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MACRO-INVERTEBRATE ASSEMBLAGES AS INDICATORS OF SEDIMENTARY ENVIRONMENTS IN EAST MISSISSIPPI DELTA REGION[1]

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ABSTRACT

As a result of a study based on three years of biological sampling in the east Mississippi Delta region, eight macro-invertebrate assemblages are recognized, each characteristic of a specific sedimentary environment ranging from the Mississippi Delta marshes to the edge of the continental shelf northeast of the Delta proper. The eight assemblages and their corresponding environments are: (I) the delta marshes, (II) delta front and lower distributaries, (III) lower Breton Sound and lower pro-delta clayey slopes, (IV) upper Breton Sound, (V) inlets, or areas of strong currents, (VI) the shallow continental shelf of the Gulf of Mexico from 0 to 12 fathoms, (VII) the deeper part of the continental shelf from approximately 13 fathoms to 60 fathoms, and (VIII) the living oyster reefs of the shallow protected bays of the Delta region. The boundaries of these environments were established by plotting the distributions of both living and dead representatives of species of invertebrates furnishing hard parts plus the distributions of living soft-bodied animals which were so abundant as to characterize regions where animals with hard parts were scarce though present.

Comparison of the distribution of the hydrographic factors with the physiography of the landmasses in this area with the macro-organism distributions made it possible to formulate criteria for the interpretation of ancient environments as far back as the Miocene on the Gulf and Atlantic coasts. Paleontologic literature shows that most of the present-day delta species have been found in the Pliocene, and most of the diagnostic forms have existed since the lower Miocene. The primary factors influencing distributions of these organisms are bottom type, salinity and temperature (especially the degree of variability), turbidity of the water, and currents. It was also found that comparative rates of deposition could be estimated by the ratio of the number of living to the number of dead, in equal-size samples. A series of marine bottom communities based on the community concept of European marine ecologists is recognized on the basis of the most abundant and widespread animals.

INTRODUCTION

This paper describes one of a series of studies of nearshore sedimentary environments in the northern Gulf of Mexico, supported by the American Petroleum Institute as Project 51, at Scripps Institution of Oceanography under the direction of Francis P. Shepard. The study was made on the east side of the Mississippi Delta in Breton Sound and beyond in the open Gulf of Mexico from the shore to approximately the 90-fathom contour (Figs. 1 and 2). The work was begun in October, 1951; biological collections and observations were made during the fall and early winter of 1951, the spring and early summer of 1952, and the last week of May and first week of June, 1953. Bottom-sediment samples for mechanical analysis yielding biological information were also obtained in the fall of 1953 and in February, 1954. Biological collections were made at more than 280 stations, and in addition 130 bottom-sediment sampling sites provided some biological data. Two maps (Figs. 3 and 4) show the locations of all stations providing biological data. Positions for most of the inshore biological stations were

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located by the use of horizontal sextant angles; the offshore stations were made by dead reckoning and are, therefore, approximate.

Acknowledgments.—For assistance in preparing the manuscript and for helpful suggestions on many aspects of this problem, the writer thanks Joel W. Hedgpeth of the Scripps Institution of Oceanography. Thanks are also due to Robert L. Miller of the University of Chicago for suggesting various methods of analyzing the field data and presenting it in statistical form. The writer is particularly grateful to Miss Joan Demond, formerly with this Project, for her assistance in identifying and establishing the synonomy of the mollusks (to be published

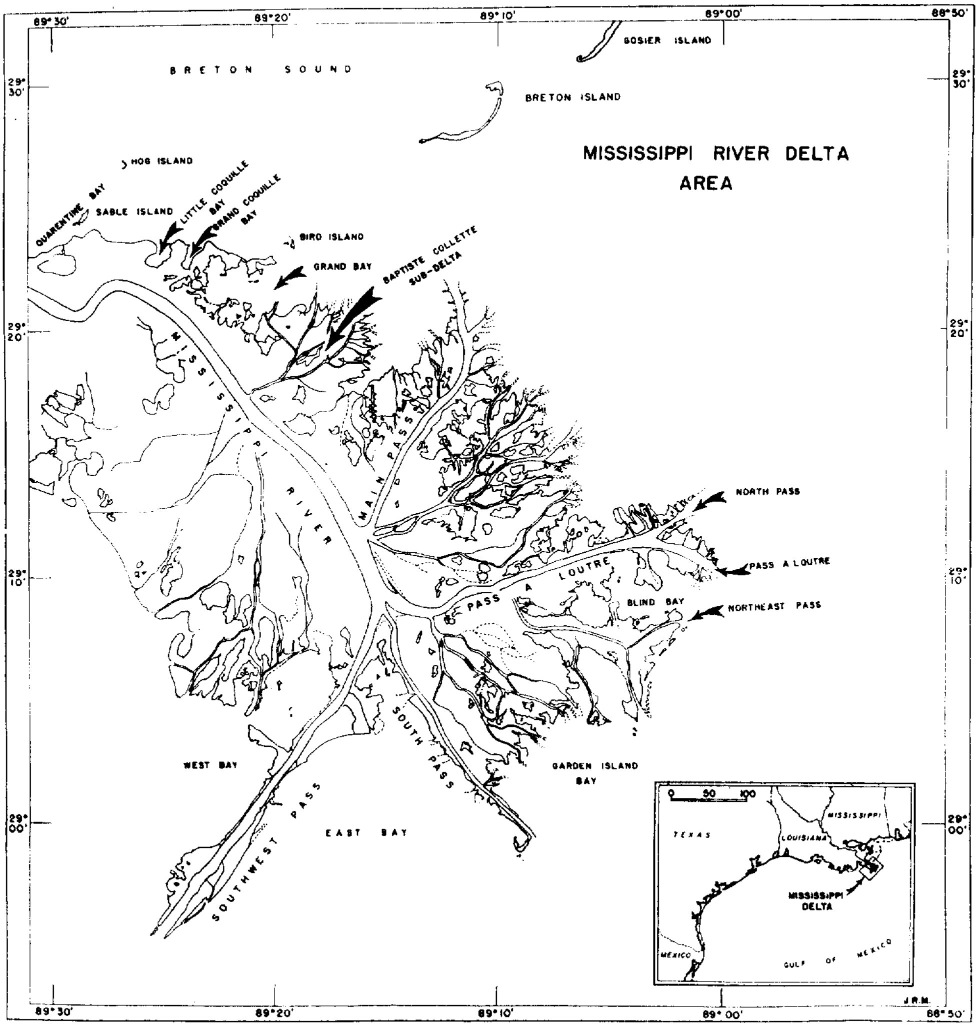


FIG. 1.—General map and place names of east Mississippi Delta region.

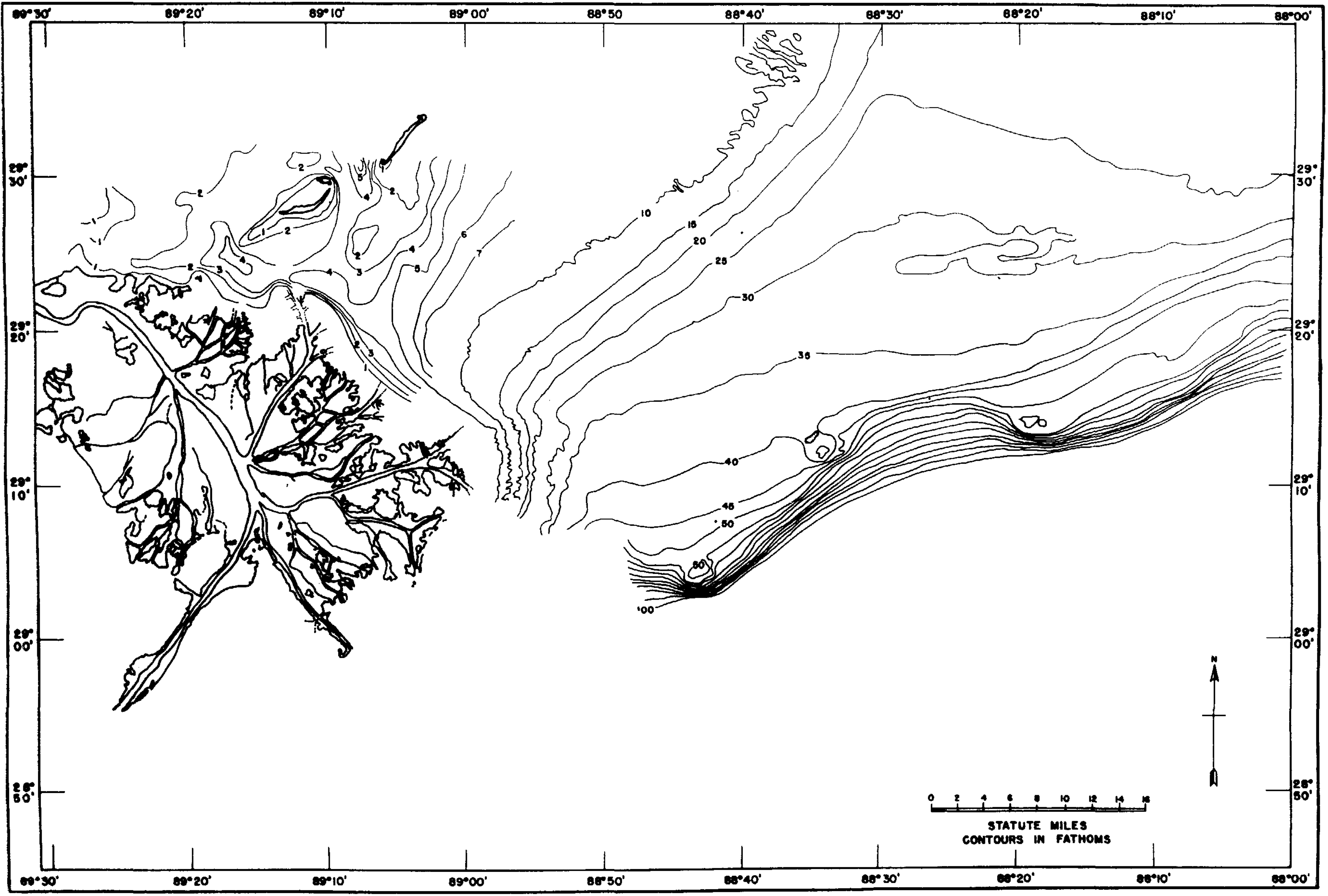


FIG. 2.—Offshore bottom contours of east Mississippi Delta area.

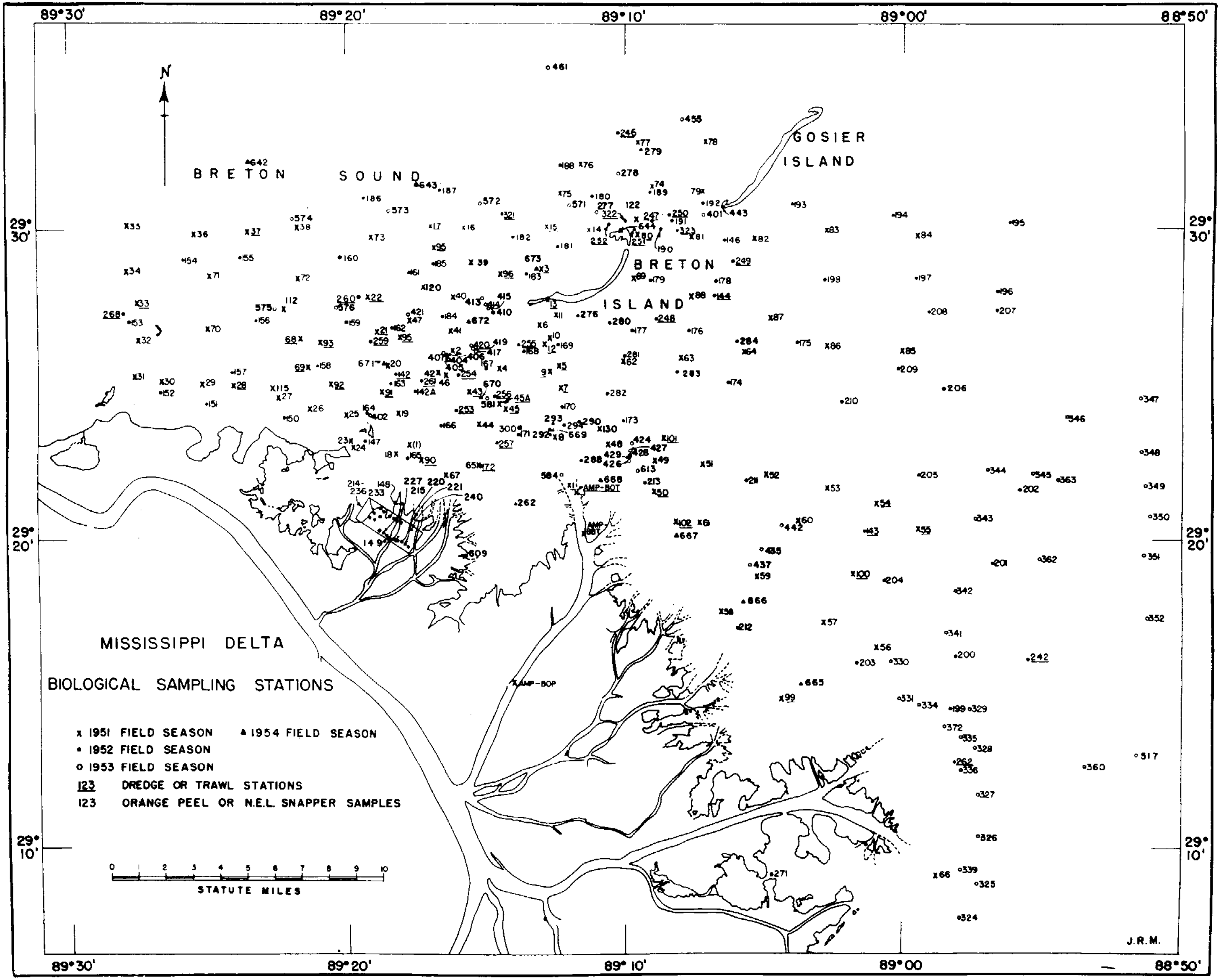


FIG. 3.—Station locations of biological samples taken from 1951 to 1954 in inshore Mississippi Delta region.

separately); and also to Thomas E. Pulley of the University of Houston who identified many of the pelecypods. He also thanks Harald A. Rehder and Joseph P. E. Morrison of the Division of Mollusks, United States National Museum, and R. Tucker Abbott of the Philadelphia Academy of Natural Sciences, for help in identifying many of the mollusks, and William K. Emerson of the American Museum of Natural History for identification of the scaphopods. Appreciation is also extended to J. Wyatt Durham and Elton L. Puffer of the Museum of Paleontology at Berkeley for identification of the echinoderms and corals and for furnishing some of the photographs used in the faunal plates; and to Donald J. Reish of the Allan Hancock Foundation, University of Southern California, for identification of the polychaete worms. James R. Moriarty of the Geology Division at Scripps prepared the charts and illustrations in this paper, and Thomas E. Mahnken made most of the photographs.

Previous work.—With the exceptions of various collections of mollusks (Vanatta, 1903; Clench, 1929; Hadley, 1936; Richards, 1954), there has been little investigation of the bottom fauna of this area before or since the preliminary survey of the clam and scallop beds in the vicinity of the Chandeleur Islands and Breton Island by Spaulding (1906), and the faunistic surveys by Cary (1905) and Cary and Spaulding (1909). Many of the species of mollusks collected during the present investigation were previously recorded only in Dall's monographs (1886, 1889) on the collections near the Mississippi Delta by the *Blake* and the *Albatross*. Rehder and Abbott (1951) described several species of mollusks which were also taken near the Mississippi Delta in the same localities where project collections were made, and Richards (1954) listed many of the Delta mollusks from borings made in the region now being studied. A general history of investigations in the Gulf of Mexico may be found in Galtsoff *et al.* (1954, pp. 25–32, 203–13).

GENERAL DESCRIPTION OF AREA

The principal physiographic features of this area (Fig. 1) are the low delta plain of the Mississippi River with its active distributaries which empty into Breton Sound or directly into the Gulf of Mexico, and the small barrier islands (Breton and Gosier), which lie about 6 miles offshore. Wide inlets have formed between Breton Island and the shores of the Delta and between Breton and Gosier islands. Both of these inlets are 26–45 feet deep and are characterized by strong tidal currents. The barrier islands are narrow and of low relief, but seem to be an effective barrier to both fresh water pouring out of the Mississippi River distributaries toward the southwest and to the high-salinity waters of the open Gulf of Mexico. Breton Island has a shallow lagoon on the south side of the island with a stand of honey mangrove (*Avicennia nitida*) on the island edge of this lagoon.

Breton Sound, although it is broadly connected with the Gulf, is shallow and fairly well enclosed by land except where it joins Chandeleur Sound on the north.

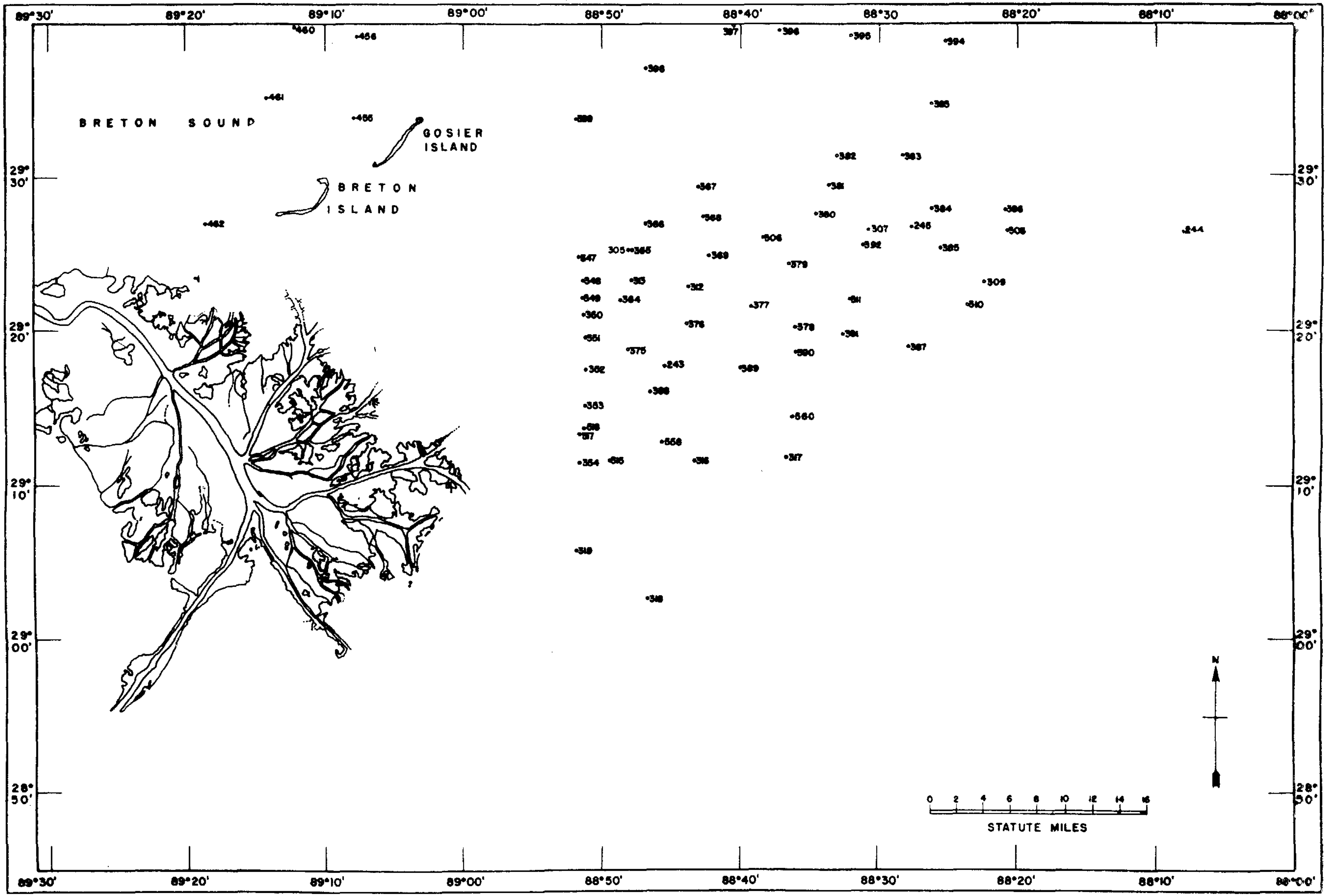


FIG. 4.—Station locations of biological and geological sediment samples taken in offshore Delta region.

Breton Sound is 8–15 feet deep in its northwest part, increasing to 18–26 feet in the southeast part (Fig. 5). A brief physical description of the region is given in a paper by Scruton (1956).

