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Louisiana Coastal Marsh Ecology

Technical Report No. 14

by

Willis A. Egger, Anthony Ekker, Richard T. Gregg, Elard Haden,
Arthur Novak, Robert P. Waldron, and Hulen B. Williams

Richard J. Russell, Editor



Coastal Studies Institute
Louisiana State University
Baton Rouge 3, Louisiana

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LOUISIANA COASTAL MARSH ECOLOGY

by

Willis A. Eggler, Anthony Ekker, Richard T. Gregg,
Elard Haden, Robert P. Waldron, and Hulen B. Williams

Richard J. Russell, Editor

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Baton Rouge, Louisiana

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FOREWORD

About 100 miles west of the delta of the Lower Mississippi River lies the Lafourche-Terrebonne region, a complex of older deltas. The most recent active distributary of the river, Bayou Lafourche, approximates the eastern boundary of the region.

In the Louisiana deltaic coastal plain the Lower Mississippi, its antecedents, and other streams build natural levees that rise from a few inches to a few feet above surrounding levels, to heights dictated by their flood stages. These natural levees vary in width from a few feet to several hundred yards, or even more. Their crests, rising to maximum elevations for the region, are located along channel banks. From crests gently concave profiles lead outward, away from channels. Irregular basins between the natural levees narrow inland, toward areas where channels branch. Basins widen coastward and include broader areas of water. Within them irregular branchworks of channels develop both to carry away runoff resulting from rain within their levee-crest-defined drainage areas and, closer to the coast, to accommodate tidal flow. Lunar tides occur once a day and rarely amount to more than a foot but changes in wind direction and velocity raise or depress water levels by more than twice that amount.

The ecological studies included in this report are concerned with parts of the basin that lies immediately west of Bayou Lafourche. Irregular lakes and bays cover the area and channels of various kinds are numerous, dominant among which is Grand Bayou Blue. As an older and southern part of the deltaic coastal plain the region has experienced regional subsidence amounting to several feet during the past 20 centuries or so--a coastward tilting. The immediate coastal area is irregularly embayed, Timbalier Bay, into which Grand Bayou Blue and other channels within its basin flow, being a large and typical example. Coastal marsh is relatively firm along the immediate shore of the Gulf of Mexico but inland is less firm and includes areas of flotant, a vegetational mat ordinarily firm enough to be walked with caution, overlying water or saturated ooze.

The Coastal Studies Institute began ecological studies in this area about ten years ago, intensifying them about six years ago. Specialists of various kinds were asked to investigate problems within their own areas of interest and reports were issued in small numbers as results accumulated. Although the combined efforts fall far short of constituting a monographic ecological study, some of the data accumulated, methods used in its collection, and conclusions advanced appear to be valuable enough to justify publication as a unit. It is thought that the chief beneficiaries may be

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persons who are engaged in marshland ecological investigations, wherever the location.

At the time of initiating ecological studies in Louisiana marshlands it was thought that detailed botanical investigations in several type areas would lead to recognition of plant associations that could be identified on aerial photographs, with a result that the entire marshland region could be mapped in detail with relatively small effort. It was found, however, that in territory as flat as the coastal marshes an inch or so difference in vertical relief changes drainage, salinity, and other edaphic values to a degree such as might occur in a mile or more horizontally. The microrelief is such that plant communities are distributed much more complexly than we had anticipated. The complex is further upset by man-induced changes, such as an active program of canal building.

Later investigations established the fact that it is easier to recognize broad ecological associations, such as between salt and fresh marsh, along the waterways than on the marsh surface itself. Possibly the most interesting relationship discovered in our chemical investigations concern ratios between total solids and chlorinity of waters. Within mappable areas these ratios remained quite constant through cycles of change in salinity. Along a comparatively narrow belt separating higher from lower ratios a zone of variability appears to be the location where colloids are flocculated most rapidly. This belt identifies a transition from fresh to salt marsh. In more saline waters evidence from population counts of foraminifera appear to be more useful than chemical data for recognition of distinctive ecological areas. Nutrients supporting foraminifera, however complex the food-chain steps along the way, are derived from the land and become less abundant as salinity increases along gradients leading to openings from Timbalier Bay to the Gulf.

These ecological studies were begun in the most inland part of the area under consideration and were supported by grants from the Texas Sulf Sulphur Company in order to determine whether industrial effluents, especially those associated with sulfur mining, might adversely affect plant and animal life. Populations of animal life were extremely small along waterways where salinities normally ranged from 5 to 25 parts per thousand. Studies were later shifted downstream and into Timbalier Bay, where salinities averaged in the neighborhood of 20 and ranged on up to about 30 parts per thousand. Financial support was obtained from the Geography Branch of the Office of Naval Research. Animal populations were larger and more varied in composition in the more saline part of the basin.

Emphasis in all of the studies presented here is placed on tables and graphs of observational data, and on methods used in their collection. Interpretation is minimized. It is felt that in any region as complex as Louisiana marshlands and waterways an understanding of ecology will require a tremendous amount of basic observational effort. These studies, we hope, constitute a step in the right direction.

Richard J. Russell

LOUISIANA COASTAL MARSH ECOLOGY

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VEGETATION OF THE DRAINAGE BASIN OF GRAND BAYOU BLUE

Willis A. Egglar

INTRODUCTION

Coastal Louisiana is a relatively uniform, low-lying area which is composed predominantly of marshlands. The marshes are similar in that they have developed on sedimentary deposits laid down by the Mississippi, and other rivers. Subsequent to deposition these sedimentary deposits, called alluvium, are subject to subsidence and compaction, finally becoming rather stable.

The marshes of Louisiana can be divided into four types. The youngest and least stable of these areas is found in the Lower Delta of the present Mississippi River (Plaquemines Parish) where alluviation is still the dominant process. The area northeast of the Lower Delta, in St. Bernard Parish, is a vast expanse of marshland formed around abandoned Mississippi River distributaries. Deprived of a supply of alluvial materials this area has been slowly subsiding for the past several hundreds of years. The third type of marsh area lies west of the Mississippi River and consists generally of a series of separate marsh basins between firm natural levees of old stream courses. These courses are no longer active so again subsidence is the dominant feature. As these basins are subsiding at different rates there are varying types of marsh which result. Many of the basins, deprived of a sediment supply, have subsided below sea level. Vegetation growth has occurred simultaneously with subsidence, leading to the formation of floating marsh or "flotant" (Russell, 1942) which forms a surface at, or slightly above, sea level. It is with this kind of marsh that the present paper is concerned. The fourth type of marsh is the relatively dry, stable marsh found flanking the coast of western Louisiana, chiefly in Cameron and Vermilion Parishes.

Vegetation types in a marsh area depend upon the physical conditions of the marsh. Elevation differences of a few inches result in a variable soil moisture content, which in turn affects the vegetation types. A young marsh with appreciable relief will support a varied vegetation with a large number of species. With subsidence, and especially with the formation of "flotant", differences in elevation become minor, moisture conditions become less variable and vegetation may be quite uniform in composition. The number of species is smaller than in the young marsh. Differences in salinity may be of particular importance in determining which species will grow successfully in a marsh of this type. Salinity was found to be an important factor in most of the area of this report.

The purpose of the study here reported is to describe as accurately as possible, within the limitations set by the time available for field observations, the vegetation of the Grand Bayou Blue drainage basin, located in southwestern Lafourche Parish, as it existed in the summer of 1955. The report is based on observations made in June and early July of that year. No attempt is made to evaluate the marsh as a habitat for wildlife, nor to forecast probable successional plant trends in the future.

DESCRIPTION OF THE AREA

The area studied botanically is shown in the map, Figure 1. It is approximately five miles wide by 17 miles long and extends from Lake Raccourci, in the south, to a point opposite Valere Guidry School, on Bayou Lafourche, in the north. The basin, delineated on the west by the natural levees of Bayou Point au Chien and on the east by the levees of Bayou Lafourche, is drained by a network of tidal channels, the most important of which is Grand Bayou Blue.

