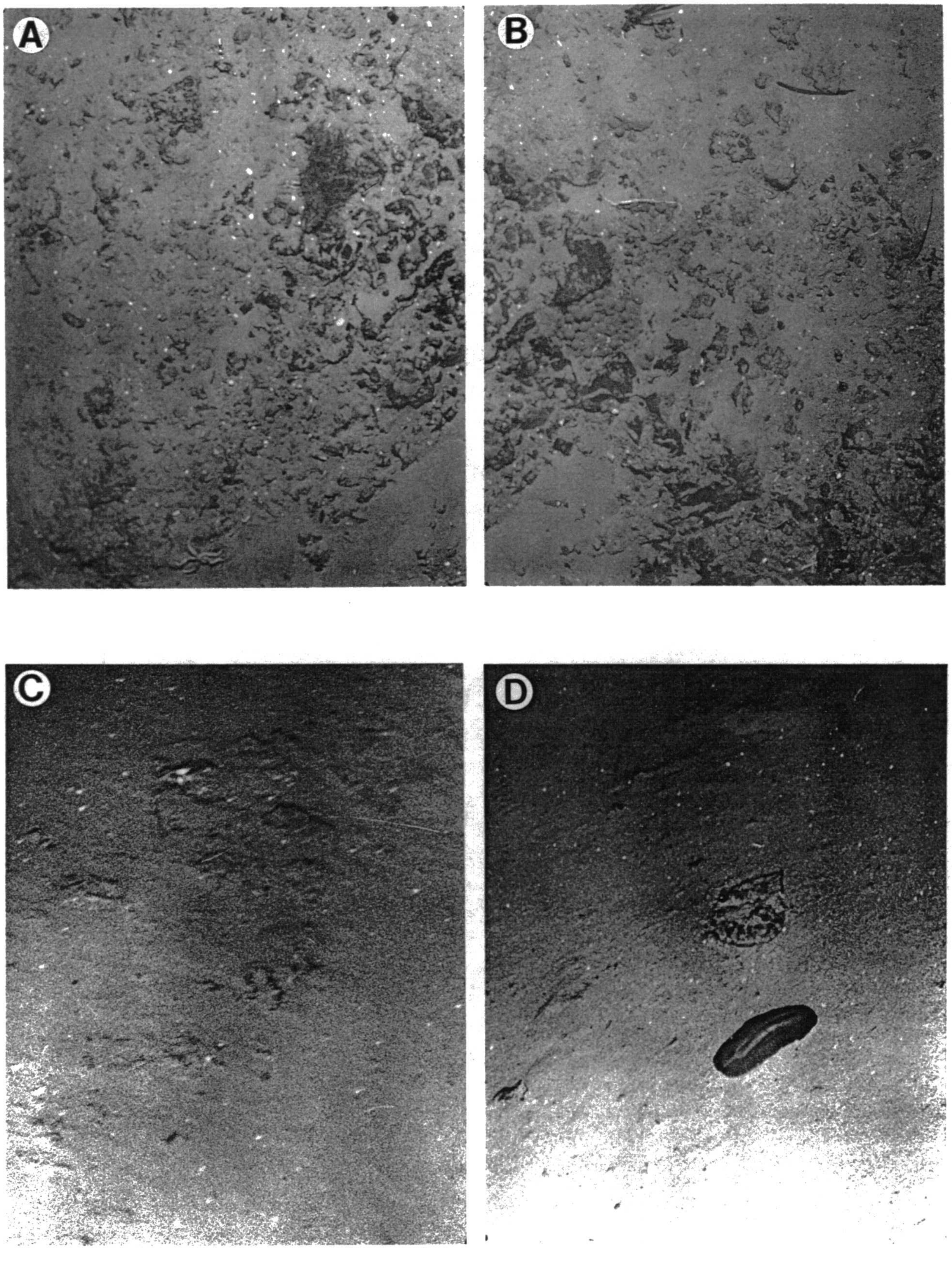
This photo is essentially a continuation of "A". The circular patch of spheroids in the center of the photo appears to be the sponge Tisiphonia. Numerous bits of plant material and numerous shells occur among the large pieces of ironstone that are swept clean by the current.

C. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3300 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 0.7 x 0.9 m

Photo taken 3 years prior to those in "A" and "B" above and about 0.3 nautical miles to the east. Here we see imbedded pieces of ironstone. All of the ironstone in this region supported a diverse group of small epifaunal species. Lineations and scour reveal the strength of the current.

D. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3300 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.1 x 1.4 m

Photo taken 3 years prior to those in "A" and "B" above and about 0.3 nautical miles to the east. Clear evidence of a current exists in the form of sediment alignment and streamlining around even small structures of low relief. The Benthodytes typica (sea cucumber) is itself hugging close to the seabed in an apparent attempt to preclude rolling.



A
B
C
D

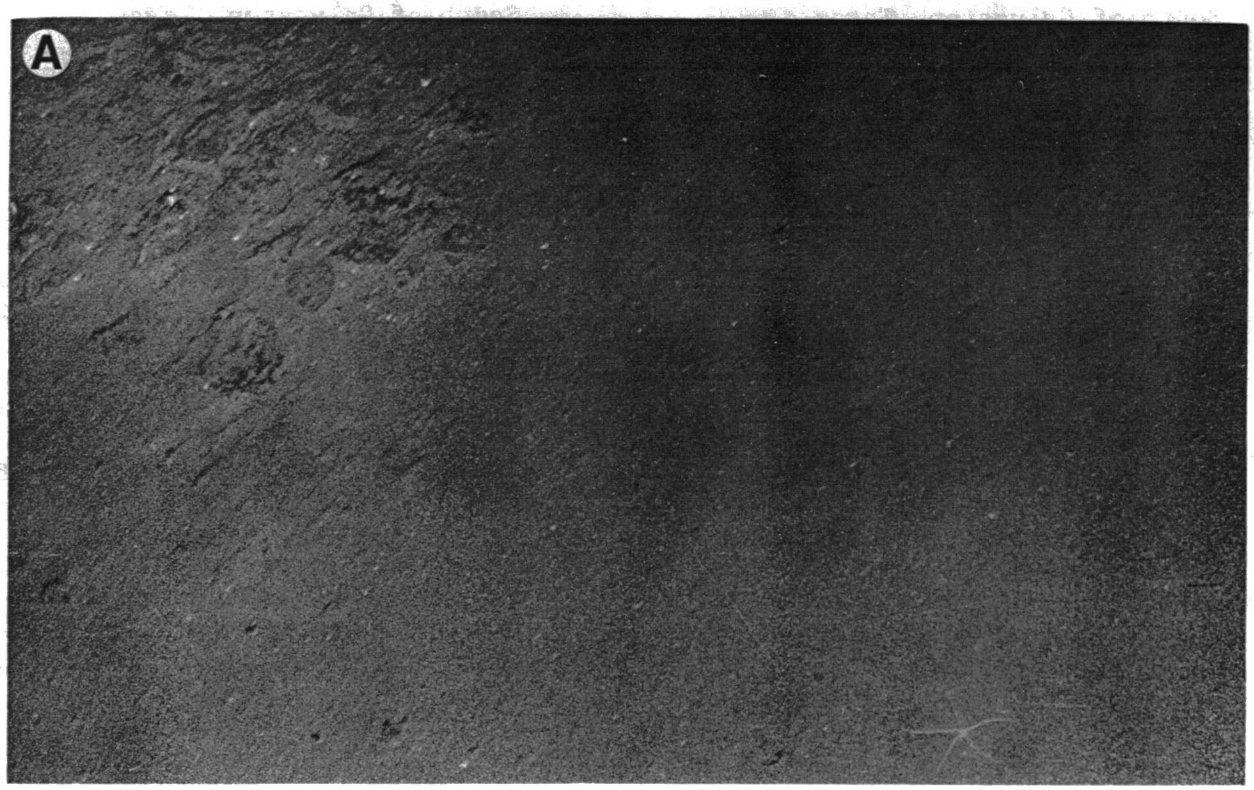
PLATE LVIII

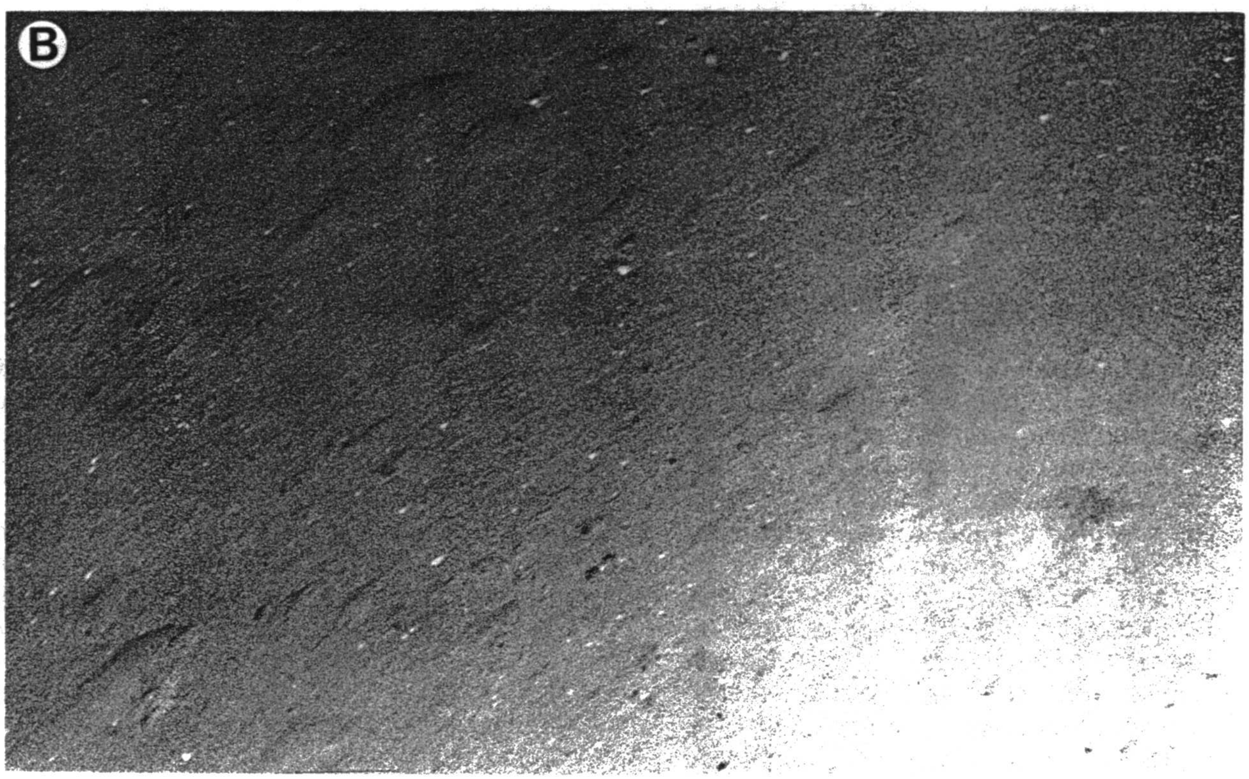
A. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3300 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 1.0 x 1.6 m

Photo taken in the eastern Gulf at the intersection of the 3300-m isobath and 86°05'W longitude. Very close to the sites of Photos "C" and "D" in Plate 57. Here we see a sloping bottom with silty mud coverage. Ironstone is exposed here and there. Current appears to be sweeping diagonally across the picture from upper right to lower left. The ophiuroid is not identifiable but the most common one here is _Ophiomusium planum_.

B. Lower Abyssal Zone.
Eastern Gulf of Mexico.
Mississippi Fan area.
Isobath: 3250 m
Cruise: 67A5
Preset focus at 1.5 m.
35-mm film. Scale 0.6 x 1.0 m

Photo taken in the eastern Gulf at the intersection of the 3300-m isobath and 86°05'W longitude. Very close to the sites of Photos "C" and "D" in Plate 57. Here we see a sloping bottom with silty mud coverage. Ironstone is exposed here and there. The streamlining marks the current flowing from upper right to lower left, as in "A" above.


A


B

A. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3675 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf on the northern edge of the Sigsbee Abyssal Plain, which is almost exclusively a feature of the Gulf west of 90°W longitude. This photo station was mounted at the intersection of the 3675-m isobath and 94°22.2'W longitude. The sediment appears to be soft and flocculant with no evidence of a bottom current. Whereas sand is an important component of the sediments in the deeper parts of the eastern Gulf, here there is 3% sand, 16% silt, and 81% clay. The stalked animal in the upper left is an unknown species, possibly a stalked crinoid or pennatulacean coelenterate. The "mounds" in the center are probably sponges (e.g. Thenea). The white blotches are luminous clouds.

B. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3675 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.4 x 0.5 m

Photo taken in the western Gulf on the northern edge of the Sigsbee Abyssal Plain, which is almost exclusively a feature of the Gulf west of 90°W longitude. This photo station was mounted at the intersection of the 3675-m isobath and 94°22.2'W longitude. The clay content of the sediments is clearly demonstrated by the lump seen in the lower part of the photo. It was falling from the camera frame. More luminous clouds here. The spheroids in the lower right are sponges.

C. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3675 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.3 x 0.4 m

Photo taken in the western Gulf on the northern edge of the Sigsbee Abyssal Plain, which is almost exclusively a feature of the Gulf west of 90°W longitude. This photo station was mounted at the intersection of the 3675-m isobath and 94°22.2'W longitude. The turbid cloud reveals the soft, flocculent nature of the sediments here. The cylindrical object to the right of the cloud is a fecal deposit, probably of a holothurian.

D. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3675 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf on the northern edge of the Sigsbee Abyssal Plain, which is almost exclusively a feature of the Gulf west of 90°W longitude. This photo station was mounted at the intersection of the 3675-m isobath and 94°22.2'W longitude. Fecal deposits of holothurians are scattered about. Holothurians of the genus Psychropotes were collected in this area.

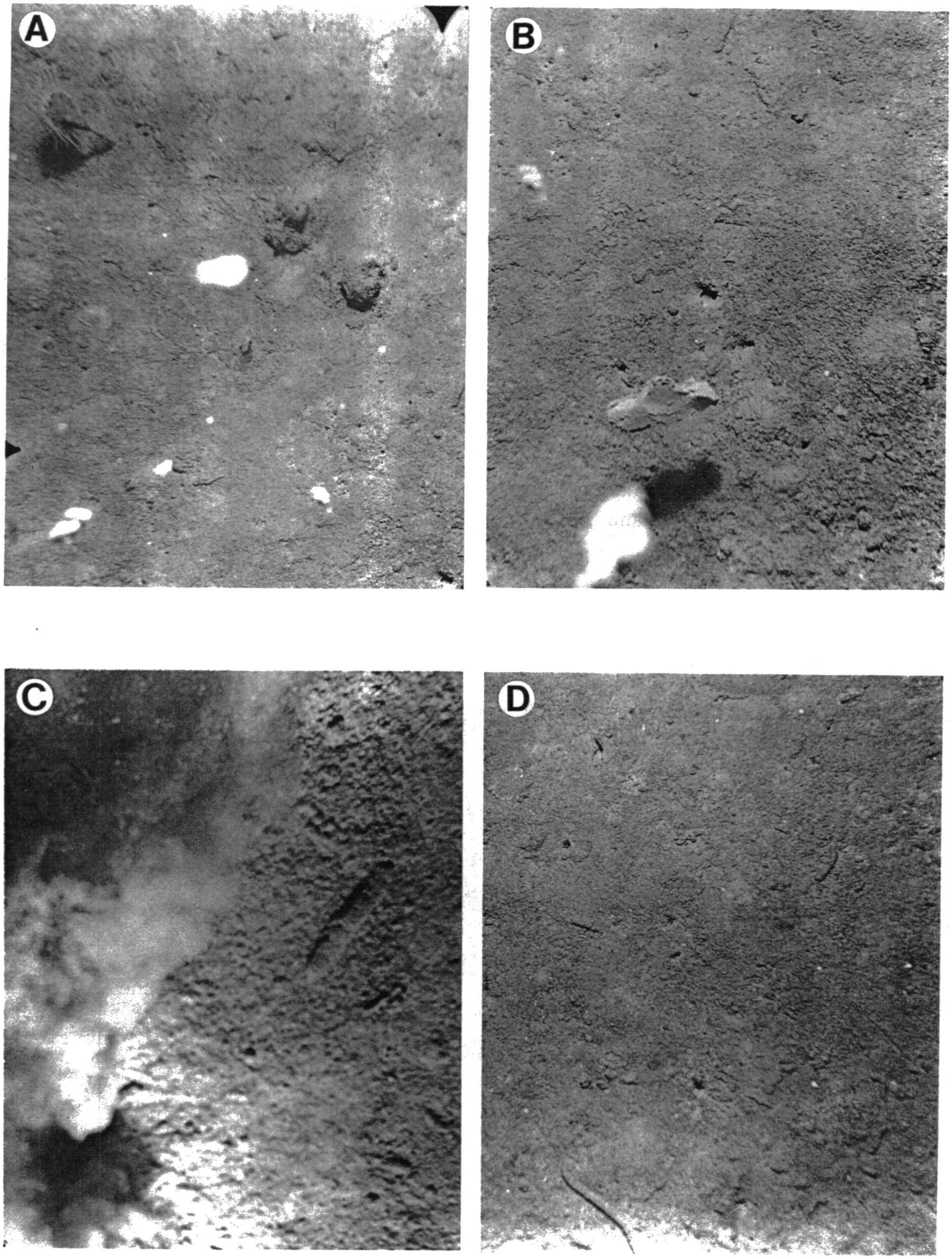

A
B
C
D

PLATE LX

A. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3675 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.3 x 0.4 m

Photo taken in the western Gulf on the northern edge of the Sigsbee Abyssal Plain. The sediments in all the photos on this plate exhibit no evidence of bottom currents. The light-colored clay lumps falling from the camera frame are in sharp contrast with the dark oxidized surficial layer. The latter is very easily disturbed. The holes in the photo probably are burrows of polychaete annelids.

B. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3675 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf on the northern edge of the Sigsbee Abyssal Plain. The sediments in all the photos on this plate exhibit no evidence of bottom currents. Burrows in the lower left quadrant are probably related to polychaetes.

C. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3675 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf on the northern edge of the Sigsbee Abyssal Plain. The sediments in all the photos on this plate exhibit no evidence of bottom currents. The lumpy nature of this sediment bed is created by sponges belonging to the genus *Radiella*. They are not *Radiella sol*.

D. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3675 m
Cruise: 69A11
Preset focus at 2.0 m.
70-mm film. Scale 0.6 x 0.8 m

Photo taken in the western Gulf on the northern edge of the Sigsbee Abyssal Plain. The sediments in all the photos on this plate exhibit no evidence of bottom currents. The sinuous furrow is made by an unknown animal, which appears to be working at the arrow. Possibly it is a boundary echinoid.

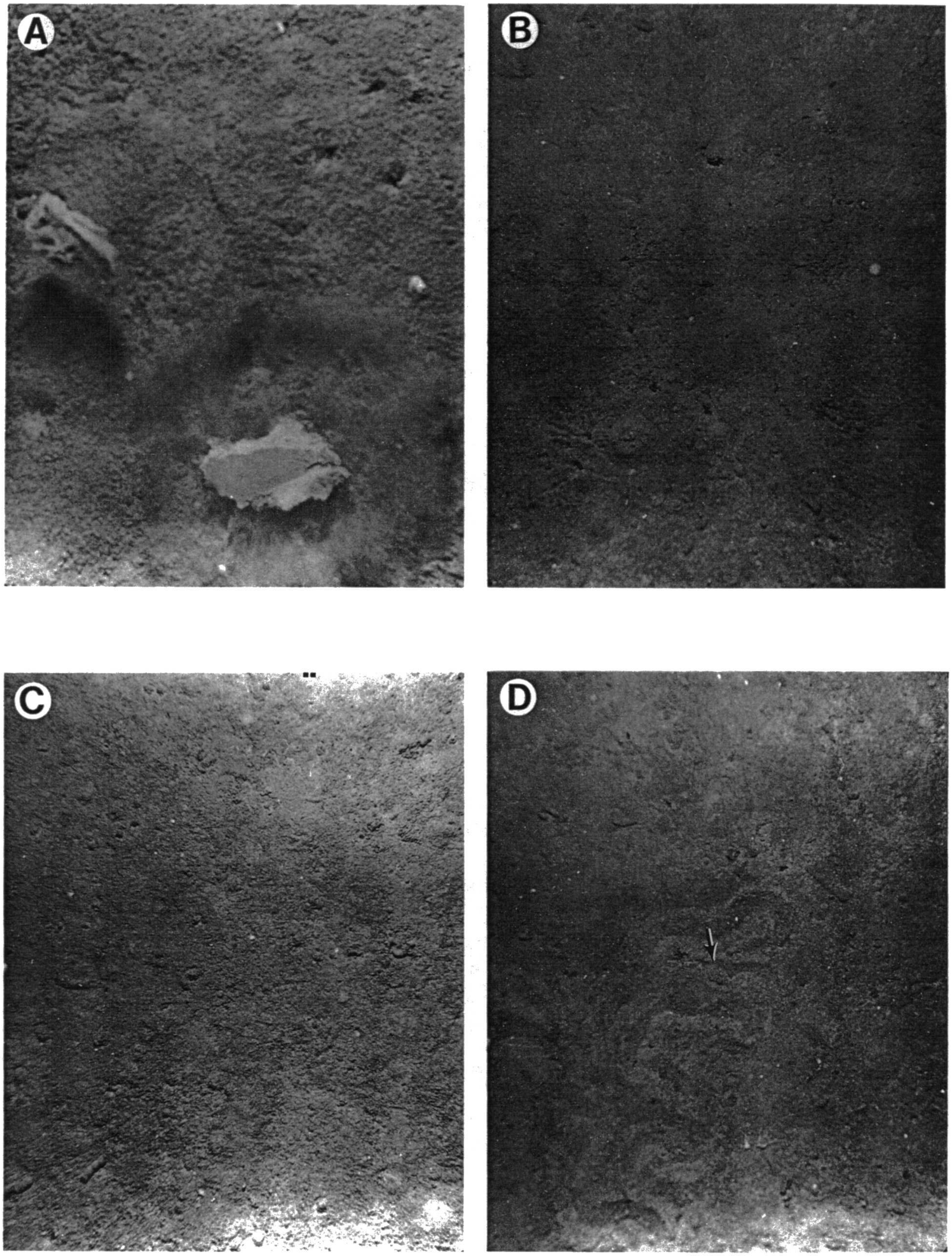

A
B
C
D

PLATE LXI

A. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the western Gulf in a typical part of the Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. Sediments here have clay levels as high as 81%. There is no evidence of bottom currents. The holes appear to be burrows of polychaete annelids. The coiled fecal deposit above right is that of a holothurian. Spheroids are sponges.

B. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the western Gulf in a typical part of the Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. Sediments here have clay levels as high as 81%. There is no evidence of bottom currents. Essentially the same as "A" except there are more sponges.

C. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the western Gulf in a typical part of the Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. Sediments here have clay levels as high as 81%. There is no evidence of bottom currents. Deteriorating holothurian fecal deposits, sponges, and worm tubes are common here.

D. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the western Gulf in a typical part of the Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. Sediments here have clay levels as high as 81%. There is no evidence of bottom currents. Almost devoid of bioturbation.

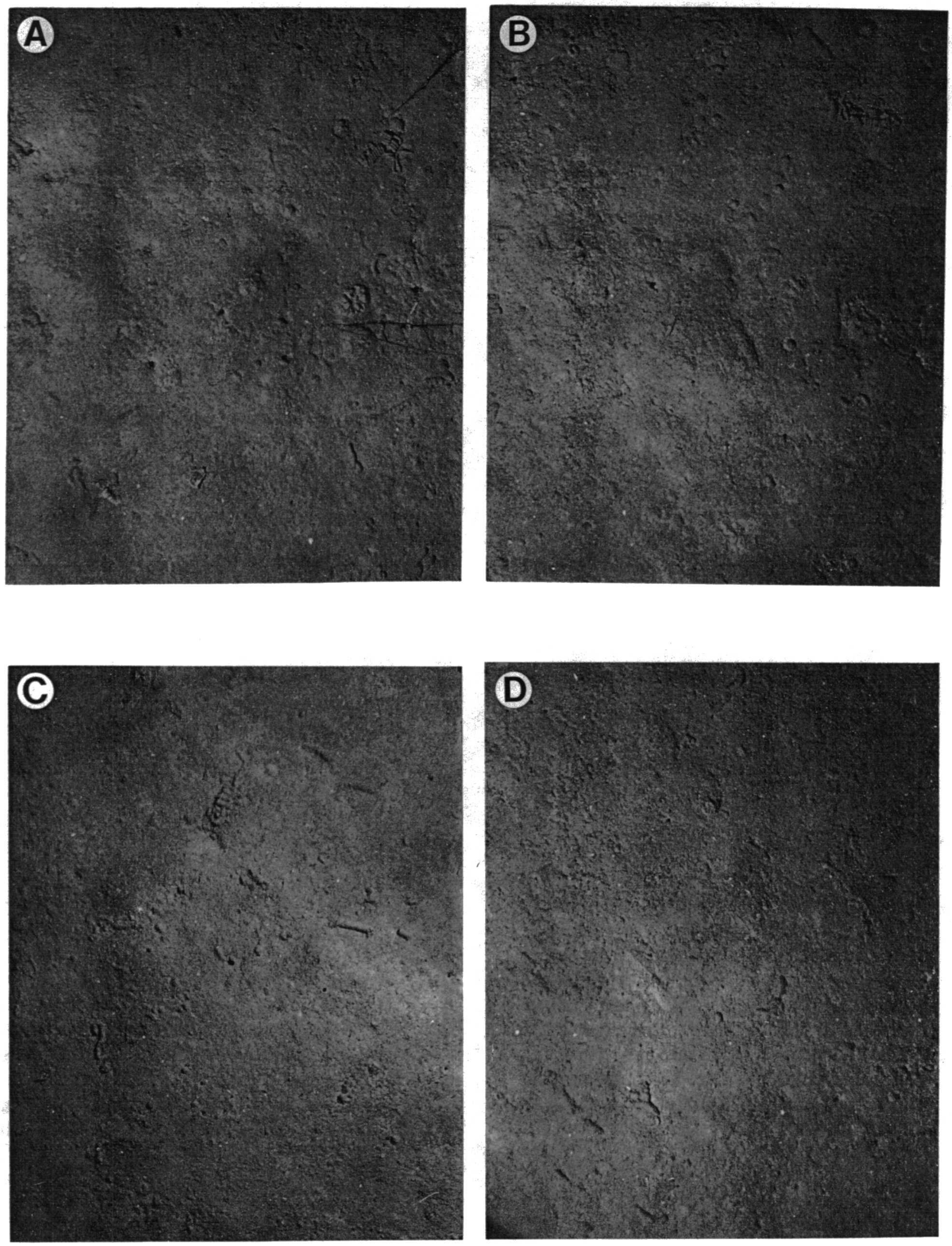

A
B
C
D

PLATE LXII

A. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the western Gulf in a typical part of the Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. There is no evidence of bottom currents. Four things are worthy of observation in this photo. At the top there is a spray of *Sargassum*. The faint track down the center was made by a polychaete dragging its tube. The spheroids and low mounds are sponges. Finally the asteroid is *Dipsacaster antillensis*.

B. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the western Gulf in a typical part of the Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. There is no evidence of bottom currents. Here we see fecal casts of *Psychropotes semperiana* and live and dead polychaete tubes. In the lower left an ampheretid polychaete can be seen making a trail.

C. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the western Gulf in a typical part of the Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. There is no evidence of bottom currents. At the top a polychaete burrow shows trails leaving it in a star-shape. In the lower left the stalked animal appears to be a crinoid.

D. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the western Gulf in a typical part of the Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. There is no evidence of bottom currents. There is a polychaete burrow in the upper left quadrant. There are various disintegrating fecal deposits. In the lower right the shadow of a stalked animal looks like the coelenterate *Umbellula* sp.

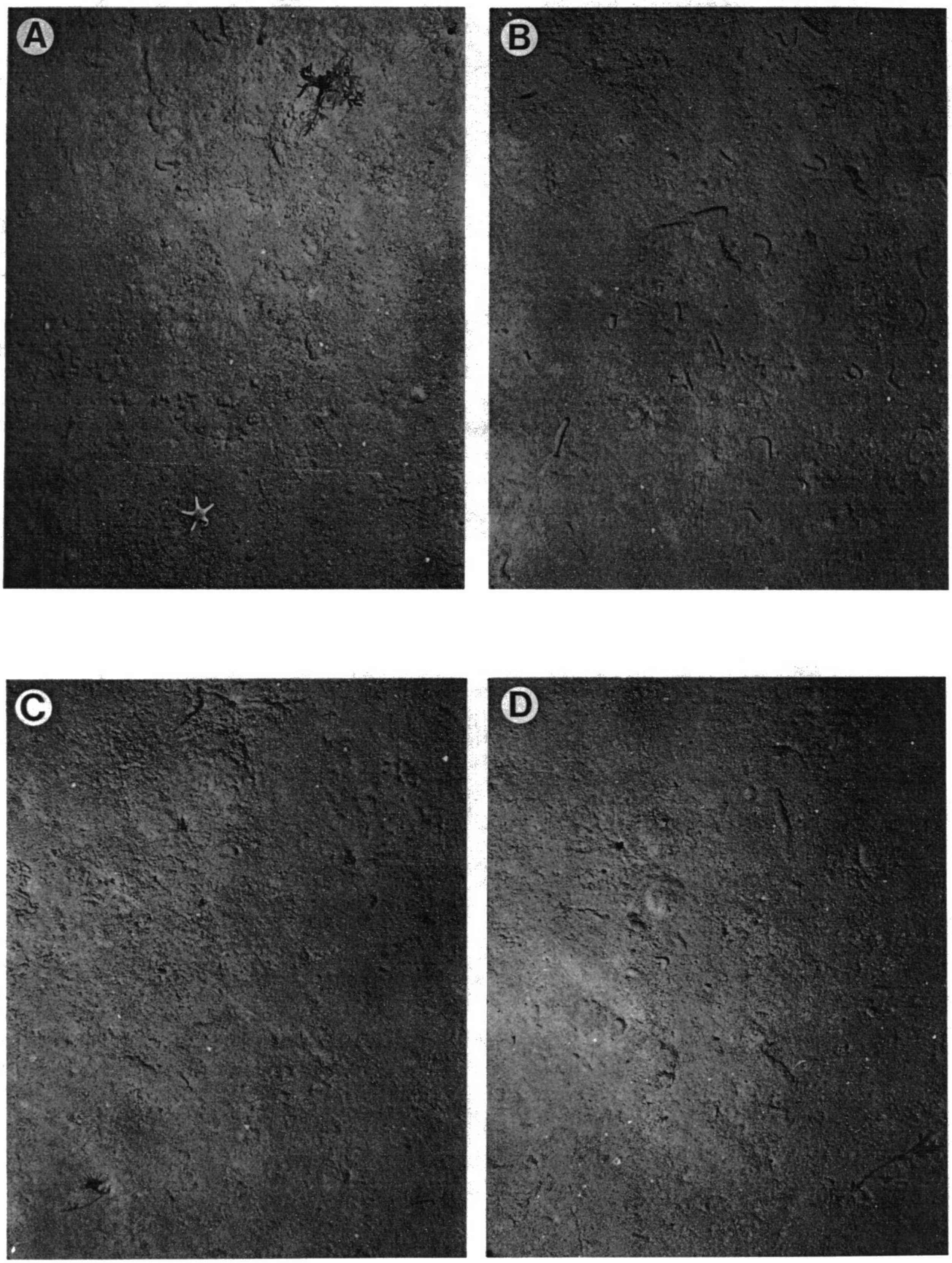

A
B
C
D

PLATE LXIII

A. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the western Gulf Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. There is no evidence of bottom currents. Note the two polychaete burrows in the upper left. The worm in the center belongs to the family Polyodontidae. The polychaete in the lower left is in the family Maldanidae. Numerous buried sponges can be seen along the right margin (small mounds).

B. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

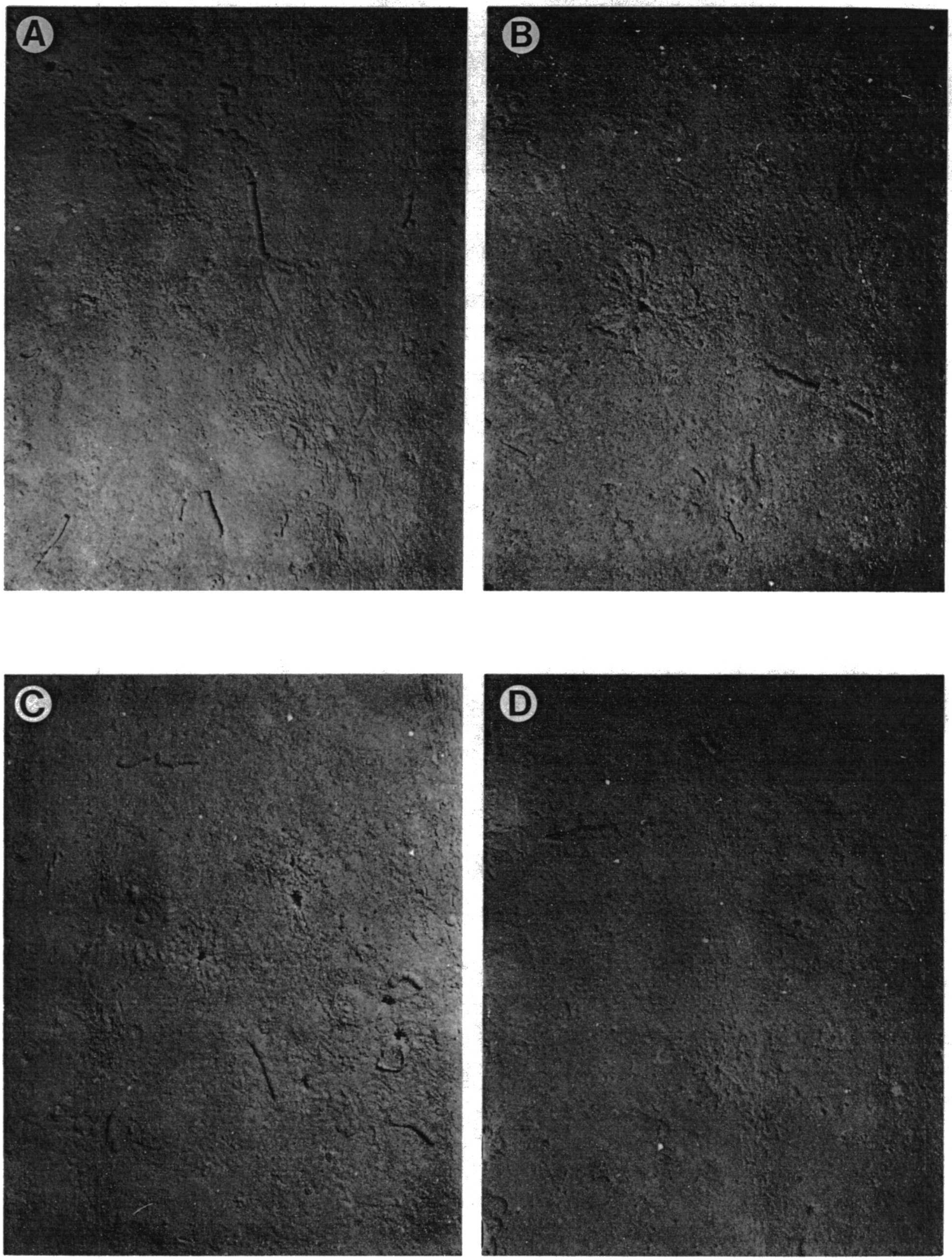
Photo taken in the western Gulf Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. There is no evidence of bottom currents. One worm burrow and deteriorating worm tubes and fecal deposits are present here, but no active worms occur in this photo.

C. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the western Gulf Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. There is no evidence of bottom currents. Three worm burrows and several inactive worm tubes are seen here.

D. Lower Abyssal Zone.
Western Gulf of Mexico.
South of Galveston, Texas.
Isobath: 3700 m
Cruise: 68A3
Preset focus at 1.5 m.
35-mm film. Scale 0.9 x 1.1 m

Photo taken in the western Gulf Sigsbee Abyssal Plain at the intersection of the 3700-m isobath and 94°04'W longitude. There is no evidence of bottom currents. The lack of bioturbation in this photo is typical of large parts of the Sigsbee Abyssal Plain.


A
B
C
D

STATION LIST OF SPECIES

APPENDIX B

STATION LIST OF SPECIES

STATION	DEPTH (m)	POSITION N. LAT.	W. LONG.	SAMPLING GEAR
64A10-2	379 m	27°40'N	93°43'W	Grab, M. Dredge

Garden Banks Map (NG 15-2) Block No. 312

POLYCHAETA
- Maldanidae & Onuphidae fragments

MOLLUSCA: BIVALVIA
- Astarte, Limposis, & Venericardia fragments

CRUSTACEA: DECAPODA
- unidentified Axiidae
- Callianassa sp. (damaged)
- Lyreidus bairdi
- Munidopsis polita

STATION	DEPTH (m)	N. LAT.	W. LONG.	SAMPLING GEAR
64A10-3	189 m	27°18'N	93°30'W	Menzies Dredge

Garden Banks Map (NG 15-2) Block No. 665

PORIFERA
- Aphrocallistes bocagei
- Aphrocallistes cf. beatrix

POLYCHAETA
- Ampharetidae, Onuphidae, & Sigalionidae fragments

CRUSTACEA: DECAPODA
- Munidopsis tridentata

ECHINODERMATA: HOLOTHUROIDEA
- ? Sphaerothuria

STATION	DEPTH (m)	N. LAT.	W. LONG.	SAMPLING GEAR
64A10-5	2244 m	25°56'N	92°35'W	Menzies Dredge

"Sparse sample - Globigerina ooze."

PORIFERA
- Thenea fenestrata

POLYCHAETA
- Onuphidae fragments

CRUSTACEA: DECAPODA
- unidentified Paguridae

STATION	DEPTH (m)	N. LAT.	W. LONG.	SAMPLING GEAR
64A10-6	3475 m	25°13.5'N	92°23'W	Menzies Dredge

PORIFERA
- Dictyonina sp.

MOLLUSCA: BIVALVIA
- Bentharca asperula
- Neilo sp. A (dead)

BRACHIOPODA
- Chlidonophora incerta

64A10-6C	3356 m	25°13.5'N	92°23'	Grab

"Completely full of brown ooze with blue-green streaks."
PORIFERA
Radiella sol
MOLLUSCA: BIVALVIA
Bentharca asperula
BRACHIOPODA
Chlodonophora incerta

64A10-7	3801 m	25°04'N	94°16'W	Grab

PORIFERA
Euplectella sp.
POLYCHAETA
Hyalinoecia sp.
MOLLUSCA: BIVALVIA
Neilo sp. A (dead)
BRACHIOPODA
Chlidonophora incerta

64A10-7	3762 m	25°04'N	94°16'W	Menzies Dredge

PORIFERA
Fangophilina sp.
Radiella sp.
POLYCHAETA
Hyalinoecia sp.
MOLLUSCA: BIVALVIA
Neilonella sp. A
BRACHIOPODA
Chlidonophora incerta

64A10-9	2811 m	25°25'N	95°14'W	Grab, M. Dredge

POLYCHAETA
Onuphidae fragments
MOLLUSCA: BIVALVIA
Tindariopsis aeolata
MOLLUSCA: SCAPHOPODA
Dentalium callithrix (dead)
Dentalium meridionale (dead)
BRACHIOPODA
Chlidonophora incerta

64A10-10	1756 m	25°27'N	95°24'W	Grab

POLYCHAETA
Onuphidae fragments
MOLLUSCA: SCAPHOPODA
Dentalium callithrix (dead)
Dentalium ensiculus (dead)
Dentalium perlongum (dead)

64A10-10	1401 m	25°30'N	95°30'W	Dredge

PORIFERA
Radiella sp.

continued

64A10-10 continued

COELENTERATA: ALCYONARIA
- ? Anthoptilum sp.

POLYCHAETA
- Amage tumida
- Hyalinoecia sp. A

MOLLUSCA: BIVALVIA
- Limopsis sulcata
- Nucula sp.

MOLLUSCA: SCAPHOPODA
- Dentalium callithrix (dead)

CRUSTACEA: DECAPODA
- unidentified Paguridae

CRUSTACEA: TANAIDACEA
- Neotanais ? serratispinosus

64A10-11 1392 m 27°29'N 95°31'W Grab
East Breaks Map (NG 15-1) Block No. 448

"Very sparse sample; Ophiuroidea fragments."

64A10-12 885 m 27°30.5'N 94°57'W Grab
East Breaks Map (NG 15-1) Block No. 460

"Sample was gray clay. Very heavy sample with few polychaetes (Maldanidae & Onuphidae); & asteroid fragments."

64A10-12 732 m 27°30'N 94°55'W Menzies Dredge
East Breaks Map (NG 15-1) Block No. 461

"Green-gray mud, some forams, worm tubes, bivalve, gastropod, & scaphopod mollusk fragments, a small holothuroid."

64A10-13 183 m 27°52.5'N 94°56'W Grab
East Breaks Map (NG 15-1) Block No. 109

MOLLUSCA: BIVALVIA
- Astarte nana (dead)
- Lima pellucida (dead)
- Nuculana acuta
- Venericardia armilla
- Vertecordia fischeriana (dead)
- Yoldia solenoides (dead)

MOLLUSCA: SCAPHOPODA
- Dentalium semistriolatum
- Pulsellum pressum

64A10-13C 121-181 m 27°52.5'N 94°56'W Menzies Dredge
East Breaks Map (NG 15-1) Block No. 109

COELENTERATA: ALCYONARIA
- Pennatula sp.

POLYCHAETA
- Acoetes pacifica
- Acoetes sp.
- Ehlersileanira incisa

continued

64A10-13C continued
  Euarche tubifex
  Polyodontes frons
SIPUNCULA
  Golfingia sp. 4 (near G. misakiana)
MOLLUSCA: BIVALVIA
  Nuculana acuta (dead)
  Yoldia solenoides
CRUSTACEA: DECAPODA
  Acanthocarpus alexandri
  Anasimus lajus
  Paguristes oxyophthalmus
  Parapenaeus longirostris
  Raninoides louisianensis
  Solenolambrus typicus
CRUSTACEA: STOMATOPODA
  Heterosquilloides armata
ECHINODERMATA: ASTEROIDEA
  Astropecten nitidus
  Tethyaster grandis
ECHINODERMATA: ECHINOIDEA
  Brissopsis atlantica

64A13-1 210 m 27°54'N 93°11'W Grab, Dredge
West Cameron South Addition Block No. 659
CRUSTACEA: DECAPODA
  Chasmocarcinus cylindricus
  Eucratodes agassizi
  Raninoides louisianensis
  Thalassoplax angusta
ECHINODERMATA: ECHINOIDEA
  Brissopsis alta/atlantica/elongata
FISH: Ophichthidae
  Echiophis mordax

64A13-2C 549 m 26°34.5'N 93°00'W Dredge
Keathley Canyon Map (NG 15-5) Block No. 415
MOLLUSCA: GASTROPODA
  Leucosyrinx verrilli
  Solariella lamellosa
MOLLUSCA: BIVALVIA
  Corbula disparilis
CRUSTACEA: DECAPODA
  Bathyplax typhla
  Munida valida

65A3-1 827 m 27°30'N 95°30'W Grab
East Breaks Map (NG 15-1) Block No. 449
"Thin film of brown sediment (Globigerina ooze) over
  gray-green mud."
COELENTERATA: ALYCONARIA
  ? Acanella sp.
POLYCHAETA
  Terebellides sp.

65A3-2 2321 m 26°15'N 95°00'W Plow Dredge
Alaminos Canyon Map (NG 15-4) Block No. 723

PORIFERA
- Dictyonina sp.
- Radiella sol
- Thenea fenestrata

MOLLUSCA: BIVALVIA
- ? Limatula subauriculata
- Neilo bermudensis
- Nucula callicredemna (dead)

BRACHIOPODA
- Chlidonophora incerta

CRUSTACEA: DECAPODA
- Paguridae sp.

ECHINODERMATA: HOLOTHUROIDEA
- Molpadia sp.

65A3-3 3717 m 25°30'N 95°00'W Plow Dredge

POLYCHAETA
- ? Myriochele sp. A

MOLLUSCA: BIVALVIA
- Malletia sp. A
- Neilo sp. A

MOLLUSCA: SCAPHOPODA
- Dentalium laqueatum

MOLLUSCA: CEPHALOPODA
- Onychoteuthis banksi

65A3-4 3563 m 25°08'N 94°58'W Plow Dredge

PORIFERA
- Fangophilina sp.
- Radiella sol
- Radiella sp.

POLYCHAETA
- Amelinna sp.
- Myriochele sp. A

MOLLUSCA: BIVALVIA
- Neilo sp. A (dead)
- Neilonella guineensis
- Nucula callicredemna

BRACHIOPODA
- Chlidonophora incerta

ECHINODERMATA: ECHINOIDEA
- Aceste bellidifera

65A3-5 511-417 m 27°36'N 94°44'W Plow Dredge
East Breaks Map (NG 15-1) Block No. 377

MOLLUSCA: BIVALVIA
- Nucula culebrensis (dead)

CRUSTACEA: DECAPODA
- Bathyplax typhla

65A3-6 240 m 27°40'N 94°45'W Grab, P. Dredge
East Breaks Map (NG 15-1) Block No. 288

POLYCHAETA
- Asychis sp. C
- Goniada norvegica
- Johnstonia sp.
- Onuphis sp. B
- Pista sp.
- Serpulidae sp.

MOLLUSCA: BIVALVIA
- Nuculana acuta (dead)

CRUSTACEA: DECAPODA
- Lyreidus bairdi

ECHINODERMATA: ECHINOIDEA
- Brissopsis alta/atlantica/elongata

65A9-1 190 m 25°12.5'N 80°03'W Grab
Miami Map (NG 17-8)

MOLLUSCA: BIVALVIA
- Nuculana acuta (dead)
- Nuculana carpenteri (dead)

MOLLUSCA: SCAPHOPODA
- Cadulus sp. (dead)

65A9-23 3206 m 25°31'N 86°13'W Plow Dredge

PORIFERA
- Thenea fenestrata

BRYOZOA
- Levinsenella sp.

MOLLUSCA: BIVALVIA
- Brevinucula verrilli
- Neilo sp. A
- Neilonella quineensis
- Nucula callicredemna (dead)

MOLLUSCA: CEPHALOPODA
- Onychoteuthis banksii
- Tremoctopus violaceus

MOLLUSCA: SCAPHOPODA
- Dentalium ensiculus
- Dentalium meridionale (dead)

ECHINODERMATA: OPHIUROIDEA
- unidentified Ophiuroid

FISH
- Coryphaena hippurus

65A9-25 797 m 27°43'N 90°56'W Plow Dredge
Green Canyon Map (NG 15-3) Block No. 240

"Gray clay with a thin film of Globigerina ooze."

POLYCHAETA
- Hyalinoecia cf. stricta

CRUSTACEA: DECAPODA
- Chasmocarcinus cylindricus

continued

65A9-25 continued

  Heterocarpus oryx
  Nematocarcinus rotundus
  Pontophilus gracilis
ECHINODERMATA: ECHINOIDEA
  Echinolampus depressa
ECHINODERMATA: OPHIUROIDEA
  unidentified Ophiuroids

66A5-2 3341 m 25°30'N 89°02'W Plow Dredge

"Some iron-rich rock clinker-like material."

PORIFERA
  Radiella sp.
POLYCHAETA
  unidentified Onuphidae
MOLLUSCA: BIVALVIA
  Neilonella guineensis (dead)
MOLLUSCA: SCAPHOPODA
  Dentalium callithrix

66A5-3 3265 m 25°30'N 86°19.5'W Plow Dredge #1

"Some iron-rich rock and clay."

POLYCHAETA
  Phyllochaetopterus sp.
MOLLUSCA: BIVALVIA
  Brevinucula verrilli (dead)
  Neilo sp. A (dead)
  Neilonella guineensis (dead)
  Neilonella sp. A
  Tindariopsis aeolata
MOLLUSCA: GASTROPODA
  Acteon sp. 2
  Acteon sp. 4
  Relichna simplex
  Relichna sp.
MOLLUSCA: SCAPHOPODA
  Dentalium ensiculus

66A5-3 3109+ m 25°31'N 86°10'W Plow Dredge #2

"Large amount of loose shell material, abundance of foram ooze, and iron rich rock."

POLYCHAETA
  Lanice/Eupolymnia
  Maldanidae sp.
MOLLUSCA: SCAPHOPODA
  Dentalium ensiculus
  Dentalium meridionale
  Dentalium perlongum (dead)
CRUSTACEA: CIRRIPEDIA
  Scalpellum sp.

66A5-3 3212 m 25°33'N 85°58'W Plow Dredge #3
Howell Hook Map (NG 16-9)

MOLLUSCA: BIVALVIA
- Brevinucula verrilli
- Neilo sp. A
- Neilonella guineensis (dead)
- Nucula callicredemna

MOLLUSCA: SCAPHOPODA
- Dentalium ensiculus
- Dentalium meridionale

66A5-3 3214 m 25°31'N 86°07'W Plow Dredge #4

POLYCHAETA
- Ampharetidae sp.
- Onuphidae sp.

MOLLUSCA: BIVALVIA
- Bentharca asperula
- Brevinucula verrilli
- Neilo sp. A (dead)
- Neilonella guineensis (dead)
- Tindaria sp. A (dead)
- Pristigloma nitens
- Tindariopsis aeolata
- Yoldiella sp. A (dead)

MOLLUSCA: SCAPHOPODA
- Dentalium ensiculus

ECHINODERMATA: HOLOTHUROIDEA
- Molpadia blakei

66A5-4 1097-1189 m 28°20'N 87°03'W Quant. Dredge
DeSoto Canyon Map (NH 16-11) Block No. 634

PORIFERA
- Thetycordyla thyris

COELENTERATA: SCLERACTINIA
- Caryophyllia ambrusia
- Deltocyathus italicus

POLYCHAETA
- Spionidae sp. A

MOLLUSCA: BIVALVIA
- Brevinucula verrilli (dead)
- Neilonella sp. B (dead)
- Nucula pernambucensis
- Nucula semen (dead)
- Nucula sp. B
- Nuculana solidula (dead)
- Nuculana sp. A
- Nuculana sp. B (dead)
- Tindaria amabilis (dead)
- Tindariopsis agathida
- Yoldia pachia (dead)
- Yoldia quadrangularis

continued

66A5-4 continued

MOLLUSCA: GASTROPODA

Aclis mizon
Basilissa sp.
Benthomangelia sp. 1
Benthomangelia sp. 2
Benthonella fisheri
"Bulla" cf. eburnea
Calliotropis calatha
Columbellidae sp. 3
Corinnaeturris leucomata
Corinnaeturris sp. 2
Drilliola loprestiana
Echinogurges clavatus
Epitoneum nitidum
Eulimidae & Aclidae (new genus)
"Mangelia" antonia
Micropleurotomella lophoessa
Pleurotomella aff. bureaui
Pyrunculus ovatus
Ringicula nitida
Rissoa pyrrhias
Scissurella alba
Seguenzia sp. 3
Seguenzia sp. 4
Seguenzia sp. 5
Seguenzia sp. 6
Solariella pourtalisi
Solariella tiara
Turridae sp. 1

MOLLUSCA: SCAPHOPODA

Cadulus sp.
Dentalium callithrix (dead)
Dentalium perlongum
Entalina ? platamodes
Entalina sp.
Pusellum pressum (dead)

CRUSTACEA: TANAIDACEA

Sphyrapus n. sp.

ECHINODERMATA: HOLOTHUROIDEA

Echinocucumis hispida

ECHINODERMATA: OPHIUROIDEA

unidentified Ophiuroids

66A5-5 1682 m 29°00'N 87°29'W Quant. Dredge
Destin Dome Map (NH 16-8) Block No. 974

PORIFERA

Dragmatyle topsenti

POLYCHAETA

Asychis n. sp.
Capitellidae sp. A
Spionidae sp. B

continued

66A5-5 continued

MOLLUSCA: BIVALVIA
- Nucula pernambucensis (dead)
- Nucula sp. A (dead)
- Nucula sp. B (dead)
- Nuculana sp. A (dead)
- Tindaria amabilis (dead)
- Tindariopsis agathida
- Yoldiella quadrangularis (dead)

MOLLUSCA: GASTROPODA
- Acteon sp. 3
- Basilissa sp.
- Belomitra exsculpta
- Benthomangelia macra
- Benthomangelia sp. 1
- Benthomangelia sp. 2
- Benthonella fisheri
- Corinnaeturris leucomata
- Epitoneum formosissimum
- Gymnobela ipara
- Pleurotomella benedicti
- Pleurotomella aff. bureaui
- Rissoa xanthias
- Seguenzia sp. 5
- Seguenzia sp. 6

CRUSTACEA: AMPHIPODA
- Oediceroides cf. rostratus

CRUSTACEA: TANAIDACEA
- Neotanais armiger

ECHINODERMATA: CRINOIDEA
- Bathycrinidae sp.

ECHINODERMATA: ECHINOIDEA
- unidentified Echinoid

ECHINODERMATA: OPHIUROIDEA
- unidentified Ophiuroid

66A5-6 752-834 m 27°54'N 90°22'W Quant. Dredge
Green Canyon Map (NG 15-3)Block No. 76

CRUSTACEA: CIRRIPEDIA
- Arcoscalpellum regina

66A5-7 350 m 28°00'N 90°25'W Quant. Dredge
Ewing Bank Map (NH 15-12) Block No. 957

POLYCHAETA
- Nephtys phyllocirra
- Onuphus sp. A

MOLLUSCA: BIVALVIA
- Nucula sp. A
- Nuculana hebes

CRUSTACEA: DECAPODA
- Nephropsis aculeata

66A9-13 3197 m 25°21'N 85°59'W Grab
Howell Hook Map (NG 16-9)

No species collected.

66A9-14 3206 m 25°26.5'N 86°15.5'W Quant. Dredge

MOLLUSCA: BIVALVIA
- Neilo sp. A (dead)
- Neilonella guineensis (dead)

66A9-15 1200-800 m 28°13.5'N 87°04'W MWT on bottom
DeSoto Canyon Map (NH 16-11) Block No. 766

PORIFERA
- Radiella sol

COELENTERATA: HYDROZOA
- Cladocarpus flexuosus

COELENTERATA: ALCYONARIA
- Acanella eburnea
- Protoptilum carpenteri

COELENTERATA: SCLERACTINIA
- Caryophyllia ambrosia caribbeana
- Deltocyathus italicus
- Stephanocyathus diadema

POLYCHAETA
- Hyalinoecia tubicola
- Myriochele sp. A
- Nothria sp. A

MOLLUSCA: BIVALVIA
- Malletia sp. B
- Neilonella sp. A
- Neilonella sp. B
- Nucula pernambucensis
- Nucula sp. B (dead)
- Nuculana solidula (dead)
- Nuculana sp. A (dead)
- Nuculana sp. B (dead)
- Tindaria amabilis (dead)
- Tindariopsis agathida
- Yoldiella pachia
- Yoldiella quadrangularis

MOLLUSCA: GASTROPODA
- Aclis sp.
- Acteon sp. 5
- Ancistrosyrinx sp.
- Basilissa alta
- Basilissa sp.
- Belomitra exsculpta
- Benthomangelia macra
- Benthomangelia sp. 1
- Benthomangelia sp. 2
- Benthonella fisheri
- Calliotropis calatha
- Cerithiella sp.

continued

66A9-15 continued

Columbellidae sp. 1
Corinnaeturris leucomata
Corinnaeturris sp. 2
Cyclostrematidae sp. 1
Cyclostrematidae sp. 2
Cyclostrematidae sp. 3
Cyclostrematidae sp. 4
Drilliola loprestiana
Echinogurges clavatus
Famelica catherinae
Famelica mormidina
Gymnobela blakeana
Gymnobela tanneri
Heliacus sp.
Leucosyrinx verrilli
"Mangelia" antonia
Micropleurotomella lophoessa
Naticidae sp. 2
Pleurotomella aff. bureaui
Pleurotomella aff. lottae
Pyramidellidae sp. 3
Ringicula nitida
Rissoa pyrrhias
Rissoa xanthias
Seguenzia sp. 2
Seguenzia sp. 3
Seguenzia sp. 4
Seguenzia sp. 5
Solariella pourtalisi
Solariella tiara
Teretia aperta
Theta pandionis
Theta sp.
Trophon aculeatus
Turridae sp. 9

MOLLUSCA: SCAPHOPODA

Dentalium callithrix
Dentalium ensiculus
Dentalium perlongum
Entalina ? platamodes
Entalina sp.
Pulsellum pressum

PYCNOGONIDA

Paranymphon spinosum

CRUSTACEA: AMPHIPODA

? Cyclocaris sp.
Cyphocaridae n. gen., n. sp.
Halicreion sp.
Rhachotropis n. sp.?
Trischizostoma longirostre

continued

66A9-15 continued

CRUSTACEA: CIRRIPEDIA
- Arcoscalpellum antillarum
- Trilasmis kaempferi inaequilaterale

CRUSTACEA: DECAPODA
- Catapaguroides microps
- Glyphocrangon aculeata
- Heterocarpus oryx
- Munidopsis simplex
- Parapagurus pilosimanus
- Polycheles crucifer
- Pontophilus gracilis
- Stereomastis sculpta
- Systellaspis pellucida

CRUSTACEA: TANAIDACEA
- Apseudes sp. A
- Apseudes sp. B
- Apseudes sp. C
- Apseudidae sp. A
- Neotanais sp. A
- ? Paranarthrura sp. A
- Sphyrapus n. sp.

ECHINODERMATA: ASTEROIDEA
- Mammaster sigsbei

ECHINODERMATA: CRINOIDEA
- Democrinus sp.
- Monachocrinus ? caribbeus

ECHINODERMATA: ECHINOIDEA
- Plesiodiadema antillarum

ECHINODERMATA: HOLOTHUROIDEA
- Echinocucumis hispida
- Molpadia barbouri

ECHINODERMATA: OPHIUROIDEA
- unidentified Ophiuroids

FISH
- Aldrovandia affinis
- Conocara mcdonaldi
- Dicrolene intronigra
- Ilyophis brunneus
- Monomitopus agassizi
- Nezumia aequalis
- Sphagemacrurus grenadae
- Squalogadus modificatus
- Stephanoberyx monae
- Venefica procera

66A9-17 589 m 27°55'N 90°20'W Grab
Green Canyon Map (NG 15-3) Block No. 32

CRUSTACEA: AMPHIPODA
- Epimera sp.

ECHINODERMATA: ECHINOIDEA
- Echinocyamus sp.

66A16-1 329 m 27°47'N 91°25'W Quant. Dredge
Green Canyon Map (NG 15-3) Block No. 186

POLYCHAETA
- Glycera cf. oxycephala
- Lumbrineris cf. latreilli
- Scoloplos rubra
- Sthenelais sp.

MOLLUSCA: BIVALVIA
- Nucula sp. A
- Nuculana acuta (dead)
- Nuculana hebes
- Phacoides filosus

MOLLUSCA: GASTROPODA
- Astyris diaphana
- Benthomangelia macra
- Glyphostoma sp.
- Gymnobela sp.
- Homalopoma linnei
- ? Inodrillea sp.
- Leucosyrinx sp.
- Mangelia sp.
- Niso sp.
- Pyrunculus ovatus
- Sauvotrochus iridea
- Turridae sp.

MOLLUSCA: SCAPHOPODA
- Dentalium circumcinctum (dead)
- Pulsellum pressum

CRUSTACEA: CIRRIPEDIA
- Arcoscalpellum regina

67A5-1A 1020 m 28°13'N 89°27'W Skimmer
Mississippi Canyon Map (NH 16-10) Block No. 714

COELENTERATA: SCLERACTINIA
- Caryophyllia ambrosia

POLYCHAETA
- Maldane sp. B

MOLLUSCA: BIVALVIA
- Abra longicallis americana

MOLLUSCA: GASTROPODA
- Corinnaeturris leucomata
- Gymnobela ipara
- Leucosyrinx tenoceras
- Theta sp.

ECHINODERMATA: HOLOTHUROIDEA
- Molpadia musculus

ECHINODERMATA: OPHIUROIDEA
- unidentified Ophiuroid

67A5-1B 1020 m 28°12'N 89°28.5'W Quant. Dredge
Mississippi Canyon Map (NH 16-10) Block No. 758

No species collected.

67A5-2B 1869 m 28°21'N 88°23'W Quant. Dredge
Mississippi Canyon Map (NH 16-10)
No species collected. Block No. 648

67A5-2F 1869 m 28°20.5'N 88°20.8'W Quant. Dredge
Mississippi Canyon Map (NH 16-10)
MOLLUSCA: BIVALVIA Block No. 649
Tindariopsis agathida

67A5-2H 1829 m 28°23'N 88°22.5'W Skimmer
Mississippi Canyon Map (NH 16-10)
POLYCHAETA Block No. 604
Eunice ? pennata
Glycera tesselata
MOLLUSCA: GASTROPODA
Spirotropis centimata
CRUSTACEA: DECAPODA
Acanthephyra eximia
Geryon quinquedens
Hymenopenaeus aphoticus
Munidopsis simplex
Nematocarcinus rotundus
Parapagurus ? pilosimanus
Stereomastis sculptus
ECHINODERMATA: ASTEROIDEA
Nymphaster arenatus
ECHINODERMATA: HOLOTHUROIDEA
Benthodytes typica
Deima validum
ECHINODERMATA: OPHIUROIDEA
Ophiernus adspersum
unidentified Ophiuroids
FISH
Progadus catena
Venefica procera
Xyelacyba myersi

67A5-4G 2651 m 28°18'N 87°21'W Skimmer
DeSoto Canyon Map (NH 16-11) Block No. 672
PORIFERA
Radiella sol
Thenea fenestrata
COELENTERATA: ALCYONARIA
Umbellula sp. A
COELENTERATA: SCLERACTINIA
Deltocyathus italicus
MOLLUSCA: SCAPHOPODA
Dentalium meridionale
Dentalium perlongum (dead)
BRACHIOPODA
Chlidonophora incerta

continued

67A5-4G continued

CRUSTACEA: DECAPODA
  Nematocarcinus ensifer (fragments)
  Parapagurus ? pilosimanus
ECHINODERMATA: ASTEROIDEA
  Dytaster insignis
ECHINODERMATA: HOLOTHUROIDEA
  Mesothuria verrilli
  Paelopatides cf. gigantea
  Peniagone sp.
ECHINODERMATA: OPHIUROIDEA
  unidentified Ophiuroids
FISH
  Bathyonus pectoralis

67A5-4H   2633 m   28°10.5'N   87°21.6'W   Quant. Dredge
DeSoto Canyon Map (NH 16-11) Block No. 804
"Foram ooze over blue mud."