The sediments and sedimentary processes of the area are described in detail by Scruton (1956), who proposed sediment units based on the particle size and gross appearance of the deposits. Inman (1956) has also compiled a chart of sediment types of the inshore region, based on the parameters of the size distribution of the sediments. Two maps (Figs. 6a and 6b) were also compiled for this study to show the size distribution of the sediments based on their percentages of sand,

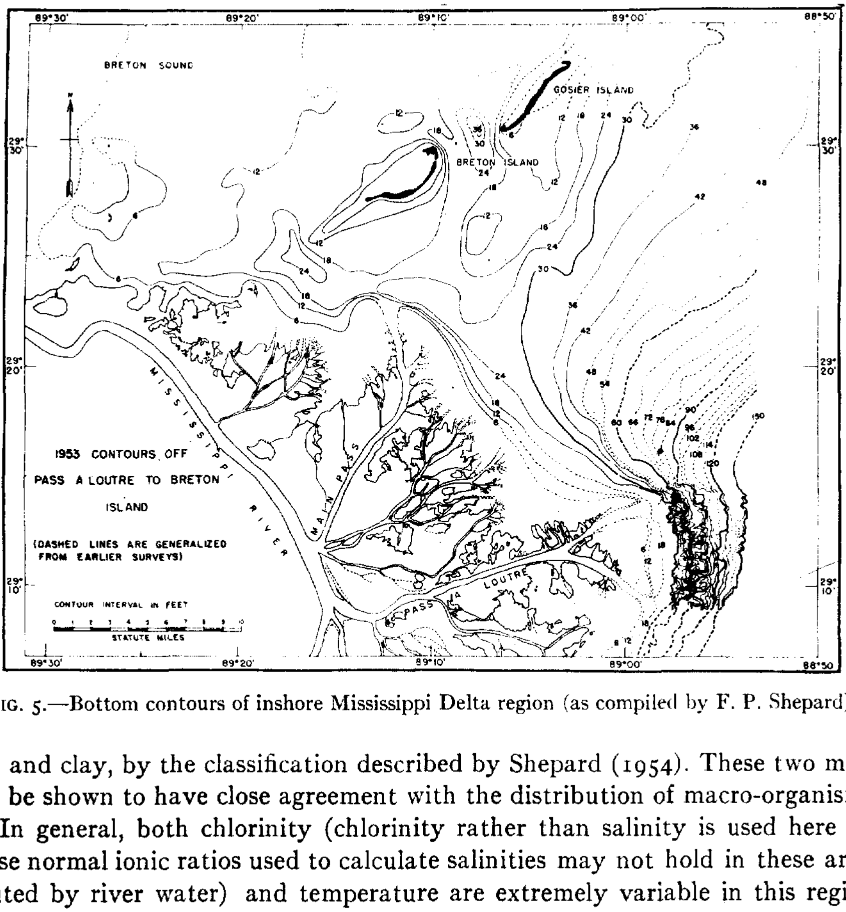


FIG. 5.—Bottom contours of inshore Mississippi Delta region (as compiled by F. P. Shepard).

silt, and clay, by the classification described by Shepard (1954). These two maps will be shown to have close agreement with the distribution of macro-organisms.

In general, both chlorinity (chlorinity rather than salinity is used here because normal ionic ratios used to calculate salinities may not hold in these areas diluted by river water) and temperature are extremely variable in this region, except in the bottom waters of the offshore parts of the Gulf of Mexico (discussed in detail by Scruton, manuscript). The northeast parts of Breton Sound are somewhat more stable and generally possess higher chlorinity and water temperature than the waters in the vicinity of the delta shores and distributaries (Figs. 7, 8, 9, and 10). According to Marcus A. Hanna of the Gulf Oil Corporation (personal

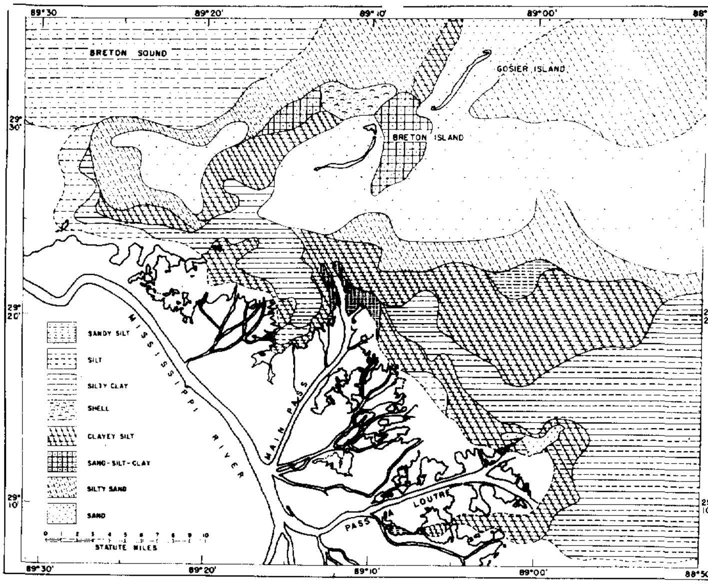


FIG. 6a.—Areal distribution of sediment types as determined by sand-silt-clay contents for inshore Delta region (compiled by Parker and D. G. Moore).

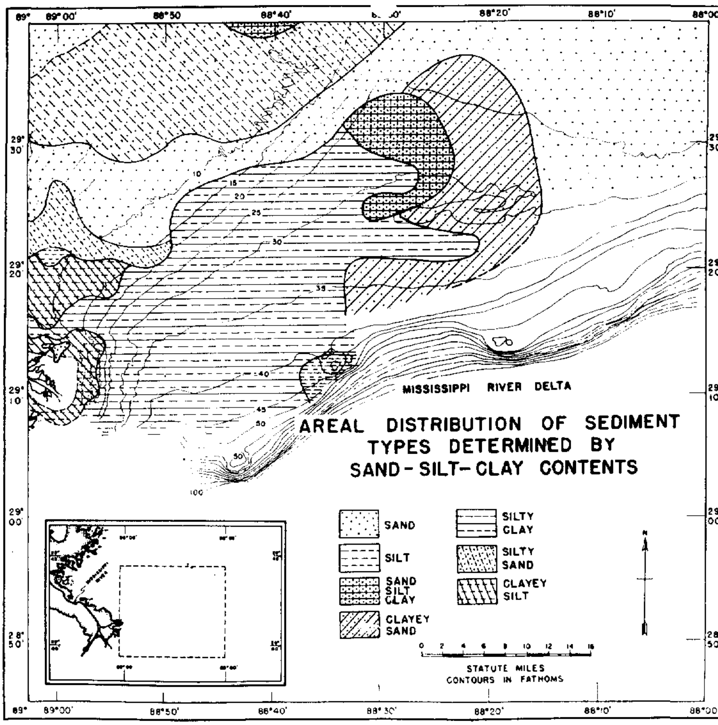


FIG. 6b.—Areal distribution of sediment types as determined by sand-silt-clay contents of offshore Delta region (compiled by Parker and D. G. Moore).

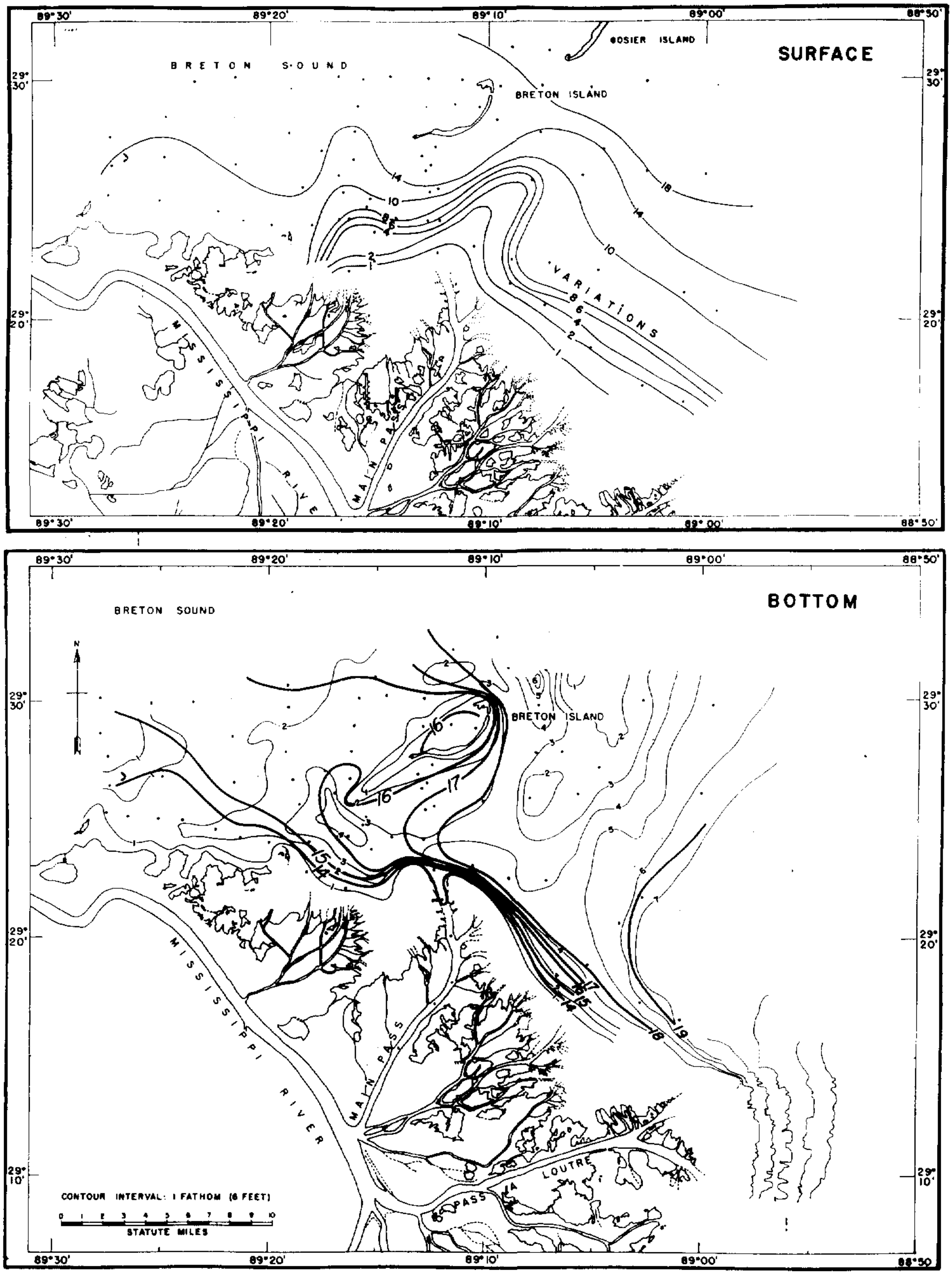


FIG. 7.—Areal distribution of chlorinities in parts per thousand as observed in fall of 1951 during time of minimum river discharge (compiled by P. C. Scruton).

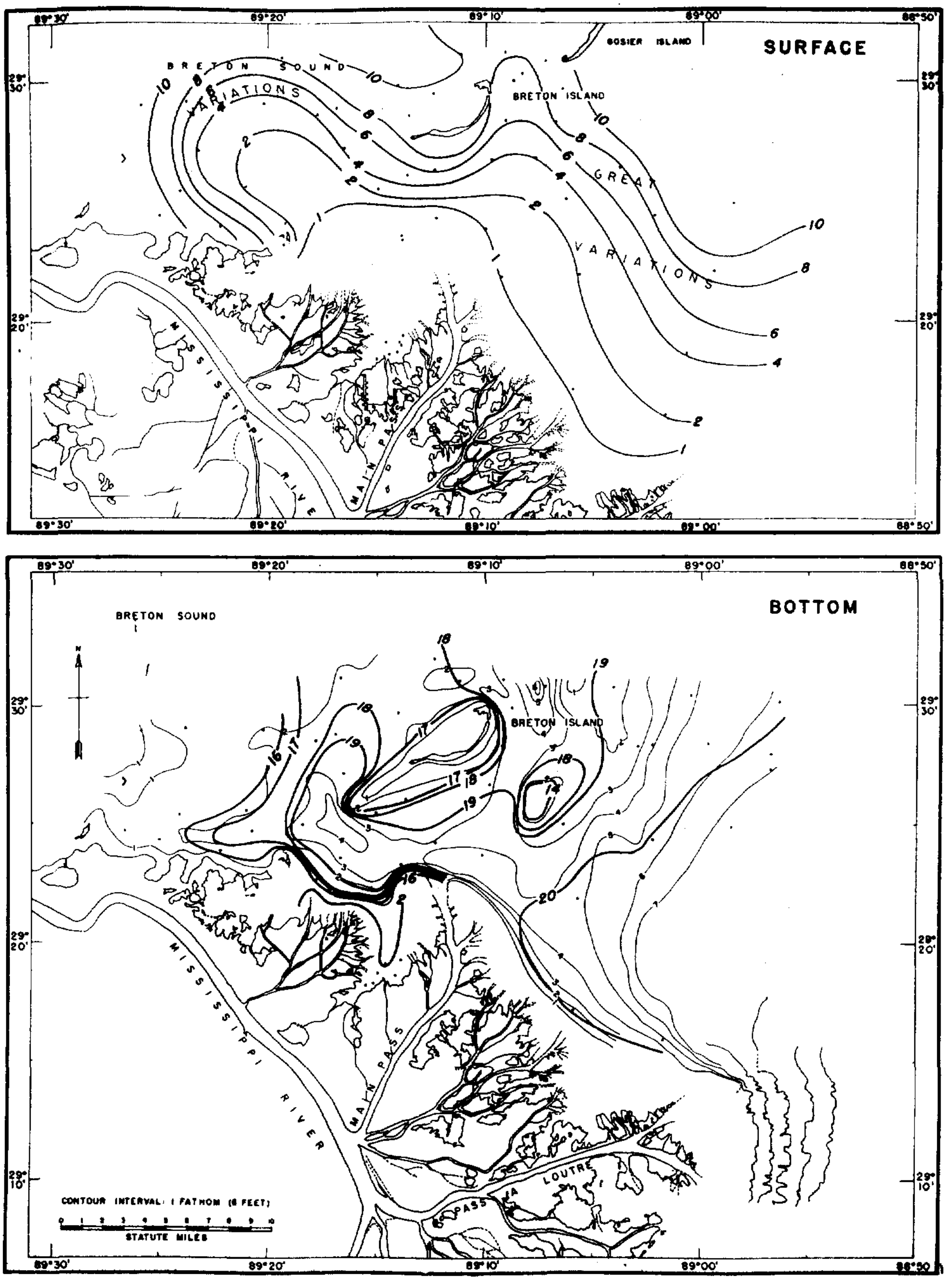


FIG. 8.—Areal distribution of chlorinities in parts per thousand as observed in spring of 1952 during time of maximum river discharge (compiled by P. C. Scruton).

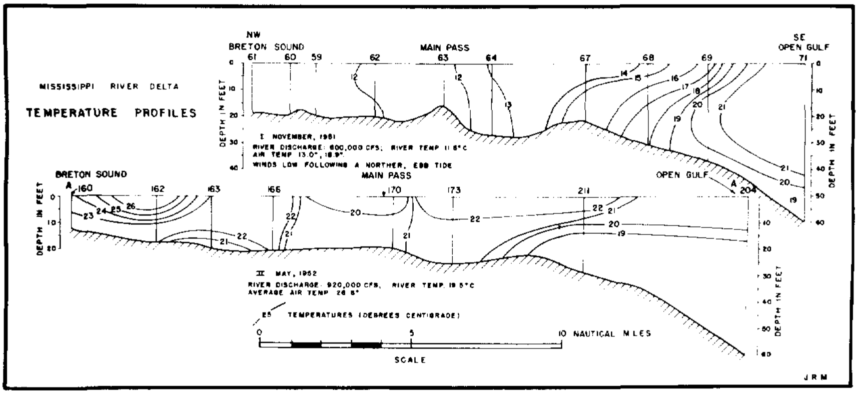


FIG. 9.—Water-temperature profiles of inshore Mississippi Delta region at times of low and high river discharge (compiled by P. C. Scruton).

communication) a semi-permanent wedge of high-salinity water impinges on the shores of the delta near Coquille and Denisse bays.

Although the chlorinities are variable in Breton Sound and in the vicinity of the delta, they are not typical of normal low-chlorinity bays, such as San An-

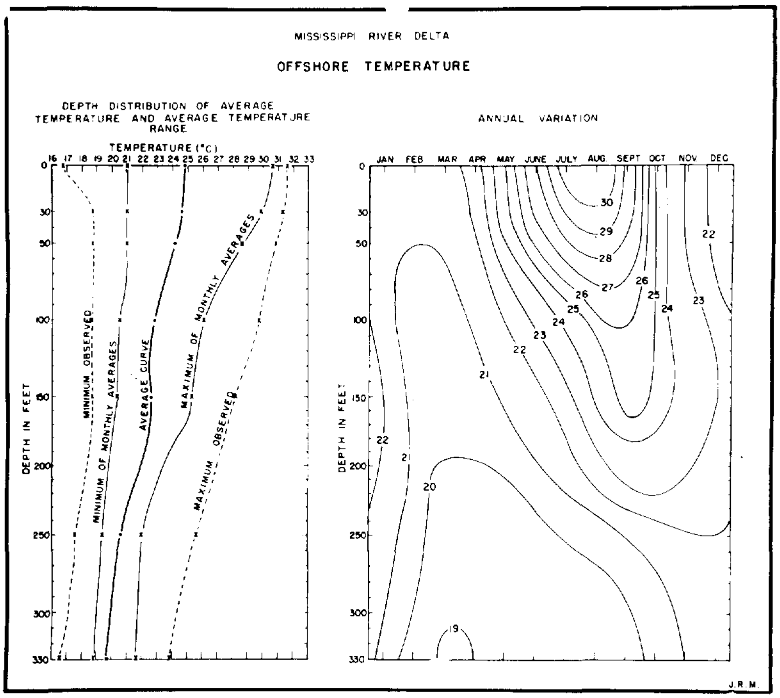


FIG. 10.—Depth distribution and annual variation of water temperatures in offshore Delta region (compiled by P. C. Scruton).

tonio and Galveston bays (Galtsoff, 1931), or Copano Bay (Collier and Hedgpeth, 1950) in Texas. The bottom chlorinities in Breton Sound seldom fall below 16 ‰ (parts per thousand) even during the flood stages of the Mississippi River (Fig. 8). The only parts of the project area which have chlorinities below 5 or 6 ‰ are the river distributaries less than 3–5 feet deep of the Delta front and the waters of the Delta marshes. The waters of the open Gulf of Mexico at depths greater than 12–13 fathoms (72–78 feet) seldom fall below 19 ‰ chlorinity and have a very narrow range of chlorinity (19.6–20.2 ‰) and temperature (20°–25°C.). Scruton (manuscript) discusses the inter-relationships of the hydrographic factors in the Delta region. Turbidity of the waters in this region may also be important in influencing the distribution of many of the invertebrates in the area. Scruton and Moore (1953) discussed turbidities in this region.

METHODS OF STUDY

Most of the biological samples were obtained with an orange-peel bucket approximately $\frac{1}{3}$ cubic foot in capacity. Because of varying hardness of the bottom sediments, samples were not of equal size; therefore, samples comparable on an unweighted basis were not obtained. On particularly hard sand bottom, a snapper grab sampler was used. Because this device took no more than a handful of sediment, several samples were taken at each station. Several dredges and trawls were used for the large animals and those organisms which were too mobile to be taken by grab samplers. Coring devices also produced valuable biological data, since comparative distribution figures could be obtained by analyzing the top 5–20 centimeters of sediments in the cores. Most of the shells from cores were collected from the sand fractions of sediment analyses from these cores.

An attempt was made to list all organisms taken at every station while in the field. Most of the material was preserved in iso-propyl alcohol for later study. From the field notes and from the condition of the preserved material it was possible to get approximate living and dead counts of all organisms at each station, although each single valve was counted as one dead individual. All major faunal groups were sorted from each sample, and all except the bryozoans, crustaceans, and fish were sent to specialists for identification. A complete list of invertebrate species and the biological station numbers at which each species was taken is listed in Table I. Most of the specimens taken in the study are at Scripps Institution of Oceanography, except the scaphopods, echinoderms, and corals, which are at the Museum of Paleontology at Berkeley. Most of the organisms used in defining the macro-organism assemblages will be illustrated in a catalogue of invertebrata of the Gulf Coast, in preparation.