The marsh of the Grand Bayou Blue basin may be described as a low, monotonously level, floating marsh which is almost everywhere under the influence of the sea tides. As is true in any floating marsh a conspicuous feature is the flotant or mat, held together by the matted, intertwining roots of plants. The mat literally floats on several feet of ooze. Below the ooze is a firm clay pan. In the area of the study the clay pan was usually more than five feet below the surface. Markers to show the locations of the areas of detailed study were pine posts, 2" by 4", by 8 feet long. These were not sharpened and it was usually not difficult for one person to push the posts into the substratum a distance of five feet. Usually the clay pan was not reached.

No salinity measurements were made in the marsh, but it was obvious on the basis of plants present that the northern part of the area is less salty than the southern part. Some species were common to both the north and south, but certain ones, such as sawgrass (Cladium jamaicense Crantz.), which are known as "freshwater" marsh plants, are present in the north and not in the south.

A factor of at least local significance is the system of canals which have been dredged in recent years. Dredgings piled up along the banks of such canals have created habitats which are higher and better drained than any natural banks in the area. A set of plants has come to occupy these spoil banks which includes some plants not found elsewhere in the area. Willow (Salix nigra Marsh.) and several shrubs are conspicuous.

DRAINAGE BASIN
GRAND BAYOU BLUE
LAFOURCHE PARISH
LOUISIANA

BOTANICAL STUDY

LEGEND

THRU 19 - STATIONS FOR DETAILED BOTANICAL STUDIES.

- APPROXIMATE BOUNDARY BETWEEN FRESH (NORTH) AND SALT (SOUTH) MARSH AS DETERMINED BY BOTANICAL INDICATORS.

SCALE IN MILES

BASE MAP MODIFIED
FROM
LAKE FELICITY QUADRANGLE
U.S.G.S 1944 ED.

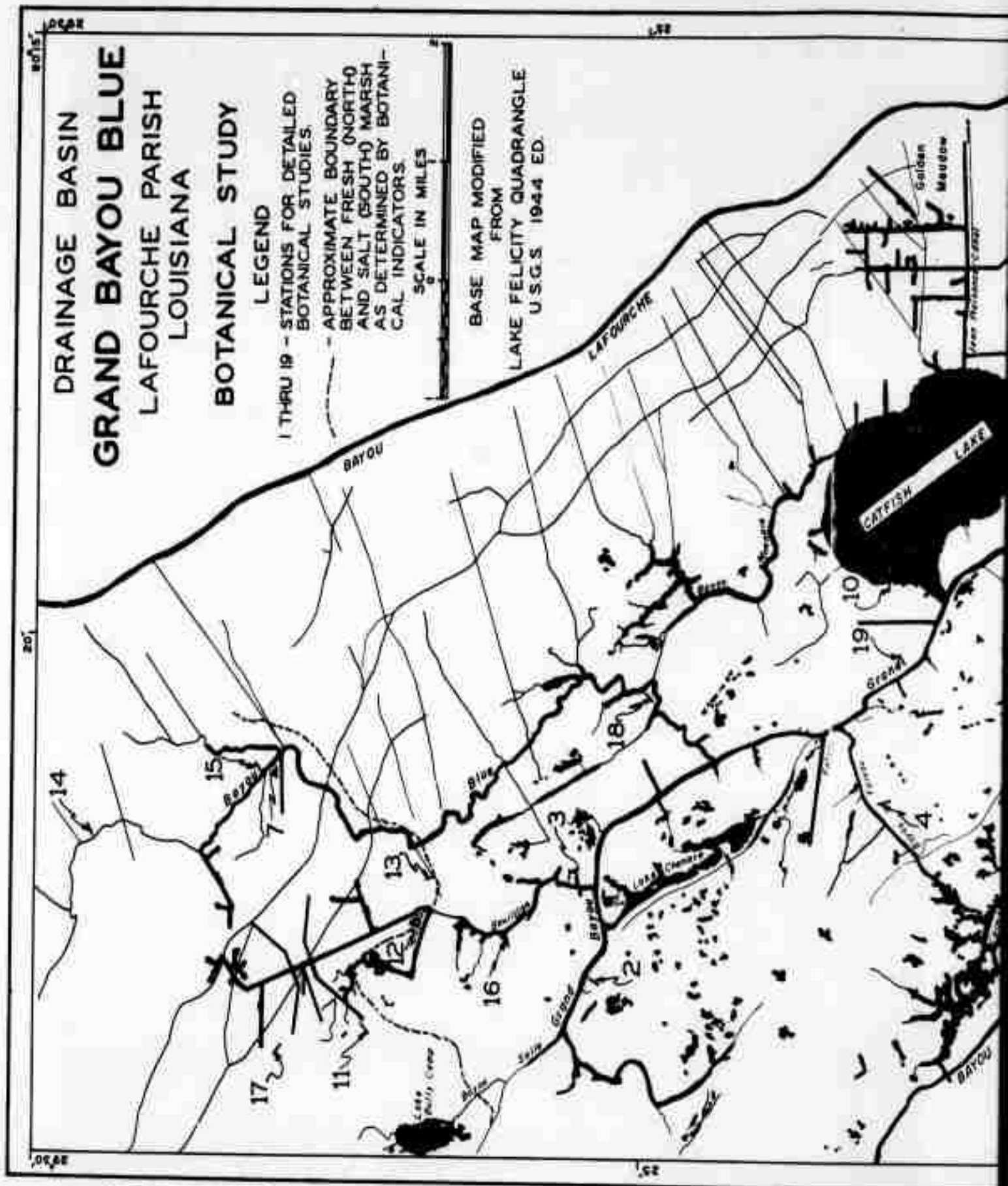


Figure 1. Drainage basin, Grand Ba



ge basin, Grand Bayou Blue, botanical study.

METHODS OF STUDY

A thorough reconnaissance was first made to determine the composition and extent of the important plant communities in the entire area. On the basis of this a series of detailed studies were made of the plants at 19 different stations.

The reconnaissance was made by boat, on foot, and from the air. A small boat was run through all the navigable bayous and canals, slowly enough to observe the vegetation while moving. Numerous stops were made and observations were made inland. Several observation towers which had been made by oil exploration crews were climbed, and observations were made from them also. These towers were especially useful in the northern part of the marsh. After some practice it was possible to recognize the important kinds of plant communities at a distance of a mile, when viewed through binoculars. Observations were also made from a small seaplane which was flown back and forth over the area at a low altitude. The plant communities were quite recognizable from the air.

Detailed analyses of the vegetation were made at 19 different stations. Stations were located to include all types of plant communities and so they would be well distributed over the total area. The locations of the stations are given in Figure 1 and in Table I. At each station a line transect was run. A transect is a sampling strip extending across a stand. Width and length of a transect are determined according to what seems to give the maximum information with the smallest possible size transect. In the present work the minimum width was used; the line transect was used, wherein a single line is stretched and plants actually touching the line are considered as being in the transect. Each transect extended into the marsh at approximately a right angle to the bayou or canal. The exact bearing of each is given in Table I. The transects varied from 20 to 100 meters, the majority being 50 meters, in length. The length was determined according to the particular conditions. In each instance the transect was made long enough to extend beyond any influence of the bayou bank and well into the vegetation of the marsh proper. In practice a line was stretched to locate the transect and every plant which touched the line was recorded. Individuals of each species were grouped by 10-meter units.

At the beginning of each 10-meter unit of the transect a quadrat, a rectangular plot, 0.25 meter by 1.0 meter in size, was located. The long axis of the quadrat paralleled the transect and hence the quadrat extended 0.125 meter on each side. The quadrat was laid out by placing a rectangular

frame of proper size on the ground, under the tightly stretched line, at the proper intervals. All plants emerging from the soil within the rectangle were tabulated.

The ends of the stations were marked by setting a chemically treated 2" by 4" at each end. To each marker an aluminum tag, marked "C.S.I. number ____", was fastened with copper nails. It is believed that both the transects and quadrats can be exactly relocated at any time, during the lifetime of the markers.