67A5-5D   1383-1524m   28°32'N   87°23'W   Skimmer
DeSoto Canyon Map (NH 16-11) Block No. 451

PORIFERA
  Radiella sol
COELENTERATA: SCLERACTINIA
  Stephanocyathus diadema
POLYCHAETA
  Ampharetidae sp.
  Asychis n. sp. (near atlanticus)
  Myriochele sp. A
  Nothria sp. A
  Spiochaetopterus sp.
  Terebellidae sp.
MOLLUSCA: BIVALVIA
  Abra longicallis americana
  Limopsis aurita paucidentata
  Propeamussium sp. A
  Propeamussium sp. C
  Tindaria amabilis
  Yoldiella quadrangularis
MOLLUSCA: GASTROPODA
  Leucosyrinx verrilli
  Solariella sp.
CRUSTACEA: DECAPODA
  Glyphocrangon nobilis
  Nematocarcinus rotundus
  Stereomastis sculpta
ECHINODERMATA: CRINOIDEA
  Bathcrinidae sp.
ECHINODERMATA: HOLOTHUROIDEA
  Deima validum
  Echinocucumis hispida
  Mesothuria lactea
  Molpadia blakei

continued

67A5-5D continued

ECHINODERMATA: OPHIUROIDEA
  unidentified Ophiuroids
FISH
  Aldrovandia affinis

67A5-6B   188 m   28°48'N   87°03'W   Skimmer
PORIFERA   DeSoto Canyon Map (NH 16-11) Block No. 194
  Tethycordyla thyris
COELENTERATA: HYDROZOA
  Cladocarpus flexuosus
POLYCHAETA
  Nothria sp. A
  Oweniidae fragments
MOLLUSCA: BIVALVIA
  Propeamussium sp. C
MOLLUSCA: GASTROPODA
  Leucosyrinx subgrundifera
CRUSTACEA: DECAPODA
  Acanthephyra armata
  Benthesicymus bartletti
  Glyphocrangon alispina
  Nematocarcinus rotundus
  Pasiphaea merriami
  Plesionika holthuisi
  Plesionika polyacanthomerus
  Polycheles typhlops
  Stereomastis sculpta
ECHINODERMATA: HOLOTHUROIDEA
  Echinocucumus hispida
  Mesothuria lactea oxysclera
  Molpadia musculus
ECHINODERMATA: OPHIUROIDEA
  unidentified Ophiuroids
FISH
  Aldrovandia affinis
  Monomitopus agassizi
  Synaphobranchus oregoni/brevidorsalis

67A5-6E   788 m   28°46.5'N   87°02'W   Quant. Dredge
DeSoto Canyon Map (NH 16-11) Block No. 194
POLYCHAETA
  Onuphis microcephala
MOLLUSCA: GASTROPODA
  Epitoneum pyrrhias
CRUSTACEA: CIRRIPEDIA
  Scalpellum gracilius

67A5-7C   918-788 m   29°10'N   87°06'W   Skimmer
Destin Dome Map (NH 16-8)   Block No. 806
COELENTERATA: ALCYONARIA
  Protoptilum carpenteri

continued

67A5-7C continued

MOLLUSCA: BIVALVIA
- Propeamussium sp. C

CRUSTACEA: DECAPODA
- Glyphocrangon alispina
- Hymenopenaeus debilis
- Nematocarcinus rotundus
- Pontophilus gracilis
- Stereomastis sculpta

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria lactea

ECHINODERMATA: OPHIUROIDEA
- Amphiura spp.
- Bathypectinura heros
- unidentified Ophiuroids

FISH
- Bathytroctes sp.
- Dibranchus atlanticus
- Etmopterus schultzi
- Gadomus longifilis
- Hydrolagus mirabilis

67A5-7E   752 m   29°13.4'N   87°00'W   Quant. Dredge
Destin Dome Map (NH 16-8) Block No. 763

POLYCHAETA
- ? Asychis biceps
- Eunice ? pennata
- Leanira hystricis

MOLLUSCA: BIVALVIA
- Neilonella sp. B (dead)
- Nuculana sp. A (dead)
- Nuculana sp. B
- Tindariopsis agathida (dead)
- Yoldiella quadrangularis (dead)

CRUSTACEA: AMPHIPODA
- Urothoides sp.

ECHINODERMATA: ECHINOIDEA
- Hemiaster expergitus

ECHINODERMATA: HOLOTHUROIDEA
- Protankyra sluiteri

ECHINODERMATA: OPHIUROIDEA
- Amphiura sp.
- unidentified Ophiuroids

67A5-8B   1494 m   28°55'N   87°24'W   Skimmer, Q. Dredge
DeSoto Canyon Map (NH 16-11) Block No. 55

PORIFERA
- Radiella sol
- Tethycordyla thyris

COELENTERATA: SCLERACTINIA
- Caryophyllia ambrosia
- Deltocyathus italicus
- Stephanocyathus diadema

continued

67A5-8B continued

POLYCHAETA
- Drilonereis sp. A
- Leanira n. sp.

MOLLUSCA: BIVALVIA
- Nucula pernambucensis
- Nuculana acuta (dead)
- Propeamussium sp. A
- Tindaria amabilis
- Tindariopsis agathida (dead)
- Yoldiella pachia (dead)
- Yoldiella quadrangularis (dead)

MOLLUSCA: GASTROPODA
- Acteon sp. 5
- Benthomangelia macra
- Cerithiella sp.
- Epitoneum formosissimum
- Epitoneum sp.
- Gymnobela ipara
- Leucosyrinx verrilli
- Pleurotomella agassizi mexicana
- Pyramidellidae sp. 2
- Seguenzia sp. 5
- Theta pandionis
- Trophon aculeatus

MOLLUSCA: SCAPHOPODA
- Dentalium circumcinctum
- Dentalium laqueatum

CRUSTACEA: AMPHIPODA
- Lysianassidae (new genus)

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Catapaguroides microps
- Glyphocrangon nobilis
- Parapagurus pilosimanus

ECHINODERMATA: ASTEROIDEA
- Nymphaster arenatus

ECHINODERMATA: HOLOTHUROIDEA
- Echinocucumis hispida

ECHINODERMATA: OPHIUROIDEA
- Amphiura sp.

FISH
- Aldrovandia gracilis
- Coryphaenoides mexicanus
- Stephanoberyx monae

67A5-9A   752 m   29°27'N   86°57'W   Skimmer
Destin Dome Map (NH 16-8) Block No. 545

POLYCHAETA
- Liphonerus ambigua
- Maldane sp. B
- Maldanidae (Leumbriclymininae) sp.

continued

67A5-9A continued

Marphysa cf. bellii
? Myriochele sp. A
Ninoe nigripes
Panthalis sp. A

MOLLUSCA: BIVALVIA

Propeamussium sp. D
Tindaria amabilis (dead)

MOLLUSCA: GASTROPODA

Gymnobela ipara
Leucosyrinx tenoceras
Leucosyrinx verrilli
Lusitanops sp.
Theta jeffreysi
Trophon aculeatus
Tugurium longleyi
Volutomitra cf. bairdii

CRUSTACEA: CIRRIPEDIA

Arcoscalpellum regina

CRUSTACEA: DECAPODA

Aristaeus antillensis
Glyphocrangon alispina
Hymenopenaeus debilis
Hymenopenaeus robustus
Munida valida
Nematocarcinus rotundus
Pleisonika holthuisi
Pleisonika polyacanthomerus
Solenocera vioscai
Stereomastis sculpta
Systellaspis pellucida

CRUSTACEA: ISOPODA

Bathynomus giganteus

SIPUNCULA

Sipunculus sp. 1

BRACHIOPODA

Platidia anomioides

ECHINODERMATA: ECHINOIDEA

Brissopsis sp.

ECHINODERMATA: HOLOTHUROIDEA

Hedingia albicans
Mesothuria lactea zygothuria
Molpadia musculus
Molpadia ? oolitica

ECHINODERMATA: OPHIUROIDEA

Bathypectinura heros
Ophiernus adspersum
Ophiopyren sp.

FISH

Bathygadus macrops
Bathygadus melanobranchus
Bathygadus sp.
Bathytroctes sp.

continued

67A5-9A continued

Chaunax pictus
Coryphaenoides sp.
Diplacanthopoma brachysoma
Etmopterus schultzi
Neoscopelus macrolepidotus
Nezumia aequalis
Polymetme coryaeola
Pseudophichthys laterodorsalis
Symphurus marginatus

67A5-9E 640 m 29°29.5'N 86°57'W Quant. Dredge

POLYCHAETA Destin Dome Map (NH 16-8) Block No. 501

Hyalinoecia tubicola
Marphysa sanguinea
Melinna ? maculata
Ninoe nigripes
Ophelina ? cylindricaudata

MOLLUSCA: BIVALVIA

Amygdalum politum

MOLLUSCA: SCAPHOPODA

Dentalium callipellum (dead)
Dentalium circumcinctum (dead)

CRUSTACEA: DECAPODA

Callianassa marginata

ECHINODERMATA: HOLOTHUROIDEA

Molpadia cubana

67A5-11C 190 m 29°25'N 86°21'W Quant. Dredge

POLYCHAETA Destin Dome Map (NH 16-8) Block No. 557

Diplocirrus capensis
Nephtys ? hombergi
Psammolyce flava
Sthenolepis ? incisa
Sthenolepis sp.

MOLLUSCA: BIVALVIA

Nuculana acuta
Nuculana bipennis (dead)
Nemocardium peramabile
Yoldia solenoides

MOLLUSCA: SCAPHOPODA

Dentalium perlongum
Pulsellum pressum (dead)

CRUSTACEA: CIRRIPEDIA

Balanus sp. (aff. calidus)

CRUSTACEA: DECAPODA

Callianassa marginata
Chasmocarcinus cylindricus
Munida flinti
Thalassoplax angusta

ECHINODERMATA: ECHINOIDEA

Brissopsis alta/atlantica/elongata

ECHINODERMATA: OPHIUROIDEA

unidentified Ophiuroid

67A5-12A 190 m 29°36'N 86°35.5'W Quant. Dredge
Destin Dome Map (NH 16-8) Block No. 376

No species collected.

67A5-13B 379 m 29°30.3'N 86°52.4'W Quant. Dredge
Destin Dome Map (NH 16-8) Block No. 459

POLYCHAETA
- Goniada sp. B
- Harmothoe sp. A
- Onuphis microcephala
- Ophelina ? cylindricaudata
- Orbinia sp.

MOLLUSCA: BIVALVIA
- Nuculana platessa
- Yoldia solenoides

CRUSTACEA: CIRRIPEDIA
- Scalpellum portoricanum

CRUSTACEA: DECAPODA
- Callianassa cf. marginata
- Thalassoplax angusta

67A5-13E 379 m 29°29.9'N 86°53.7'W Skimmer
Destin Dome Map (NH 16-8) Block No. 502

POLYCHAETA
- Maldane sarsi
- Ophelina sp. A

CRUSTACEA: DECAPODA
- Benthochascon schmitti
- Geryon quinquedens
- Munida longipes
- Parapandalus willisi
- Penaeopsis megalops
- Plesionika tenuipes

ECHINODERMATA: ECHINOIDEA
- unidentified Echinoids

ECHINODERMATA: OPHIUROIDEA
- Ophiuroidea sp.

FISH
- Bembrops gobioides
- Coelorinchus coelorhinchus carminatus
- Dibranchus atlanticus
- Peristedion greyae
- Scorpaena cf. plumieri

67A5-14A 2340-2527 m 28°39.9'N 87°38.7'W Quant. Dredge
DeSoto Canyon Map (NH 16-11) Block No. 314

"Chocolate ooze over gray."

MOLLUSCA: BIVALVIA
- Malletia sp. A
- Neilonella sp. A
- Neilonella sp. B
- Nucula culebrensis (dead)

continued

67A5-14A continued

Nucula fernandinae (dead)
Nuculana acuta
Nuculana carpenteri (dead)
Nuculana platessa (dead)
Nuculana sp. A (dead)
Nuculana sp. C (dead)
Yoldiella mirmidina
Yoldiella pachia (dead)

MOLLUSCA: GASTROPODA
Epitonium sp. 1

BRACHIOPODA
Chlidonophora incerta

ECHINODERMATA: HOLOTHUROIDEA
Protankyra brychia

67A5-14E   2367 m   28°41.5'N   87°37.8'W   Skimmer
DeSoto Canyon Map (NH 16-11) Block No. 270

COELENTERATA: PENNATULACEA
Umbellula sp. B

MOLLUSCA: BIVALVIA
Malletia sp. A

BRACHIOPODA
Chlidonophora incerta

CRUSTACEA: DECAPODA
Acanthephyra acutifrons
Glyphocrangon longirostris
Hymenopenaeus aphoticus
Nematocarcinus ensifer
Parapagurus pilosimanus
Plesiopenaeus coruscans
Pontophilus talismani

ECHINODERMATA: ECHINOIDEA
Phormosoma placenta

ECHINODERMATA: HOLOTHUROIDEA
Benthodytes lingua
Paelopatides cf. gigantea
Peniagone cf. azorica
Protankyra brychia
Psychropotes depressa
Scotoanassa sp.
Synallactidae sp.

ECHINODERMATA: OPHIUROIDEA
Bathypectinura heros

FISH
Dicrolene kanazawai
Ipnops murrayi

67A5-15F   3092 m   27°38.4'N   86°38'W   Skimmer
Lloyd Map (NG 16-2)   Block No. 335

"Wood."

PORIFERA
Thenea fenestrata

continued

67A5-15F continued

POLYCHAETA
- Nothria sp. A
- Oweniidae sp.
- Sabellidae sp.

MOLLUSCA: BIVALVIA
- Malletia sp. A
- Nucula callicredemna
- Poromya tornata

MOLLUSCA: GASTROPODA
- Solariella infundibulum

MOLLUSCA: SCAPHOPODA
- Dentalium meridionale (dead)
- Dentalium perlongum (dead)

CRUSTACEA: DECAPODA
- Plesiopenaeus armatus

ECHINODERMATA: ASTEROIDEA
- Ampheraster alaminos
- Dytaster insignis

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes typica
- Psychropotes depressa
- Synallactidae sp.

ECHINODERMATA: OPHIUROIDEA
- Homalophiura cf. inornata

FISH
- Bassozetus normalis
- Bathyonus pectoralis

67A5-15G 3080 m 27°41.4'N 86°39.6'W Quant. Dredge
Lloyd Map (NG 16-2) Block No. 290

PORIFERA
- Radiella sol

POLYCHAETA
- Onuphis microcephala
- Spirochaetopterus sp.

MOLLUSCA: BIVALVIA
- Brevinucula verrilli
- Neilonella guineensis (dead)
- Tindaria sp. A (dead)

MOLLUSCA: SCAPHOPODA
- Dentalium meridionale

ECHINODERMATA: OPHIUROIDEA
- Amphioplus sp.

67A5-16E 3255 m 25°24.3'N 86°06'W Skimmer

PORIFERA
- Desmacidon sp.
- Dictyonina sp.
- Radiella sp.

POLYCHAETA
- ? Eunoe sp.
- Paradiopatra cf. solenotecton

continued

67A5-16E continued

MOLLUSCA: BIVALVIA
- Neilo sp. A (dead)
- Nucula callicredemna (dead)

MOLLUSCA: SCAPHOPODA
- Dentalium meridionale

CRUSTACEA: DECAPODA
- Willemoesia forceps

ECHINODERMATA: ASTEROIDEA
- Ampheraster alaminos
- Dytaster insignis

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes ? typica

ECHINODERMATA: OPHIUROIDEA
- Amphilepis sp.
- Ophiomusium planum

FISH
- Bassozetus normalis
- Bathytroctes sp.

68A3-2A 3148 m 25°47'N 94°26'W Skimmer

"Many sponges."

PORIFERA
- Euplectella sp.

68A3-3B 3658 m 25°09'N 94°11'W Skimmer

"Many Porifera."

PORIFERA
- Radiella sol
- Thenea sp.

POLYCHAETA
- Amellina sp.

MOLLUSCA: BIVALVIA
- Neilo sp. A
- Neilonella guineensis (dead)

BRACHIOPODA
- Chlidonophora incerta

CRUSTACEA: DECAPODA
- Benthesicymus cereus
- Hepomadus tener
- Parapagurus sp.
- Plesiopenaeus armatus

ECHINODERMATA: ASTEROIDEA
- Dytaster insignis

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes ? typica

FISH
- Apodes (unidentified eel)
- Synaphobranchidae (mutilated)

68A3-10B 969-1006 m 25°09'N 96°16'W Skimmer

PORIFERA
- Radiella sol

continued

68A3-10B continued

COELENTERATA: PENNATULACEA
  Funiculina quadrangularis
POLYCHAETA
  Paradiopatra cf. solenotecton
MOLLUSCA: GASTROPODA
  Latiromitra bairdi
CRUSTACEA: CIRRIPEDIA
  Arcoscalpellum regina
CRUSTACEA: DECAPODA
  Nematocarcinus rotundus
  Parapagurus pilosimanus
  Parapagurus sp.
  Stereomastis sculpta
ECHINODERMATA: ASTEROIDEA
  Goniopecten demonstrans
  Zoroaster fulgens
ECHINODERMATA: ECHINOIDEA
  Phormosoma placenta
  Plesiodiadema antillarum
ECHINODERMATA: HOLOTHUROIDEA
  Benthodytes ? sanguinolenta

68A3-12C   732 m   26°22'N   96°08'W   Quant. Dredge
Port Isabel Map (NG 14-6) Block No. 610

POLYCHAETA
  Capitellidae (cf. Notomastus)
  Nothria sp. A
  Opheliidae sp.
MOLLUSCA: BIVALVIA
  Nucula pernambucensis
  Nuculana acuta (dead)
  Nuculana bipennis (dead)
  Nuculana concentrica (dead)
  Yoldia solenoides (dead)
MOLLUSCA: SCAPHOPODA
  Dentalium laqueatum
  Dentalium perlongum (dead)
BRYOZOA
  Cupuladria doma
  Discoporella umbellata

68A7-1A   864-528 m   28°51'N   88°47.5'W   Skimmer
Mississippi Canyon Map (NH 16-10) Block No. 112

"A great deal of plant material and reed material in this sample."

COELENTERATA: SCLERACTINIA
  Deltocyathus italicus
POLYCHAETA
  Hyalinoecia cf. stricta
  Maldane sarsi
  Oweniidae sp. (fragment)
  Polydora websteri

continued

68A7-1A continued

MOLLUSCA: BIVALVIA
- Abra longicallis americana
- Amygdalum politum
- Nucula sp. A
- Propeamussium sp. D

MOLLUSCA: CEPHALOPODA
- Benthoctopus januari

MOLLUSCA: GASTROPODA
- Gaza superba
- Gymnobela edgariana
- Gymnobela ipara
- Leucosyrinx cf. sigsbei
- Leucosyrinx subgrundifera
- Leucosyrinx cf. verrilli
- Pleurotomella cf. agassizi
- Scaphander clavus
- Scaphander mundus
- Volutomitra cf. bairdi

CRUSTACEA: DECAPODA
- Acanthephyra armata
- Aristeus antillensis
- Bathyplax typhla
- Glyphocrangon alispina
- Hymenopenaeus debilis
- Hymenopenaeus robustus
- Munida valida
- Munidopsis longimanus
- Nematocarcinus rotundus
- Parapagurus pilosimanus
- Pasiphaea merriami
- Plesionika acanthonotus
- Plesionika holthuisi
- Plesionika polyacanthomerus
- Plesionika sp. (cf. acanthonotus)
- Polycheles typhlops
- Pontophilus gracilis
- Stereomastis sculpta
- Sympagurus pictus
- Sympagurus pilimanus
- Trichopeltarion nobile

ECHINODERMATA: ASTEROIDEA
- unidentified Asteroid
- Doroaster constellatus
- Dytaster sp.
- Zoroaster fulgens

ECHINODERMATA: ECHINOIDEA
- Homolampus fragilis
- Phormosoma placenta
- Plesiodiadema antillarum

ECHINODERMATA: HOLOTHUROIDEA
- Hedingia albicans

continued

68A7-1A continued

Mesothuria lactea
Molpadia musculus
Molpadia oolitica
Ypsilothuria talismani

ECHINODERMATA: OPHIUROIDEA

Bathypectinura heros
Bathypectinura sp.
Ophiernus adspersum
Ophiopyren sp.

FISH

Anguilliformes sp. (damaged)
Coryphaenoides sp.
Dibranchus atlanticus
Gadella maraldi
Halosaurus guentheri
Lophiiformes sp. (damaged)
Perciformes sp. (damaged)
Peristedion greyae
Pseudophichthys sp.
Ophidioidei sp. (damaged)
Synaphobranchus oregoni/brevidorsalis
Yarrella blackfordi

68A7-2A   408 m   28°56'N   88°42'W   Skimmer
Mississippi Canyon Map (NH 16-10)
"Small amount of plant material in sample."   Block No. 26

POLYCHAETA

Maldane sarsi
Panthalis sp. A

MOLLUSCA: BIVALVIA

Abra longicallis americana
Amygdalum politum

MOLLUSCA: GASTROPODA

Leucosyrinx tenoceras
Scaphander watsoni

CRUSTACEA: DECAPODA

Benthochascon schmitti
Lyreidus nitidus
Munida longipes
Parapandalus willisi
Penaeopsis megalops
Plesionika tenuipes

ECHINODERMATA: OPHIUROIDEA

unidentified Ophiuroid

68A7-2B   567-622 m   28°53'N   88°38'W   Skimmer
Mississippi Canyon Map (NH 16-10)
"Very little vegetation."   Block No. 71

MOLLUSCA: GASTROPODA

Gaza superba
Scaphander clavus

continued

68A7-2B continued

CRUSTACEA: DECAPODA
- Hymenopenaeus debilis
- Pasiphaea merriami
- Pleisonika acanthonotus
- Pleisonika holthuisi
- Stereomastis sculpta

ECHINODERMATA: HOLOTHUROIDEA
- Ypsilothuria talismani

68A7-2C 677-715 m 28°51.5'N 88°37'W Skimmer
Mississippi Canyon Map (NH 16-10) Block No. 115

"A great deal of mud; one piece of large rock was taken with a number of Polycheles lobsters on it."

POLYCHAETA
- Amellina sp.
- Capitellidae sp. B
- Goniada sp. A

MOLLUSCA: GASTROPODA
- Leucosyrinx tenoceras
- Leucosyrinx verrilli
- Scaphander mundus

CRUSTACEA: DECAPODA
- Bathyplax typhla
- Glyphocrangon alispina
- Munida valida
- Nematocarcinus rotundus
- Pleisonika holthuisi
- Stereomastis sculpta

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria lactea
- Molpadia oolitica

ECHINODERMATA: OPHIUROIDEA
- Bathypectinura heros
- Ophiernus adspersum
- unidentified Ophiuroids

FISH
- Dibranchus atlanticus
- Hydrolagus cf. media
- Pseudophichthys sp.

68A7-3C 2743 m 27°36'N 87°41.5'W Skimmer
Lloyd Map (NG 16-2) Block No. 357

"Large amount of shell material, largely bivalve material, which appear to be forms that do not live at this depth - possible evidence of slump? Some ironstone material."

PORIFERA
- Thenea fenestrata

POLYCHAETA
- Eunice pennata

MOLLUSCA: BIVALVIA
- Neilo sp. B (dead)

continued

68A7-3C continued

MOLLUSCA: GASTROPODA

Buccinidae sp.
Gymnobela bairdi
Gymnobela blakeana
Leucosyrinx verrilli
Oocorys succata
Phymorhynchus sp. 2
Pleurotomella bairdi
Trophon aculeatus
Turridae sp. 6

MOLLUSCA: SCAPHOPODA

Dentalium callithrix (dead)
Dentalium meridionale (dead)
Dentalium perlongum (dead)

CRUSTACEA: DECAPODA

Nematocarcinus ensifer
Parapagurus sp.
Stereomastis sculpta

ECHINODERMATA: ASTEROIDEA

Ampheraster alaminos
Dytaster insignis
Litonotaster intermedius
Plinthaster dentatus
Zoroaster fulgens

ECHINODERMATA: ECHINOIDEA

Sarsiaster griegi

ECHINODERMATA: HOLOTHUROIDEA

Benthodytes typica
Mesothuria verrilli
Psychropotes depressa

ECHINODERMATA: OPHIUROIDEA

Bathypectinura heros
Homalophiura cf. inornata
Ophiomusium planum
Silax verrilli

68A7-4A 3237 m 25°20'N 86°07'W Skimmer

"Turtle grass and wood in this sample; a good deal of ironstone, pumice, some coal, and some evidences of oil."

PORIFERA

Euplectella sp.
Radiella sol
Radiella sp.

POLYCHAETA

Nothria sp. A

MOLLUSCA: BIVALVIA

Bentharca asperula
Cetoconcha bulla
Malletia sp. A (dead)
Neilo sp. A

continued

68A7-4A continued

Neilonella guineensis
Nucula callicredemna

MOLLUSCA: GASTROPODA

Acteon sp. 1
Acteon sp. 2
Corinaeturris leucomata
Fusinus sp.
Theta jeffreysi
Trophon aculeatus

MOLLUSCA: SCAPHOPODA

Dentalium meridionale

CRUSTACEA: DECAPODA

Acanthephyra acutifrons
Acanthephyra microphthalma
Benthesicymus ? cereus
Ethusina abyssicola
Hemipenaeus carpenteri
Parapagurus ? pilosimanus

ECHINODERMATA: ASTEROIDEA

Ampheraster alaminos
Dytaster insignis
Litonotaster intermedius
Paragonaster subtilis

ECHINODERMATA: HOLOTHUROIDEA

Benthodytes lingua
Benthodytes ? typica

ECHINODERMATA: OPHIUROIDEA

Bathypectinura heros
Ophiomusium planum
Silax verrilli

FISH

Acanthonus armatus
Bassozetus sp.

68A7-4E 3255 m 25°24.8'N 86°16.5'W Skimmer

"Foram ooze abundant; a moderate amount of ironstone."

PORIFERA

Desmacidon sp.
Hyalonema sp. B
Radiella sol
Radiella sp.

POLYCHAETA

Maldane sp. B
Nothria sp. A

MOLLUSCA: BIVALVIA

Cetoconcha bulla
Neilo sp. A (dead)
Nucula callicredemna (dead)

MOLLUSCA: GASTROPODA

Turridae sp. 6

continued

68A7-4E continued

MOLLUSCA: SCAPHOPODA
- Dentalium meridionale
- Dentalium perlongum (dead)

CRUSTACEA: DECAPODA
- Acanthephyra microphthalma
- Benthesicymus ? cereus
- Benthesicymus iridescens
- Hemipenaeus carpenteri
- Hymenopenaeus aphoticus
- Parapagurus ? pilosimanus

ECHINODERMATA: ASTEROIDEA
- Ampheraster alaminos
- Dytaster insignis
- Litonotaster intermedius
- Nymphaster arenatus

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes ? typica
- Pseudostichopus sp. A
- Psychropotes depressa

ECHINODERMATA: OPHIUROIDEA
- Ophiomusium planum

FISH
- Bathytroctes macrolepis

68A7-7A   2809 m   27°55'N   86°07'W   Skimmer
Lloyd Map (NG 16-2)   Block No. 81

CRUSTACEA: DECAPODA
- Plesiopenaeus armatus

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria candelabri

68A7-7B   1097 m   28°00'N   86°08.5'W   Skimmer
DeSoto Canyon Map (NG 16-11)
Block No. 1005

PORIFERA
- Tethycordyla thyris

COELENTERATA: SCLERACTINIA
- Caryophyllia ambrosia

POLYCHAETA
- Chaetopteridae sp.
- Onuphidae sp.

MOLLUSCA: BIVALVIA
- Propeamusium sp. A

MOLLUSCA: CEPHALOPODA
- Opisthoteuthis agassizi

MOLLUSCA: SCAPHOPODA
- Heteroschizmoides callithrix

CRUSTACEA: AMPHIPODA
- Epimera sp.

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Glyphocrangon nobilis

continued

68A7-7B continued

    Hymenopenaeus aphoticus
    Polychelidae sp.
    Pontophilus gracilis
  CRUSTACEA: ISOPODA
    Bathynomus giganteus
  ECHINODERMATA: OPHIUROIDEA
    unidentified Ophiuroid
  FISH
    Dibranchus atlanticus

68A7-8A 190 m 29°31.7'N 86°29.6'W Skimmer
Destin Dome Map (NH 16-8) Block No. 466

  POLYCHAETA
    Sthenolepis ? incisa
  CRUSTACEA: DECAPODA
    Alpheus sp.
    Munida flinti
  FISH
    Bembrops anatirostris

68A7-8C 199 m 29°33'N 86°33.5'W Skimmer
Destin Dome Map (NH 16-8) Block No. 421

  COELENTERATA: SCLERACTINIA
    Deltocyathus italicus
  POLYCHAETA
    Protula tubularia
  MOLLUSCA: BIVALVIA
    Aequipecten glyptus
  CRUSTACEA: DECAPODA
    Acanthocarpus alexandri
    Chasmocarcinus cylindricus
    Collodes leptocheles
    Ethusa microphthalma
    Euphrosynoplax clausa
    Lyreidus nitidus
    Munida forceps
    Myropsis quinquespinosa
    Paguristes sp. A
    Palicus obesus
    Parapenaeus longirostris
    Porcellana sigsbeiana
    Pyromaia arachna
    Solenocera necopina
    Solenocera vioscai
    Tetraxanthus rathbunae
    Thalassoplax angusta
  FISH
    Lepophidium brevibarbe
    Monolene sp.
    Physiculus fulvus
    Poecilopsetta beani
    Pontinus longispinus

68A7-9A	384 m	29°27.6'N	86°45.5'W	Skimmer

Destin Dome Map (NH 16-8) Block No. 505

PORIFERA
- Acanthascus sp.
- Hexasterophoridae sp.
- Thenea fenestrata
- Tylodesma sp.

COELENTERATA: HYDROIDEA
- Acryptolaria conferta
- Thecocarpus bispinosus

COELENTERATA: ZOANTHARIA
- Deltocyathus italicus
- Schizocyathus fissilis
- Zoanthidae sp.

POLYCHAETA
- Eunice floridana
- Eunice norvegica
- Goniada sp. A
- Harmothoe sp. A
- Lumbrineris cf. latreilli
- Panthalus sp. A
- Sabellastarte sp.
- Syllus sp.
- Terebellides sp.

