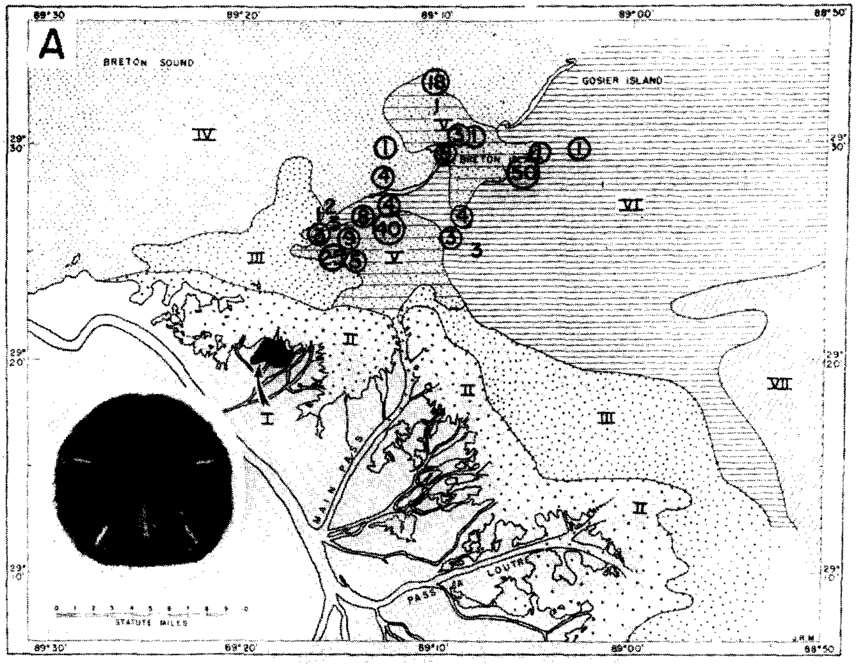


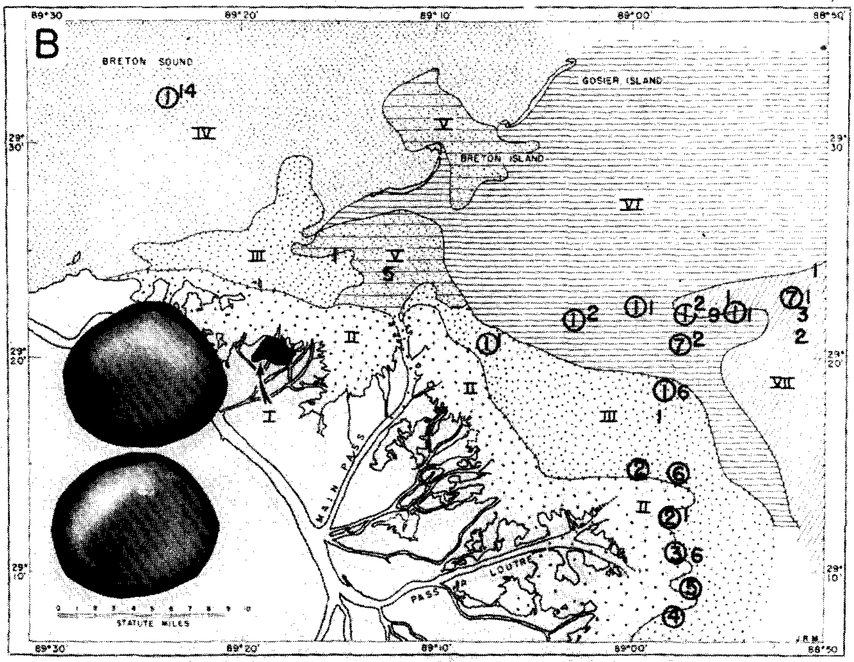
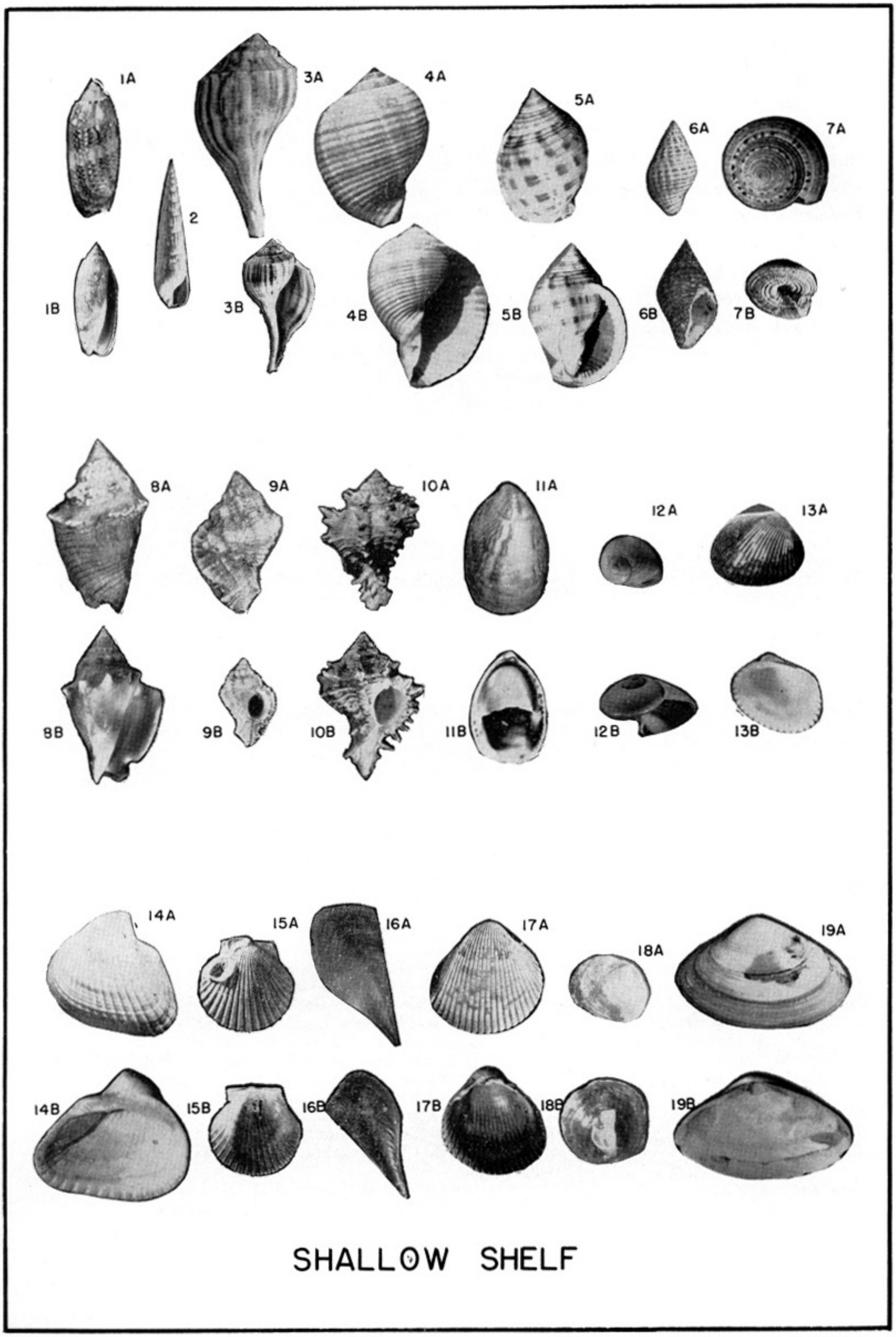


FIG. 23a.—Distribution of sand dollar, *Mellita quinquiesperforata*, indicative of shallow-shelf and inlets.

FIG. 23b.—Distribution of pelecypod, *Abra lioica*, indicative of shallow-shelf and pro-delta slope.

this clam has never been seen alive and is thought to be extinct, but the valve from Gosier Island still had organic material in the hinge. Pulley (1953) cites an open-Gulf record of *Panope* from Port Isabel, Texas. The mollusks which are characteristic of the surf zone and sand beach are *Donax tumida* Philippi, *Terebra cinerea* (Born), and occasionally large populations of *Olivella mutica* Say. The ghost crab, *Ocypode albicans* Bosc, is also a prominent member of the sand-beach community. Its remains are common in beach drift and *Ocypode* claws are commonly preserved in old Gulf beach assemblages found deep in borings from the Texas coast. The general distribution of the other shallow-shelf invertebrates can be seen in Tables II and III. A list of the invertebrates characteristic of the nearshore Gulf follows (Pls. V–VI).

MOLLUSKS	
GASTROPODS	
Architectonica nobilis	—Uncommon in delta collections, but abundant off Rockport, Texas
Strombus alatus	—Common on Gulf beaches, common living taken by shrimp trawlers, and occasionally found in deeper parts of continental shelf
Cantharus cancellarius	—Common, living on shallow shelf, and also found on Gulf side of inlets
Busycon spiratum plagosum	—Few dead on Gulf beach, living in inlets, although farther south, this species is confined to shallow shelf and is common
Oliva sayana	—Common dead, few living
Phalium granulatum	—Common dead on Gulf beaches and living, taken by shrimp trawls in 5–15 fathoms
Tonna galea	—Rare dead on Gulf beaches, and occasionally picked up in shrimp trawls
Janthina janthina	—At times extremely abundant on Gulf beaches, is pelagic, but rafts up on beaches after storms
Murex fulvescens	—Not uncommon on Gulf beaches, rare living
Murex pomum	—Rare on Gulf beaches, seldom found living
Terebra cinerea	—Common, living in surf zone and somewhat less common out to 10 fathoms
PELECYPODS	
Nuculana acuta (nearshore)	—Common dead, although also found in upper sound and inlet
Anadara campechiensis	—Often large numbers of valves cast up on Gulf beach
Anadara chemnitzi	—Rare shells on Gulf beach
Noetia ponderosa	—Large numbers of valves on Gulf beach
Volsella demissa granosissima	—Few on Gulf beaches
Atrina serrata	—After storms, extremely abundant on Gulf beaches, seldom seen living
Aequipecten irradians concentricus	—Common scallop of Gulf beaches, but seldom taken living
Lucina amiantus	—Abundant, living but also found in inlets and upper sound
Dinocardium robostum	—Common large cockle of Gulf beach, although seldom seen living
Spisula solidissima similis	—Few found dead on Gulf beach, not seen living, except off Rockport
Callocardia texasiana	—Few, dead in dredge hauls and on Gulf beach, never taken living
Dosinia discus	—Large valves common on Gulf beach, also few large individuals taken living, very small *Dosinia* common in upper sound
Chione intapurpurea	—Few dead, also found in deep shelf region
Labiosa plicatella	—Common dead on Gulf beaches
Labiosa lineata	—Common dead on Gulf beaches, occasionally taken living on shallow shelf
Donax tumida	—Extremely abundant in surf zone of Gulf beaches, living, common dead in somewhat deeper water to 3–5 fathoms
Abra lioica	—Common living in clayey bottoms on east slope of delta and shallow shelf
Quadrans lintea	—Few dead on shallow shelf, also found in inlets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SHALLOW SHELF

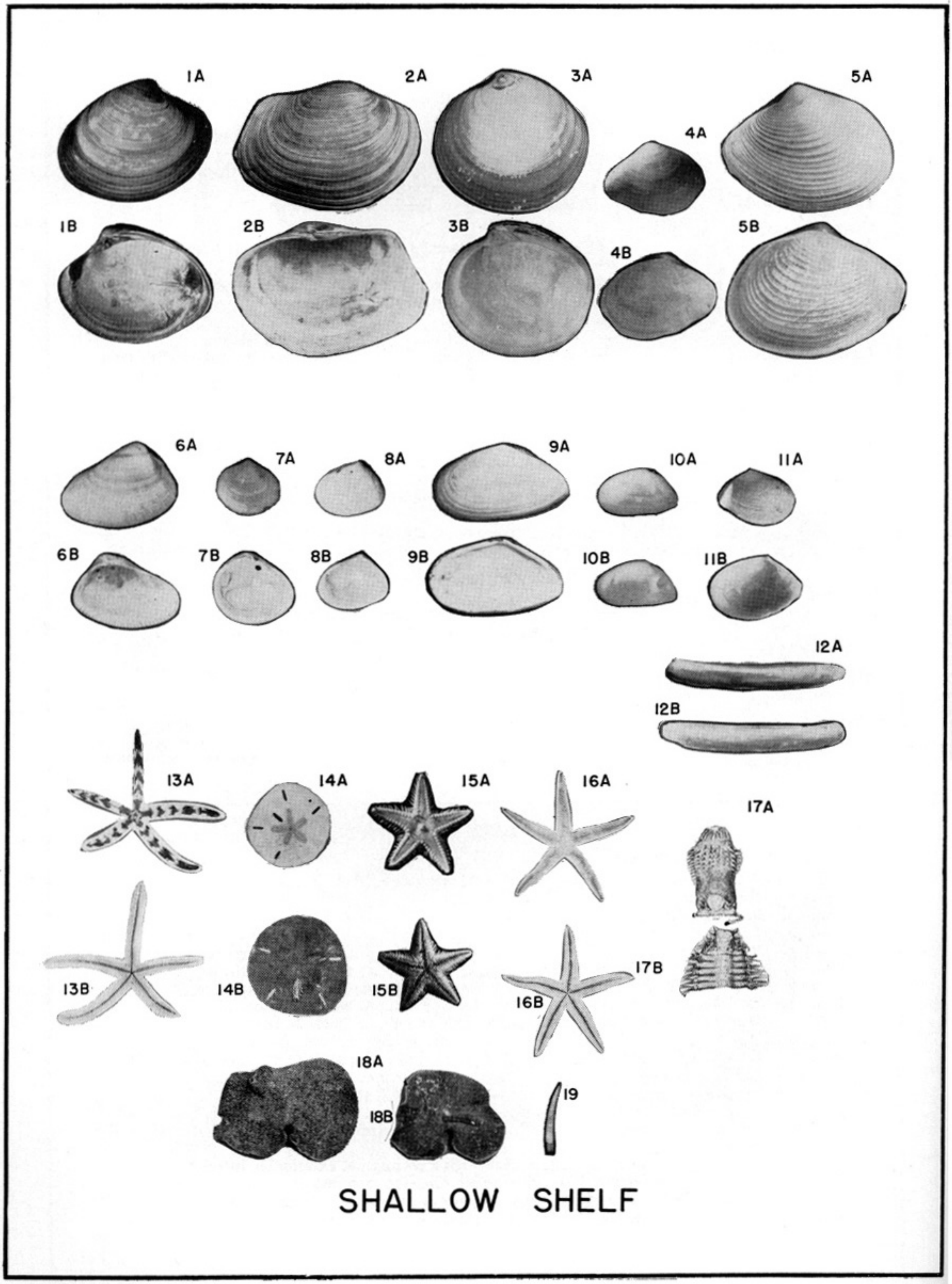
PLATE V

Tellina versicolor	—Most abundant living on shallow shelf, although also found in upper sound and inlet
Strigilla mirabilis	—Most abundant (dead) on shallow shelf, few found in inlets and upper sound
Ensis minor	—Common living and dead on shallow shelf, although also found in inlets and upper sound to less extent
Panope bitruncata	—Found dead only on Gosier Island beach
COELENTERATES	
Renilla mülleri	—Extremely abundant on sand bottom off barrier islands to about 5 fathoms
Leptogorgia setacea	—Only dead strands found in delta, but very common on sand bottom off barrier islands on Texas coast
ECHINODERMS	
Luidia clathrata	—Common living on sand bottom near barrier islands
Luidia alternata	—Reported by Perrier (1876) as *Luidia variegata* taken alive from Gulf shores of Breton Island. Verrill (1919, p. 202) states this specimen was *L. alternata*, a species common on Texas coast
Astropecten antillensis	—Few living in outer part of shallow-shelf region, abundant, close to shore on Texas coast
Mellita quinquiesperforata	—Extremely common on sand bottom around barrier islands out to about 5 fathoms
Moira atropos	—At times, tests of this heart urchin forms large windrows on Gulf beaches, not taken living
POLYCHAETES	
Aglaophamus dicirris	—Common living on shallow shelf only
Prionospio, sp. and *Cossura*, sp.	—Extremely abundant in clayey sediments in shallow-shelf region close to delta
BRYOZOA	
Zoobytron, sp.	—At certain seasons, extremely abundant on shallow-shelf, filling shrimp trawls to exclusion of other invertebrates
CRUSTACEANS	
Ovalipes ocellatus	—Not uncommon on shallow-shelf out to at least 13 fathoms
Sicyonia dorsalis	—Abundant on shallow shelf, usually taken with other species of shrimp such as *Penaeus setiferus* and *Penaeus duorarum*, both found also in upper and lower sound. Shrimp were taken up in distributaries to head of Denise Pass in fall of 1954 according to Louisiana Department of Conservation (personal communication)

