A STUDY OF THE DEEP WATER BENTHOS OF THE NORTHWESTERN GULF OF MEXICO

A Thesis

By

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Submitted to the Graduate College of the
Texas A&M University in
partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

January 1968
(month) (year)

Major Subject Oceanography

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ACKNOWLEDGMENTS

I would like to express my appreciation to Dr. Willis E. Pequegnat and the Department of Oceanography for the valuable ship time and equipment that were used in the collection of samples considered in this thesis. I am grateful to William R. Bryant, Dr. Sewell H. Hopkins, and Dr. Pequegnat for offering many helpful suggestions concerning the style and content of the thesis. The help of Mr. Harvey R. Bullis is appreciated not only because he provided me with space in his laboratory and the use of many of his references, but also because he confirmed many of my identifications and offered many of his ideas about the ecology of deep-water organisms in the Gulf of Mexico. Dr. Meredith Jones, Curator-in-Charge of the Division of Worms of the U. S. National Museum, is to be thanked for his help in identifying the polychaetes in these collections, and also for his helpful suggestions concerning the style of the thesis and a proper taxonomic approach to this study. Other specialists who provided useful information concerning the identity of organisms are acknowledged in the appropriate taxonomic divisions presented in the text (Chapter IV).

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CHAPTER I

INTRODUCTION

Review of Previous Work

The purpose of this study is to provide some insight into the nature of the bottom fauna of the deep water of the northwestern Gulf of Mexico. Deep water, in this case, is considered to be from 100 fathoms to a maximum depth of over 2000 fathoms. The samples considered in this study were collected during three cruises of the R/V Alaminos at depths within the above range. The positions and depths of the sampling stations of these cruises are listed in Table I. The lack of published material on the benthos from these depths in the northwestern Gulf of Mexico is evidenced in the following review.

An historical sketch of the explorations of the Gulf of Mexico has been presented by Galtsoff (1954). In this summary, the major expeditions and subsequent investigations of biological significance have been reviewed. Not all of these included the benthos. Those that did concern bottom-organisms were Louis Agassiz's biological survey of Florida reefs (Agassiz, L., 1880), Folin and Perier's (1867-72) references to bottom animals of the Gulf of Mexico, systematic deep-sea explorations in 1867 and 1868 by Pourtalès and Mitchel on the U. S. C. S. ships Corwin and Bibb (Pourtalès, 1867; L. Agassiz, 1880;

A. Agassiz, 1888, V. i. p. 49, and Pierce and Patterson, 1881), explorations along the west coast of Florida by Howell aboard the Blake in 1872, the explorations by Sigsbee and Bartlett from 1875-78 (Agassiz, 1888), the explorations by the Albatross in the Yucatan Strait (Tanner, 1886; Hedgpeth, 1947; and Hedgpeth and Schmitt, 1945), and the investigation of fisheries resources by the M/V Oregon beginning in 1951 (Springer and Bullis, 1956).

In importance, the cruises of the Blake stand above the other expeditions in the deep water of the Gulf of Mexico. Two volumes, one describing the sampling procedures and the other describing the fauna, are even today a good source of information on the fauna of the Gulf of Mexico and Caribbean Sea to depths of 2000 fathoms. Numerous publications on the material obtained by the Blake have appeared in the first 19 volumes of the Bulletin of the Harvard Museum of Comparative Zoology and also in the Memoirs of the Harvard Museum of Comparative Zoology.

The major disadvantage in using this large body of information is its lack of consolidated reports on the fauna of specific areas. An investigator working on the continental shelf in the northern Gulf of Mexico, for instance, would have a difficult time bringing together all the data available on animals from that geographical location. In other words, no attempt has been made either to list the species by stations or to list all the species sampled and then to indicate the stations at which they were found. However, an attempt to organize the Blake information concerning the western Gulf of Mexico in this manner might be of dubious value because the Blake never went farther west than 90 degrees west longitude.

Many investigations, undertaken since the turn of the century in connection with fisheries resources (oyster and shrimp industries) and the oil industry, have contributed greatly to the information available on the benthonic fauna of the continental shelf and continental slope of the northwestern Gulf of Mexico. Among the more recent studies are Ladd's (1953) publication on the marine assemblages of the Texas coast, the work of Lowman (1949) on the sedimentary facies of the Gulf coast, and Pulley's (1952) investigations concerning the distribution of mollusks in the Gulf of Mexico. The first two works mentioned here were geological in nature rather than studies considering complete biocoenoses. In the latter publications, Pulley presents a summary of the information available on mollusks along the Texas coast, and points out the probable errors that occur in previous publications. Pulley's check-list included those forms that Dall (1880) lists as Gulf of Mexico species, and Pulley indicates that even though they were included, many of Dall's species do not actually occur off the Texas coast. However, one probably cannot trust the distributional limits Pulley places on many of the deep-water species because of the lack of deep water sampling since the *Blake* expedition.

Hildebrande (1954) has published considerable data on the fauna off the Texas coast at depths of 20-60 fathoms. This includes a great variety of crustaceans and demersal fish, but the shrimp trawls used in sampling did not take burrowing worms and many of the mollusks.

Hedgpeth (1953) has discussed the zoogeography of the northwestern Gulf of Mexico with reference to the invertebrate fauna. His history of the northern Gulf of Mexico and its fauna is very thorough, as is his treatment of the present environmental conditions as they were known at the time of his publication. The publication lacks data on the deep-water fauna, and, as a result, it gives one no picture of the oceanic fauna of the Gulf of Mexico. His reference to the characteristic fauna of the offshore bottoms could easily be misconstrued to mean all the shelf fauna or even all the deep-water fauna. Hedgpeth (1954) has discussed the bottom communities of the Gulf, but he concedes that knowledge of the deep-water communities is limited to Agassiz's *Three Cruises of the Blake* and to the other scattered reports on these cruises, previously mentioned.

In 1951, the American Petroleum Institute began Project 51, a multimillion dollar attempt to gain information of possible use to the oil industry of the Gulf Coast. Along with many other activities, Project 51 dredged the continental shelf and continental slope of the northern Gulf of Mexico. R. H. Parker (1955, 1956, 1959, 1960) and Parker and Curry (1956) have used these data for many accounts of animal assemblages as indicators of the sedimentary environments of this geographic area. Through these publications, information has become available, not only on the composition of the Gulf fauna, but also on the recurrent groups that might be expected in various habitats. Parker describes eight macrofaunal assemblages occurring on the continental shelf and upper continental slope to depths of 500 fathoms, six of which are modified by sediment type and average bottom-water temperature conditions. He points out that changes in climate and associated environments are demonstrated for the Holocent (Recent) Transgression across the continental shelf by the use of Carbon 14-dated shells of species with restricted depth and environmental range and temperature-restricted geographic ranges. He has used the presence of extensive shell deposits comprised of species preferring low salinity as well as surf zone species on the continental shelf to delineate the location of large lagoons and estuaries and extensive stretches of barrier beaches during various periods of the Holocene Transgression. Certain of Parker's findings are very significant to this present study of deep-water benthic fauna. He states that the upper continental slope, from 60 to at least 250 fathoms, has a seasonally constant bottom temperature with the temperature decreasing with increased depth, and that below 150 fathoms water temperatures are always found to be less than the coldest inshore water temperatures. The sediments of the upper slope are mostly clayey silt or silty clay. He indicates that these temperature and substrate conditions on the upper continental slope zone could account for the lack of variation in species composition from the eastern to the western Gulf, while shallower zones show marked variations. But this interpretation is questionable since many species listed by Parker were cited from the literature, and he evidently worked with few actual samples from these depths.

Parker includes in his assemblages all species, alive and dead, that contain hard parts that are likely to be preserved in the fossil record. As a result, he cannot actually define communities in relation to certain environments because the specimens may have survived from times when hydrographic conditions were quite different, or may have been transported and deposited by slumping action or turbidity currents (see Chapter VI). A faunal study should enable one to list the species of animals found in defined environments. Parker's work enables geologists to locate combined macro-invertebrate thanatocoenoses and biocoenoses, but it does not help ecologists find and define communities in the manner prescribed by Petersen (1913), Thorson (1957), and Jones (1950).

Springer and Bullis (1952, 1956) and Bullis (1956) have published data on the species of crustaceans, mollusks, and fish collected by the M/V Oregon in the Gulf of Mexico. This work was done under the auspices of the Exploratory Fishing and Gear Research Base of the U. S. Bureau of Commercial Fisheries at Pascagoula, Mississippi. A variety of sampling devices were used in these collections, including various modifications of trawls ranging in size from 12 to 100 feet across. The majority of the trawling stations were confined to the shallow water of the continental shelf, but a few extended to the continental slope and a maximum depth of 1200 fathoms. This work has added much to the data available on the composition of the fauna of the Gulf of Mexico, and it has procured many species that were formerly known only from a few isolated specimens. The lamentable inadequacy of much of the work is the lack of data on those species of animals that are important members of the ecological communities in question but are of no foreseeable economic importance.

CHAPTER II

OCEANOGRAPHY OF THE AREA

Geography

The area studied in the northwestern Gulf of Mexico is bounded on the north and south by the 27°50' and 25°00' north latitude lines respectively, and on the east and west by the 92°23' and 95°31' west longitude lines respectively. Within these boundaries, the study was restricted to depths of from 100 to 2020 fathoms, i. e., from the outer margin of the continental shelf to the greatest depths of the defined area. These limits were placed on the study in order to minimize the duplication of previous work in the Gulf (Parker, 1960; Springer and Bullis, 1956; etc.). The positions of all the stations of the three biological cruises during 1964 and the first half of 1965 were determined by the officers of the R/V *Alaminos* using celestial and sun fixes, Loran, and dead reckoning; these positions are listed in Table I.

Physiography

The upper continental slope in this area exhibits a rough, rolling, and hilly topography referred to as the Hummocky Zone (Geally, 1955; Ewing et al., 1958). The hummocks are probably the result of tectonic

Table I

Three Biological Cruises of the R/V *Alaminos*

Cruise	Station	Position	Depth
64-A-10	2	93°43'W. x 27°40'N.	200 fathoms
"	3	93°39'W. x 27°15'N.	420 fathoms
"	5	92°44'W. x 26°00'N.	1200 fathoms
"	6	92°23'W. x 25°13'N.	1800 fathoms
"	7	94°00'W. x 25°13'N.	2020 fathoms
"	8	94°48'W. x 25°02'N.	1920 fathoms
"	9	95°05'W. x 25°21'N.	1500 fathoms
"	10	95°30'W. x 25°30'N.	965 fathoms
"	11	95°31'W. x 25°29'N.	745 fathoms
"	12	94°55'W. x 27°30'N.	472 fathoms
"	13	95°00'W. x 27°50'N.	100 fathoms
64-A-13	2	93°00'W. x 26°35'N.	300 fathoms
"	3	92°00'W. x 26°28'N.	1000 fathoms
65-A-3	2	94°57'W. x 26°16'N.	1250 fathoms

activity and slumping, and the sediment appears to be terrigenous clay and silt. On the continental rise the topography is less rugged, and the sediment changes to a brown foraminiferan ooze with numerous interspersed pteropod tests. The abyssal plain, or Sigsbee Deep, has a gradient of less than 1:8,000, and is, therefore, one of the flattest areas on the earth (Geally, 1955). The surface sediment here is well-compacted gray clay, and cores indicate that the plain was formed by turbidity current action that continued to occur as recently as the Holocene (Recent) Transgression (Ewing et al., 1958).

Hydrography

Many of the hydrographic features of the area studied have been presented by McClellan and Nowlin (1963). The salinity varies from nearly 36.00 ‰ at a depth of 100 fathoms, to approximately 34.5 ‰ at 2000 fathoms. The temperature decreases continuously from approximately 17.5° C. at the shallow limit of the study to a minimum of approximately 4.35° C. near the bottom at a depth of 2000 fathoms. The upper continental slope has virtually constant bottom temperatures, and the temperature decreases as the depth increases (Parker, 1960). This lack of seasonal variation probably prevails at the greater depths of the continental rise and Sigsbee Deep. The dissolved oxygen concentration of the water varies from approximately

3.0 ml/l at 100 fathoms to approximately 2.5 ml/l at depths near 200 fathoms. Hydrocasts from the Alaminos during biological cruises have revealed an increase of 0.1 - 0.2 ml/l in the last ten meters above the bottom in the deep water of the abyssal plain. These data indicate clearly that the oxygen concentration is in no way a limiting factor on the abyssal plain, and it cannot account for the paucity or the type of the macro-invertebrates encountered there. It has been, in essence, eliminated as an ecological parameter at great depths in the Gulf of Mexico.