Specimens of each species of plant have been collected and placed in the herbarium of Newcomb College at Tulane University.

VEGETATION ANALYSIS

It was found to be convenient to consider the vegetation of the southern, more saline part of the marsh as one unit, and the northern, less saline part as a second. They will be referred to as "southern marsh" and "northern marsh". As stated before, no measurements of salinity were made, so differences are relative and not quantitative. It is not likely that any part of the northern marsh is truly freshwater, although O'Neil (1949) refers to it as such. The approximate line of division, where changing salinity is reflected in changing vegetation, is shown on Figure 1. It should be emphasized that the transition from one type of vegetation to another is gradual and not as sharp as the line indicates.

SOUTHERN MARSH

General Description

It became evident that three grasses, wiregrass (Spartina patens (Ait.) Muhl.), paille fine (Panicum hemitomon Schult.), and oyster grass (Spartina alterniflora Poisel.), are the three most important species in the southern marsh, both in number of individuals present and in the area covered by them. The order of listing here indicates their relative order of abundance. It is estimated that these species, in various combinations, are dominant in over 90 per cent of the area of the southern marsh. Observations from the air indicate that wiregrass and paille fine do not usually grow in close inter-mixture. One or the other tends to dominate, with wiregrass covering the greater area. These communities of dominance vary from two or three feet across to a few hundreds of feet. Although oyster grass is quite apt to be mixed in with one or the other of the other grasses mentioned, it may grow in nearly pure stands in very wet sites, or where the flotant is partially broken up, due to fire or other cause.

Following the three grasses, in importance, are black rush (Juncus Roemerianus Scheele.), and sand rush (Fimbristylis castanea (Michx.) (Vahl.)). The black rush grows in nearly pure stands, or in combination with the grasses. Areas which are dominated by black rush vary from a few feet across to a half mile. The total area dominated by black rush is estimated not to exceed five per cent of the total of the southern marsh. As will be pointed out later, at the stations where detailed studies were made, the black rush was even less significant than the general estimate would indicate. Sand rush was in fruit at the time the field work was done. The plant is usually taller than the associated plants and its fruits are a reddish-brown in color. At first glance the sedge seemed to dominate the sites in which it grew, but closer observation showed that it is never as abundant as the grasses with which it is always associated in this marsh. Sand rush may be present in 40 per cent of the marsh, but only as a subordinate species.

Four other sedges, goosegrass (Scirpus robustus Pursh.), three square (Scirpus olneyi A. Gray.), and the bulrushes* (Scirpus californicus (C. A. Meyer) Britton), and (Scirpus validus Vahl.), were very minor members in the plant population. Goosegrass was seen in several places, but was quite localized. It always grew with one or more of the grasses, to which it was subordinate. Three square was seen in only one place, in and around station 18. Bulrush was extremely scarce in the southern marsh.

Detailed Studies

Twelve stations were located in the southern marsh. Transects at these 12 stations had a total length of 660 meters. Plants of each species were counted and recorded for each 10-meter unit of the transects. There were 66 units. Also, there was one quarter-meter quadrat to each 10-meter unit. Data obtained from these observations are recorded in Table II. Numbers represent actual numbers of plants present in the particular area or unit at the time field work was done.

Consideration of the data from transects and quadrats substantiates the conclusions reached by general observations in regard to the importance of the three grasses, wiregrass, paille fine, and oyster grass. Values of density, total number of individuals of a species per unit area, show wiregrass to be first, paille fine is second, and oyster grass third. Because the quadrats represent actual areas and not distances, as do the transects, the density values for the quadrats will be the basis for comparison. The ratio

*It is likely that both were present, but only Scirpus validus was collected and identified.

of wiregrass to paille fine is 4310 to 1521, or about two and one-half to one. The ratio of wiregrass to oyster grass is about 4310 to 749, or 5.7 to one.

Besides giving information on the density of each species the results of transect and quadrat study also indicate the frequency of each. Frequency refers to the percentage of the total number of areas or units in which a particular species is present. The three grasses are present in 11 transects; two are present in all 12. This indicates the widespread distribution of these three grasses. In the 10-meter units the grasses are present as follows: all three in 43 units, or 65.1 per cent of the total; wiregrass and oyster grass (no paille fine) in 13 units; paille fine and oyster grass in seven; oyster grass in two; wiregrass and paille fine in one. Twenty nine quadrats, 43.9 per cent of the total, have all three grasses; 25 have wiregrass and paille fine only; five have paille fine and oyster grass; three have wiregrass and oyster grass only; two have oyster grass only; one has paille fine only; one has no plants.

Presence of all three grasses in about two-thirds of the 10-meter units, and less than half of the quadrats, indicates that the species are not equally distributed. The difference can be readily explained when it is recalled that, as was stated earlier, these grasses tend to segregate somewhat. It is much more likely that a 10-meter transect would include all grasses than that a one-meter quadrat would include them all.

No other species of plant was as important as the grasses mentioned, either in density or in frequency. The species which approached closest to the grasses, in density, was black rush. There were 131 plants in only four quadrats. This number of plants is less than two per cent of all plants in the quadrats, and restriction to four quadrats shows a limited distribution. Sand rush totalled 34 plants, in five quadrats. Goosegrass and bulrush were absent from the quadrats and transects. False foxglove (*Agalinis maritima* Ref.) is a minor member of the community, wherever it grows in the marsh. It was in flower at the time the field work was done, otherwise it might well have been overlooked.

Vegetation of the Bayou Banks

In some places the vegetation of the main marsh extends right to the water of the bayou, but in other places there is a narrow zone of plants peculiar to the bayou bank. The elevation of the bank appears to be the deciding factor. Just a few inches, probably always under a foot, makes a great difference in the drainage of the marsh. In general, the banks of Grand Bayou Blue, below Catfish Lake, have a little elevation. But along the smaller bayous, especially above Catfish Lake, there is usually such a slight difference

between the level of the marsh and surface of the water of the bayou that there is little drainage provided.

Bayou banks with slight drainage may support a narrow zone of shrubs. These are usually marsh elder (Iva frutescens L.), or buckrush (Baccharis halimifolia L.). With even less elevation big cord grass (Spartina cynosuroides (L.) Roth.) is the usual inhabitant of the bank. In a few places the marsh beggar's tick (Bidens Nashii Small.) occupies a comparable situation.

A substantial part of the total bayou banks of the area have such slight elevation that, except at the time of very low tide, conditions are so similar to those of the main marsh that grasses grow right to the water. Oyster grass is usually the one that is most abundant on low banks and it may grow in pure stands. The zone of oyster grass seldom extends more than ten or 15 feet in from the stream bank, where the other two grasses may begin to appear.

NORTHERN MARSH

General Description

In contrast to the uniform vegetation of the southern marsh the northern area is characterized by vegetation which is much more variable. The same three grasses which were so prominent in the south are in the north, but they are not always dominant when present and they may be completely absent in places. Several other plants assume importance also, such as sawgrass, alligator weed (Alternanthera philoxeroides Mart.), cattail (Typha latifolia L.), wapato (Sagittaria latifolia Willd.), three square, spikerush (Eleocharis macrostachya Britton.), goosegrass, bulrush, false foxglove, St. John's wort (Hypericum sp. (Tourn.) L.), morning glory (Ipomoea sagittata Cav.), marsh elder, marsh mallow (Kosteletzkya virginica (L.) A. Gray.), Ludwigia sp. L., and smartweed (Polygonum coccineum Muhl.).

Four main kinds of plant communities can be recognized in the northern marsh, exclusive of the bayou and canal banks. The four, with the estimated part of the total area each occupies, are as follows: sawgrass community- 40 per cent; wiregrass, paille fine, oyster grass community- 25 per cent; mixed community- 15 per cent; cattail, alligator weed community- 12 per cent. The other eight per cent consists of vegetation occupying spoil banks along canals. This consists of willow, various shrubs, roseau cane (Phragmites communis Trin.), and weedy herbs. It is believed there was little of this growth present before the canals were dredged in recent years. The spoil banks have resulted in a special habitat which these plants occupy.