From the collections in the east Mississippi Delta region the following numbers of species were found: 93 gastropods (and 7 pteropods), 116 pelecypods, 6 scaphopods, 1 chiton, 3 cephalopods, 7 anthozoa (coelenterates), 8 echinoderms, 31 polychaete worms, 8 identifiable bryozoa, and 34 crustaceans, a total of 314 species. A series of species distribution maps for the more important invertebrates

TABLE I. SPECIES AND STATION OCCURRENCES OF INVERTEBRATE ANIMALS COLLECTED IN MISSISSIPPI DELTA REGION

Species	*Biological Station Numbers at Which Species Was Collected*
MOLLUSCA	
GASTROPODA	
Diodora cayenensis	33, 62, 74, 75, 76, 246, 247, 309, 311
Fissurella barbadensis	247
Neritina reclivata	33, 35, 38, 52, 62, 74, 75, 76, 81, 122, 146a, 151, 153, 180, 188, 190, 220, 221, 227, 240, 246, 277, 278, 284, 311, 323, 398, 402, 457, 571, 642, 643, 672
Littorina irrorata	12, 13, 15, 244, 321
Littoridina sphinctostoma(?)	426, 643, 670
Modulus modulus	11
Architectonica nobilis	309
Cerithium muscarum	33
Cerithiopsis subulata	75
Bittium varium	643
Calyptraea centralis	244, 308, 309, 311, 316
Crucibulum auricula	308, 309, 311, 393
Crepidula fornicata	33, 34, 62, 68, 77, 142, 151, 244, 308, 309, 311, 321, 393
Crepidula plana	4, 13, 17, 32, 33, 34, 36, 37, 38, 62, 73, 74, 76, 80, 153, 154, 155, 157, 160, 180, 188, 251, 268, 316, 321, 322, 383, 429, 575, 642, 643
Strombus alatus	13, 244, 321, 393, 443
Polinices duplicatus	1, 2, 4, 9, 11, 12, 13, 15, 17, 20, 28, 32, 33, 35, 37, 43, 48, 52, 62, 69, 71, 77, 142, 143, 153, 154, 155, 160, 171, 181, 183, 189, 233, 246, 247, 248, 250, 251, 254, 255, 256, 257, 261, 321, 322, 323, 405, 406, 424, 642, 643, 669, 672
Polinices uberinus	244, 308, 309, 311, 316, 317, 387, 393
Natica pusilla	8, 10, 14, 43, 73, 82, 88, 171, 188, 190, 197, 248, 283, 294, 308, 309, 311, 313, 316, 321, 345, 346, 366 382, 402, 424, 584, 643, 669, 670
Natica canrena	308, 309, 311
Sinum perspectivum	189, 322, 366
Phalium granulatum	13, 244, 443
Distorsio clathrata	308, 309, 311
Sconsia striata	316, 366, 560
Tonna galea	443
Murex recurvirostrus rubidus	244, 308, 309
Murex cabritii	309
Murex florifer arenarius	309
Thais haemastoma floridana	4, 9, 12, 15, 37, 74, 189, 249, 250, 321, 323, 458
Thais haemastoma haysae	13, 143, 252, 261
Anachis (Astyris) perpicta	244, 308, 309, 311, 342, 364, 365, 367, 382, 383, 384
Anachis obesa	4, 6, 7, 8, 11, 12, 15, 17, 20, 21, 32, 33, 38, 39, 43, 48, 50, 52, 53, 55, 56, 62, 68, 69, 72, 73, 75, 76, 79, 80, 81, 82, 120, 146a, 151, 152, 153, 158, 160, 167, 168, 169, 171, 183, 188, 189, 197, 205, 206, 244, 247, 254, 257, 277, 278, 280, 288, 311, 313, 323, 345, 346, 347, 348, 350, 352, 362, 363, 366, 367, 368, 375, 382, 393, 406, 413, 415, 419, 420, 424, 428, 460, 571, 572, 573, 575, 642, 643, 669, 670, 672
Anachis iontha	244, 309, 311
Anachis avara semiplicata	7, 39, 43, 62, 70, 142, 143, 152, 154, 155, 188, 246, 247, 250, 252, 254, 321, 322, 401, 575, 581, 642, 670
Anachis avara similis	17, 76, 81, 142, 254, 257, 261, 288, 323, 393, 643, 669
Mitrella lunata	7, 142, 250, 311, 404, 642, 643, 670
Colubraria lanceolata	309
Seila adamsi	74, 76, 250, 311
Nassarius ambiguus consensus	244, 308, 309, 311, 316, 317, 366, 382, 385, 386, 387, 391, 393, 560
Nassarius acutus	2, 4, 5, 6, 7, 8, 10, 11, 12, 15, 17, 19, 20, 21, 22, 23, 25, 26, 27, 29, 30, 31, 32, 33, 35, 38, 39, 40, 41, 42, 43, 46, 49, 51, 52, 56, 61, 62, 68, 69, 70, 71, 72, 73, 76, 77, 78, 79, 82, 84, 86, 88, 142, 142a, 143, 146a, 150, 151, 152, 154, 155, 156, 157, 158, 159, 160, 161, 162, 165, 167, 168, 169, 170, 171, 172, 174, 178, 181, 182, 183, 187, 188, 190, 196, 205, 213, 246, 247, 248, 250, 254, 261, 262, 268, 276, 277, 290, 292, 293, 300, 309, 321, 322, 323, 326, 330, 331, 336, 367, 383, 384, 402, 404, 405, 406, 407, 410, 414, 417, 419, 420, 424, 426, 428, 435, 455, 459, 461, 491, 573, 581, 584, 642, 643, 666, 667, 669, 670, 671, 672, 673,
Nassarius vibex	15, 643
Cantharus cancellarius	7, 12, 15, 32, 33, 34, 35, 43, 51, 62, 73, 74, 75, 78, 80, 81, 143, 144, 146a, 155, 160, 171, 186, 188, 189, 197, 246, 247, 248, 250, 254, 277, 278, 321, 322, 323, 346, 404, 457, 571, 643
Odostomia impressa	153
Busycon contrarium	12, 13, 15, 33, 43, 62, 73, 80, 246, 247, 251, 259, 321, 443
Busycon spiratum plagosum	12, 13, 37, 45, 244, 261, 321, 443, 642
Oliva sayana	12, 33, 62, 171, 244, 308, 311, 321, 322, 346, 347, 367, 387, 399, 560
Oliva caribaeensis	311
Olivella mutica	3, 6, 10, 11, 14, 17, 22, 35, 38, 39, 40, 43, 49, 56, 62, 68, 74, 76, 87, 88, 112, 130, 167, 168, 169, 170, 171, 173, 178, 180, 181, 188, 190, 244, 276, 277, 281, 282, 283, 290, 292, 294, 308, 309, 321, 398, 410, 414, 419, 420, 424, 428, 429, 457, 571, 572, 581, 584, 642, 643, 669, 670, 672, 673
Epitonium, species	308, 643
Marginella aureocincta	308, 309, 311, 316, 391
Marginella denticulata	244, 311
Mangelia citronella	382
Mangelia serga	393
Mangelia jewetti	382
Mangelia ceroplasta	309
Melanella bilineata	316
Turbonilla hemphilli	77, 80, 154, 160, 180, 382, 642, 643
Turbonilla, species	32, 40, 53, 76, 155, 309, 311, 316, 317, 348, 349, 571, 642
Liostraca bilineata	154, 244, 311, 317
Rissoina cancellata	308
Polystira albida	393
Polystira tellea	316

TABLE I—(*continued*)

Species	*Biological Station Numbers at Which Species Was Collected*
Conus clarki	244, 308, 309, 393
Niso interrupta	183, 308, 309, 311, 316
Litiopa melanostoma	244
Liotia variabilis	316
Ancystosyrinx radiata	308, 311, 316
Janthina, species	316
Trigonostoma smithi	309
Mathilda yucatecana	244, 311, 316, 317
Aedeorbis supranitidis	316
Terebra cinerea	251, 669
Terebra dislocata	33, 75, 76, 80, 122, 180, 382, 673
Terebra protexta	10, 12, 35, 38, 62, 63, 70, 73, 76, 152, 154, 247, 398, 666, 672
Retusa canaliculata	14, 21, 27, 30, 31, 32, 40, 54, 70, 72, 73, 76, 150, 151, 154, 155, 157, 159, 160, 171, 262, 316, 428, 457, 459, 460, 571, 573, 642, 643, 672
Arene variabilis	316, 317
Acteon canadensis	309
Scaphander watsoni	309, 311, 316
Cyclichna alba	305, 316, 317, 348, 398, 643
Truncatella, species	461
Atlanta peroni	316
PELECYPODA	
Nucula proxima	244, 308, 309, 311, 316, 317, 344, 345, 348, 349, 363, 366, 367, 382, 387, 391, 393, 396, 560
Nuculana acuta (nearshore form)	15, 17, 31, 53, 54, 74, 76, 77, 82, 188, 201, 244, 257, 277, 279, 308, 309, 311, 343, 642, 643
Nuculana acuta (deep shelf form)	242, 244, 308, 309, 311, 316, 317, 319, 362, 366, 367, 382, 383, 384, 385, 387, 391, 393, 560
Nuculana eborea	5, 6, 8, 16, 17, 19, 21, 25, 27, 29, 32, 33, 34, 35, 38, 39, 40, 41, 46, 49, 57, 61, 70, 73, 74, 79, 115, 142a, 150, 151, 152, 155, 157, 159, 161, 167, 168, 170, 171, 181, 182, 205, 244, 290, 309, 311, 316, 342, 348, 349, 366, 382, 393, 419, 420, 424, 428, 429, 642, 670
Yoldia solenoides	244, 308, 309, 311, 316, 382, 384, 385, 387, 390, 391, 393, 560
Limopsis sulcata	317
Arcopsis adamsi	308
Barbatia domingensis	316
Anadara chemnitzi	13
Anadara campechiensis	4, 5, 8, 9, 10, 12, 15, 23, 27, 28, 32, 33, 37, 38, 39, 42, 49, 55, 57, 62, 68, 70, 73, 76, 80, 112, 143, 153, 154, 155, 157, 159, 160, 167, 171, 178, 180, 200, 244, 257, 268, 277, 278, 279, 293, 294, 316, 402, 419, 424, 428, 455, 642, 669, 670, 672
Anadara lienosa floridana	244, 308, 309, 311, 316, 560
Anadara transversa	3, 11, 15, 16, 28, 34, 40, 42, 43, 55, 62, 70, 74, 75, 76, 77, 80, 81, 146a, 153, 156, 159, 160, 178, 180, 188, 189, 247, 278, 290, 321, 322, 382, 402, 404, 405, 417, 424, 428, 458, 461, 642, 643
Anadara baughmani	311, 316, 366, 382, 387
Anadara brasiliana	12, 13, 16, 17, 36, 62, 64, 74, 75, 76, 155, 159, 167, 171, 178, 188, 257, 321, 322, 367, 643
Noetia ponderosa	32, 33, 45, 70, 171, 250, 443, 642
Volsella demissa granosissima	13, 251, 322, 443
Brachidontes recurvus	33, 34, 37, 74, 76, 82, 153, 180, 189, 322, 402, 642
Brachidontes exustus	246
Atrina rigida	13, 33
Atrina serrata	13, 443
Pinna carnea	348, 367
Pecten raveneli	244, 308, 309, 311, 316, 560
Pecten papyraceum	244, 309, 377
Chlamys sentis	309, 316
Chlamys benedicti	308
Aequipecten gibbus gibbus	244, 250, 308, 309, 316, 317, 382, 383, 385, 386, 387, 393, 560
Aequipecten irradians concentricus	13, 443
Aequipecten irradians amplicostatus	3, 45, 443
Cyclopecten nanus	244, 308, 309, 311, 316, 317, 382, 385, 386, 387, 393, 394, 560
Plicatula gibbosa	316, 560
Anomia simplex	12, 13, 15, 33, 62, 153, 244, 308, 309, 311, 316, 317, 363, 366, 382, 391, 393, 396, 402, 420, 455, 643
Crassostrea virginica	3, 4, 13, 15, 17, 23, 33, 34, 35, 36, 37, 43, 45, 62, 72, 74, 75, 76, 77, 82, 152, 153, 154, 155, 160, 178, 180, 188, 190, 233, 244, 247, 251, 261, 268, 277, 278, 308, 322, 323, 393, 402, 417, 419, 420, 443, 455, 461, 571, 575, 642, 672
Ostrea equestris	34, 35, 36, 38, 74, 75, 76, 151, 152, 153, 155, 160, 161, 178, 188, 190, 277, 309, 394, 398, 406, 458, 459, 642, 643
Lima pellucida	244, 311, 316, 317, 349, 393
Eucrassatella speciosa	244, 308, 309, 311
Crassinella martinicensis	33, 34, 38, 43, 74, 75, 76, 80, 82, 112, 153, 169, 180, 181, 182, 188, 190, 246, 247, 252, 277, 278, 311, 322, 386, 417, 424, 429, 458, 459, 461
Diplodonta punctata	34, 75, 180, 246, 420, 455, 458, 642
Diplodonta semiaspera	12, 14, 15, 16, 30, 32, 35, 36, 38, 62, 68, 70, 72, 74, 76, 146a, 152, 154, 155, 169, 188, 244, 316, 321, 414, 457, 642, 643
Lucina amiantus	3, 10, 14, 15, 35, 41, 62, 64, 68, 74, 75, 76, 78, 80, 81, 82, 84, 85, 154, 159, 160, 169, 178, 180, 181, 183, 188, 190, 192, 246, 276, 277, 278, 281, 282, 309, 311, 316, 321, 323, 344, 345, 346, 348, 363, 366, 367, 386, 393, 398, 399, 417, 420, 457, 458, 461, 571, 575, 584, 642, 643, 672, 673
Lucina crenella	3, 10, 14, 17, 73, 74, 76, 77, 79, 82, 112, 115, 155, 159, 169, 180, 181, 183, 188, 197, 311, 316, 321, 346, 347, 402, 456, 457, 459, 571, 642, 643, 672, 673
Lucina sombrerensis	244, 308, 309, 311, 316
Lucina pennsylvanica	244
Phacoides nassula	244, 308
Divaricella quadrisulcata	244, 308, 309, 311
Echinochama cornuta	244, 308, 309, 311, 316, 386, 393

TABLE I—(*continued*)

Species	*Biological Station Numbers at Which Species Was Collected*
Chama congregata	308
Trachycardium muricatum	9, 13, 33, 34, 37, 38, 39, 62, 74, 75, 76, 80, 82, 153, 154, 155, 178, 180, 188, 189, 191, 233, 246, 247, 248, 250, 268, 278, 308, 321, 323, 406, 420, 429, 458, 642, 643, 673
Dinocardium robustum	4, 13, 15, 37, 69, 76, 181, 248, 321, 398, 443, 571
Dinocardium robustum vanhyningi	244
Laevicardium laevigatum	244, 308, 317, 367
Laevicardium fiski	244, 308, 309, 311, 316, 382, 393, 560
Laevicardium sybariticum	309
Microcardium transversum	308, 309, 316
Papyridea soleniformis	309
Gouldia cerina	244, 308, 309, 311, 316, 383, 386, 393
Pitar cordata	245, 311, 349, 382
Pitar simpsoni	244, 309
Spisula solidissima similis	62, 74, 329, 443
Mactra fragilis	250
Macrocallista maculata	244, 311, 319
Dosinia discus	3, 4, 5, 9, 10, 12, 13, 14, 15, 17, 32, 33, 35, 36, 37, 38, 42, 45, 55, 69, 70, 72, 73, 75, 76, 77, 82, 115, 152, 154, 155, 156, 157, 159, 160, 169, 173, 180, 181, 183, 188, 189, 190, 197, 244, 246, 248, 257, 268, 280, 282, 316, 321, 322, 344, 346, 347, 364, 366, 367, 383, 398, 399, 402, 410, 414, 415, 419, 420, 424, 428, 443, 455, 457, 461, 572, 574, 575, 576, 642, 643, 669, 672, 673
Cyclinella tenuis	321, 322
Antigona strigillina	244, 309, 316
Mercenaria campechiensis texana	3, 4, 11, 12, 13, 14, 15, 16, 28, 30, 32, 33, 34, 36, 37, 38, 62, 68, 70, 72, 73, 75, 76, 77, 82, 122, 152, 153, 154, 155, 159, 160, 169, 180, 182, 183, 186, 187, 188, 196, 251, 277, 278, 280, 321, 322, 420, 428, 443, 457, 458, 575, 576, 642, 643, 672, 673
Chione cancellata	12, 244
Chione intapurpurea	3, 244, 309, 346, 367, 387, 396, 398
Chione grus	244, 308, 309, 311, 386
Chione clenchi	244, 308, 309, 311, 316, 317, 319, 344, 348, 366, 367, 382, 393, 397, 560
Petricola pholadiformis	38, 70, 76, 81, 146a, 151, 323, 401
Periploma fragilis	30, 79, 161
Periploma inaequalis	38
Mulinia lateralis	3, 5, 6, 9, 10, 11, 12, 14, 15, 16, 17, 19, 21, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 48, 49, 50, 51, 52, 57, 58, 59, 60, 61, 62, 63, 64, 66, 68, 69, 70, 71, 72, 73, 74, 75, 76, 80, 81, 82, 87, 115, 120, 142a, 146a, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 167, 168, 169, 170, 171, 173, 174, 177, 178, 179, 180, 183, 186, 187, 188, 190, 197, 205, 213, 244, 247, 248, 276, 281, 282, 283, 284, 288, 290, 292, 293, 294, 300, 308, 309, 311, 316, 319, 321, 322, 323, 327, 331, 334, 345, 346, 382, 383, 393, 394, 402, 404, 406, 407, 410, 414, 417, 419, 420, 424, 426, 427, 428, 429, 437, 442, 455, 457, 459, 461, 642, 643, 644, 666, 669, 670, 672, 673
Rangia cuneata	13, 28, 246, 250, 268, 271, 410, 672, 673
Rangia flexuosa	15, 33, 76, 153, 246, 250, 257, 420, 443, 643, 672
Labiosa plicatella	13, 38, 252, 346, 420, 428, 443, 673
Labiosa lineata	13, 51, 443
Donax tumida	14, 16, 33, 62, 64, 82, 178, 181, 193, 244, 309, 345, 394, 402, 410, 419, 420, 672, 673
Donax denticulata(?)	72
Tagelus divisus	10, 12, 13, 15, 17, 20, 30, 32, 33, 34, 35, 36, 37, 38, 39, 62, 68, 69, 70, 72, 73, 74, 75, 76, 77, 79, 80, 82, 152, 153, 154, 155, 157, 158, 159, 160, 167, 170, 171, 178, 180, 181, 183, 186, 187, 188, 189, 246, 249, 268, 277, 279, 308, 316, 321, 322, 323, 363, 404, 407, 414, 420, 424, 429, 455, 457, 458, 461, 573, 642, 643, 670
Tagelus plebeius	37, 155, 160, 443
Semele proficua	12, 32, 33, 34, 62, 74, 75, 76, 77, 153, 154, 155, 180, 188, 246, 247, 268, 321, 322
Semele purpurescens	74, 308, 309, 321, 458
Semele bellastriata	244, 311
Abra aequalis	5, 9, 11, 12, 15, 16, 17, 20, 33, 34, 36, 37, 38, 39, 40, 41, 42, 49, 52, 53, 54, 56, 60, 62, 68, 70, 72, 74, 75, 76, 79, 80, 81, 82, 112, 146a, 151, 153, 154, 155, 157, 158, 159, 160, 161, 167, 169, 171, 173, 178, 180, 181, 186, 188, 189, 201, 244, 246, 247, 248, 252, 272, 279, 316, 321, 322, 345, 346, 348, 366, 367, 382, 404, 405, 406, 407, 414, 415, 419, 420, 424, 428, 458, 461, 642, 643, 669, 670, 672
Abra lioica	53, 61, 205, 324, 325, 326, 329, 334, 336, 341, 342, 343, 344, 345, 348, 349, 350, 362, 363, 364, 463, 642, 669, 670
Tellina alternata	1, 5, 9, 10, 12, 14, 15, 16, 32, 35, 36, 37, 40, 45, 62, 72, 73, 76, 77, 154, 155, 156, 160, 169, 171, 178, 180, 182, 183, 186, 197, 246, 247, 290, 311, 321, 322, 344, 366, 367, 398, 406, 410, 415, 420, 424, 428, 643, 669, 672
Quadrans lintea	12, 74, 197, 201, 244, 321, 367, 393, 398
Tellina versicolor	5, 6, 9, 11, 15, 16, 17, 30, 31, 35, 37, 38, 39, 40, 42, 49, 53, 54, 60, 62, 68, 70, 71, 72, 73, 74, 76, 81, 82, 84, 85, 86, 146a, 154, 157, 159, 160, 167, 169, 170, 171, 173, 177, 181, 182, 183, 186, 188, 189, 205, 206, 308, 309, 316, 321, 322, 343, 344, 345, 346, 347, 348, 349, 363, 365, 366, 367, 396, 404, 406, 413, 415, 420, 424, 428, 429, 435, 437, 457, 573, 642, 643, 669, 670, 672, 673
Tellina georgiana	244, 308, 309, 311
Tellina texana	308, 309, 316
Phylloda squamifera	244, 308, 309, 311, 316, 317, 348, 366, 386, 393
Strigilla mirabilis	62, 72, 75, 87, 88, 283, 311, 362, 382, 394, 419
Tellidora cristata	12, 15, 32, 36, 38, 76, 77, 142a, 154, 160, 187, 188, 311, 316, 321, 345, 424, 457, 043, 673
Macoma tageliformis	180, 325, 372, 674, 675
Macoma tenta	5, 12, 15, 17, 32, 38, 39, 42, 73, 79, 152, 157, 158, 160, 167, 169, 183, 188, 192, 201, 205, 244, 247, 308, 311, 316, 321, 344, 345, 348, 363, 39[illegible] 404, 407, 420, 572, 642, 643, 669, 670, 672
Macoma extenuata	244, 308, 309, 311, 317, 366, 382, 393
Macoma mitchelli	76, 149, 151, 215, 227, 609, 643, 674
Macoma constricta	37, 171
Ensis minor	6, 13, 32, 37, 42, 51, 52, 53, 73, 76, 85, 87, 154, 169, 349, 402, 417, 442, 457
Solecurtus cummingianus	308, 311

TABLE I—(*continued*)

Species	*Biological Station Numbers at Which Species Was Collected*
Panope bitruncata	443
Varicorbula operculata	244, 308, 309, 311, 316, 317, 363, 366, 367, 382, 387, 393, 560
Corbula contracta	3, 34, 73, 74, 75, 76, 80, 180, 181, 188, 277, 278, 279, 309, 642
Corbula dietziana	244, 309, 316
Corbula swiftiana	33, 38, 154, 155, 169, 188, 244, 308, 309, 311, 316, 317, 321, 322, 344, 346, 348, 363, 364, 365, 366, 367, 382, 384, 385, 386, 387, 390, 393, 396, 427, 560, 642
Cyrtopleura costata	1, 13, 14, 22, 31, 33, 37, 42, 62, 74, 76, 173, 188, 190, 244, 321, 402, 428, 443, 672
Pandora trilineata	10, 12, 14, 39, 42, 53, 62, 68, 73, 87, 154, 158, 160, 162, 169, 170, 173, 178, 183, 189, 280, 322, 402, 419, 420, 424, 642, 643, 669, 673
Pandora bushiana	308, 309, 311, 316, 366, 382, 393, 398
Cuspidaria ornatissima	244, 308, 309, 311, 316
Cuspidaria media	309, 317
Cuspidaria granulata	244, 308, 309, 311, 316
Cuspidaria jeffreysi	309
Cuspidaria costellata	244
Cuspidaria perrostrata	309
Verticordia ornata	244, 308, 309, 311, 316, 317, 345, 366, 382, 384, 386, 393, 560
SCAPHOPODA	
Dentalium laqueatum	309, 317
Dentalium texasianum	40, 76, 178, 277, 311, 316, 317, 344, 345, 347, 348, 349, 365, 366, 367, 398
Dentalium sowerbyi	244, 308, 309, 311, 316
Cadulus mayori	311, 316, 317
Cadulus carolinensis	244, 308, 309, 311, 316, 346, 347, 348, 349, 366, 367, 378, 379, 393
Cadulus arctus	244, 309, 311, 344, 382
PTEROPODA	
Cavolina uncinata	171, 201, 244, 308, 309, 311, 316, 393
Cavolina longirostris	244, 308, 309, 342, 345, 350, 362, 363, 364, 366
Euclio pyramidata	244, 309
Creseis virgula	309
Creseis acicula	309, 311, 366, 393
Diacria quadridentata	309
CHITONS	
Chaetopleura apiculata	247, 323
CEPHALOPODA	
Lolliguncula brevis	17, 20, 37, 43, 62, 69, 143, 144, 246, 249, 252, 254, 256, 257
Loligo pealei	243, 366
Argonauta argo	244
COELENTERATA	
HYDROZOA	
Hydractinia, species	321
ANTHOZOA	
ANENOMES	
Calliactis tricolor	12, 143, 244, 257, 323
HEXACORALS	
Eupsamnia floridana	308, 309, 315
Bathycyathus, species	309
Astrangia astreiformis	11, 13, 15, 16, 33, 72, 74, 75, 76, 77, 167, 188, 321, 443, 643, 672
OCTOCORALS	
Leptogorgia setacea	256
Eugorgia stheno	244, 308, 346
PENNATULIDS	
Renilla mülleri	7, 12, 43, 53, 55, 62, 89, 143, 144, 242, 248, 249, 346, 366
ECHINODERMATA	
ASTEROIDS	
Luidia clathrata	4, 12, 62, 144, 246, 247, 261, 346
Astropecten articulatus valenciennesi	243, 346, 366
OPHIUROIDS	
Hemipholis elongata	5, 12, 15, 45, 50, 188, 246, 247, 322, 323
Amphiodia limbata	9, 15, 28, 29, 33, 34, 35, 36, 38, 40, 70, 75, 76, 77, 146a, 154, 155, 168, 169, 182, 189, 211, 250, 321, 404
Ophiolepis elegans	322
Unidentified species	167, 343, 362, 364
ECHINOIDS	
Mellita quinquiesperforata	3, 4, 11, 12, 15, 43, 62, 82, 83, 246, 247, 248, 249, 250, 254, 255, 256, 278, 283, 322, 419, 420, 672, 673
Clypeaster prostratus	244, 319
Clypeaster raveneli	317