CHAPTER III

EQUIPMENT AND METHODS

In a descriptive faunal study, the sampling equipment used should, as much as possible, satisfy the requirements set by the investigator, and the degree to which these requirements are met should be scrutinized carefully. With this in mind, the sampling devices in this investifation follow the philosophy of Thorson (1957). They were chosen with the intention of combining a reliable quantitative sampling device for determining the number of live organisms per unit area with a dependable qualitative sampler capable of capturing much of the fauna that might escape the former device. The quantitative sampler used was a large Campbell Grab purchased by the Texas A&M Research Foundation in 1964. The grab weighs 780 pounds empty and covers 0.56 square meters of the bottom. The 0.2 cubic meters of sediment it picks up with a full sample adds approximately 500 pounds to the empty weight. This device, with its tremendous weight, is much more efficient in deep water than are the smaller, conventional van Veen and Petersen grabs.

Two different dredges were used to take the samples considered in this investigation. They were modified from cruise to cruise and even from station to station, depending on the relative success of their operation. The first dredge used was a modification of the dredge described by Menzies (1962); its specifications are included in its illustration (Plate V, figure 1). One-inch stretch mesh was used in the anterior three feet of the net, and the posterior six feet of the net were made of 1/2-inch stretch mesh. In operation, it was noted that when the dredge reached the surface of the water after a hawl it was often clogged with mud, and it was evident that much of the sediment that contained organisms was rejected from the orifice of the dredge because of the overflow due to this clogging.

The second dredge used (Plate V, figure 2) was designed by Dr. Willis E. Pequegnat. No protection was provided for the net on the first cruise using this dredge, and the net often became tangled in the plow share teeth. As a result a light aluminum frame was installed to hold it in place. The "bottom" and "top" of this were covered with hardware cloth to protect the net from bottom protuberances.

The modified Menzies dredge was equipped with two bottom metering devices (Plate VI, figure 1). The degree of accuracy and the reliability of these meters is, of course, unknown, and the data presented should, in the opinion of the author, be regarded as positive evidence of a minimum amount of the bottom that the dredge covered. Any attempt to determine the concentration of organisms per unit area of the bottom is merely conjecture. The second dredge was equipped with a single metering device (Plate VI, figure 2), and the data from this are appended with those from the original dredge. A comparison of the "distances" the two dredges are supposed to have covered per length of time on the bottom makes it evident that this single device failed to function properly. Its heavy construction and short paddle blades probably caused it to clog and drag through the sediment without allowing it to spin freely.

Menzies (1964) has described the dredging techniques used aboard the R/V Vema to facilitate an approximation of the density of benthic organisms. The dredge used is weighted heavily and lowered to the bottom with the ship hove to. The position of the ship is determined and then it is allowed to drift. When the dredge leaves the bottom at the end of the operation the new position is determined and the distance the dredge covered is a simple matter of subtraction. It is evident that an error is introduced into this method with the initial assumption that the ship's position can be accurately determined, but nevertheless Menzies favors this method over bottom metering devices of a mechanical nature. Unfortunately these techniques were not amenable with the procedural vagaries aboard the R/V Alaminos, and they were ignored in the hope that the bottom metering devices would suffice. Perhaps if both methods had been used data would be available to either support or refute Menzies' distrust of bottom metering devices.

The sediment retained by the sampling devices was sieved through a table made of four layers with varying mesh sizes; the openings in the fine mesh of the bottom screen are two millimeters in diameter. As a result the meiobenthos and the microbenthos, as defined by Mare (1942), were washed through the table, and, therefore, only the macrobenthos is considered in this study.

CHAPTER IV

LIVING MACRO-INVERTEBRATE FAUNA ENCOUNTERED

The following is a list of the living macro-invertebrates taken from the area and depths described in the preceding chapter of this thesis and subsequently identified by the author. In cases where the identification of a specimen was not possible or was possibly inaccurate, duplicate specimens were sent to recognized specialists in the group concerned. Credit has been given when these specialists have supplied useful information concerning questionable identifications and/or indeterminable species. If replies have not been received as yet, the descriptions and tentative identifications have been supplied by the author.

Brachiopoda

Chlidonophora incerta (Davidson), 1878; *fidé* Cooper, 1954.
(Plate I, figure 6)

This relatively abundant species has been found from 1250 to 2020 fathoms at the stations listed in Table II. It is one of the few species sampled in this study that consistently appeared at deep-water stations. The *Blake* (Davidson, 1878) took this species in 1181 fathoms of water between the Mississippi delta and Cedar Keys, Florida.

Table II

Occurance of Chlidonophora incerta

No. Live	Cruise	Station	Depth (fms)
14	64-A-10	6	1800
2	"	7	2020
3	65-A-3	2	1250 (Dredge No. 1)
13	"	"	" (Dredge No. 2)
3	"	"	" (Dredge No. 3)

Dr. W. E. Pequegnat (unpublished data) has also found this species in the eastern Gulf of Mexico within the depths listed above for the western Gulf. Dr. G. Arthur Cooper of the U. S. National Museum confirmed the identification of this species, and he indicated (personal communication) that his brief description of C. incerta in the U. S. Fish and Wildlife Service Bulletin No. 89, The Gulf of Mexico, Its Origin, Waters, and Marine Life, is incorrect concerning the pedicle. His description there comes from a specimen that he believes to have been identified incorrectly. The pedicle of the true C. incerta of Davidson is widely branched at its base, and not long and frayed on the end.

Crustacean Arthropods

Family Neotanaidae (Tanaidacea).

Neotanais serratispinosus Norman and Stebbing, 1886; fidé Wolff, 1956. (Plate II, figure 2)

A crustacean resembling this tanaid was dredged at Station 10 (940-770 fathoms) on Cruise 64-A-10. It is 9.0 mm. long and it was housed in a small, transparent tube. Wolff (1956) reports that the members of the family Neotanaidae are cosmopolitan, deep water organisms, and that there has been only one record of a neotanaid being found at depths less than 4,000 meters or at temperatures greater than 4.0° C.

The subspecific separation of this species suggested by Wolff has not been attempted, because it would entail removing the mouth-parts, and therefore damaging this single specimen.

Family Goneplacidae (Brachyura).

Bathyplax typhla A. Milne-Edwards, 1880.

Eleven individuals of this species were dredged up at Station 2 (300 fathoms) on Cruise 64-A-13. The *Oregon* (Springer and Bullis, 1956) has taken this species in trawl samples between 200 and 375 fathoms in the northern Gulf of Mexico. Pounds (1961, Plate III, figure 3) lists this species as a common crab in deep water off the coast of Texas.

Family Raninidae (Brachyura).

Lyreidus bairdii Smith, 1880.

One ovigerous female of this species was dredged at Station 2 (200 fathoms) on Cruise 64-A-10. The Oregon (Springer and Bullis, 1956) has found this species between 250 and 300 fathoms in the northern Gulf of Mexico. The specimen from which Smith's description comes was encountered off New England in water 100 to 125 fathoms deep. Pounds (1961, Plate III, figure 2) lists this as a deep water crab of the Gulf of Mexico.

Family Galatheidae (Anomura).

Munida pusilla Benedict, 1903.

(Plate II, figure 5)

A small galatheid minus its thoracic appendages was dredged up at Station 3 (400 fathoms) on Cruise 64-A-10. It closely resembles the species it is referred to above. This species was dredged up in the Gulf of Mexico and the western Atlantic by the Albatross and subsequently described by Benedict (1903). The Oregon (Springer and Bullis, 1956) captured this species with a trawl in the eastern Gulf of Mexico at a depth of 62 fathoms.

Munidopsis cylindrophthalma (Alcock),1894; fidé Benedict, 1903.

(Plate II, figure 3)

Another galatheid decapod, minus its thoracic appendages and closely resembling the above species, was dredged at Station 2 (200 fathoms) on Cruise 64-A-10. Benedict (1903) lists the known distribution of this species as 188-265 fathoms in the Andaman Sea and 406 fathoms in the Arabian Sea. This species is similar in general appearance to M. cylindropus Benedict, 1903, but the former has a broader rostrum, smaller eyes, a smoother carapace, and its antero-lateral angles are rounded.

Munida iris A. Milne-Edwards, 1880; fidé Benedict, 1903.

A large galatheid minus its abdomen was captured by the dredge at

Incertae sedis (Plate III, figure 5).

What appeared to be a burrowing decapod was found at Station 2 (200 fathoms) on Cruise 64-A-10. Only the first pair of thoracic appendages and the last left thoracic appendage remain intact.

Pelecypod Mollusks

Family Limopsidae.

Limopsis sulcata Verrill and Bush, 1898.

One live specimen was found at Station 12 (472 fathoms) on Cruise 64-A-10. It is 2.25 mm long and it has a height of 2.5 mm. There are four anterior and four posterior teeth. Parker (1960, Plate VI, figure 10) lists this species as a common member of his "upper continental slope assemblage." Johnson (1934) indicates that it is distributed from Massachusetts to Virginia at depths of from 64 to 349 fathoms.

Limopsis antillensis Dall, 1881; *fidé* Parker, 1960.

One live specimen of this species was found at Station 2 (200 fathoms), Station 5 (1200 fathoms), and Station 12 (472 fathoms). The first two were 7.0 mm long and 8.0 mm high. The latter shell was 3.0 mm long and 3.0 mm high. Parker (1960) says that this species is present, but rare, west of the Mississippi delta, and he includes it in his "upper continental slope assemblage."

Johnson (1934) states that the distribution of this species is from North Carolina to the Florida Strait and the West Indies at depths of from 80 to 683 fathoms.

Family Arcidae.

Arca pteroessa Smith, 1885.

(Plate I, figure 6)

A live specimen of this species was found attached to the shell of a living brachiopod, *Chidonophora incerta*, at Station 6 (1800 fathoms) on Cruise 64-A-10. Smith (1885) indicates that the *Challenger* took this species in grey mud in the Pacific at a depth of 2050 fathoms, in 1000 and 1675 fathoms of water west of the Azores, and off Culebra Island in the West Indies at a depth of 390 fathoms. The *Alaminos* recently took this species (Cruise 65-A-9, 25°32'N. x 86°00'W., 1707 fathoms) from the abyssal plain off the west coast of Florida. The shells were attached to a thin veneer of soft rock that was exposed on the bottom. The recurrence of this species in the east and west Gulf under similar bathymetric and hydrographic conditions would seem to indicate that where a suitable substrate can be found this species is a ubiquitous member of the abyssal plain fauna of the Gulf of Mexico.

Family Limidae.

Limatula subauriculata Montagu, 1808; *fidé* Abbott, 1954.

A single, live individual of this species was taken at Station 2

(1250 fathoms) on Cruise 65-A-3. It is 11.0 mm high and 5.0 mm long. The distribution of this species (Abbott, 1954) is from Greenland to Puerto Rico and from Alaska to Mexico to depths of 1000 fathoms.

Family Astartidae.

Astarte nana Dall, 1886; fidé Parker, 1960.

(Plate IV, figures 10a, 10b)

Two live specimens of this species were found at Station 2 (200 fathoms) on Cruise 64-A-10. The shells were 8.0 mm in length, yellow, with twenty-five well-developed, evenly spaced concentric rings. The inside margin of the shell is marked by 40 to 50 small pits or crenulations. Dall (1886) found this species in Blake collections taken near the Florida reefs and in the West Indies at from six to 227 fathoms. Parker (1960) says that it is common along the northern Gulf coast from 50 to more than 100 fathoms, and he included it in his "upper continental slope assemblage."

Family Carditidae.

Venericardia armilla Dall, 1903; fidé Parker, 1960.

