DISTRIBUTION OF BENTHIC MACROINVERTEBRATES--
BEAUMONT-PORT ARTHUR AREA

by

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assisted by

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INTRODUCTION

On March 1, 1976, the Bureau of Economic Geology began an extensive program of benthic sampling in the State submerged lands (McGowen and Morton, 1979). The State-owned submerged lands of Texas encompass nearly 6,000 mi^2 (15,540 km^2) and extend from Mexico to Louisiana. The area includes the bays, estuaries, and lagoons as well as the inner continental shelf 10.3 mi (16.6 km) seaward of the Gulf shoreline (fig. 1). Benthic samples were taken at 1-mi (1.6-km) intervals. By January 1978, 6,697 samples had been collected. Sample analysis included textural studies (grain size properties), geochemistry (trace elements and total organic carbon), and biological studies.

This report on the biology of the submerged lands in the Beaumont-Port Arthur area provides preliminary information on benthic macroinvertebrate assemblages and diversity. It is a baseline inventory of biological data necessary to predict and assess potential problems and environmental impacts related to energy production, food production, recreation, and transportation.

PHYSICAL SETTING

The Beaumont-Port Arthur study area (fig. 2) includes the following lakes, rivers, and passes: Sabine Lake, Sabine Pass, and the Neches and Sabine Rivers. It also includes the inner continental shelf 10.3 mi (16.6 km) seaward of the Gulf shoreline.

Two major river systems, the Neches and Sabine, empty into the upper reaches of Sabine Lake. Smaller drainage systems, such as Taylor Bayou, discharge into either the Sabine-Neches Canal or the Port Arthur Canal (McGowen and Morton, 1979). Both rivers have been extensively altered by man. River flow has been impeded by two

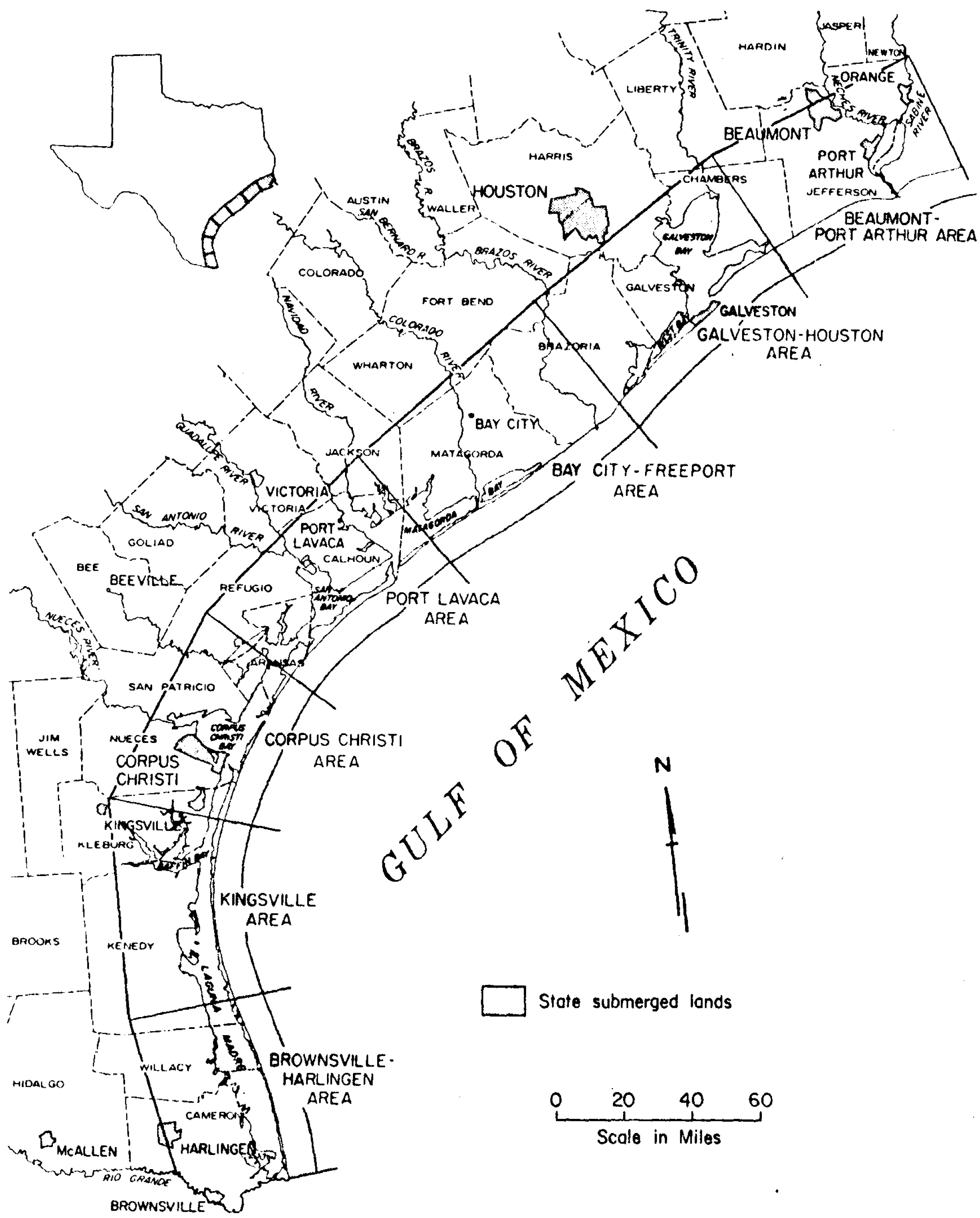

Figure 1. Index map of the Texas Coastal Zone showing areas for projected atlas series on submerged lands.