MOLLUSCA: BIVALVIA
- Nuculana acuta (dead)
- Nuculana platessa (dead)

MOLLUSCA: GASTROPODA
- Antillophos candaei
- Cerithium sp.
- Glyphostoma sp.
- Scaphander watsoni

CRUSTACEA: DECAPODA
- Benthochascon schmitti
- Collodes leptocheles
- Hymenopenaeus robustus
- Munida longipes
- Parapandalus willisi
- Penaeopsis megalops
- Plesionika tenuipes
- Rochinia crassa

ECHINODERMATA: ASTEROIDEA
- Astropecten americanus

FISH
- Bembrops gobioides
- Bregmaceros atlanticus
- Breviraja sinusmexicanus
- Chlorophthalmus agassizii
- Coelorinchus coelorhinchus carminatus
- Dibranchus atlanticus
- Merluccius bilinearis
- Peristedion greyae
- Symphurus piger
- Ventrifossa occidentalis

68A7-10A 566 m 29°15.5'N 86°55'W Skimmer
Destin Dome Map (NH 16-8) Block No. 722

POLYCHAETA
- Hyalinoecia cf. stricta
- Loimia sp.
- Panthalis sp. A
- Spiophanes cf. soederstromi

MOLLUSCA: BIVALVIA
- Amygdalum politum
- Propeamussium sp. D

MOLLUSCA: CEPHALOPODA
- Benthoctopus januari
- Petroctopus tetracirrhus
- Rossia bullisi
- Rossia tortugaensis

MOLLUSCA: GASTROPODA
- Corinnaeturris leucomata
- Gaza superba
- Homalopoma sp.

CRUSTACEA: CIRRIPEDIA
- Arcoscalpellum regina

CRUSTACEA: DECAPODA
- Bathyplax typhla
- Benthochascon schmitti
- Hymenopenaeus debilis
- Hymenopenaeus robustus
- Munida valida
- Munidopsis alaminos
- Munidopsis robusta
- Plesionika acanthonotus
- Plesionika holthuisi
- Pontophilus gracilis

ECHINODERMATA: ASTEROIDEA
- Cheiraster enoplus
- Persephonaster echinulatus
- Pseudarchaster gracilis

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria lactea
- Molpadia cubana
- Molpadia musculus
- Molpadia ? oolitica

ECHINODERMATA: OPHIUROIDEA
- Amphioplus sp.
- Ophiernus adspersum
- Ophiochiton grandis
- Ophioleptoplax sp.

FISH
- Bathophilus pawneei
- Breviraja sinusmexicanus
- Coelorinchus coelorhinchus carminatus
- Nezumia aequalis
- Physiculus fulvus
- Physis chesteri
- Symphurus marginatus
- Yarrella blackfordi

68A7-11A 788 m 29°14'N 87°00'W Skimmer
Destin Dome Map (NH 16-8) Block No. 763

"East wall of DeSoto Canyon."

POLYCHAETA
- Eunice pennata
- Loimia sp.
- ? Myriochele sp. B

MOLLUSCA: BIVALVIA
- Propeamussium sp. C

MOLLUSCA: GASTROPODA
- Scaphander clavus

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Glyphocrangon alispina
- Hymenopenaeus debilis
- Munidopsis alaminos
- Nematocarcinus rotundus
- Parapagurus pilosimanus
- Plesionika holthuisi
- Stereomastis sculpta

ECHINODERMATA: ASTEROIDEA
- Cheiraster echinulatus
- Goniopecten demonstrans
- Psilaster patagiatus

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria lactea
- Mesothuria lactea oxysclera
- Psychropotes semperiana

ECHINODERMATA: OPHIUROIDEA
- Ophiernus adspersum
- unidentified Ophiuroids

FISH
- Bathygadus melanobranchus
- Chaunax pictus
- Coryphaenoides colon
- Coryphaenoides mexicanus
- Dibranchus atlanticus
- Dicrolene intronigra
- Myxine sp.

68A7-12A 585 m 29°18.4'N 86°56.4'W Dredge
Destin Dome Map (NH 16-8) Block No. 677

"East wall of DeSoto Canyon. Gray mud with brown film over it."

POLYCHAETA
- Capitellidae sp.
- Eunice sp.
- Hyalinoecia tubicola
- Marphysa sp.
- Notomastus latericeus

CRUSTACEA: DECAPODA
- Bathyplax typhla

68A7-12B 900 m 29°14'N 86°59.7'W Skimmer
Destin Dome Map (NH 16-8) Block No. 763

"Down center of DeSoto Canyon. Good sample; a good deal of plant material."

POLYCHAETA
- Maldane sp. B

MOLLUSCA: GASTROPODA
- Benthomangelia macra
- Corinnaeturris leucomata
- Latiromitra bairdi
- Leucosyrinx tenoceras
- Oocorys sulcata
- Scaphander mundus
- Theta jeffreysi
- Turridae sp. 3

MOLLUSCA: SCAPHOPODA
- Dentalium circumcinctum (dead)
- Dentalium perlongum

CRUSTACEA: DECAPODA
- Acanthephyra armata
- Benthesicymus bartletti
- Glyphocrangon alispina
- Hymenopenaeus debilis
- Munidopsis longimanus
- Nematocarcinus rotundus
- Parapagurus pilosimanus
- Rochinia umbonata
- Stereomastis sculpta
- Sympagurus pilimanus

ECHINODERMATA: ASTEROIDEA
- Dytaster insignis
- Plinthaster dentatus
- Zoroaster fulgens

ECHINODERMATA: ECHINOIDEA
- Hypselaster brachypetalus

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria lactea
- Molpadia musculus
- unidentified Holothuroids

ECHINODERMATA: OPHIUROIDEA
- Bathypectinura heros
- Ophiernus adspersum
- unidentified Ophiuroids

FISH
- Bathygadus melanobranchus
- Coryphaenoides colon
- Dicrolene intronigra
- Gadomus longifilis
- Halosaurus guentheri
- Monomitopus agassizi
- Nezumia aequalis
- Pseudophichthys sp.
- Raja bigelowi
- Synaphobranchus oregoni/brevidorsalis
- Venefica procera

68A7-13A 1061 m 29°03'N 87°15'W Skimmer
Destin Dome Map (NH 16-8) Block No. 935

PORIFERA
- Radiella sol

COELENTERATA: SCLERACTINIA
- Caryophyllia ambrosia
- Deltocyathus italicus
- Stephanocyathus coronatus

MOLLUSCA: BIVALVIA
- Propeamussium sp. A
- Propeamussium sp. C
- Tindaria amabilis
- Yoldiella quadrangularis

MOLLUSCA: GASTROPODA
- Leucosyrinx tenoceros
- Pleurotomella cf. agassizi
- Pleurotomella cf. chariessa
- Trophon aculeatus
- Volutomitra cf. bairdi

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Glyphocrangon aculeata
- Glyphocrangon nobilis
- Heterocarpus oryx
- Hymenopenaeus debilis
- Nematocarcinus rotundus
- Parapagurus ? pilosimanus
- Parapagurus sp.
- Plesiopenaeus edwardsianus
- Stereomastis sculpta

ECHINODERMATA: ASTEROIDEA
- Dytaster insignis
- Nymphaster arenatus
- Plutonaster intermedius
- Odontaster intermedius

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria lactea
- Mesothuria lactea oxysclera
- Molpadia musculus

ECHINODERMATA: OPHIUROIDEA
- ? Amphiura sp.
- Ophiernus adspersum

FISH
- Aldrovandia gracilis
- Bathypterois quadrifilis
- Conocara cf. macroptera
- Dicrolene intronigra
- Gadomus longifilis
- Ilyophis brunneus
- Monomitopus agassizi
- Nezumia aequalis
- Squalogadus modificatus
- Stephanoberyx monae
- Synaphobranchus oregoni/brevidorsalis

68A7-13B 1372-1426 m 28°59.5'N 87°21.3'W Skimmer
Destin Dome Map (NH 16-8) Block No. 977

PORIFERA
- Dragmatyle topsenti
- Radiella sol
- Tethycordyla thyris
- Thenea fenestrata

COELENTERATA: SCLERACTINIA
- Caryophyllia ambrosia
- Stephanocyathus diadema

POLYCHAETA
- Leanira hystricis

MOLLUSCA: BIVALVIA
- Tindaria amabilis

MOLLUSCA: GASTROPODA
- Benthonella fisheri
- Drilliola sp.
- Gymnobela ipara
- Leucosyrinx tenoceras
- Theta jeffreysi

CRUSTACEA: DECAPODA
- Acanthephyra eximia
- Benthesicymus bartletti
- Glyphocrangon nobilis
- Nematocarcinus rotundus
- Parapagurus ? pilosimanus
- Pontophilus gracilis

ECHINODERMATA: ASTEROIDEA
- Plutonaster intermedius

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria lactea

FISH
- Aldrovandia affinis
- Aldrovandia gracilis
- Bathypterois quadrifilis
- Conocara mcdonaldi
- Dicrolene intronigra

68A7-13D 1463 m 28°59'N 87°23.3'W Skimmer
Destin Dome Map (NH 16-8) Block No. 976

"Large bed of Propeamussium bivalves."

PORIFERA
- Dragmatyle topsenti
- Radiella sol
- Radiella sp.
- Tetilla sp.
- Tethycordyla thyris
- Thenea fenestrata

COELENTERATA: SCLERACTINIA
- Deltocyathus italicus
- Stephanocyathus diadema

continued

68A7-13D continued

MOLLUSCA: BIVALVIA
- Abra longicallis americana
- Propeamussium sp. A
- Tindaria amabilis

MOLLUSCA: GASTROPODA
- Gymnobela ipara
- Leucosyrinx cf. verrilli
- Pleurotomella cf. agassizi
- Theta pandionis

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Glyphocrangon nobilis
- Nematocarcinus rotundus
- Parapagurus ? pilosimanus
- Polychelidae sp.
- Stereomastis sculpta

ECHINODERMATA: ASTEROIDEA
- Plutonaster intermedius
- Pteraster acicula

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria lactea

ECHINODERMATA: OPHIUROIDEA
- ? Amphiura sp.
- Ophiernus adspersum
- Silax verrilli
- unidentified Ophiuroids

FISH
- Coryphaenoides mexicanus
- Dicrolene intronigra
- Gadomus longifilis
- Sphagemacrurus grenadae
- Stephanoberyx monae
- Synaphobranchus oregoni/brevidorsalis

68A7-14B 1829 m 28°56'N 87°32.7'W Skimmer
DeSoto Canyon Map (NH 16-11) Block No. 52

PORIFERA
- Radiella sol
- Thenea fenestrata

COELENTERATA: SCLERACTINIA
- Cladocarpus flexuosus

POLYCHAETA
- Chaetopteridae sp.
- Leanira hystricis
- Nephtys ? hombergi

MOLLUSCA: BIVALVIA
- Poromya sp.
- Retusa cf. domitus
- Tindaria amabilis

CRUSTACEA: DECAPODA
- Bathypalaemonella serratipalma

continued

68A7-14B continued

Geryon quinquedens
Glyphocrangon nobilis
Nematocarcinus ensifer
Nematocarcinus rotundus
Stereomastis sculpta

SIPUNCULA
Golfingia flagrifera

ECHINODERMATA: ASTEROIDEA
Astropecten antillensis

ECHINODERMATA: ECHINOIDEA
Plesiodiadema antillarum
unidentified Echinoid

ECHINODERMATA: HOLOTHUROIDEA
Deima blakei
Protankyra brychia

ECHINODERMATA: OPHIUROIDEA
Silax verrilli
unidentified Ophiuroids

FISH
Aldrovandria gracilis
Conocara mcdonaldi
Dicrolene intronigra
Porogadus catena

68A7-14C 2103 m 28°51'N 87°31.5'W Skimmer
DeSoto Canyon Map (NH 16-11) Block No. 96

"Sinking area (gyro); also green water (Mississippi River water?); much Sargassum in this sample."

PORIFERA
Radiella sol
Thenea fenestrata

POLYCHAETA
Leanira hystricis

MOLLUSCA: BIVALVIA
Malletia sp. A
Poromya sp.

MOLLUSCA: CEPHALOPODA
Benthoctopus januari

MOLLUSCA: GASTROPODA
Leucosyrinx verrilli
Turridae sp. 6

CRUSTACEA: DECAPODA
Glyphocrangon sculptus
Hemipenaeus carpenteri
Hymenopenaeus aphoticus
Nematocarcinus ensifer
Parapagurus ? pilosimanus
Polycheles validus

ECHINODERMATA: ASTEROIDEA
Dytaster insignis
Hymenaster rex
Nymphaster arenatus

continued

68A7-14C continued

ECHINODERMATA: ECHINOIDEA
- Hygrosoma petersi
- Phormosoma placenta
- Plesiodiadema antillarum

ECHINODERMATA: HOLOTHUROIDEA
- Pelopatides gigantea
- Penagione islandica
- Psychropotes depressa

ECHINODERMATA: OPHIUROIDEA
- Bathypectinura heros

FISH
- Aldrovandia gracilis
- Alepocephalus sp.
- Bassozetus normalis
- Cataetyx sp.
- Porogadus catena

68A7-15D 1097 m 29°10.3'N 87°31.5'W Skimmer
Destin Dome Map (NH 16-8) Block No. 797

"Green water (Mississippi River water?). Contact between green and blue water was 29°10.9'N, 87°22.5'W.

PORIFERA
- Radiella sol

COELENTERATA: PENNATULACEA
- Stylatula antillarum

COELENTERATA: SCLERACTINIA
- Caryophyllia ambrosia
- Deltocyathus italicus

POLYCHAETA
- Notomastus latericeus

MOLLUSCA: BIVALVIA
- Malletia sp. A (dead)
- Propeamussium sp. A
- Tindaria amabilis

MOLLUSCA: GASTROPODA
- Gymnobela ipara
- Leucosyrinx verrilli
- Mangelia exsculpta
- Volutomitra cf. bairdi

CRUSTACEA: DECAPODA
- Catapaguroides microps
- Geryon quinquedens
- Glyphocrangon nobilis
- Nematocarcinus rotundus
- Stereomastis sculpta

SIPUNCULA
- Golfingia catherinae

ECHINODERMATA: ASTEROIDEA
- Plutonaster intermedius

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria lactea oxysclera

continued

68A7-15D continued

ECHINODERMATA: OPHIUROIDEA

? Amphioplus sp.
Ophiernus adsperum
unidentified Ophiuroids

FISH

Aldrovandia gracilis
Chalinura carapina
Coryphaenoides colon
Dicrolene intronigra
Gadomus longifilis
Ilyophis brunneus
Monomitopus agassizi
Nezumia aequalis
Squalogadus modificatus
Stephanoberyx monae
Synaphobranchus oregoni/brevidorsalis

68A7-15H 914 m 29°10.5'N 87°16'W Skimmer
Destin Dome Map (NH 16-8) Block No. 803

PORIFERA

Hyalonema sp.
Radiella sol

COELENTERATA: ALCYONARIA

Acanella sp.

POLYCHAETA

Chaetopteridae sp.

MOLLUSCA: GASTROPODA

"Bulla" abyssicola
Cocculina sp.
Homalopoma sp.
Latiromitra bairdi
Leucosyrinx tenoceras
Leucosyrinx verrilli

CRUSTACEA: DECAPODA

Acanthephyra armata
Benthesicymus bartletti
Geryon quinquedens
Glyphocrangon nobilis
Heterocarpus oryx
Hymenopenaeus debilis
Munidopsis sigsbei
Nematocarcinus rotundus
Plesiopenaeus edwardsianus
Stereomastis sculpta

SIPUNCULA

Sipunculus sp. 1

ECHINODERMATA: ASTEROIDEA

Nymphaster arenatus
Plinthaster dentatus
Plutonaster intermedius

ECHINODERMATA: HOLOTHUROIDEA

Mesothuria lactea

continued

68A7-15H continued

ECHINODERMATA: OPHIUROIDEA
Ophiernus adspersum
unidentified Ophiuroid arms
FISH
Bathygadus melanobranchus
Coryphaenoides colon
Dicrolene intronigra
Gadomus longifilis
Halosaurus guentheri
Ilyophis brunneus
Monomitopus agassizii
Nezumia aequalis
Synaphobranchus oregoni/brevidorsalis

68A7-16C   2140 m   28°46.8'N   87°36.4'W   Skimmer
Destin Dome Map (NH 16-8)   Block No. 183

PORIFERA
Euplectella sp.
Radiella sol
POLYCHAETA
? Travisia sp.
MOLLUSCA: BIVALVIA
Abra longicallis americana
Malletia sp. A
MOLLUSCA: GASTROPODA
Calliotropis calatha
CRUSTACEA: ISOPODA
Bathynomus giganteus
CRUSTACEA: DECAPODA
Nematocarcinus ensifer
BRACHIOPODA
Chlidonophora incerta
ECHINODERMATA: ECHINOIDEA
Hygrosoma petersi
Phormosoma placenta
unidentified Echinoids
ECHINODERMATA: HOLOTHUROIDEA
Benthodytes lingua
Paroriza prouhoi
Paelopatides cf. gigantea
Psychropotes depressa
Synallactidae sp.
FISH
Porogadus catena

68A7-17B   900 m   29°09.5'N   87°02'W   Skimmer
Destin Dome Map (NH 16-8) Block No. 807

"Sampling crosses bottom mouth of DeSoto Canyon."
PORIFERA
Hyalonema sp.
COELENTERATA: ALCYONARIA
Acanella sp.

continued

POLYCHAETA
  Acoetidae sp.
  Leanira hystricus
  Myriochele sp. A
  Notomastus latericeus
  Onuphis sp. A
  Rhamphobrachium agassizi
  Scoloplos rubra
  Sigalionidae sp.
  Spiochaetopterus sp.
  unknown Polychaete A
MOLLUSCA: BIVALVIA
  Abra longicallis americana
  Propeamussium sp. C
MOLLUSCA: CEPHALOPODA
  Semirossia equalis
  Semirossia tenera
MOLLUSCA: GASTROPODA
  Mangelia exsculpta
  Oocarys bartschi
  Scaphander clavus
CRUSTACEA: AMPHIPODA
  Cyphocarid genus (probably new)
CRUSTACEA: DECAPODA
  Benthesicymus bartletti
  Geryon quinquedens
  Glyphocrangon alispina
  Munidopsis longimanus
  Nematocarcinus ensifer
  Parapagurus pilosimanus
  Plesionika polyacanthomerus
  Pontophilus gracilis
  Stereomastis sculpta
BRACHIOPODA
  Chlidonophora incerta
ECHINODERMATA: ASTEROIDEA
  Plutonaster intermedius
ECHINODERMATA: OPHIUROIDEA
  Ophiernus adspersum
  unidentified Ophiuroids
FISH
  Bathygadus melanobranchus
  Coryphaenoides mexicanus
  Dicrolene intronigra
  Malacosteus niger
  Nezumia aequalis
  Synaphobranchus oregoni/brevidorsalis

68A13-1 878 m 25°38'N 96°07.3'W Skimmer
PORIFERA
  Euplectella sp.
  Hyalonema sp.

continued

68A13-1 continued

Radiella sol
Thenea fenestrata

COELENTERATA: ALCYONARIA
? Acanella sp.
Funiculina quadrangularis

POLYCHAETA
Amage tumida
Eunice floridana
Eupolymnia/Lanice sp.
Hyalinoecia stricta
Nereis sp. A
Terebellides sp.

MOLLUSCA: GASTROPODA
Ancistrosyrinx sp.
Corinnaeturris leucomata
Cylichnium spatha
Fusinus sp.
Gaza fisheri
Gaza superba
Gymnobela agassizi
Gymnobela tanneri
Latiromitra bairdi
Leucosyrinx tenoceras
Leucosyrinx verrilli
Theta pandionis

MOLLUSCA: SCAPHOPODA
Cadulus sp.
Dentalium perlongum

CRUSTACEA: CIRRIPEDIA
Arcoscalpellum regina

CRUSTACEA: DECAPODA
Acanthephyra eximia
Benthesicymus bartletti
Glyphocrangon aculeata
Heterocarpus oryx
Hymenopenaeus debilis
Lithodes agassizi
Nematocarcinus rotundus
Nephropsis agassizi
Parapagurus pilosimanus
Parapagurus sp.
Stereomastis sculpta

ECHINODERMATA: ASTEROIDEA
Nymphaster arenatus
Persephonaster echinulatus
Plutonaster intermedius
Psilaster cassiope
Zoroaster fulgens

ECHINODERMATA: CRINOIDEA
Democrinus sp.

continued

68A13-1 continued

ECHINODERMATA: ECHINOIDEA
- Plesiodiadema antillarum
- Phormosoma placenta

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria lactea
- Molpadia barbouri
- Molpadia musculus
- Paelopatides gigantea

ECHINODERMATA: OPHIUROIDEA
- Bathypectinura heros
- Ophioplinthaca dipsacos
- unidentified Ophiuroids

FISH
- Bathygadus melanobranchus
- Coryphaenoides mexicanus
- Halosaurus guentheri
- Monomitopus agassizi
- Nezumia aequalis
- Synaphobranchus oregoni/brevidorsalis
- Trachonurus villosus

68A13-3 713 m 25°39'N 96°11'W 2m Dredge

"Small sample. Indications that much sediment had been taken but worked out."

POLYCHAETA
- Asychis cf. gotoi
- Drilonereis sp. A
- Sosane sp.
- Spiochaetopterus sp.

MOLLUSCA: GASTROPODA
- Benthobia tryoni
- Leucosyrinx verrilli

CRUSTACEA: DECAPODA
- Bathyplax typhla
- Glyphocrangon alispina
- Hymenopenaeus debilis
- Nematocarcinus rotundus
- Plesionika holthuisi
- Plesiopenaeus edwardsianus
- Pontophilus gracilis
- Richardina spinicincta

ECHINODERMATA: ASTEROIDEA
- Cheiraster sp.

ECHINODERMATA: ECHINOIDEA
- Phormosoma placenta

ECHINODERMATA: OPHIUROIDEA
- unidentified Ophiuroids

FISH
- Halosaurus guentheri
- Synaphobranchus oregoni/brevidorsalis

68A13-4 512 m 25°38.4'N 96°18.3'W Skimmer

PORIFERA
- Hyalonema sp.

COELENTERATA: ALCYONARIA
- Chrysogorgia elegans
- ? Keratoisis sp.
- Protoptilum carpenteri

POLYCHAETA
- Acoetidae sp.
- Chaetopteridae sp.
- Ehlersileanira incisa
- Leanira n. sp.
- Lumbrinereis cf. latreilli
- Myriochele sp. A
- Myriochele sp. B
- Onuphis sp. A
- Panthalis sp. A

MOLLUSCA: GASTROPODA
- Gaza superba
- Leucosyrinx tenoceras
- Oocorys bartschi

CRUSTACEA: DECAPODA
- Bathyplax typhla
- Hymenopenaeus robustus
- Munida valida
- Munidopsis alaminos
- Munidopsis erinaceus
- Munidopsis polita
- Munidopsis robusta
- Nematocarcinus rotundus
- Nephropsis aculeata
- Nephropsis rosea
- Pasiphaea merriami
- Plesionika holthuisi
- Plesionika polyacanthomerus
- Plesionika sp. (near acanthonotus)
- Polycheles typhlops
- Rochinia crassa
- Stereomastis sculpta
- Sympagurus pictus
- Trichopeltarion nobile

CRUSTACEA: ISOPODA
- Bathynomus giganteus

SIPUNCULA
- Sipunculus sp. 1

ECHINODERMATA: ASTEROIDEA
- Midgardia xandaros
- Persephonaster echinulatus
- Plinthaster dentatus

ECHINODERMATA: CRINOIDEA
- Atelecrinus balanoides
- Comatulidae sp.
- Democrinus sp.

continued

68A13-4 continued

ECHINODERMATA: ECHINOIDEA
- Phormosoma placenta
- Plesiodiadema antillensis

ECHINODERMATA: HOLOTHUROIDEA
- Hedingia albicans
- Mesothuria lactea oxysclera
- Molpadia musculus

ECHINODERMATA: OPHIUROIDEA
- Ophiernus adspersum
- Ophiochiton grandis
- Ophiopyren sp.

FISH
- Dibranchus atlanticus
- Merluccius albidus
- Nezumia aequalis
- Synaphobranchus oregoni/brevidorsalis
- Urophycis regia
- Ventrifossa occidentalis

68A13-5 274 m 26°12.5'N 96°19.8'W Skimmer
Port Isabel Map (NH 14-6) Block No. 782

POLYCHAETA
- Ehlersileanira incisa
- Leanira alba
- Panthalis pacifica

MOLLUSCA: BIVALVIA
- Aequipecten glyptus

MOLLUSCA: GASTROPODA
- Polystira albida
- Sconsia striata

CRUSTACEA: CIRRIPEDIA
- Scalpellum portoricanum

CRUSTACEA: DECAPODA
- Acanthocarpus alexandri
- Lyreidus bairdi
- Munida longipes
- Parapandalus willisi
- Parapenaeus longirostris
- Penaeopsis serrata
- Plesionika tenuipes
- Stenocionops spinosissima

ECHINODERMATA: ASTEROIDEA
- Tethyaster grandis

ECHINODERMATA: ECHINOIDEA
- Brissopsis/alta/atlantica/elongata
- Brissopsis sp.

FISH
- Bembrops anatirostris
- Coelorinchus caribbeaus
- Dibranchus atlanticus
- Gnathagnus egregius

continued

68A13-5 continued

Moridae sp.
Poecilopsetta beani
Steindachneria argentea
Urophycis cirrata
Ventrifossa occidentalis

68A13-7 274 m 26°17'N 96°18'W Skimmer
Port Isabel Map (NG 14-6) Block No. 695

POLYCHAETA
Ehlersileanira incisa
MOLLUSCA: BIVALVIA
Nuculana acuta
MOLLUSCA: GASTROPODA
Gemmula periscelida
CRUSTACEA: DECAPODA
Benthochascon schmitti
Hymenopenaeus robustus
Lyreidus bairdi
Munida longipes
Nematocarcinus rotundus
Palicus gracilis
Parapandalus willisi
Parapenaeus longirostris
Penaeopsis serrata
Plesionika tenuipes
Porcellana sigsbeiana
Solenocera necopina
Systellaspis pellucida
ECHINODERMATA: ASTEROIDEA
Astropecten americanus
FISH
Bembrops anatirostris
Bembrops gobiodes
Coelorinchus caribbeaus
Hymenocephalus italicus
Parasudis truculentus
Poecilopsetta beani
Steindachneria argentea
Ventrifossa occidentalis

68A13-8 732 m 26°18'N 96°08'W Skimmer
Port Isabel Map (NG 14-6) Block No. 654

POLYCHAETA
Hyalinoecia tubicola
Phyllampharete longicirrata
COELENTERATA: ALCYONARIA
Funiculina quadrangularis
MOLLUSCA: GASTROPODA
Ancistrosyrinx sp.
Gemmula periscelida
Latiromitra bairdi

continued

68A13-8 continued

CRUSTACEA: DECAPODA

Acanthephyra armata
Benthesicymus bartletti
Glyphocrangon alispina
Munidopsis longimanus
Nematocarcinus rotundus
Parapagurus pilosimanus
Penaeopsis serrata
Plesionika holthuisi
Pontophilus gracilis
Stereomastis sculpta

ECHINODERMATA: ASTEROIDEA

Brisingella verticellata
Cheiraster mirabilis
Goniopecten demonstrans
Persephonaster echinulatus

ECHINODERMATA: CRINOIDEA

Antedonidae sp.
Democrinus sp.

ECHINODERMATA: ECHINOIDEA

Plesiodiadema antillarum
Phormosoma placenta

ECHINODERMATA: HOLOTHUROIDEA

Bathyplotes natans
Mesothuria lactea
Mesothuria lactea oxysclera

ECHINODERMATA: OPHIUROIDEA

Bathypectinura heros
Ophiura ? lepida
unidentified Ophiuroids

FISH

Bathygadus melanobranchus
Dicrolene intronigra
Leptoderma macrops
Poecilopsetta beani
Pseudophichthys laterodorsalis
Synaphobranchus oregoni/brevidorsalis
Trachonurus villosus

68A13-9 3365 m 25°14'N 95°13'W Skimmer

PORIFERA

Radiella sol
Thenea fenestrata

MOLLUSCA: BIVALVIA

Malletia sp. A
Nucula callicredemna

MOLLUSCA: GASTROPODA

Abra longicallis americana
Acar asperula
Corinnaeturris leucomata
Crenilabrium exilis

continued

68A13-9 continued
Cuspidaria glacialis
Fusinis sp.
Neilo sp.
Oocorys sulcata
Poromya tornata
MOLLUSCA: SCAPHOPODA
Dentalium meridionale
CRUSTACEA: CIRRIPEDIA
Arcoscalpellum vitreum
CRUSTACEA: DECAPODA
Benthesicymus iridescens
Nematocarcinus ensifer
Plesiopenaeus armatus
Polycheles validus
ECHINODERMATA: ASTEROIDEA
Dytaster insignis
Litonotaster intermedius
ECHINODERMATA: HOLOTHUROIDEA
Benthodytes ? typica
Molpadia blakei
Psychropotes depressa
unidentified Holothuroids
FISH
Coryphaenoides sp.

68A13-10 3385-3493 m 25°21'N 95°08'W 2m Dredge
PORIFERA
Radiella sp.
Thenea fenestrata
POLYCHAETA
Ehlersileanira incisa
Maldane sp.
Myriochele sp. A (n. sp.)
Travisia ? forbesi
MOLLUSCA: BIVALVIA
Neilo sp. A
Nucula callicredemna
MOLLUSCA: GASTROPODA
Turridae sp. 8
CRUSTACEA: DECAPODA
Hemipenaeus carpenteri
Hepomadus tener
ECHINODERMATA: ASTEROIDEA
Litinotaster intermedius
ECHINODERMATA: HOLOTHUROIDEA
Benthodytes ? typica
Molpadia oolitica

68A13-11 1061-1372 m 25°23'N 95°57'W Skimmer
PORIFERA
Radiella sol
Thenea fenestrata

continued

68A13-11 continued

POLYCHAETA
- Nephtys paradoxa

MOLLUSCA: BIVALVIA
- Tindaria amabilis (dead)

MOLLUSCA: SCAPHOPODA
- Dentalium perlongum

CRUSTACEA: AMPHIPODA
- Epimera sp.

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Glyphocrangon aculeata
- Glyphocrangon nobilis
- Munidopsis sigsbei
- Nematocarcinus rotundus
- Parapagurus ? pilosimanus
- Parapagurus sp.
- Stereomastis sculpta

CRUSTACEA: ISOPODA
- Bathynomus giganteus

ECHINODERMATA: ASTEROIDEA
- Nymphaster arenatus

ECHINODERMATA: ECHINOIDEA
- Phormosoma placenta
- Plesiodiadema antillarum

ECHINODERMATA: HOLOTHUROIDEA
- Echinocucumis hispida

ECHINODERMATA: OPHIUROIDEA
- unidentified Ophiuroids

FISH
- Aldrovandia gracilis
- Bathypterois quadrifilis
- Dicrolene intronigra
- Gadomus longifilis
- Polyacanthonotus africanus
- Trachonurus villosus

68A13-12A 1061-1317 m 25°31'N 95°51'W Skimmer

PORIFERA
- Euplectella sp.
- Hyalonema sp. A

COELENTERATA: ALCYONARIA
- Acanella eburnea
- Isididae sp.