Detailed Studies

Seven stations were established in the northern marsh. Transects totalled 370 meters in length; 10-meter units were 37 in number, as were quadrats. Where stations were located on dredged canals the transect and first quadrat were begun far enough back from the canal to avoid the vegetation on the spoil bank.

The most extensive kind of plant community is, as stated in the previous section, one dominated by sawgrass. It is somewhat unusual to have a community of one species, but that condition may exist where sawgrass becomes established. It grows densely and is taller than most of its competitors. One station, number 17, was located in sawgrass. Data for that station (Table III) indicate that only the first 10-meter unit has any other species, where a few plants of St. John's wort were mixed in with the sawgrass near the canal.

The community second to sawgrass, in importance, is one in which grasses are dominant, the same three grasses which were most important in the southern marsh. Stations 12 and 13 are located in grass communities. The grasses had the same order of abundance as was observed in the south, wiregrass, paille fine, and oyster grass. In addition to the grasses other species present in these two stations were St. John's wort, marsh elder, morning glory, and marsh mallow. But these species were very minor members of the community.

The term "mixed community", as used here, does not indicate a single, uniform community, but rather a variety of types. Certain sedges are usually important constituents. Stations seven and eleven are located in the mixed community. In transect seven the order of abundance of species is: paille fine, alligator weed, three square, Ludwigia, St. John's wort, cattail, wiregrass, bulrush, goosegrass, and wapato. In the quadrats at station seven paille fine is also first in abundance, but is followed by wiregrass, then by alligator weed. At station eleven wiregrass has the highest total density in the quadrats and the greatest abundance in the transect. Spikerush follows wiregrass. Sawgrass is important in one end of the transect but is absent from the other. Cattail, wapato, three square, paille fine, bulrush, false foxglove, morning glory, marsh elder, St. John's wort, and millet (Echinochloa crus-galli (L.) Beauv.) are present in small numbers. It is believed this type of mixed community could very easily change to either of the preceding types of community, or to the one described next. Increase of some species now present and elimination of others would bring about the change.

The cattail-alligator weed community is more closely related to the mixed community than to either of the others. As its name suggests this community has cattail and alligator weed as important components. Cattail, wapato, three square, paille fine, bulrush, false foxglove, morning glory, marsh elder, St. John's wort, and millet (Echinochloa crus-galli (L.) Beauv.) are present in small numbers. It is believed this type of mixed community could very easily change to either of the preceding types of community, or to the one described next. Increase of some species now present and elimination of others would bring about the change.

The cattail-alligator weed community is more closely related to the mixed community than to either of the others. As its name suggests this community has cattail and alligator weed as important components. Stations 14 and 15 are in the cattail-alligator weed community. There can be no doubt about number 14 because there were almost no other plants present. This was a very short transect, only 20 meters, but the monotony of the vegetation type indicated that nothing would have been gained by making the transect longer. Station 15 contains more species than 14 and cattail is exceeded in abundance by sawgrass. But because both cattail and alligator weed are present it is believed proper to include this station with 14, as an example of the cattail-alligator weed community. Present also, in transect 15, are paille fine, goosegrass, bulrush, St. John's wort, marsh elder, marsh mallow, and wapato.

Vegetation of the Canal and Bayou Banks

Reference has already been made to the kind of vegetation on the canal banks but it will be repeated here, for completeness. Plants on canal banks include roseau, willow, buckrush, marsh elder, and annual weeds. Bayou banks may have grasses growing right to the water, similar to the situation in the southern marsh. Where sawgrass is dominant in the marsh it may continue to the edge of the bayou.

SUMMARY

The vegetation of the drainage basin of Grand Bayou Blue was studied in the summer of 1955. All the marsh observed is of the "floating" type and, being very near sea level, is under the influence of tides. The southern 80 per cent of the marsh is almost everywhere dominated by three grasses: wiregrass (Spartina patens (Ait.) Muhl.), paille fine (Panicum hemitomum Schult.), and oyster grass (Spartina alterniflora Poisel.). The only other species important in the south is black rush (Juncus Roemerianus Scheele.), which may be dominant in very limited areas. The northern 20 per cent of the marsh has a more varied type of vegetation. Presumably, lower salinity in the north

permits more species of plants to grow successfully. Sawgrass (Cladium jamaicense Crantz.) is the most abundant species and it often grows in pure stands, forming the largest community type. The second community, areally speaking, is one dominated by the three grasses so common in the southern part of the marsh, wiregrass, paille fine, and oyster grass. A third type of community is termed "mixed", because of the numerous species present. No one species is outstanding in the community. The fourth type of community is dominated by cattail (Typha latifolia L.) and alligator weed (Alternanthera philoxeroides Mart.).

TABLE I. Locations of stations and direction of transects from bayou or canal. (Number refers to station.)

1. West bank of Grand Blue Bayou, about 1/4 mile below the cutoff to Bayou Courant. S. 15 degrees W.
2. West bank Grand Bayou, approximately midway between Salle and Bouillon. W. 40 degrees S.
3. East bank Bayou Bouillon. E. 5 degrees N.
4. South bank Bayou Faleau. S. 22 degrees E.
5. South side of a cross bayou between Grand Blue and Courant. S. 17 degrees W.
6. West bank Grand Blue Bayou, about 50 yards below Bayou Tete de Ours. W. 30 degrees S.
7. Upper Bayou Blue, about 200 yards above canal.
8. North bank Grand Blue Bayou, at point where it empties into Lake Raccourci. N. 8 degrees W.
9. East bank Bayou de la Valle.
10. West bank Catfish Lake, about one mile above juncture with Grand Blue Bayou.
11. North end of the area, end of a long canal running southwest.
12. North end of the area, west bank of a canal. W. 17 degrees S.
13. South bank of a cross-canal.
14. East bank of extreme upper end of Bayou Blue.
15. East bank of upper end of Bayou Blue. N. 6 degrees W.

TABLE I. (Continued)

16. West bank Bayou Bouillon. S. 18 degrees W.
 17. West bank of canal at north end of area. NW.
 18. West bank of lower Bayou Blue.
 19. East bank Grand Blue Bayou, above Catfish Lake. Opposite
 a canal. E. 26 degrees N.

TABLE II. Results of study of transects and quadrats in southern marsh

	Panicum Hemitomum	Spartina alterniflora	Spartina patens	Fimbristylis castanea	Juncus Roemerianus	Scirpus olneyi	Agalinis maritima	Bidens Nashii	Polygonum coccineum
<u>Section 1</u>									
Transect									
1-10 M.		23	310		11		0		
10-20 M.		23	300		0		0		
20-30 M.		23	350		0		0		
30-40 M.		40	575		0		0		
40-50 M.		48	330		0		4		
50-60 M.		32	370		0		7		
60-70 M.		25	440		0		0		
70-80 M.		38	410		0		0		
80-90 M.		50	185		0		0		
90-100 M.		70	250		0		0		
Totals		372	3520		11		11		
Quadrat									
1		16	282						
2		11	198						
3		16	85						
4		13	230						
5		3	335						
6		17	150						
7		12	260						
8		9	135						
9		23	75						
10		17	48						
Totals		137	1798						

Table II. (Continued)

	Panicum Hemitomum	Spartina alterniflora	Spartina patens	Fimbristylis castanea	Juncus Roemerianus	Scirpus olneyi	Agalinis maritima	Bidens Nashii	Polygonum coccineum
<u>Station 2</u>									
Transect									
1-10 M.	75	56	105	0	2		0		0
10-20 M.	31	65	200	0	0		0		0
20-30 M.	24	55	326	0	0		0		1
30-40 M.	155	25	524	36	0		4		0
40-50 M.	256	0	346	20	0		4		1
Totals	541	201	1501	56	2		8		1
Quadrat									
1	12	12	0		2				0
2	0	20	22		0				0
3	0	25	141		0				1
4	26	15	315		0				5
5	45	0	252		0				0
Totals	83	72	730		2				6
<u>Station 3</u>									
Transect									
1-10 M.	380	30	265						
10-20 M.	175	30	270						
20-30 M.	203	27	310						
30-40 M.	301	47	180						
40-50 M.	297	57	70						
Totals	1356	191	1095						
Quadrat									
1	70	6	170						
2	35	2	82						
3	22	4	3						
4	56	10	10						
5	48	9	35						
Totals	231	31	300						