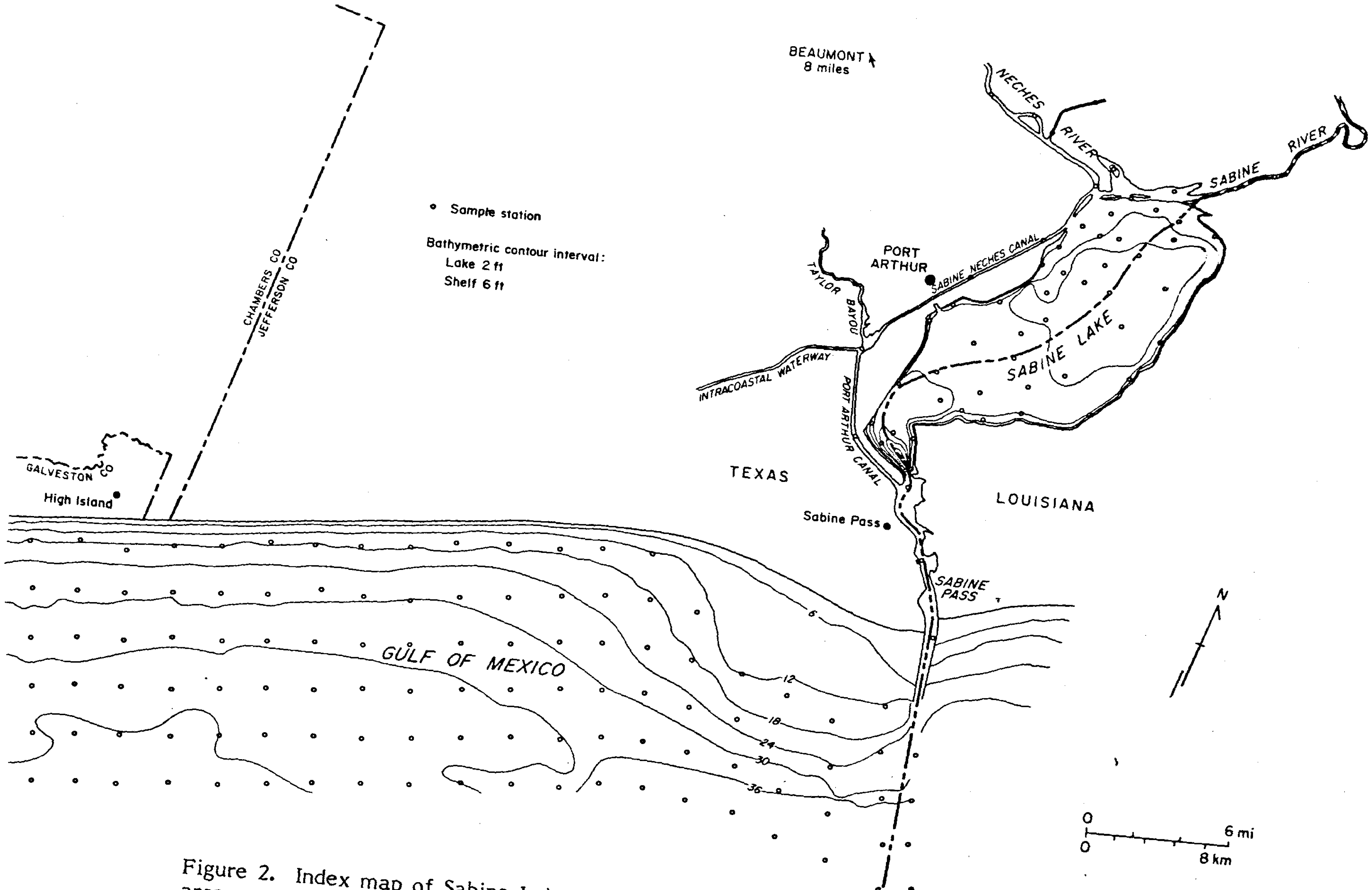

Figure 2. Index map of Sabine Lake and the inner shelf in the Beaumont-Port Arthur area.

reservoirs on the Neches River, B. A. Steinhagen and Sam Rayburn Lakes, and one reservoir on Sabine River, Toledo Bend Lake. Both rivers have been straightened and dredged along their lower reaches. Between 1906 and 1908, a channel 10 ft (3 m) deep was dredged from the Port Arthur Ship Channel to the mouth of the Neches River. During 1914-1916, a channel 25 ft (7.5 m) deep was extended to the city of Beaumont. A channel 40 ft (12.1 m) deep now extends from Beaumont to Orange (Scrudato and others, 1976).