COELENTERATA: SCLERACTINIA
- Caryophyllia ambrosia

POLYCHAETA
- Hyalinoecia tubicola
- Nephtys paradoxa

MOLLUSCA: BIVALVIA
- Propeamussium sp. A
- Tindaria amabilis

continued

68A13-12A continued

MOLLUSCA: GASTROPODA

- Corinnaeturris leucomata
- Gymnobela tanneri
- Leucosyrinx tenoceras
- Leucosyrinx verrilli
- "Mangelia" antonia
- Oocorys sulcata
- Phymorhynchus sulcifera
- Solariella pourtalisi
- Spirotropis lithocollata
- Theta jeffreysi

MOLLUSCA: SCAPHOPODA

- Dentalium perlongum

CRUSTACEA: AMPHIPODA

- Valettiopsis cf. dentatus

CRUSTACEA: DECAPODA

- Acanthephyra eximia
- Benthesicymus bartletti
- Geryon quinquedens
- Glyphocrangon aculeata
- Glyphocrangon nobilis
- Heterocarpus oryx
- Hymenopenaeus aphoticus
- Lithodes agassizi
- Munidopsis sigsbei
- Nematocarcinus rotundus
- Parapagurus ? pilosimanus
- Parapagurus sp.
- Polycheles crucifer
- Pontophilus gracilis
- Stereomastis sculpta
- Uroptychus nitidus

CRUSTACEA: ISOPODA

- Bathynomus giganteus

ECHINODERMATA: ASTEROIDEA

- Nymphaster arenatus
- Pteraster acicula

ECHINODERMATA: CRINOIDEA

- Atelecrinus balanoides

ECHINODERMATA: ECHINOIDEA

- ? Hypselaster limicolus
- Phormosoma placenta
- Plesiodiadema antillarum

ECHINODERMATA: HOLOTHUROIDEA

- Benthodytes sanguinolenta
- Deima validum

ECHINODERMATA: OPHIUROIDEA

- Amphiophiura sp.
- Homalophiura sp.
- Ophiuroidea spp.

continued

68A13-12A continued

FISH

Aldovandria gracilis
Cetonurus globiceps
Coryphaenoides mexicanus
Coryphaenoides sp.
Cyclothone sp.
Dicrolene intronigra
Gadomus longifilis
Malacosteus niger
Monomitopus agassizi
Poecilopsetta beani
Stephanoberyx monae
Synaphobranchus oregoni/brevidorsalis
Venefica procera

68A13-14 969 m 25°39.5'N 95°49.5'W 2m Dredge

PORIFERA

Euplectella sp.

POLYCHAETA

Eupolymnia/Lanice sp.
Leanira n. sp.
Maldane sp.
Myriochele sp. A (n. sp.)
Nephtys paradoxa
Nephtys phyllocirra
Orbinia riseri
Sosane sp.
Travisia ? forbesi

MOLLUSCA: BIVALVIA

Tindaria amabilis (dead)

MOLLUSCA: GASTROPODA

Gymnobela tanneri
Leucosyrinx verrilli
Spirotropis lithocollata
Theta pandionis

MOLLUSCA: SCAPHOPODA

Dentalium perlongum

CRUSTACEA: AMPHIPODA

Epimera sp. A (n. sp.)

CRUSTACEA: DECAPODA

Acanthephyra acutifrons
Acanthephyra eximia
Geryon quinquedens
Glyphocrangon aculeata
Glyphocrangon nobilis
Heterocarpus oryx
Munidopsis sigsbei
Nematocarcinus rotundus
Parapagurus pilosimanus
Plesiopenaeus edwardsianus
Pontophilus gracilis
Stereomastis sculpta

continued

68A13-14 continued

ECHINODERMATA: ECHINOIDEA
- Phormosoma placenta
- Plesiodiadema antillarum

ECHINODERMATA: HOLOTHUROIDEA
- Molpadia barbouri
- Molpadia musculus
- Protankyra abyssicola

ECHINODERMATA: OPHIUROIDEA
- Bathypectinura heros
- Ophiuroidea spp.

FISH
- Conocara mcdonaldi
- Dicrolene intronigra
- Gadomus longifilis
- Nezumia aequalis
- Stephanoberyx monae
- Synaphobranchus oregoni/brevidorsalis
- Venefica procera

68A13-15   658-860 m   27°34.5'N   95°10.5'W   Skimmer
East Breaks Map (NG 15-1) Block No. 368

PORIFERA
- Tethycordyla thyris
- Thenea fenestrata

COELENTERATA: PENNATULACEA
- ? Funiculina sp.
- Protoptilum carpenteri

POLYCHAETA
- Acoetidae sp.
- Amphicteis gunneri
- Harmothoinae sp. 2
- Hyalinoecia cf. stricta
- Leanira n. sp.
- Lumbrinereis sp. A
- Sabellides sp.

MOLLUSCA: GASTROPODA
- Leucosyrinx tenoceros
- Scaphander mundus
- Spirotropis lithocollata

CRUSTACEA: CIRRIPEDIA
- Arcoscalpellum regina
- Verruca sp. 2

CRUSTACEA: DECAPODA
- Bathyplax typhla
- Glyphocrangon alispina
- Munida valida
- Munidopsis erinaceus
- Munidopsis polita
- Munidopsis sigsbei
- Nematocarcinus rotundus
- Parapagurus pilosimanus

continued

68A13-15 continued

SIPUNCULA
- Sipunculus sp. 1

ECHINODERMATA: ASTEROIDEA
- Cheiraster mirabilis
- Goniopecten demonstrans
- Midgardia xandaros
- Nymphaster arenatus
- Plutonaster intermedius
- Pseudarchaster gracilis
- Psilaster cassiope

ECHINODERMATA: CRINOIDEA
- Democrinus sp.

ECHINODERMATA: ECHINOIDEA
- Phormosoma placenta

ECHINODERMATA: HOLOTHUROIDEA
- Bathyplotes natans
- Mesothuria lactea

ECHINODERMATA: OPHIUROIDEA
- Bathypectinura heros
- Ophiochiton ? grandis
- Ophiomusium monoplax
- Ophiuroidea spp.

FISH
- Synaphobranchus oregoni/brevidorsalis

68A13-16 713 m 27°37'N 95°08'W 2m Dredge
East Breaks Map (NG 15-1) Block No. 325

COELENTERATA: ALCYONARIA
- ? Acanella sp.

POLYCHAETA
- Asychis cf. gotoi
- Goniada teres
- Nothria sp. A
- Notomastis latericeus
- Spiochaetopterus sp.

MOLLUSCA: GASTROPODA
- Theta pandionus

CRUSTACEA: DECAPODA
- Bathyplax typhla

SIPUNCULA
- Golfingia sp. 3
- Sipunculus sp. 1

ECHINODERMATA: OPHIUROIDEA
- Bathypectinura heros

FISH
- Chimaeroidei egg case
- Pseudophichthys schmitti
- Synaphobranchus oregoni/brevidorsalis

68A13-17 183 m 27°50'N 95°12.5'W Skimmer
East Breaks Map (NG 15-1) Block No. 103

"Sticky, gray mud."

continued

68A13-17 continued

POLYCHAETA
- Acoetes pacifica
- Ehlersileanira incisa
- Polyodontes sp. B

MOLLUSCA: BIVALVIA
- Abra longicallis americana
- Aequipecten glyptus
- Nuculana acuta
- Parvamussium cancellatum

MOLLUSCA: GASTROPODA
- Conus mazei

CRUSTACEA: DECAPODA
- Acanthocarpus alexandri
- Lyreidus bairdi
- Parapenaeus longirostris
- Raninoides louisianensis

ECHINODERMATA: ASTEROIDEA
- Anthenoides pierci

ECHINODERMATA: ECHINOIDEA
- Brissopsis alta/atlantica/elongata

ECHINODERMATA: OPHIUROIDEA
- Ophiuroidea spp.

FISH
- Monolene sp.
- Myrophis punctatus
- Pontinus longispinis

68A13-18 439 m 27°45'N 95°16.2'W 2m Dredge
East Breaks Map (NG 15-1) Block No. 190

POLYCHAETA
- Diplocirrus sp.
- Ehlersileanira incisa
- Leanira n. sp.
- Melinna sp.
- Nothria sp. A
- Orbinia riseri
- Orbinia ? riseri
- Panthalis sp. A
- Scoloplos sp. A

MOLLUSCA: GASTROPODA
- Gemmula periscelida
- Turridae sp. 3

CRUSTACEA: DECAPODA
- Benthochascon schmitti
- Geryon quinquedens
- Lyreidus bairdi
- Munida longipes
- Palicus gracilis
- Parapandalus willisi
- Penaeopsis serrata
- Polycheles typhlops
- Pontophilus gracilis

continued

68A13-18 continued

FISH

Bembrops gobioides
Chimaeroidei egg cases
Hymenocephalus italicus

68A13-19   338-384 m   27°44.9'N   95°20.1'W   Skimmer
East Breaks Map (NG 15-1) Block No. 188

"Sticky, gray mud."

POLYCHAETA

Ehlersileanira incisa
Panthalis pacifica
Panthalis sp. A
Rhamphobrachium agassizi

MOLLUSCA: BIVALVIA

Abra longicallis americana
Nuculana acuta (dead)
Venericardia armilla

MOLLUSCA: GASTROPODA

? Inodrillia sp.
Scaphander watsoni

CRUSTACEA: DECAPODA

Benthochascon schmitti
Lyreidus bairdi
Munida longipes
Palicus gracilis
Penaeopsis megalops
Polycheles typhlops

ECHINODERMATA: ASTEROIDEA

Astropecten americanus

ECHINODERMATA: OPHIUROIDEA

Ophiuroidea sp.

FISH

Bembrops gobioides
Chimaeroidei egg case
Coelorinchus caribbeaus
Gnathagnus egregius
Poecilopsetta beani
Saccogaster maculatus

68A13-21   512-640 m   27°38'N   95°21.5'W   Skimmer
East Breaks Map (NG 15-1) Block No. 320

PORIFERA

Hyalonema sp.

COELENTERATA: ALCYONARIA

Chrysogorgia elegans

POLYCHAETA

Ehlersileanira incisa
Harmothoinae sp. 2
Hyalinoecia cf. stricta
Lumbrineris cf. latreilli

continued

68A13-21 continued

Myriochele sp. A
Myriochele sp. B
Panthalis pacifica
Sosane sp.

MOLLUSCA: GASTROPODA

Hyalorissia galeus
Scaphella cf. gouldiana

CRUSTACEA: CIRRIPEDIA

Scalpellum portoricanum

CRUSTACEA: DECAPODA

Bathyplax typhla
Hymenopenaeus debilis
Lyreidus bairdi
Munida valida
Munidopsis erinaceus
Munidopsis longimanus
Nematocarcinus rotundus
Nephropsis aculeata
Nephropsis rosea
Palicus gracilis
Pasiphaea merriami
Plesionika acanthonotus
Plesionika holthuisi
Pontophilus gracilis
Stereomastis sculpta
Sympagurus pictus
Systellaspis pellucida

SIPUNCULA

Sipunculus sp. 1

ECHINODERMATA: ASTEROIDEA

Benthopecten sp.
Doraster constellatus
Persephonaster echinulatus

ECHINODERMATA: CRINOIDEA

Atelecrinus balanoides
Caryometra cf. alope
Democrinus sp.

ECHINODERMATA: ECHINOIDEA

Phormosoma placenta

ECHINODERMATA: HOLOTHUROIDEA

Bathyplotes natans
Hedingia albicans
Mesothuria lactea

ECHINODERMATA: OPHIUROIDEA

Bathypectinura heros
Ophiernus adspersum
Ophiopyren sp.

FISH

Barathronus bicolor
Dibranchus atlanticus

continued

68A13-21 continued
Diplacanthopoma brachysoma
Hymenocephalus italicus
Malacosteus niger
Pseudophichthys sp.
Ventrifossa atlantica
Ventrifossa occidentalis

68A13-22   476 m   27°38'N   95°22.5'W   2m Dredge
East Breaks Map (NG 15-1) Block No. 319
"Dredge hung up on soft metallic object - possibly a wreck."
COELENTERATA: ALCYONARIA
Chrysogorgia elegans
MOLLUSCA: CEPHALOPODA
Pteroctopus tetracirrhus
MOLLUSCA: GASTROPODA
"Bulla" abyssicola
Leucosyrinx sp.
Oocorys bartschi
MOLLUSCA: SCAPHOPODA
Dentalium circumcinctum
CRUSTACEA: DECAPODA
Bathyplax typhla
Benthochascon schmitti
Hymenopenaeus debilis
Munida valida
Munidopsis robusta
Nephropsis aculeata
Plesionika tenuipes
FISH
Hymenocephalus sp.

68A13-23   732 m   27°35'N   95°23'W   Skimmer
East Breaks Map (NG 15-1) Block No. 363
"Sticky mud."
COELENTERATA: ALCYONARIA
Chrysogorgia elegans
Funiculina quadrangularis
POLYCHAETA
Hyalinoecia tubicola
Marphysa cf. bellii
Notomastus latericeus
MOLLUSCA: BIVALVIA
Propeamussium sp.
MOLLUSCA: GASTROPODA
Ancistrosyrinx sp.
Capulus cf. galea
Gymnobela ipara
Latiromitra bairdi
Leucosyrinx verrilli

continued

68A13-23 continued

MOLLUSCA: SCAPHOPODA
  Dentalium ? obscurum
CRUSTACEA: DECAPODA
  Bathyplax typhla
  Glyphocrangon alispina
  Hymenopenaeus robustus
  Lyreidus bairdi
  Munida valida
  Nematocarcinus rotundus
  Nephropsis rosea
  Parapagurus pilosimanus
  Plesionika acanthonotus
  Plesionika holthuisi
  Plesionika sp. (near acanthonotus)
  Rochinia crassa
  Stereomastis sculpta
  Uroptychus nitidus
CRUSTACEA: ISOPODA
  Bathynomus giganteus
SIPUNCULA
  Sipunculus sp. 1
ECHINODERMATA: ASTEROIDEA
  Cheiraster mirabilis
  Plutonaster intermedius
ECHINODERMATA: CRINOIDEA
  Atelicrinus balanoides
ECHINODERMATA: ECHINOIDEA
  Phormosoma placenta
  Plesiodiadema antillarum
ECHINODERMATA: HOLOTHUROIDEA
  Benthodytes sanguinolenta
  Hedingia albicans
  Mesothuria lactea
  Protankyra abyssicola
ECHINODERMATA: OPHIUROIDEA
  Bathypectinura heros
  Ophiernus adspersum
  Ophiochiton sp.
FISH
  Bathypterois longipes
  Nezumia aequalis
  Synaphobranchus oregoni/brevidorsalis
  Yarrella blackfordi

68A13-24 878 m 27°29.5'N 95°31'W Skimmer
East Breaks Map (NG 15-1) Block No. 448

"Soft bottom with very little sticky clay - very different from previous three stations."

PORIFERA
  Hyalonema sp.
  Tethycordyla thyris
  Thenea fenestrata

continued

68A13-24 continued

COELENTERATA: ALCYONARIA
- Funiculina quadrangularis

POLYCHAETA
- Acoetidae sp.
- Asychis cf. gotoi
- Hyalinoecia cf. stricta
- Phyllampharete longicirrata

MOLLUSCA: BIVALVIA
- Parvamussium cancellatum
- Propeamussium sp. A (dead)
- Propeamussium sp. B

MOLLUSCA: GASTROPODA
- Capulus cf. galea
- Gaza fisheri
- Leucosyrinx verrilli
- Scaphander mundus
- Spirotropis lithocollata

CRUSTACEA: CIRRIPEDIA
- Arcoscalpellum albatrossianum
- Arcoscalpellum regina

CRUSTACEA: DECAPODA
- Bathypalaemonella serratipalma
- Bathyplax typhla
- Ethusina abyssicola
- Glyphocrangon aculeata
- Glyphocrangon alispina
- Hymenopenaeus debilis
- Munidopsis longimanus
- Munidopsis sigsbei
- Nematocarcinus rotundus
- Parapagurus pilosimanus
- Pontophilus gracilis
- Stereomastis sculpta

SIPUNCULA
- Sipunculus sp. 1

ECHINODERMATA: ASTEROIDEA
- Astropecten americanus
- Nymphaster arenatus
- Plutonaster intermedius
- Psilaster cassiope

ECHINODERMATA: ECHINOIDEA
- Phormosoma placenta
- unidentified Echinoid

ECHINODERMATA: HOLOTHUROIDEA
- Bathyplotes natans
- Mesothuria lactea
- Molpadia barbouri
- Molpadia musculus
- Protankyra abyssicola
- unidentified Holothuroidea

ECHINODERMATA: OPHIUROIDEA
- Ophiuroidea spp.

continued

68A13-24 continued

FISH

Dibranchus atlanticus
Dicrolene intronigra
Halosaurus guentheri

68A13-26   1372-1435 m   27°00.3'N   95°08'W   Skimmer
East Breaks Map (NG 15-1) Block No. 940

PORIFERA

Euplectella sp.
Plakortis sp.
Radiella sol
Radiella sp.
Tethycordyla thyris

COELENTERATA: ALCYONARIA

? Anthoptilum sp.

POLYCHAETA

Harmothoinae sp. 1
Leanira n. sp.

MOLLUSCA: BIVALVIA

Abra sp.
Limopsis sp. (dead)
Propeamussium dalli
Tindaria amabilis

MOLLUSCA: CEPHALOPODA

Vampyroteuthis infernalis

MOLLUSCA: GASTROPODA

Benthomangelia macra
Coralliophila dalli
Cylichnium spatha
Leucosyrinx tenoceras
Leucosyrinx verrilli
Scaphander mundus

MOLLUSCA: SCAPHOPODA

Dentalium callithrix (dead)
Dentalium perlongum

CRUSTACEA: DECAPODA

Bathypalaemonella serratipalma
Benthesicymus bartletti
Ethusina abyssicola
Geryon quinquedens
Glyphocrangon aculeata
Glyphocrangon nobilis
Heterocarpus oryx
Hymenopenaeus aphoticus
Munidopsis sigsbei
Munidopsis simplex
Nematocarcinus rotundus
Parapagurus pilosimanus
Polycheles crucifer
Stereomastis sculpta

ECHINODERMATA: ECHINOIDEA

Plesiodiadema antillarum

continued

68A13-26 continued

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes sanguinolenta
- Deima validum
- Molpadia blakei

ECHINODERMATA: OPHIUROIDEA
- unidentified Ophiuroids

FISH
- Bassozetus normalis
- Conocara mcdonaldi
- Dicrolene intronigra
- Stephanoberyx monae
- Synaphobranchus oregoni/brevidorsalis
- Venefica procera

68A13-27 1097-1170 m 27°17.5'N 95°08.5'W Skimmer
East Breaks Map (NG 15-1) Block No. 676

PORIFERA
- Euplectella sp.
- Hyalonema sp.
- Radiella sol

COELENTERATA: ALCYONARIA
- ? Anthoptilum sp.

POLYCHAETA
- Diplocirrus sp.
- Glycera oxycephala
- Hyalinoecia tubicola
- Nephtys phyllocirra
- Phyllodoce sp.
- Terebellides sp.

MOLLUSCA: BIVALVIA
- Abra longicallis americana
- Propeamussium sp. A
- Tindaria amabilis (dead)

MOLLUSCA: SCAPHOPODA
- Dentalium perlongum

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Ethusina abyssicola
- Glyphocrangon aculeata
- Glyphocrangon nobilis
- Heterocarpus oryx
- Munidopsis abbreviata
- Munidopsis longimanus
- Munidopsis sigsbei
- Nematocarcinus rotundus
- Parapagurus ? pilosimanus
- Pontophilus gracilis
- Stereomastis sculpta
- Uroptychus nitidus

continued

68A13-27 continued

ECHINODERMATA: ASTEROIDEA
- Dytaster insignis
- Plutonaster intermedius
- unidentified Asteroid

ECHINODERMATA: ECHINOIDEA
- Phormosoma placenta
- Plesiodiadema antillarum

ECHINODERMATA: HOLOTHUROIDEA
- Molpadia blakei
- Molpadia musculus

ECHINODERMATA: OPHIUROIDEA
- unidentified Ophiuroids

FISH
- Gadomus longifilis
- Ilyophis brunneus
- Venefica procera

69A11-2 942 m 27°24.3'N 94°32'W Skimmer
East Breaks Map (NG 15-1) Block No. 557

PORIFERA
- Hyalonema sp.

POLYCHAETA
- Lumbrineris sp. A
- Myriochele sp. A (n. sp.)
- Onuphis sp. A

MOLLUSCA: BIVALVIA
- Limopsis pelagica
- Propeamussium sp.
- Tindaria amabilis (dead)

MOLLUSCA: GASTROPODA
- Leucosyrinx tenoceras

MOLLUSCA: SCAPHOPODA
- Dentalium callithrix
- Dentalium perlongum (dead)

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Catapaguroides microps
- Glyphocrangon aculeata
- Munidopsis sigsbei
- Nematocarcinus rotundus
- Nephropsis agassizi

ECHINODERMATA: HOLOTHUROIDEA
- Molpadia barbouri
- Molpadia musculus

69A11-4 1006 m 27°24.9'N 94°44.5'W Skimmer
East Breaks Map (NG 15-1) Block No. 552

"Sample had a great deal of clay in it."

PORIFERA
- Hyalonema sp. B

continued

69A11-4 continued

COELENTERATA: ALCYONARIA
- Chrysogorgia elegans
- Deltocyathus italicus

POLYCHAETA
- Paradiopatra cf. solenotecton

MOLLUSCA: BIVALVIA
- Limopsis pelagica
- Propeamussium sp.
- Tindaria amabilis

MOLLUSCA: GASTROPODA
- Scaphander cf. clavus

MOLLUSCA: SCAPHOPODA
- Dentalium perlongum

CRUSTACEA: DECAPODA
- Catapaguroides sp.
- Geryon quinquedens
- Glyphocrangon aculeata
- Glyphocrangon nobilis
- Heterocarpus oryx
- Munidopsis sigsbei
- Nematocarcinus rotundus
- Parapagurus pilosimanus
- Parapagurus sp.
- Pontophilus gracilis
- Stereomastis sculpta
- Uroptychus nitidus

CRUSTACEA: ISOPODA
- Bathynomus giganteus

ECHINODERMATA: ECHINOIDEA
- Plesiodiadema antillarum

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria sp.

FISH
- Bathypterois quadrifilis
- Bathytroctes melanocephalus
- Conocara mcdonaldi
- Coryphaenoides colon
- Dicrolene intronigra
- Nezumia aequalis
- Stephanoberyx monae
- Synaphobranchus oregoni/brevidorsalis
- Venefica procera

69A11-7 1399 m 27°01.3'N 94°43.5'W Skimmer
East Breaks Map (NG 15-1) Block No. 993

PORIFERA
- Euplectella sp.

MOLLUSCA: BIVALVIA
- Abra longicallis americana
- Arca orbiculata
- Cyclopecten strigillatum

continued

69A11-7 continued

Limopsis pelagica
Pectinidae sp.
Propeamussium sp. A
Tindaria amabilis
Tindariopsis agathida (dead)

MOLLUSCA: GASTROPODA

Aclis cf. egregia
Basilissa alta
Benthobia tryoni
Calliotropis calatha
Leucosyrinx tenoceras
Leucosyrinx verrilli
"Mangelia" antonia
Ringicula nitida
Solariella cf. obscura
Solariella pourtalisi

MOLLUSCA: SCAPHOPODA

Dentalium callithrix
Dentalium ensiculus
Dentalium laqueatum
Dentalium perlongum
Pulsellum pressum

CRUSTACEA: AMPHIPODA

Epimera sp.
Trischizostoma longirostris

CRUSTACEA: DECAPODA

Acanthephyra eximia
Benthesicymus bartletti
Catapaguroides microps
Glyphocrangon aculeata
Glyphocrangon nobilis
Hepomadus tener
Heterocarpus oryx
Hymenopenaeus aphoticus
Munidopsis gulfensis
Munidopsis sigsbei
Munidopsis simplex
Nematocarcinus rotundus
Stereomastis sculpta

ECHINODERMATA: CRINOIDEA

Atelecrinus balanoides

ECHINODERMATA: HOLOTHUROIDEA

Mesothuria lactea oxysclera

FISH

Aldrovandia affinis
Dicrolene intronigra
Sphagemacrurus grenadae

69A11-12 1463 m 27°00.6'N 94°50.3'W 2m Dredge
East Breaks Map (NG 15-1) Block No. 990

POLYCHAETA

Sabellidae sp.

continued

69A11-12 continued

MOLLUSCA: BIVALVIA
- Propeamussium sp.

MOLLUSCA: GASTROPODA
- Calliotropis calatha

MOLLUSCA: SCAPHOPODA
- Dentalium perlongum (dead)

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Glyphocrangon nobilis

69A11-13 1463 m 27°01.6'N 94°42'W Skimmer
East Breaks Map (NG 15-1)
Block No. 993

COELENTERATA: ALCYONARIA
- ? Anthoptilum sp.
- ? Funiculina quadrangularis

POLYCHAETA
- Leanira n. sp.

MOLLUSCA: BIVALVIA
- Limopsis pelagica
- Propeamussium sp.
- Tindaria amabilis (dead)

MOLLUSCA: GASTROPODA
- Leucosyrinx tenoceras
- Lischkeia sp.
- Retusa sp.
- Solariella sp. A

MOLLUSCA: SCAPHOPODA
- Dentalium callithrix
- Dentalium perlongum

CRUSTACEA: DECAPODA
- Bathypalaemonella serratipalma
- Bathypalaemonella texana
- Benthesicymus bartletti
- Benthesicymus ? cereus
- Catapaguroides microps
- Geryon quinquedens
- Glyphocrangon aculeata
- Glyphocrangon nobilis
- Hymenopenaeus aphoticus
- Munidopsis sigsbei
- Nematocarcinus rotundus
- Parapagurus pilosimanus
- Stereomastis sculptus

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes ? sanguinolenta

FISH
- Aldrovandia gracilis
- Alepocephalus sp.
- Coryphaenoides mexicanus
- Dicrolene intronigra

69A11-14 2432 m 26°18.5'N 94°37.4'W Skimmer
Alaminos Canyon Map (NG 15-4) Block No. 686

MOLLUSCA: BIVALVIA
- Poromya tornata

MOLLUSCA: GASTROPODA
- Oocorys sulcata

MOLLUSCA: SCAPHOPODA
- Dentalium callithrix
- Dentalium perlongum (dead)

CRUSTACEA: DECAPODA
- Parapagurus sp.
- Stereomastis sculpta

ECHINODERMATA: ASTEROIDEA
- Litonotaster intermedius

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes ? typica

69A11-17 3292 m 25°50.5'N 94°27'W Skimmer

MOLLUSCA: BIVALVIA
- Bentharca asperula
- Cardiomya sp.
- Cuspidaria glacialis
- Malletia sp.
- Neilo sp. A
- Nucula callicredemna
- Poromya tornata

MOLLUSCA: CEPHALOPODA
- Onychoteuthis banksi

MOLLUSCA: SCAPHOPODA
- Dentalium perlongum

CRUSTACEA: DECAPODA
- Munidopsis bermudezi
- Parapagurus sp.

ECHINODERMATA: ASTEROIDEA
- Ampheraster alaminos
- Hydrasterias ophidion

ECHINODERMATA: HOLOTHUROIDEA
- Molpadia blakei
- Psychropotes depressa

69A13-4 1984 m 26°25'N 91°55'W Skimmer
Keathley Canyon Map (NG 15-5) Block No. 569

PORIFERA
- Dragmatyle topsenti
- Thenea fenestrata

COELENTERATA: ALCYONARIA
- ? Keratoisis sp.

MOLLUSCA: CEPHALOPODA
- Pholidoteuthis adami

MOLLUSCA: SCAPHOPODA
- Dentalium callithrix
- Dentalium perlongum

CRUSTACEA: DECAPODA
- Nematocarcinus ensifer

continued

69A13-4 continued

ECHINODERMATA: ASTEROIDEA
- Benthopecten simplex
- Hymenaster anomalous

69A13-6 3477 m 25°00'N 90°51'W Skimmer

PORIFERA
- Thenea fenestrata

69A13-28 3239 m 25°27'N 86°04'W Skimmer

"Sample had much decaying turtle grass."

PORIFERA
- Radiella sp.

POLYCHAETA
- Maldanidae sp.
- Myriochele sp. A
- Oweniidae sp.

MOLLUSCA: GASTROPODA
- Calliotropis calatha

MOLLUSCA: SCAPHOPODA
- Dentalium meridionale

CRUSTACEA: DECAPODA
- Parapagurus sp.

ECHINODERMATA: ASTEROIDEA
- Dytaster insignis
- Ampheraster alaminos

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes ? typica

ECHINODERMATA: OPHIUROIDEA
- Ophiomusium planum

FISH
- Bathytroctes macrolepis

69A13-29 3230 m 25°30'N 86°09'W Skimmer

"Much ironstone."

PORIFERA
- Euplectella sp.
- Radiella sol
- Thenea sp.

POLYCHAETA
- Hyalinoecia tubicola
- Maldanella sp.
- Myriochele sp. A
- Onuphidae sp.
- Onuphis sp.
- Rhamphobrachium agassizi

MOLLUSCA: BIVALVIA
- Bentharca asperula
- Cetoconcha bulla
- Neilo sp. A
- Neilonella guineensis
- Nucula callicredemna
- Poromya tornata (dead)

continued

69A13-29 continued

MOLLUSCA: GASTROPODA
- Fusinus sp.
- Leucosyrinx sigsbei
- Theta jeffreysi

MOLLUSCA: SCAPHOPODA
- Dentalium ensiculus
- Dentalium meridionale
- Dentalium perlongum (dead)

CRUSTACEA: DECAPODA
- Acanthephyra microphthalma
- Hemipenaeus carpenteri
- Parapagurus sp.

ECHINODERMATA: ASTEROIDEA
- Dipsacaster antillensis
- Paragonaster subtilis

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes lingua
- Benthodytes ? typica
- Molpadia blakei
- Pseudostichopus sp. A
- Psychropotes depressa

ECHINODERMATA: OPHIUROIDEA
- Amphilepis norvegica
- Ophiomusium planum

69A13-37 3001 m 26°55'N 86°48'W Skimmer

Henderson Map (NG 16-5)

"Considerable ironstone, but no vegetation."

POLYCHAETA
- Nothria sp. A

MOLLUSCA: BIVALVIA
- Cetoconcha bulla
- Neilo sp. A

MOLLUSCA: SCAPHOPODA
- Dentalium meridionale (dead)
- Dentalium perlongum (dead)

CRUSTACEA: DECAPODA
- Acanthephyra microphthalma
- Benthesicymus cereus
- Parapagurus sp.
- Plesiopenaeus armatus

BRYOZOA
- Nellia oculata

ECHINODERMATA: ASTEROIDEA
- Ampheraster alaminos
- Dytaster insignis
- Litonotaster intermedius
- Paragonaster subtilis

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes ? typica

ECHINODERMATA: OPHIUROIDEA
- Amphilepis norvegica

continued

69A13-37 continued
Bathypectinura heros
Homalophiura abyssorum
Homalophiura cf. inornatum
Ophiomusium planum

69A13-38 2736 m 28°04'N 87°26'W Skimmer
DeSoto Canyon Map (NH 16-11)
Block No. 890

PORIFERA
Thenea fenestrata
POLYCHAETA
Chaetopteridae sp.
Myriochele sp. B
MOLLUSCA: GASTROPODA
Calliotropis calatha
MOLLUSCA: SCAPHOPODA
Dentalium perlongum (dead)
CRUSTACEA: DECAPODA
Nematocarcinus ensifer
SIPUNCULA
Golfingia flagrifera
Golfingia sp. 2
ECHINODERMATA: ASTEROIDEA
Psilaster sp.
ECHINODERMATA: HOLOTHUROIDEA
Benthodytes lingua
Benthodytes ? typica
Paelopatides cf. gigantea
Pseudostichopus sp. A
Psychropotes depressa
Synallactidae sp.
ECHINODERMATA: OPHIUROIDEA
Bathypectinura heros
Silax verrilli

69A13-39 2105 m 28°51'N 87°36'W Skimmer
DeSoto Canyon Map (NH 16-11) Block No. 95

CRUSTACEA: DECAPODA
Nematocarcinus ensifer
ECHINODERMATA: ECHINOIDEA
Phormosoma placenta
ECHINODERMATA: HOLOTHUROIDEA
Paroriza prouhoi
Protankyra brychia
ECHINODERMATA: OPHIUROIDEA
Bathypectinura heros

69A13-40 476 m 29°07'N 88°18'W Skimmer
Viosca Knoll Map (NH 16-7) Block No. 864

COELENTERATA: ALCYONARIA
Protoptilum carpenteri
COELENTERATA: SCLERACTINIA
Deltocyathus italicus

continued

69A13-40 continued

POLYCHAETA
- Ehlersileanira incisa
- Goniada sp. A
- Myriochele sp. A (n. sp.)
- Onuphis sp. A
- Polydora ? websteri
- Sabellidae sp.