TABLE I—(*continued*)

Species	*Biological Station Numbers at Which Species Was Collected*
ANNELIDA	
POLYCHAETA	
Lepidonotus sublevis	70
Polydontis lupina	39
Sthenelais articulata	33, 81, 322, 404
Paeurythoe, species	25, 26
Aglaophamus dicirris	51, 54, 56, 57, 84, 86, 344
Glycera americana	5, 15, 33, 34, 35, 36, 39, 154, 205, 328
Marphysa sanguinea	153
Diopatra cuprea	2, 4, 5, 9, 15, 16, 21, 22, 33, 45, 50, 56, 62, 71, 77, 80, 81, 171, 174, 247, 362, 399
Lumbrineris erecta	15, 188
Lumbrineris bifilaris	26, 27, 52, 150, 200, 201
Lumbrineris, species	25, 29, 57, 322, 325, 336, 349, 366
Prionospio, species	54
Nerine agilis	150
Chaetopterus variopedatus	38, 77, 155
Spiochaetopterus oculatus	31, 70
Maldane sarsi	77
Clymenella torquata calida	154, 346, 349
Owenia fusiformis	5, 16, 321, 349
Sternapsis scutata	54
Sthenelais, species	345
Eurythoë complanata	324
Nereis, species	343, 362
Nephtys picta	404
Nephtys, species	324, 325, 336, 339, 350
Glycera dibranchiata	404
Lumbrineris? bassi	336
Ancistrosyllis bassi	324
Cossura, species	328, 335, 336, 339
Prionospio treadwelli	322, 335
Magelona (near) *cerae*	363
Branchioasychis americana	366
BRYOZOA	
Bugula neritina	2, 4, 7, 9, 12, 15, 16, 17, 20, 22, 28, 33, 37, 43, 45, 48, 51, 53, 55, 69, 70, 71, 76, 80, 81, 142, 142a, 143, 187, 188, 189, 246, 247, 248, 249, 250, 252, 254, 255, 257, 268, 321, 322, 323, 346, 428
Zoobytron, species	7, 12, 37, 43, 45, 51, 53, 55, 62, 74, 76
Schizoporella floridana	244, 308, 309, 311, 316
Schizoporella unicornis	244, 308, 309, 311, 316
Mamillopora cupula	244, 308, 309, 311, 316, 321, 346
Cupuladria canariensis	244, 308, 309, 311, 316, 321, 322, 349, 410
Smittina trispinosa	244, 308, 309, 311, 316
Membranipora, species	17, 32, 33, 74, 75, 76, 80, 81, 246, 322, 323, 424, 428, 455
ARTHROPODA	
DECAPODA	
Libinia emarginata	17, 37, 55, 246, 247, 250, 256, 321
Petrolisthes armatus	33
Heterocrypta granulata	75, 81, 246, 322, 323
Portunus spinimanus	1, 37, 247, 321, 322, 323
Portunus gibbesi	4, 7, 20, 43, 50, 69
Porcellana sayana	4, 12, 17, 323
Neopanope packardi	12, 17, 28, 33, 36, 62, 74, 171, 246, 247, 248, 250, 260, 321, 322, 323, 404
Callinectes sapidus	(1), AMP-BBT, AMP-BOT, 20, 28, 32, 53, 55, 143, 144, 242, 246, 247, 250, 252, 253, 254, 255, 256, 257, 259, 260, 261, 262, 321
Callinectes danae	(1), 37, 62, 142, 143, 242, 243, 261, 262, 268, 360
Calappa springeri	244, 365
Polyonyx macrocheles	16
Euceramus praelongus	17, 62, 322, 399
Pilumnus dasypodus	17
Persephone punctata	29
Chasmocarcinus, species	39
Ovalipes occellatus	62
Hepatus epheliticus	321
Metoporhaphis calcatus	322
Crangon heterochaelis	17, 33, 36, 74, 80, 321
Pagurus floridanus	1, 2, 12, 13, 15, 17, 33, 37, 62, 69, 71, 251, 321, 322
Pagurus longicarpus	12, 321
Clibinarius vittatus	12, 142, 321
Squilla empusa (*stomatopoda*)	1, (1), 7, 20, 53, 55, 142, 143, 242, 253, 254, 257, 259, 261, 262, 319, 360
Xiphopenaeus kroyeri	AMP-BOT, 262
Penaeus setiferus	1, (1), AMP-BOT, 12, 17, 45, 50, 55, 59, 142, 143, 242, 249, 268
Penaeus duoarum	1, AMP-BOT, 7, 20, 28, 33, 37, 43, 55, 62, 142, 252
Palaemonetes, species	17
Sicyonia dorsalis	242, 319, 323
Uca mordax	214 to 239 (marsh stations)
Uca pugnax	Marsh stations
Uca pugilator	Marsh stations
Crayfish (*Cambarus*, species)	Fresh-water marsh stations
XIPHOSURA	
Limulus polyphemus	13

is included in the discussion of macro-organism assemblages. The physical and chemical data taken at each of the biological stations have been discussed in full by Scruton (*op. cit.*).

MACRO-ORGANISM ASSEMBLAGES

Seven divisions of the region were recognized on the basis of the distribution of the macro-organisms collected in this study, published distribution records of the same organisms, and consideration of the environmental factors which affect animal distribution. These seven divisions are: (I) the delta marshes; (II) delta front and lower distributaries; (III) lower Sound and pro-delta slopes; (IV) Upper Breton Sound and Chandeleur Sound; (V) inlets; (VI) shallow continental shelf of the Gulf of Mexico from the barrier islands to 12–13 fathoms; and (VII) the deep continental shelf of the Gulf of Mexico from 13 fathoms to the outer edge of the continental shelf. A possible eighth environment or assemblage is represented by the living oyster reefs, most of which are outside the project area and accordingly not discussed in any detail here. The approximate boundaries of these seven major environments and their characteristic assemblages are illustrated in Figures 11 and 12. Table I shows the station distribution of all the important faunal elements of these divisions in the east Mississippi Delta region. Table II

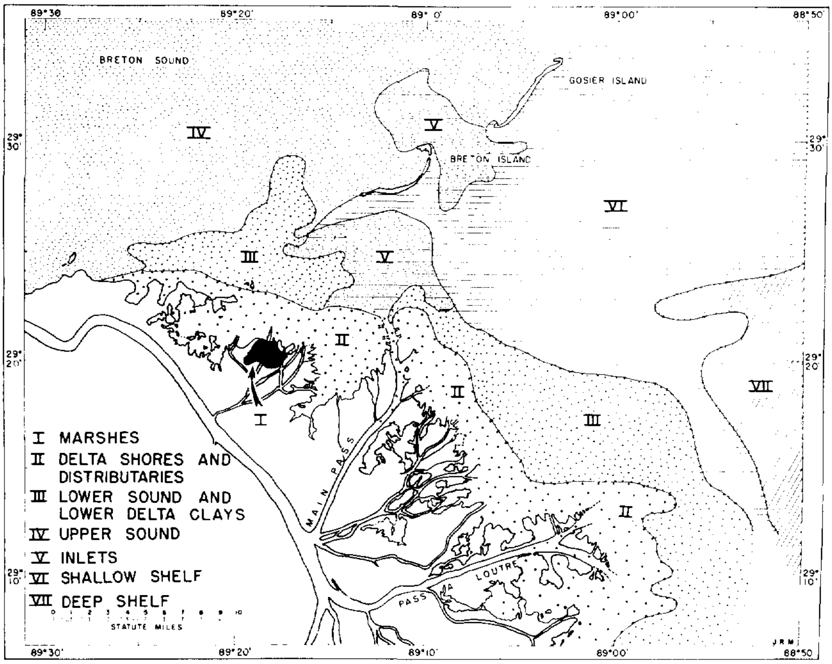


FIG. 11.—Areal distribution of environments as characterized by macro-invertebrate assemblages in inshore Delta region. Actually, marsh environment is of far greater extent, but area in black represents only part studied.

shows the environmental distribution of most of the common invertebrates found in these environments, with their comparative abundance living and dead, and Table III is a similar table of macro-organism distribution compiled from published data.

I. *Delta marshes.*—Although the marshes are not strictly a marine environment, they do contain macro-invertebrates which are tolerant of salt water, and which are occasionally found as remains in reworked marine deposits. The vegetation of the Mississippi Delta marshes has been discussed in detail by O'Neil (1949). The only part of the delta marsh sampled for macro-organisms was in the vicinity of Baptiste Collette Bayou. This marsh area contains both

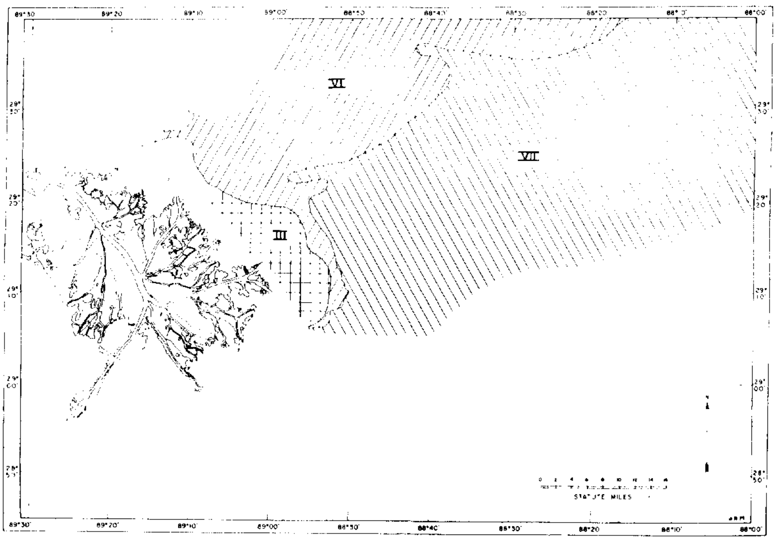
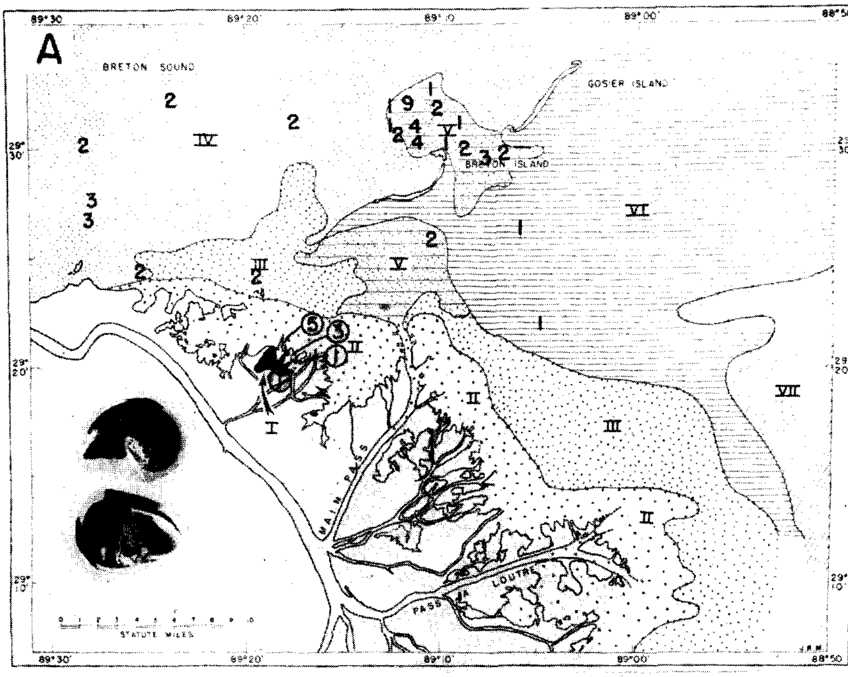


FIG. 12.—Areal distribution of environments as characterized by macro-invertebrate assemblages in offshore Delta region. (Key to Roman numerals: III, Lower sound and pro-delta slope; VI, Shallow shelf; VII, Deep shelf).

fresh- and salt-water marsh vegetation which grows in from several inches to 2 feet of water.

Animals which can produce fossil remains are rare in the marsh environment. The principal mollusk found in this study was *Neritina reclivata* (Say), a snail found from a few inches to a foot or so above the surface of the water on the stems of the grasses and sedges (Fig. 13a).[3] Another littoral gastropod reported from these and neighboring marshes (Hadley, 1936, p. 404; Fisk *et al.*, 1954, p. 89) is *Littorina irrorata* (Say). No living specimens of this gastropod were found, although empty shells were common in old shell deposits in Breton Sound and on the shores of the inner side of Breton Island. It has been reported to be living

[3] *Neritina reclivata* and *Rangia cuneata* proved to be abundant in marshes adjacent to natural levees at North Pass as determined by a reconnaissance of this area in November, 1955.



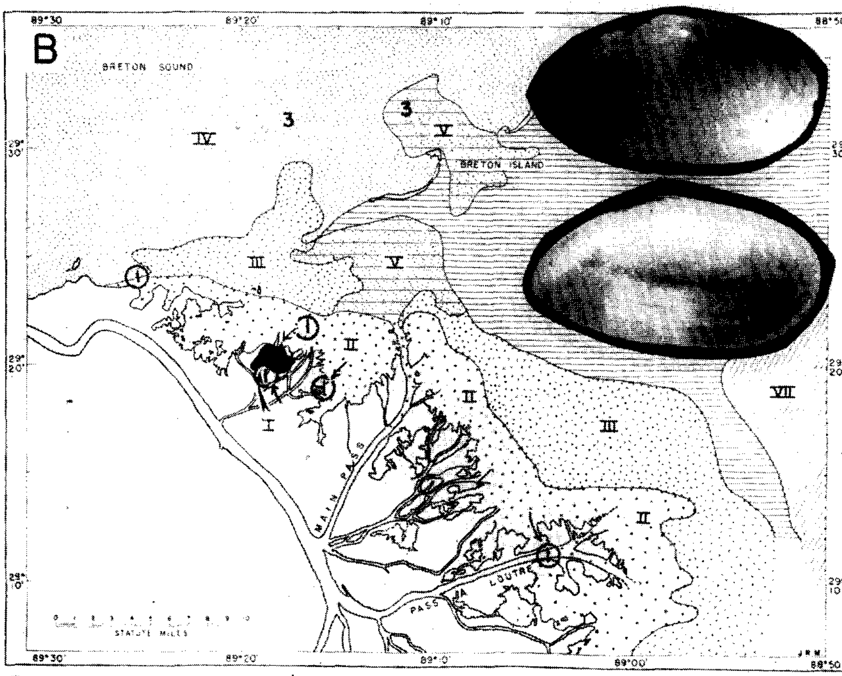


FIG. 13a.—Distribution of marsh snail *Neritina reclivata* as related to areal distribution of environments. Circled numbers indicate living occurrences; numbers indicate number of individuals at each station.

FIG. 13b.—Distribution of pelecypod *Macoma mitchelli*, indicative of delta front and distributaries. Circled numbers indicate living occurrences.

TABLE II. DISTRIBUTION OF MARINE ORGANISMS TAKEN IN EAST MISSISSIPPI DELTA REGION

Species	*Marsh*	*Delta Front*	*Lower Sound*	*Upper Sound*	*Inlets*	*Shallow Shelf*	*Deep Shelf*
Neritina reclivata M	xxxxx		- - -	-----	-----		
Uca, sp. C	xxxxx						
Cambarus, sp. C	xxxxx						
Littorina irrorata M	xxxxx		- - -	- - -	- - -		-
Littordina, sp. M		- -					
Macoma mitchelli M		xxxxx		- -			
Macoma tageliformis M		xxxxx				- - -	
Mulinia lateralis M		xxxxx	xxxxx	xxxxx	- - -	xxxxx	
Crassostrea virginica M		xxxxx	- x -	-----	-----	- - -	-
Rangia flexuosa M	x	-	-	-----	- - -		
Lumbrineris bifilaris P		x x x				x	
Lumbrineris erecta P		x x x				x	
Nassarius acutus M		xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	
Penaeus setiferus C		xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	
Portunus spinimanus C		x		x-x--			
Nuculana eborea M		-	xxxxx	x	- - -	- -	
Polinices duplicatus M		- - -	xxxxx	x-x-x	x-x-x	x-x	
Squilla empusa C			xxxxx		x x x	x x x	
Portunus gibbesi C			x x x	x	x x x		
Anachis avara similis M			xxxxx	- x -	x x		
Anachis obesa M		x-x-x	x-x-x	xxxxx	xxxxx	xxxxx	-----
Callinectes sapidus C		xxxxx	xxxxx	x x x	xxxxx	xxxxx	
Penaeus duoarum C			xxxxx	xxxxx	xxxxx	xxxxx	xxxxx
Prionospio, sp. P			xxxxx				
Diopatra cuprea P			xxxxx	x x x	xxxxx	xxxxx	
Callinectes danae C			xxxxx	x x x	xxxxx	xxxxx	
Bugula neritina B			xxxxx	xxxxx	xxxxx	xxxxx	
Thais haemastoma floridana M			x x x			xxxxx	
Abra lioica M			xxxxx	- x -		xxxxx	x-x-x
Zoobytron, sp. B			xxxxx	xxxxx	xxxxx	xxxxx	
Corbula contracta M				xxxxx			
Petrolisthes armatus C				x x x			
Crangon heterochelis C				xxxxx			
Chaetopterus variopedatus P				x x x			
Lumbrineris, sp.				x x			
Brachidontes exustus M				x			
Nassarius vibex M				x			
Diplodonta punctata M				-----			
Retusa canaliculata M			-	-----			
Periploma fragilis M				- - -			
Periploma inaequalis M				-			
Cerithium muscarum M				-			
Amphiodia limbata E			x	xxxxx	x x x	x	
Diplodonta semiaspera M				x-x-x	- - -		
Semele proficua M				--x--		-	
Sthenelais articulata P				x x	x		
Tagelus gibbus M				- x -		-	
Astrangia astreiformis CO				-----	- - -		
Donax tumida M				-----		-----	
Macoma tenta M				xxxxx	- - -	x-x-x	
Pagurus floridanus C		x		xxxxx	xxxxx		
Thais haemastoma haysae M				x-x-x	--x--	-	
Lolliguncula brevis M				xxxxx	xxxxx	xxxxx	
Libinia emarginata C				x x x	x x x	x	
Pagurus longicarpus C				x x x	x x x	x x x	
Mercenaria campechiensis texana M				x-x-x	- - -	- -	
Glycera americana P				x x x	x	x	
Tellidora cristata M			-	--x--	x -		
Brachidontes recurvus M			-	-----	-		
Ostrea equestris M				-----	- - -	- - -	
Terebra dislocata M			-	- - -	- -		
Nuculana acuta (nearshore form) M				-----	-	- - -	
Aequipecten irradians amplicostatus M				- -	-	-	
Tagelus divisus M			- -	xxxxx	x-x--	- -	
Crepidula plana M			-	xxxxx	x-x-x	-----	
Neopanope packardii C			x	xxxxx	xxxxx	x x x	
Anadara brasiliana M			-	--x--	--x--	- - -	
Ensis minor M		-		--x--	- - -	--x--	
Crassinella martinicensis M			-	--x--	- - -	-	
Lucina crenella M			-	-----	-		- - -
Moira atropos E			- - -	-----	-----	-----	
Crepidula fornicata M			-	-----		-	-----
Abra aequalis M		-	- - -	xxxxx	--x-x	-----	
Tellina alternata M		-	- -	x-x-x	--x--	--x--	
Dosinia discus M			-----	--x--	--x--	--x--	- -
Cyrtopleura costata M		- -	- - -	-----	-----	- - -	
Heterocrypta granulata C					xxxxx		
Hemipholis elongata E					xxxxx		
Mitrella lunata M					xxxxx		
Ophiolepis elegans E					xxxxx		

TABLE II—(*continued*)