Sabine Lake is approximately 20 mi (32 km) long and 8 mi (13 km) wide and has an average depth of about 6.6 ft (2 m) (Gosselink and others, 1979). Maximum depths of over 10 ft (3 m) occur near Sabine Pass. A dredged channel system is maintained along the west and northwest margins of the lake. Sabine Pass (fig. 2) connects Sabine Lake and the Gulf of Mexico via a dredged channel 7 mi (11.2 km) long.

Tidal ranges vary considerably in Sabine Lake and are dependent on wind direction and velocity as well as diurnal variations. A constant northerly wind may lower lake levels by as much as 19.7 to 27.6 inches (0.5 to 0.7 m) (Scrudato and others, 1976). Normal tidal ranges are about 7.9 to 11.0 inches (0.2 to 0.3 m).

Depths on the inner shelf in the Beaumont-Port Arthur area are generally shallow compared to other inner shelf areas on the Texas Coast. The Gulf seafloor slopes gulfward from about 20 to 25 ft (6.1 to 7.6 m) per mile nearshore to about 1 ft (0.3 m) per mile on the inner shelf (Fisher and others, 1973). In contrast, slopes on the Gulf side of Padre Island range from 47 to 82 ft (14.3 to 25 m) per mile nearshore, to 18 to 55 ft (5.5 to 16.8 m) per mile farther offshore (Brown and others, 1980). The maximum depth of the stations examined for benthic macroinvertebrates was 49 ft (14.9 m) offshore at Beaumont-Port Arthur.

Industrial development is concentrated along the northwest side of Sabine Lake at Port Arthur, along the Neches Ship Channel as far inland as Beaumont, and along channels leading inland from the Sabine River near Orange. River waters are used for processing and cooling by the predominantly petrochemical industries. Sewage discharge contributes significantly to the water quality of the rivers and is responsible for the closing of Sabine Lake to commercial and sport oystering because of bacterial contamination (Scrudato and others, 1976).

Salinities in Sabine Lake vary considerably and are dependent on tides, wind direction and velocity, and river discharge. Saline waters enter through Sabine Pass and form a dense wedge extending along the bottoms of the Sabine-Neches Canal and the Neches and Sabine Rivers (Gosselink and others, 1979). Some freshwater enters Sabine Lake from the Sabine and Neches Rivers, but an estimated average of 80% travels down the Sabine-Neches Canal and is separated from the main lake (Wiersema and others, 1976). The relative shallowness of the lake probably precludes the development of long-term vertical stratification. Mean monthly surface salinities taken by Wiersema and others (1976) from September 1974 to August 1975 at eight Sabine Lake stations ranged from 0.1 to 10.6 ppt. Mean surface temperatures during the same period ranged from 50°F to 86.4°F (10°C to 30.2°C).

Climate

Average annual rainfall at Port Arthur is 55 inches (140 cm) and the net annual rain surplus is 17 inches (43 cm) (Gosselink and others, 1979). Temperatures in counties along the Gulf of Mexico range from average winter minimum lows of 44°F (6.6°C) to average maximum summer highs of 91°F (32.8°C). Between 1931 and 1960, the average annual mean free-air temperature in the Beaumont-Port Arthur area was approximately 70°F (21.1°C) (Fisher and others, 1973).

Prevailing winds are southeasterly from March to November, shifting to northerly from December to February. The importance of the large net rain surplus is indicated by the large expanse of coastal wetlands between High Island and Port Arthur. These wetlands are key waterfowl areas on the Texas coast.

Sediment

Silty substrates are most common in Sabine Lake. Clayey silts and sandy silts with mean grain size greater than 5 ϕ are predominant. Sandy substrates (80 to 100% sand) (fig. 3) occur at the northern part of Sabine Lake adjacent to Humble Island and at the mouth of the Sabine River. Shell occurs in conjunction with isolated oyster reefs located at the head of Sabine Pass.

The Beaumont-Port Arthur inner shelf is affected by sediment input from Sabine Lake and westward-flowing littoral currents from southwestern Louisiana (McGowen and Morton, 1979). It is largely silty clay or clayey silt of a mean grain size greater than 6 ϕ. In general, both the sand content (fig. 3) and the mean grain size of the sediment increase as the distance from the shore increases. Sand content and mean grain size of the sediment also increase with distance westward from Sabine Pass.

Pleistocene relict muds extent 9 mi (14.4 km) offshore in up to 40 ft (12.2 m) of water. Most of the relict muds occur from 1 to 3 mi (1.6 to 4.8 km) offshore and commonly contain or are overlain by caliche, which indicates subaerial exposure and soil formation (McGowen and Morton, 1979). Shells of brackish-water mollusks, commonly *Rangia cuneata*, *Crassostrea virginica*, and *Texadina sphinctostoma*, are generally associated with the relict sediment.