PLATE V

VI. SHALLOW SHELF ASSEMBLAGE

FIG. 1.—*Oliva sayana* Ravenel, 1834, size—43×17 mm., a. back, b. aperture.
FIG. 2.—*Terebra cinerea* (Born, 1778), size—32×7 mm., front or aperture.
FIG. 3.—*Busycon spiratum plagosum* Conrad, 1863, size—119×57 mm., a. back, b. front.
FIG. 4.—*Tonna galea* (Linné, 1758), size—51×36 mm., a. back, b. front or aperture.
FIG. 5.—*Phalium granulatum* (Born, 1778), size—59×40 mm., a. back, b. front.
FIG. 6.—*Cantharus cancellarius* (Conrad, 1846), size—30×17 mm., a. back, b. front.
FIG. 7.—*Architectonica nobilis* Röding, 1798, size—49×31 mm., a. top, b. aperture.
FIG. 8.—*Strombus alatus* Gmelin, 1790, size—85×54 mm., a. back, b. front.
FIG. 9.—*Murex pomum* (Gmelin, 1790), size—48×31 mm., a. back, b. front.
FIG. 10.—*Murex fulvescens* Sowerby, 1834, size—54×36 mm., a. back, b. front.
FIG. 11.—*Crepidula fornicata* (Linné, 1758), size—23×14 mm., a. exterior, b. interior.
FIG. 12.—*Janthina janthina* (Linné, 1758), size—16×21 mm., a. top, b. aperture.
FIG. 13.—*Anadara campechiensis* (Gmelin, 1790), size—38×30 mm., a. exterior, b. interior.
FIG. 14.—*Noetia ponderosa* (Say, 1822), size—32×28 mm., a. exterior, b. interior.
FIG. 15.—*Aequipecten irradians concentricus* (Say, 1822), size—62×44 mm., a. exterior, b. interior.
FIG. 16.—*Atrina serrata* (Sowerby, 1825), size—175×76 mm., a. exterior, b. interior.
FIG. 17.—*Dinocardium robustum* (Solander, 1786), size—96×90 mm., a. exterior, b. interior.
FIG. 18.—*Anomia simplex* d'Orbigny, 1842, size—21×20 mm., a. exterior, b. interior.
FIG. 19.—*Spisula solidissima similis* (Say, 1822), size—80×55 mm., a. exterior, b. interior.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SHALLOW SHELF

PLATE VI

XIPHOSURA
Limulus polyphemus —One specimen of horseshoe crab was found on Breton Island beach

VII. *Deeper continental shelf of Gulf of Mexico, from approximately 13 to 50 fathoms.*—At approximately 13 fathoms out from the barrier islands off the east Mississippi Delta, a distinct assemblage of animals is encountered. The species composing the major part of this group make an infrequent appearance at 13 fathoms, and increase in individuals per station out to at least 40 fathoms, which was the limit of biological sampling in this study (Fig. 12 shows limits of deep-shelf environment). Fresh specimens of these deep-shelf species are never found on the beaches and worn specimens are rare. A detailed description of the free-swimming epi-benthic or just-off-the-bottom assemblages of the "inshore" and "offshore" shrimp grounds off the Louisiana and Texas coasts is given by Hildebrand (1954), who characterizes the grounds inside 12–14 fathoms by the dominant organisms *Penaeus setiferus*, *Callinectes danae*, *Renilla mülleri*, and several species of fish, such as the sand sea trout, hardhead sea catfish, and croakers. The offshore grounds, extending from about 12 to 25 fathoms, were dominated by *Penaeus aztecus*, *Squilla empusa*, *Pitar cordata*, and the sea robin, *Prionotus rubio*. Hildebrand's study did not extend to the outer edge of the continental shelf, where a completely different type of fauna is found.

Since the physical-chemical conditions in the deeper Gulf of Mexico are by no means well known, the reasons for this separate assemblage beginning at 13 fathoms can only be guessed. It has been suggested by Pulley (1953), that the waters of the Gulf of Mexico at these depths seldom fall below 65°F. at any time during the year. An examination of unpublished temperature data at the United

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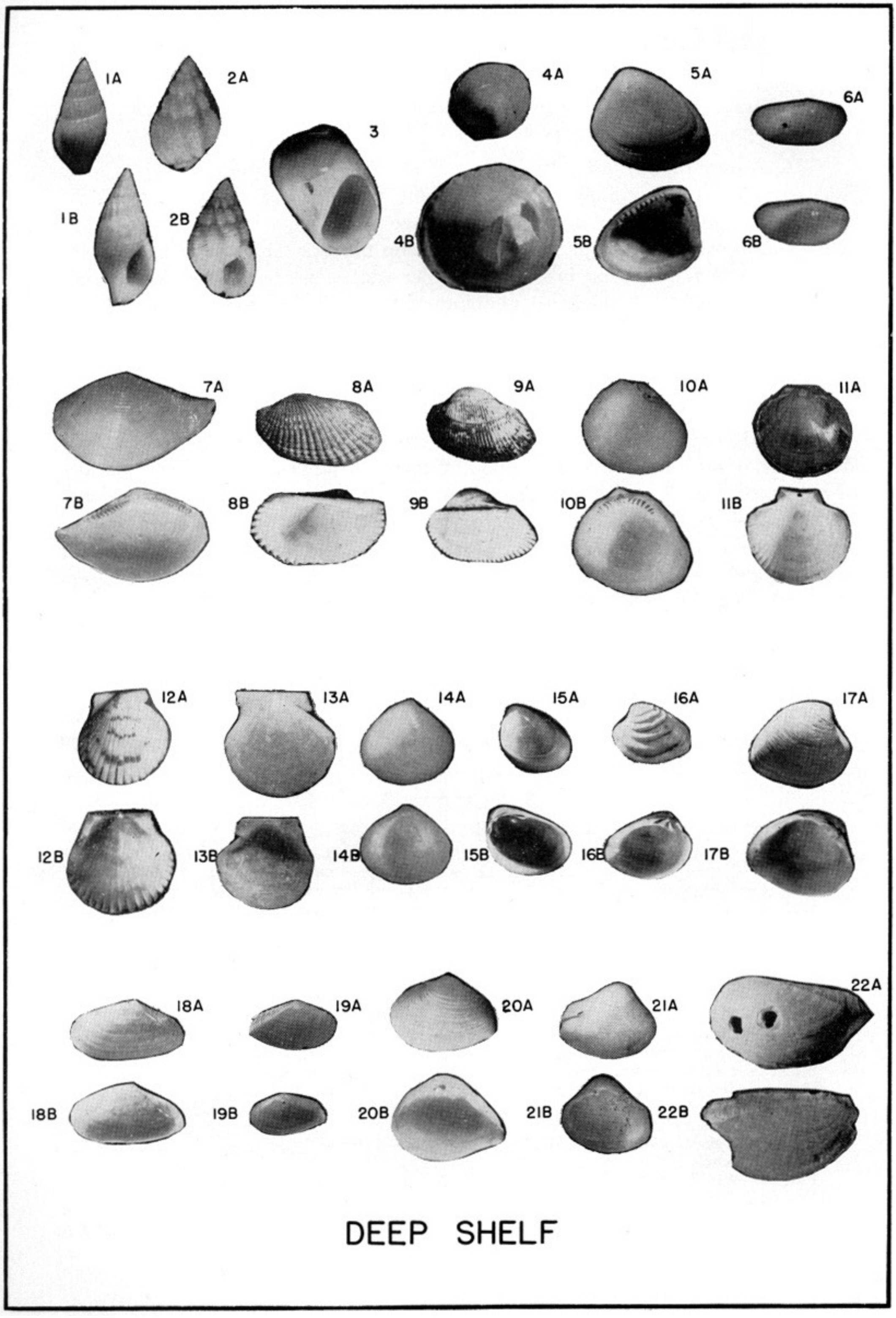
PLATE VI

VI. SHALLOW SHELF ASSEMBLAGE (CONTINUED)

FIG. 1.—*Callocardia texasiana* (Dall, 1892), size—50×40 mm., a. exterior, b. interior.
FIG. 2.—*Panope bitruncata* (Conrad, 1872), size—160×106 mm., a. exterior, b. interior.
FIG. 3.—*Dosinia discus* (Reeve, 1850), size—73×71 mm., a. exterior, b. interior.
FIG. 4.—*Macoma constricta* Brugière, 1792, size—59×41 mm., a. exterior, b. interior.
FIG. 5.—*Labiosa plicatella* (Lamarck, 1818), size—68×50 mm., a. exterior, b. interior.
FIG. 6.—*Donax tumida* Philippi, 1848, size—10×7 mm., a. exterior, b. interior.
FIG. 7.—*Strigilla mirabilis* (Philippi, 1841), size—10×9 mm., a. exterior, b. interior.
FIG. 8.—*Abra lioica* Dall, 1881, size—8×7 mm., a. exterior, b. interior.
FIG. 9.—*Tellina alternata* Say, 1822, size—52×29 mm., a. exterior, b. interior.
FIG. 10.—*Tellina versicolor* De Kay, 1843, size—12×6 mm., a. exterior, b. interior.
FIG. 11.—*Quadrans lintea* Conrad, 1837, size—16×12 mm., a. exterior, b. interior.
FIG. 12.—*Ensis minor* Dall, 1899, size—54×10 mm., a. exterior, b. interior.
FIG. 13.—*Luidia alternata* (Say, 1825), size—120×130 mm., a dorsal, b. ventral.
FIG. 14.—*Mellita quinquiesperforata* (Leske), size—53×46 mm., a. test, b. dorsal, live.
FIG. 15.—*Astropecten antillensis* Lütken, 1859, size—34 mm., a. dorsal, b. ventral.
FIG. 16.—*Luidia clathrata* (Say, 1825), size—95 mm., a. dorsal, b. ventral.
FIG. 17.—*Aglaophamus dicciris* Hartman, 1950, size—30 mm. long, a. and b. head and proboscis.*
FIG. 18.—*Renilla mülleri* Kölliker, size—75×58 mm., a. dorsal, b. ventral.
FIG. 19.—*Dentalium texasianum* Philippi, 1849, size—20 mm., side view.

* Drawing from Hartman, Olga, 1950, "Goniadidae, Glyceridae, and Nephytyidae," *Allan Hancock Expeditons*, Vol. 15, No. 1, p. 178.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DEEP SHELF

PLATE VII

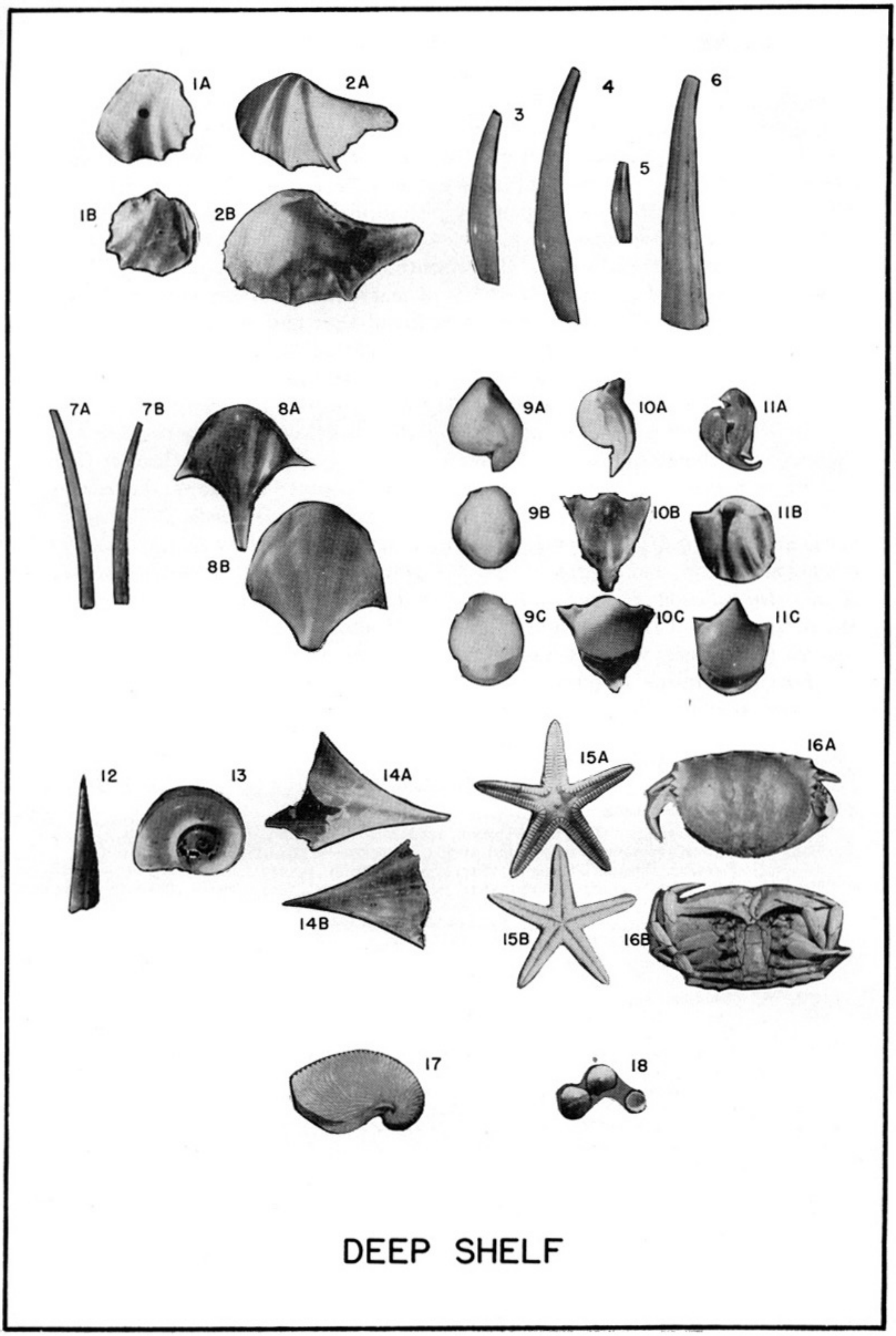
States Navy Hydrographic Office substantiates this. Winter surface-water temperatures periodically fall well below 50°F. in the northern Gulf of Mexico, but it is thought that the bottom waters of the deeper shelf may be deep enough to escape the effects of intermittent seasonal cooling in the winter. The faunal affinity of this assemblage of organisms is close to West Indian or sub-tropical, since many of the species which are rare at these depths in the northern Gulf are plentiful in the shallower waters farther south.