Species	*Marsh*	*Delta Front*	*Lower Sound*	*Upper Sound*	*Inlets*	*Shallow Shelf*	*Deep Shelf*
Chaetopleura apiculata M					x x x		
Modulus modulus M					-		
Calliactis tricolor CO					xxxxx	x x x	
Mamillopora cupula B					x x x		- -
Cupuladria canariensis B					x x x		-----
Diodora cayenensis M					x-x-x		-
Chione cancellata M					x-x-x	-	
Owenia fusiformis P				x	x x		
Porcellana sayana C				x x	x x x		
Turbonilla hemphilli M				-	- - -		
Rangia cuneata M		(xxxxx)		-	- - -		
Sinum perspectivum M					- -	-	
Petricola pholadiformis M					--x--	- - -	
Terebra protexta M				-	- - -	-	
Olivella mutica M				-----	xxxxx	-	
Cantharus cancellarius M				-----	xxxxx	xxxxx	
Mellita quinquiesperforata E				x -	xxxxx	xxxxx	
Anachis avara semiplicata M				-----	xxxxx	- x -	
Busycon spiratum plagosum M			-	- - -	-x-x-	- - -	
Trachycardium muricatum M				---	x-x-x		
Anadara transversa M			- - -	x-x-x	x-x-x	- x -	
Busycon contrarium M			- x	- x -	x-x-x	- - -	
Natica pusilla M		-	- - -	x	x-x-x	- - -	
Lucina amiantus M		-	- - -	--x--	x-x-x	x-x-x	--x--
Pandora trilineata M			- - -	--x--	xxxxx	-----	
Aglaophamus dicirrus P			x x			xxxxx	
Atrina serrata M						-----	
Volsella demissa granonissima M						- - -	
Aequipecten irradians concentricus M						- - -	
Anadara chemnitzi M						- -	
Labiosa lineata M						- -	
Spisula solidissima similis M						- -	
Tonna galea M						- -	
Panope bitruncata M						-	
Xiphopenaeus kroyeri C						xxxxx	xxxxx
Luidia clathrata E					x x x	xxxxx	
Renilla mülleri CO					x x x	xxxxx	
Noetia ponderosa M					- - -	-----	
Strombus alatus M						- - -	- - -
Phalium granulatum M						- - -	- - -
Labiosa plicatella M					-	- - -	
Chione intapurpurea M				-		- - -	- -
Strigilla mirabilis M				-	-	-----	
Oliva sayana M				- - -	-	--x--	- - -
Quadrans lintea M				-	- - -	-----	- -
Dinocardium robustum M			-	- - -	- -	-----	
Tellina versicolor M			- x -	--x--	--x--	xxxxx	xxxxx
Anadara campechiensis M		- - -	- - -	--x--	--x--	x-x-x	
Anomia simplex M			-	- - -	-	-----	-----
Eugorgia stheno CO							x x x
Clypeaster prostratus E							x x x
Verticordia ornata M							x-x-x
Anadara baughmani M							x---x
Eucrassatella speciosa M							-x-x-
Polystira albida M							x x
Loligo pealii M							x x
Pitar cordata M							--x--
Pecten papyraceum M							--x--
Limopsis sulcata M							- x -
Cuspidaria ornatissima M							-----
Varicorbula operculata M							-----
Tellina texana M							-----
Macoma extenuata M							-----
Phylloda squamifera M							--x--
Laevicardium fiski M							- - - -
Divaricella quadrisulcata M							- -
Lucina sombrerensis M							----
Chlamys muscosus M							-----
Nassarius ambiguus consensus M							-----
Anadara lienosa floridana M							-----
Yoldia solenoides M							-----
Cyclopecten nanus M							-----
Gouldia cerina M							-----
Echinochama cornuta M							-----
Marginella aureocincta M							-----
Cavolinia uncinata M							-----
Polinices uberinus M							-----
Calyptraea centralis M							-----
Dentalium sowerbyi M							-----
Chione grus M							-----

TABLE II—(*continued*)

Species	*Marsh*	*Delta Front*	*Lower Sound*	*Upper Sound*	*Inlets*	*Shallow Shelf*	*Deep Shelf*
Cuspidaria granulata M							-----
Cavolinia longirostris M							-----
Schizoporella floridana B							-----
Smittina trispinosa B							-----
Corbula swiftiana M				- - -			xxxxx
Nuculana acuta (offshore form) M						- - -	x-x-x
Chione clenchi M						-	x-x-x
Aequipecten gibbus gibbus M					-		-x-x-
Nucula proxima M						-	xxxxx
Astyris perpicta M						-	x-x-x
Dentalium texasianum M					- - -	- - -	-----
Phacoides nassula M							- - -
Cadulus carolinensis M						- - -	-----
Cadulus mayori M							- - -
Crucibulum auricula M							- - -
Corbula dietziana M							- - -
Pecten raveneli M							- - -
Macrocallista maculata M							- - -
Tellina georgiana M							- - -
Lima pellucida M							- - -
Anachis iontha M							- - -
Chlamys benedicti M							- - -
Microcardium transversum M							- - -
Cuspidaria perrostrata M							- - -
Scaphander watsoni M							- - -
Mangelia jewetti M							- - -
Melanella bilineata M							- - -
Ancystocyrinx radiata M							- - -
Pandora bushiana M							- - -
Eupsamnia floridana CO							- - -
Bathycyathus, sp. CO							- -
Oliva caribaeensis M							- -
Murex recurvirostrus rubidus M							- -
Plicatula gibbosa M							x x

x = Living.	Frequency of x's and -'s indicate relative abundance.
- = Dead.	
M—Mollusks.	C—Crustacean.
E—Echinoderm.	P—Polychaete worm.
CO—Coelenterate.	B—Bryozoan.

on the vegetation on the inner side of the Chandeleur Islands by Cary and Spaulding (1909, p. 20). Cary and Spaulding found that *Rangia cuneata* Gray was common in the fresh-water marshes along the Louisiana coast, but only one living specimen of this species of pelecypod was found in the delta region during this study. Characteristic crustaceans of the marshes are two species of fiddler crab of the genus *Uca* and at least one species of crayfish (*Cambarus*) which are mentioned as preserved in marsh sediments by Fisk (1954). The fiddler crab, *Uca mordax* Smith, was also mentioned by Cary and Spaulding (p. 11) as a common inhabitant of the salt marshes of the coastal parishes. The diagnostic macro-invertebrates for the delta marshes are the following (Pl. I).

Neritina reclivata—Common
Littorina irrorata—Somewhat less common
Rangia cuneata —Common in some areas
Uca pugilator —Common in salt or brackish marshes
Uca pugnax —Common in salt or brackish marshes
Uca mordax —Common in salt or brackish marshes
Cambarus, sp. —Very common in fresh-water marshes

II. *Delta front and lower distributaries.*—The delta front region with its characteristic low chlorinity (2–10 $^{0}/_{00}$), wide range of temperature (21°C.), fine, clayey silt substrate, shallow water, and proximity to the marshes is also charac-

TABLE III. DISTRIBUTION OF MARINE ORGANISMS, EAST MISSISSIPPI DELTA REGION, FROM PUBLISHED DATA

Species	*Marsh*	*Delta Front*	*Lower Sound*	*Upper Sound*	*Inlets*	*Shallow Shelf*	*Deep Shelf*
Cary and Spaulding, 1909							
GASTROPODS							
Bulla striata				x x x			
Haminoea succinea				x x x			
Melampus flavus				x x x			
Terebra cinerea				x x x			
Cancellaria reticulata						- - -	
Oliva sayana				- - -		- - -	
Fasciolaria distans						- - -	
Busycon spiratum plagosum						- - -	
Busycon contrarium						- - -	
Nassarius vibex						- - -	
Anachis avara						- - -	
Anachis obesa				xxxxx			
Mitrella lunata				x x x			
Murex fulvescens		- - -					
Murex pomum						- - -	
Thais haemastoma						xxxxx	
Epitonium sayana				x x x			
Janthina, sp.						- - -	
Distorsio clathrata						- - -	
Phalium granulatum						- - -	
Tonna galea						- - -	
Strombus alatus						- - -	
Seila terebralis						- - -	
Cerithiopsis, sp.						- - -	
Bittium nigrum				- -			
Bittium varium				- - -			
Cerithium muscarum				- - -			
Cerithidea varicosa(?)				- - -			
Modulus modulus					- - -		
Littorina irrorata	x x			x x x (on land)			
Architectonica nobilis						- - -	
Rissoina chesneli						- - -	
Crepidula fornicata						x x x	
Crepidula convexa						x x x	
Crepidula plana						x x x	
Polinices duplicatus						- - -	
Sinum perspectivum					- - -	- - -	
Neritina reclivata	x x x			x x x (on land)			
Chaetopleura apiculata				x x x			
Spirula spirula						- - -	
Lolliguncula brevis						xxxxx	
PELECYPODS							
Crassostrea virginica						- - -	
Anomia simplex				x x x			
Aequipecten irradians amplicostatus				xxxxx			
Atrina rigida				xxxxx			
Atrina serrata						x x x	
Brachidontes recurvus						- - -	
Volsella americana	x x x			x x x			
Anadara campechiensis						- - -	
Nuculana acuta (*eborea*?)			x x x				
Lucina floridana				x x x			
Dinocardium robustum						x x x	
Trachycardium muricatum					x x x	x x x	
Laevicardium laevigatum						- - -	
Callocardia texasianum						- - -	
Mercenaria campechiensis texana				xxxxx			
Macrocallista maculata						- - -	
Dosinia discus						- - -	
Petricola pholadiformis		- - -				- - -	
Donax tumida						xxxxx	
Tagelus gibbus						- - -	
Tagelus divisus				- - -		- - -	
Tellina alternata						- - -	
Rangia cuneata	xxxxx						
Spisula solidissima similis						x x x	
Mactra brasiliana		x x x				- - -	
Labiosa lineata		- - -				- - -	
Labiosa plicatella		- - -				- - -	
Ensis minor						- - -	
Pholas campechiensis						- - -	
Cyrtopleura costata						- - -	
SPONGES							
Cliona sulphurea						x x x	

TABLE III—(*continued*)

Species	*Marsh*	*Delta Front*	*Lower Sound*	*Upper Sound*	*Inlets*	*Shallow Shelf*	*Deep Shelf*
COELENTERATES							
Bougainvillea superciliaris						x x x	
Bougainvillea carolinensis						x x x	
Hydractinlia polyclina						x x x	
Porporita lineana					x x x		
Renilla mülleri						x x x	
Calliactis tricolor						x x x	
Cerianthus americanus						x x x	
ECHINODERMS							
Luidia clathrata						x x x	
Luidia alternata						x x x	
Mellita quinquiesperforata						x x x	
Moira atropos						x x x	
Ophiura brevispina				xxxxx			
POLYCHAETE WORMS							
Nereis pelagica						x x x	
Diopatra cuprea				x x x			
Chaetopterus pergamentaceous						x x x	
Arenicola, sp.						x x x	
Sabellaria vulgaris						x x x	
CRUSTACEANS							
Lepus antifera						xxxxx	x x x
Penaeus setiferus						xxxxx	xxxxx
Crangon heterochelis						x x x	x x x
Hyppolyte zostericola				x x x			
Tozeuma carolinense				x x x			
Palaemon tenuicornis			x x x				
Conchordia gibberosa				x x x			
Palaemonetes carolinensis				x x x			
Emerita talpoidea						xxxxx	
Eupogebia affinis						x x x	
Pagurus floridanus						x x x	
Clibinarius vitattus						x x x	
Uca mordax	xxxxx						
Pinnotheres maculatus				x x x			
Eupanopeus herbstii				x x x			
Eupanopeus rugosus				x x x			
Neopanope texana						x x x	
Menippe mercenaria				x x x			
Menippe nodifrons						x x x	
Callinectes sapidus			x x x	x x x	x x x	x x x	
Petrolisthes armatus			x x x	x x x	x x x	x x x	
Libinia dubia						x x x	
Hepatus ephiliticus				x x x			
Squilla empusa						x x x	
Hadley, 1936							
GASTROPODS							
Littorina irrorata	xxxxx	- - -					
Busycon contrarium		- - -					
Busycon spiratum		- - -					
Cantharus cancellarius		- - -					
Neritina reclivata		- - -					
Oliva sayana		- - -					
Polinices duplicatus		- - -					
Crepidula plana		x x x					
Thais haemastoma floridana		- - -					
PELECYPODS							
Anadara campechiensis		- - -					
Anadara brasiliana		- - -					
Cyrtopleura costata		- - -					
Dinocardium robustum		- - -					
Dosinia discus		- - -					
Ensis minor		-----					
Macoma constricta		- - -					
Mulinia lateralis		- - -					
Crassostrea virginica		-----					
Atrina, sp.		- - -					
Labiosa plicatella		- - -					
Rangia cuneata		-----					
Tagelus gibbus		- - -					
Mercenaria campechiensis texana		-----					
Periploma inaequalis		-----					

x = Living. Frequency of x's and –'s indicate relative abundance.
– = Dead.

terized by a scarcity of species and individuals of macro-organisms. Biological material from cores and the few biological stations taken in this environment indicates a distinct fauna. Living *Macoma mitchelli* Dall was collected only in this region (Fig. 13b). In Texas it has been reported to be very abundant in the waters near the Guadalupe River Delta where environmental conditions are somewhat similar (Ladd, 1951, p. 142, as *Tellina texana*; Parker, 1955). Another species, *Macoma tageliformis* Dall, was also common, living in the delta front region, especially in the vicinity of the mouth of Pass a'Loutre. At several stations during the fall of 1951 there were large numbers of very small *Mulinia lateralis* (Say) in the delta front region when the Mississippi River was at a low stage.

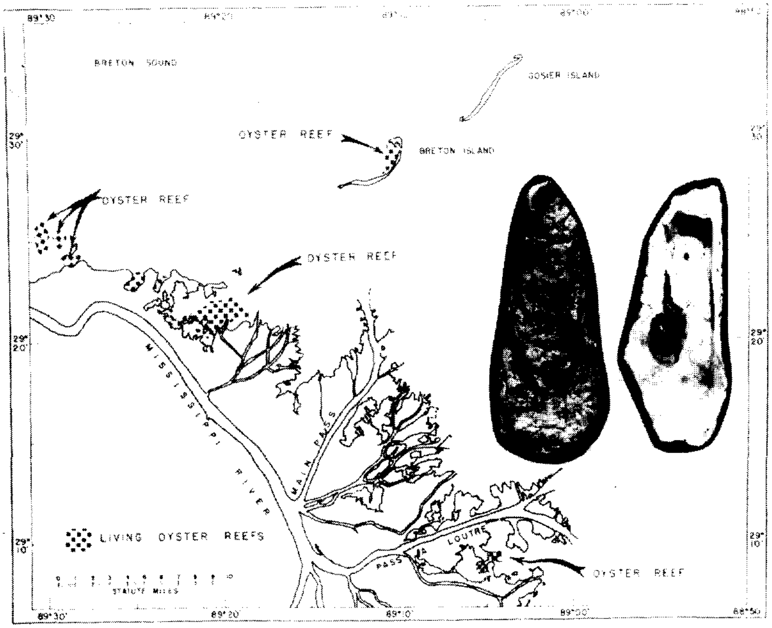


FIG. 14.—Location of living oyster reefs (*Crassostrea virginica*) in east Mississippi Delta area.

This pelecypod can not be considered a characteristic mollusk of this area alone, since its shell was taken in varying numbers from almost every station in Breton Sound and on the shallow part of the continental shelf.[4] In certain areas near the delta shores the common commercial oyster, *Crassostrea virginica* (Gmelin) could be considered the characteristic invertebrate. Extensive reefs of living oysters were found in the large indentations or bays of the Delta, especially Quarantine, Coquille, and California bays, several miles northwest of the area studied (Fig. 1).[5] A small oyster reef was observed in Blind Bay, which lies be-

[4] In November, 1955, a survey of the submarine natural levee at North Pass showed a predominance of living *Macoma mitchelli*, *Neritina reclivata*, *Rangia flexuosa*, and dead shell composed of *Mulinia lateralis*, *Petricola pholadiformis*, *Macoma constricta*, and *Rangia cuneata*.

tween Pass a'Loutre and Southeast Pass in the southern part of the Delta, and also another small reef was located behind Breton Island in the lagoon on the Sound side. Figure 14 shows the locations of living oyster reefs in the east delta region. The fauna which one might expect to be associated with oyster reefs in the delta region is similar to that described by Puffer and Emerson (1953). Although Puffer and Emerson's paper deals with the oyster-reef biota of the central Texas coast, the same species were found dead in old oyster-reef deposits in upper Breton Sound, and are illustrated in Puffer and Emerson's paper. The polychaete *Lumbrineris bifilaris* (Ehlers) was found living very close to the delta shore. Fresh shells of *Rangia cuneata* and *Rangia flexuosa* were observed in the delta front region, although no living *Rangia* was found. A similar assemblage of mollusks is discussed by Van Andel (1954, pp. 113–17) as occurring in the shallow waters surrounding the Orinoco River Delta. The characteristic macro-organism species for the delta front and lower distributaries are the following (Pl. I).

Macoma mitchelli	—Few living and dead, should be found more abundant with more intensified collecting
Macoma tageliformis	—Fairly common, living in Pass a'Loutre region
Rangia cuneata	—Probably common in certain areas
Rangia flexuosa	—Less common than *R. cuneata*
Crassostrea virginica	—Very common, forming reefs in protected areas
Lumbrineris bifilaris	—May be found abundant with better sampling
Anachis obesa	—Common, although equally as common in inlets
Littoridina sphinctostoma	—Several specimens thought to be this species were taken in delta front region, and it is one of most characteristic forms of Guadalupe River Delta region in Texas (Ladd, 1951, p. 143).

III. *Lower Breton Sound and pro-delta slopes.*—This subdivision of the Breton Sound-shallow shelf region, corresponds roughly with Scruton's "Pro-Delta silty clay" sedimentary unit (Scruton, 1956), and is based primarily on the small numbers of species and individuals which live in this fluid clayey bottom. As can be expected in a division where no topographic boundaries exist, there is no definite boundary between faunas. There is a gradation from an area where few or no animals are found to increasing populations on the north and to the rich and varied faunas of the upper sound. If a boundary exists it can be found at the farthest extent of the most turbid waters pouring out of Baptiste Collette Bayou, Main Pass, and Pass a'Loutre, producing the clayey silt and silty clay bottoms shown in the general area in Figure 11. The physical characteristics which differentiate this region from surrounding areas are: a somewhat more variable chlorinity than surrounding waters of equal depth; a very fine silty clay to clayey silt bottom; and a generally year-round occurrence of high turbidity (suspended sediments) from the river distributaries. Although little is known concerning the influence of high turbidity and fine fluid bottom upon the particular animals living in the delta region, there is some reason to believe that

[5] A representative sample obtained in November, 1955, from one of these reefs contained many living *Crassostrea virginica*, *Brachidontes recurvus*, *Crepidula plana*, *Martesia* sp., and barnacles.

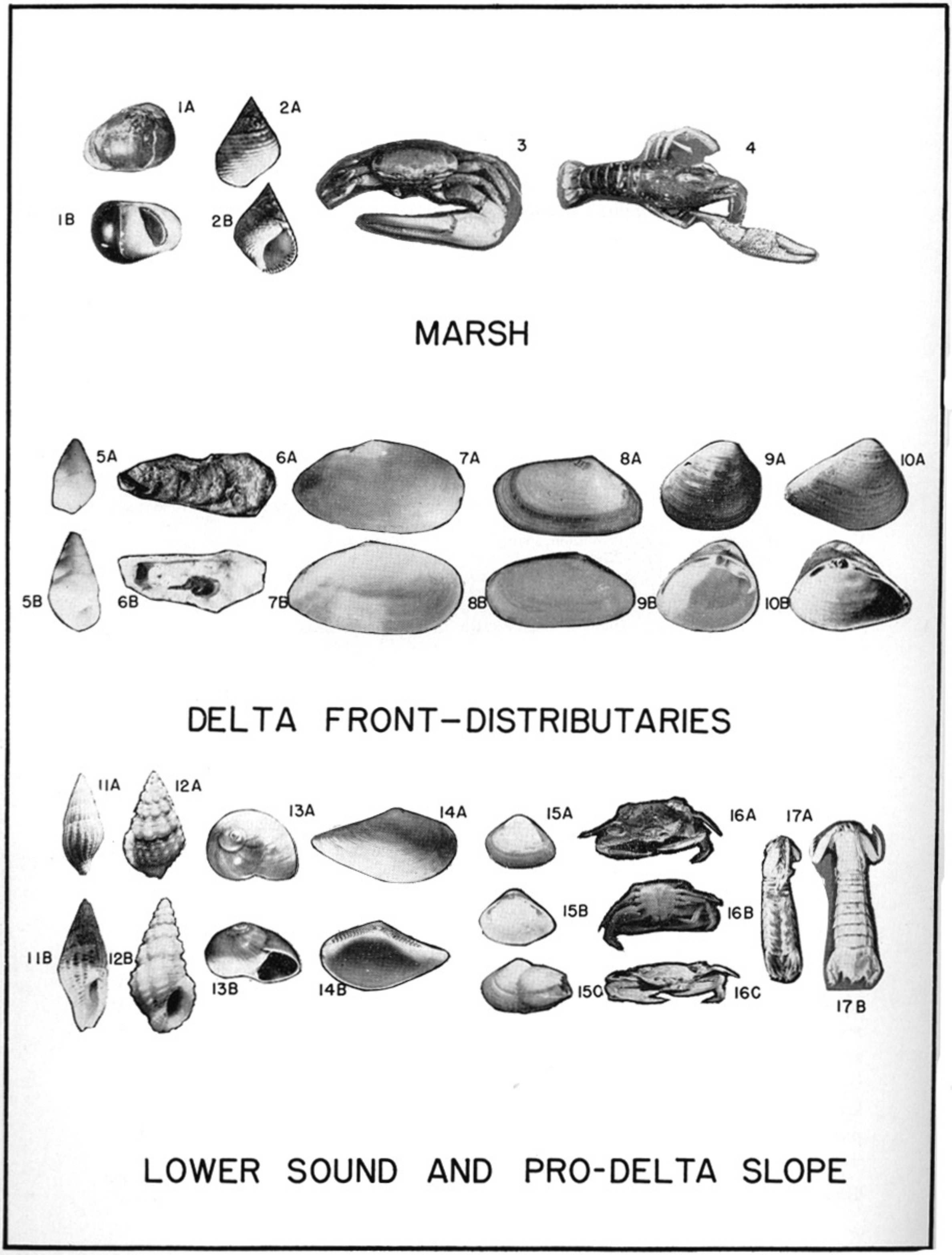

1A
2A
3
4
1B
2B
MARSH
5A
6A
7A
8A
9A
10A
5B
6B
7B
8B
9B
10B
DELTA FRONT-DISTRIBUTARIES
11A
12A
13A
14A
15A
16A
17A
15B
16B
11B
12B
13B
14B
15C
16C
17B
LOWER SOUND AND PRO-DELTA SLOPE

PLATE I

the filter-feeding of some animals and the larval settlement of many invertebrates may be inhibited by these two factors; thus only certain types of organisms may occur in the lower sound and pro-delta slope area.