FIELD PROCEDURES

Inner Shelf

Surface sediment samples were collected on the Texas inner continental shelf with a Smith-McIntyre grab sampler (capacity 0.013 m^3); samples were spaced 1 mi (1.6 km) apart. Penetration depths ranged from 1.6 to 2.8 inches (4 to 7 cm). Shelf samples were collected during two separate cruises, October 27-29, 1976, and September 15-16, 1977. Precision navigation was accomplished primarily with a Motorola Mini Ranger system.

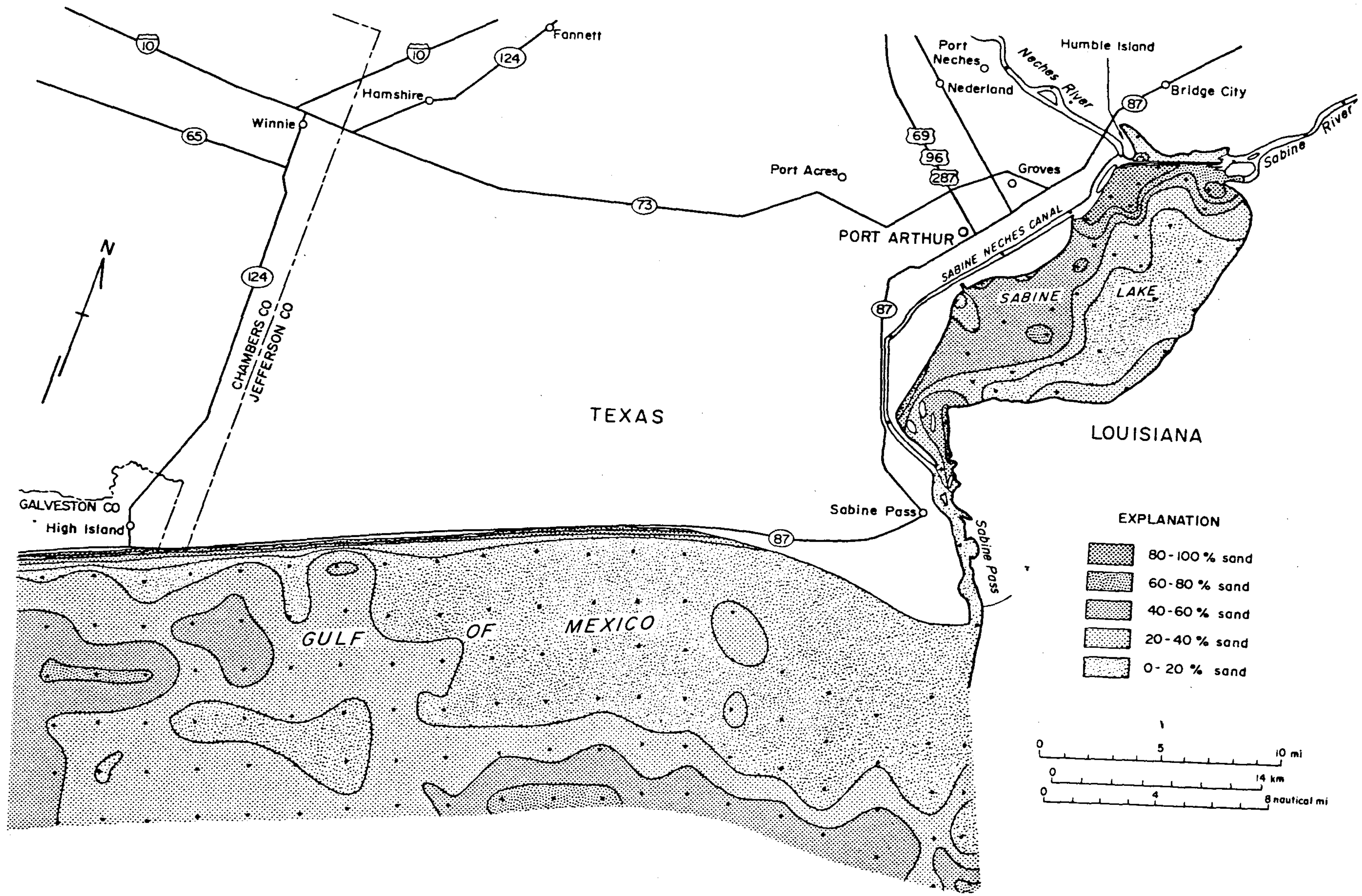

Figure 3. Percent sand map of Sabine Lake and the inner shelf in the Beaumont-Port Arthur area.

Shipboard descriptions of the samples were based on visual observations of sediment type, sediment color, shell content, degree of bioturbation, abundance of worms, and preservation of individual sediment layers in a vertical sequence. Samples were (1) washed through a 0.5-mm or 1-mm screen, (2) narcotized with a solution of propylene phenoxytol, and (3) stored in a neutral solution of 10% formalin. Rose bengal was placed in the formalin to help distinguish live from dead specimens.

Bays

Surface sediment samples were taken on 1-mi (1.6-km) intervals with a clam shell grab sampler with a capacity of 0.004 m^3. Enough grabs were taken at a station to equal approximately 0.004 m^3; the samples were semiquantitative because the volume was estimated visually. Samples in Sabine Lake and the canals and rivers were taken from January 19 to January 28, 1977. Shipboard processing was essentially the same as on the inner shelf except that samples were always washed through a 1-mm mesh screen and narcotized with magnesium sulfate.