One hundred and twenty-two species of macro-invertebrates were identified from this region, of which 21 species were found alive and 101 were found only as dead remains. Many more species of gastropods were collected, but because of the confusion existing in the systematics of certain groups, could not be identified to species. There are at least 42 good diagnostic species of macro-invertebrates from the deep-shelf region, and an equal number which appear to be good indicator species, although not as abundant as the first 42. The distributions of four mollusks repeatedly taken in offshore waters are illustrated as follows: the pelecypods *Cyclopecten nanus* Verrill and Bush (Fig. 24a), *Chione clenchi* Pulley (Fig. 24b), *Yoldia solenoides* Dall (Fig. 25a), and *Nucula proxima* Say (Fig. 25b). Two echinoderms, the cake urchin *Clypeaster prostratus* Ravenel, and the starfish *Astropecten articulatus valenciennesi* Müller and Troschel, are common living in the deeper shelf of the Gulf and fragments of another cake urchin, *Clypeaster raveneli* (A. Agassiz) were also taken offshore. Three species of corals, *Eupsammia floridana* (Pourtalès), *Eugorgia stheno* Bayer and *Bathycyathus*, sp.; one crustacean, the large boxcrab, *Calappa springeri* Rathbun; as well as many calcareous

PLATE VII

VII. DEEP SHELF ASSEMBLAGE

FIG. 1.—*Astyris perpicta* (Dall and Simpson, 1902), size—9×4 mm., a. back, b. front.
FIG. 2.—*Nassarius ambiguus consensus* Ravenel, 1861, size—8×5 mm., a. back, b. front.
FIG. 3.—*Polinices uberinus* d'Orbigny, 1842, size—6×8 mm., aperture.
FIG. 4.—*Calyptraea centralis* (Conrad, 1841), size—(large) 7×6 mm., (small) 4×3 mm. a., exterior, b. interior.
FIG. 5.—*Nucula proxima* Say, 1822, size—5×5 mm., a. exterior, b. interior.
FIG. 6.—*Yoldia solenoides* Dall, 1881, size—13×7 mm., a. exterior, b. interior.
FIG. 7.—*Nuculana acuta* Conrad, 1832 (offshore form), size—8×5 mm., a. exterior, b. interior.
FIG. 8.—*Anadara lienosa floridana* (Conrad, 1869), size—58×37 mm., a. exterior, b. interior
FIG. 9.—*Anadara baughmani* Hertlein, 1951, size—33×21 mm., a. exterior, b. interior.
FIG. 10.—*Limopsis sulcata* Verrill and Bush, 1898, size—11×10 mm., a. exterior, b. interior.
FIG. 11.—*Pecten papyraceus* (Gabb, 1873), size—58×54 mm., a. exterior, b. interior.
FIG. 12.—*Aequipecten gibbus gibbus* (Linné, 1758), size—27×26 mm., a. exterior, b. interior.
FIG. 13.—*Cyclopecten nanus* Verril and Bush, 1897, size—6×5.5 mm., a. exterior, b. interior.
FIG. 14.—*Gouldia cerina* (C. B. Adams, 1845), size—8×7 mm., a. exterior, b. interior.
FIG. 15.—*Laevicardium fiski* Richards, 1954, size—12×17 mm., a. exterior, b. interior.
FIG. 16.—*Chione clenchi* Pulley, 1952, size—18×15 mm., a. exterior, b. interior.
FIG. 17.—*Pitar cordata* Schwengel, 1951, size—43×48 mm., a. exterior, b. interior.
FIG. 18.—*Tellina georgiana* Dall, 1900, size—29×17 mm., a. exterior, b. interior.
FIG. 19.—*Phylloda squamifera* (Deshayes, 1854), size—16×10 mm., a. exterior, b. interior.
FIG. 20.—*Corbula swiftiana* C. B. Adams, 1852, size—6×4 mm., a. exterior, b. interior.
FIG. 21.—*Varicorbula operculata* (Philippi, 1848), size—9×7 mm., a. exterior, b. interior.
FIG. 22.—*Pandora bushiana* Dall, 1886, size—8×5 mm., a. exterior, b. interior.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DEEP SHELF

PLATE VIII

bryozoans, were taken in the deep-shelf region. Other mollusks which are characteristic of the deep-shelf region and frequently taken in shrimp trawls (Hildebrand, 1954) are *Anadara baughmani* Hertlein, *Anadara lienosa floridana* (Conrad), *Gouldia cerina* C. B. Adams, *Laevicardium pictum* Ravenel, *Laevicardium fiski* Richards, *Laevicardium laevigatum* Linné, *Limopsis sulcata* Verrill and Bush, *Tellina georgiana* Dall, *Nuculana acuta* (offshore variety), *Polinices uberinus* d'Orbigny, *Astyris perpicta* Dall and Stearns,[6] *Calyptraea centralis* Conrad, *Pitar cordata* Schwengel, *Pecten papyraceus* Gabb, *Corbula swiftiana* C. B. Adams, and *Cuspidaria ornatissima* (d'Orbigny). The list of all species of macro-invertebrates found in the deep-shelf environment is too long to be included separately, but most of them are indicated in Tables I and II, and representatives are illustrated in Plates VII and VIII. Several species which are common offshore near the Mississippi Delta but which were not recorded in this study are illustrated in Rehder and Abbott (1951).

ANIMAL COMMUNITY CONCEPT AS APPLIED TO MISSISSIPPI DELTA

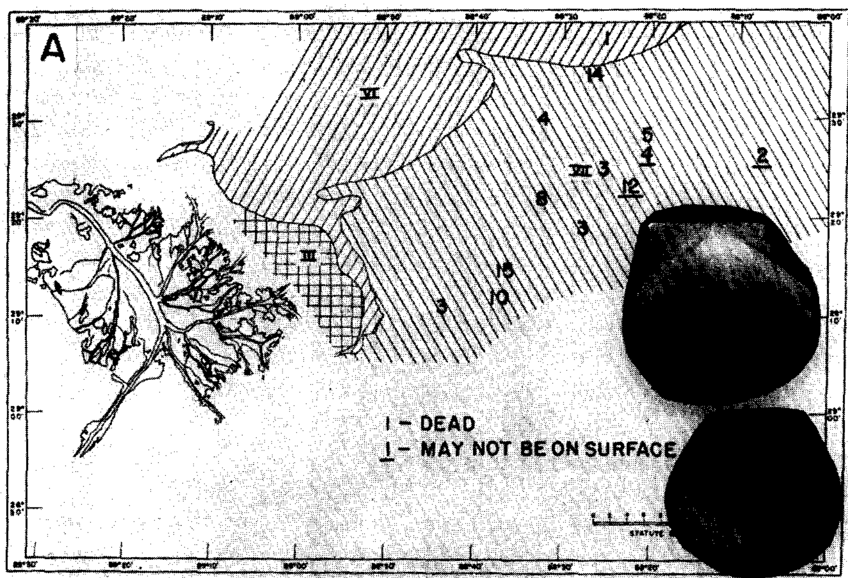
Many European and American ecologists have attempted to define various marine environments or regions by the animal community which predominates in each particular region. Allee and Schmidt (1951), Petersen (1913), and Jones (1950) working in the more northern latitudes have introduced several classifica-

[6] Comparison with museum collections indicates that this is an undescribed species, and here and in text should be referred to as *Astyris*, species.

PLATE VIII

VII. Deep Shelf Assemblage (continued)

Fig. 1.—*Verticordia ornata* (d'Orbigny, 1846), size—4×4 mm., a. exterior, b. interior.
Fig. 2.—*Cuspidaria ornatissima* (d'Orbigny, 1846), size—9×6 mm., a. exterior, b. interior.
Fig. 3.—*Cadulus carolinensis* Bush, 1885, size—9×1 mm., side view.
Fig. 4.—*Cadulus arctus* Henderson, 1920, size—12×2 mm., side view.
Fig. 5.—*Cadulus mayori* Henderson, 1920, size—4×1 mm., side view.
Fig. 6.—*Dentalium laqueatum* (Verrill, 1885), size—27×5 mm., side view.
Fig. 7.—*Dentalium sowerbyi* (Guilding, 1834), size—10×.5 mm., a. and b. side views.
Fig. 8.—*Diacria trispinosa* ('Lesueur' Blainville, 1821), size—7×7 mm., a. and b. dorsal views.
Fig. 9.—*Diacria quadridentata* ('Lesueur' Blainville, 1821), size—2×1.5 mm., a. side, b. dorsal, c. ventral.
Fig. 10.—*Cavolinia longirostris* 'Lesueur' Blainville, 1821, size—4.5×5.5 mm., a. side, b. dorsal, c. ventral.
Fig. 11.—*Cavolinia uncinata* 'Rang' d'Orbigny, 1836, size—3.5×4 mm., a. side, b. dorsal, c. ventral.
Fig. 12.—*Styliola subula* Quoy and Gaimard, 1827, size—6×1 mm., side view.
Fig. 13.—*Atlanta*, species (*A. peroni* Lesueur, 1817) ?, size—6×4 mm., dorsal view.
Fig. 14.—*Euclio pyramidata* (Linné, 1767), size—7×5 mm., a. dorsal, b. ventral.
Fig. 15.—*Astropecten articulatus valenciennesi* Müller and Troschel, size—92 mm., a. dorsal, b. ventral.
Fig. 16.—*Calappa springeri* Rathbun, 1931, size—101×67 mm. (carapace), a. dorsal, b. ventral.
Fig. 17.—*Argonauta argo* Linné, 1758, size—90×60 mm. (egg case), side view.
Fig. 18.—*Schizoporella umbellata* (Defrance), size—12 mm. diameter, 2 exterior, 1 interior colonies.



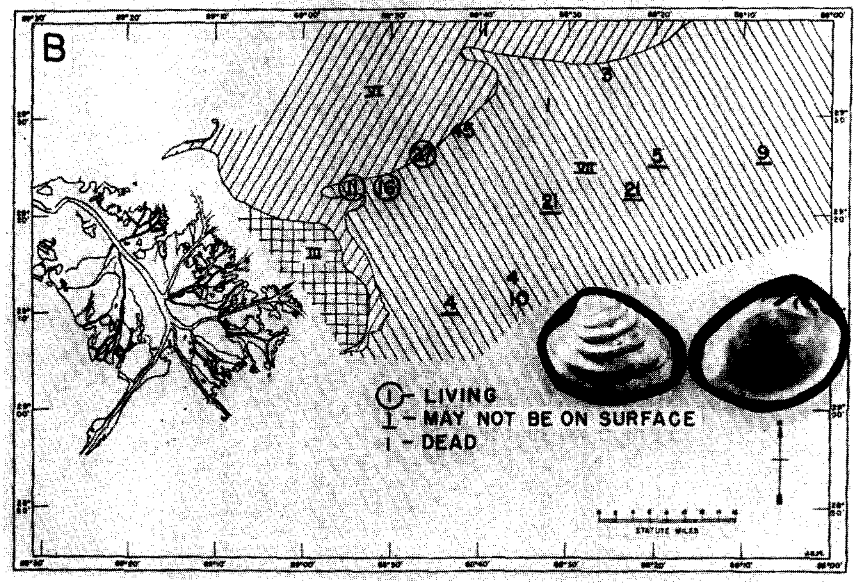
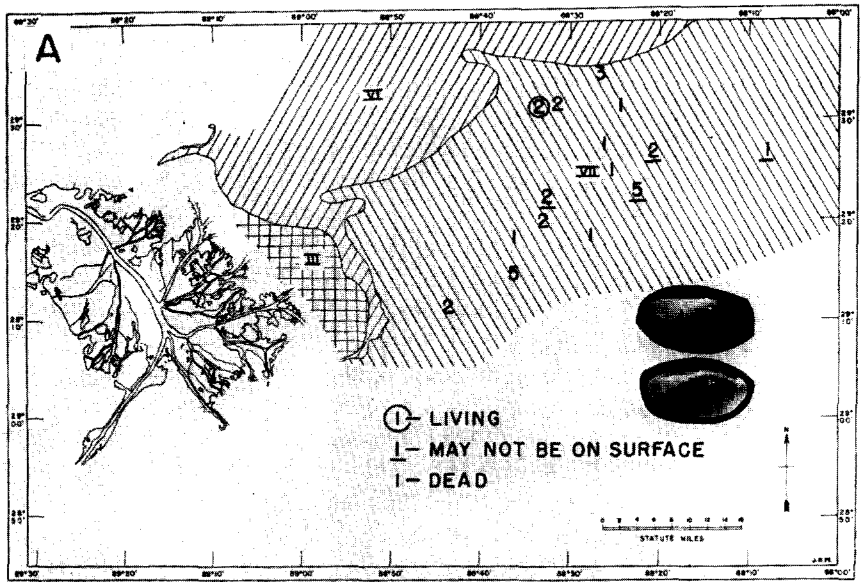


FIG. 24a.—Distribution of pelecypod, *Cyclopecten nanus*, indicative of deep-shelf environment (all dead, underlined occurrences indicate specimens found at various depths in core samples).
FIG. 24b.—Distribution of pelecypod, *Chione clenchi*, indicative of deep-shelf environment.