Table II. (Continued)

	Panicum Hemitomum	Spartina alterniflora	Spartina patens	Fimbristylis castanea	Juncus Roemerianus	Scirpus olneyi	Agalinis maritima	Bidens Nashii	Polygonum coccineum
<u>Station 4</u>									
Transect									
1-10 M.	92	48	215						
10-20 M.	91	59	178						
20-30 M.	161	78	222						
30-40 M.	11	67	140						
40-50 M.	0	54	345						
50-60 M.	<u>216</u>	<u>58</u>	<u>192</u>						
Totals	571	364	1292						
Quadrat									
1	0	26	151						
2	63	11	28						
3	80	22	163						
4	0	14	45						
5	0	12	33						
6	<u>0</u>	<u>20</u>	<u>95</u>						
Totals	143	105	515						
<u>Station 5</u>									
Transect									
1-10 M.	185	54	198						
10-20 M.	34	88	47						
20-30 M.	0	95	0						
30-40 M.	0	65	78						
40-50 M.	<u>3</u>	<u>66</u>	<u>90</u>						
Totals	222	368	413						
Quadrat									
1	58	8	24						
2	47	22	10						
3	0	32	2						
4	0	22	2						
5	<u>0</u>	<u>19</u>	<u>32</u>						
Totals	105	103	70						

Table II. (Continued)

	Panicum Hemitomum	Spartina alterniflora	Spartina patens	Fimbristylis castanea	Juncus Roemerianus	Scirpus olneyi	Agalinis maritima	Bidens Nashii	Polygonum coccineum
<u>Station 6</u>									
Transect									
1-10 M.	240	46	210		0				
10-20 M.	665	26	0		0				
20-30 M.	86	8	0		93				
30-40 M.	140	12	120		123				
40-50 M.	120	29	280		52				
Totals	1251	121	610		268				
Quadrat									
1	8	16	35		0				
2	186	6	0		0				
3	210	6	0		80				
4	0	0	0		0				
5	0	7	50		0				
Totals	404	35	85		80				
<u>Station 8</u>									
Transect									
1-10 M.	20	4	160		0				
10-20 M.	32	57	0		57				
20-30 M.	0	80	0		0				
30-40 M.	4	63	0		0				
40-50 M.	15	61	0		10				
Totals	71	265	160		67				
Quadrat									
1	0	1	25						
2	0	10	0						
3	0	19	0						
4	15	7	10						
5	0	21	20						
Totals	15	58	55						

TABLE II. (Continued)

	Panicum Hemitomum	Spartina alterniflora	Spartina patens	Fimbristylis castanea	Juncus Roemerianus	Scirpus olneyi	Agalinis maritima	Bidens Nashii	Polygonum coccineum
<u>Station 9</u>									
Transect									
1-10 M.	480	3	0		0				6
10-20 M.	272	47	0		0				0
20-30 M.	65	59	50		7				0
30-40 M.	225	53	46		49				0
40-50 M.	141	54	15		32				0
Totals	1183	216	111		88				6
Quadrat									
1	20	0	0		0				22
2	90	6	0		0				0
3	35	19	8		0				0
4	20	12	40		0				0
5	48	7	0		24				0
Totals	213	44	48		24				22
<u>Station 10</u>									
Transect									
1-10 M.	168	12	120						
10-20 M.	23	30	245						
20-30 M.	12	37	275						
30-40 M.	8	28	286						
40-50 M.	0	41	415						
Totals	211	148	1341						
Quadrat									
1	25	0	20						
2	10	11	40						
3	0	4	85						
4	5	13	38						
5	0	10	105						
Totals	40	38	288						

TABLE II. (Continued)

	Panicum Hemitomum	Spartina alterniflora	Spartina patens	Fimbristylis castanea	Juncus Roemerianus	Scirpus olneyi	Agalinis maritima	Bidens Nashii	Polygonum coccineum
<u>Station 16</u>									
Transect									
1-10 M.	23	31	47	0	0				
10-20 M.	91	14	57	34	0				
20-30 M.	55	37	50	88	0				
30-40 M.	135	42	21	34	6				
40-50 M.	16	33	260	13	5				
Totals	320	157	435	169	11				
Quadrat									
1	2	10	50	0					
2	23	0	35	0					
3	38	3	11	18					
4	4	1	7	14					
5	18	6	58	0					
Totals	85	20	161	32					
<u>Station 18</u>									
Transect									
1-10 M.	67	71	41	0		0			
10-20 M.	42	67	147	0		0			
20-30 M.	38	52	165	0		0			
30-40 M.	135	43	102	0		2			
40-50 M.	97	57	116	2		46			
Totals	379	290	571	2		48			
Quadrat									
1	5	18	2						
2	11	14	10						
3	11	13	26						
4	41	10	14						
5	9	11	12						
Totals	77	66	64						

Table II. (Continued)

	Panicum Hemitomum	Spartina alterniflora	Spartina patens	Fimbristylis castanea	Juncus Roemerianus	Scirpus olneyi	Agalinis maritima	Bidens Nashii	Polygonum coccineum
<u>Station 19</u>									
Transect									
1-10 M.	167	12	56		0				
10-20 M.	76	12	262		10				
20-30 M.	63	29	236		0				
30-40 M.	68	60	143		0				
40-50 M.	38	52	204		0				
Totals	412	165	901		10				
Quadrat									
1	53	1	2						
2	57	2	8						
3	6	9	115						
4	9	10	20						
5	0	18	51						
Totals	125	40	196						

TABLE III. Results of study of transects and quadrats in northern marsh

	<i>Enchinochloa crus-galli</i>	<i>Panicum hemitomum</i>	<i>Spartina alterniflora</i>	<i>Spartina patens</i>	<i>Cladium jamaicense</i>	<i>Eleocharis macrostachya</i>	<i>Scirpus olneyi</i>	<i>Scirpus robustus</i>	<i>Scirpus validus</i>	<i>Agalinis maritima</i>	<i>Alternanthera philoxeroides</i>	<i>Hypericum sp.</i>	<i>Ipomoea sagittata</i>	<i>Iva frutescens</i>	<i>Kosteletzkya virginica</i>	<i>Ludwigia sp.</i>	<i>Sagittaria latifolia</i>	<i>Typha latifolia</i>
Station 7																		
Transect																		
1-10 M.	95		0			0	5	0		245	0				1	0	0	4
10-20 M.	270		0			1	0	0	4	122								
20-30 M.	240		0			57	0	0	2	50	12				0	1	1	6
30-40 M.	45		10			36	0	0	4	76	7				55	6	0	3
40-50 M.	0		10			73	2	2		16	18				0	6	10	
Totals	650		20			167	7	12		509	41				110	21	11	3
Quadrat																		
1	0					0	3			27								
2	52					0	0			28					0		0	1
3	35					4	0			0					0		0	0
4	25					12	0			3					15	0	0	0
5	0					2	0			6					2	0	0	0
Totals	112					18	3			64					17	2	1	1
Station 11																		
Transect																		
1-10 M.	2	0	65	31	0					17	3						12	0
10-20 M.	0	0	80	37	0					7	0						1	0
20-30 M.	0	0	0	30	0					0	0						5	0
30-40 M.	0	22	195	0	0					6	0						1	0
40-50 M.	0	0	130	0	0					0	0						13	0
50-60 M.	1	0	80	0	0					0	0						11	0
60-70 M.	2	0	0	0	0					23	0						19	0
70-80 M.	0	0	0	0	38					0	0						11	0
80-90 M.	0	0	12	0	102					0	0						19	0
90-100 M.	0	0	0	44	85					0	0						16	0
Totals	5	40	562	142	250					53	3						116	63