LABORATORY PROCEDURES

Laboratory processing included further washing of the sample and storing it in 70 percent ethanol. All live invertebrates were identified to species level when possible and all individuals were counted. Dead shell was identified and recorded but not counted. Gravel/sand/mud proportions in the sediment were determined by oxidation, desaltation, sample drying, and then wet sieving.

INVERTEBRATE DISTRIBUTIONS

One hundred fifty-one species and 2,991 individuals were found living in the 88 benthic samples examined in the Beaumont-Port Arthur area (table 1). Polychaetes

Table 1. Abundance of the taxonomic groups within the submerged State lands of the Beaumont-Port Arthur area.

	Inner Shelf		Bays and Rivers	
	Species	Individuals	Species	Individuals
Mollusca	36	458	14	251
Polychaeta	54	964	12	348
Crustacea	22	201	14	461
Other groups	9	188	5	120
Total	121	1,811	45	1,180

Total species (all phyla) = 151

Total molluscan species (live and dead) = 129

had the highest total species count on the inner shelf; crustaceans and mollusks were more abundant in Sabine Lake and the Neches and Sabine Rivers.

Inner Shelf

Total species counts per station ranged from 5 to 27 on the inner shelf. Species counts generally ranged from 10 to 19; only 7 stations had more than 20 species. High species counts were scattered and never occurred at the nearshore stations, the same as on the Corpus Christi inner shelf (Calnan and others, 1980).

Polychaetes were dominant in both numbers of species and individuals (table 1). Two polychaete species, Magelona phyllisae and Paraprionospio pinnata, composed over 40% of the total number of polychaete individuals. Few suspension-feeding polychaetes were present, and all dominant species were either surface-deposit feeders or carnivores. The sandier environment of the Corpus Christi inner shelf supported a much higher population of suspension feeders (Calnan and others, 1980).

Of the 36 species of mollusks collected live on the inner shelf, 19 (53%) were gastropods and 17 (47%) were bivalves. Nassarius acutus, constituting 24% of the total number of individuals, was the most abundant mollusk. The dominant bivalve was Nuculana concentrica (17% of the total). A large number of brackish-water species, including Crassostrea virginica, Rangia cuneata, Texadina sphinctostoma, and Probythenella louisianae, occurred as dead shell at many stations, especially at those stations associated with relict muds (McGowen and Morton, 1979).

The almost total absence of sediment with high sand content was reflected in the low number (22) of crustacean species. Most of the dominant crustacea on the inner shelf are associated with substrates of high sand (Calnan and others, 1980, 1981). The two dominant crustaceans, which together constituted over 50% of the total, were the decapod, Pinnixa sp., and the cumacean, Oxyurostylis salinoi.

Sabine Lake, Sabine River, Neches River, and Sabine-Neches Canal

Sabine Lake was dominated by a few brackish-water species, commonly found where salinities are consistently low. Three species, Balanus sp. (barnacle), Streblospio benedicti (polychaete), and Rangia cuneata (mollusk), composed over 50% of the total number of macroinvertebrates. Balanus sp. accounted for 34% of the total.

A typical low-salinity oyster reef assemblage of Crassostrea virginica and Ischadium recurvum occurred at stations 10½ and 12 near Sabine Pass. The polychaetes, Nereis succinea and Polydora ligni, were also fairly abundant at the two reef stations.

Total species counts per station were uniformly low. The highest count was 10 at station 88 in the upper part of Sabine Lake.

TOTAL SPECIES DIVERSITY

A major aspect of benthic communities is their diversity, that is, the number of species present and their numerical composition. The Shannon-Weaver diversity index, H' (Sanders, 1968), provides a method for calculating a numerical value for diversity with the formula $H' = -\sum_{r=1}^{s} p_r \log_2 p_r$, where s equals the total number of species from the sample, and p equals the observed proportion of individuals that belong to the r^{th} species (r = 1, 2, . . ., s). High numerical values for H' correspond to high species diversity, whereas low values for H' signify low species diversity.

The diversity index can be used as an indirect measure of stress (natural and/or man-made) upon a system. High numerical values for H' are assumed to indicate areas of low stress, whereas low numerical values for H' are assumed to be areas of high stress. Clearcut ranges defining different degrees of stress, however, are difficult to define (Holland and others, 1973).

Diversity indices in the study area have been contoured into areas of low, medium, and high diversity (fig. 4). Low faunal diversity is often associated with low sand content of the substrate. High faunal diversity occurs most often in conjunction with substrates high in sand content.

Inner Shelf

The majority of stations examined on the inner shelf exhibited moderate diversity (H' = 1.500 - 2.499). Isolated stations contained a less diverse or more diverse fauna; one group of stations due south of High Island was high in faunal diversity (fig. 4). In other areas on the Texas coast, faunal diversity tends to be highest nearshore and decreases with distance from shore (Calnan and others, 1980). No such patterns were found in this area.