One live individual measuring 8.0 mm long and 9.0 mm in height was taken at Station 2 (200 fathoms) on Cruise 64-A-10. Johnson (1934) states that this species has been found from 24 to 196 fathoms between the Mississippi delta and Cedar Keys, Florida. Parker (1960, Plate VI, figures 14a, 14b) found this species common between 60 and 120 fathoms in the northwestern Gulf; he places this species in his "upper continental slope assemblage."

Family Corbulidae.

Corbula disparilis d'Orbigny, 1853; fidé Johnson, 1934.

(Plate IV, figures 14a, 14b, and 14c)

Two live specimens were taken at Station 2 (300 fathoms) on Cruise 64-A-13. They were both approximately 10.0 mm long, 9.0 mm high, and 9.0 mm thick. Dall (1881, p. 115; 1886, p. 314, Plate I, figures 4, 4a, and 4b) found this species at depths of from 50 to 450 fathoms in the Caribbean.

Family Nuculidae.

Nucula torresi Smith, 1885.

(Plate IV, figure 11)

One live specimen resembling this species was taken at Station 7 (2020 fathoms) and again at Station 10 (940-770 fathoms) on Cruise 64-A-10. They measured 3.5 mm and 4.5 mm in length, respectively. The yellow and glossy triangular shell has five anterior teeth and six posterior teeth. The Challenger (Smith, 1885) took this species in coral sand 135 fathoms deep at Cape York off northern Australia. This species has been taken by the Alaminos (Cruise 65-A-9, 25°32'N. x 86°00'W., 1707 fathoms) in the eastern Gulf of Mexico, and it evidently also enjoys a wide distribution on the abyssal plain of the Gulf of Mexico.

Family Nuculanidae.

Ledella messanensis messanensis (Seguenza), 1877; fidé Verrill and Bush, 1898.

(Plate VII, figures 9a, 9b)

Three live specimens were taken at Station 2 (1250 fathoms) on Cruise 65-A-3, and one live specimen was taken at Station 7 (2020 fathoms) on Cruise 64-A-10. This species has 13 anterior teeth and 20 posterior teeth. All the shells are about 10.0 mm long, 5.0 mm high, and 4.0 mm thick. According to Smith (1885), L. messanensis (Seguenza), 1877, is more sharply beaked than L. ultima Smith, 1885 (Sci. Res. Challenger Exp. XIII, p. 324, text figure), and it is larger than L. confinis Smith, 1885 (Sci. Res. Challenger Exp. XIII, p. 233, Plate XIX, figures 5, 5a). Verrill and Bush (1898) have separated this species into two subspecies. The one encountered in this study is L. messanensis messanensis (Seguenza) which has been found from Virginia to the West Indies at depths of 32 to 2620 fathoms (Johnson, 1934). L. messanensis sublevis Verrill and Bush has been found off Grand Banks to Virginia in 1188 to 2088 fathoms of water (Johnson, 1934). This species is also among those found in the eastern Gulf by the Alaminos (Cruise 65-A-9, 25°32'N. x 86°00'W., 1707 fathoms).

Anthozoan Coelenterates

Family Hormathiidae.

Two anemones were found attached to the root spicules of a species of *Hyalonema*, a glass sponge, at Station 7 (2020 fathoms) on Cruise 64-A-10. Charles E. Cutress of the U. S. National Museum has indicated that they are *Actinauge* sp. or *Hormathia* sp. A more specific identification is not possible because the nematocysts of the acontia are not preserved well enough.

Family Pennatulidae.

One specimen of a species belonging to this family was found at Station 10 (940-770 fathoms) on Cruise 64-A-10. A more specific identification could not be made because of the rapid deterioration of the specimen before it was preserved.

Pogonophora

Tubes and fragments of a species of Pogonophora were dredged up at Station 12 (425-395 fathoms) and also taken with the grab at the same station (472 fathoms) on Cruise 64-A-10. Only one anterior end was encountered, and this was without any tentacles it might have had. The tubes are less than 0.25 mm in diameter and some apparently complete tubes were as much as 100.0 mm long. The reddish-brown tubes are annulated by many small, white rings.

Polychaete Annelids

Most of the polychaetes found in this study were represented by single and often badly damaged specimens. The following list includes both those that were identified specifically with confidence and those which were not. In every dubious case the worm has been identified to family and/or genus, briefly described, and then sent to Dr. Meredith Jones, Curator-in-Charge of the Division of Worms of the U. S. National Museum. In some cases tentative specific diagnoses presented here may warrant change after further examination by Dr. Jones.

Family Onuphidae.

Hyalinoecia sp. "A"

(Plate I, figure 3)

Twelve individuals closely resembling H. branchiata Treadwell, 1934, were found at Station 5 (1200 fathoms), one was found at Station 7 (2020 fathoms), and six were taken at Station 9 (1600 fathoms); all were on Cruise 64-A-10.

Hyalinoecia sp. "B"

Two specimens of another species of this genus were taken by the grab at Station 2 (200 fathoms) on Cruise 64-A-10.

Rhamphobrachium agassizii Ehlers, 1887.

(Plate VII, figure 8)

Two specimens of this species were taken at Station 3

(420 fathoms) on Cruise 64-A-10. Ehlers (1887) reports that the Blake dredged this species off Carysfort Reef, Florida, off the Marquesas, and in the eastern Gulf of Mexico at depths of 333 to 539 fathoms. McIntosh (1900) reports that the Porcupine dredged up this species between 628 meters and 2165 meters in the North Atlantic and off the Azores.

Onuphis sp. "A"

(Plate VIII, figures 1 and 2)

A single specimen of this species was taken by the grab at Station 12 (472 fathoms) on Cruise 64-A-10, and again at Station 3 (420 fathoms) on the same cruise.

Onuphis sp. "B"

(Plate I, figure 7)

Another species of the genus Onuphis was found at Station 10 (965 fathoms) on Cruise 64-A-10.

Paronuphis sp.

(Plate II, figure 4)

Fragments of 49 individuals of this species were found in a dredge sample taken at Station 3 (420 fathoms) on Cruise 64-A-10. Dr. Meredith Jones has indicated that this belongs in the genus Paronuphis because of the absence of branchiae. This was set up as a subgenus by Ehlers (1887) specifically for Diopatra glutinatrix.

in tubes constructed with round Foraminifera.

Maldanid (?) sp. "D"

(Plate II, figures 7 and 7a)

A single specimen of an unidentified polychaete was taken by the grab at Station 2 (200 fathoms) on Cruise 64-A-10. It has been placed in the family Maldanidae on the basis of its prostomial plaque, apparent nuchal organs, and cone-shaped pygidium. The segments are also longer than they are wide. Dr. Meredith Jones of the U. S. National Museum has not yet seen the specimen, but he has examined drawings of it, and he indicated that he has not seen a maldanid with tentacles encircling its prostomial plaque. More proper placement of this species will have to wait for a decision from him.

Family Lumbrineridae.

Lumbrineris sp.

(Plate II, figures 8 and 8a)

A single fragment of a species of this genus was taken by the dredge at Station 12 (395-425 fathoms) on Cruise 64-A-10.

Family Cirratulidae (Plate II, figures 6 and 6a)

A fragment of a polychaete probably in this family was taken by the dredge at Station 12 (395-425 fathoms) on Cruise 64-A-10.

Porifera

Class Demospongiae.

Radiella sol Schmitt, 1870; fidé de Laubenfels, 1936.

(Plate III, figure 6)

One individual of a species of monaxonid sponge similar to the above species was dredged up at Station 10 (940-770 fathoms) on Cruise 64-A-10, and another specimen was taken at Station 2 (1250 fathoms) on Cruise 65-A-3. These, along with the other sponges yet to be mentioned, have been sent to Dr. Frank Little of the Allen Hancock Foundation for further study.

Fangophilina sp.

A small monaxonid sponge of the order Hadromerina and this genus was taken at Stations 5, 6, and 7; the depths were 1200, 1820, and 2020 fathoms, respectively. These oval-shaped sponges were from 5.0 to 10.0 mm in diameter.

Tisiphonia sp.

Another small species of monaxonid sponge of the order Hadromerina was found at the stations listed on Table III.

Class Hexactinellida.

Aphrocallistes ramosus Schulze, 1887.

Numerous fragments of this and possibly other species of Aphrocallistes were found at Station 6 (1800 fathoms) and Station 7

Table III

Occurrence of Tisiphonia sp.

Station	Cruise	No. of Indiv.	Depth
5	64-A-10	2	1200 fms
6	"	3	1800 fms
7	"	2	2020 fms
2	65-A-3	4	1250 fms (Dredge No. 1)
2	"	9	" (Dredge No. 2)
2	"	3	" (Dredge No. 3)

(2020 fathoms) on Cruise 64-A-10.

Hyalonema sp.

The root spicules of a species of *Hyalonema* were used by hormathiid anemones and a tubiculous polychaete as a substrate at Station 7 (2020 fathoms) on Cruise 64-A-10.

Echinodermata

Class Holothuroidea.

Sphaerothuria talismani Perrier, 1902; *fidé* Deichmann, 1954.

(Plate III, figure 7)

One specimen of this species was taken with the dredge at Station 10 (940-770 fathoms) on Cruise 64-A-10, and another specimen was taken at Station 12 (425-395 fathoms) on the same cruise.

Molpadia cubana Deichmann, 1940; *fidé* Deichmann, 1954.

(Plate V, figures 3 and 3a)

A single specimen of this species was taken at Station 2 (1250 fathoms) on Cruise 65-A-3. Deichmann (1954) indicated that this species has been found in the Gulf at depths of 13 to 210 fathoms, and that a single record of this species from 1440 fathoms should possibly be regarded as erroneous. The fact that it has again been found in relatively deep water refutes the limits she is putting on this organism's depth range.

Class Asteroidea (Plate VIII, figure 3).

A small, white starfish 7.5 mm in diameter was taken at Station 12 (472 fathoms) on Cruise 64-A-10.

Class Ophiuroidea (Plate V, figure 4)

A small ophiuroid measuring 7.5 mm in diameter was found at Station 11 (745 fathoms) on Cruise 64-A-10.

Echiurida

Echiurida sp.

The badly damaged fragments of a worm-like organism with many of the characteristics of the above phylum were found at Station 10 (965-940 fathoms) on Cruise 64-A-10.

CHAPTER V

MACRO-INVERTEBRATE REMNANTS

The remnants of many shelled organisms were encountered in this study, and it would be apropos to indicate here that little ecological significance should be attached to where the shells were found. The mass movement of sediment could have moved shells from one environment to another, or the migration of sea level could account for shallow water forms being in deep water. And if it is true that little ecological significance can be attached to the location in which shells are found, then the location of the shells that are found should reflect whether or not the phenomena mentioned occurred. An interpretation to this effect has been attempted in the final chapter of this thesis.

Scaphopod Mollusks

Nine species of scaphopods were found from 100 to 1500 fathoms. Henderson's monograph (1920) of the east American scaphopods proved to be invaluable in working with these specimens. All the shells collected fall into the genus _Dentalium_, and, for convenience in this study, they have been grouped into the subgenera presented by Henderson. Neither Parker (1960) nor Springer and Bullis (1956) mention scaphopods in their deep water bottom samples from the Gulf of Mexico.

Subgenus Laevidentalium.

Dentalium perlongum Dall, 1878; fidé Henderson 1920.

(Plate VII, figure 1)

One shell of this species was taken on Cruise 64-A-10 at Station 10. Its length and the diameters of its anterior and posterior cross-sections measured 55, 4, and 1 mm, respectively. The white shell is devoid of any sculpturing. Dall (1889) recored this species from depths ranging from 227 fathoms to 1,568 fathoms in the Yucatan Strait, the Gulf of Mexico, and also in the Caribbean. The temperature of the water at these stations ranged from 39° to 48.6° F.

Dentalium callipeplum Dall, 1889; fidé Henderson, 1920.

(Plate VII, figure 5)

One shell of this species was found in a dredge sample taken at Station 2 on Cruise 64-A-10. The depth was 200 fathoms. The specimen measured 30, 4, and 1 mm and it lacked sculpturing. Faint, transverse, grey lines on the smooth, white shell make it appear subtranslucent. Henderson (1920) indicated that this species has been found at 169 fathoms in grey mud between the Mississippi delta and Cedar Keys, Florida.

Dentalium liodon Pilsbry and Sharp, 1879; fidé Henderson, 1920.