TABLE III. (Continued)

	<i>Enchinochloa crus-galli</i>	<i>Panicum hemitomum</i>	<i>Spartina alterniflora</i>	<i>Spartina patens</i>	<i>Cladium jamaicense</i>	<i>Eleocharis macrostachya</i>	<i>Scirpus olneyi</i>	<i>Scirpus robustus</i>	<i>Scirpus validus</i>	<i>Agalinis maritima</i>	<i>Alternanthera philoxeroides</i>	<i>Hypericum sp.</i>	<i>Ipomoea sagittata</i>	<i>Iva frutescens</i>	<i>Kosteletzkya virginica</i>	<i>Ludwigia sp.</i>	<i>Sagittaria latifolia</i>	<i>Typha latifolia</i>
<u>Station 11</u>																		
Quadrat																		
1	4	0		0	3	0			10			0	0				1	0
2	0	0		63	4	0			0			0	0				2	0
3	0	0		0	6	0			0			0	0				0	1
4	0	2		23	0	0			1			0	0				0	1
5	0	3		80	0	0			0			0	0				1	1
6	0	0		6	0	0			2			0	0				3	5
7	0	0		10	0	5			3			0	0				1	3
8	0	0		0	0	15			0			0	0				0	3
9	0	0		0	0	37			0			1	0				1	3
10	0	0		0	0	35			0			1	0				1	1
Totals	4	5		182	13	92			16			2	1				9	16
<u>Station 12</u>																		
Transect																		
1-10 M.	49	22	205										0	0	2			
10-20 M.	103	45	120										0	0	18			
20-30 M.	54	19	142										3	1	24			
30-40 M.	48	1	240										2	3	0			
40-50 M.	59	1	240										1	3	1			
Totals	313	88	947										6	7	45			
Quadrat																		
1	16	1	11											0	0			
2	9	3	29											0	0			
3	20	2	21											1	2			
4	2	1	121											0	0			
5	2	1	120											2	0			
Totals	49	7	302											3	2			

TABLE III. (Continued)

	Enchinochloa crus-galli	Panicum hemitomum	Spartina alterniflora	Spartina patens	Cladium jamaicense	Eleocharis macrostachya	Scirpus olneyi	Scirpus robustus	Scirpus validus	Agalinis maritima	Alternanthera philoxeroides	Hypericum sp.	Ipomoea sagittata	Iva frutescens	Kosteletzkya virginica	Ludwigia sp.	Sagittaria latifolia	Typha latifolia
<u>Station 13</u>																		
Transect																		
1-10 M.	66	22	95									1						
10-20 M.	47	45	105									0						
20-30 M.	51	19	110									0						
30-40 M.	41	1	193									0						
40-50 M.	0	1	175									0						
Totals	205	88	678									0						
Quadrat																		
1	0	10	4															
2	0	7	12															
3	8	9	33															
4	3	3	8															
5	16	6	45															
Totals	27	35	102															
<u>Station 14</u>																		
Transect																		
1-10 M.											130					0	17	
10-20 M.											101					2	15	
Totals											231					2	32	
Quadrat																		
1											38						0	
2											48						2	
Totals											86						2	

TABLE III. (Continued)

	<i>Enchinochloa crus-galli</i>	<i>Panicum hemitomum</i>	<i>Spartina alterniflora</i>	<i>Spartina patens</i>	<i>Cladium jamaicense</i>	<i>Eleocharis macrostachya</i>	<i>Scirpus olneyi</i>	<i>Scirpus robustus</i>	<i>Scirpus validus</i>	<i>Agalinis maritima</i>	<i>Alternanthera philoxeroides</i>	<i>Hypericum</i> sp.	<i>Ipomoea sagittata</i>	<i>Iva frutescens</i>	<i>Kosteletzkya virginica</i>	<i>Ludwigia</i> sp.	<i>Sagittaria latifolia</i>	<i>Typha latifolia</i>
<u>Station 15</u>																		
Transect																		
1-10 M.	0				0		0	0		160	4	0						8
10-20 M.	50				0		11	2		123	2							10
20-30 M.	0				2		9	6		195	4							18
30-40 M.	0				32		0	0		120	0							1
40-50 M.	0				41		0	0		106	0							0
Totals	50				75		20	8		704	10			4				37
Quadrat																		
1	0						0			48					0			1
2	5						0			20					0			1
3	0						1			11					3			0
4	0						0			7					0			1
5	0						0			15					0			0
Totals	5						1			101				3				3
<u>Station 17</u>																		
Transect																		
1-10 M.						23						7						
10-20 M.						28						0						
20-30 M.						30						0						
30-40 M.						29						0						
40-50 M.						33						0						
Totals						143						7						
Quadrat																		
1						11												
2						6												
3						5												
4						6												
5						6												
Totals						34												

TABLE IV. Plants present in the Grand Blue Bayou drainage basin in June-July, 1955. Scientific and common names.

Grasses

<u>Echinochloa crus-galli</u> (L.) Beauv.	Millet
<u>Panicum hemitomum</u> Schult.	Paille fine
<u>Phragmites communis</u> Trin.	Roseau cane
<u>Spartina alterniflora</u> Poisel.	Oyster grass
<u>Spartina cynosuroides</u> (L.) Roth.	Big cord grass
<u>Spartina patens</u> (Ait.) Muhl.	Wiregrass

Sedges and Rushes

<u>Cladium jamaicense</u> Crantz.	Sawgrass
<u>Eleocharis macrostachya</u> Britton.	Spikerush
<u>Fimbristylis castanea</u> (Michx.) Vahl.	Sand rush
<u>Juncus Roemerianus</u> Scheele.	Black rush
<u>Scirpus californicus</u> (C. A. Meyer) Britton.	Bulrush
<u>Scirpus olneyi</u> A. Gray.	Three square
<u>Scirpus robustus</u> Pursh.	Goose grass
<u>Scirpus validus</u> Vahl.	Bulrush

Other Herbs

<u>Agalinis maritima</u> Raf.	False foxglove
<u>Alternanthera philoxeroides</u> Mart.	Alligator weed
<u>Bidens Nashii</u> Small.	Marsh beggar's tick
<u>Ipomoea sagittata</u> Cav.	Morning glory
<u>Kosteletzkya virginica</u> (L.) A. Gray	Marsh mallow
<u>Ludwigia</u> sp. L.	No common name
<u>Polygonum coccineum</u> Muh.	Smartweed
<u>Sagittaria latifolia</u> Willd.	Wapato
<u>Typha latifolia</u> L.	Cattail

Trees and Shrubs

<u>Baccharis halimifolia</u> L.	Buckbrush
<u>Hypericum</u> sp. (Tourn.) L.	St. John's wort
<u>Iva frutescens</u> L.	Marsh elder
<u>Salix nigra</u> Marsh.	Black willow

LITERATURE CITED

- O'Neil, Ted. 1949. The muskrat in the Louisiana Coastal Marshes. Louisiana Department of Wildlife and Fisheries. New Orleans, Louisiana.
- Russell, R. J. 1942. Flotant. Geogr. Review 32: 74-98.

EVALUATION OF BIOLOGICAL CONDITIONS FOR WINTER MONTHS

Richard T. Gregg

DIVISIONS OF THE AREA AND COLLECTING STATIONS

The first part of the area studied is the upper Grand Bayou Blue drainage. Within this section eight collecting stations have been established as follows:

29° 28' 46" N 90° 21' 54" W. This site is in upper Bayou Blue.

29° 26' 54" N 90° 22' 30" W. This location is in upper Bayou Bouillon.

29° 26' 43" N 90° 21' 48" W. This station is in Bayou Blue.

29° 25' 52" N 90° 23' 42" W. This site is in Bayou Salle one-quarter of a mile above its junction with Grand Bayou.

29° 25' 34" N 90° 23' 42" W. This station is in Grand Bayou one-quarter of a mile above its junction with Bayou Salle.

29° 25' 27" N 90° 22' 15" W. This location is at the mouth of Bayou Bouillon.