MOLLUSCA: BIVALVIA
- Amygdalum politum

MOLLUSCA: GASTROPODA
- Gaza superba
- Scaphander watsoni

CRUSTACEA: DECAPODA
- Benthochascon schmitti
- Hymenopeneaus debilis
- Hymenopenaeus robustus
- Munidopsis robusta
- Polycheles typhlops paramatur
- Polychelidae sp.
- Rochinia crassa

ECHINODERMATA: HOLOTHUROIDEA
- Molpadia musculus

ECHINODERMATA: OPHIUROIDEA
- Ophiomusium eburneum

FISH
- Bembrops gobioides
- Callionymus agassizi
- Coelorinchus coelorhinchus carminatus
- Dibranchus atlanticus
- Nezumia cf. sclerorhynchus
- Phycis chesteri
- Symphurus marginatus
- Symphurus piger

69A13-41 311 m 29°11.5'N 88°12.6'W Skimmer
Viosca Knoll Map (NH 16-7) Block No. 778

POLYCHAETA
- Myriochele sp. A
- Panthalis pacifica

MOLLUSCA: BIVALVIA
- Astarte cf. nana

MOLLUSCA: CEPHALOPODA
- Abralia veranyi

MOLLUSCA: GASTROPODA
- Gemmula periscelida
- Oocorys bartschi
- Polystira albida

CRUSTACEA: DECAPODA
- Hymenopenaeus debilis
- Hymenopenaeus robustus
- Lyreidus bairdi

continued

69A13-41 continued

Munida longipes
Parapandalus willisi
Parapenaeus longirostris
Penaeopsis megalops
Plesionika tenuipes

ECHINODERMATA: ASTEROIDEA
Astropecten americanus

ECHINODERMATA: OPHIUROIDEA
unidentified Ophiuroid

FISH
Bembrops gobioides
Chlorophthalmus chalybeius
Poecilopsetta beani
Urophycis cirrata

69A13-42 183 m 29°14'N 88°15'W Otter Trawl
South and East Addition Block No. 284

POLYCHAETA
Polyodontes lupinus
Rhamphobrachium agassizi
Sthenolepis ? incisa

MOLLUSCA: BIVALVIA
Aequipecten glyptus
Anadara cf. baughmani

MOLLUSCA: GASTROPODA
Hindsiclava alesidota
Phalium granulatum
Polystira tellea
Scaphella dubia

CRUSTACEA: DECAPODA
Acanthocarpus alexandri
Ethusa microphthalma
Munida flinti
Munida forceps
Myropsis quinquespinosa
Pagurus bullisi
Parapenaeus longirostris
Porcellana sigsbeiana
Raninoides louisianensis
Thalassoplax angusta

CRUSTACEA: STOMATOPODA
Squilla edentata

ECHINODERMATA: ASTEROIDEA
Anthenoides piercei

ECHINODERMATA: ECHINOIDEA
Brissopsis alta/atlantica/elongata
Hypselaster limicolus

FISH
Bembrops anatirostris
Congrina flava
Monolene sp.
Pontinus longispinis

continued

69A13-42 continued

Prionotus rubio
Prionotus stearnsi
Steindachneria argentea
Urophycis regia

69A13-43 210 m 29°13.5'N 88°16.5'W Skimmer
South and East Addition Block No. 284

POLYCHAETA
Chloeia ? viridis
Rhamphobrachium agassizi
MOLLUSCA: GASTROPODA
Antillophos candaei
Conus mazei
Polystira tellea
Scaphella dubia
CRUSTACEA: DECAPODA
Callianassa latispina
Eucratodes agassizi
Euphrosynoplax clausa
Munida flinti
Myropsis quinquespinosa
Parapenaeus longirostris
Raninoides louisianensis
Solenocera vioscai
Thalassoplax angusta
CRUSTACEA: STOMATOPODA
Squilla edentata
ECHINODERMATA: ECHINOIDEA
Brissopsis alta/atlantica/elongata
FISH
Bythitidae sp.
Congridae sp.
Myrophis punctatus
Nettenchelys pygmaeus

69A13-44 752 m 28°58'N 88°28'W Otter Trawl
Mississippi Canyon Map (NH 16-10) Block No. 30

COELENTERATA: HYDROZOA
Eudendrium sp.
Opercularella sp. B
COELENTERATA: SCYPHOZOA
Stephanoscyphus sp. (polyp)
POLYCHAETA
Aphrodita sp.
Hyalinoecia tubicola
Leanira hystricis
Maldane sarsi
MOLLUSCA: BIVALVIA
Amygdalum politum
MOLLUSCA: CEPHALOPODA
Benthoctopus januari

continued

69A13-44 continued

MOLLUSCA: GASTROPODA

Colus sp.
Leucosyrinx subgrundifera
Leucosyrinx cf. verrilli
Oocorys bartschi
Scaphander clavus
Spirotropis lithocollata
Volutomitra cf. bairdi

CRUSTACEA: DECAPODA

Benthesicymus bartletti
Ethusa microphthalma
Geryon quinquedens
Glyphocrangon alispina
Glyphocrangon nobilis
Munidopis longimanus
Nematocarcinus rotundus
Nephropsis aculeata
Parapagurus pilosimanus
Parapagurus sp.
Parapenaeus longirostris
Plesionika acanthonotus
Plesionika holthuisi
Plesionika sp. (cf. acanthonotus)
Pontophilus gracilis
Porcellana sigsbeiana
Stereomastis sculpta
Thalassoplax angusta
Trichopeltarion nobile

ECHINODERMATA: ASTEROIDEA

Dipsacaster antillensis
Doraster constellatus
Dytaster sp.
Nymphaster arenatus
Plutonaster intermedius
Zoroaster fulgens

ECHINODERMATA: HOLOTHUROIDEA

Mesothuria lactea
Molpadia cubana

ECHINODERMATA: OPHIUROIDEA

Bathypectinura heros

FISH

Bathygadus melanobranchus
Coryphaenoides colon
Dibranchus atlanticus
Dicrolene intronigra
Gadomus longifilis
Halosaurus guentheri
Monomitopus agassizi
Nettastoma melanura
Nezumia aequalis
Pseudophichthys sp.
Synaphobranchus oregoni/brevidorsalis

70A10-58 3248 m 25°21.3'N 86°06.5'W 20m Trawl

MOLLUSCA: SCAPHOPODA
  Dentalium meridionale
CRUSTACEA: DECAPODA
  Hemipenaeus carpenteri
  Munidopis bermudezi
  Parapagurus sp.
  Plesionika armatus
ECHINODERMATA: ASTEROIDEA
  Dytaster insignis
  Litonotaster intermedius
  Paragonaster subtilis
ECHINODERMATA: HOLOTHUROIDEA
  Benthodytes lingua
  Benthodytes ? typica
  Paelopatides gigantea
  Pseudostichopus sp.
  unidentified Holothuroid
ECHINODERMATA: OPHIUROIDEA
  Ophiomusium eberneum
  Ophiomusium planum
FISH
  Bassozetus sp.

71A7-2 567 m 26°41.1'N 96°13.9'W Quant. Dredge
Port Isabel Map (NG 14-6) Block No. 300

"Dredge full of mud (part foraminifers and part blue-gray clay)."
POLYCHAETA
  Sigalionidae sp.

71A7-4 576 m 26°47.8'N 96°12.5'W Skimmer
Port Isabel Map (NG 14-6) Block No. 168

"Small sample with mud lumps."
POLYCHAETA
  Ehlersileanira incisa
  Marphysa cf. belli
  Myriochele sp. B
  Notomastus ? latericeus
CRUSTACEA: CIRRIPEDIA
  Verruca sp. 3
SIPUNCULA
  Sipunculus sp. 1
ECHINODERMATA: HOLOTHUROIDEA
  unidentified Holothuroid

71A7-7 878-869 m 26°26.7'N 96°06'W Skimmer
Port Isabel Map (NG 14-6) Block No. 523

POLYCHAETA
  Asychis cf. gotoi
  Hyalinoecia cf. stricta

continued

71A7-7 continued

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Glyphocrangon aculeata
- Nematocarcinus rotundus
- Parapagurus sp.
- Pontophilus gracilis
- Stereomastis sculpta

ECHINODERMATA: ASTEROIDEA
- Nymphaster arcuatus

ECHINODERMATA: HOLOTHUROIDEA
- unidentified Holothuroids

FISH
- Alepocephalidae sp.
- Nezumia cyrano

71A7-9 906 m 26°32'N 96°07'W 20m Trawl
Port Isabel Map (NG 14-6) Block No. 435

"Mud."

COELENTERATA: ALCYONARIA
- Funiculina quadrangularis
- Umbellula sp. C
- Umbellula sp. F

POLYCHAETA
- Asychis byceps

MOLLUSCA: CEPHALOPODA
- Japetella diaphana

MOLLUSCA: GASTROPODA
- Leucosyrinx tenoceras
- Oocorys bartschi
- Scaphander mundus

CRUSTACEA: CIRRIPEDIA
- Arcoscalpellum regina

CRUSTACEA: DECAPODA
- Glyphocrangon aculeata
- Glyphocrangon nobilis
- Munidopsis abbreviata
- Munidopsis sigsbei
- Nematocarcinus rotundus
- Nephropsis agassizi
- Parapagurus pilosimanus
- Parapagurus sp.
- Plesiopenaeus edwardsianus
- Stereomastis sculpta

ECHINODERMATA: ECHINOIDEA
- Hypselaster brachypetalus
- Phormosoma placenta

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes sanguinolenta
- Mesothuria lactea
- Molpadia barbouri
- Molpadia musculus

continued

71A7-9 continued

FISH

Bathygadus melanobranchus
Chimaera monstrosa
Coryphaenoides mexicanus
Coryphaenoides sp.
Dibranchus atlanticus
Dicrolene intronigra
Gadomus longifilis
Halosaurus guentheri
Ilyophis brunneus
Macrouridae sp.
Monomitopus agassizi
Nezumia aequalis
Raja clarki
Synaphobranchus oregoni/brevidorsalis

71A7-10 937 m 26°32.9'N 96°06.4'W 20m Trawl
Port Isabel Map (NG 14-6) Block No. 391

"No mud, fair bottom sample."

COELENTERATA: ALCYONARIA

Funiculina quadrangularis
Pennatulacea sp.
Umbellula sp. F

POLYCHAETA

Hyalinoecia cf. stricta

MOLLUSCA: CEPHALOPODA

Japetella diaphana

MOLLUSCA: GASTROPODA

Calliotropis calatha
Gymnobela agassizi
Leucosyrinx tenoceras
Leucosyrinx verrilli
Oocorys bartschi
Oocorys sulcata
Phymorhynchus sulcifera
Scaphander mundus

CRUSTACEA: CIRRIPEDIA

Arcoscalpellum regina

CRUSTACEA: DECAPODA

Benthesicymus bartletti
Geryon quinquedens
Glyphocrangon aculeata
Lithodes agassizi
Munidopsis sigsbei
Nematocarcinus rotundus
Parapagurus pilosimanus
Plesiopenaeus edwardsianus
Porcellana sigsbeiana
Stereomastis sculpta

CRUSTACEA: ISOPODA

Bathynomus giganteus

continued

71A7-10 continued

ECHINODERMATA: ASTEROIDEA
- Astropecten americanus
- Cheiraster mirabilis
- Doraster constellatus
- Goniopecten demonstrans
- Nymphaster arenatus
- Plinthaster dentatus

ECHINODERMATA: HOLOTHUROIDEA
- Molpadia musculus

FISH
- Bathygadus macrops
- Bathygadus melanobranchus
- Chauliodus sloanei
- Coryphaenoides colon
- Coryphaenoides sp.
- Dibranchus atlanticus
- Dicrolene intronigra
- Halosaurus guentheri
- Histiobranchus bathybius
- Melanostomias biseriatus
- Monomitopus agassizi
- Nezumia aequalis
- Oneirodes eschrichti
- Penopus macdonaldi
- Raja fuliginea
- Sphagemacrurus grenadae
- Synaphobranchus oregoni/brevidorsalis
- Yarrella blackfordi

71A7-11 636 m 26°32.3'N 96°13.3'W 20m Trawl
Port Isabel Map (NG 14-6) Block No. 432

POLYCHAETA
- Hyalinoecia cf. stricta

MOLLUSCA: CEPHALOPODA
- Benthoctopus januari

MOLLUSCA: GASTROPODA
- Gaza superba
- Homalopoma sp.
- Oocorys sulcata
- Scaphander mundus

CRUSTACEA: DECAPODA
- Aristaeomorpha foliacea
- Bathyplax typhla
- Glyphocrangon alispina
- Glyphocrangon longleyi
- Hymenopenaeus robustus
- Munida valida
- Munidopsis erinaceus
- Munidopsis longimanus
- Nematocarcinus rotundus
- Nephropsis aculeata

continued

71A7-11 continued

Parapagurus sp.
Pasiphaea merriami
Plesionika holthuisi
Plesionika polyacanthomerus
Plesiopenaeus edwardsianus
Psalidopus barbouri
Rochinia crassa
Stereomastis sculpta
Trichopeltarion nobile

ECHINODERMATA: ASTEROIDEA

Brisinga costata
Ceramaster sp.
Cheiraster enoplus
Cheiraster mirabilis
Doraster constellatus
Goniopecten demonstrans
Midgardia xandaros
Persephonaster echinulatus
Plinthaster dentatus
Zoroaster fulgens

ECHINODERMATA: ECHINOIDEA

Phormosoma placenta

ECHINODERMATA: HOLOTHUROIDEA

Bathyplotes pourtalesi
unidentified Holothuroid

ECHINODERMATA: OPHIUROIDEA

Ophiuroidea sp.

FISH

Bathygadus macrops
Bathygadus cf. melanobranchus
Brosmiculus imberbis
Bythites sp.
Chaunax nuttingii
Chaunax pictus
Chimaera monstrosa
Coryphaenoides caribbaeus
Coryphaenoides carminatus
Coryphaenoides colon
Dibranchus atlanticus
Diplancanthopoma brachysoma
Etmopterus pusillus
Gadella maraldi
Halosaurus guentheri
Merluccius bilinearis
Myrophis punctatus
Nezumia sp.
Polymixia lowei
Synaphobranchus oregoni/brevidorsalis
Synaphobranchus sp.
Urophycis cirrata
Ventrifossa atlantica
Yarrella blackfordi

71A7-16 939 m 26°34.7'N 96°05'W Quant. Dredge
Port Isabel Map (NG 14-6) Block No. 391

"Light brown ooze."

POLYCHAETA

Asychis sp.

ECHINODERMATA: HOLOTHUROIDEA

Molpadia musculus

71A7-17 204 m 26°43.1'N 96°26.9'W Quant. Dredge
Port Isabel Map (NG 14-6) Block No. 252

"Brownish-gray ooze."

POLYCHAETA

Euarche tubifex

CRUSTACEA: CIRRIPEDIA

Arcoscalpellum intonsum

FISH

Myrophis punctatus

71A7-18 229 m 26°46'N 96°26'W 20m Trawl
Port Isabel Map (NG 14-6) Block No. 208

MOLLUSCA: BIVALVIA

Aequipecten glyptus

MOLLUSCA: GASTROPODA

Euchelis carbis

CRUSTACEA: DECAPODA

Ethusa microphthalma
Lyreidus bairdi
Porcellana sigsbeiana
Solenocera vioscai

CRUSTACEA: STOMATOPODA

Squilla edentata

ECHINODERMATA: ASTEROIDEA

Luidia clathrata

ECHINODERMATA: ECHINOIDEA

Brissopsis alta/atlantica/elongata

ECHINODERMATA: HOLOTHUROIDEA

Molpadia cubana

FISH

Ancylopsetta dilecta
Argentina striata
Bellator militaris
Bembrops anatirostris
Coelorinchus cf. coelorhinchus
Dibranchus atlanticus
Hoplunnis tenuis
Lepophidium sp.
Macrouridae sp.
Merluccius albidus
Monolene sessilicauda
Neobythites sp.
Paraxenomystax bidentatus
Poecilopsetta beani
Polymixia lowei

continued

71A7-18 continued
  Pontinus longispinis
  Pristipomoides aquilonaris
  Pseudophichthys laterodorsalis
  Scyliorhinidae egg cases
  Squalus cubensis
  Steindachneria argentea
  Urophycis cirrata

71A7-20 229 m 26°42.2'N 96°25.3'W Skimmer
Port Isabel Map (NG 16-4) Block No. 252
"Poor haul."
POLYCHAETA (unidentified)
ECHINODERMATA: ASTEROIDEA (unidentified)
ECHINODERMATA: ECHINOIDEA (unidentified)
CRUSTACEA: DECAPODA
  Acanthocarpus alexandri
  Lyreidus bairdi

71A7-23 210 m 27°54.7'N 92°50.5'W Skimmer
Garden Banks Map (NG 15-2) Block No. 66
"Skimmer full of mud - very few organisms."
CRUSTACEA: DECAPODA
  Acanthocarpus alexandri

71A7-24 190 m 27°54.5'N 92°50.7'W Quant. Dredge
Garden Banks Map (NG 15-2) Block No. 66
"No organisms taken."

71A7-32 192 m 27°55.7'N 92°48.5'W Skimmer
Garden Banks Map (NG 15-2) Block No. 67
POLYCHAETA
  Euarche tubifex
  Polyodontes lupinus
CRUSTACEA: DECAPODA
  Acanthocarpus alexandri
  Solenocera vioscai
FISH
  Ophichthus sp.

71A7-34 192 m 27°52'N 92°55'W 20m Trawl
Garden Banks Map (NG 15-2) Block No. 109
"Good haul - some mud, numerous fish and invertebrates."
CRUSTACEA: CIRRIPEDIA
  Arcoscalpellum portoricanum intonsum
CRUSTACEA: DECAPODA
  Collodes leptocheles
  Ethusa microphthalma
  Myropsis quinquespinosa
  Paguristes oxyophthalmus
  Pagurus bullisi
  Palicus obesus
  Parapenaeus longirostris
  Porcellana sigsbeiana

continued

71A7-34 continued

Solenocera vioscai
Squilla edentata

ECHINODERMATA: ASTEROIDEA

Anthenoides piercei
Astropecten duplicatus
Ceramaster grenadensis

ECHINODERMATA: CRINOIDEA

Democrinus sp.

ECHINODERMATA: ECHINOIDEA

Brissopsis alta/atlantica/elongata

ECHINODERMATA: HOLOTHUROIDEA

unidentified Holothuroids

FISH

Ancylopsetta dilecta
Bembrops anatirostris
Callionymus agassizi
Citharichthys gymnorhinus
Decodon puellaris
Dibranchus atlanticus
Gnathagnus egregius
Hemanthias leptus
Hollardia hollardi
Hoplunnis macrurus
Hoplunnis schmidtii
Hoplunnis tenuis
Lepophidium brevibarbe
Macrorhamphosus scolopax
Merluccius bilinearis
Monolene sp.
Muraenesox sp.
Neobythites gillii
Parahollardia lineata
Poecilopsetta beani
Pontinus longispinis
Prionotus beani
Prionotus rubio
Pristipomoides aquilonaris
Raja garmani
Trichopsetta ventralis
Uroconger syringinus
Urophycis cirrata
Urophycis floridana
Urophycis regia
Xenomystax atarius

71A7-35 502-567 m 27°35.7'N 92°59'W Skimmer
Garden Banks Map (NG 15-2) Block No. 371

"Large amount of rocks."

71A7-38 511-556 m 27°35.6'N 92°58.6'W 20m Trawl
Garden Banks Map (NG 15-2) Block No. 372

"Trawl hung up."

MOLLUSCA: GASTROPODA

Gaza superba

continued

71A7-38 continued

CRUSTACEA: CIRRIPEDIA
- Verruca sp. 3

CRUSTACEA: DECAPODA
- Aristaeomorpha foliacea
- Bathyplax typhla
- Glyphocrangon longleyi
- Hymenopenaeus robustus
- Munida valida
- Munidopsis serratifrons
- Munidopsis n. sp. (near abbreviata)
- Nephropsis aculeata
- Plesionika holthuisi
- Rochinia crassa

FISH
- Bathygadus macrops
- Bythites sp.
- Coelorinchus coelorhinchus carminatus
- Dibranchus atlanticus
- Gadella maraldi
- Gadomus sp.
- Hymenocephalus italicus
- Macrouridae sp.
- Nezumia aequalis
- Peristedion greyae
- Raja clarki
- Urophycis regia
- Ventrifossa occidentalis

71A7-40 546 m 27°35.2'N 92°58'W Quant. Dredge
Garden Banks Map (NG 15-2) Block No. 372

"Mud with hydrogen sulfide odor."
No organisms taken.

Garden Banks Map (NG 15-2) Block No. 415
71A7-41 732 m 27°34.8'N 92°59.5'W Skimmer

"Hung up - counter lost. Volcanic material with pumice; few sponges and stony corals attached."

CRUSTACEA: DECAPODA
- Parapagurus sp.

71A7-42 936 m 27°30.4'N 92°49.3'W Skimmer
Garden Banks Map (NG 15-2) Block No. 463

CRUSTACEA: DECAPODA
- Glyphocrangon aculeata
- Munidopsis abbreviata
- Munidopsis spinosa
- Nephropsis agassizi
- Parapagurus sp.

ECHINODERMATA: HOLOTHUROIDEA
- Molpadia barbouri

FISH
- Nezumia cyrano

71A7-43 887-1097 m 27°27.8'N 92°46'W 20m Trawl

Garden Banks Map (NG 15-2) Block No. 508

PORIFERA
- Euplectella sp.
- Hyalonema sp.

MOLLUSCA: CEPHALOPODA
- Heliocranchia pfefferi

CRUSTACEA: CIRRIPEDIA
- Arcoscalpellum regina

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Geryon quinquedens
- Glyphocrangon aculeata
- Heterocarpus oryx
- Lithodes agassizi
- Munidopsis riveroi
- Munidopsis sigsbei
- Nematocarcinus rotundus
- Parapagurus pilosimanus
- Parapagurus sp.
- Plesiopenaeus edwardsianus
- Stereomastis sculpta

CRUSTACEA: ISOPODA
- Bathynomus giganteus

ECHINODERMATA: ASTEROIDEA
- Goniopecten demonstrans
- Litonotaster intermedius
- Nymphaster arenatus
- Plutonaster intermedius
- Pseudarchaster sp.

ECHINODERMATA: HOLOTHUROIDEA
- Mesothuria lactea
- Molpadia barbouri
- Molpadia musculus
- Paroriza prouhoi

FISH
- Aldrovandia affinis
- Aldrovandia gracilis
- Apodes sp.
- Barathronus sp.
- Bathygadus favosus
- Bathygadus melanobranchus
- Congridae sp.
- Coryphaenoides colon
- Coryphaenoides mexicanus
- Dibranchus atlanticus
- Dicrolene intronigra
- Dicrolene sp.
- Gadomus arcuatus
- Gadomus longifilis
- Halosaurus guentheri

continued

71A7-43 continued

Monomitopus agassizi
Nezumia aequalis
Nezumia bairdi
Nezumia cyrano
Stephanoberyx monae
Synaphobranchus oregoni/brevidorsalis
Yarrella blackfordi

71A7-47   878 m   27°32.3'N   92°47.8'W   Skimmer
Garden Banks Map (NG 15-2) Block No. 463

CRUSTACEA: DECAPODA
Plesionika holthuisi
ECHINODERMATA: HOLOTHUROIDEA
unidentified Holothuroids
ECHINODERMATA: OPHIUROIDEA
Amphiuridae sp.

71A7-48   890 m   27°32.6'N   92°48.5'W   Quant. Dredge
Garden Banks Map (NG 15-2) Block No. 463

"No specimens taken."

71A7-49   937 m   27°26'N   92°42'W   20m Trawl
Garden Banks Map (NG 15-2) Block No. 553

"Note this is a night haul; crustacea more abundant than in day."

CRUSTACEA: DECAPODA
Benthesicymus bartletti
Geryon quinquedens
Glyphocrangon aculeata
Glyphocrangon nobilis
Heterocarpus oryx
Munidopsis sigsbei
Nematocarcinus rotundus
Parapagurus sp.
Plesiopenaeus edwardsianus
Stereomastis sculpta
ECHINODERMATA: ASTEROIDEA
Nymphaster arenatus
ECHINODERMATA: ECHINOIDEA
Phormosoma placenta
ECHINODERMATA: HOLOTHUROIDEA
Benthodytes sanguinolenta
Mesothuria lactea
Molpadia barbouri
Molpadia musculus
FISH
Aldrovandia gracilis
Alepocephalidae sp.
Bathygadus favosus
Bathypterois quadrifilis
Coryphaenoides colon
Coryphaenoides mexicanus
Coryphaenoides sp.
Dibranchus atlanticus
Dicrolene intronigra

continued

71A7-49 continued

Gadomus arcuatus
Gadomus longifilis
Halosaurus guentheri
Ilyophis brunneus
Macrouridae sp.
Malacosteus niger
Monomitopus agassizi
Nezumia bairdi
Squalogadus modificatus
Stephanoberyx monae
Synaphobranchus oregoni/brevidorsalis
Yarrella blackfordi

71A7-56 538 m 27°35.8'N 93°01'W 20m Trawl
Garden Banks Map (NG 15-2) Block No. 371

"Fish predominant in biomass. Crustacea very abundant with about 5 gallons of pagurids, many shrimp, several crabs. Fish biomass/crustacea biomass = 2 or 3/1."

CRUSTACEA: DECAPODA

Aristaeomorpha foliacea
Benthochascon schmitti
Glyphocrangon longleyi
Hymenopenaeus robustus
Munidopsis robusta
Nephropsis aculeata
Parapagurus sp.
Polycheles typhlops perarmatus
Rochinia crassa
Sympagurus pictus

ECHINODERMATA: OPHIUROIDEA

Ophiernus adspersum

FISH

Apristurus chesteri
Bathygadus melanobranchus
Bembrops anatirostris
Bembrops gobioides
Carangidae sp. (immature)
Chlorophthalmus agassizi
Coelorinchus coelorhinchus carminatus
Dibranchus atlanticus
Etmopterus schultzi
Etmopterus spinax
Gnathagnus egregius
Hydrolagus alberti
Hymenocephalus italicus
Laemonema barbatulum
Merluccius bilinearis
Neobythites marginatus
Peristedion greyae
Physiculus kaupi
Scylliorhinus profundorum
Phycis cirrata
Urophycis regia
Venefica procera
Ventrifossa occidentalis
Yarrella blackfordi

71A7-57 1216-1234 m 26°55.8'N 92°57.9'W 20m Trawl
Keathley Canyon Map (NG 15-5) Block No. 64

"Five gallons fish, five gallons crustacea. Biomass ratio fish/crustacea = 1 1/2 or 2/1."

PORIFERA
- Dragmatyle topsenti

COELENTERATA: ALCYONARIA
- ? Acanella sp. (axis)
- Isididae sp. (axis)

COELENTERATA: SCLERACTINEA
- unidentified branching corals

CRUSTACEA: DECAPODA
- Geryon quinquedens
- Glyphocrangon aculeata
- Glyphocrangon nobilis
- Heterocarpus oryx
- Homolodromia paradoxa
- Munidopsis sigsbei
- Nematocarcinus rotundus
- Parapagurus sp.
- Stereomastis sculpta
- Uroptychus nitidus

CRUSTACEA: ISOPODA
- Bathynomus giganteus

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes sanguinolenta
- Molpadia blakei
- Molpadia cubana

FISH
- Bathygadus favosus
- Bathypterois quadrifilis
- Coryphaenoides colon
- Dibranchus atlanticus
- Dicrolene intronigra
- Gadomus arcuatus
- Monomitopus agassizi
- Nezumia aequalis
- Stephanoberyx monae
- Synaphobranchus oregoni/brevidorsalis
- Venefica procera
- Yarrella blackfordi

71A7-58 1198 m 26°59.1'N 92°58.5'W Quant. Dredge
Garden Banks Map (NG 15-2) Block No. 988

"Dredge full of brown mud."
No specimens taken.

71A7-62 1198 m 27°00'N 93°01.5'W Skimmer
Garden Banks Map (NG 15-2) Block No. 987

COELENTERATA: SCLERACTINEA
- Caryophyllia ambrosia caribbeana

CRUSTACEA: DECAPODA
- Stereomastis sculpta

FISH
- Conocara cf. macroptera

71A7-65 237 m 27°57'N 92°44.9'W Skimmer
East Cameron S. Addition Block No. 376

CRUSTACEA: DECAPODA
- Acanthocarpus alexandri
- Ethusa microphthalma
- Euphrosynoplax clausa
- Lyreidus bairdi
- Myropsis quinquespinosa
- Parapenaeus longirostris

ECHINODERMATA: ASTEROIDEA
- Anthenoides piercei

ECHINODERMATA: ECHINOIDEA
- Brissopsis alta/atlantica/elongata

FISH
- Echiophis sp.
- Lepophidium brevibarbe
- Monolene sp.
- Pontinus longispinis
- Trichopsetta ventralis

71A8-3 1196 m 27°03'N 93°23'W Skimmer
Garden Banks Map (NG 15-2) Block No. 935

PORIFERA
- Radiella sol

COELENTERATA: ALCYONARIA
- ? Acanella sp.

POLYCHAETA
- Glycera oxycephala
- Nephthys paradoxa

MOLLUSCA: GASTROPODA
- Phymorhynchus sulcifera
- Theta pandionis

ECHINODERMATA ASTEROIDEA
- Dytaster insignis

ECHINODERMATA: HOLOTHUROIDEA
- Echinocucumis hispida

FISH
- Coryphaenoides mexicanus

71A8-4 1364 m 27°08.6'N 93°08.4'W Skimmer
Garden Banks Map (NG 15-2) Block No. 853

"Small sample."

PORIFERA
- Dragmatyle topsenti
- Radiella sol

MOLLUSCA: CEPHALOPODA
- Cranchia scabra
- Mastigoteuthis grimaldi

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Glyphocrangon aculeata
- Glyphocrangon nobilis

continued

71A8-4 continued

Heterocarpus oryx
Munidopsis sigsbei
Nematocarcinus rotundus
Stereomastis sculpta

71A8-5 1448 m 26°54'N 92°54.5'W Skimmer
Keathley Canyon Map (NG 15-5) Block No. 65

No specimens taken.