Only 20 species of macro-invertebrates were found living in the lower sound and pro-delta slope area as compared with more than 50 species living in the upper sound region. A few mollusks and other invertebrates can be considered indicative for the lower sound area and are common enough to make good environmental indicators. Of these, the pelecypods, *Nuculana eborea* (Conrad) and *Mulinia lateralis*, and the two gastropods, *Polinices duplicatus* (Say) and *Anachis avara similis* (Ravenel), are the most abundant and distinctive. The distributions of *Nuculana eborea* and *Mulinia lateralis* are shown in Figure 15a and b, and those of *Polinices duplicatus* and *Squilla empusa* in Figure 16a and b. The macro-organisms which can be considered characteristic for the lower sound and pro-delta slope area are as follows (Pl. I).

Mulinia lateralis	—Extremely abundant, living on clayey slope near Main Pass. Dead throughout inshore delta region
Nuculana eborea	—Common living in northwestern part of this environment, dead throughout inshore regions of Mississippi Delta area
Polinices duplicatus	—Common living here, a few scattered in upper sound and inlet environments
Anachis a. similis	—Few living and dead, few also found in inlets
Anachis a. semiplicata	—Few, more common in near-by inlet region
Squilla empusa	—Mantis shrimp are strangely common in this region
Portunus gibbesi	—This swimming crab is also common in inlet between Breton Island and Main Pass
Nassarius acutus	—Abundant, especially where there are large populations of *Mulinia*. Not strictly characteristic of lower sound and delta, as occurs in varying numbers throughout whole delta region
Abra lioica	—Although primarily shallow-shelf species, this pelecypod is common in lower delta region in vicinity of Pass a'Loutre

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PLATE I

I. Marsh Assemblage

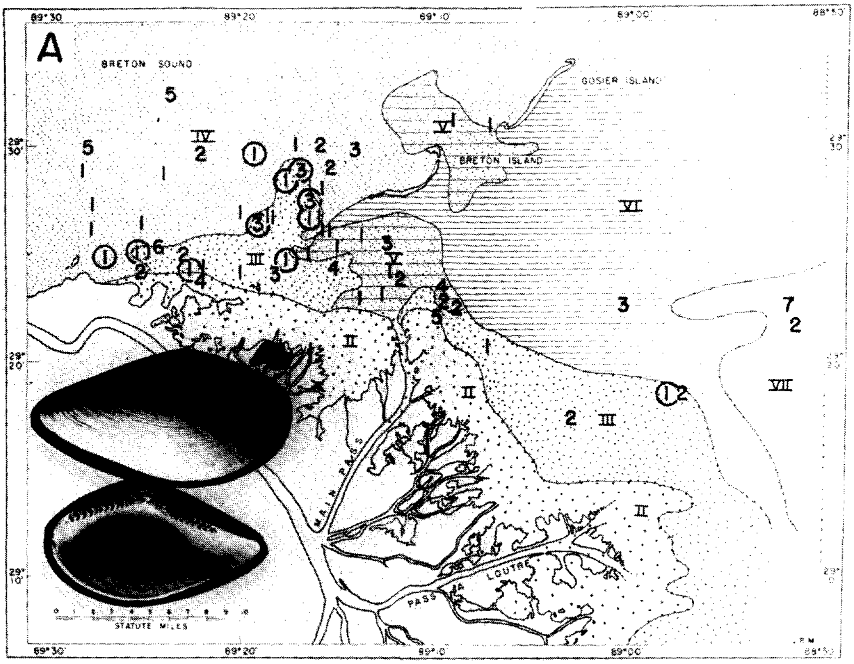
Fig. 1.—*Neritina reclivata* (Say, 1822), size—11×13 mm., a. side view, b. front.
Fig. 2.—*Littorina irrorata* (Say, 1822), size—19×14 mm., a. back view, b. aperture.
Fig. 3.—*Uca*, species, size—24×17 mm., side view.
Fig. 4.—*Cambarus*, species, size—125 mm., top or dorsal.

II. Delta Front and Distributaries Assemblage

Fig. 5.—*Littoridina sphinctostoma* Abbott and Ladd, 1951, size—3×2 mm., a. back view, b. front or aperture.
Fig. 6.—*Crassostrea virginica* (Gmelin, 1790), size—170×70 mm. a. exterior, b. interior.
Fig. 7.—*Macoma mitchelli* Dall, 1895, size—21×12 mm., a. exterior, b. interior.
Fig. 8.—*Macoma tageliformis* Dall, 1900, size—44×25 mm., a. exterior, b. interior.
Fig. 9.—*Rangia cuneata* (Gray, 1831), size—42×39 mm., a. exterior, b. interior.
Fig. 10.—*Rangia flexuosa* (Conrad, 1840), size 36×30 mm., a. exterior, b. interior.

III. Lower Sound and Pro-Delta Slope Assemblage

Fig. 11.—*Anachis avara similis* (Ravenel, 1861), size—8×3 mm., a. back, b. front view.
Fig. 12.—*Nassarius acutus* (Say, 1822), size—11×4 mm., a. back, b. front view.
Fig. 13.—*Polinices duplicatus* (Say, 1822), size—39×41 mm., a. top, b. aperture.
Fig. 14.—*Nuculana eborea* (Conrad, 1846), size—11×6 mm., a. exterior, b. interior.
Fig. 15.—*Mulinia lateralis* (Say, 1822), size—10×7 mm., a. exterior, b. interior, c. typical association with barnacle, commonly occurring in the Delta Slope environment.
Fig. 16.—*Portunus gibbesi* (Stimpson, 1859), size—49×22 mm., a. dorsal, b. ventral, c. side view.
Fig. 17.—*Squilla empusa* Say, 1818, size—95 mm., a. ventral, b. dorsal side.



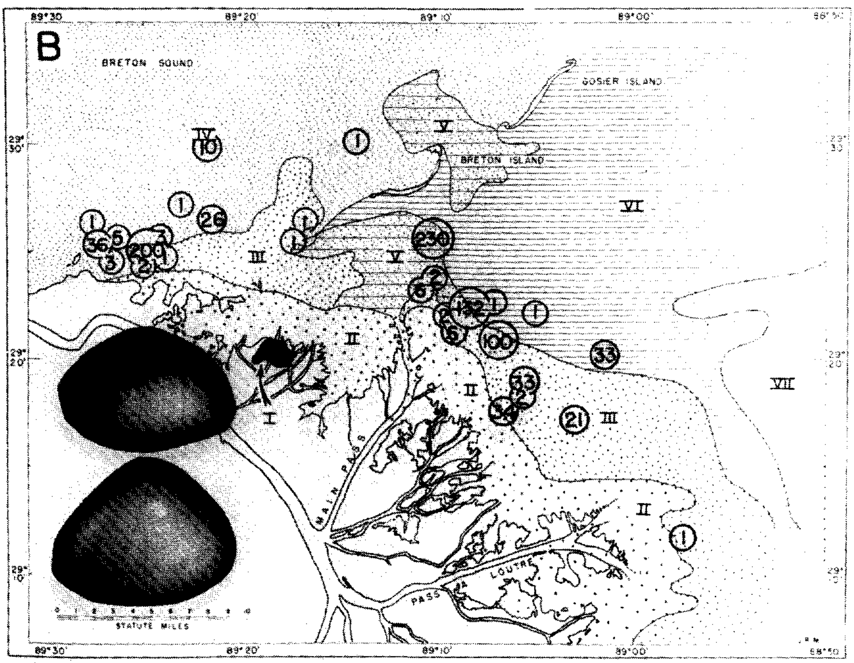
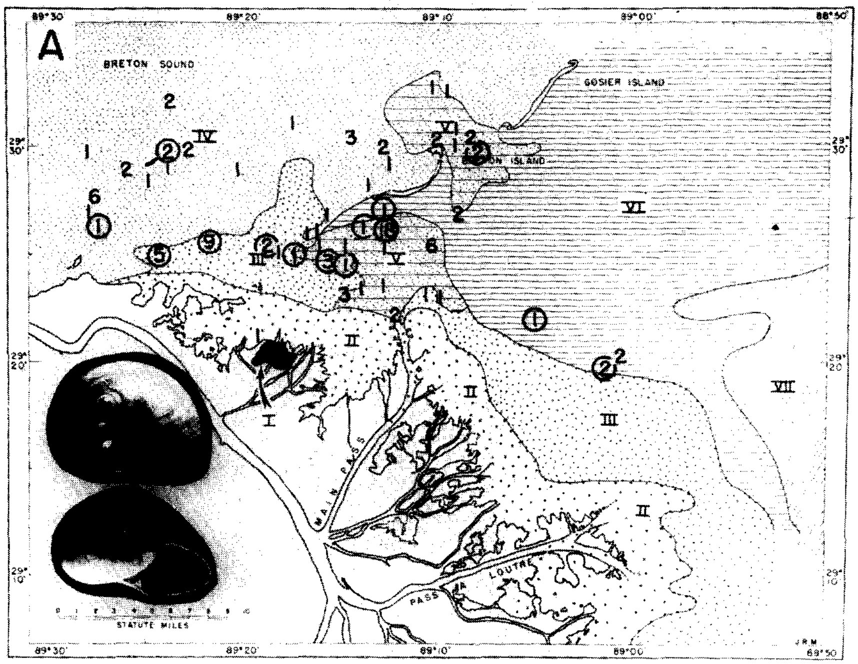


FIG. 15a.—Distribution of pelecypod, *Nuculana eborea*, indicative of lower sound and pro-delta slope. Circled numbers indicate living occurrences, uncircled numbers, dead occurrences.

FIG. 15b.—Distribution (all living) of pelecypod, *Mulinia lateralis*, indicative of lower sound and pro-delta slope environment.



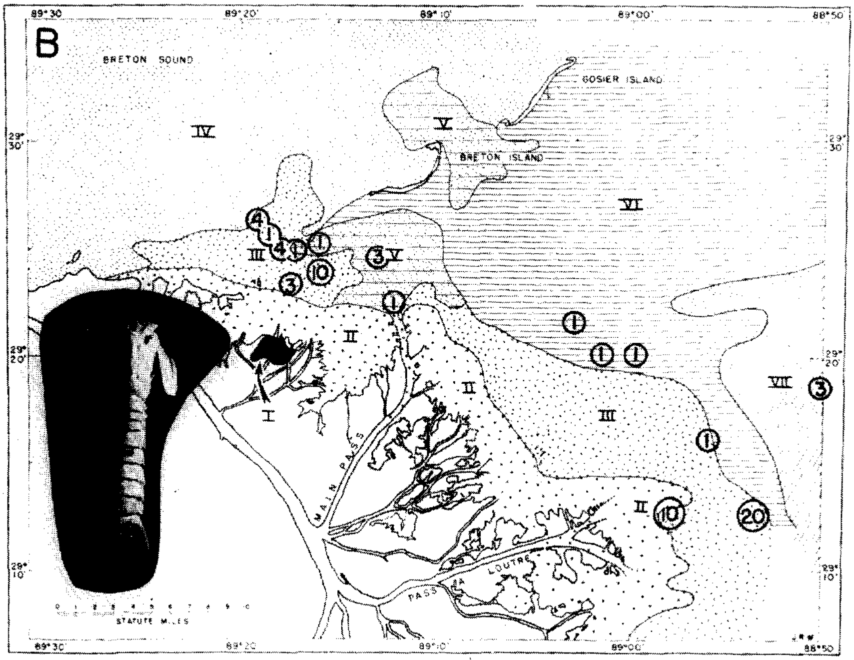


FIG. 16a.—Distribution of gastropod, *Polinices duplicatus*, indicative of lower sound and pro-delta slope environment. Circled numbers indicate living, uncircled—dead occurrences.

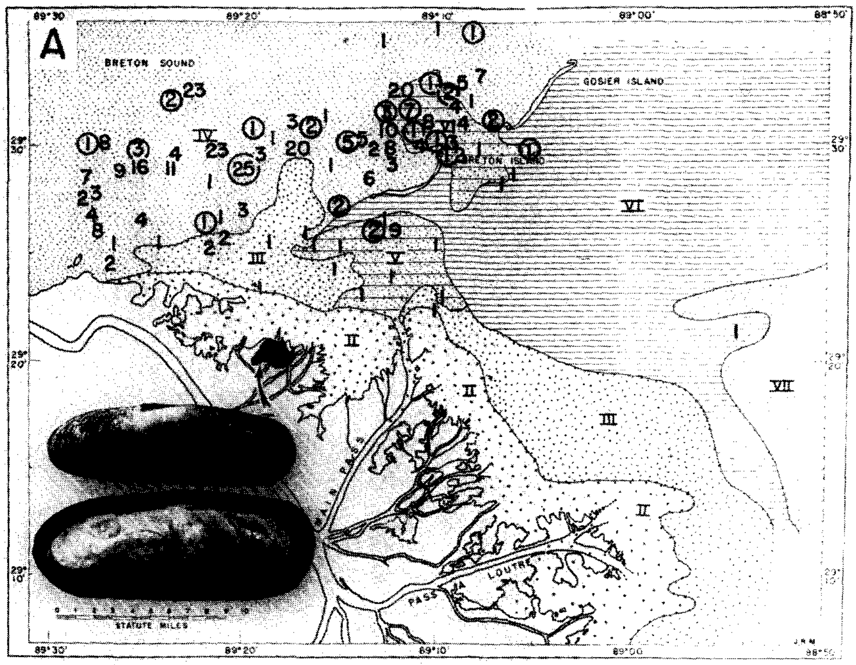
FIG. 16b.—Distribution of stomatopod, *Squilla empusa*, indicative of lower sound and pro-delta slope environment.

IV. *Upper Breton Sound and Chandeleur Sound.*—This part of the east Mississippi Delta area is more like the typical high-chlorinity bay environments along the Texas coast (Ladd, 1951, pp. 149, 152–54) than any other part of the Delta region. The physical characteristics of these waters resemble to some extent those of lower Aransas Bay, Matagorda, and Corpus Christi bays on the Texas coast (Galtsoff, 1931; Collier and Hedgpeth, 1950; Hedgpeth, 1953; and Parker, 1955), and many of the organisms are common to both areas. The chlorinity of the upper sound region is somewhat more constant than in the lower sound area, and normally ranges from about 10 to 19 ‰. These relatively unstable but rather high chlorinities apparently exclude any extensive living oyster reefs of *Crassostrea virginica* (except for a small one behind Breton Island), and also exclude many of the very low-chlorinity animals such as *Rangia* and *Macoma mitchelli*.

Many species were found only in the upper sound region, although many of these were represented by a few specimens. Of the more than 90 species of invertebrates collected in the area, 20 species were characteristic and abundant, both living and dead. Most of the species found in the upper sound environment are listed in Tables I–III. These tables also demonstrate the difference in the number and abundance of species between the two sound environments. Several distribution maps of the more characteristic upper sound animals are given: the pelecypods, *Tagelus divisus* (Spengler) (Fig. 17a) and *Abra aequalis* Say (Fig. 17b) and the gastropod, *Retusa canaliculata* (Say) (Fig. 18a), and the brittle-star, *Amphiodia limbata* (Grube) (Fig. 18b). A more complete list of the characteristic macro-invertebrates of the upper sound region follows (Pls. II–III).

MOLLUSKS
PELECYPODS

Anadara transversa	—Fairly common, few living
Noetia ponderosa	—Few, some living
Nuculana acuta	—These specimens lack characteristic ridges and shape of variety of *Nuculana acuta* consistently found offshore in 13–50 fathoms
Brachidontes recurvus	—Rather common as dead fragments
Crassostrea virginica	—Very common as dead shell reefs
Ostrea equestris	—Very common dead, mixed with dead *C. virginica*
Crassinella martinicensis	—In some localities extremely common dead, although very few found living
Diplodonta punctata	—Fairly common dead, uncommon living
Diplodonta semiaspera	—Common, both living and dead
Lucina crenella	—Common, dead
Mercenaria c. texana	—Very common dead as juveniles, few living adults, reported living in large beds back of barrier islands
Dosinia discus	—Very common dead, scarce living (juveniles), indications that living adults more common in shallow shelf region
Abra aequalis	—Common both living and dead in both upper sound and shallow shelf near barrier islands
Tagelus divisus	—Very abundant living and dead (most characteristic pelecypod)
Tagelus plebeius	—Few, one living
Semele proficua	—Common, few living
Tellina alternata	—Common, few living, probably common on shallow shelf also
Tellidora cristata	—Common, few living in both upper sound and inlets
Macoma tenta	—Abundant, living and dead, also very characteristic
Corbula contracta	—Common, few living



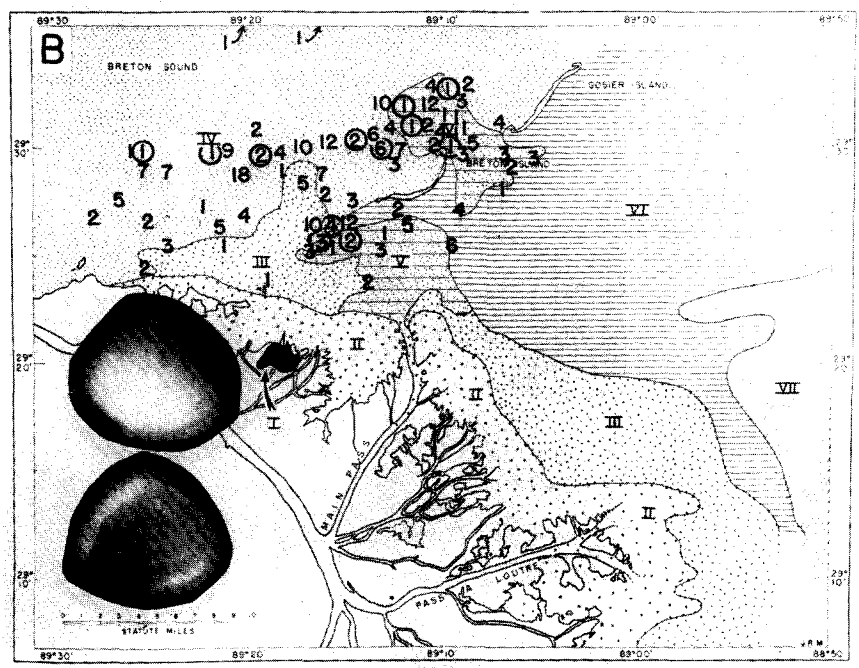
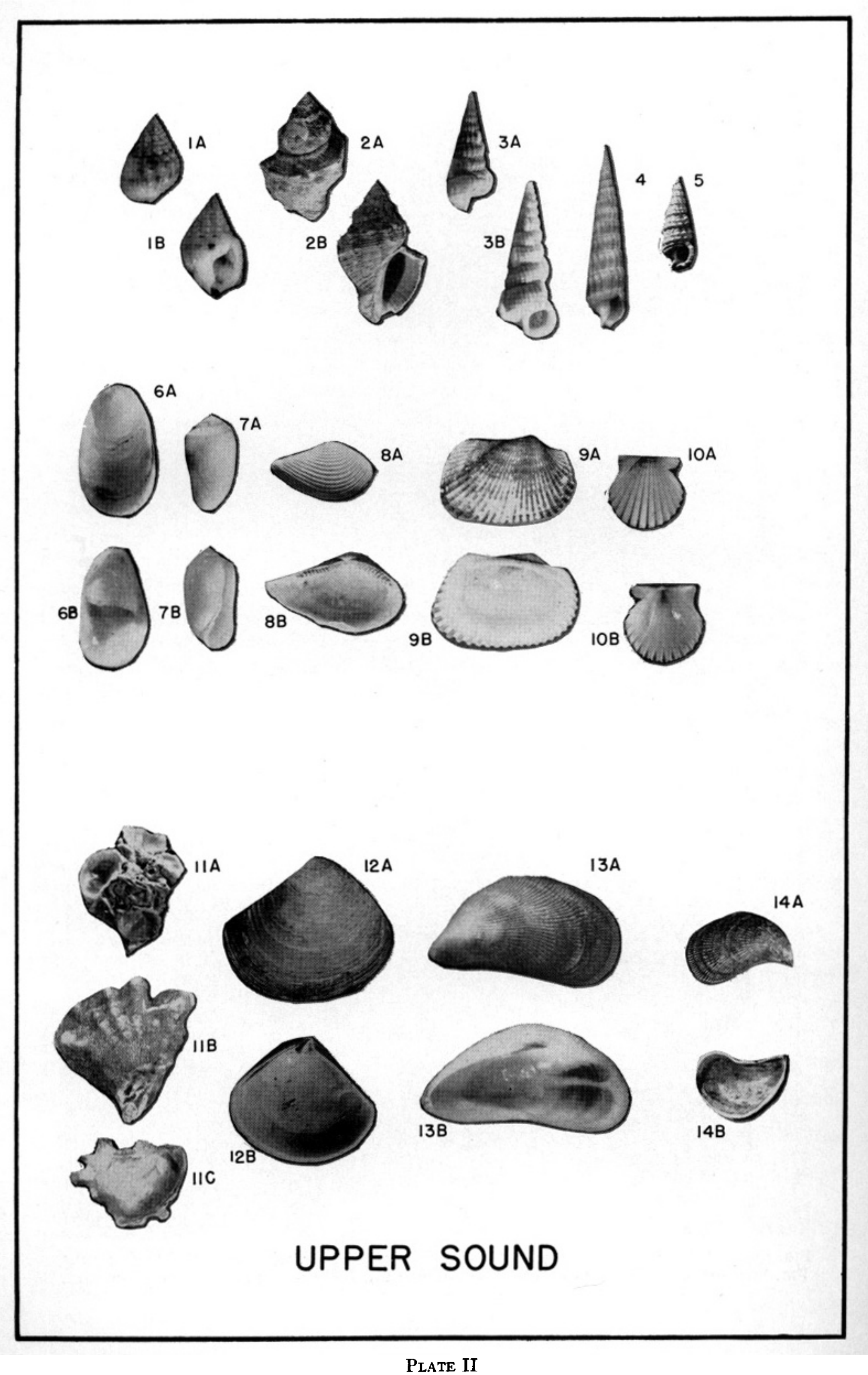


FIG. 17a.—Distribution of pelecypod, *Tagelus divisus*, indicative of upper sound environment.
FIG. 17b.—Distribution of pelecypod, *Abra aequalis*, indicative of upper sound environment.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11C
UPPER SOUND

PLATE II

GASTROPODS	
Crepidula plana	—Abundant living and dead
Crepidula fornicata	—Common dead, found also in inlets and Gulf
Nassarius vibex	—Rare, living and dead in open sound, common living on inner side of Breton Island
Terebra protexta	—Common dead, rare living
Turbonilla hemphilli	—Common dead, also common in inlets
Retusa canaliculata	—Common dead in upper sound only
POLYCHAETE WORMS	
Glycera americana	—Common, living
Chaetopterus variopedatus	—Common, living
Sthenelais articulata	—Rare, living
Lumbrineris, sp.	—Rare, living
CRUSTACEANS	
Petrolisthes armatus	—Few, living
Crangon heterochelis	—Common, living
ECHINODERMS	
Amphiodia limbata	—Abundant, living
COELENTERATES	
Astrangia astreiformis	—Common, dead

Cary and Spaulding (1909) list many organisms living in Breton and Chandeleur sounds which were not collected by the writer, but are common in the other high-salinity bays of the northern Gulf of Mexico. Those species collected as fragments by the writer and collected abundantly, living, by Cary and Spaulding are: *Epitonium sayana*, *Anomia simplex*, *Aequipecten irradians amplicostatus*, and *Atrina rigida*, the more common mollusks, and many species of crustaceans. Of particular interest is Spaulding's (1906; see Galtsoff, 1954, p. 209) report on the extensive beds of *Mercenaria campechiensis texana* and *Aequipecten irradians amplicostatus*, the commercial clam and scallop, in the lagoons behind the Chandeleur and Breton islands. No living scallops and only a few large living clams were collected on this survey, although the method of sampling may be responsible for not finding these beds.