29° 24' 28" N 90° 21' 06" W. This station is in the mouth of Bayou Blue.

29° 22' 34" N 90° 19' 42" W. This, the southernmost site in the first part of the area, is located in Catfish Lake.

The second part of the area is the lower Grand Bayou Blue drainage, which extends from Catfish Lake to Lake Raccourci, a part of Timbalier Bay. The four collecting stations established in the lower Grand Bayou Blue drainage are as follows:

29° 20' 19" N 90° 19' 36" W. This station is in a channel connecting Grand Bayou Blue with Bayou Courant.

29° 19' 25" N 90° 18' 15" W. This location is in the mouth of Bayou Sevin.

29° 17' 01" N 90° 16' 21" W. This station is in the mouth of Laurier Bayou.

29° 15' 09" N 90° 15' 18" W. This, the southernmost of all the collecting stations for the entire area, is located in the mouth of Grand Bayou Blue.

The third part of the area is the drainage associated with Bay Courant and Little Grand Bay, which is connected with the main Grand Bayou Blue drainage by a series of minor lateral waterways. The four collecting stations in this area are as follows:

29° 20' 09" N 90° 22' 27" W. This collecting station is in a complex of small waterways west of Bay Courant.

29° 20' 06" N 90° 20' 42" W. This site is in a channel connecting Little Grand Bay with Bay Courant.

29° 19' 10" N 90° 20' 45" W. This collecting station lies in the middle of Bay Courant.

29° 17' 01" N 90° 20' 45" W. This site is in the mouth of Chinaman Bayou, a wide waterway connecting Bay Courant with the open waters of Timbalier Bay.

CATEGORIES OF THE FAUNA

For purposes of discussion, the aquatic fauna will be grouped into the three major categories, plankton, benthos, and nekton. These categories are the ones generally employed in limnological studies, but they seem more applicable to the fauna and conditions of the area being investigated than do the categories such as pelagic and littoral, which are categories employed in oceanographic studies.

The plankton consists of those free floating organisms with little or no powers of locomotion and thus have their movements and distribution determined by winds, tides, and water currents. Most of the forms comprising this group are minute organisms, but some members, such as the jellyfishes (Coelenterata) and comb jellies (Ctenophora), attain fair sizes. Within the plankton are found immature forms of some species whose adults belong in the other categories.

The benthic group consists of bottom dwelling organisms showing little or no daily movement from place to place. In general their powers of locomotion are very limited. Some may creep along the surface of the bottom while others may burrow into the bottom or may be attached permanently or temporarily to various objects. These organisms cover the

size range from minute forms to forms of fair size. At certain stages of the the life cycle or under given conditions, some members of the benthos may become part of the other catagories.

The group denoted as nekton consists of the larger forms with well developed powers of locomotion by swimming. They may spend various amounts of time resting on the bottom, but all of them move freely from place to place and show a distribution that is independent of winds, tides, and water currents.

FIELD COLLECTING TECHNIQUES

For the sake of uniformity a standard procedure is used each time a collecting station is worked.

The first sample taken at each station is a water sample for plankton analysis. For this purpose a water sample of 15,000 cc is taken with a 3000 cc Foerst Water Bottle and the plankters of this sample are concentrated into one of approximately 25 cc by passing the water through a Birge and Juday Plankton Net.

The second sample taken is for benthos. This consists of a bottom sample of two square feet taken with a Peterson or an Ekman Dredge. Where the bottoms are soft and rather free from debris the Ekman Dredge is used and where the bottoms are hard or littered with debris the Peterson Dredge is used. The material obtained in the dredge is washed through a number forty screen and the material retained by the screen is carefully examined for organisms.

The final sample taken at a station is the one for nekton. This sample is secured by pulling a six foot bait trawl of three-quarter inch mesh for a distance of from one-quarter to one-half of a mile. This trawl run is made at the highest speed possible with the fifteen horsepower motor used in order to secure an adequate sample of the more active forms such as most of the fishes. All material, including plant debris, is very carefully examined for small species and individuals.

All the samples are preserved with formalin at the time of collection for later examination in the laboratory.

LABORATORY TECHNIQUES

All identifications, size measurements, and counts for plankton, benthos, and nekton are made in the laboratory.

For the plankton, counts are made under 112X magnification of all plankters present in three aliquots of 1 cc

each for every sample. These counts are then converted to numbers of plankters per liter after determination of the constant to be used for each individual sample by measurement of the volume of its concentrate. For purposes of identification, representative specimens are removed from the aliquots with small pipets and examined under very high magnification. The size of the organism is based on the longest axis of each form and is estimated by the portion of the field of view of the scope occupied by this axis.

For benthos and nekton the identifications are made first and then counts and size measurements are made of all specimens in the samples. For the benthos these counts are expressed as numbers per square foot of bottom and for the nekton they are converted to numbers per acre of trawling.

The data thus obtained from laboratory analysis of the samples is then converted to areal and seasonal averages to eliminate excessive emphasis on minor variations, which tend to confuse the true picture of the condition of the fauna.

PLANKTON

The plankton, which is fairly uniformly distributed throughout the entire drainage, shows a rather low number of individuals and a great paucity of species. The major emphasis has been placed on quantitative rather than qualitative data since it is felt that the affect of the environment on the total number of plankters of various types is more important than the affect on the species composition of the plankton. However, most of the forms collected have been identified to genus.

The following table gives the average number of plankters per liter for each of the three parts of the drainage. These figures are based on five samples per collecting station or a total of forty samples for the upper Grand Bayou Blue drainage, twenty for the lower Grand Bayou Blue drainage, and twenty for the Bay Courant drainage.

<u>Organism</u>	<u>Upper Grand Blue</u>	<u>Lower Grand Blue</u>	<u>Bay Courant</u>
Nauplius larvae	241	245	229
Diatoms	22	35	34
Rotifers	23	17	8
Copepods	12	10	10
Foraminifera	0	3	12
Total	298	310	293

An additional indication of the area's low productivity of plankton is the small size of the plankters, which, even if abundance was high, would cause a low volumetric

production. Size ranges for the various classes of plankters are as follows:

Organism	Length in Microns
Diatoms	50-90
Rotifers	75-125
Nauplius larvae	90-190
Copepods	350-400
Foraminifera	500-700

For the sake of comparison, similar samples were run for the University Lake in Baton Rouge for the same period. Here the average number of organisms per liter was 895 and the volumetric production was approximately 15 times as great as that of the Grand Bayou Blue drainage.

The principal plankters collected in the Grand Bayou Blue drainage are as follows:

Diatoms---Three unidentified forms.

Foraminifera---Globigerina.

Coelenterates---Aurellia is found in small numbers in the lower portions of the drainage when carried in by strong southerly winds. However, it will not live long in areas of such low salinities and should not be considered a true member of the fauna of the area.

Ctenophorans---Beroe ovata is found under the same conditions as Aurellia but in much greater numbers.

Rotifers---Notholca and one unidentified loricate species.

Nauplius larvae---Probably those of copepods.

Copepods---Halicyclops.

BENTHOS

Macroscopic bottom dwelling organisms within the area are so poorly represented that in most cases it is meaningless, if not impossible, to express their occurrence in terms of organisms per square foot. One possible explanation for this low level of benthos is the high concentration of hydrogen sulfide in the bottom muds.

Most of the benthic organisms have been collected from materials picked up in trawling and thus do not lend themselves to quantitative expression. Only in the Bay Courant

area have enough organisms (exclusive of oysters) been taken in the dredges be expressed in terms of organisms per square foot. In this area the count per square foot, based on twenty samples of two square feet each, is as follows:

Polychaete Annelids	
<u>Nereis</u>	5
<u>Polydora</u>	2
Mollusca	
<u>Mactra</u>	2
<u>Mitrella</u>	6

The following is a list of the benthic organisms encountered in the area with a brief comment on the status of each form:

Annelids

Nereis---The mudworms are found throughout the entire area, but they are most abundant in the lower parts of the drainage and decrease in abundance as one proceeds up the drainage.