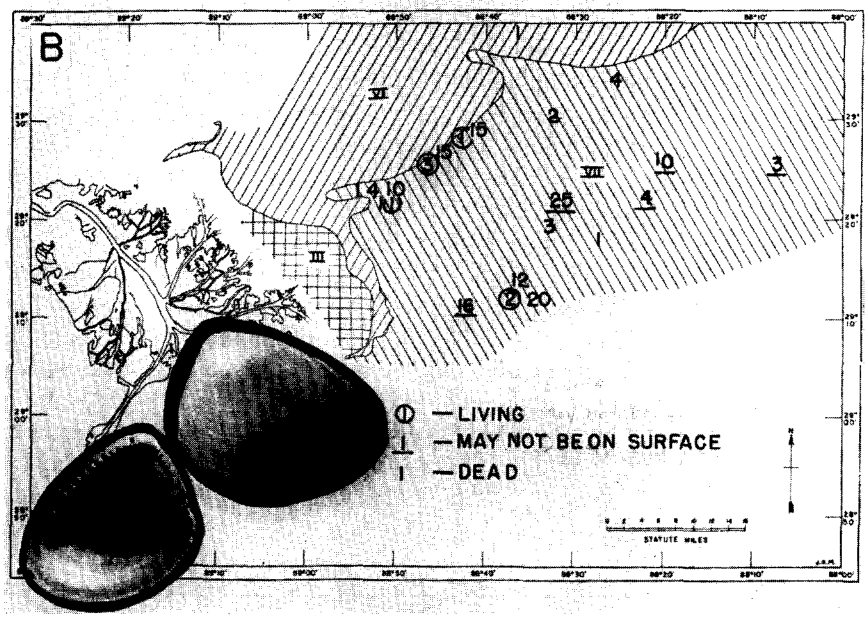


FIG. 25a.—Distribution of pelecypod, *Yoldia solenoides*, indicative of deep-shelf environment.
FIG. 25b.—Distribution of pelecypod, *Nucula proxima*, indicative of deep-shelf environment.

tions of marine bottom communities based on the distribution of benthic invertebrates in relation to the character of the bottom sediments, temperature, salinity, light, and other physical and biological factors. Since more exact quantitative studies of bottom fauna than obtained by this study are needed to approximate the communities defined by Jones and Petersen, it is possible only to indicate the probable communities and dominant organisms. According to Hedgpeth in Galtsoff *et al.* (1954, pp. 207–10), the delta mud-bottom community is apparently "comparable to the *Syndosmya* (=*Abra*) community of 'shallow and protected waters of estuarine character' (Jones, 1950)." This suggestion was made before all the Delta material was analyzed, but apparently is still true, although there appears to be more than one community in this region.

Although *Mulinia lateralis* exists in large concentrations (as many as 200 per orange-peel sample) in the fine silty clay and clayey silt bottoms close to the shores of the active Delta, this species is not widespread, but localized (Fig. 15b). By referring to Table IV, which gives the number of station occurrences of the more abundant organisms in the delta region, it can also be seen that of the total 150 station occurrences of *Mulinia*, only 29 produced living specimens. However, the distribution of the dead remains of *Mulinia* (Tables I and II) shows that its shells occur at nearly every biological station in the inshore delta region. Where *Mulinia* was found living in large numbers it was present almost to the exclusion of any other invertebrates except *Nassarius acutus* and *Anachis obesa*, which are the two most abundant mollusks in station occurrences taken on this project. The other pelecypod which is rather abundant and is consistently found at every station with *Mulinia* is *Abra lioica* (Fig. 23b). If the distributions of *Mulinia*, *Abra lioica*, and *Nassarius acutus* along with those of *Polinices duplicatus* (Fig. 16a) and *Aglaophamus dicirris* (Fig. 22a) are compared, it can be seen that the probable community of the clayey bottoms near the delta is a *Mulinia-Nassarius* one in the shallow waters close to Main Pass, grading into a *Abra-Aglaophamus* one in deeper waters near Pass a'Loutre. Indications from the more detailed biological collecting in June, 1953, of the Pass a'Loutre region show that a species of *Cossura* (a polychaete) is extremely abundant in the silty clays off the mouth of Pass a'Loutre, and at some stations coated the bottom of the sifting screen to a depth of $\frac{1}{2}$ inch. Individuals numbered in the thousands from one orange-peel sample. Associated with these small polychaetes in the bottom were *Abra lioica* and an occasional *Nassarius acutus*. It should be mentioned that this particular region appears to be a very productive shrimp-fishing area, since at the times of sampling concentrated trawling operations were taking place all around. It has been suggested by various workers on the Gulf of Mexico that the primary food of the commercial shrimp may be the small worms which live in the muddy or clayey bottoms where most shrimp are fished (Hedgpeth, personal communication). The observation of large numbers of polychaetes and large shrimp production from the same area supports this suggestion.

In the sand and poorly sorted sandy, silty clay bottoms in the upper sound

TABLE IV. STATION OCCURRENCES OF ABUNDANT SPECIES OF INVERTEBRATES TAKEN FROM ALL STATIONS IN MISSISSIPPI DELTA REGION

Species	*Total Number of Station Occurrences*	*Number of Stations (Living)*	*Number of Stations (Dead)*
GASTROPODS			
Nassarius acutus	144	74	70
Anachis obesa	91	39	52
Olivella mutica	63	9	54
Polinices duplicatus	53	14	39
Cantharus cancellarius	41	8	33
Neritina reclivata	33	4	29
Crepidula plana	31	3	28
Retusa canaliculata	31	0	31
Natica pusilla	30	2	28
Anachis avara semiplicata	24	12	12
Oliva sayana	15	1	14
Terebra protexta	15	1	14
Busycon contrarium	14	5	9
Nassarius ambiguus consensus	14	0	14
Crepidula fornicata	13	0	13
Anachis avara similis	12	6	6
Thais haemastoma floridana	12	2	10
Astyris perpicta	11	1	10
Diodora cayenensis	9	1	8
Mitrella lunata	8	4	4
Busycon spiratum plagosum	8	1	7
Turbonilla hemphilli	8	1	7
Terebra dislocata	8	0	8
Polinices uberinus	8	0	8
PTEROPODS			
Cavolinia uncinata	8	0	8
Cavolinia longirostris	10	0	10
PELECYPODS			
Mulinia lateralis	150	29	121
Abra aequalis	87	12	75
Tellina versicolor	86	17	69
Dosinia discus	85	4	81
Tagelus divisus	83	22	61
Lucina amiantus	63	14	49
Nuculana eborea	60	11	49
Anadara campechiensis	57	6	51
Mercenaria campechiensis texana	57	5	52
Crassostrea virginica	52	1	51
Tellina alternata	51	5	46
Anadara transversa	43	7	46
Macoma tenta	41	11	33
Trachycardium muricatum	38	5	33
Lucina crenella	34	1	33
Corbula swiftiana	33	5	28
Crassinella martinicensis	31	2	29
Pandora trilineata	30	2	28
Diplodonta semiaspera	28	4	24
Ostrea equestris	25	0	25
Anomia simplex	22	0	22
Anadara brasiliana	21	1	20
Nuculana acuta (nearshore)	21	0	21
Nuculana acuta (offshore)	20	4	16
Tellidora cristata	20	2	18
Abra lioica	24	16	8
Nucula proxima	19	4	15
Ensis minor	19	2	17
Semele proficua	19	1	18
Donax tumida	19	0	19
Cyrtopleura costata	19	0	19
Corbula contracta	16	1	15
Chione clenchi	15	3	12
Yoldia solenoides	13	1	12
Aequipecten gibbus gibbus	13	0	13
Cyclopecten nanus	13	0	13
Varicorbula operculata	13	0	13
Verticordia ornata	13	0	13
Brachidontes recurvus	12	0	12
Dinocardium robustum	12	0	12
Rangia flexuosa	11	0	11
Phylloda squamifera	10	1	9
Strigilla mirabilis	10	0	10
Rangia cuneata	9	1	8
Tellina lintea	9	0	9
Noetia ponderosa	8	1	7

TABLE IV—(*continued*)

Species	*Total Number of Station Occurrences*	*Number of Stations (Living)*	*Number of Stations (Dead)*
Diplodonta punctata	8	1	7
Petricola pholadiformis	8	1	7
Laevicardium fiski	8	0	8
Gouldia cerina	8	0	8
Chione intapurpurea	8	0	8
Labiosa plicatella	8	0	8
Macoma extenuata	8	0	8
Pandora bushiana	8	0	8
Macoma mitchelli	8	5	3
SCAPHOPODS			
Dentalium texasianum	16	0	16
Cadulus carolinensis	14	0	14
CEPHALOPODS			
Lolliguncula brevis	14	14	0
HEXACORALS			
Astrangia astraeiformis	16	0	16
PENNATULIDS			
Renilla mülleri	13	13	0
ECHINODERMS (asteroids)			
Luidia clathrata	8	8	0
OPHIUROIDS			
Hemipholis elongata	10	10	0
Amphiodia limbata	24	24	0
ECHINOIDS			
Mellita quinquiesperforata	24	18	6
Moira atropos	9	0	9
POLYCHAETES			
Diopatra cuprea	20	20	0
Glycera americana	9	9	0
BRYOZOA			
Bugula neritina	46	46	0
Zoobytron, sp.	12	12	0
Membranipora, sp.	14	0	14
Cupuladria canariensis	9	3	6
Mamillipora cupula	7	2	5
CRUSTACEANS			
Callinectes sapidus	25	23	2
Neopanope packardii	18	18	0
Squilla empusa	17	17	0
Pagurus floridanus	14	14	0
Penaeus setiferus	14	14	0
Penaeus duoarum	12	12	0
Callinectes danae	11	11	0
Libinia emarginata	8	8	0

and inlet region there are indications of a different community. Although many species of invertebrates are found in these environments, only a few are abundant enough and occur commonly enough to constitute a community. Of these, *Tagelus divisus* (Fig. 17a) is the most abundant (Table IV), occurring alive at 22 of 83 stations. Two other pelecypods which are important members of this community in numbers of individuals and station occurrences are *Tellina versicolor* and *Abra aequalis* (Table IV). Since the most common type of bottom in which this community lives is sand or a muddy sand, *Tagelus* and *Tellina* are to be expected (Allee and Schmidt, 1951, pp. 226–27). As in other communities on sand and muddy sand bottoms, there are large numbers of the brittle star, *Amphiodia* *limbata* (Fig. 18b); these occurred at 24 stations in the upper sound environment. The common polychaetes of this community are *Glycera americana* with 9 station occurrences and *Diopatra cuprea* with 20 station occurrences. This, then, is a sand or muddy sand-bottom community of shallow inshore waters and is characterized by the thin-shelled *Tellina* and *Tagelus*, a large population of brittle stars, and tube-building polychaete worms, for which the name *Tagelus-Amphiodia* community is proposed.

There is an indication that a separate community exists on the hard sand bottoms in the Gulf, adjacent to the barrier islands. The most abundant organism in this community is the sand dollar, *Mellita quinquiesperforata* (Fig. 23a), which occurred at 18 stations with as many as 50 specimens at one station. Another abundant echinoderm in this region is the asteroid *Luidia clathrata*, with 8 station occurrences and as many as 11 individuals at one station. An important member of this community is the sea pansy *Renilla mülleri* (Fig. 21b), found at 13 stations in this environment, with an average of 20–30 individuals per station. Hedgpeth in Galtsoff *et al.* (1954, p. 211) comments that *Renilla* is the most conspicuous member of the shrimp ground community and must pave the bottom in some localities. Hildebrand (1954) also mentions *Renilla* as one of the more abundant members of the "inshore" shrimp grounds. The common pelecypods of this community are *Tellina alternata*, *Macoma tenta*, *Strigilla mirabilis*, and *Ensis minor* (Table IV gives number of station occurrences), all thin-shelled members of the family Tellinidae except *Ensis*, which is closely related to the Tellinidae. This community might be designated the *Mellita-Renilla-Tellina* community of the shallow-shelf sand bottoms.

Not enough quantitative or distributional data are available to adequately describe the deep-shelf clay and sand or muddy sand-bottom community. Observations from the present study and Hildebrand's work indicate that other prominent members providing hard parts of the deep clayey bottom community are probably a starfish, *Astropecten articulatus valenciennesi*, a large crab, *Calappa springeri*, the shrimp, *Penaeus aztecus*, and two pelecypods, *Pecten papyraceus* and *Anadara baughmani*. Sand or predominantly sand bottoms are comparatively rare in the deeper waters of the northern Gulf of Mexico, and little information is available concerning the abundant invertebrates from this type of environment.

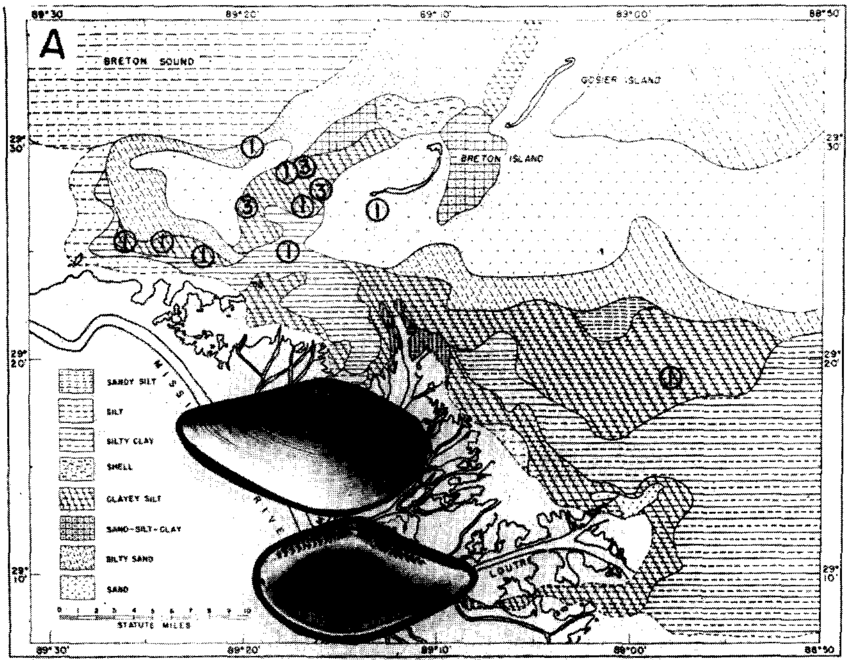
BOTTOM SEDIMENTS AS INFLUENCING DISTRIBUTION OF MACRO-ORGANISMS IN MISSISSIPPI DELTA REGION

It is generally recognized that the type of bottom sediment has a pronounced influence on the distribution of animal communities. The principal studies of relationship of organisms to bottom sediments have been made in Europe, initiated by the classic work of Petersen (1913–1915). In the United States the earliest attempt to relate marine benthic fauna distribution to substrate was by Verrill (1873), in Vineyard Sound, Massachusetts. Several papers since then have been published on distributions of invertebrates related to bottom sediments in North America, although all have been in colder waters in the Atlantic and Pacific (Sumner, Osburn, and Cole, 1911; Packard, 1918; Allee, 1923; Lee, 1944; and Pratt, 1953). Jones (1950) recently discussed the bottom communities of European waters.