V. *Inlets or passes.*—The inlets (Fig. 11) are distinct from the rest of the environmental regions in the delta area, both in the biological assemblage and en-

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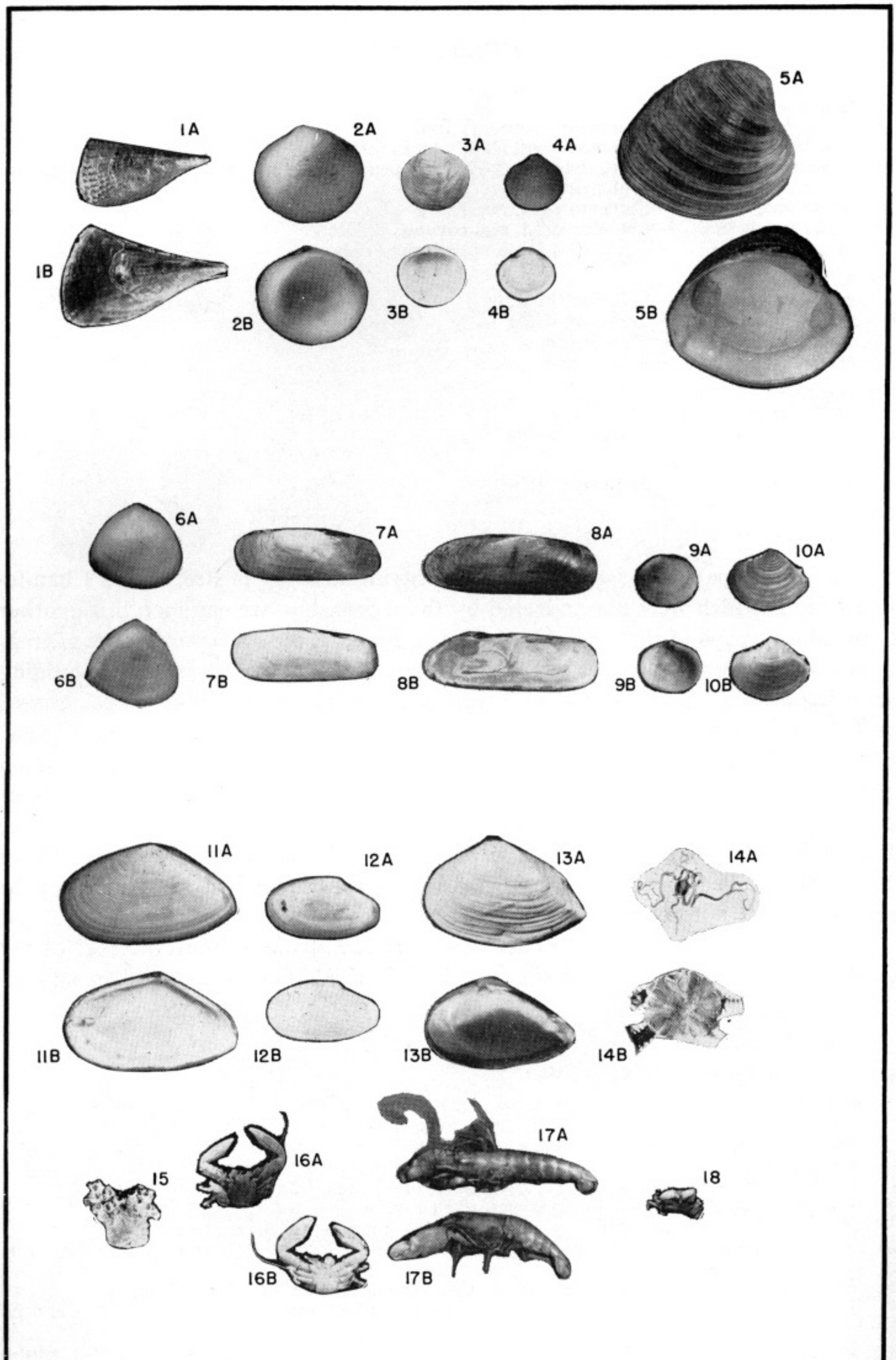
PLATE II

IV. UPPER SOUND ASSEMBLAGE

FIG. 1.—*Nassarius vibex* Say, 1822, size—12×8 mm., a. back, b. aperture.
FIG. 2.—*Thais haemastoma haysae* Clench, 1927, size—59×33 mm., a. back, b. front.
FIG. 3.—*Cerithidea pliculosa* (Menke, 1824), size—32×11 mm., a. back, b. front.
FIG. 4.—*Terebra dislocata* (Say, 1822), size—27×7 mm., front or aperture view.
FIG. 5.—*Cerithium muscarum* Say, 1832, size—19×7 mm., front or aperture view.
FIG. 6.—*Crepidula plana* Say, 1822, size—22×12 mm., a. exterior, b. interior.
FIG. 7.—*Retusa canaliculata* (Say, 1827), size—6×3 mm., a. back, b. aperture.
FIG. 8.—*Nuculana acuta* Conrad, 1832 (nearshore form), size—6×4 mm., a. exterior, b. interior.
FIG. 9.—*Anadara transversa* (Say, 1822), size—15×10 mm., a. exterior, b. interior.
FIG. 10.—*Aequipecten irradians amplicostatus* (Dall, 1898), size 65×63 mm., a. exterior, b. interior.
FIG. 11.—*Ostrea equestris* Say, 1834, size—a. clump—38×50 mm., b. exterior, c. interior—19×14 mm.
FIG. 12.—*Crassinella martinicensis* (d'Orbigny, 1842), size 8×7 mm., a. exterior, b. interior.
FIG. 13.—*Brachidontes exustus* (Linné, 1758), size—17×9 mm., a. exterior, b. interior.
FIG. 14.—*Brachidontes recurvus* (Rafinesque, 1820), size—16×11 mm., a. exterior, b. interior.



UPPER SOUND

PLATE III

vironmental factors. Physically, the inlets are characterized by strong tidal currents (Scruton, manuscript), a firm bottom of sand, sandy, silty clay, and old shell material concentrated by the currents, and greater depths with narrower ranges of temperature and chlorinity than those of surrounding areas. The inlets show close faunal affinities with both the upper and lower sound environments and the shallow shelf, which is to be expected, since the currents bring water into this environment from each direction. Although faunal elements are present from environments on each side of the inlets, there are at least 12 species of macro-organisms which were found only in the inlets. Of the 100 species collected in the inlets, 56 were found alive, and 44 dead. The distribution of *Anachis avara semiplicata* (Stearns) and *Hemipholis elongata* (Say), the two species restricted mostly to inlets, is illustrated in Figure 19a and b. Two species which are not restricted entirely to the inlets and are represented by occasional individuals in other environments are the gastropod, *Olivella mutica* (Say), and the pelecypod, *Trachycardium muricatum* (Linné) (Fig. 20a and b). Those macro-invertebrates which may be considered characteristic of the inlets are the following (Pl. IV).

MOLLUSKS
PELECYPODS

Anadara brasiliana	—Common dead, few living
Trachycardium muricatum	—Common living and dead
Chione cancellata	—Few living
Lucina amiantus	—Abundant living and dead, but also occurs commonly in upper sound and shallow-shelf region
Petricola pholadiformis	—Few living, fairly common dead
Cyrtopleura costata	—Common dead, at times abundant as dead shell on barrier-island beaches
Pandora trilineata	—Few living, fairly common dead, but also found in upper sound near inlets

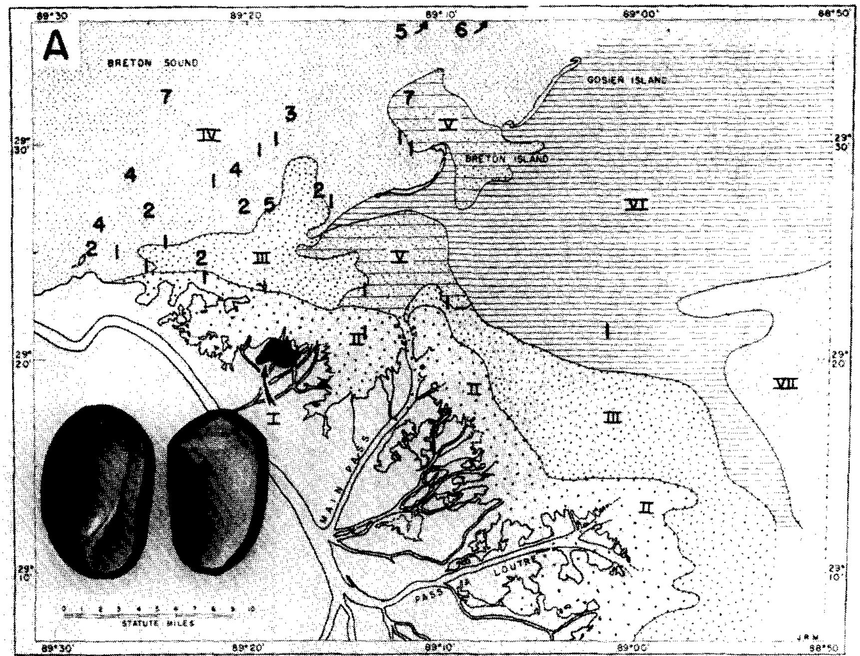
GASTROPODS

Diodora cayenensis	—Few living, common dead
Natica pusilla	—Few living, common dead

PLATE III

IV. UPPER SOUND ASSEMBLAGE (CONTINUED)

FIG. 1.—*Atrina rigida* (Solander, 1786), size—188×108 mm., a. exterior, b. interior.
FIG. 2.—*Diplodonta punctata* (Say, 1822), size—12×11 mm., a. exterior, b. interior.
FIG. 3.—*Diplodonta semiaspera* Philippi, 1836, size—10×9 mm., a. exterior, b. interior.
FIG. 4.—*Lucina crenella* (Dall, 1901), size—5×5 mm., a. exterior, b. interior.
FIG. 5.—*Mercenaria campechiensis texana* (Dall, 1902), size—102×94 mm., a. exterior, b. interior.
FIG. 6.—*Abra aequalis* (Say, 1822), size—12×10 mm., a. exterior, b. interior.
FIG. 7.—*Tagelus plebeius* (Solander, 1786), size—42×16 mm., a. exterior, b. interior.
FIG. 8.—*Tagelus divisus* (Spengler, 1794), size—27×9 mm., a. exterior, b. interior.
FIG. 9.—*Semele proficua* (Pultney, 1799), size—13×11 mm., a. exterior, b. interior.
FIG. 10.—*Tellidora cristata* (Recluz, 1842), size—15×13 mm., a. exterior, b. interior.
FIG. 11.—*Tellina alternata* Say, 1822, size—52×29 mm., a. exterior, b. interior.
FIG. 12.—*Macoma tenta* (Say, 1834), size—10×9 mm., a. exterior, b. interior.
FIG. 13.—*Corbula contracta* Say, 1822, size—7×5 mm., a. exterior, b. interior.
FIG. 14.—*Amphiodia limbata* (Grube), size—disc diameter—6 mm., a. top, b. disc.
FIG. 15.—*Astrangia astreiformis* Milne-Edwards and Haime, size—clump or colony, 25 mm.
FIG. 16.—*Petrolisthes armatus* (Gibbes), size—10×12 carapace, a. dorsal, b. ventral.
FIG. 17.—*Crangon heterochelis* (Say), size—37 mm., a. dorsal, b. side view.
FIG. 18.—*Neopanope packardi* (Kingsley, 1789), size—8×7 (carapace), ventral view.



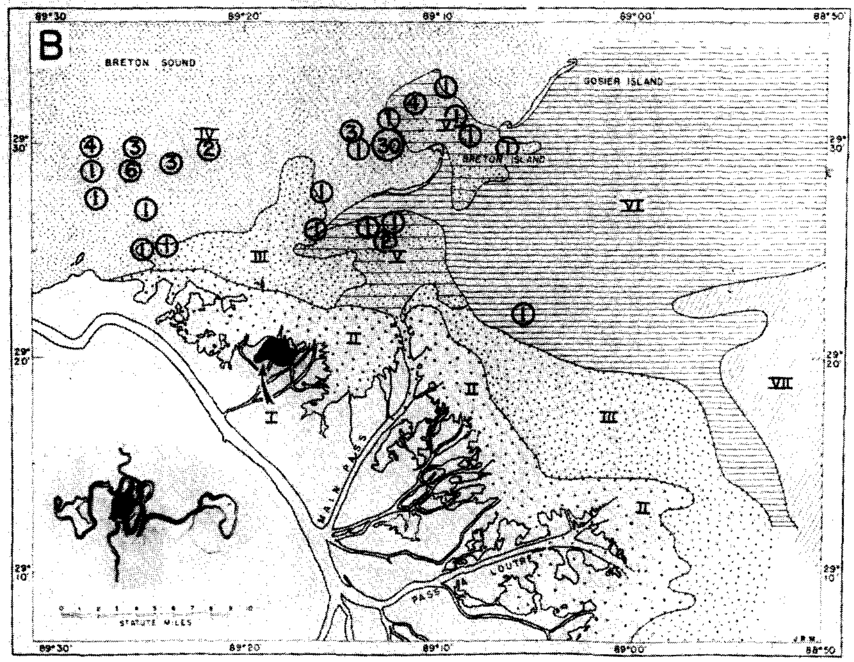
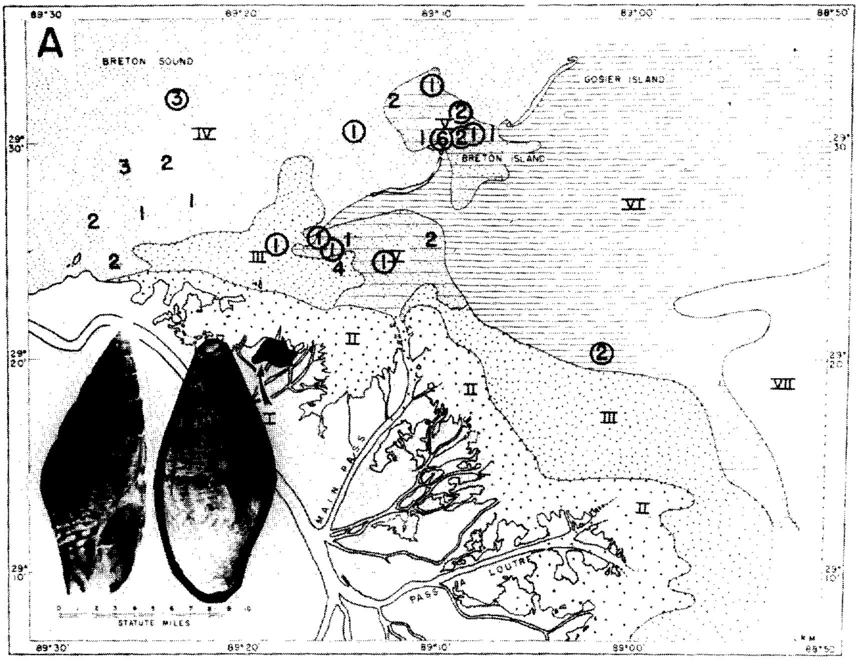


FIG. 18a.—Distribution of gastropod, *Retusa canaliculata* (all dead), indicative of upper sound environment.

FIG. 18b.—Distribution of brittle star, *Amphiodia limbata* (all living), indicative of upper sound environment.



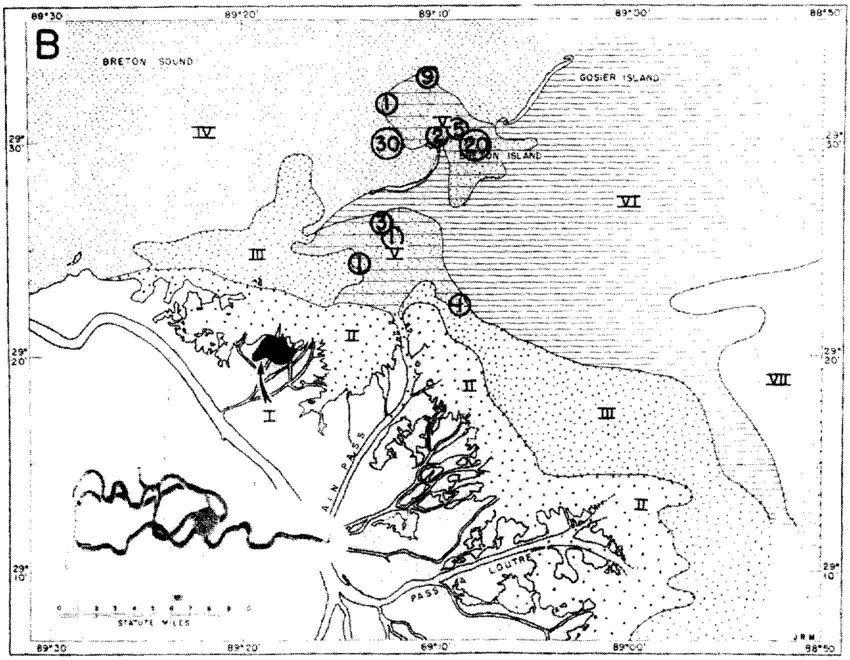
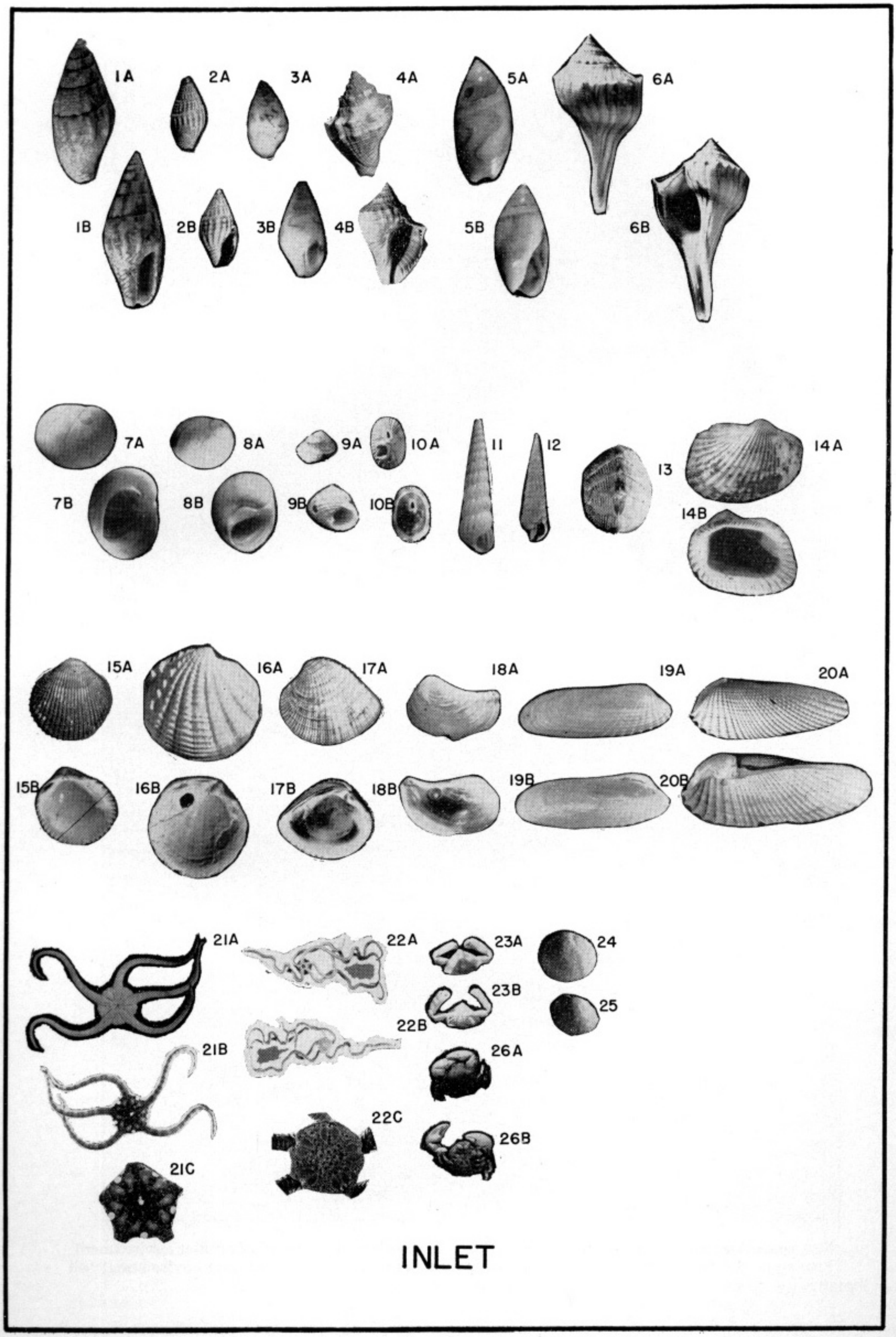