One shell of this species was taken with the grab at Station 13 on Cruise 64-A-10. It measures 24, 2.5, and 1 mm. The bludsh white, subtranslucent shell is brilliantly polished. The only markings on the shell are transverse growth lines. This specimen lacks the "V" shaped notch that is often found in the tip of the shell of this species. The tip may be damaged, or, as Henderson (1920) says, the tip of this species can "be peculiarly variable," and, therefore, perhaps no notch was ever present on this particular shell. This species has been divided into two subspecies, D. liodon liodon Pilsbry and Sharp, and D. liodon alloschismum Pilsbry and Sharp. The former has an apical notch on the convex side and, in cross-section it is slightly dorso-ventrally compressed. In the latter subspecies the apical notch is on the concave side or is laterally placed, and the shell is circular in cross section. If only the shape of the cross section is used to separate subspecies, this specimen most closely fits D. liodon alloschismum, but because this separation is also contingent on the notch that is missing from the specimen studied, this investigator feels justified in following Henderson's suggestion and ignoring this subspecific separation. Henderson (1920) indicates that this species has been found at a depth of 80 fathoms off Bridgetown, Barbados, and off English Harbor, Antigua, in 200 fathoms of water.

Subgenus Antalis.

Dentalium bartletti Henderson, 1920

(Plate VII, figure 2)

At Station 10 on Cruise 64-A-10, two shells of this species were taken with the grab. This species is dorso-ventrally compressed. Ribs are indistinct at the tip, but 18 appear near the posterior third of the shell; an intercalation occurs near the anterior third and there are 24 ribs at the anterior end of the shell. A groove is present on the convex side of the tip. These white shells measured 25, 3.5, and 0.5 mm and 14, 2, and 0.5 mm. Henderson (1920) reports that this species has been found in 17 fathoms of water off Cape Fear, North Carolina, and at 539 fathoms northwest of Tortugas. The water temperature at the latter station was 39.5° F.

Subgenus Fissidentalium.

Dentalium meridionale Pilsbry and Sharp, 1897; fidé Henderson, 1920.

(Plate VII, figure 3)

Two shells and a fragment of this species were found in the dredge sample taken at Station 9 on Cruise 64-A-10. The two intact specimens measured 56, 9, and 2 mm and 44, 7, and 1.5 mm. They have a chalky texture with a grey outer layer covering a porcellanous portion. Faint, longitudinal riblets appear anteriorly in the grey layer. A short, irregular apical fissure on the convex side should be present in this species. The apices of these shells were evidently broken and the presence or absence of this diagnostic feature could not be determined. Henderson (1920) indicates that this species has been taken from a depth of 1,568 fathoms north of the Yucatan (Campeche) Bank.

Dentalium amphialum Watson, 1879; fidé Henderson, 1920.
(Plate VII, figure 7)

Two fragments and one complete shell of this species were taken at Station 9 and at Station 5, respectively, on Cruise 64-A-10. The single shell measured 33, 6, and 2 mm. Fifty fine, yellowish riblets run longitudinally along the dark brown shell of this species. The Challenger Expedition found this species near the La Plata River mouth at a depth of 1,900 fathoms. The bottom was "blue mud" and the water temperature was 33.1° F.

Subgenus Heteroschisma.

Dentalium callithrix Dall, 1889; fidé Henderson, 1920.
(Plate VII, figure 6)

Two shells of this species were found in the dredge sample taken at Station 9, and two shells and two shell fragments were taken at Station 10. The former shells measured 19, 2.7, and 0.75 mm and 28, 3, and 1.0 mm. The tip of this species has nine ribs; anteriorly an intercalation of these ribs occurs first by one and then by two more riblets. Hence, the anterior end displays three riblets between each pair of ribs. The shell is compressed laterally, and it has a long slit on the concave side of the tip. Most of the shells in this collection are in poor condition, and what appeared to be the remains of a slit could be seen in only one of the shells. The Blake took this species in 1,591 fathoms of water in the Yucatan Strait, in 200 fathoms of water off Bahia Honda, Cuba, and at 1,181 fathoms between the Mississippi delta and Cedar Keys, Florida.

Dentalium sp., fidé Henderson, 1920.

A shell measuring 23, 2.5, and 0.5 mm was taken in the grab at Station 12 on Cruise 64-A-10. It has nine primary ribs; the apex is round in cross section as is the anterior end. The tip has a laterally placed notch or wide slit. The primary ribs are doubled by intercalation, but it is impossible to determine the extent of the intercalation toward the anterior end. The shell is white and highly arcuate. Even though it cannot be identified specifically, it is evident from its nine primary ribs and its laterally placed notch that it belongs in the subgenus Heteroschisma.

Subgenus Compressidens.

Dentalium ophiodon Dall, 1881; fidé Henderson, 1920.

(Plate VII, figure 4)

One shell of this species measuring 17, 2.0, and 0.5 mm was found on Cruise 64-A-10 at Station 13. This species is white and glossy, but not highly polished. There is no apical slit, and only faint riblets mark the shell longitudinally. Transverse growth lines are present and they arch forward on the concave side. It is dorso-ventrally compressed. According to Henderson, most of the numerous specimens in the U. S. National Museum came from depths near 100 fathoms off southern Florida. One specimen came from 287 fathoms off Bahia Honda, Cuba.

Gastropod Mollusks

Ten species of gastropod mollusks were found at depths greater than 100 fathoms. Of these, seven species belonged to the family Turridae, a group commonly found in deep water. The species of turrids are extremely numerous and extremely difficult to define and classify (Smith, 1937). Harvey R. Bullis, Jr. (personal communication) has indicated that many new species of turrids have been described on the basis of very minute morphological differences, and, as a result, several months work at the U. S. National Museum would probably not bring success in identifying many species with confidence. This is especially true when specimens are not captured alive, and are therefore not available for the radula examinations so necessary for proper species diagnoses. In light of these opinions, this author submits these descriptions of the turrids with the reservations that a future revision of this group and/or more detailed work on better specimens from the Gulf of Mexico may indicate that some of the diagnoses presented in this section may be erroneous.

Family Turridae (Turritidae).

Mangilia oxytata Bush, 1885; fidé Smith, 1937.
(Plate III, figure 3)
Trans. Conn. Acad. Arts Sci. VI, p. 455, pl. 45.

A dead shell of this species measuring 8.0 x 3.0 mm was found at Station 10 (940-770 fathoms) on Cruise 64-A-10. Johnson (1934) reports that the U. S. Fish Commission steamer Albatross dredged this species at depths ranging from 14 to 51 fathoms off Cape Hatteras, North Carolina.

Mangilia pelagia (Dall), 1881; fidé Johnson, 1934.
(Plate IV, figure 5)

This shell containing a hermit crab was found at Station 10 (940-770 fathoms) on Cruise 64-A-10. It measures 18 x 6 mm. The Blake captured this species off Georgia in 440 fathoms of water and at a depth of 539 fathoms in the Gulf of Mexico (Johnson, 1934).

Mangilia bandella (Dall), 1881; fidé Johnson, 1934.
(Plate III, figure 1)

This shell, measuring 10.0 x 4.5 mm was taken at Station 2 (200 fathoms) on Cruise 64-A-10. It was taken in the Gulf of Mexico at

321 fathoms and off the east coast at depths of from 1200 to 2100 fathoms by the Albatross (Johnson, 1934).

Mangilia antonia (Dall), 1881; fidé Johnson, 1934.

(Plate IV, figure 2)

A shell of this species was taken by the dredge on Cruise 64-A-10 at Station 12 (425-395 fathoms). The Blake captured it off Cape San Antonio in 640 fathoms of water and near Guadelupe at a depth of 769 fathoms (Dall, 1881). The Albatross (Johnson, 1934) took this species off Fernandina, Florida, and in the Gulf of Mexico at 294 and 640 fathoms respectively.

Leucosyrinx sigsbeei (Dall), 1881; fidé Johnson, 1934.

(Plate IV, figure 3)

This shell was dredged up at Station 2 (300 fathoms) on Cruise 64-A-13, and it measured 22.0 x 10.0 mm. The Blake (Dall, 1881) took this species in the Caribbean off Bequia at 1,591 fathoms and in the Yucatan Strait at 640 fathoms.

Crassispira tampaensis Bartsch and Rehder, 1941; fidé Perry and Schwengel, 1955.

(Plate IV, figure 1)

A shell, very close to this species and definitely of this genus, was found at Station 2 (300 fathoms) on Cruise 64-A-13. It measured 33.0 x 7.0 mm. The only salient disparity between this shell and that described by Bartsch and Rehder is the absence of the sutural ridge in this shell. The type, U. S. N. M. No. 493409, was taken at Tampa Bay, Florida.

Turridae sp. (Plate IV, figure 4)

A badly worn turrid containing a hermit crab was taken at Station 6 (1800 fathoms) on Cruise 64-A-10. It measured 23 x 8 mm.

Family Atyidae.

Atys sandersoni Dall, 1881; fidé Abbott, 1954.

(Plate V, figure 6)

A shell of this species was taken at Station 2 (200 fathoms) on Cruise 64-A-10. It measured 6.5 x 5 mm. The Blake (Dall, 1886) dredged this species in the Atlantic and in the Gulf of Mexico at 805 and 450 fathoms, respectively.

Family Volutidae.

Aurina robusta (Dall) 1889; fidé Wagner and Abbott, 1964.

(Plate III, figure 4)

Two badly worn shells of this species measuring 19.0 x 8.0 mm and 45.0 x 15.0 mm were taken at Station 2 (200 fathoms) on Cruise 64-A-10. Wagner and Abbott (1964) indicate that this species is distributed in the Florida Strait and in the Gulf of Mexico. Dall (1889) found it in samples taken by the Blake off Havana at 119 fathoms and in the Gulf of Mexico at 280 fathoms.

Family Trochidae.

Solariella lamellosa Verrill and Smith, 1882; fidé Abbott, 1954.
(Plate IV, figure 2)

This top shell measuring 9.0 x 11.0 mm was found at Station 2 (300 fathoms) on Cruise 65-A-13. Johnson (1934) indicates that it has been found at 115 fathoms off Martha's Vineyard, between 15-32 fathoms off North Carolina, and at 100 fathoms off the Barbados. Abbott (1954) lists the distribution of this species as Massachusetts to Yucatan and the West Indies.

Pelecypod Mollusks

Family Nuculanidae.

Yoldia solenoides Dall, 1881; fidé Parker, 1960.

Three valves of this species were taken at Station 13 (100 fathoms) on Cruise 64-A-10. Parker (1960; Plave VI, figure 9) found this bivalve alive from 40 to 118 fathoms. These shells were 12.0 mm long and 6.0 mm high.

Nuculana carpenteri Dall, 1881; fidé Parker, 1960.

Parker (1960) considers this a member of the "upper continental slope assemblage." The data collected in this study agree; a dead shell was found at Station 2 (200 fathoms) on Cruise 64-A-10. It is 18.0 mm long and 5.5 mm high. There are 15 anterior teeth and 42 posterior teeth on this shell. Abbott (1954) states that it is common from North Carolina to the West Indies from 10 to 100 or more fathoms. The *Blake* (Dall, 1881) found it in from 100 to 287 fathoms off Barbados.

Ledella messanensis messanensis (Seguenza), 1877; *fidé* Verrill and Bush, 1898.

(Plate VII, figure 9)

One pair of valves of this species was taken at Station 7 (2020 fathoms) and four valves were taken at Station 6 (1800 fathoms) on Cruise 64-A-10.

Family Limopsidae.

Limopsis sulcata Verrill and Bush, 1898.

A pair of valves of this species were found at Station 10 (940-770 fathoms) on Cruise 64-A-10. It should be repeated that Parker (1960) includes this species in his "upper continental slope assemblage."

Family Arcidae.

Arca pteroessa Smith, 1885.

(Plate I, figure 6)

One valve of this species was found at Station 9 (1500 fathoms) on Cruise 64-A-10. It is 4.5 mm long.

Arca inaequisculpta Smith, 1885.

(Plate V, figure 5)

One shell of this species was taken on Cruise 64-A-13 at Station 2

(300 fathoms). The shell, 9.0 mm high and 10.0 mm long, has 17 teeth. This species was also found by the Challenger off Culebra Island, West Indies, according to Smith (1885). The water was 390 fathoms deep.