In the present study, the biological station locations were first superimposed upon detailed sediment distribution charts shown in Figures 6a and 6b. It was observed that the distributions of many of the benthic macro-invertebrates agreed closely with the distribution of certain types of sediments. For example, the distribution of living *Nuculana eborea* was very closely related to the distribution of silty clays in the lower sound region (Fig. 26a), while the distributions of *Mellita quinquiesperforata* and *Renilla mülleri* were in good agreement with the distribution of hard sand bottom in the vicinity of Breton Island (Fig. 27a and b). The heavily concentrated populations of *Mulinia lateralis* (more than 30 living individuals per orange-peel grab sample) were practically all found in the clayey silt or silty clay types of sediment, and occurred primarily in the fall season (Fig. 26b). Since these heavy concentrations of *Mulinia* were found only on clayey types of bottom, and these sediments were located both in the shallow-shelf parts of the Delta shores and in the lower Sound regions (all areas of differing chlorinity and temperature), the major factor associated with the distribution of this pelecypod was apparently bottom type.

With the exception of *Mulinia* and *Nuculana eborea* at some of the stations, most of the stations occupied in silty clay areas produced few or no organisms. Typical stations with little or no biological material in them from clayey areas are: BS 22, BS 25, BS 46, BS 47, GM 54, PL 354, and PL 352 (Fig. 28a gives locations of the inshore stations with no biological material). The same is also true for the stations on the very hard sand bottom (Fig. 28a), although this may have been the function of the sampling devices which were not designed to take large biological samples in sand areas. The principal difference between the fauna on the hard sand bottoms and on the clayey bottoms was the presence of many living starfish, sand dollars, and sea pansies on the sand bottoms, although echinoid plates are common in the deep-shelf clays.

On the other hand, sampling from areas of predominantly poorly sorted sand and silty clays of varying concentrations produced a very abundant and varied invertebrate population, including many species of macro-organisms confined to this type of substrate. The distributions of two pelecypods, *Tagelus divisus* and *Macoma tenta* (Say) (Figs. 29a and b), are superimposed upon the distribution of sandy, silty clays and other poorly sorted sediments. A striking example of differences in invertebrate populations between deep-shelf clays and the deep-shelf sandy, silty clays can be observed by comparing the distribution of stations containing few or no organisms in the surface sediments, composed of silty clay, with that of similar stations located on coarser sediments (Fig. 28b). Stations from the deep-shelf silty clays produced very few or no mollusks (except pteropod and scaphopod fragments) and several echinoid spines and plates. Fisk *et al.*



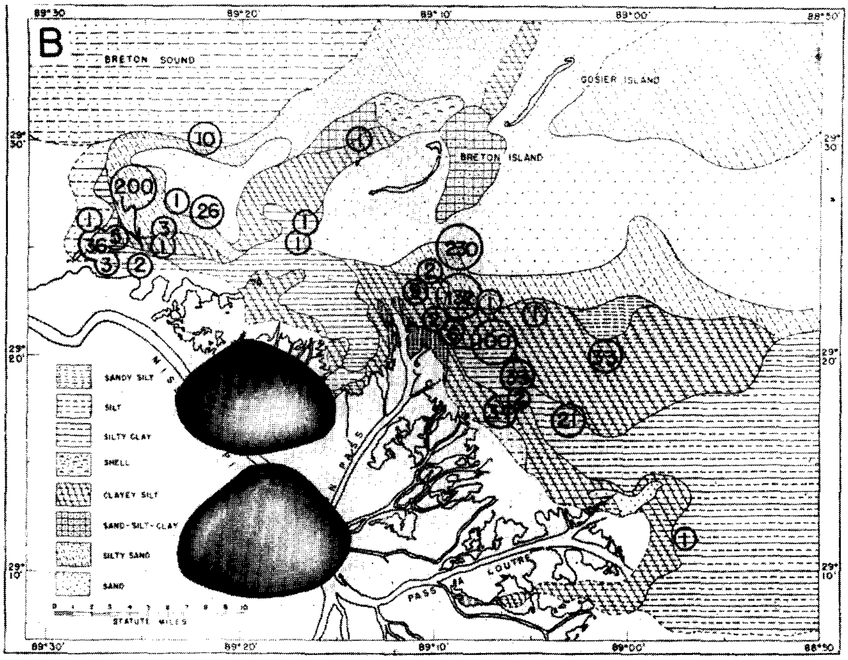
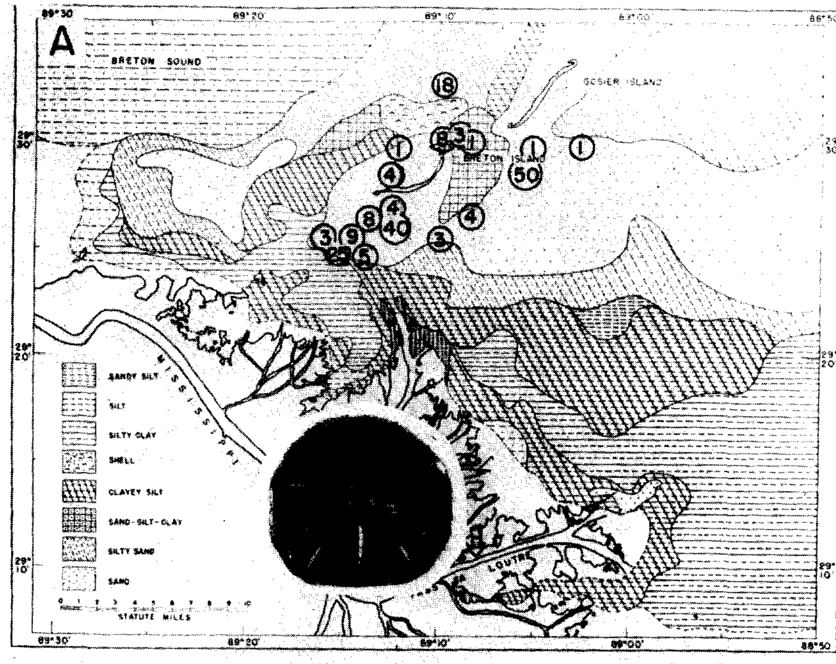


FIG. 26a.—Distribution of living *Nuculana eborea* as related to distribution of sediment types in inshore Mississippi Delta region.

FIG. 26b.—Distribution of living *Mulinia lateralis* as related to distribution of sediment types in inshore Mississippi Delta region.



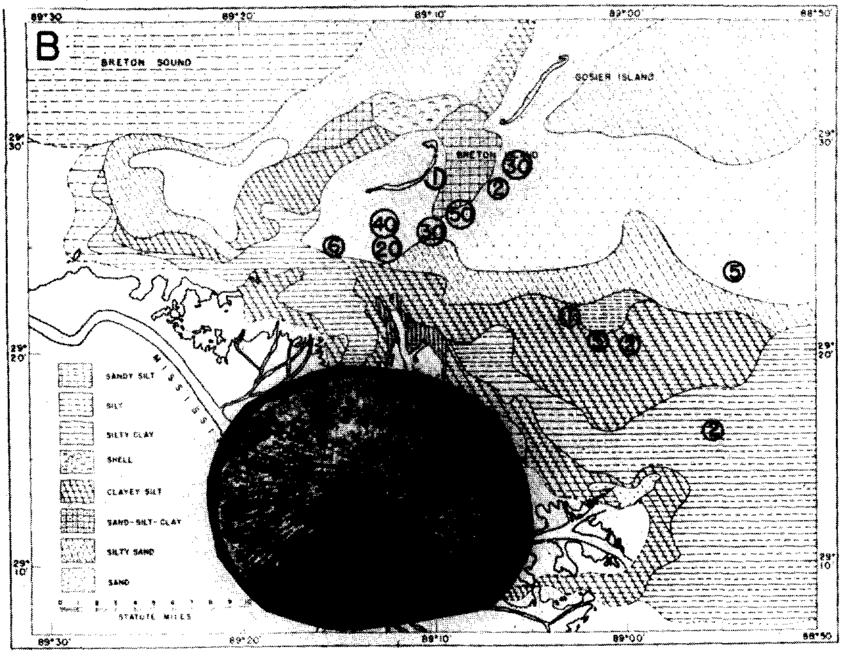


FIG. 27a.—Distribution of *Mellita quinquiesperforata* as related to distribution of sediment types in inshore Mississippi Delta region.

FIG. 27b.—Distribution of *Renilla mülleri* as related to distribution of sediment types in inshore Mississippi Delta region.

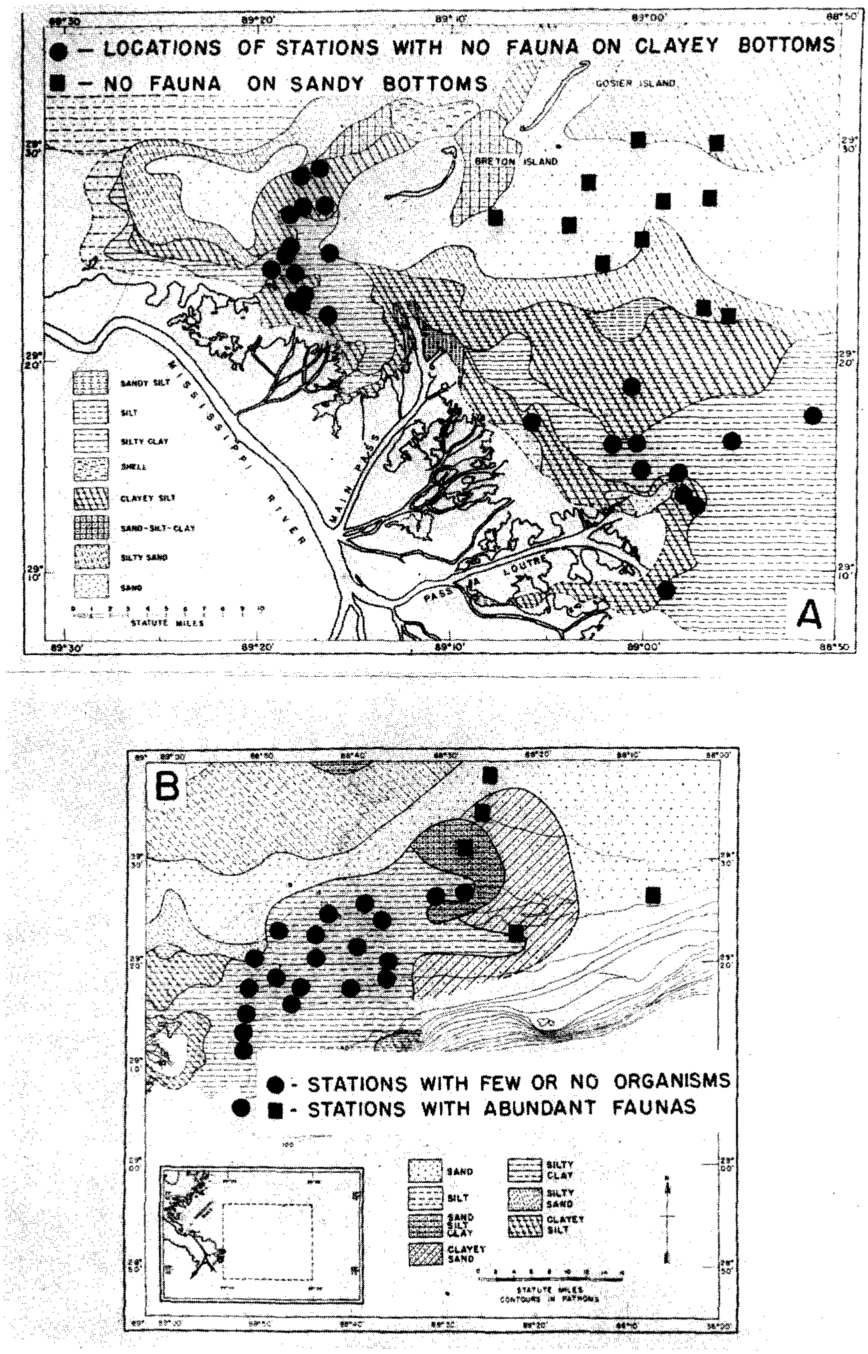
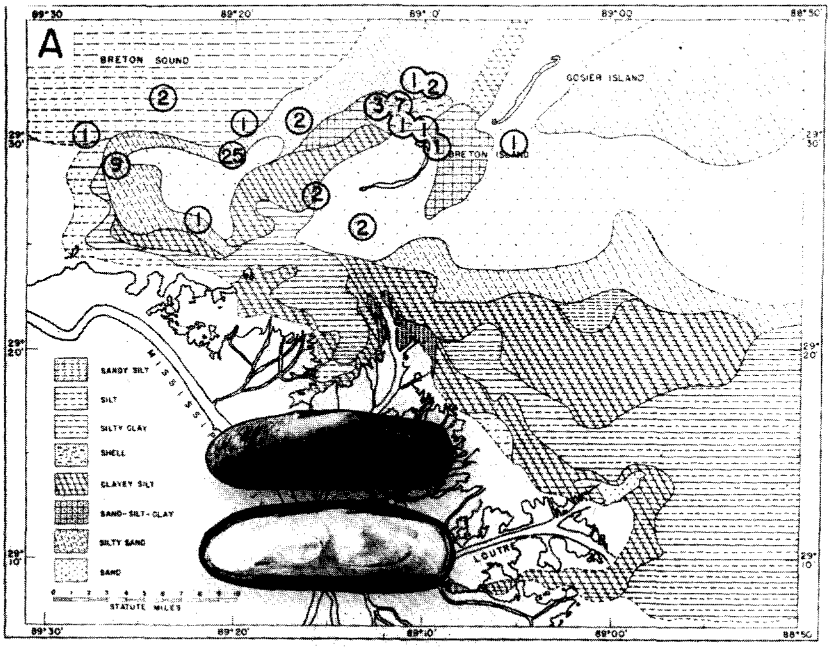


FIG. 28a.—Relationship between sediment type and stations where no organisms were taken in inshore Delta region.

FIG. 28b.—Relationship of stations with no organisms on clayey bottoms, and stations with abundant fauna on sandy clay or sandy, silty clay bottoms.