A variety of stresses affect the inner shelf, including low sand content of the substrate and influx of sediment and brackish water from Sabine Lake. It is unknown how much influence these factors have on the faunal diversity of the area.

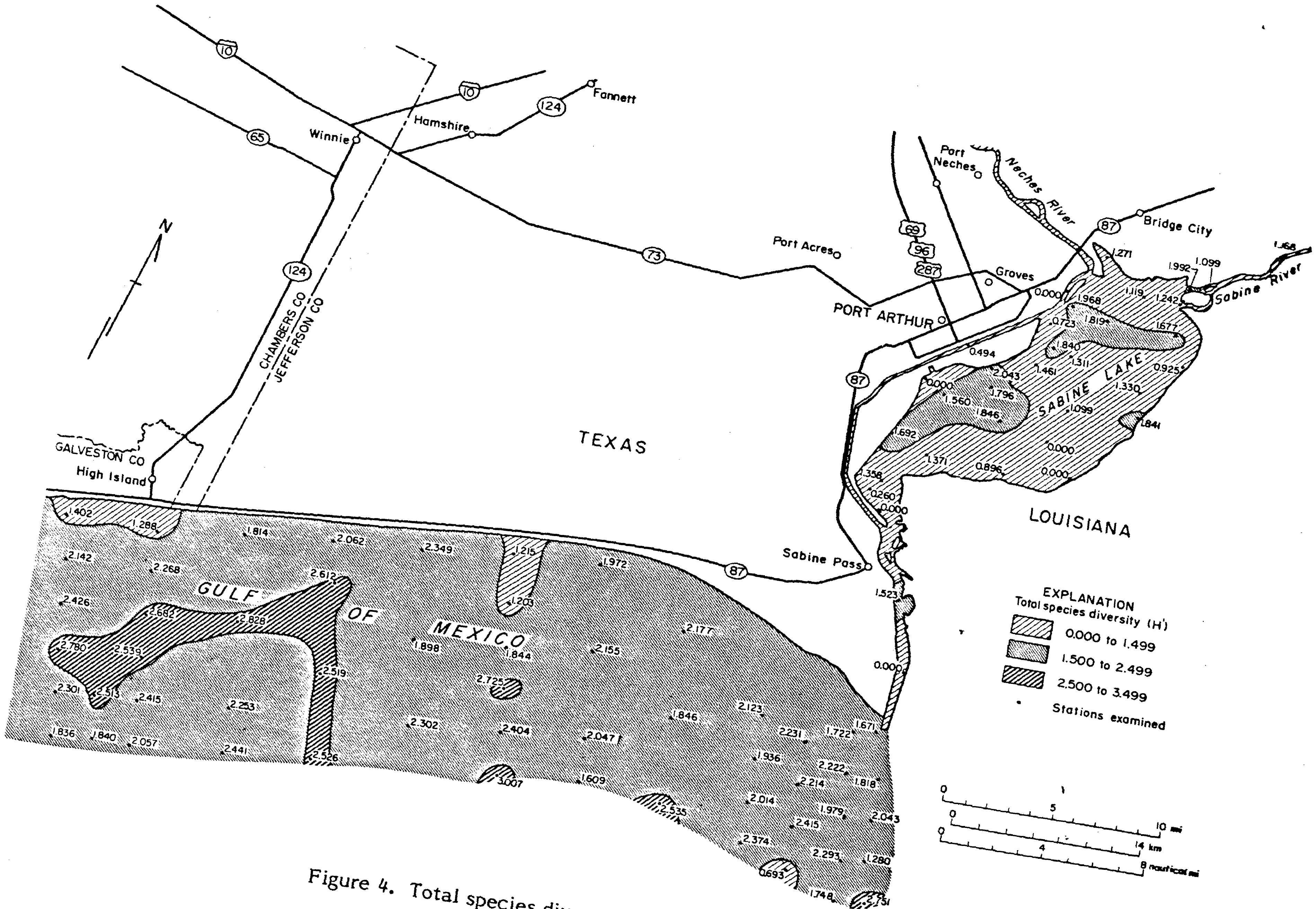

Figure 4. Total species diversity for all examined stations.

Sabine Lake

The fauna of Sabine Lake exhibits low diversity (H' , 1.500) in the majority of stations sampled. This low diversity indicates that the environment is one in which the fauna is often subjected to stress. In Sabine Lake, two natural phenomena contribute to this stress: freshwater inflow from the Sabine and Neches Rivers and low sand content of the substrate. Variable salinity strongly limits both number and kinds of organisms able to survive and, in previous studies, substrate composition has been found to be a strong limiting factor on species composition (Calnan and others, 1980). Two small areas near the city of Port Arthur (fig. 4) have moderate faunal diversity; the substrate of these areas contains a higher percentage of sand, which may contribute to the relatively higher faunal diversity.