Arca transversa Say, 1821; fidé Perry and Schwengel, 1955.

(Plate IV, figures 12a and 12b)

Two valves of this species were found at Station 2 (200 fathoms) on Cruise 64-A-10. They measured 16.0 x 10.0 mm. Smith (1937) says that this species is often found off Nantucket and Martha's Vineyard, and also in the shallow water off western Florida.

Family Limidae.

Lima pellucida C. B. Adams; fidé Abbott, 1954.

Two valves of this species were taken at Station 13 (100 fathoms) on Cruise 64-A-10. The fragile, semi-translucent white shells are 5.0 mm long and 7.0 mm high. Abbott (1954) indicates that this species is distributed from North Carolina to both sides of Florida and the West Indies.

Family Astartidae.

Astarte nana Dall, 1886; fidé Parker, 1960.

(Plate IV, figures 10a and 10b)

Two valves of this species were found at Station 2 (200 fathoms), and three valves were found at Station 13 (100 fathoms) on Cruise 64-A-10.

Family Verticordiidae.

Verticordia fischeriana Dall, 1886; *fidé* Parker, 1960.

A left valve of this species was taken at Station 13 (100 fathoms) on Cruise 64-A-10. It measures 9.0 mm x 9.0 mm, and it has 28 small, finely beaded, radial ribs over its entire, subtriangular surface. Parker (1960, Plave VI, figures 17a, 17b) found it to be common on the upper continental slope and he put it in his "upper continental slope assemblage."

Family Carditidae.

Venericardia armilla Dall, 1903; *fidé* Parker, 1960.

Two valves of this species were found at Station 2 (200 fathoms) on Cruise 64-A-10.

Family Corbulidae.

Corbula disparilis d'Orbigny, 1853; *fidé* Johnson, 1934.

Two valves very similar to this species were found at Station 2 (300 fathoms) on Cruise 64-A-13.

Family Tellinidae.

Tellina sp.

(Plate IV, figure 13)

Two valves of a *Tellina* were found at Station 13 (100 fathoms) on Cruise 64-A-10.

CHAPTER VI

RESULTS AND CONCLUSIONS

General Considerations

The amount of sampling done in this study is so limited in view of the vast amount of area included that little if any statistical significance can be attached to the presented data. However, general trends in common with other deep-sea investigations are evident; the most obvious is the apparent decrease in the number of individuals and in the number of species as both the distance from land and the depth increase (Wolff, 1960). The data also suggest that the composition of the deep water fauna in the northwestern Gulf of Mexico differs in some respects from that found by other deep-sea investigations around the world. The numerous elasipod holothuroids and ophiuroids that have been listed (Wolff, 1960) as among the most common of the deep-sea forms of life, have not been found at the depp-water stations in this study. Their absence is difficult to explain. According to Menzies (1964) the type of sampling gear used plays a large part in the sizes and types of organisms that appear to inhabit a biotope, and perhaps the sampling devices used here missed these forms.

The area of the study where the "oxygen minimum" impinges against the sides of the Gulf basin appears to be inhabited by burrowing decapods, tube-dwelling polychaetes, and pogonophores. More motile organisms seem to be found above and below this zone. Similar data were noted by Parker (1964) and developed by Calvert (1964) for the Gulf of California. The oxygen minimum there is very pronounced (0.1 ml/1) and results in an azoic region which is not found in the Gulf of Mexico.

Thin veneers of diatomaceous ooze are preserved in the sediment in this azoic region in the Gulf of California without being disturbed, but both above and below this region the sediment has been thoroughly "mottled" by burrowing forms of invertebrates. Most of these burrowers appear to be deposit feeders, and would survive best in areas with little competition and sediments with a high organic content. Richards and Redfield (1954) state than an inverse relationship exists between the organic content of sediments and the dissolved oxygen content of the ambient water. The data they present, collected from the Gulf of Mexico, indicate that conditions prevail in the zone where the oxygen minimum impinges on the bottom that both supply organic matter and eliminate competition. But Richards and Redfield have no data on what portion of the organic material is utilizable by bacteria and animals. If much of it is utilizable, it is very interesting that Stephens (1963) has shown that many invertebrates can preferentially absorb utilizable organic compounds directly through their integuments. Therefore this author suggests that in this zone especially, the dissolved organic matter absorbed in this manner may be a major means of nourishment for many of the organisms.

Shell Deposits

The migration of the sea level is an accepted phenomenon that is well researched in this area (Parker, 1960), but it is of little direct significance to this study because sea level variations did not approach a magnitude of 100 fathoms. The mass movement of sediment by slumping is another matter. If it does occur it would seem most probable in the shallow regions of this study, i. e., from the outer margin of the continental shelf to depths near 300 or 400 fathoms, and also between the 900 and 1600 fathom isobaths where the depth may increase 100 fathoms in less than a mile. The gradient in both these areas is sometimes as great as 1:10, and the relatively level regions below these slopes would be the place to look for shell deposits resulting from slumping action. The difficulty with looking for evidence of slumping in this indirect manner is the general paucity of organisms in the deep water, alive or dead. It is noteworthy here to mention that shell material at Station 10 (940-770 fathoms) on Cruise 64-A-10 is very abundant for water of this depth, and some of the species are those commonly found on the upper continental slope (Parker, 1960). This could, perhaps, be the result of slumping initiated by sedimentation from the Rio Grande. Such slumping in this area could initiate a turbidity flow that would move from west to east across the abyssal plain.

Slumping

Moore and Bullis (1954) recorded a deep-water coral reef on the slope in the eastern Gulf of Mexico. Later attempts to find it were unsuccessful, and Bullis (personal communication) indicated that Precision Depth Recorder traces show that this coral reef may have been covered by a slump from shallower water. Therefore, the ubiquitous and essentially constant environment of the deep-sea that is so often referred to (Wolff, 1960) may be reflected in the deep water of the Gulf of Mexico by such factors as salinity and temperature, but what has been assumed to be a quiet environment of constant physical characters may in fact undergo cataclysmic changes as a result of mass movements of the sediment. There is evidence that wide-spread turbidity current action occurred in the Gulf during the late Pleistocent (Ewing et al., 1958), and, although turbidites representing turbidity flows of the present have not been recognized in cores from the Gulf (William R. Bryant, personal communication), the possibility of these occurring today should not be discounted. The ecological significance of these phenomena has been suggested by Heezen et al. (1955). The transport of sediment by slumping or a turbidity flow can move organic material and thus "fertilize" the new position, or the movement can have a smothering effect and eliminate some or much of the bottom fauna. In the Gulf such sediment movements may have had, and still may have, both effects. The presence of pogonophores is evidence that the bottom is rich in nutrient material (Kirkegaard, 1956), and the absence of the elasipod holothuroids and ophiuroids could be related to the smothering effect of sediment movement. It is noteworthy then that there is an increase in the number of live organisms from Station 8, east to Station 7, and then to Station 6 on Cruise 64-A-10. This may reflect a lessening of the smothering effect referred to by Heezen et al. (1955) as the distance from the apex of the conjectured turbidity current increases.

Recurrent Groups

At depths less than about 1000 fathoms the rapidly changing bathymetry, oxygen concentration, and temperature have evidently eliminated the establishment of recurrent groups that could be recognizable from the small amount of sampling that has been done in this study. Below 1000 fathoms the lack of variation in the environment has apparently given rise to a group of organisms that have recurred with some degree of consistency, and, although statistically defined communities cannot be described in the usual manner, it is the judgment of the author that this group probably prevails in numbers on the abyssal plain of the entire Gulf of Mexico. This assemblage includes the following:

Brachiopoda

Chlidonophora incerta

Porifera

Radiella sol

Tisiphonia sp.

Fangophilina sp.

Molluska

Nucula torresi

Ledella messanensis messanensis

Annelida

Hyalinoecia sp. "A"

This prediction is supported by the fact that all the above species were taken from the abyssal plain of the eastern Gulf of Mexico by the *Alaminos* (Cruise 65-A-9). Further sampling throughout the Gulf with a wide variety of sampling devices will no doubt procure many more species, but it is likely that these will remain among the most numerous of those taken on the abyssal plain.

TABLE IV

LIST OF SPECIES BY STATION

Cruise 64-A-10

Station 2.

6/22/64; Grab; 200 fathoms; 93°43'W. x 27°40'N.
Five live individuals; four live species.

2 *Hyalinoecia* sp. "B"
1 Maldanid sp. "A"
1 Incertae sedis (Anomura, Decapoda)
1 Axiidae sp.

Grab No. 2
Three live individuals; three live species.

1 *Nephtys* sp.
1 *Callianassa* sp.
1 *Limopsis antillensis*

Dredge, Meter-1250 turns.
Seven live individuals, five live species.

2 *Astarte nana*
2 *Venericardia armilla*
1 *Munidopsis cylindrophthalma*
1 Maldanid sp. "A"
1 *Lyreidus bairdii*

Remnants: 2 *Aurinia robusta* shells, 1 *Nuculana carpenteri* valve, 1 *Dentalium callipeplum* shell.

Station 3.

6/22/64; Dredge, Meters-1073 and 1361 turns; 420 fathoms;
93°39'W. x 27°15'N.
61 live individuals, 8 live species.

49 Paronuphis sp.
1 Onuphis sp. "A"
6 Amage tumida
1 Psammolyce occidentalis
1 Rhamphobrachium agassizii
1 Spaerothuria talismani
1 Munida pusilla
1 Polynoëlla pachylepsis

Station 5.

6/23/64; Dredge, Meters-1857 & 1970; 1200 fathoms;
92°44'W. x 26°00'N.
16 live individuals, 4 live species.

1 Paguridae sp. "A"
12 Hyalinoecia sp "X"
2 Tisiphonia sp.
1 Fangophilina sp.

Remnants: 1 Dentalium amphilialum, 1 Dentalium bartletti, 1 Janthina janthina.

Station 6.

6/24/64; Dredge, Meters-1863 & 1502; 1820 fathoms;
92°23'W. x 25°13'N.
21 live individuals, 6 live species.

1 Paguridae sp.
14 Chlidonophora incerta
1 Arca pteroessa
1 Fangophilina sp.
3 Tisiphonia sp.
1 Incertae sedis (Polychaeta)

Remnants: 4 valves of _Ledella messanensis messanensis_,
1 Turridae sp.

Grab; 1800 fathoms.
0 live individuals, 0 live species.

Remnants: 4 valves of _Chlidonophora incerta_.

Station 7.

6/25/64; Dredge, Meters-2682 & 3565; 2020 fathoms;
$94^{o}00'W. \times 25^{o}13'N.$
Ten live individuals, seven live species.

1 _Ledella messanensis messanensis_
1 _Hyalinoecia_ sp. "A"
1 _Radiella sol_
2 _Fangophilina_ sp.
1 _Tisiphonia_ sp.
2 _Chlidonophora incerta_
2 Anemones (Hormathiidae)

Remnants: _Hyalonema_ sp. spicules.

Grab (Station 7 - cont'd)
Four live individuals, two live species.

1 _Nucula torresi_
3 _Hyalinoecia_ sp. "B"

Remnants: _Chlidonophora incerta_ shell fragments close to dissolving, hyaline worm tubes, 1 small urchin test (Echinoidea, Echinodermata)

Station 8.

6/26/64; Dredge, Meter-1231 & _____; 1920 fathoms;
$94^{o}48'W. \times 25^{o}02'N.$
One live individual, one live species.

1 Polychaete sp.

Remnants: *Hyalonema* sp. fragments, 3 hyaline worm tubes, 1 hyaline, annulated worm tube.

Station 9.

6/26/64; Dredge, Meters-1591 & 1598; 1500 fathoms; 95°05'W. x 25°21'N.
Six live individuals, one live species.

1 *Hyalinoecia* sp. "A"
5 Maldanidae sp. "C"

Remnants: 1 *Dentalium meridionale* shell, 1 *Dentalium amphialum* shell, 1 *Dentalium callithrix* shell.

Station 10.

6/27/64; Grab; 965-940 fathoms; 94°30'W. x 25°30'N.
Two live individuals, two live species.

1 *Onuphis* sp. "A"
1 Echiurida sp.