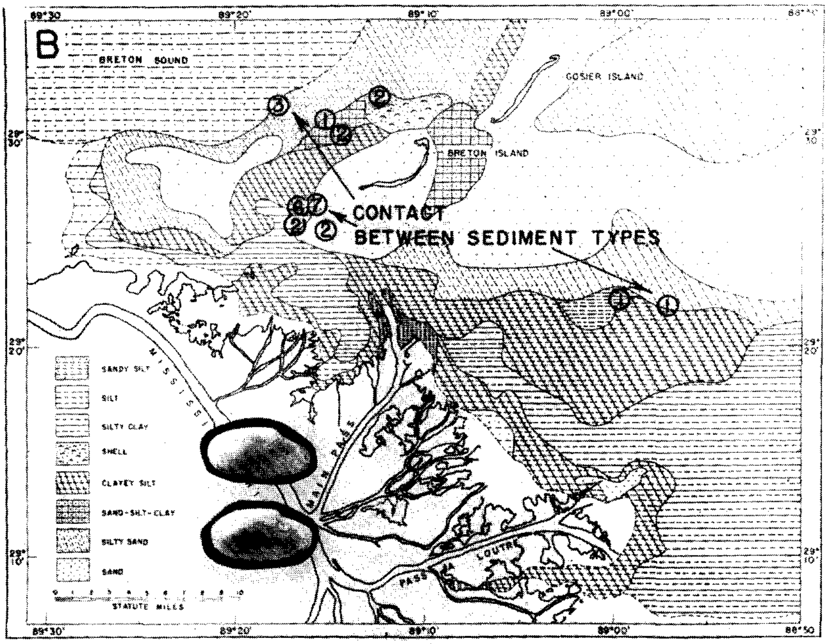


FIG. 29a.—Distribution of *Tagelus divisus* as related to distribution of sediment types (poorly sorted or mixed sediments) in inshore Mississippi Delta region.

FIG. 29b.—Distribution of *Macoma tenta* as related to distribution of sediment types (particularly at contacts between sediments) in inshore Delta region.

(1954, p. 87) also mention abundant scaphopods, bryozoans, and echinoids in the clays of the outer shelf. The stations such as GM 244, GM 309, GM 383, GM 393, and GM 394 (Figs. 4 and 28b) on the coarse sediments were productive, at least in dead shell, and, where sampling techniques were successful with an orange-peel grab, an abundant living population was found.

Organisms as possible indicators of rates of deposition.—Although this study did not produce quantitative results which can be interpreted as numbers of organisms per station, comparative results were obtained with the orange-peel and biological material from the top 15 centimeters of the cores taken by the geologists. Counts of macro-organisms from orange-peel and core samples which were taken in areas of rapid deposition, such as the "pro-delta silty clay" region (Scruton, 1956), where deposition can take place at the rate of 1–2 feet per year, show either very little material living or dead, or fairly large numbers of living forms, and practically no dead material. In areas where the deposition rate is relatively slow, such as the deep-shelf coarse deposits, and the shell-sand deposits of upper Breton Sound, there were comparatively few living forms in relation to the large number of dead shells in the form of large shell deposits with very many mollusk species represented. This was especially true of the deep-shelf areas where littoral and beach deposits were exposed on the bottom at depths of 30–35 fathoms (Fig. 30). The fact that so few dead representatives of the very common living species are found on the surface in areas of rapid sedimentation can be explained by the rapid burial of those individuals as they die, while the living mollusks maintain themselves on or near the surface. Since it is not likely that the whole population dies at once, there would be a considerable layer of sediment over each individual which dies and becomes part of the sediment column. This was observed in several cores from the pro-delta slope region, where many live individuals were preserved at the top of the cores, and only a few single shells were found throughout the rest of the cores.

In areas without recent deposition, there might be the same number of living individuals in the surface sediments as in the rapid depositional area, but instead of being covered by a layer of sediment after death, those individuals would lie at the surface among the living population. Over a period of years or centuries, along with changing hydrographic conditions, there would be many generations and species representing the changing ecological conditions, making up a shell deposit. This is illustrated by some deep-shelf deposits (Fig. 30) where there were large numbers of dead specimens of species representing shallow, low-salinity environments mixed with many dead specimens and living representatives of species now living in the deep-shelf region. Table V shows the comparative numbers of living and dead macro-organisms from stations in rapid depositional and non-depositional areas.

The indication of depositional rate of sediments by the ratio of live *versus* dead organisms has been suggested by F. B Phleger, who has worked out this principle in more detailed analyses, using foraminiferal assemblages (Phleger,

TABLE V. COMPARISON OF NUMBERS OF LIVING AND DEAD MACRO-ORGANISMS FROM RAPID DEPOSITIONAL AND NON-DEPOSITIONAL AREAS, MISSISSIPPI DELTA

*Station Number**	*Number of Species*	*Number of Specimens (Living)*	*Number of Specimens (Dead)*
Stations from rapid-depositional areas: 1–2 feet depth change per year			
BS 25 BOP	4	6	1
BS 26 BOP	4	2	3
BS 27 BOP	6	9	6
BS 46 BOP	2	2	1
GM 57 BOP	5	24	3
GM 58 BOP	1	39	14
GM 61 BOP	4	106	3
BS 142a BOP	5	3	3
BS 165 BOP	1	1	0
PL 324 BOP	1	4	0
PL 325 BOP	2	6	0
PL 326 BOP	2	4	5
PL 329 BOP	2	6	1
PL 334 BOP	2	2	3
PL 342 BOP	4	2	11
MP 666 BOP	3	4	10
MP 667 BOP	1	2	0
Average, 17 stations	2.9 species	13 living specimens	3.8 dead specimens
Stations from non-depositional areas: no depth change, or scour, in 30–50 years			
BS 32 BOP	23	13	40
BS 34 BOP	19	2	60
BS 36 BOP	17	10	22
BS 38 BOP	27	25	64
BS 70 BOP	20	6	31
BS 72 BOP	15	8	38
BS 73 BOP	22	12	43
BS 74 BOP	36	19	74
BS 75 BOP	25	3	65
BS 76 BOP	47	21	151
BS 80 BOP	19	14	23
BS 81 BOP	15	10	18
BS 153 BOP	14	2	52
BS 154 BOP	28	15	128
BS 180 BOP	18	2	88
BS 171 BOP	22	10	80
BS 188 BOP	32	11	97
Average, 17 stations	23.5 species	10.8 living specimens	63.2 dead specimens

* Orange-peel grab samples.

1951, pp. 64–67, and personal communication). Phleger suggests that relative sedimentation rates can be obtained by comparing the distribution of the living benthonic Foraminifera with those of the empty tests. Moore (1955) used total numbers of Foraminifera per unit volume of sediment to determine rates of deposition, assuming a constant rate of production.

INFLUENCE OF WATER TEMPERATURE UPON DISTRIBUTION OF MACRO-INVERTEBRATES IN MISSISSIPPI DELTA REGION

Most of the biogeographic regions in the sea have been based on the distribution of animals in relation to the distribution of maximum and minimum sea temperatures (Hutchins, 1947; Allee and Schmidt, 1951, pp. 325–43; Ekman, 1953, pp. 1–308; Sverdrup, Johnson, and Fleming, 1942, pp. 799–810; and Phleger, 1951, pp. 59–63). Pulley (1953) established a series of zoögeographic provinces on the Atlantic coast and in the Gulf of Mexico based on the distribution of pelecypods in relation to mean maximum summer and mean minimum water temperatures (Fig. 31). Essentially, the criteria used in establishing Pul-

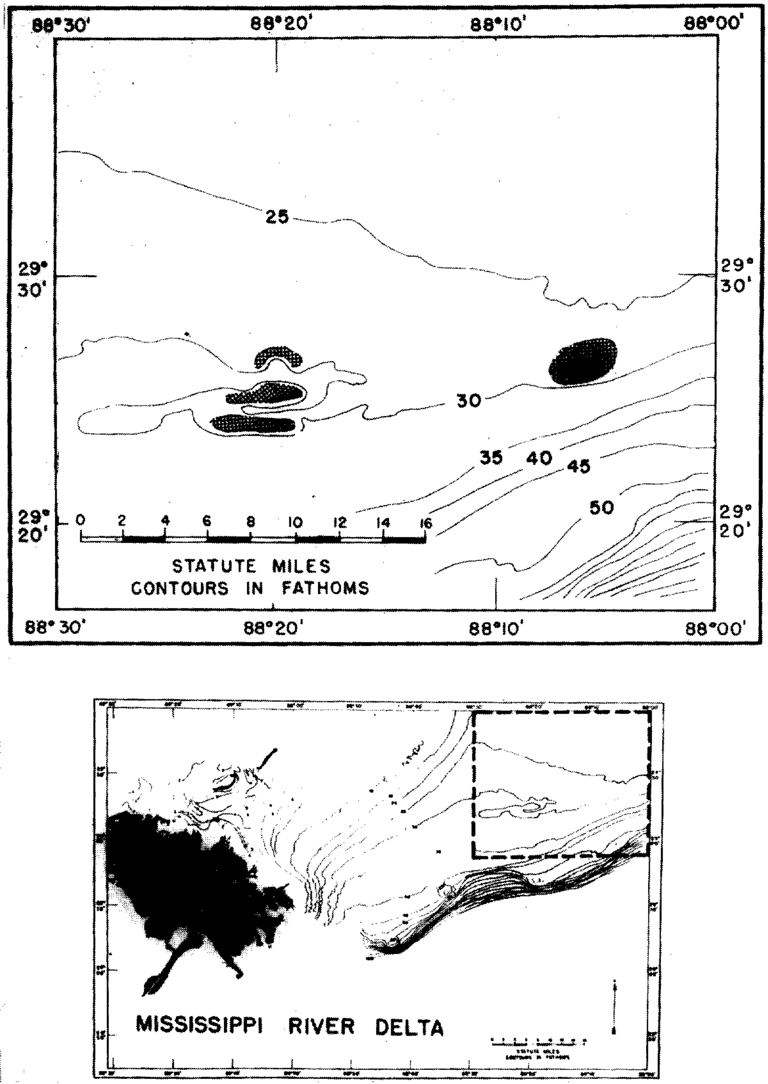


FIG. 30.—Location of deep-shelf littoral deposits containing oyster shell (*Crassostrea virginica*), marsh snails (*Littorina irrorata*), and Gulf beach clams (*Donax tumida*) from surface sediments. Note resemblance of bottom contours to barrier island or peninsula.

ley's temperature provinces are those stated in Hutchins (1947), who maintains that there are four basic types of zonation of marine animals with boundaries poleward and equatorward. These four criteria are: (1) minimum temperature for survival or winter poleward boundary, (2) minimum temperature for repopulation (reproduction) or summer poleward boundary, (3) maximum temperature for repopulation or winter equatorward boundary, and (4) maximum temperature for survival or summer equatorward boundary. Pulley found that wherever natural divisions of the coast occurred in relation to natural temperature divisions (breaks in mean minimum and mean maximum inshore temperatures, such as Cape Hatteras, Cape Canaveral, Cape Romano, Anclote Keys, the mouth of the Mississippi), he also found breaks in distribution of a large number of species of pelecypods. These breaks were usually indicated by the presence of the larval stages or juveniles in the northern part of the species range, but an absence of adults (which may not have been collected, but could have been present), indicating that the water temperatures are too cold for adult survival; and by the presence of adults alone in the southern part of these faunal breaks, indicating that the

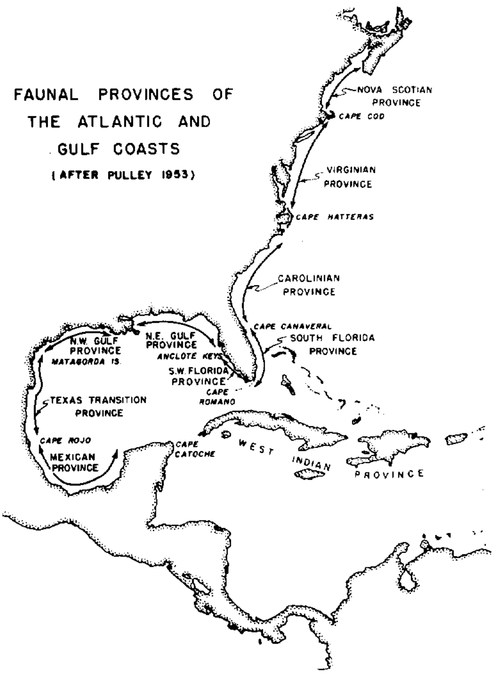


FIG. 31.—Location of molluscan faunal provinces on Atlantic and Gulf coasts as proposed by Pulley (1953).

water was too warm for reproduction. According to the series of 11 faunal provinces proposed by Pulley (1953), the shallow inshore region of the east Mississippi Delta region falls into the "northeast Gulf of Mexico province," with the Anclote Keys on the west coast of Florida as its eastern boundary, and the Mississippi River Delta on the west (Fig. 31). Pulley states that the mean maximum summer water temperature for this province is between 88° and 89°F., and the range of mean winter water temperatures is approximately 57° to 60°F. On the other hand, the waters west of the Mississippi River (which contain many mollusks that were not found east of the river) were reported by Pulley to have a mean maximum water temperature of 90°F., and mean minimum winter water temperatures of between 46° and 48°F., which may account for the difference between molluscan fauna on opposite sides of the Delta. There has been some question about the application of the temperature data cited by Pulley (tide-station data from the Coast and Geodetic Survey Publication TW-1) to the distributions of animals which range out to 40–60 feet deep. Many of the tide stations are located very close to shore in sheltered localities, and water temperature data from those stations are thought to represent only very local conditions. However, Scruton (manuscript) states that the minimum observed water temperature in Breton Sound is approximately 52°F. (11°C.) and has an average maximum of 88°–89°F. (31°–32°C.), and that these extreme variations do not extend to depths greater than approximately 30–40 feet in the immediately adjacent Gulf.

There are also indications from the positions of the surface and 200-meter iso-

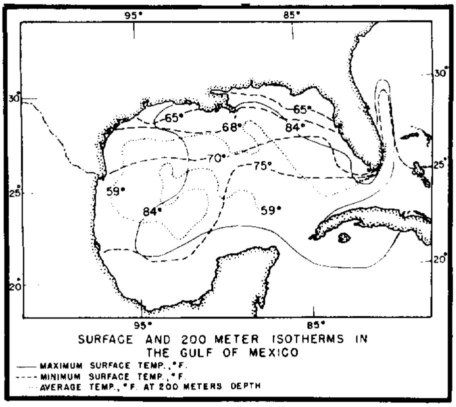


FIG. 32.—Surface (maximum and minimum) and 200-meter (average) isotherms of Gulf of Mexico, showing warmer water closer to shore in east Delta region. Data taken from Fuglister (1947, 1954).

therms in the Gulf of Mexico (Fuglister, 1947 and 1954) that warm water swings closer to the shore near the delta and the northeastern Gulf than in the northwestern Gulf (Fig. 32). This hypothesis of warmer waters closer to the shore in the east Delta region is verified to some degree by the fact that many of the West Indian or subtropical mollusks are taken in 10–12 fathoms offshore of the Chandeleur Islands, while these same species are not found in less than 15–20 fathoms offshore of the Texas coast, with the exception of Sabine and Heald banks off Galveston, Texas (personal communication from Willis G. Hewatt for the Magnolia Petroleum Company, Field Research Laboratories, and Hildebrand, 1954), where warmer bottom-water isotherms are further offshore. The region just north of the Delta area also has many Florida shallow-water species, such as *Melongena corona* Gmelin and *Scaphella junonia johnstoneae* Clench, which have not been reported west of Mississippi Sound (Clench, 1953, p. 376).