INVERTEBRATE ASSEMBLAGES

Numerical analysis methods were used to identify species assemblages and to delineate the spatial distribution of each assemblage. The analysis involved use of the Canberra-Metric dissimilarity index to aid in computing the dissimilarity between all possible pairs of stations based on the species present. Individual stations were clustered into groups with the greatest affinities; the clustering strategy used was the flexible sorting method (Boesch, 1973). Station and species dendrograms were constructed to produce station and species groups. Performing both normal (Q mode) and inverse (R mode) cluster analyses allowed construction of a two-way coincidence table (Holland and others, 1977) to aid in identification of species assemblages characteristic of geographical zones. Cluster analyses were run on Sabine Lake (including the Sabine and Neches Rivers) and the Beaumont-Port Arthur inner shelf. Species that occurred at only one station were eliminated from the analysis in order to reduce computer time and to help prevent clutter in the dendrograms.

The assemblages map of Sabine Lake and the inner shelf (fig. 5) shows the distribution of assemblages at a given time but not sequential or temporal changes in map units. Samples were carefully preselected according to a number of factors including sediment type and proximity to other stations. A data base was created that allows for a minimum of interpretation between units. Map units are named for geographical and physical parameters and, except for the oyster reef assemblage, not for characteristic species (table 2).

Inner Shelf

Cluster analysis of faunal data from the inner shelf separated the stations into two assemblages, assemblages A and B (fig. 5). The two assemblages are similar in species content, having no distinct transitional zone between them as is found on the inner shelf in the Corpus Christi area (Calnan and others, 1980). The distinction between the two assemblages may be so small that with further analyses the two groups may be combined into one inner shelf assemblage. The similarity of the two groups may be the result of the homogeneity of the sediment on the inner shelf in the Beaumont-Port Arthur area.

Assemblage A is farther offshore in slightly deeper waters (average depth 40 ft [12.2 m]) than assemblage B (average depth 29.8 ft [9.1 m]). Since sand content increases slightly with distance from shore, the average percent sand at assemblage A stations is higher (42.2%) than at B stations (19.3%).

Deposit-feeding mollusks and polychaetes dominate both assemblages (table 2). The only abundant crustacean species, Oxyurostylis salinoi, occurs in assemblage B. The average number of species and individuals per station for each group is similar (table 3).

Sabine Lake and the Neches and Sabine Rivers

Cluster analysis of faunal data in Sabine Lake and the Neches and Sabine Rivers separated the stations into (1) a river-influenced assemblage, (2) an oyster reef assemblage, and (3) an inlet-influenced assemblage (fig. 5). The river-influenced assemblage covers the largest area, whereas the inlet-influenced and oyster reef assemblages are limited to a small group of stations near and within Sabine Pass (fig. 5).

All three assemblages are dominated by mollusks and polychaetes, primarily brackish-water species. Species in the river-influenced assemblage, such as Rangia cuneata, Texadina sphinctostoma, Streblospio benedicti, and Parandalia fauveli are typical of low-salinity bays. Relative to other environments this assemblage is probably more subject to greater natural stress, which adversely affects the survival of marine organisms. Species diversity (H') values are uniformly low at stations in the river-influenced assemblage.

A small oyster reef is located in Sabine Lake, near Sabine Pass. Live Crassostrea virginica and Ischadium recurvum are abundant, although restricted to only a few stations. The polychaetes, Polydora ligni and Nereis succinea, are also fairly abundant. An inlet-influenced assemblage occurs in Sabine Pass. Species characteristic of this assemblage also occur in Sabine Lake and on the inner shelf.

SUMMARY

Results of this preliminary baseline study include the following:

(1) Most stations on the inner shelf exhibited moderate diversity (H'), ranging from 1.500 to 2.499.

(2) Most of Sabine Lake was low in diversity (H') values, possibly owing to natural stress from fresh-water inflow from the Sabine and Neches Rivers and the low sand content of the sediment.

Table 2. Invertebrate assemblages, Sabine Lake and inner shelf.

Sabine Lake

River Influenced — Neches and Sabine Rivers and most of Sabine Lake; variable salinities; high stress environment predominantly silt-clay.

Characteristic species: Mollusca; Rangia cuneata, Texadina sphinctostoma, Polychaeta; Streblospio benedicti, Polydora ligni, Hobsonia gunneri, Parandalia fauveli.

Inlet Influenced -- Strong tidal influence; good circulation and exchange with other parts of bay and open Gulf, predominantly sand and shell.

Characteristic species: Polychaeta; Nereis succinea, Paraprionospio pinnata.

Oyster Reef — Distinct shoals commonly aligned normal to circulation; composed of living and dead oysters.

Characteristic species: Mollusca; Crassostrea virginica, Ischadium recurvum.

Gulf of Mexico -- Inner Shelf

Inner Shelf A -- Average depth of 40 ft (12.2 m); average percent sand of 42.2%.

Characteristic species: Mollusca; Corbula contracta, Nuculana concentrica, Nassarius acutus, Parvanachis obesa. Polychaeta; Magelona phyllisae, Clymenella torquata, Branchiosychis americana, Lepidasthenia maculata. Nemerteans.

Inner Shelf B -- Average depth of 30 ft (9.1 m); average percent sand of 19.3%.

Characteristic species: Mollusca; Nuculana concentrica, Vitrinella floridana, Nassarius acutus. Polychaeta; Magelona phyllisae, Diopatra cuprea, Paraprionospio pinnata, Linopherus ambigua. Crustacea; Oxyurostylis salinoi. Nemerteans. Hemichordates.