Remnants: 1 *Dentalium perlongum* shell, 1 *Dentalium bartletti* shell.

Dredge, Meters-1726 & 2426.
22 live individuals, 9 live species.

1 *Neotanias serratispinosus*
1 Pennatulidae sp.
1 *Radiella sol*
6 *Amage tumida*
9 *Hyalinoecia* sp. "A"
1 Paguridae sp.
1 *Nucula torresi*
1 *Limopsis sulcata*
1 *Sphaerothuria talismani*

Remnants: _Solariella lamellosa_, _Dentalium callithrix_, _Limopsis sulcata_, _Mangilia oxytata_, _Mangilia pelagia_ (one shell of each).

Station 11.

6/27/64; Grab; 745 fathoms; 95°31'W. x 25°27'N.
One live individual, one live species.

1 Ophiuroidea sp.

Station 12.

6/28/64; Grab; 472 fathoms; 95°55'W. x 27°30'N.
Four live individuals, four live species.

1 Pogonophora sp.
1 _Onuphis_ sp. "A"
1 Maldanidae sp. "B"
1 Asteroidea sp.

Dredge, Meters-227 & 293; 425-395 fathoms.
Four live individuals, four live species.

1 _Sphaerothuria talismani_
1 Pogonophora sp.
1 Cirratulidae sp.
1 _Lumbrineris_ sp.

Remnants: 1 _Dentalium_ sp. shell, 1 _Mangilia antonia_ shell.

Station 13.

6/28/64; Grab; 100 fathoms; 94°56'W. x 27°52'N.
Two live individuals, one live species.

2 _Venericardia armilla_

Remnants: 1 _Lima pellucida_ valve, 17 _Microcardium peramabile_ valves, 28 _Venericardia armilla_ valves, 3 _Yoldia solenoides_ valves, 2 _Astarte nana_ valves, 1 _Verticordia fischeriana_ valve.

Cruise 64-A-13

Station 2.

11/3/64; Dredge, Meters-8660 & 8951; 93°00'W. x 26°36'N.
14 live individuals, three live species.

2 *Corbula disparilis*
11 *Bathyplax typhla*
1 *Munida iris*

Remnants: 1 *Solariella lamellosa* shell, 1 *Leucosyrinx sigsbeei* shell, 2 *Tellina* sp. valves, 2 valves of *Arca inaequisculpta*, 1 *Crassispira tampaensis* shell.

Cruise 65-A-3

Station 2.

3/7/65; Dredge No. 1, Meter-36; 94°57'W. x 26°16'N.
Nine live individuals, four live species.

1 *Radiella sol*
3 *Chlidonophora incerta*
1 Paguridae sp.
4 *Tisiphonia* sp.

Dredge No. 2, Meter - 139
24 live individuals, three live species.

9 Tisiphonia sp.
13 Chlidonophora incerta
2 Ledella messanensis messanensis

Dredge No. 3, Meters - 510
10 live individuals, five live species.

3 Tisiphonia sp.
3 Chlidonophora incerta
2 Ledella messanensis messanensis
1 Limatula subauriculata
1 Molpadia cubana

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Plate I

1. *Psammolyce occidentalis*, ventral view.

2. Paguridae sp.

3. *Hyalinoecia* sp. "A," dorsal and ventral views, respectively.

4. *Polynoëlla pachylepsis*, dorsal view.

5. *Nephtys* sp., dorsal view.

6. *Chlidonophora incerta* with *Arca pteroessa*.

7. Onuphis sp. "B."

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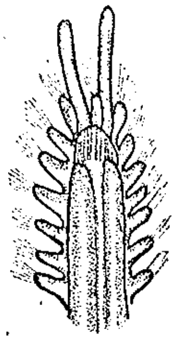

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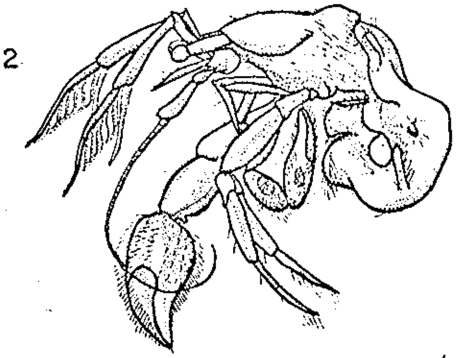

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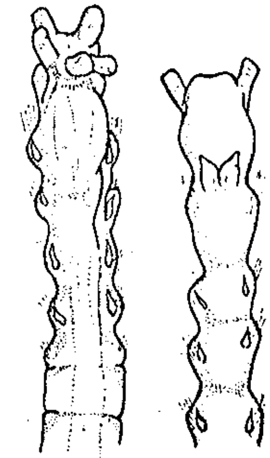

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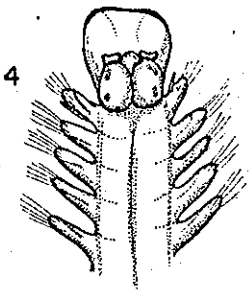

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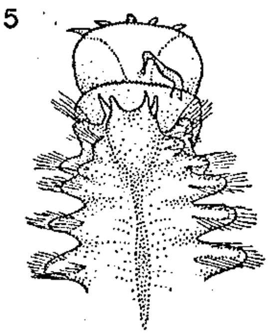

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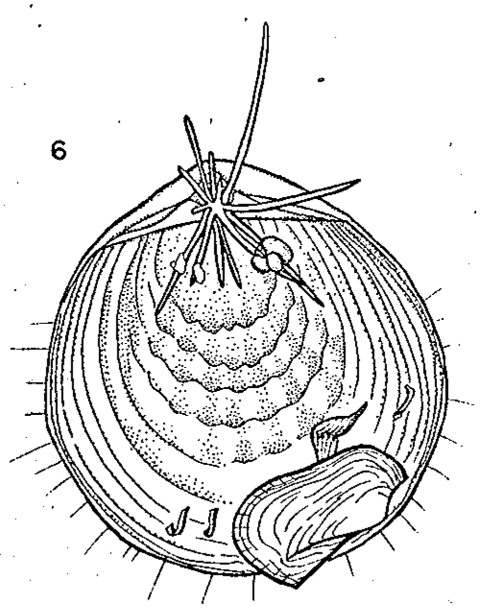

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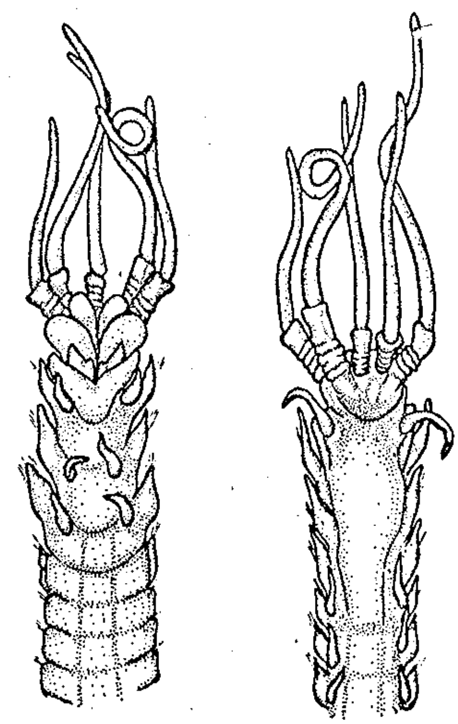

Plate II

1. Axiidae sp.

2. *Neotanias serratispinosus*.

3. *Munidopsis cylindrophthalma*, ventral and dorsal views, respectively.

4. *Paronuphis* sp.

5. *Munida pusilla*.

6. Cirratulidae sp.
   a. Fourth setiger.

7. Maldanidae sp. "D" prostomium.
   a. Pygidium

8. Lumbrineris sp.
   a. Third setiger.

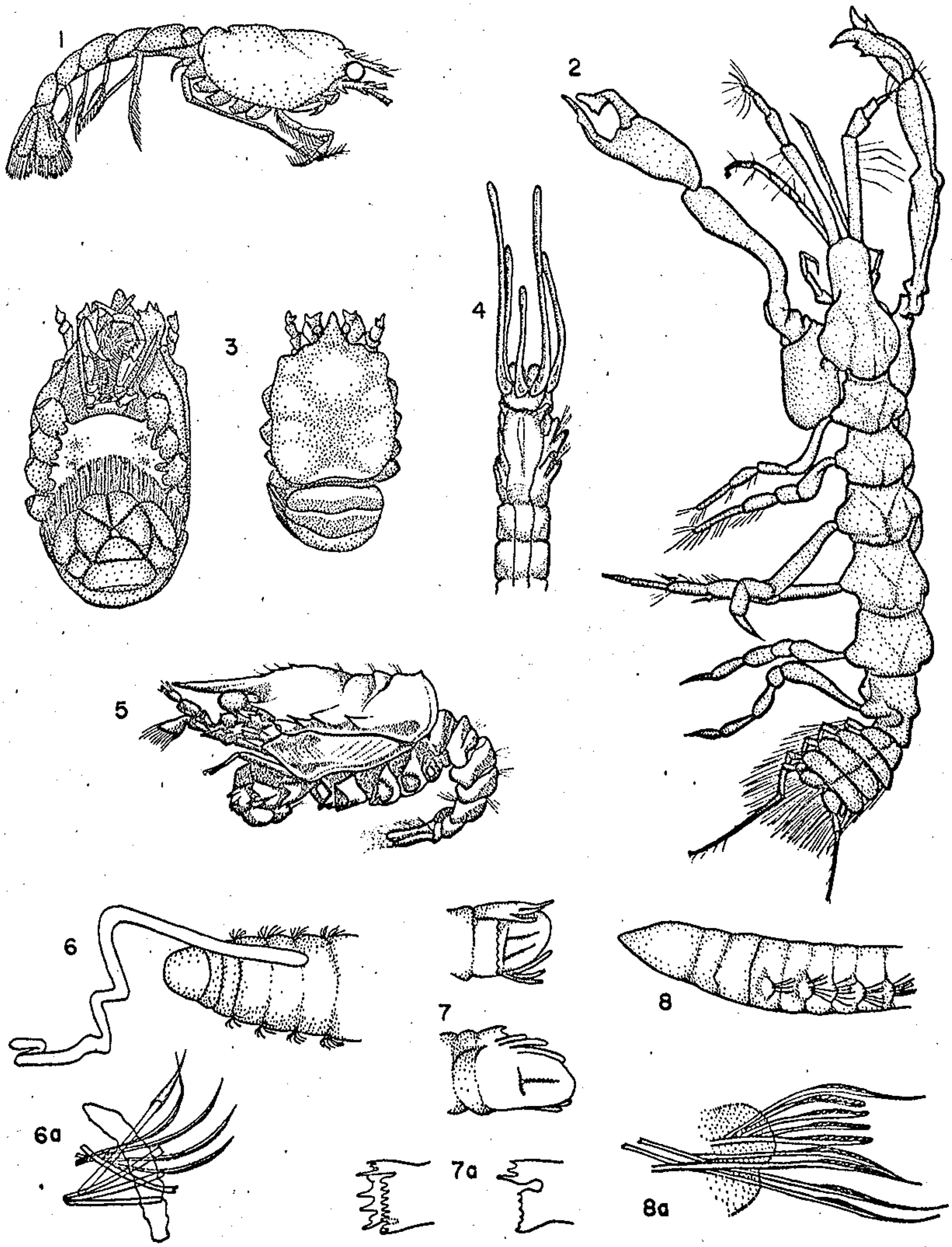
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Plate III

1. *Amage tumida.*
2. Polychaete sp. "A."
3. Maldanidae sp. "A."
4. *Callianassa* sp.
5. *Incertae sedis* (Anomura, Decapoda).
6. *Radiella sol.*
7. *Sphaerothuria talismani.* 15 mm.
8. Maldanidae sp. "C."