If the mean minimum and mean maximum bottom-water temperatures are among the more important factors for limiting the distribution of benthic invertebrates, these factors can be used to explain in part the faunal discontinuity which appears in approximately 12–15 fathoms off the Mississippi Delta. These deep-shelf waters of the study area fall partly into Pulley's "offshore West Indian province," which consists of the outer part of the continental shelf of the northern Gulf of Mexico from 25–35 fathoms to approximately 100 fathoms. According to Pulley (1953), the temperatures at the upper level should be near 65° or 70°F. and at the lower level from 55° to 60°F. These figures were originally obtained from Phleger (1951) and have since then been verified by temperature studies of the Gulf of Mexico by Adams and Sorgnit (1951) and Scruton (manuscript). The offshore temperature data are discussed by Scruton for this project, and he indicates that the average temperature varies from approximately 78°F. at the surface to 68°F. at a depth of 330 feet (Fig. 10). The average range of temperature at the surface is 9.8°C. (49°F.) and at 330 feet about 2.5°C. (36.5°F.). The deep-shelf bottom-water extremes differ radically from those of the inshore bottom water extremes where the average bottom water can range from 52° to 89°F. (Fig. 9, and Scruton, manuscript). These temperature observations may explain the occurrence of many species of invertebrates on the outer shelf of the northern Gulf of Mexico, which occur normally in the shallow waters of southwestern Florida and the Gulf of Campeche, Mexico (Galtsoff *et al.*, 1954, pp. 472–73, and Table VI). To date, few of the species in Table VI have been found in the shallow-shelf waters of the northern Gulf of Mexico, where apparently the mean minimum winter air temperatures which are effective to at least 60 feet are too low for either survival of the adults or for reproduction.

Richards (1954) cites a number of these deep-shelf species from deep borings made in the Delta region, and explains their occurrence (as warmer-water forms) by the lack of the cooling influence of the Mississippi River waters at the time the shells were deposited, about 450 years ago. These same species are common now in water depths of from 12 to 50 fathoms along most of the northern Gulf coast; therefore, it is not necessary to attribute these species to the absence of cooler Mississippi River waters. It is probable that the thin overlying river water could not exert a cooling influence on bottom waters at these depths. Their presence may be explained on the basis of warmer deep water at the time of deposition.

DISTRIBUTION OF MARINE MACRO-INVERTEBRATES AS INFLUENCED BY SALINITY

Many workers in marine ecology have determined that certain organisms are confined to, or apparently prefer, waters of either low or high salinities. Ladd (1951), working with brackish-water and marine assemblages on the Texas coast, based his communities or facies on the distributions of marine invertebrates and Foraminifera, and found that there were relationships between the

TABLE VI. PUBLISHED* RANGE OF SOME SPECIES OF MOLLUSKS FOUND AT 15–50 FATHOMS OFF MISSISSIPPI RIVER DELTA

Species	*Depth Range off Mississippi Delta (Fathoms)*	*Published Geographic Range*
GASTROPODS		
Crucibulum auricula	25–40	Cedar Keys, Fla., to Barbados, West Indies
Polinices uberinus	20–40	N. Carolina to Caribbean (not on NW. Florida coast)
Murex recurvirostrus rubidus	25–30	South half of Florida and to Bahamas
Nassarius ambiguus consensus	15–40	N. Carolina, south Florida to Bahamas, from 0 to 100 fathoms
Oliva caribaeensis	30–40	Puerto Rico, Caribbean Sea in shallow water
Marginella aureocincta	20–40	N. Carolina to both sides of Florida and West Indies
Ancystocyrinx radiata	25–40	Cedar Keys, west Florida to West Indies
Arene variabilis	30–40	N. Carolina, east Florida and West Indies, to 20 fathoms
Acteon candens	30–60	N. Carolina, SE. Florida to Cuba in 2–6 fathoms
Scaphander watsoni	30–40	Florida Keys to Bahamas
PELECYPODS		
Pinna carnea	20–30	SE. Florida and West Indies and Mexico
Chlamys sentis	25–40	N. Carolina, SE. Florida, West Indies at low-tide mark
Aequipecten muscosus	20–40	N. Carolina, both sides of Florida to West Indies, shallow
Aequipecten gibbus gibbus	20–40	Southern Florida to West Indies and Mexico in shallow water
Cyclopecten nanus	13–40	West Indies and Mexico in shallow water
Lima pellucida	20–35	Cedar Keys, Fla., to West Indies, in shallow water
Lucina sombrerensis	20–40	Known only from Miami and Florida Keys in 20 fathoms
Phacoides nassula	30–35	South Florida, Cape San Blas to Bahamas
Divaricella quadrisulcata	30–40	East coast from Cape Cod to West Indies, in shallow water
Echinochama cornuta	13–40	Florida Keys, West Indies, and Mexico in shallow water
Laevicardium pictum	20–40	South Florida to West Indies and Mexico, 3–100 fathoms
Gouldia cerina	15–40	South Florida to West Indies and Brazil in shallow water
Pitar simpsoni	30–35	SW. Florida, Cuba, Caribbean and Veracruz, Mexico
Macrocallista maculata	30–40	Alabama to West Indies, S. Texas to Campeche banks
Chione grus	25–40	Southern Florida and Campeche banks in shallow water
Semele bellastriata	30	Florida Keys, West Indies to Brazil, in 13–16 fathoms
Phylloda squamifera	13–40	South half of Florida and Campeche banks, 1–20 fathoms
Tellina georgiana	20–40	West Indies and Florida Keys in 10 fathoms
Strigilla mirabilis	5–40	South Florida, West Indies, and Mexico
Macoma extenuata	20–40	Cape San Blas, Florida to Florida Keys
Tellina texana	20–40	S. Carolina, south Florida, Florida Keys, and West Indies
Varicorbula operculata	13–40	Florida Keys to West Indies and Port Isabel, Texas, to Campeche
Corbula dietziana	30–40	Southern Florida and Campeche banks in shallow water
Pandora bushiana	12–40	Known only from SW. Florida in 13–19 fathoms
Verticordia ornata	20–40	South half of Florida to West Indies in 2 fathoms
Cuspidaria ornatissima	25–40	Florida Keys, West Indies, and Port Isabel, Texas
Cuspidaria granulata	25–40	Known only from Miami, Fla., and West Indies

* References used:
Abbott, R. Tucker, 1954, *American Seashells.*
Dall, W. H., 1889, "A Preliminary Catalogue of Shell-Bearing Marine Mollusks," *U. S. Natl. Museum Bull. 37*
Johnson, C. W., 1934, "List of Marine Mollusca of the Atlantic Coast from Labrador to Texas," *Proc. Boston Soc. Nat. Hist.*, Vol. 40, pp. 1–204.
Pulley, Thomas E., 1953, "A Zoogeographic Study Based on the Bivalves of the Gulf of Mexico," *Ph.D. dissertation,* Harvard University.

distributions of certain species with the increasing salinity gradient from river mouth to the open Gulf of Mexico. Gunter (1950) also discussed at length the relationship between invertebrate distribution and salinity in the Texas bays. Both Ladd and Gunter arrived at the conclusion that the distribution of invertebrates in these bays was controlled primarily by salinity. Hedgpeth (1953), Puffer and Emerson (1953), and Parker (1955) also discuss the importance of salinity in influencing the distribution of Gulf coast macro-organisms.

In the Texas area, although salinity conditions are more or less stable over long periods of time, they fluctuate seasonally, and tend to fluctuate only in the upper or lower ranges over several years' duration (Parker, 1955). This is not the case in the east Mississippi Delta region, where bottom salinities in some shallow-water areas can fluctuate as much as 18 °/₀₀ in a very short time throughout the year (Geyer, 1950; Scruton, manuscript). It is also evident that no enclosed hydrographic system exists in the delta area similar to the Rockport, Texas, region, where a river empties into an enclosed bay, and communication with the Gulf waters is restricted to a few narrow, shallow inlets. The delta region is almost completely open to the discharge of the Mississippi River distributaries and to the influx of Gulf water. This results in rather broad areas of somewhat unstable salinity characteristics with no fixed boundaries. Because this region is open to the Gulf, there is only a narrow fringe of the delta shores and perhaps some of the small bays close to and between the distributaries, with conditions comparable with those of the upper bays of the Rockport area. It is only in the narrow fringe of the delta that the species which are common in the Rockport low-salinity assemblage were found, such as *Macoma mitchelli* and *Rangia cuneata*. Apparently the only areas near the delta which contain relatively stable salinity characteristics needed for the continual growth of oyster reefs such as found in the Rockport area, are the shallow protected bays such as Quarantine, Coquille, and California bays west and north of the project area (Fig. 14). The fact that small oyster reefs also exist behind Breton Island indicates that this area is also protected enough to maintain relatively stable salinities.

Salinity is also a major factor influencing the distribution of macro-invertebrates in the shallow-shelf area. The species which are confined to Gulf waters, or occasionally come into parts of the sounds near the inlets, are those which are adapted to fairly high, stable salinities. They have not been reported from the bays on other parts of the northern Gulf coast, but are common on the shallow parts of the shelf along the entire northern Gulf coast. Although Breton Sound salinities are generally high enough to permit many species of invertebrates to exist there, they are still too low and variable for those species which seem to prefer normal Gulf salinities of 32–36 ‰. Harry (1942), Behre (1950), Hildebrand (1954), and Parker (1955) list many of the organisms which are found only in the higher Gulf salinities. The deep-shelf waters of typical high salinity are also characterized by pelagic open-ocean mollusks whose presence can be detected in the underlying sediments by abundant pteropod shells and an occasional egg case of *Argonauta argo* Linné, the paper nautilus, as well as a few remains of species of the gastropod genus *Janthina*.

It may be significant that there is an increasing number of species in the samples proceeding outward into the Gulf of Mexico. The marshes contained 2.1 per cent of the total number of species, or 5 species; the delta front, 9.4 per cent, or 22 species; the lower sound and pro-delta slopes, 19.7 per cent, or 46 species; the upper sound, 39.9 per cent, or 93 species; the inlets, 42.9 per cent, or 100 species; the shallow shelf, 34.8 per cent, or 81 species; and the deep shelf, 52.4 per cent, or 122 species, of all species taken. The inlet has somewhat more species than either the upper sound or shallow shelf, which is to be expected since species from both environments are found there plus endemic species. The number of index or characteristic species of invertebrates also increases from the marshes to the outer edge of the shelf, with only 2–6 species characteristic for the very nearshore areas, increasing to 30–40 index species in the stable upper sound and deep-shelf areas. This increase in numbers of species outward into the Gulf corresponds roughly with the degree of stability of the physical factors, particularly salinity in the delta region. These factors close to the delta and its distributaries are extremely variable and tend to stabilize in narrower ranges outward from the delta, so that the deep-shelf region has the largest number of species associated with a very narrow range of salinity and temperature.

APPLICATION OF MACRO-INVERTEBRATE DISTRIBUTIONS IN MISSISSIPPI DELTA TO ANCIENT MARINE ENVIRONMENTS

It may be possible to apply several features of the distribution of macro-organisms found in the Delta area to ancient environments and fossil assemblages preserved at least to the Pleistocene and Pliocene, and probably to the Miocene of the Gulf and south Atlantic coasts. All the species considered characteristic for the Recent delta environments are known to have been present in the Pleistocene, and the majority of the species have been found in the Pliocene sediments of the Gulf coast. Maury (1920, 1922) lists 17 species of gastropods and 40 species of pelecypods found in this present study as extending to lower Miocene. Richards (1947), in a study of the deep wells on the Atlantic coast, cites 38 species of mollusks from the Pleistocene, of which 32 have been found living in the delta; 46 from the Pliocene, of which 23 were found in the delta; and 209 species from the Miocene, of which 29 were found in the delta. None of the delta species was listed from the Cretaceous, although most of the genera found in the Cretaceous have species represented in the Recent of the Delta region. Richards (1939, p. 1894), in a list of invertebrate fossils from the marine Pleistocene of Texas, indicates that more than 90 per cent of these species are living to-day along the Gulf of Mexico coast, and thus it can be seen that most of them are species which occur living in the project area. Table VII gives the published distribution in geologic time of the mollusks used here to establish the macro-organism assemblages and to define environments (the following give details on geologic ranges used in compiling this table: Gardner, 1926–1947; Dall, 1898–1903; Maury, 1920, 1922; Richards, 1939, 1947; Moore, Lalicker, and Fischer, 1952; and Shrock and Twenhofel, 1953).

Since many of the macro-invertebrates which serve to define the environments in this study have also been found as fossils as far back as the Miocene, it should be possible to reconstruct some ancient environments on the following characteristics.

1. River deltas and mainland shores with associated salt marshes could be detected in the sediments by the presence of numerous wood and plant fibers in association with the gastropods *Neritina reclivata* and *Littorina irrorata*, and possibly the claws and carapaces of various species of fiddler crabs, *Uca*, and crayfish, *Cambarus*.