Table 3. Characteristics of benthic faunal assemblages in the Beaumont-Port Arthur area.

Assemblage	Total number examined stations	Average number species/station	Average number ind./station	Average % sand	Average depth in feet (m)
Inner shelf A	22	13.9	28	42.2	40 (12.2)
Inner shelf B	34	11.4	36	19.3	30 (9.1)
Bays					
River influenced	27	5.5	25.7	42.5	
Inlet influenced	3	2.7	12.3	3.2	
Oyster reef	2	6.5	224.5	34.7	

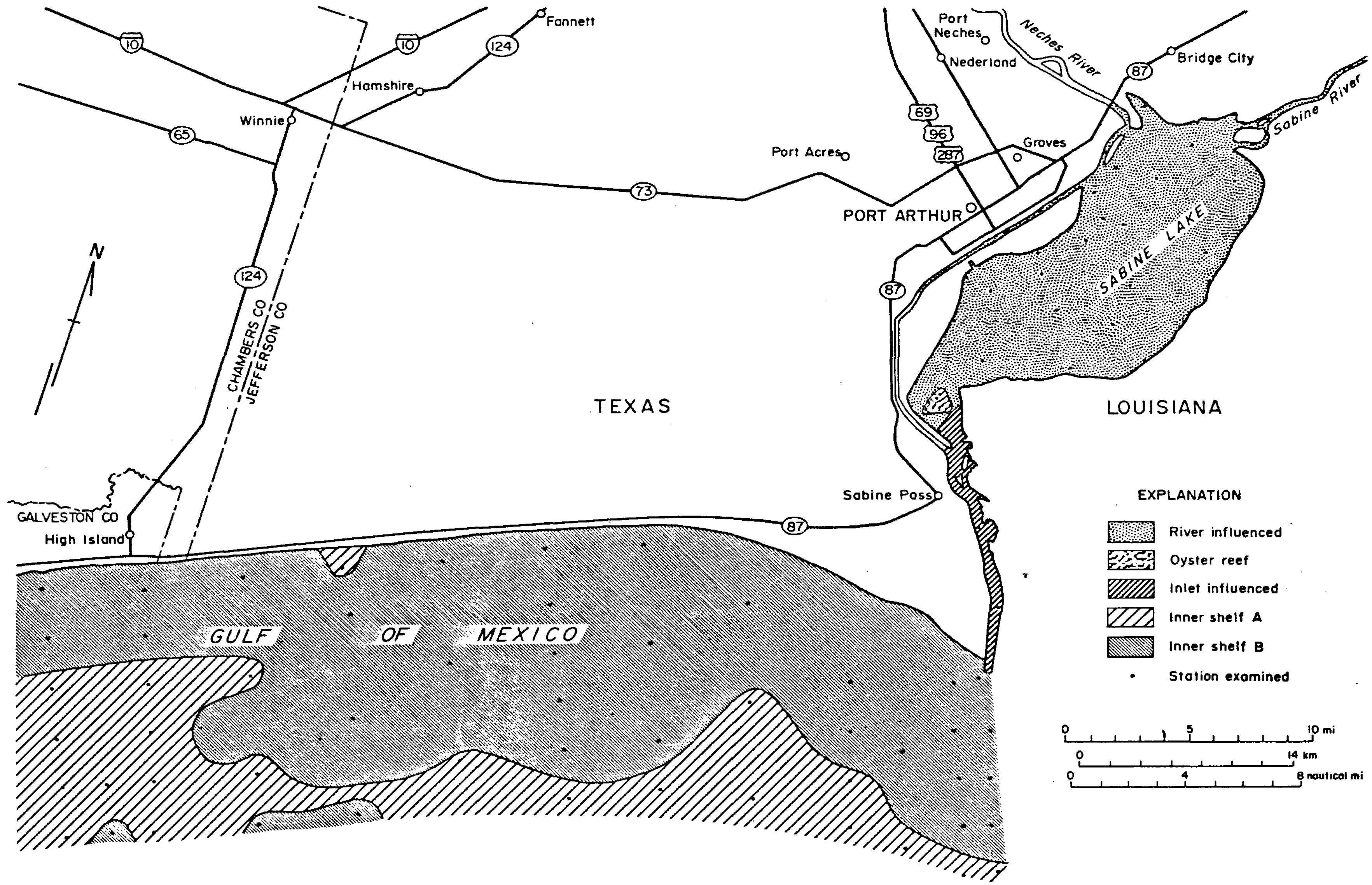

Figure 5. Macroinvertebrate assemblages.

(3) Cluster analysis of faunal data in Sabine Lake and the Neches and Sabine Rivers separated the stations into river-influenced, oyster reef, and inlet-influenced assemblages.

(4) The two inner shelf assemblages were similar in species content.

(5) Deposit-feeding mollusks and polychaetes dominated both assemblages on the inner shelf.

(6) Three macroinvertebrate species, Balanus sp., Streblospio benedicti, and Rangia cuneata, composed over 50% of the total fauna in Sabine Lake.

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