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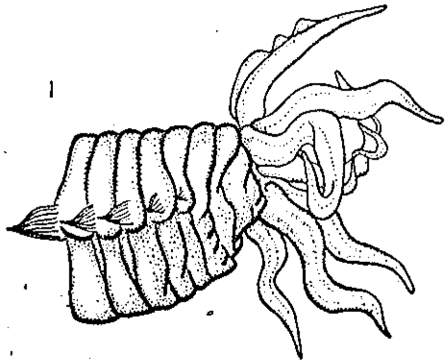

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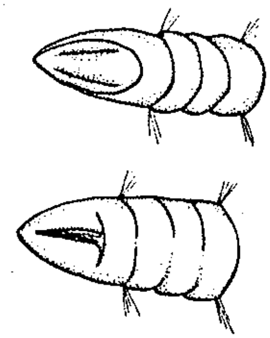

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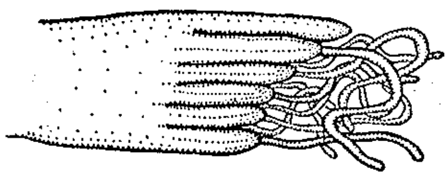

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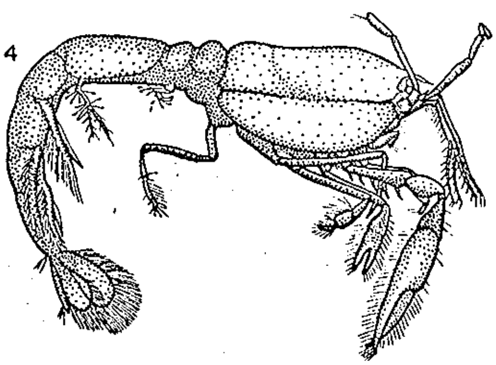

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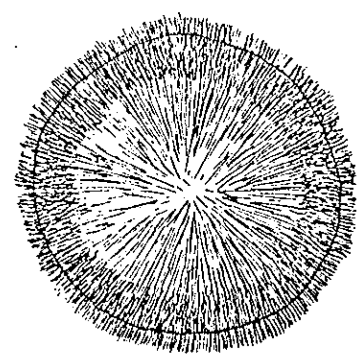

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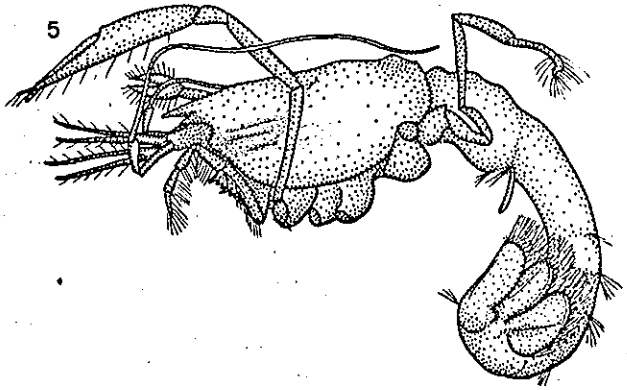

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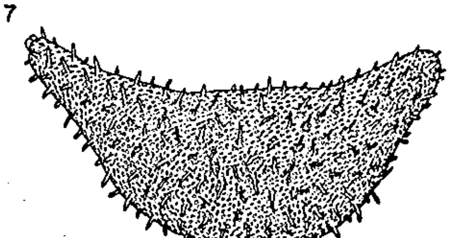


Plate IV

1. *Mangilia bandella*, 10 x 4.5 mm.

2. *Mangilia antonia*, 13 x 5 mm.

3. *Mangilia oxytata*, 8 x 3 mm.

4. *Aurinia robusta*, 19 x 8 mm.

5. *Mangilia pelagia*, 18 x 6 mm.

6. *Crassispira tampoensis*, 22 x 7 mm.

7. *Solariella lamellosa*, 11 x 9 mm.

8. *Leucosyrinx sigsbeei*, 22 x 10 mm.

9. Turridae sp. 23 x 8 mm.

10a. *Astarte nana*.

10b. *Astarte nana*.

11. *Nucula torresi*.

12a. *Arca transversa*, internal view.

12b. *Arca transversa*, external view.

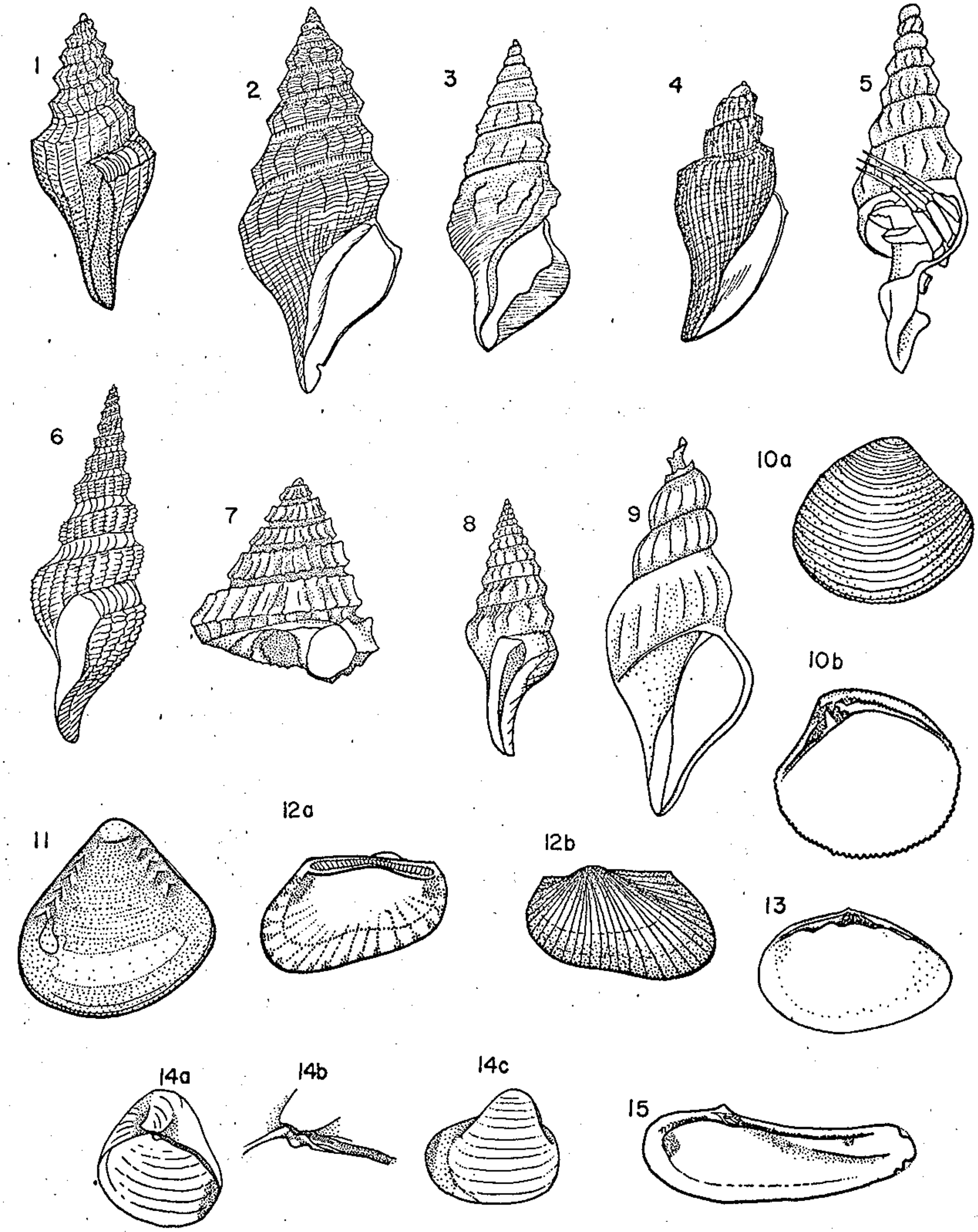
13. *Tellina* sp., 20 x 12 mm.

14a. *Corbula disparilis*.

14b. *Corbula disparilis* umbo, ligament and tooth.

14c. *Corbula disparilis*.

15. *Nuculana carpenteri*.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12a
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14a
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14c
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Plate V

1. Menzies dredge, net - 1 meter wide and 3 meters long.

2. Pequegnat dredge, net - 1 meter wide and 2 meters long.

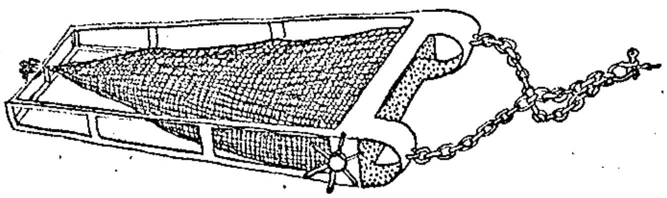
3. Molpadia cubana, 20 mm long.

    a. Three-pillared tables (spicules) of Molpadia cubana

4. Ophiuroidea sp., 7.5 mm in diameter.

5. Arca inaequisculpta, 10 x 9 mm, 17 teeth.

6. Atys sandersoni, 6.5 x 5 mm.



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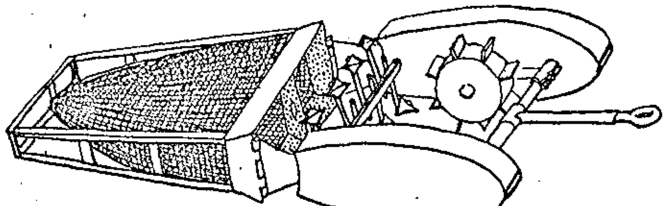

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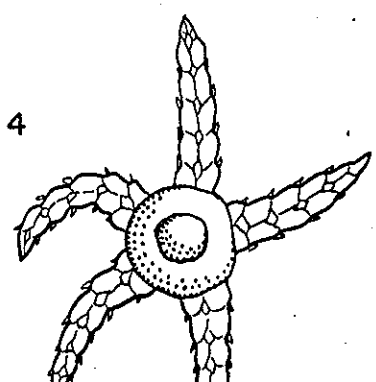

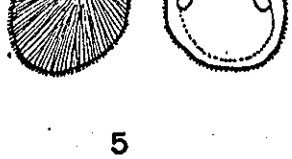

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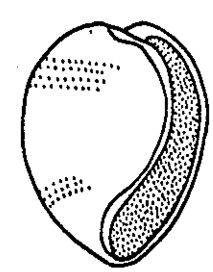

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Plate VI

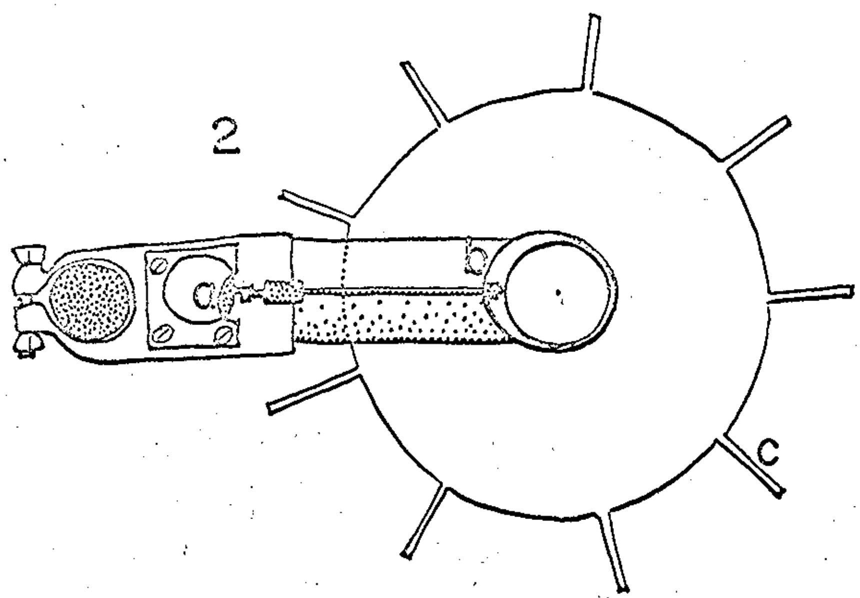
1. Metering Device - Menzies dredge.