2. The shorelines of deltas and river mouths or areas where chlorinity is continually reduced below 10 $^{\circ}/_{\circ\circ}$ should be characterized by the presence of the

TABLE VII. GEOLOGIC RANGE OF SPECIES AND RELATED SPECIES OF MACRO-ORGANISMS FROM EAST MISSISSIPPI DELTA REGION*

Species	*Recent*	*Pleistocene*	*Pliocene*	*Miocene*	*Range of Related Species and Genera*
Abra aequalis M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to lower Oligocene
Abra lioica M	xxxxx	xxxxx			Genus to lower Oligocene
Aequipecten i. amplicostatus M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Jurassic
Aequipecten g. gibbus M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Jurassic
Aequipecten musocus M	xxxxx				Genus to Jurassic
Amphiodia limbata E	xxxxx				Related forms to Miocene
Anachis avara ssp. M	xxxxx	xxxxx			Related species and genus to Miocene
Anachis obesa M	xxxxx	xxxxx	xxxxx		Genus to Miocene
Anadara baughmani M	xxxxx				Related species to Jurassic
Anadara brasiliana M	xxxxx	xxxxx	xxxxx	xxxxx	Related species through Miocene
Anadara lienosa floridana M	xxxxx	xxxxx			Related species to Jurassic
Anadara campechiensis M	xxxxx	xxxxx	xxxxx	xxxxx	Related species through Miocene
Anadara transversa M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Jurassic
Anomia simplex M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Cretaceous
Architectonica nobilis M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Upper Cretaceous
Astrangia astraeiformis CO	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Cretaceous
Astyris perpicta M	xxxxx				Genus to Miocene
Atrina rigida M	xxxxx	xxxxx			Related forms to Jurassic
Atrina serrata M	xxxxx	xxxxx	xxxxx		Related forms to Jurassic
Brachidontes exustus M	xxxxx	xxxxx	xxxxx		Genus to Triassic
Brachidontes recurvus M	xxxxx	xxxxx	xxxxx		Genus to Triassic
Bugula neritina B	xxxxx				Related forms to Cretaceous
Busycon contrarium M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Upper Cretaceous
Busycon spiratum plagosum M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Upper Cretaceous
Cadulus carolinensis	xxxxx	xxxxx			Related species to Cretaceous
Calliactis tricolor CO	xxxxx				Anemone remains(?) (*Mackenzia*) in Cambrian rocks
Callocardia texasiana M	xxxxx	xxxxx			Related genus to Paleocene
Calyptraea centralis M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Upper Cretaceous
Cantharus cancellarius M	xxxxx	xxxxx			Related forms to Eocene
Cavolinia uncinata M	xxxxx	xxxxx			Related species to Miocene
Cerithium floridanum M	xxxxx	xxxxx	xxxxx		Genus to Cretaceous
Chione cancellata M	xxxxx	xxxxx	xxxxx	xxxxx	Related forms to Jurassic
Chione clenchi M	xxxxx				Closely related species to Miocene
Chione latilirata M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Cretaceous
Clypeaster prostratus E	xxxxx				Genus to Miocene
Corbula contracta M	xxxxx	xxxxx	xxxxx		Genus to Triassic
Corbula swiftiana M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Triassic
Crassinella martinicensis M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Eocene
Crassostrea virginica M	xxxxx	xxxxx	xxxxx	xxxxx	Related forms to Triassic
Crepidula fornicata M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Upper Cretaceous
Crepidula plana M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Upper Cretaceous
Crucibulum auricula M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Miocene
Cuspidaria ornatissima M	xxxxx				Genus to Jurassic
Cyclopecten nanus M	xxxxx				Related species to Miocene
Cyrtopleura costata M	xxxxx	xxxxx	xxxxx		Genus to Jurassic
Dentalium laqueatum M	xxxxx				Related forms to Ordovician
Dentalium texasianum M	xxxxx	xxxxx			Related species to Ordovician
Dinocardium robustum M	xxxxx	xxxxx	xxxxx	xxxxx	Related forms to Upper Cretaceous
Diodora cayenensis M	xxxxx				Related species to Miocene, genus to Cretaceous
Diopatra cuprea P	xxxxx				Polychaete jaws and tubes from Cambrian
Diplodonta punctata M	xxxxx	xxxxx	xxxxx		Genus to Paleocene
Diplodonta semiaspera M	xxxxx	xxxxx	xxxxx		Genus to Paleocene
Divaricella quadrisulcata M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Upper Paleocene
Donax tumida M	xxxxx	xxxxx			Genus to Eocene
Dosinia discus M	xxxxx	xxxxx	xxxxx		Genus to Eocene
Echinochama cornuta M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Oligocene
Ensis minor M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Eocene
Glycera americana P	xxxxx				Polychaete jaws and tubes from Cambrian
Gouldia cerina M	xxxxx				Closely related species to lower Eocene
Hemipholis elongata E	xxxxx				Related forms to Miocene
Labiosa lineata M	xxxxx				Related species to Miocene
Labiosa plicatella M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Jurassic
Laevicardium laevigatum M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Triassic
Laevicardium pictum M	xxxxx				Genus to Triassic
Limopsis sulcata M	xxxxx	xxxxx	xxxxx	xxxxx	Related forms to Cretaceous
Littoridina sphinctostoma M	xxxxx	xxxxx			Related genus (*Amnicola*) to Paleocene
Littorina irrorata M	xxxxx	xxxxx			Genus to Cretaceous
Lucina amiantus M	xxxxx	xxxxx			Related species to Miocene, genus to Silurian
Lucina crenella M	xxxxx	xxxxx	xxxxx		Genus to Silurian
Lucina sombrerensis M	xxxxx	xxxxx			Genus to Silurian
Luidia clathrata E	xxxxx				Related forms to Upper Cretaceous
Lumbrineris bifilaris P	xxxxx				Polychaete jaws and tubes from Cambrian

TABLE VII—(*continued*)

Species	*Recent*	*Pleistocene*	*Pliocene*	*Miocene*	*Range of Related Species and Genera*
Macoma constricta M	xxxxx	xxxxx	xxxxx		Genus to Miocene
Macoma extenuata M	xxxxx				Related species to Miocene
Macoma mitchelli M	xxxxx	xxxxx			Genus to Miocene
Macoma tageliformis M	xxxxx	xxxxx			Genus to Miocene
Macoma tenta M	xxxxx	xxxxx	xxxxx		Related species to Miocene
Macrocallista maculata M	xxxxx	xxxxx	xxxxx	xxxxx	Related forms to Paleocene
Mangelia cerina M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Eocene
Marginella aureocincta M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Eocene
Mellita quinquiesperforata E	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Miocene
Mercenaria campechiensis M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Jurassic
Mitrella lunata M	xxxxx	xxxxx	xxxxx		Related species to Eocene
Modulus modulus M	xxxxx	xxxxx			Genus to Miocene
Mulinia lateralis M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to late Eocene
Nassarius acutus M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Eocene
Nassarius ambiguus consensus	xxxxx	xxxxx	xxxxx		Related species to Miocene
Nassarius vibex M	xxxxx	xxxxx	xxxxx		Related species to Miocene
Natica pusilla M	xxxxx	xxxxx	xxxxx		Genus to Triassic
Neritina reclivata M	xxxxx	xxxxx			Genus to Jurassic
Noetia ponderosa M	xxxxx	xxxxx	xxxxx	xxxxx	Related forms to Eocene
Nucula proxima M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Silurian
Nuculana acuta M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Silurian
Nuculana eborea M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Silurian
Oliva sayana M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Eocene
Olivella mutica M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Paleocene
Ostrea equestris M	xxxxx	xxxxx			Related forms to Triassic
Pandora bushiana M	xxxxx	xxxxx	xxxxx		Genus to Lower Eocene
Pandora trilineata M	xxxxx	xxxxx	xxxxx		Genus to Lower Eocene
Panope bitruncata M	xxxxx	xxxxx	xxxxx		Genus to Upper Cretaceous
Pecten papyraceous M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Cretaceous
Petricola pholadiformis M	xxxxx	xxxxx			Genus to Cretaceous
Phacoides nassula M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Silurian
Phalium granulatum M	xxxxx	xxxxx			Genus to Paleocene
Phylloda squamifera M	xxxxx				Closely related species to Miocene
Pitar cordata M	xxxxx				Related species to Paleocene
Plicatula gibbosa M	xxxxx	xxxxx			Genus to Triassic
Polinices duplicatus M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Cretaceous
Polinices uberinus M	xxxxx				Related species to Eocene
Polystira albida M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Lower Miocene
Quadrans lintea M	xxxxx	xxxxx	xxxxx	xxxxx	Related genus to Jurassic
Rangia cuneata M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Eocene(?)
Rangia flexuosa M	xxxxx	xxxxx			Genus to Eocene(?)
Renilla mülleri CO	xxxxx				Fossil Pennatulids from Triassic rocks
Retusa canaliculata M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Oligocene
Sconsia striata M	xxxxx				Related species to Eocene
Semele bellastriata M	xxxxx	xxxxx	xxxxx		Related species to Miocene
Semele proficua M	xxxxx	xxxxx	xxxxx		Related species to Eocene
Semele purpurescens M	xxxxx	xxxxx	xxxxx		Genus to Eocene
Simum perspectivum M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Upper Cretaceous
Solecurtus cummingianus M	xxxxx	xxxxx	xxxxx		Genus to Cretaceous
Spisula s. similis M	xxxxx	xxxxx	xxxxx		Genus to Upper Cretaceous
Strigilla mirabilis M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Oligocene
Strombus alatus M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Cretaceous
Tagelus divisus M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Cretaceous
Tagelus plebeius M	xxxxx	xxxxx	xxxxx	xxxxx	Genus to Cretaceous
Tellidora cristata M	xxxxx				Related genus to Miocene
Tellina alternata M	xxxxx	xxxxx	xxxxx		Genus to Jurassic
Tellina texana M	xxxxx	xxxxx			Genus to Jurassic
Tellina versicolor M	xxxxx	xxxxx			Genus to Jurassic
Terebra dislocata M	xxxxx	xxxxx	xxxxx	xxxxx	Related species to Eocene
Terebra protexta M	xxxxx	xxxxx			Related species through Tertiary
Thais haemastoma floridana M	xxxxx	xxxxx			Related genera to Eocene
Thais haemastoma haysae M	xxxxx	xxxxx			Related genera to Eocene
Tonna galea M	xxxxx				Genus to Eocene
Trachycardium muricatum M	xxxxx	xxxxx			Genus to Miocene, related genera to Cretaceous
Turbonilla hemphilli M	xxxxx				Genus to Upper Cretaceous
Varicorbula operculata M	xxxxx	xxxxx	xxxxx		Related genera to Jurassic
Verticordia ornata M	xxxxx				Genus to Paleocene
Volsella d. granossisima	xxxxx	xxxxx	xxxxx		Genus to Devonian
Yoldia solenoides M	xxxxx	xxxxx			Related species to Pennsylvanian

* References used to compile this table: Dall (1890–1903), Gardner (1926–1947), Maury (1920–1922), Richards (1939, 1947), Moore, Lalicker, and Fischer (1952), Shrock and Twenhofel (1953).

M—Mollusk. E—Echinoderm.
C—Crustacean. P—Polychaete worm.
B—Bryozoan. CO—Coelenterate.

pelecypods *Rangia cuneata*, *R. flexuosa*, *Macoma mitchelli*, and *M. tageliformis*, and a small gastropod *Littoridina sphinctostoma* (mentioned by Ladd, 1951, and only tentatively identified from the Mississippi Delta by the writer).

3. Nearshore sound and gulf areas in the vicinity of large rivers where salinity is reduced and the sedimentation rate is rapid could be detected by the presence of comparatively few molluscan remains at any one level, the majority of which are *Mulinia lateralis*, *Nuculana eborea*, *Abra lioica*, and the gastropod *Nassarius acutus*.

4. Bay or sound areas with considerable gulf and river influence and widely spaced barrier islands should be characterized by the presence of many bay species such as listed in Tables I, II, and III and in the discussion of the upper sound environment, plus a considerable number of shallow shelf and inlet species, discussed under the headings of these two environments.

5. A bay or sound area which has been cut off from the Gulf by a series of uninterrupted barrier islands, should contain characteristic bay fauna (Ladd, 1951), with very little Gulf influence. If small rivers emptied into the bay or sound, causing the chlorinity to be decreased consistently below 11 ‰, oyster reefs composed of *Crassostrea virginica* would be found. Whenever the *Crassostrea* reefs contain an abundance of *Ostrea equestris*, the gulf oyster, it can be assumed that salinities have risen either from a series of droughts or from an increase in the size of the inlets from the open Gulf (Parker, 1955).

6. Inlets between the barrier islands or areas of strong currents which bring about an interchange of high and lower salinity water should be detected by the presence of many reworked shells with such sessile or attached organisms as limpets, chitons, and calcareous bryozoans. Certain pelecypods such as *Crassinella martinicensis*, *Trachycardium muricatum*, *Chione cancellata*, *Anadara brasiliana*, *Pandora trilineata*, and *Tellidora cristata* (only in the Delta region) and gastropods such as *Natica pusilla*, *Anachis avara semiplicata*, *Olivella mutica*, *Cantharus cancellarius*, and various species of *Turbonilla*, as well as the brittle stars, *Ophiolepis elegans* and *Hemipholis elongata*, have their centers of populations in or confined to the inlets.

7. The sound or bay sides of barrier islands, close to shore are apparently characterized by beds of *Mercenaria campechiensis texana* and *Aequipecten irradians amplicostatus*, and such gastropods as *Cerithium floridanum*, *C. muscarum*, *C. variabile*, and *Cerithidea pliculosa* (Cary and Spaulding, 1909).

8. The gulf side of barrier islands which have been subjected to considerable wave or surf action creating sand beaches may be detected by shell concentrates of *Donax*, *Terebra cinerea*, *Olivella*, many valves and bits of the large shallow-shelf Gulf mollusks, plus many fragments of heart urchins and sand dollars thrown on the shores by storms.

9. The shallow continental shelf areas out to 12–13 fathoms should be characterized by a large number of mollusks and echinoderms which can withstand moderate extremes of temperature, but are seldom found in waters where the

chlorinity falls below 17 $^{\circ}/_{\circ\circ}$ (discussions of shallow-shelf assemblage for animals characteristic of this region: Harry, 1942; Behre, 1950; Ladd, 1951; Hildebrand, 1954; and Parker, 1955).

10. Various depth contours on the continental shelf can be detected by distinct assemblages. These extend from 0 to approximately 13 fathoms, from 13 to approximately 50–60 fathoms, and from 50–100 fathoms and deeper (discussions on shelf assemblages of organisms characteristic of these depths: Rehder and Abbott, 1951; Pulley, 1953; and Dall, 1889). Since depth range appears to have a specific temperature range, these assemblages may also be used to detect possible bottom-water temperature ranges, at least in the northern Gulf of Mexico.

11. It may be possible to determine the approximate climate existing during the deposition of sediments in the ancient environments, by analyzing the species composition of the imbedded fossils, and checking these species against their present geographical distribution.

12. Reduced rates of sedimentation may be detected by shell concentrates of large numbers of valves and shell fragments, which may have died in place, representing many species and several environmental conditions. Rapid sedimentation rates should be indicated by a lack of shell material, few species, and an assemblage indicating only one set of environmental conditions at any one level in the formation.

It must be emphasized that the presence of only one or two of the organisms characteristic of a certain environment is not enough to establish the presence of this particular environment. The appearance of the entire assemblage and the comparative abundance of each species within the assemblage must be considered.

SUMMARY

1. Biological data on macro-invertebrates were obtained from 280 biological collecting stations and 130 geological (core) collecting stations. The following numbers of species of invertebrates were identified: 93 (+7 pteropods) gastropods, 116 pelecypods, 6 scaphopods, 1 chiton, 3 cephalopods, 7 anthozoans, 8 echinoderms, 31 polychaete worms, 8 bryozoans, and 34 crustaceans.

2. Seven divisions of the east Mississippi Delta region were recognized by the distribution of the macro-organisms collected in this study, from published records of invertebrates from this region, and from the distribution of the hydrographic factors in the area. The seven divisions are: (I) the delta marshes, (II) delta front and lower distributaries, (III) lower Breton Sound and 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 13 fathoms, and (VII) the deeper parts of the continental shelf from 13 fathoms to the outer edge of the shelf. A possible eighth assemblage is the living oyster reef. Tables and distribution charts are included to show the characteristic forms for each environment.

3. A series of bottom communities based upon the community concepts of Petersen, Thorson, and Jones were recognized on the basis of the most abundant and widespread animals.

4. Certain species may be used to detect the range of the environmental factors (substrate, temperature, and salinity) which are associated with the distribution of these characteristic invertebrates.

5. Most of the species with hard parts found in the Delta sediments, which have been used to characterize these environments, have existed in the past on the Gulf of Mexico coast to the Pliocene and many extend back to the lower Miocene. Since the known environmental data can be applied to the distribution of these species to-day, it should be possible to reconstruct ancient environments from fossil beds containing these species back to the Miocene.

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