71A8-8 2057 m 26°08'N 92°43.9'W 20m Trawl
Keathley Canyon Map (NG 15-5) Block No. 860

COELENTERATA: ALCYONARIA
? Acanella sp.
? Keratoisis sp.
MOLLUSCA: SCAPHOPODA
Dentalium callithrix (dead)
Dentalium meridionale (dead)
Dentalium perlongum (dead)
CRUSTACEA: DECAPODA
Benthesicymus bartletti
Geryon quinquedens
Glyphocrangon longirostris
Glyphocrangon sculpta
Hemipenaeus carpenteri
Munidopsis nitida
Munidopsis rostrata
Nematocarcinus ensifer
Parapagurus sp.
Plesiopenaeus armatus
Polycheles validus
Stereomastis sculpta
ECHINODERMATA: ASTEROIDEA
Benthopecten simplex
Ceramaster sp.
Drachmaster sp.
Dytaster insignis
Evoplosoma n. sp.
Litonotaster intermedius
Marsipaster sp.
ECHINODERMATA: HOLOTHUROIDEA
Benthodytes lingua
Benthodytes sanguinolenta
Benthodytes typica
Mesothuria lactea
Molpadia barbouri
Molpadia musculus
FISH
Bathypterois quadrifilis

71A8-10 2077 m 26°09'N 92°48.3'W 20m Trawl
Keathley Canyon Map (NG 15-5) Block No. 859

"Trawl hung up. Sample contained tar, coal, and miscellaneous plant material."

continued

71A8-10 continued

COELENTERATA: SCLERACTINEA
- unidentified coral

MOLLUSCA: CEPHALOPODA
- Grimalditeuthis bomplandii
- Histioteuthis dofleini

CRUSTACEA: DECAPODA
- Glyphocrangon nobilis
- Nematocarcinus ensifer
- Parapagurus sp.
- Polycheles validus

ECHINODERMATA: ASTEROIDEA
- Dytaster insignis
- Litonotaster intermedius
- ? Marsipaster sp.
- Nymphaster arenatus

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes lingua
- Benthodytes sanguinolenta
- Benthodytes typica
- Mesothuria lactea
- Molpadia blakei
- Pseudostichopus sp.
- Psychropotes depressa

FISH
- Bathypterois quadrifilis
- Cataetyx sp.
- Hemipterois sp.
- Venefica procera

71A8-11 3287 m 25°51'N 93°03'W 20m Trawl

"Trawl hung up."

CRUSTACEA: DECAPODA
- Plesiopenaeus armatus

ECHINODERMATA: ASTEROIDEA
- Benthopecten simplex
- Litonotaster intermedius
- Nymphaster arenatus

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes typica

ECHINODERMATA: OPHIUROIDEA
- Ophiomusium planum

FISH
- Bassozetus normalis
- Bathypterois longipes
- Malacosteus niger
- Ophidiidae sp.

71A8-13 3267 m 25°52'N 93°15.8'W 20m Trawl

POLYCHAETA
- Onuphis sp. A

continued

71A8-13 continued
MOLLUSCA: BIVALVIA
Nucula callicredemna (dead)
MOLLUSCA: CEPHALOPODA
Grimpoteuthis sp. A
Octopoteuthis megaptera
MOLLUSCA: GASTROPODA
Oocorys sulcata
MOLLUSCA: SCAPHOPODA
Dentalium perlongum
CRUSTACEA: DECAPODA
Benthesicymus cereus
Munidopsis sundi
Nematocarcinus acanthitelsonis
Parapagurus sp.
Polycheles ? validus
FISH
Barathronus bicolor
Bassozetus normalis
Bathytroctes sp.
Haptenchelys texis
Hemipterois sp.
Ilyophis brunneus

71A8-16 3517 m 25°04.2'N 94°23.7'W Quant. Dredge
BRACHIOPODA
Chlidonophora incerta

72A13-32 1774 m 26°25'N 94°47.5'W 20m Trawl
Alaminos Canyon Map (NG 15-4) Block No. 551
PORIFERA
Radiella sol
COELENTERATA: ALCYONARIA
? Acanella sp.
MOLLUSCA: BIVALVIA
Tindaria amabilis (dead)
MOLLUSCA: CEPHALOPODA
Bathothauma lyromma
Eledonella pygmaea
Japetella diaphana
MOLLUSCA: SCAPHOPODA
Dentalium callithrix (dead)
Dentalium perlongum
CRUSTACEA: CIRRIPEDIA
Scalpellum svetlanae
CRUSTACEA: DECAPODA
Geryon quinquedens
Glyphocrangon aculeata
Glyphocrangon nobilis
Nematocarcinus ensifer
Parapagurus sp.
Plesiopenaeus armatus
Polycheles validus
Stereomastis sculpta

continued

72A13-32 continued
ECHINODERMATA: ASTEROIDEA
Nymphaster arenatus
FISH
Aldrovandia affinis

72A13-39 1061 m 27°26.4'N 94°07.6'W 20m Trawl
East Breaks Map (NG 15-1) Block No. 565
"A very rich haul, but very few holothuroids, many fish and starfish."
PORIFERA
Euplectella sp.
POLYCHAETA
Hyalinoecia cf. stricta
Hyalinoecia tubicola
MOLLUSCA: CEPHALOPODA
Bathothauma lyromma
Pholidoteuthis adami
MOLLUSCA: GASTROPODA
Ancistrosyrinx sp.
Gaza fisheri
Gymnobela bairdi
Leucosyrinx tenoceras
Leucosyrinx verrilli
Oocorys bartschi
Theta jeffreysi
CRUSTACEA: DECAPODA
Benthesicymus bartletti
Funchalia cf. villosa
Geryon quinquedens
Glyphocrangon aculeata
Glyphocrangon alispina
Glyphocrangon nobilis
Heterocarpus oryx
Homolodromia paradoxa
Munidopsis abbreviata
Munidopsis spinosa
Nematocarcinus rotundus
Nephropsis agassizi
Parapagurus sp.
Plesiopenaeus edwardsianus
Stereomastis sculpta
ECHINODERMATA: ASTEROIDEA
Astropecten americanus
Astropecten sp.
Brisingidae sp.
Doraster constellatus
Midgardia xandaros
Nymphaster arenatus
Plutonaster intermedius
Poranisca lepida
ECHINODERMATA: ECHINOIDEA
Phormosoma placenta

continued

72A13-39 continued

ECHINODERMATA: OPHIUROIDEA

Bathypectinura heros
Ophiernus adspersum
Ophiochiton grandis

FISH

Alepocephalus agassizi
Apristurus profundorum
Barathronus bicolor
Bathygadus melanobranchus
Bathypterois quadrifilis
Bathytroctes melanocephalus
Bathytroctes sp.
Coelorinchus occa
Coryphaenoides colon
Coryphaenoides mexicanus
Dibranchus atlanticus
Dicrolene intronigra
Gadomus longifilis
Luciobrotula sp.
Monomitopus agassizi
Nezumia aequalis
Raja fuliginea
Sphagemacrurus grenadae
Stephanoberyx monae
Synaphobranchus sp.
Trachonurus villosus
Venefica procera
Ventrifossa occidentalis

72A13-45 412 m 27°46.7'N 94°47.5'W 20m Trawl
East Breaks Map (NG 15-1) Block No. 199

"A rich haul of fishes, shrimps, brachyurans, galatheids, squids."

CRUSTACEA: DECAPODA

Benthochascon schmitti
Ethusa microphthalma
Hymenopenaeus robustus
Lyreidus bairdi
Munida longipes
Munidopsis robusta
Palicus gracilis
Parapandalus willisi
Penaeopsis serrata
Pyromaia arachna
Rochinia crassa
Systellaspis pellucida

CRUSTACEA: ISOPODA

Bathynomus giganteus

ECHINODERMATA: ASTEROIDEA

Astropecten americanus
Doraster constellatus
Nymphaster arenatus

continued

72A13-45 continued

FISH

- Bembrops gobioides
- Chlorophthalmus agassizi
- Chlorophthalmus chalybeius
- Coelorinchus caribbaeus
- Coelorinchus ? coelorhinchus carminatus
- Gadella maraldi
- Gnathagnus egregius
- Hemanthius vivanus
- Hoplosteuthus mediterraneus
- Hymenocephalus italicus
- Merluccius bilinearis
- Poecilopsetta beani
- Rajidae sp.
- Setarches guentheri
- Urophycis cirrata
- Ventrifossa occidentalis

72A13-49 640-530 m 27°40'N 94°49.8'W 20m Trawl
East Breaks Map (NG 15-1) Block No. 287

"Rich haul."

POLYCHAETA

- Hyalinoecia cf. stricta

MOLLUSCA: GASTROPODA

- Gaza superba

CRUSTACEA: CIRRIPEDIA

- Arcoscalpellum regina

CRUSTACEA: DECAPODA

- Glyphocrangon alispina
- Glyphocrangon longleyi
- Hymenopenaeus robustus
- Munida valida
- Munidopsis alaminos
- Munidopsis erinaceus
- Nematocarcinus rotundus
- Nephropsis rosea
- Parapagurus sp.
- Psalidopus barbouri
- Rochinia crassa
- Stereomastis sculpta
- Trichopeltarion nobile

CRUSTACEA: ISOPODA

- Bathynomus giganteus

ECHINODERMATA: ASTEROIDEA

- Astropecten americanus
- Astropectenidae sp.
- Benthopecten sp.
- Brisingidae sp.
- Ceramaster sp.
- Cheiraster enoplus
- Doraster constellatus
- Goniopecten demonstrans

continued

72A13-49 continued

Midgardia xandaros
Nymphaster arenatus
Pseudarchaster gracilis
Psilaster cassiope

ECHINODERMATA: ECHINOIDEA

Phormosoma placenta

ECHINODERMATA: HOLOTHUROIDEA

Bathyplotes natans

ECHINODERMATA: OPHIUROIDEA

Bathypectinura heros
Ophiernus adspersum
Ophiochiton grandis
Ophioplax ljungmani

FISH

Bathophilus pawneei
Bathygadus macrops
Bathygadus sp.
Breviraja sinusmexicanus
Chaunax pictus
Coelorinchus coelorhinchus carminatus
Conger oceanicus
Coryphaenoides colon
Dibranchus atlanticus
Diplacanthopoma brachysoma
Etmopterus spinax
Gadomus longifilis
Halosaurus guentheri
Luciobrotula sp.
Merluccius bilinearis
Nezumia aequalis
Poecilopsetta beani
Urophycis cirrata
Ventrifossa atlantica
Yarrella blackfordi

72A13-51 1399-1353 m 26°55.6'N 95°10.5'W 20m Trawl
Alaminos Canyon Map (NG 15-4) Block No. 15

PORIFERA

Euplectella sp.
Radiella sol

COELENTERATA: ALCYONARIA

Anthoptilum sp.

MOLLUSCA: CEPHALOPODA

Neorossia sp.

CRUSTACEA: DECAPODA

Acanthephyra eximia
Benthesicymus bartletti
Benthesicymus carinatus
Benthonectes filipes
Geryon quinquedens
Glyphocrangon aculeata
Glyphocrangon nobilis

continued

72A13-51 continued

Heterocarpus oryx
Munidopsis nitida
Munidopsis sigsbei
Munidopsis simplex
Nematocarcinus rotundus
Nephropsis agassizi
Parapagurus sp.
Polycheles validus
Stereomastis sculpta

CRUSTACEA: ISOPODA
Bathynomus giganteus

ECHINODERMATA: ASTEROIDEA
Pteraster abyssorum

ECHINODERMATA: HOLOTHUROIDEA
Pseudostichopus sp.

FISH
Aldrovandia affinis
Aldrovandia gracilis
Bathypterois longipes
Cataeyx sp.
Cetonurus globiceps
Coryphaenoides mexicanus
Dibranchus atlanticus
Dicrolene intronigra
Dicrolene sp.
Stephanoberyx monae
Synaphobranchus oregoni/brevidorsalis
Venefica procera

72A13-53 1161 m 27°24.4'N 94°56.5'W 20m Trawl
East Breaks Map (NG 15-1) Block No. 548

PORIFERA
Euplectella sp.

CRUSTACEA: DECAPODA
Benthesicymus bartletti
Geryon quinquedens
Glyphocrangon aculeata
Glyphocrangon nobilis
Heterocarpus oryx
Munidopsis abbreviata
Munidopsis longimanus
Munidopsis sigsbei
Munidopsis simplex
Nematocarcinus rotundus
Parapagurus sp.
Stereomastis sculpta
Uroptychus nitidus

CRUSTACEA: ISOPODA
Bathynomus giganteus

ECHINODERMATA: ASTEROIDEA
unidentified Asteroids

continued

72A13-53 continued

ECHINODERMATA: HOLOTHUROIDEA
- Benthodytes sanguinolenta
- Molpadia barbouri

FISH
- Aldrovandia affinis
- Bathypterois quadrifilis
- Cataeyx sp.
- Coryphaenoides mexicanus
- Coryphaenoides sp.
- Dicrolene intronigra
- Gadomus longifilis
- Monomitopus agassizi
- Nezumia aequalis
- Nezumia bairdi
- Nezumia sp.
- Sphagemacrurus grenadae
- Stephanoberyx monae
- Venefica procera

73A2-8 869 m 27°21'N 94°00'W 20m Trawl
East Breaks Map (NG 15-1) Block No. 656

CRUSTACEA: DECAPODA
- Benthesicymus bartletti
- Geryon quinquedens
- Glyphocrangon alispina
- Glyphocrangon nobilis
- Heterocarpus oryx
- Lithodes agassizi
- Munidopsis sigsbei
- Nephropsis agassizi
- Parapagurus sp.
- Stereomastis sculpta

73A10-20 805-1134 m 27°15.3'N 93°41.4'W 20m Trawl
Keathley Canyon Map (NG 15-5) Block No. 225

PORIFERA
- Eurete sp.
- Geodia sp. C

MOLLUSCA: GASTROPODA
- Ancistrosyrinx sp.
- Gaza fisheri

CRUSTACEA: DECAPODA
- Acanthacaris caeca
- Acanthephyra armata
- Aristaeus antillensis
- Bathyplax typhla
- Benthesicymus bartletti
- Geryon quinquedens
- Glyphocrangon aculeata
- Glyphocrangon alispina
- Homolodromia paradoxa
- Munida valida

continued

73A10-20 continued

Munidopsis spinosa
Nematocarcinus rotundus
Nephropsis aculeata
Psalidopus barbouri
Rochinia umbonata
Stereomastis sculpta

ECHINODERMATA: ASTEROIDEA

Goniopecten demonstrans

ECHINODERMATA: HOLOTHUROIDEA

Enypniastes ecalcara
Molpadia barbouri

ECHINODERMATA: OPHIUROIDEA

Ophiernus adspersum

FISH

Barathronus sp.
Bathygadus macrops
Bathypterois quadrifilis
Bathyuroconger vicinus
Coelorinchus occa
Coryphaenoides colon
Dibranchus atlanticus
Dicrolene sp.
Diplacanthopoma sp.
Gadiformes sp.
Gadomus arcuatus
Gadomus sp.
Howella sp.
Macrouridae sp.
Monomitopus sp.
Neoscopelus macrolepidotus
Nezumia aequalis
Nezumia sp.
Synaphobranchus oregoni/brevidorsalis
Yarrella blackfordi

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This work will probably be a series of monographs on the Propeamussiidae and Pectinidae, which will consist of about 10 parts. Part 1 will review morphology, anatomy, and supraspecific classification on a worldwide basis, while subsequent parts will deal with detailed species descriptions arranged by family and oceanic region. The new Western Atlantic propeamussiids will be described in Part 2, "The Propeamussiidae of the Western Atlantic".

Wenner, E.L. 1980. Notes on the biology of a deep-sea penaeid, Benthesicymus bartletti Smith. Crustaceana. 38(2):290-294.

The biology of Benthesicymus bartletti, an abundant deep-Gulf of Mexico species is discussed, including notes on its bathymetric distribution, reproduction, abundance, and size. However, the particular specimens examined were from the continental slope off the Middle Atlantic Bight.

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Betzer, P.R. and M.E. Pilson. 1971. Particulate iron and the nepheloid layer in the western North Atlantic, Caribbean, and Gulf of Mexico. Deep-Sea Res. 18:753-761.

Custodi, G.L. 1971. A survey of mercury in the Gulf of Mexico. M.S. thesis, Texas A&M Univ. 140 pp.

Feely, R.A. 1974. Chemical characterization of the particulate matter in the near-bottom nepheloid layer of the Gulf of Mexico. Ph.D. thesis, Texas A&M Univ. 144 pp.

Feely, R.A. 1975. Major-element composition of the particulate matter in the near-bottom nepheloid layer of the Gulf of Mexico. Mar. Chem. 3:121-156.

A study of the chemical composition of the supsended matter in the nepheloid layer of the Gulf of Mexico. The composition of this material is compared with that of the suspended matter in the overlying water and underlying sediments, with intent to determine the source, distribution, and possible transport mechanisms of suspended matter in the nepheloid layer.

Feely, R.A., W.M. Sackett, and J.E. Harris. 1971. Distribution of particulate aluminum in the Gulf of Mexico. Jour. Geophys. Res. 76:5893-5902.

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Holmes, C.W. 1973. Distribution of selected elements in surficial marine sediments of the northern Gulf of Mexico continental shelf and slope. U.S. Geol. Survey Prof. Paper 814. 7 pp.

Holmes, C.W. 1976. Distribution, regional variation, and geochemical coherence of selected elements in the sediments of the central Gulf of Mexico. U.S. Geol. Survey Prof. Paper 928. 24 pp.

A semiquantitative six-step spectrographic method was used to analyze 2,482 sediment samples from 50 piston cores, averaging 6 m in length, from the Gulf of Mexico. Of the 30 elements scanned for, 20 (B, Ba, Be, Ca, Co, Cr, Cu, Fe, La, Mg, Mn, Nb, Ni, Pb, Sc, Sr, Ti, V, Y, Zr) occurred in a sufficient number of samples for valid statistical analysis. The analytical method used permitted rapid analysis of a large number of samples, however analytical resolution was sacrificed.

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The specific objectives of this dissertation were to 1) determine present-day rates of transport of dissolved and particulate metals to the Gulf of Mexico from the Mississippi River, 2) isolate the chemical phases of particulate metal transport by the river and determine whether river particulates typify average crustal material, 3) identify alterations in metal distribution in river particulates across the freshwater-seawater interface, 4) determine metal concentrations and accumulation rates in nearshore sediments and the extent of metal remobilization within them, and 5) identify and trace metal enrichment in Gulf of Mexico pelagic sediment and relate it to grain size, Al, $CaCO_3$, sedimentation rate and other factors.

Trefry, J.H. 1981. A review of existing knowledge on trace metals in the Gulf of Mexico. pp. 225-259. In: Proceedings of a symposium on environmental research needs in the Gulf of Mexico (GOMEX), vol. II B. U.S. Dept. Comm., NOAA, Environ. Res. Lab.

A somewhat selective review of the present state of knowledge of trace metals in the Gulf of Mexico, which presents only the credible data available. The author discusses the sources, distributions and fate of heavy metals in the Gulf. Residence times of metals are estimated and geographically important areas are identified. Critical information gaps and potential research endeavors are also discussed.

Trefry, J.H. and B.J. Presley. 1976. Heavy metal transport from the Mississippi River to the Gulf of Mexico. pp. 39-76. In: H.L. Windom and R.A. Duce, eds. Marine Pollutant Transfer. D.C. Heath and Co., Lexington, Mass.

This study is an attempt to estimate the total flux of particulate and dissolved heavy metals from the Mississippi River to the Gulf of Mexico and to look for evidence that this flux has been influenced by man. Heavy metal concentrations were measured in Mississippi River water and suspended matter, and in Gulf of Mexico plankton and sediments. The total river load of several heavy metals and their distribution in the Gulf plankton and sediments is estimated.

Trefry, J.H. and R.F. Shokes. 1979. The history of heavy metal inputs to Mississippi Delta sediments. pp. 193-208. In: R.A. Geyer, ed. Studies in Marine Environmental Pollution. Wiley Interscience.

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The author divides the northern Gulf of Mexico slope into four structurally distinct provinces: central slope, northwest slope, Mississippi slope, and lower slope. These provinces are distinguished by their structural styles which are related to the shape of diapirs and normal faults. A discussion of the structural styles of the provinces in relation to salt layers, sediment loading, and growth faults follows.

Antoine, J.W. 1972. Structure of the Gulf of Mexico. pp. 1-34. In: R. Rezak and V.J. Henry, eds. Contributions on the Geological and Geophysical Oceanography of the Gulf of Mexico. Texas A&M Univ. Oceanogr. Studies, vol. 3. Gulf Publ. Co., Houston.

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Antoine, J.W., W. Bryant, and B. Jones. 1967. Structural features of the continental shelf, slope, and scarp, northwestern Gulf of Mexico. Amer. Assoc. Petrol. Geol. Bull. 51:257-262.

Antoine, J.W. and J.I. Ewing. 1963. Seismic refraction measurements on the margins of the Gulf of Mexico. Jour. Geophys. Res. 68(7):1975-1996.

Antoine, J.W. and J.C. Gilmore. 1970. Geology of the Gulf of Mexico. Ocean Industry. 5(5):34-38.

Antoine, J.W. and B.R. Jones. 1967. Geophysical studies of the continental slope, scarp, and basin, eastern Gulf of Mexico. Gulf Coast Assoc. Geol. Soc. Trans. 17:268-286.

Antoine, J.W., R.G. Martin, Jr., T.G. Pyle, and W.R. Bryant. 1974. Continental margins of the Gulf of Mexico. pp. 683-693. In: C.A. Burk and C.L. Drake, eds. The Geology of Continental Margins. Springer-Verlag. New York.

Antoine, J.W. and T.E. Pyle. 1970. Crustal studies in the Gulf of Mexico. Tectonophysics. 10(5-6):477-494.

Appelbaum, B.S. 1972. Geologic investigation of a portion of upper continental slope: northern Alabamian Canyon region. Texas A&M Univ. Res. Found. Tech. Rept. 72-4-T. 77 pp.

Bailey, N.G. and L.E. Garrison. 1979. Single-channel high-resolution seismic data from the northern Gulf of Mexico Upper Continental Slope. U.S. Geol. Survey Open File Report 80-89. 2 pp.

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Ballard, J.A. and R.H. Feden. 1970. Diapiric structures on the Campeche shelf and slope, western Gulf of Mexico. Geol. Soc. Amer. Bull. 81(2):505-512.

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Booth, J.S. 1979. Recent history of mass-wasting on the upper continental slope, northern Gulf of Mexico, as interpreted from the consolidation states of the sediment. pp. 153-164. In: L.J. Doyle and O.H. Pilkey, eds. Geology of Continental Slopes. Soc. Econ. Paleont. Mineral. Spec. Pub. No. 27. Tulsa, Okla.

The objectives of this paper were 1) to demonstrate how consolidation data (of sediments) may be used to interpret the history of mass-wasting and 2) to determine the recent history of mass-wasting on the upper continental slope in the northern Gulf of Mexico. Interpretation was based on geotechnical and geologic properties of 13 piston cores. Results indicated that the northern Gulf has been a dynamic environment for the last 10,000 years. Examples of mass-wasting in the Gulf are presented, and the causes for this sediment instability are outlined.

Booth, J.S. and L.E. Garrison. 1978. A geologic and geotechnical analysis of the upper continental slope adjacent to the Mississippi Delta. Proceedings Tenth Annual Offshore Technology Conference, Houston, Texas. OTC Paper No. 3165.

The results of an investigation of the upper continental slope adjacent to the modern (Balize) delta are described, based on the investigation objectives to 1) establish the basic geologic and geotechnical character of the surficial sediments, 2) gain an understanding of the recent geologic history, and 3) define potential geologic hazards in the area. A wide range of geologic and geotechnical analyses were performed using primarily acoustic profile and piston core data.

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A general discussion and classification of continental slopes, particularly those in the Atlantic Ocean. The eastern Gulf of Mexico has a type D slope (one supported by growth of massive calcareous reefs) while the western Gulf has a type E slope (one controlled by evaporite layers and their resulting diapirs).

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Bouma, A.H. and L.E. Garrison. 1979. Intraslope basins, Gulf of Mexico. Geol. Soc. Amer. Bull. Abstr. w. programs. 1979 Ann. Meeting, 392 (Abstr.).

Two types of intraslope basins that occur on the Gulf of Mexico continental slope are described on the basis of their origins. One type results from diapirism-induced damming of the submarine canyon, the other from diapiric uplifting which creates isolated depressions among local highs. The Gyre Basin is an example of the former while the Orca Basin is an example of the latter. The authors suggest that anoxic basins like the Gyre Basin may be suitable sites for offshore dumping of hazardous wastes.

Bouma, A.H., R.G. Martin, and W.R Bryant. 1980. Shallow structure of upper continental slope, central Gulf of Mexico. Proceedings Twelfth Annual Offshore Technology Conference, Houston, Texas. OTC Paper No. 3913, pp. 583-587.

A report on the preliminary results of a long-term study of the tectonic history of the Gulf of Mexico. General conclusions are drawn from some 8,000 nautical miles of multichannel seismic reflection data.

Bouma, A.H., G.T. Moore, and J.M. Coleman, eds. 1978. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7.

A collection of 15 papers based on presentations at the 1976 AAPG short course "Beyond the Shelf Break", conducted at the New Orleans national meeting, dealing primarily with characteristics of slope deposits of the northern Gulf of Mexico, the modes of deposition, stratigraphic relationships, and generalized structural features of sedimentation on other continental margins. The papers can be grouped into five categories: 1) the overall geologic setting of the Gulf of Mexico, 2) a conceptual treatment of seismic stratigraphy and paleoenvironments, 3) regional Gulf stratigraphy and structure of the Mexico continental margin, 4) continental slope sediments and paleoenvironments, and 5) the seismic, sedimentologic, and geochemical aspects of intraslope basins. Various papers within this volume are annotated under the respective author listings.

Bouma, A.H., L.B. Smith, B.R. Sidner, and T.R. McKee. 1975. Submarine geomorphology and sedimentation patterns of the Gyre Intraslope Basin, northwest Gulf of Mexico. Texas A&M Univ. Res. Found. Proj. 3196. Tech. Rept. No. 75-9-T. 163 pp.

This technical report was the basis for the article by the same authors, cited below.

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The Gyre Basin, located on the continental slope in the northwestern Gulf of Mexico, is described in terms of its morphology, geologic setting, shallow subbottom characteristics and sediments. The basin probably developed by salt blockage of a submarine-canyon complex.

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Bryant, W.R., J.W. Antoine, M. Ewing, and B. Jones. 1968. Structure of Mexican continental shelf and slope, Gulf of Mexico. Amer. Assoc. Petrol. Geol. Bull. 52(7):1204-1227.

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Carsey, J.B. 1950. Geology of Gulf Coast area and continental slope, Gulf of Mexico. Amer. Assoc. Petrol. Geol. Bull. 34:361-385.

Caughey, C.A. and C.J. Stuart. 1976. Where the potential is in the deep Gulf of Mexico. World Oil. 183(1):67-72.

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Coleman, J.M. and L.E. Garrison. 1977. Geological aspects of marine slope stability, northwestern Gulf of Mexico. Marine Geotechnology. 2:9-44.

A large number of data on the continental shelf and upper continental slope off the modern Mississippi River are compiled and used to document the major types of slope instabilities. Seven major types of sediment instabilities are identified: peripheral slumping, shallow diapiric intrusions, radial graben (tensional faulting), circular collapse depressions, surface mudflows, shelf-edge arcuate slumps, and various deep-seated faults.

Coleman, J.M., D.B. Prior, and J.E. Lindsay. in press. Deltaic influences on shelf edge instability processes. In: D.J. Stanley and G.T. Moore, eds. The shelf break - critical interface on continental margin. Soc. Econ. Paleon. Mineral. Spec. Publ. 33.

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Frohlich, C. 1982. Seismicity of the central Gulf of Mexico. Geology. 10:103-106.

This study describes a 1978 earthquake that occurred in the Gulf of Mexico near the edge of the Mississippi Fan, at a depth of about 15 km (approximately the depth of the Moho). The Gulf is practically aseismic, but the location and reverse-faulting mechanism of this event suggest that it may be related to stresses associated with the downwarping of the lithosphere caused by the accumulation of sediments from the Mississippi River.

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This paper describes a project begun by the U.S. Geological Survey to map the distribution of unstable bottom features on the northern Gulf of Mexico Continental Slope and to estimate the present degree of their instability. A preliminary interpretation of seismic reflection and piston core data indicated that many slump features are relict from late Pleistocene low sea levels but that some are presently unstable. The slope area off the Mississippi Delta seems to have active faulting, ancient slumps, and a large mudflow.

Garrison, L.E., J.M. Coleman, and D.B. Prior. 1978. Delta draws interest in research. Offshore 38(5):346-354.

An informative, generalized version of geological, hydrological, and zoomorphological research of the Mississippi River Delta, stimulated by findings that some parts of the offshore sediments are extremely unstable. The problems of slope instability near the offshore delta are discussed.

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Griffin, G.M. 1962. Regional clay-mineral facies products of weathering intensity and current distribution in the northeastern Gulf of Mexico. Geol. Soc. Amer. Bull. 73:737-768.

Grim, R.E. and W.D. Johns. 1954. Clay mineral investigation of sediments in northern Gulf of Mexico. Proc. Second Nat. Conf. Clays and Clay Minerals. Nat. Acad. Sci. Nat. Res. Council Pub. 327. pp. 81-103.

Hagerty, R.M. 1969. Clay mineralogy of the southwestern Gulf of Mexico and adjacent river outlets. Ph.D. thesis, Texas A&M Univ. 111 pp.

Hales, A.L. 1973. The crust of the Gulf of Mexico: a discussion. Tectonophysics. (20):217-225.

Hall, D.J., T.D. Cavenaugh, J.S. Watkins, and K.J. McMillen. in press. The rotational origin of the Gulf of Mexico based on regional free-air gravity data.

Annotation not yet available.

Harbison, R.N. 1968. Geology of DeSoto Canyon. Jour. Geophys. Res. 73(16): 5175-5185.

Harding, J.L. and W.D. Nowlin. 1966. Gulf of Mexico. pp. 324-331. In: R.W. Fairbridge, ed. The Encyclopedia of Oceanography. Reinhold Publ. Co., New York.

Harlan, R.W. 1966. A clay mineral study of Recent and Pleistocene sediments from the Sigsbee Deep. Ph.D. dissertation, Texas A&M Univ. 147 pp.

Holcomb, C.W. 1971. Hydrocarbon potential of Gulf Series of western Gulf basin. pp. 887-900. In: I.H. Cram, ed. Future petroleum provinces of the United States - their geology and potential. Amer. Assoc. Petrol. Geol. Mem. 15, vol. 2.

Holland, W.C. 1970. Bathymetry maps eastern continental margin, U.S.A. of 3, Northern Gulf of Mexico. Amer. Assoc. Petrol. Geol.

Hottman, W.E. 1975. Areal distribution of clay minerals and their relationship to physical properties, Gulf of Mexico. M.S. thesis, Texas A&M Univ. 53 pp.

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Houtz, R., J.E. Ewing, and X. Le Pichon. 1968. Velocity of deep-sea sediments from sonobuoy data. Jour. Geophys. Res. 73(8):2615-2641.

Huang, T.C. and H.C. Goodell. 1970. Sediments and sedimentary processes of eastern Mississippi Cone, Gulf of Mexico. Amer. Assoc. Petrol. Geol. Bull. 54(11):2070-2100.

Huerta, R. 1980. Seismic, stratigraphic and structural analysis of northeast Campeche Escarpment, Gulf of Mexico. M.S. thesis, Univ. of Texas, Austin. 107 pp.