    a. Counter
    b. Eccentric
    c. Spoke

2. Metering Device - Pequegnat dredge.

    a. Counter
    b. Eccentric
    c. Paddle blade

2



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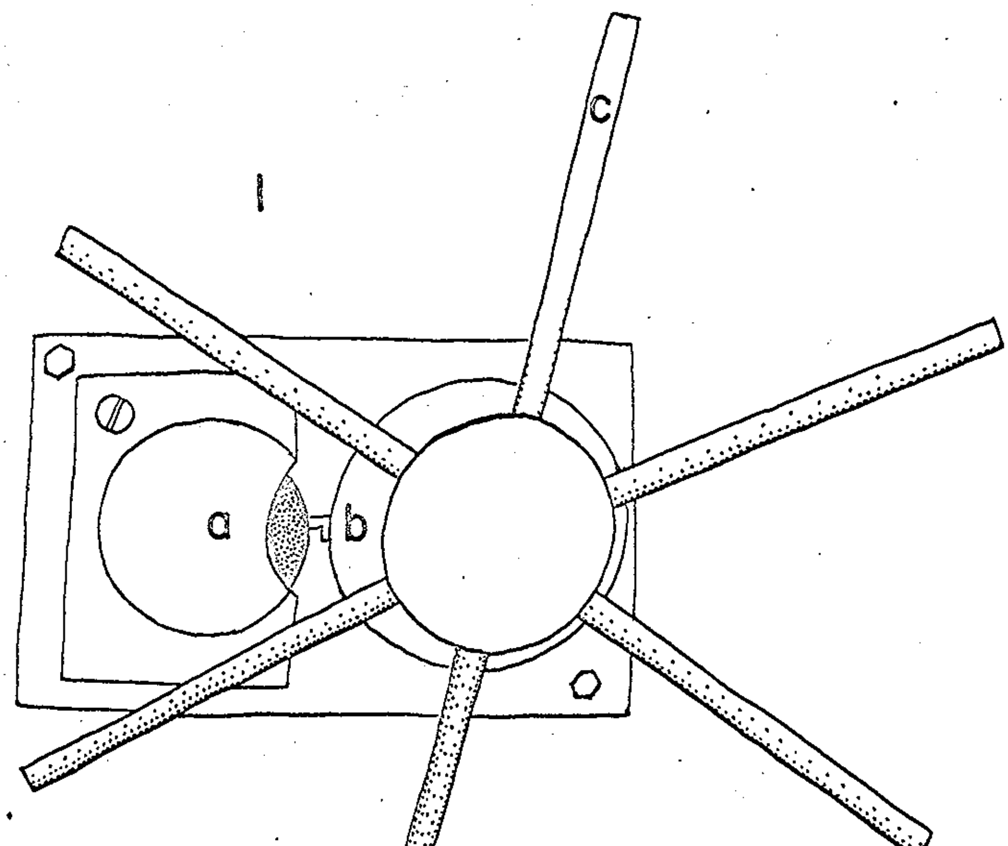

Plate VII

1. *Dentalium perlongum*, 55 x 4 x 1 mm.

2. *Dentalium bartletti*, 24 x 3.5 x 0.5 mm.

3. *Dentalium meridionale*, 56 x 9 x 2 mm.

4. *Dentalium ophiodon*, 17 x 2 x 0.5 mm.

5. *Dentalium callipeplum*, 30 x 4 x 1 mm.

6. *Dentalium callithrix*, 19 x 2.7 x 0.75 mm.

7. *Dentalium amphialum*, 33 x 6 x 2 mm.

8. *Rhamphobrachium agassizii*.

9. *Ledella messanensis messanensis*, 10 x 5 mm.

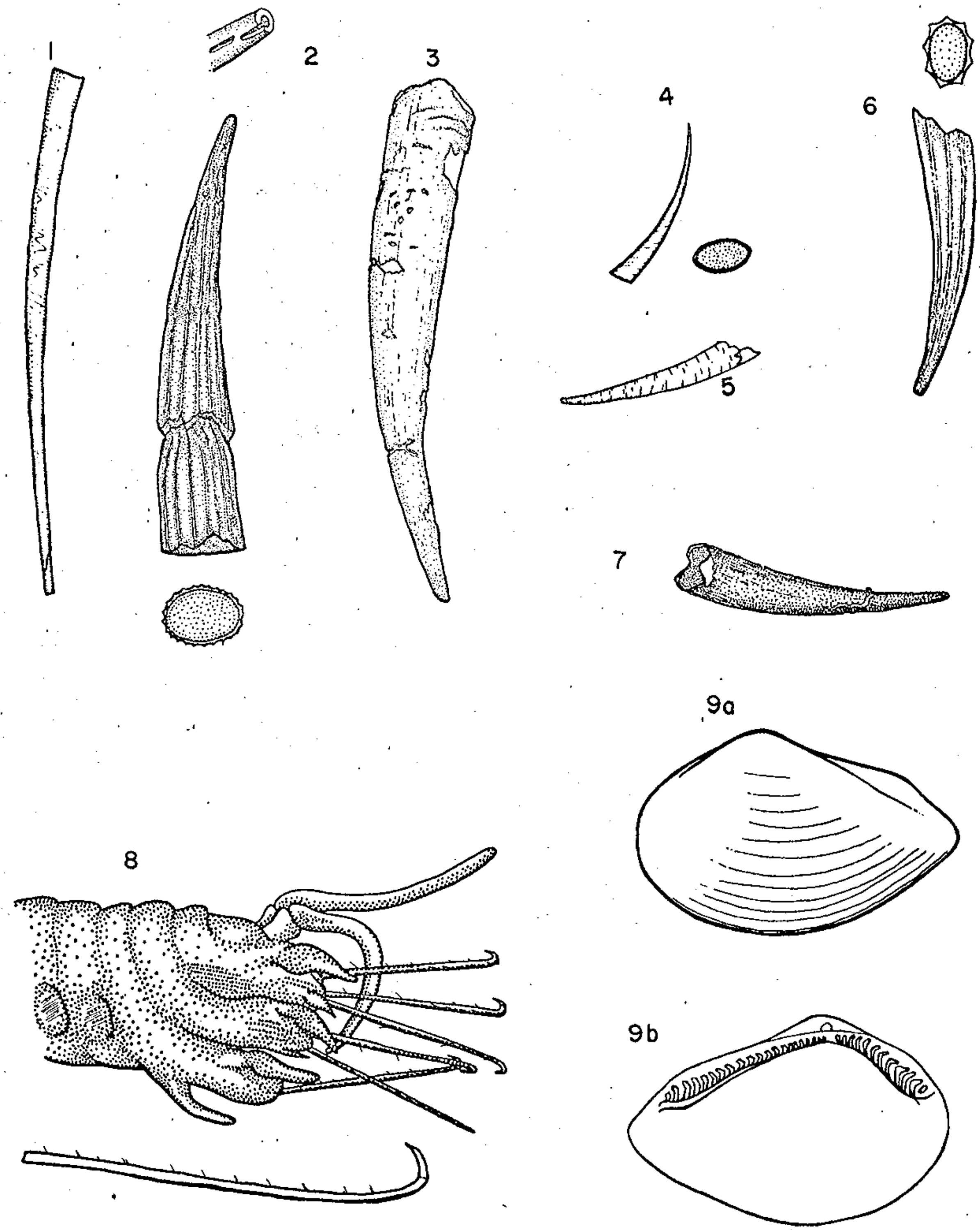
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Plate VIII

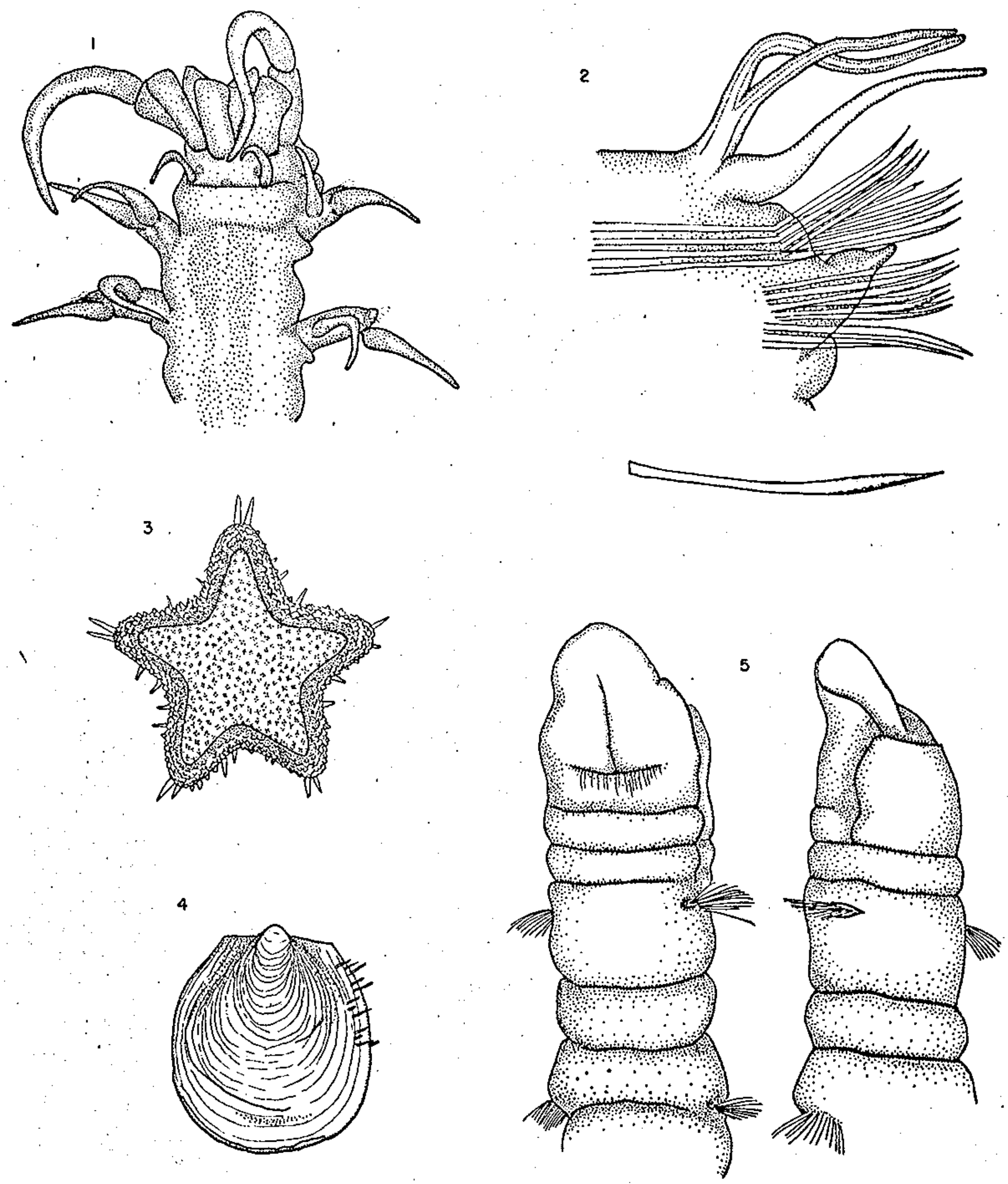
1. *Onuphis* sp. "A."

2. *Onuphis* sp. "A," 13th parapodium, with setae and a single seta below.

3. Asteroidea sp., 7.5 mm in diameter.

4. *Limopsis antillensis*, 4 x 3 mm.

5. Maldanidae sp. "B."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APPENDIX

BOTTOM METER DATA

Cruise 64-A-10

Station	Revolutions	Depth
1	1490 & 2210	20 fms
2	1250 & ____	200 fms
3	1073 & 1361	423 fms
5	1857 & 1970=	1200 fms
6		
6	868 & 1502	1850 fms
7	2882 & 3656	2000 fms
8	1231 & ____	1920 fms
9	1591 & 1598	1500 fms
10	1726 & 2426	750 fms
12	0227 & 0293	435 fms
13	3128 & 2109	96 fms - 60 fms
14	0846 & 0660	20 fms
15	0149 & ____	10 fms

Cruise 64-A-10

Station	Revolutions	Depth
1	7200 & 7224	75 fms
3	Bag tangled, no sample	990 fms
2	Bag tangled Meters=8660 & 8951	300 fms

Cruise 65-A-3-I

I	0004	445 fms
II (1)	0036	1250 fms
(2)	0139	1250 fms
(3)	0510	1250 fms
III	0103	1845 fms
IV	0250	1900 fms
V	1158	392 fms
VI	——	140 fms
VII	——	60 fms