FIG. 19a.—Distribution of gastropod, *Anachis avara semiplicata*, indicative of inlet environment.
FIG. 19b.—Distribution of brittle star, *Hemipholis elongata*, indicative of inlet environment (all living).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21C
INLET

PLATE IV

Thais haemastoma floridana	—Few living, common dead, although not restricted to inlets
Anachis obesa	—Common living and dead, center of population in inlets
Anachis a. semiplicata	—Common living and dead
Mitrella lunata	—Few living and dead
Busycon contrarium	—Common living and dead, but not entirely restricted to inlet
Busycon spiratum plagosum	—Less common than other species of *Busycon*, and probably is more common on shallow shelf
Sinum perspectivum	—Few dead in inlets only
Olivella mutica	—Abundant both living and dead with center of abundance in inlets
Turbonilla hemphilli	—Common dead in inlets and upper sound
CHITONS	
Chaetopleura apiculata	—Few living in inlets only
ECHINODERMS	
Hemipholis elongata	—Abundant living
Ophiolepis elegans	—Abundant living, found also in deep channels of Chandeleur Sound
Luidia clathrata, *Mellita quinquiesperforata*, and *Moira atropos* all range into inlets, although are more indicative of shallow shelf	
CRUSTACEANS	
Heterocrypta granulata	—Common, living
Porcellana sayana	—Few living
POLYCHAETE WORMS	
Owenia fusiformis	—Few living
COELENTERATES	
Calliactis tricolor	—Fairly common, attached to hermit shell
BRYOZOA	
Discoporella umbellata	—Few, living
Cupuladria canariensis	—Few, living
Membranipora, sp.	—Abundant, living

Cary and Spaulding (1909) list the following species from the inlets of the Chandeleurs: the gastropods, *Modulus modulus* and *Sinum perspectivum*; the

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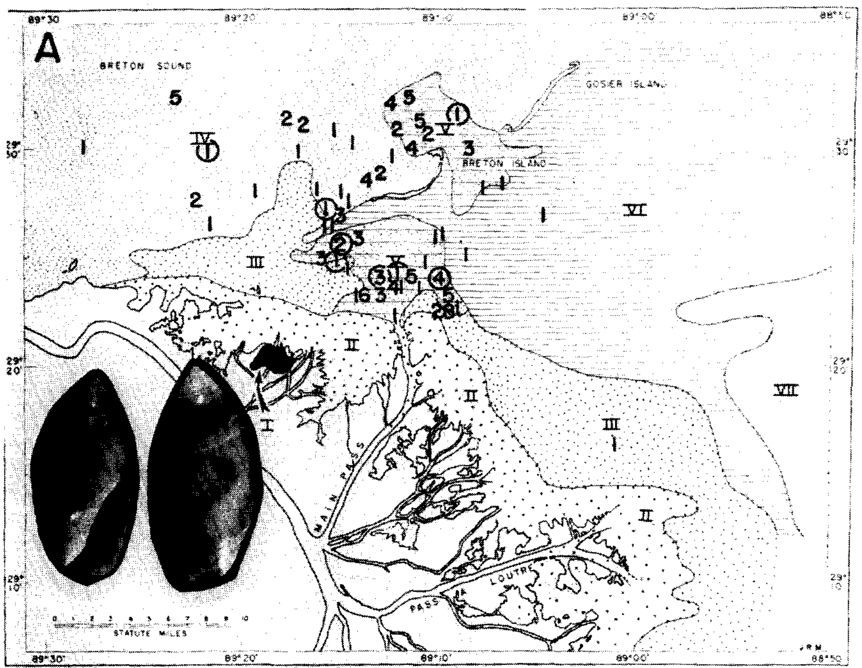
PLATE IV

V. INLET ASSEMBLAGE

FIG. 1.—*Anachis avara semiplicata* Stearns, 1873, size—11×5 mm., a. back, b. front.
FIG. 2.—*Anachis obesa* C. B. Adams, 1845, size—4×2 mm., a. back, b. aperture.
FIG. 3.—*Mitrella lunata* (Say, 1826), size—4×2 mm., a. back, b. aperture.
FIG. 4.—*Thais haemastoma floridana* (Conrad, 1837), size—47×29 mm., a. back, b. front.
FIG. 5.—*Olivella mutica* (Say, 1822), size—2×8 mm., a. back, b. aperture.
FIG. 6.—*Busycon contrarium* (Conrad, 1840), size—80×39 mm., a. back, b. aperture.
FIG. 7.—*Sinum perspectivum* (Say, 1831), size—31×31 mm., a. top, b. aperture.
FIG. 8.—*Natica pusilla* Say, 1822, size—3×4 mm., a. top view, b. aperture.
FIG. 9.—*Modulus modulus* (Linné, 1758), size—9×10 mm., a. side view, b. aperture.
FIG. 10.—*Diodora cayenensis* (Lamarck, 1822), size—12×7 mm., a. exterior, b. interior.
FIG. 11.—*Turbonilla hemphilli* (Bush, 1899), size—2×8 mm., front or aperture.
FIG. 12.—*Terebra protexta* (Conrad, 1843), size—26×6 mm., front or aperture.
FIG. 13.—*Chaetopleura apiculata* Say, 1830, size—10×7 mm., exterior or top view.
FIG. 14.—*Anadara brasiliana* (Lamarck, 1819), size—13×9 mm., a. exterior, b. interior.
FIG. 15.—*Trachycardium muricatum* (Linné, 1758), size—42×44 mm., a. exterior, b. interior.
FIG. 16.—*Lucina amiantus* (Dall, 1901), size—6×6 mm., a. exterior, b. interior.
FIG. 17.—*Chione cancellata* (Linné, 1758), size—26×22 mm., a. exterior, b. interior.
FIG. 18.—*Pandora trilineata* Say, 1822, size—20×11 mm., a. exterior, b. interior.
FIG. 19.—*Petricola pholadiformis* Lamarck, 1818, size—23×8 mm., a. exterior, b. interior.
FIG. 20.—*Cyrtopleura costata* (Linné, 1758), size—98×39 mm., a. exterior, b. interior.
FIG. 21.—*Ophiolepis elegans* (Lütken), size—disc—20 mm., arms 55 mm., a. ventral, b. dorsal, c. disc.
FIG. 22.—*Hemipholis elongata* (Say), size—disc 7 mm., a. ventral, b. dorsal, c. disc.
FIG. 23.—*Heterocrypta granulata* (Gibbes, 1849), size—15×10 (carapace), a. top, dorsal, b. ventral.
FIG. 24.—*Mamillopora cupula* Smitt, size—22 mm., colony.
FIG. 25.—*Cupuladria canariensis* Busk, size—18 mm., colony.
FIG. 26.—*Porcellana sayana* (Leach), size—12×11 mm., a dorsal, b. ventral.



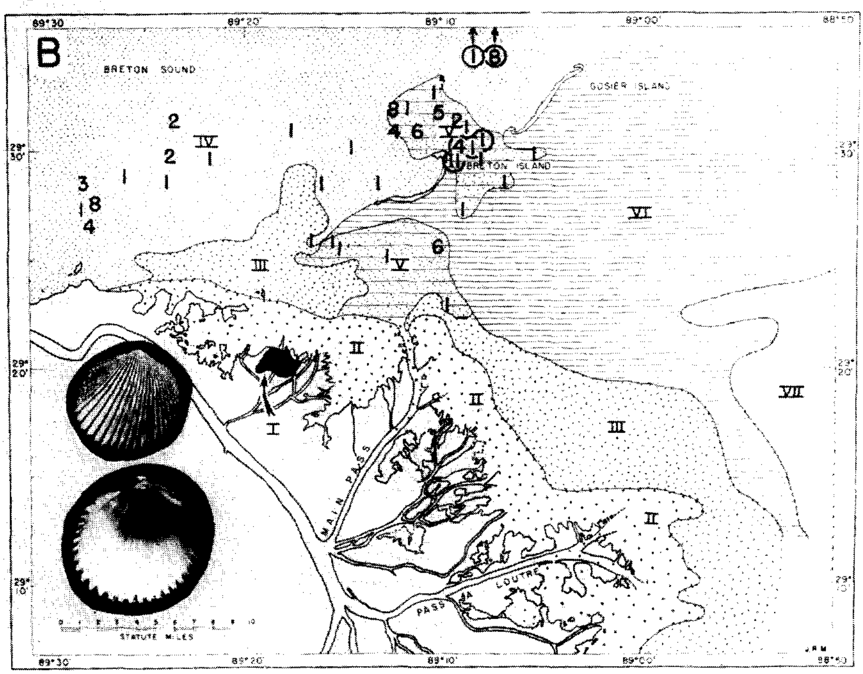


FIG. 20a.—Distribution of gastropod, *Olivella mutica*, indicative of inlet environment.

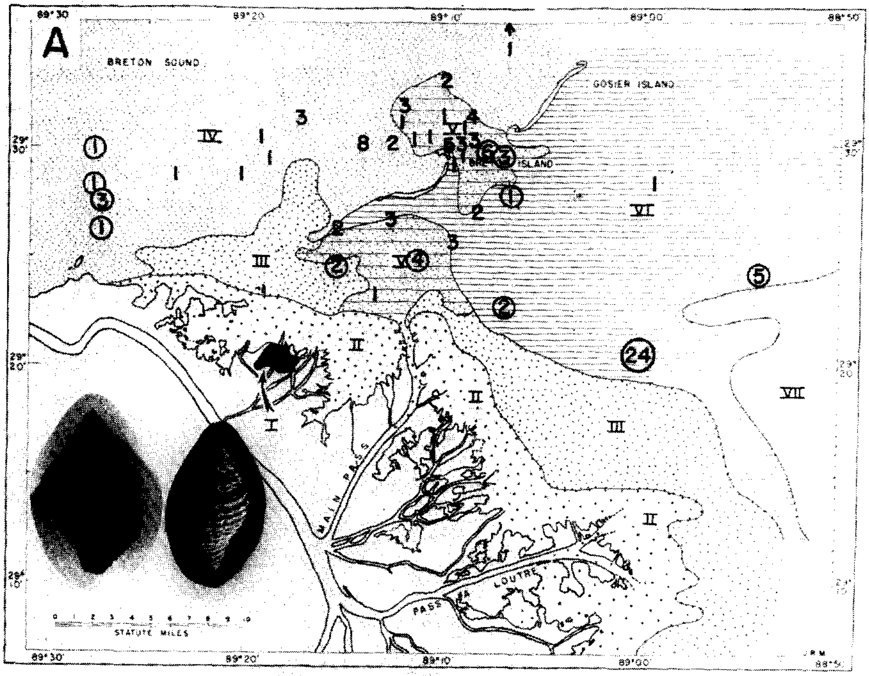
FIG. 20b.—Distribution of pelecypod, *Trachycardium muricatum*, indicative of inlet environment.

pelecypod, *Trachycardium muricatum*; and the crab, *Petrolisthes armatus* (Gibbes).

VI. *Shallow continental shelf of Gulf of Mexico from 0 to 13 fathoms, off barrier islands.*—Although no exact boundary can be drawn between the inlets and shallow continental shelf of the Gulf where the inlets are very wide, the shallow-shelf assemblage is distinct from that of the other areas. It does not extend to the vicinity of the shores of the active Mississippi Delta and other parts of the Gulf coast where rivers empty directly into the Gulf, because of the effect of the fresh water and sediments discharged directly into the open Gulf of Mexico. However, where the open Gulf meets the barrier islands and sandy peninsulas or coastline without barrier islands or large rivers, wave action forms sandy shores, and there is a typical high-salinity shallow-shelf fauna close to shore with characteristic surf-zone animals. In the typical shallow-shelf region, the chlorinities are generally above 14 ‰, and usually above 17 ‰, while the water temperatures are variable according to the season of the year. The fauna of this region is related to the warm-temperate waters of the Carolina coast, with occasional forms typical of the west coast of Florida (Hedgpeth, 1953; Pulley, 1953).

Although the characteristic invertebrates of the shallow-shelf region are many and varied, few were taken alive on this project because of inadequate collecting methods. The shells of many of the shallow-shelf species of mollusks often occur in large drifts on the beaches after storms, and their presence should characterize Gulf beach deposits in older formations. Eighty-one species of macroinvertebrates were collected in this area during the investigation, of which 32 species were living and 49 were dead remains. The distribution maps for some of the characteristic shallow-shelf organisms collected on this project are shown as follows: the gastropod, *Cantharus cancellarius* (Conrad) (Fig. 21a); the sea pansy, *Renilla mülleri* Kölliker (Fig. 21b); the polychaete worm, *Aglaophamus dicirris* Hartman (Fig. 22a); the starfish, *Luidia clathrata* (Say) (Fig. 22b); and the sand dollar, *Mellita quinquiesperforata* (Leske) (Fig. 23a). A pelecypod which is found in the shallow-shelf region that borders the active delta, but does not live on the sand bottoms near the barrier islands, is *Abra lioica* Dall, whose distribution is shown in Figure 23b.

The mollusks observed on the Gulf beaches in large numbers and reported living in the shallow part of the shelf by other investigators (Cary and Spaulding, 1909; Harry, 1942; Behre, 1950; Pulley, 1953; Hedgpeth, 1953; Parker, 1955) are the pelecypods, *Dinocardium robustum* (Solander), *Atrina serrata* (Sowerby), *Aequipecten irradians concentricus* (Say), *Callocardia texasiana* Dall, *Cyrtopleura costata* (Linné), *Labiosa plicatella* (Lamarck), *Labiosa lineata* Say, *Macoma constricta* Bruguière, *Spisula solidissima similis* (Say), and *Dosinia discus* (Reeve); and the gastropods, *Phalium granulatum* (Born), *Olvia sayana* Ravenel, *Tonna galea* Linné, *Murex fulvescens* Sowerby, *Murex pomum* Gmelin, and *Strombus alatus* Gmelin. Of particular interest was the presence of the valves of the giant clam, *Panope bitruncata* Conrad, a close relative of the geoduck (*P. generosa*) of the Pacific coast, on the beach of Gosier Island. According to Abbott (1954)



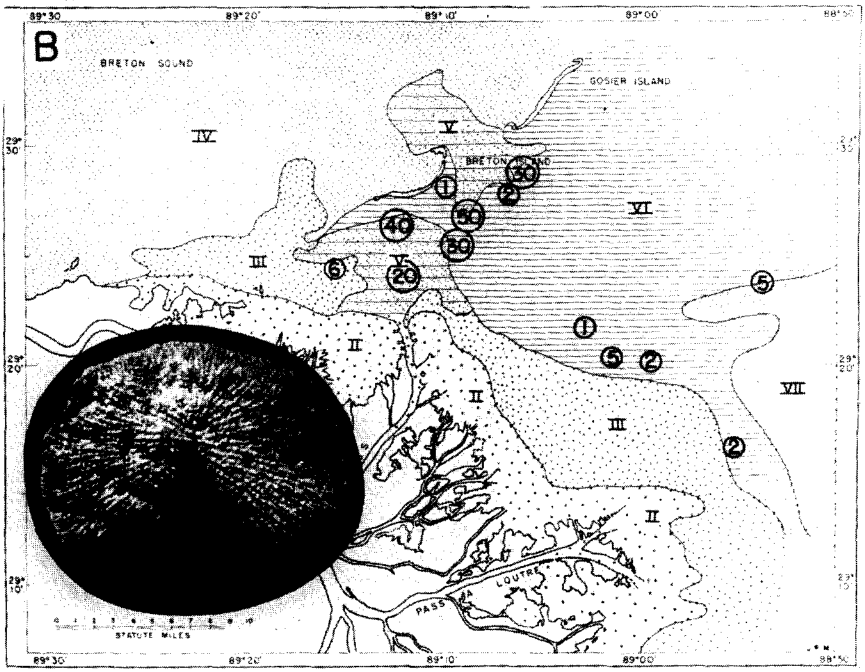
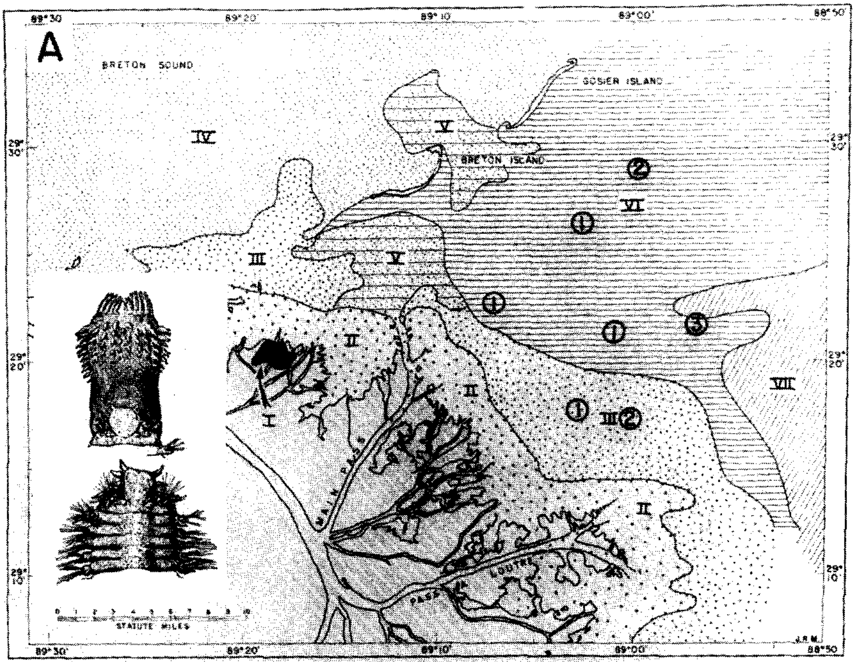


FIG. 21a.—Distribution of gastropod, *Cantharus cancellarius*, indicative of shallow-shelf and inlet environments.

FIG. 21b.—Distribution of pennatulid, *Renilla mülleri*, indicative of shallow-shelf environment (all living).



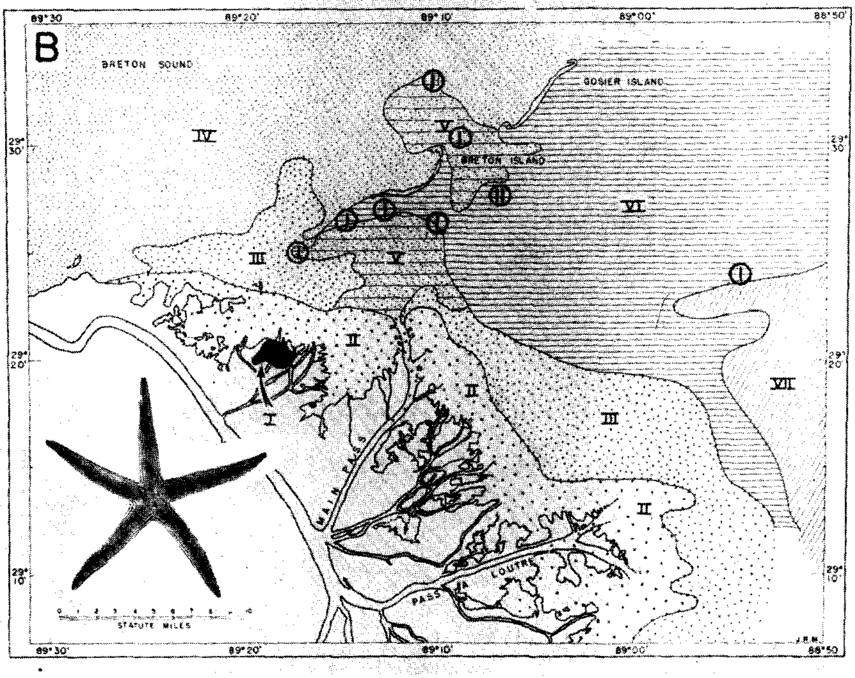


FIG. 22a.—Distribution of polychaete worm, *Aglaophamus dicirris*, indicative of shallow-shelf environment (all living).

FIG. 22b.—Distribution of starfish, *Luidia clathrata*, indicative of shallow-shelf and inlet environments (all living).