Annotation not yet available.

Humphris, C.C., Jr. 1978. Salt movement on continental slope, northern Gulf of Mexico. pp. 69-85. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7. Tulsa, Okla.

This paper relates sediment deposition to salt movement on the Gulf of Mexico continental slope. Salt dome growth on the slope, and the origin of the Sigsbee Escarpment are discussed, and a model for the formation of the Gulf of Mexico is presented.

Ibrahim, A.K., J. Carye, G. Latham, and R.T. Buffler. 1981. Crustal structure in the Gulf of Mexico from OBS refraction and multichannel reflection data. Amer. Assoc. Petrol. Geol. Bull. 65(7):1207-1229.

This is a first-time report of the detailed results of the 12 reversed refraction profiles collected by the University of Texas Marine Science Institute - Galveston Geophysical Laboratory in a long-term project to study the geology and geophysics of the Gulf of Mexico basin. The data confirm earlier refraction interpretation that most of the deep Gulf basin in underlain by an oceanic crustal layer flanked by transitional crust. This layer may have been formed by a mantle thermal event accompanied by a period of rapid sea-floor spreading.

Ibrahim, A.K. and E. Uchupi. in press. Continental/Oceanic crustal transition in the Gulf Coast Geosyncline. Amer. Assoc. Petrol. Geol. Mem. 34.

Annotation not yet available.

Johns, W.D. and R.E. Grim. 1958. Clay mineral composition of Recent sediments from the Mississippi River delta. Jour. Sed. Petrol. 28(2):186-199.

Jones, B.R., J.W. Antoine, and W.R. Bryant. 1967. A hypothesis concerning the origin and development of salt in the Gulf of Mexico sedimentary basin. Gulf Coast Assoc. Geol. Soc. Trans. 17:211-216.

Jordan, G.F. 1951. Continental slope off Apalachicola River, Florida. Amer. Assoc. Petrol. Geol. Bull. 35(9):1978-1993.

Kennett, J.P. and P. Huddleston. 1972. Late Pleistocene paleoclimatology, foraminiferal biostratigraphy and tephrochronology, western Gulf of Mexico. Quaternary Res. 2:38-69.

Ladd, J.W., R.T. Buffler, J.S. Watkins, and J.L Worzel. 1976. Deep seismic reflection results from the Gulf of Mexico. Geology. 4:365-368.

New data are reported on the deep structure and geologic history of the central gulf as revealed by two 24-fold multichannel seismic lines, one extending from the Gulf of Campeche NNE to the Sigsbee Escarpment and another extending from the Challenger Knoll SE to the Campeche Escarpment. A thick sedimentary section and six overlying seismic units are defined on the basis of reflection characteristics and basinwide continuity.

Ladd, J.W., R.T. Buffler, J.S. Watkins, J.L. Worzel, and A. Carranza. 1976. Interpretation of multi-channel seismic reflection records from the Gulf of Mexico. Phys. Earth Planet. Inter. 12:241-247.

Details of the structure, stratigraphy, and geologic history beneath the abyssal plain of the Gulf of Mexico are presented through the interpretation of multi-channel seismic reflection data. The data show deep sub-salt reflectors and a deep irregular acoustic basement which probably represents oceanic crust formed furing the Mesozoic. The crust seems to be composed of six seismic units.

Ladd, J.W. et al. 1976. Multi-channel seismic reflection results from the western Gulf of Mexico. An. Acad. Bras. Cienc. 48(Supplemento):141-151.

Annotations not yet available.

Lehner, P. 1969. Salt tectonics and Pleistocene stratigraphy on continental slope of northern Gulf of Mexico. Amer. Assoc. Petrol. Geol. Bull. 53(12): 2431-2479.

Lofton, C.L. and W.M. Adams. 1971. Possible future petroleum provinces of Eocene and Paleocene, western Gulf basin. pp. 855-886. In: I.H. Cram, ed. Future petroleum provinces of the United States - their geology and potential, vol. 2. Amer. Assoc. Petrol. Geol. Mem. 15.

Long, J.M. 1978. Seismic stratigraphy of part of the Campeche Escarpment, southern Gulf of Mexico. M.S. thesis, Univ. of Texas, Austin. 99 pp.

Annotations not yet available.

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Lynch, S.A. 1954. Geology of the Gulf of Mexico. pp. 67-86. In: P.S. Galtsoff, ed. Gulf of Mexico: its origin, waters, and marine life. U.S. Fish Wildl. Serv., Fish. Bull. 55(89).

Lyons, P.L. 1957. Geology and geophysics of the Gulf of Mexico. Gulf Coast Assoc. Geol. Soc. Trans. 7:1-10.

Martin, R.G., Jr. 1972. Structural feature of the continental margin, northeastern Gulf of Mexico. U.S. Geol. Survey Prof. Paper 800-B. pp. B1-B8. U.S. Govt. Printing Off., Washington, D.C.

Martin, R.G. 1978. Northern and eastern continental margin: stratigraphic and structure framework. pp. 21-42. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies. No. 7. Tulsa, Okla.

A digest of the geologic highlights of the continental margin of the northern and eastern regions of the Gulf of Mexico. It is not an exhaustive summary of knowledge of the province, but rather a broad framework of reference for the subjects included in the volume.

Martin, R.G., Jr. 1980. Distribution of salt structures in the Gulf of Mexico: map and descriptive text. U.S. Geol. Survey Misc. Field Studies Map MF-1213, Scale 1:2,500,000. 8 pp.

Annotation not yet available.

Martin, R.G., Jr. and A.H. Bouma. 1978. Physiography of Gulf of Mexico. pp. 3-19. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7. Tulsa, Okla.

A summary of the physiography of the Gulf of Mexico, focusing on the continental slope province, but including descriptions of all the physiographic provinces and familiar geomorphic features in the Gulf, with intentions of ordering the physiographic names into a coherent scheme.

Martin, R.G., Jr. and A.H. Bouma. 1981. Evidence of active diapirism and engineering constraints, Texas-Louisiana slope, northwest Gulf of Mexico. Marine Geotechnology.

Evidence is presented that supports the authors conclusions that the continental slope region of the northern Gulf of Mexico is undergoing active diapirism and consequent slope steepening. Topographic highs are related to vertical diapiric growth while topographic depressions are related to withdrawal of large volumes of salt and shale. The distribution patterns of both diapiric features and sediment accumulations on the slope are explained as the result of a complex relationship between sediment loading and diapirism. Because most of the sediments on the flanks of diapiric structures consist of underconsolidated muds, slumping is predicted to take place regularly in response to further diapiric movement.

Martin, R.G. and J.E. Case. 1975. Geophysical studies in the Gulf of Mexico. pp. 65-106. In: A.E.M. Nairn and F.G. Stehli, eds. The Ocean Basins and Margins, vol. 3. The Gulf of Mexico and the Caribbean. Plenum Press, New York.

This chapter is a discussion of the Gulf of Mexico's crustal structure as inferred from seismic refraction, magnetic, gravity, and heat flow data. Some of the main interpretations that are important in understanding the evolution of the gulf basin are described.

Martin, R.G., Jr. and R.G. Foote. 1981. Geology and geophysics of the maritime boundary assessment areas. pp. 30-67. In: R.B. Powers, ed. Geologic framework, petroleum potential, petroleum resource estimates, mineral and geothermal resources, geologic hazards, and deep-water drilling technology of the maritime boundary region in the Gulf of Mexico. U.S. Geol. Survey Open-File Rept. 81-265.

Annotation not yet available.

Mason, B.B. 1971. Summary of possible future petroleum potential of Region 6, western Gulf basins. pp. 805-812. In: I.H. Cram, ed. Future petroleum provinces of the United States - their geology and potential, vol. 2. Amer. Assoc. Petrol. Geol. Mem. 15.

McAllister, R.F., Jr. 1964. Clay minerals from west Mississippi Delta marine sediments. pp. 457-473. In: R.L. Miller, ed. Papers in Marine Geology. MacMillan Co., New York.

McFarlan, E. in prep. Lower Cretaceous geology - Gulf of Mexico Basin. Chapter 10. In: A. Salvador and R.T. Buffler, eds. The Gulf of Mexico Basin. Geol. Soc. America.

Annotation not yet available.

McGeary, D.F.R. and J.E. Damuth. 1973. Postglacial iron-rich crusts in hemipelagic deep-sea sediment. Geol. Soc. Amer. Bull. 84:1201-1212.

McKee, T.R., L.M. Jeffrey, B.J. Presley, and U.G. Whitehouse, II. 1978. Holocene sediment geochemistry of continental slope and intraslope basin areas, northwest Gulf of Mexico. pp. 313-326. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7. Tulsa, Okla.

This paper compares a "normal" slope environment to that encountered in four intraslope basins. Three of the basins are "normal" oxic types which are illustrated by the Gyre basin while the fourth, the Orca basin, contains a thick layer of high-salinity, anoxic water.

Mitchum, R.M., Jr. 1978. Seismic stratigraphic investigation of west Florida Slope, Gulf of Mexico. pp. 193-224. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7. Tulsa, Okla.

Seven core holes and 2,500 nautical miles of seismic sparker lines from the West Florida Slope were analyzed to determine its post-Early Cretaceous geologic development. The development of the Florida slope and the causative processes are presented from the Early Cretaceous to the Pleistocene.

Moody, C.L. 1967. Gulf of Mexico distributive province. Amer. Assoc. Petrol. Geol. Bull. 51(2):179-199.

Moore, D.G. and J.R. Curray. 1963. Structural framework of the continental terrace, northwest Gulf of Mexico. Jour. Geophys. Res. 68(6):1725-1747.

Moore, G.T., G.W. Starke, L.C. Bonham, and H.O. Woodbury. 1978. Mississippi Fan, Gulf of Mexico - physiography, stratigraphy, and sedimentational patterns. pp. 155-191. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7. Tulsa, Okla.

A general overview of the geology of the Mississippi Fan. Core data and seismic profiles from a variety of sources: oil companies, Lamont-Doherty Geological Observatory, and the National Geophysical and Solar-Terrestrial Data Center, are utilized to describe the geomorphology of the upper, middle, and lower fan. Seismic characteristics of the fan are discussed, particularly of the upper part of the sedimentary section (Units A, B, and C). The sediments of each unit are studied with reference to the Neogene-Quaternary regional depositional patterns.

Moore, G.T., H.O. Woodbury, J.L. Worzel, J.S. Watkins, and G.W. Starke. 1979. Investigation of Mississippi Fan, Gulf of Mexico. pp. 383-402. In: J.S. Watkins, L. Montadert, and P.W. Dickerson, eds. Geological and geophysical investigations of continental margins. Amer. Assoc. Petrol. Geol. Mem. 29. Tulsa, Okla.

The Mississippi Fan is discussed in reference to its physiography, age of sediments, stratigraphy, sedimentation rates, petroleum potential, and geologic history. The fan is divided into three geomorphic units: upper, middle, and lower, based on 3.5 kHz high-resolution records and bathymetric data. The different morphology and channel system for each is discussed. Seismic-stratigraphic units of the fan are also recognized but only Unit A (the upper interval) is discussed in detail. The petroleum potential of the fan is lightly discussed.

Moore, G.W. and L. del Castillo. 1974. Tectonic evolution of the southern Gulf of Mexico. Geol. Soc. Amer. Bull. 85:607-618.

Murray, H.H. and J.L. Harrison. 1956. Clay mineral composition of Recent sediments from the Sigsbee Deep. Jour. Sed. Petrol. 6:363-368.

Newkirk, T.F. 1971. Possible future petroleum potential of Jurassic Western Gulf basin. pp. 927-953. In: I.H. Cram, ed. Future petroleum provinces of the United States - their geology and potential. Amer. Assoc. Petrol. Geol. Mem. 15, vol. 2.

Newman, J.W., P.L. Parker, and E.W. Behrens. 1971. Quaternary sediments from the Gulf of Mexico: characterization by organic carbon isotope ratios (Abstr.) Geol. Soc. America & Assoc. Soc. Mtg. Abstr. w. Program. 3(7): 658-659.

Nowlin, W.D., Jr., J.L. Harding, and D.E. Amstutz. 1965. A reconnaissance study of the Sigsbee Knolls of the Gulf of Mexico. Jour. Geophys. Res. 70(6):1339-1347.

Ousterhoudt, W.J. 1946. The seismograph discovery of an ancient Mississippi River channel (Abstr.). Geophysics. 11(3):417.

Paine, W.R. and A.A Meyerhoff. 1970. Gulf of Mexico Basin: interactions among tectonics, sedimentation, and hydrocarbon accumulation. Gulf Coast Assoc. Geol. Soc. Trans. 20:5-44.

Penrose, N.L. and J.P. Kennett. 1979. Anoxic and aerobic basins in the northern Gulf of Mexico. Comparison of microfossil preservation. Geol. Soc. Amer. Bull. Abstr. w. Programs. 1979 Ann. Meeting. 493 (Abstr.).

The authors compare microfossil assemblages between the anoxic Orca Basin and a nearby aerobic basin. The anoxic sediments contain well-preserved foraminifera, radiolarians, and pteropods, while the aerobic sediments are nearly devoid of pteropods. The anoxic sediments have an unusual assemblage of delicate radiolarians while the aerobic sediments contain more familiar, robust forms. The article suggests that the Quaternary sequence in the Orca Basin provides excellent opportunity for paleoclimatic investigations on assemblages closer to their biocoenoses.

Pequegnat, W.E., W.R. Bryant, A.D. Fredericks, T. McKee, and R. Spalding. 1972. Deep-sea ironstone deposits in the Gulf of Mexico. Jour. Sed. Petrol. 42:700-710.

Pequegnat, W.E., B.M. James, A.H. Bouma, W.R. Bryant, and A.D. Fredericks. 1972. Photographic study of deep-sea environments of the Gulf of Mexico. pp. 67-128. In: V.J. Henry and R. Rezak, eds. Contributions on the Geological Oceanography of the Gulf of Mexico. Texas A&M Univ., Oceanogr. Studies, vol. 3. Gulf Publ. Co., Houston.

Pew, E. 1982. Seismic structural analysis of deformation in the southern Mexican Ridges. M.S. thesis, Univ. of Texas, Austin. 102 pp.

Annotations not yet available.

Phleger, F.B. 1960. Sedimentary patterns of microfaunas in northern Gulf of Mexico. pp. 267-301. In: F. Shepard, F. Phleger, and Tj. van Andel, eds. Recent sediments, northwest Gulf of Mexico. Amer. Assoc. Petrol. Geol., Tulsa, Okla.

Phleger, F.B. 1967. Some problems in marine geology, Gulf of Mexico. Gulf Coast Assoc. Geol. Soc. Trans. 17:173-178.

Pinsak, A.P. and H.H. Murray. 1960. Regional clay mineral patterns in the Gulf of Mexico. Proc. Seventh Nat. Conf. Clays and Clay Minerals. 7:162-177.

Powell, L.C. and H.O. Woodbury. 1971. Possible future petroleum potential of Pleistocene, western Gulf basin. pp. 813-823. In: I.H. Cram, ed. Future petroleum provinces of the United States - their geology and potential. Amer. Assoc. Petrol. Geol. Mem. 15, vol. 2.

Prior, D.B. and J.M. Coleman. 1978. Submarine landslides on the Mississippi delta-front slope. pp. 41-53. In: Geoscience and Man, School of Geosciences, Louisiana State Univ., Baton Rouge, Louis.

Annotation not yet available.

Prior, D.B. and J.M. Coleman. 1980. Sonograph mosaics of submarine slope instability, Mississippi River delta. Marine Geology. 36:227-239.

In this report sonograph mosaics of submarine slope instabilities are compiled from new sonographs of an area of the Mississippi delta-front slope. Various types of subaqueous mass movement are interpreted, including subparallel scarps, blocky areas enclosed by scarps, elongate sinuous channels, depositional lobes, and collapse depressions.

Prior, D.B., J.M Coleman, and L.E. Garrison. 1979. Digitally acquired undistorted side-scan sonar images of submarine landslides, Mississippi River Delta. Geology. 7:423-425.

This article discusses the promise of significant advances in assessing the spatial distribution of submarine landslides through an advanced, scale-corrected digital side-scan sonar. A side-scan sonar mosaic of the Mississippi River Delta is presented with an interpretation of its geologic features.

Prior, D.B. and J.N. Suhayda. 1979. Submarine mudslide morphology and development mechanisms. Proceedings Eleventh Annual Offshore Technology Conference. OTC Paper No. 3482.

The principal process concepts that apply to each of the three fundamental components of mudslide systems: subsidence source bowls, transport chutes, and depositional loading zones, are discussed along with the potential affects of these components on offshore structures. The inferred mechanisms are based upon diagnostic morphological criteria and comparison with better known subaerial instabilities.

Rainwater, E.H. 1967. Resume of Jurassic to Recent sedimentation history of the Gulf of Mexico basin. pp. 179-210. In: Symposium on the geological history of the Gulf of Mexico, Antillean-Caribbean Region. Gulf Coast Assoc. Geol. Soc. Trans. 17.

Rainwater, E.H. 1971. Possible future petroleum potential of Lower Cretaceous, western Gulf basin. pp. 901-926. In: I.H. Cram, ed. Future petroleum provinces of the United States - their geology and potential. Amer. Assoc. Petrol. Geol. Mem. 15, vol. 2

Rezak, R. and G.S. Edwards. 1972. Carbonate sediments of the Gulf of Mexico. pp. 263-280. In: R. Rezak and V.J. Henry, eds. Contributions on the Geological and Geophysical Oceanography of the Gulf of Mexico. Texas A&M Univ. Oceanogr. Studies, vol. 3. Gulf Publ. Co., Houston.

Rezak, R. and V.J. Henry, eds. 1972. Contributions on the Geological and Geophysical Oceanography of the Gulf of Mexico. Texas A&M Univ. Oceanogr. Studies, vol. 3. Gulf Publ. Co., Houston. 303 pp.

Sangree, J.B., D.C. Waylett, D.E. Frazier, G.B. Amery, and W.J. Fennessy. 1978. Recognition of continental slope seismic facies, offshore Texas-Louisiana. pp. 87-116. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7. Tulsa, Okla.

Six seismic-facies types are defined on the basis of data from a high-resolution arcer survey of the young sediments in the western clastic region of the Gulf of Mexico continental slope, and 29 300-m core holes. Transportation deposition processes responsible for each facies are also suggested.

Scafe, D.W. 1968. A clay mineral investigation of six cores from the Gulf of Mexico. Ph.D. dissertation, Texas A&M Univ. 76 pp.

Scafe, D.W. and G.W. Kunze. 1971. A clay mineral investigation of six cores from the Gulf of Mexico. Mar. Geol. 10:69-85.

Schlager, W., et al. in press. DSDP Leg 77 - early history of the Gulf of Mexico. Geol. Soc. Amer. Bull.

Annotation not yet available.

Shaub, F.J., R.T. Buffler, and J.G. Parsons. in press. The post-middle Cretaceous geologic history of the deep Gulf of Mexico. Amer. Assoc. Petrol. Geol. Studies in Geol.

Annotation not yet available.

Shepard, F.P. 1937. "Salt" domes related to Mississippi submarine trough. Geol. Soc. Amer. Bull. 48:1349-1362.

Shepard, F.P. 1955. Delta front valleys bordering the Mississippi distributaries. Geol. Soc. Amer. Bull. 66:1489-1498.

Shepard, F.P., F.B. Phleger, and Tj. van Andel, eds. 1960. Recent sediments, northwest Gulf of Mexico. Amer. Assoc. Petrol. Geol., Tulsa, Okla. 394 pp.

Shih, T.C. and J.S. Watkins. 1974. Northeastward extension of the Sigsbee scarp, Gulf of Mexico (Abstr.). Geol. Soc. Amer. Abstr. w. Programs. 6:953.

Shih, T., J.L. Worzel, and J.S. Watkins. 1977. Northeast extension of Sigsbee scarp, Gulf of Mexico. Amer. Assoc. Petrol. Geol. Bull. 61(11):1962-1978.

The Sigsbee Scarp is shown to extend across the Mississippi Cone for about 60 km from 27°10'N, 90°10'W to 28°50'N, 88°05'W. Seismic reflection and bathymetric data were used to trace the extension of the scarp although most of it is buried beneath the Mississippi Cone.

Shih, T., J.L. Worzel, J.S. Watkins, and T.H. Shipley. 1975. Origin of giant slump features on the Mississippi Fan, Gulf of Mexico (Abstr.). EOS. 56(6):381.

Data from a 1973 cruise by the R/V ALAMINOS are used to interpret the origin of a slump feature south of the Mississippi Trough. The first suggestion of the northeast extension of the Sigsbee Scarp is presented in the paper,and the Mississippi Trough is shown to terminate at a terrace-like feature at 1200-1350 m instead of at 2250 m as shown by other investigators. The northeast limits of the Sigsbee Scarp is felt to have stopped the development of the Mississippi Trough, as diapiric uplifting of the scarp dammed sediments from the trough and formed a terrace.

Shinn, A.D. 1971. Possible future petroleum potential of upper Miocene and Pliocene, western Gulf basin. pp. 824-835. In: I.H. Cram, ed. Future petroleum provinces of the United States - their geology and potential. Amer. Assoc. Petrol. Geol. Mem. 15, vol. 2.

Shokes, R.F., P.K. Trabant, B.J. Presley, and D.F. Reid. 1977. Anoxic, hypersaline basin in the northern Gulf of Mexico. Science. 196:1443-1446.

Annotation not yet available.

Sidner, B.R., S. Gartner, and W.R. Bryant. 1977. Late Pleistocene geologic history of the outer continental shelf and upper continental slope, northwest Gulf of Mexico. Texas A&M Univ., Dept. of Oceanogr. Tech. Rep. 77-5-T. 131 pp.

This technical report was the basis for the article by the same authors, cited below.

Sidner, B.R., S. Gartner, and W.R. Bryant. 1978. Late Pleistocene geologic history of Texas continental shelf and upper continental slope. pp. 243-266. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7. Tulsa, Okla.

This study integrated high-resolution seismic and core data from the Texas outer continental shelf and upper continental slope to describe in detail the late Pleistocene history of shelf-edge progradation. The investigation also addresses the relation of shelf-edge outbuilding to upper continental slope sediment stability and seismic character.

Sorenson, F.H., L.W. Snodgrass, J.H. Rebman, R.R. Murchison, C.R. Jones, and R.G. Martin. 1975. Preliminary bathymetric map of Gulf of Mexico region. U.S. Geol. Survey Open-File Map, n. 75-140, scale 1:2,500,000.

Annotation not yet available.

State University System of Florida (SUSIO). 1977. Baseline monitoring studies Mississippi, Alabama, Florida outer continental shelf, 1975-76. Prepared for Bureau of Land Management under Contract No. 08550-CT5-30, 5 vols. 782 pp.

Stuart, C.J. and C.A. Caughey. 1976. Form and composition of the Mississippi Fan. Gulf Coast Assoc. Geol. Socs. Trans. 26:333-343.

The Mississippi Fan, which extends about 600 km from the Mississippi River Delta to the Sigsbee Abyssal Plain, is divided into three regions: upper, middle, and lower, based on seafloor gradient, relative smoothness, seismic character, and salt structures. The structural and seismic characteristics of each region are discussed.

Stuart, C.J. and C.A. Caughey. 1977. Seismic facies and sedimentology of terrigenous Pleistocene deposits in the northwest and central Gulf of Mexico. Amer. Assoc. Petrol. Geol. Mem. 26. 26:249-275.

Annotation not yet available.

Swolfs, H.S. 1967. Seismic refraction studies in the southwestern Gulf of Mexico. M.S. thesis, Texas A&M Univ. 42 pp.

Tanner, W.F. 1965. The origin of the Gulf of Mexico. Gulf Coast Assoc. Geol. Soc. Trans. 15:41-44.

Tanner, W.F. 1968. The origin of the Gulf of Mexico, II: Additional data. Gulf Coast Assoc. Geol. Soc. Trans. 18:98-105.

Tatum, T. 1977. Shallow geologic features of the upper continental slope, northern Gulf of Mexico. M.S. thesis, Texas A&M Univ. 61 pp.

Annotation not yet available.

Tatum, T. 1979. Shallow geologic features of the upper continental slope, northern Gulf of Mexico. Dept. of Oceanogr., Texas A&M Univ. Tech. Rept. 79-2-T. 60 pp.

Annotation not yet available.

Tieh, T.T. and T.E. Pyle. 1972. Distribution of elements in Gulf of Mexico sediments. pp. 129-152. In: R. Rezak and V.J. Henry, eds. Contributions on the Geological and Geophysical Oceanography of the Gulf of Mexico. Texas A&M Univ. Oceanogr. Studies, vol. 3. Gulf Publ. Co., Houston.

Tipsword, H.L., W.A. Fowler, Jr., and B.J. Sorrell. 1971. Possible future petroleum potential of lower Miocene-Oligocene, western Gulf basin. pp. 836-854. In: I.H. Cram, ed. Future petroleum provinces of the United States - their geology and potential. Amer. Assoc. Petrol. Geol. Mem. 15, vol. 2.

Trabant, P.K. and B.J. Presley. 1978. Orca Basin, anoxic depression on the continental slope, northwest Gulf of Mexico. pp. 303-311. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7. Tulsa, Okla.

This paper describes the uncommon chemistry and results of low-energy seismic surveys of the Orca basin, an intraslope basin on the continental slope of the northwestern Gulf of Mexico. The basin appears to have formed by salt-induced deformation. Leaching and diffusion of the salt source has enriched the bottom water in the basin, forming a stable brine pool which is anoxic and hypersaline.

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Annotation not yet available.

Watkins, D.J. and L.M. Kraft, Jr. 1978. Stability of continental shelf and slope off Louisiana and Texas: geotechnical aspects. pp. 267-286. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7. Tulsa, Okla.

This paper attempts to 1) describe the types of common deformational features on the outer continental shelf and upper continental slope off the Louisiana and Texas coasts, 2) briefly describe factors that may cause and contribute to the development of these features, and 3) describe the data base required and the geologic and geotechnical procedures used to assess the hazards of faults and soil movements on the anticipated performance of offshore facilities constructed in these regions.

Watkins, J.S., J.W. Ladd, R.T. Buffler, F.J. Shaub, M.H. Houston, and J.L. Worzel. 1978. Occurrence and evolution of salt in deep Gulf of Mexico. pp. 43-65. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7. Tulsa, Okla.

A review of the data collected by the University of Texas Marine Science Institute Geophysics Laboratory in a common depth point (CDP) seismic reflection investigation of the geology of the deeper Gulf of Mexico. The Challenger seismic unit is discussed most extensively, particularly in relation to mobilization of salt within the Challenger. The Mexican ridges are suggested to be cored with shale rather than with salt.

Watkins, J.S., J.W. Ladd, F. Jeanne Shaub, R.T. Buffler, and J.L. Worzel. 1976. Seismic section WG-3, Tamaulipas shelf to Campeche Scarp, Gulf of Mexico. Amer. Assoc. Petrol. Geol. Seismic Section No. 1.

Annotations not yet available.

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Reports on the results of a deep sounding common-depth-point (CDP) seismic reflection survey across a portion of the lower slope, Sigsbee Scarp, continental rise, and abyssal plain of the northern Gulf of Mexico. Undeformed reflectors occurred at depths down to 11 km beneath the continental rise and abyssal plain and 7 km in basins of the lower slope. Weak reflectors are visible beneath the salt of the Sigsbee Scarp and within salt ridges separating the lower slope basins.

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The character of sparker reflections at core hole sites on the continental slope of the northern Gulf of Mexico were related to grain size, coarse fraction analysis, and depositional environment (as interpreted from microfauna) determined from the cores. A large portion of the volume of continental slope sediments appeared to consist of displaced sediments from the shelf through slumping, sliding, and creep.

Woodbury, H.O., J.H. Spotts, and W.H. Akers. 1978. Gulf of Mexico continental slope sediments and sedimentation. pp. 117-137. In: A.H. Bouma, G.T. Moore, and J.M. Coleman, eds. Framework, Facies, and Oil-trapping Characteristics of the Upper Continental Margin. Amer. Assoc. Petrol. Geol. Studies in Geol. No. 7. Tulsa, Okla.

Data from nine core tests and sparker surveys are analyzed in an interpretation of sediments and sedimentation of the northern Gulf of Mexico continental slope. Continous sparker reflections are correlated with slowly deposited, evenly bedded sediments containing bathyal faunas. The coarse fraction is dominated by the tests of foraminifers. Discontinuous, discordant reflections and diffractions are correlated with sediments more rapidly emplaced in the bathyal environment of the continental slope by slumping and sliding from the continental shelf. These sediments contain neritic faunas that lived on the continental shelf. Their coarse fraction is dominated by terrigenous sand grains. A large part of the volume of continental-slope sediments appears to consist of these "displaced" sediments, including an area 3 to 24 km wide and 80 km long, southeast of Corpus Christi, Texas, and much of the Mississippi Fan southeast of New Orleans.

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A summary of preliminary findings of a long-term study of the tectonic history of the Gulf of Mexico. Some 4,000 nautical miles of 12 fold seismic reflection data and 4,000 nm of 24-fold data are used to describe five major stratigraphic units and their characteristics for the western, northern, southern, and eastern Gulf of Mexico, and the southeastern approach to the Gulf of Mexico. The five units are named, from base to surface, as the Challenger Unit, Campeche Unit, Mexican Ridges Unit, Cinco de Mayo Unit, and the Sigsbee Unit.

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The report addresses the benthic ecology of the upper continental slope in the northern Gulf of Mexico. The physiography of the Gulf is summarized as are various physico-chemical aspects of the pelagic realm. Discussions of the pelagic biota are presented, though the major thrust of the report is towards synthesizing the benthic ecology of the area.

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This comprehensive literature study provides background information on the deep ocean as a disposal alternative to nearshore, estuarine, and inland dredged material disposal areas. The geographic expanse of this report is the East, West, and Gulf coasts of the U.S., Gulf of Alaska, Hawaiian, Puerto Rican, and U.S. Virgin Islands.

Schuller, R.E. and H.J. McLellan. 1964. The oceanographic research vessel Alaminos. Texas A&M Univ., Dept. of Oceanogr. Ref. 64-6F.

State University System of Florida (SUSIO). 1977. Baseline monitoring studies Mississippi, Alabama, Florida outer continental shelf, 1975-76. Prepared for Bureau of Land Management under Contract No. 08550-CT5-30, 5 vols. 782 pp.

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Elliott, B.A. 1982. Anticyclonic rings in the Gulf of Mexico. Jour. Phys. Oceanogr. 12:1292-1309.

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Molinari, R.L., J.F. Festa, and D.W. Behringer. 1978. The circulation in the Gulf of Mexico derived from estimated dynamic height fields. Jour. Phys. Oceanogr. 8(6):987-996.

Monthly mean dynamic height topographies for the upper 500 m of the Gulf of Mexico, seasonal mean topographies for the upper 1000 m and annual topographies for the deep flow are presented. The deep circulation between 1500 and

3000 m is hypothesized to be dominated by an anticyclonic gyre which fills the entire deep basin.

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Sturges, W. and J.P. Blaha. 1976. A western boundary current in the Gulf of Mexico. Science. 192:367-369.

Proposes that the circulation of the western Gulf is largely driven by the curl of the wind stress. They calculate a negative curl of the wind stress for the entire Gulf Basin. They propose that the anticyclone located in the western Gulf is driven by this negative curl and they predict the presence in the Gulf of a small Gulf Stream-like system including a western boundary current.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.