Polydora---The clamworms are found associated with the oyster beds in the Bay Courant area. Their numbers are low and the oyster shells show little damage from their borings.

Cistenides---This tubiferous polychaete is encountered in very limited numbers in the Bay Courant area.

Isopods

Idothea---This medium sized isopod is found living in the hollow stems of decomposing plant materials in the lower portions of the drainage.

Amphipods

Gammarus---This small amphipod is found in small numbers throughout the entire area.

Molluscs

Crepidula---This small gastropod is found in limited numbers associated with the oyster beds in the Bay Courant area.

Mactra---This small bivalve is found associated with the oyster beds in the Bay Courant area. Most evidence of its presence is empty and broken shells as few living individuals are found.

Mitrella---This small gastropod is found under the same conditions as Macra, but is much more abundant.

Mytilus---The horse mussel is found attached to plants and shells in the lower part of the drainage.

Rangia---Numerous shells with the periostracum intact have been taken in the trawl in the lower part of the drainage, but no living individuals have been taken.

Tagelus---This small bivalve is found in very limited numbers in the lower part of the area.

Thyas---The oyster drill is found in the lower Bay Courant area. It is not abundant and appears to do little damage to the oysters as few shells are found with holes made by the oyster drill.

Venus---This thick shelled bivalve is found scattered over the lower part of the drainage. It is far from abundant and the principal evidence of its presence is empty shells rather than living individuals.

Tunicates

Molgula---This small sea squirt is found singly or in small clusters buried in the mud or attached to various objects. It is found in fair numbers in the drainage below Catfish Lake.

NEKTON

As is true of the plankton and benthos, the larger free swimming organisms are low in both numbers of individuals and species. In addition, the population consists primarily of small immature specimens.

The averages for the three parts of the area in terms of yield per acre of trawling are given in the following tables. These are based on five samples per station or a total of forty for the upper Grand Bayou Blue drainage, twenty for the lower Grand Bayou Blue drainage, and twenty for the Bay Courant drainage. It is not purported that these figures represent the total production per acre for the nekton, but they should reflect the relative abundance of the various forms in the different parts of the area.

In addition, several parasites of fishes have been found in the area. They are two parasitic isopods, Aega

and Livoneca, found in the branchial chambers of Micropogon undulatus and Brevoortia tyrannus and a parasitic leech of the genus Pisicola.

YIELD PER ACRE OF TRAWLING FOR UPPER GRAND BAYOU BLUE DRAINAGE

Form	Number Acre	Size Range in Inches
Blue Crab (<u>Callinectes</u>)*	14	
Croaker (<u>Micropogon undulatus</u>)	11	3/4 - 3 1/2
Shrimp (<u>Peneus</u>)*	9	3/4 - 4
Common Anchovy (<u>Anchoviella mitchilli</u>)	2	1 1/2 - 4
Hog Choker (<u>Achirus fasciatus</u>)	1	1 - 2
Menhaden (<u>Brevoortia tyrannus</u>)	1	2 - 3 1/2
Spot-finned Whiff (<u>Citharichthys spilopterus</u>)	1	2 - 6
Speckled Trout (<u>Cynoscion nebulosus</u>)	1	1 1/2 - 2
Striped Mullet (<u>Mugil cephalus</u>)	1	3 - 8
Total	41	5 - 8

*The two genera, Callinectes and Peneus, listed by genus only are represented in the Grand Bayou Blue basin by complexes of species. Within these genera, Callinectes sapidus and Peneus setiferous are the major components.

YIELD PER ACRE OF TRAWLING FOR LOWER GRAND BAYOU BLUE DRAINAGE

Form	Number Acre	Size Range in Inches
Croaker (<u>Micropogon undulatus</u>)	55	
Shrimp (<u>Peneus</u>)	52	3/4 - 6
Blue Crab (<u>Callinectes</u>)	18	1 1/2 - 6
Big-eyed Sardine (<u>Sardinella Macrophthalmus</u>)	8	3/4 - 7
Speckled Trout (<u>Cynoscion nebulosus</u>)	5	1 1/2 - 2
Menhaden (<u>Brevoortia tyrannus</u>)	4	3 - 8
Common Anchovy (<u>Anchoviella mitchilli</u>)	4	1 - 5
Spot (<u>Leiostomus xanthurus</u>)	3	1 - 1 1/2
Silver Perch (<u>Bairdella chrysura</u>)	2	5 - 7
Spot-finned Whiff (<u>Citharichthys spilopterus</u>)	2	4 - 6
Sheepshead (<u>Archosargus probatocephalus</u>)	1	1 1/2 - 2
Toadfish (<u>Opsanus tau</u>)	1	4 - 6
Eyed Flounder (<u>Platophrys ocellatus</u>)	1	4 - 6
Total	158	4 - 8

YIELD PER ACRE OF TRAWLING FOR BAY COURANT AND LITTLE
GRAND BAY DRAINAGE

Form	Number Acre	Size Range in Inches
Croaker (<u>Micropogon undulatus</u>)	61	3/4 - 5
Blue Crab (<u>Callinectes</u>)	12	3/4 - 4
Shrimp (<u>Peneus</u>)	8	1 1/2 - 4
Stone Crab (<u>Menippe mercenaria</u>)	5	1/2 - 1 1/2
Speckled Trout (<u>Cynoscion nebulosus</u>)	4	3 1/2 - 7
Spot-finned Whiff (<u>Citharichthys spilopterus</u>)	3	1 1/2 - 2
Common Anchovy (<u>Anchoviella mitchilli</u>)	2	1 - 2
Menhaden (<u>Brevoortia tyrannus</u>)	2	1 - 6
Sheepshead (<u>Archosargus probatocephalus</u>)	1	3 - 5
Broad Killifish (<u>Cyprinodon variegatus</u>)	1	2 - 3
Southern Fluke (<u>Paralichthys lethostigmus</u>)	1	5 - 7
Eyed Flounder (<u>Platophrys ocellatus</u>)	1	1 1/2 - 2
Striped Mullet (<u>Mugil cephalus</u>)	1	4 - 6
Pistol Shrimp (<u>Crangon armatus</u>)	1	2 - 2 1/2
Total	103	

MUSKRATS

The activity of muskrat trappers in the area is much more limited than it was formerly. During the past season there were six trappers operating in the area with their activities centered on that portion of the basin between Grand Bayou Blue and Bay Courant. Three of the trappers have their camps on Grand Bayou Blue immediately below Catfish Lake, one has his camp at the junction of Bayou Bouillon and Grand Bayou, another has his camp near the junction of Bayou Faleau and Grand Bayou Blue, and the last trapper has his camp on Bayou Blue near the cutoff canal to Bayou Bouillon. In addition to the camps that were in use, there are a number of camps that have been abandoned. In general, the trappers above Catfish Lake seem to be more successful than those below Catfish Lake. For the former the total number of pelts seen at any one time has varied from 6 to 700 and for the latter from 0 to 375.

Conversations with the various trappers and Mr. Marshal, engineer for La Terre Company, have brought forth the following information:

1. A successful trapping operation requires a catch of 50 to 100 skins per day (Marshal).
2. Success of the trapping operations in the area is marginal (Marshal).

3. Trapping success and condition of pelts are satisfactory only during the months of January and February.
4. The usual catch per trapper per year is about 3000 to 4000 pelts.
5. Trapping success is dependent on weather conditions with the highest catches occurring during cold spells.
6. The highest day's catch by one trapper for the season was 265 skins which represented the catch from setting of 300 traps.

OYSTERS

Commercial activity in oysters in the Grand Bayou Blue area is limited to the operations of three individuals with Levy Collins being the principal one. The commercial beds are located in Bay Courant and Little Grand Bay. Operations in these localities are based on natural reproduction as no seeding of the beds is employed and managerial practices are held to a minimum. The expected return from these oyster beds is about five sacks per square.

In addition to the activity in the Grand Bayou Blue area, there are extensive oyster beds west of Bayou Point au Chien in an area that has a connection with the Grand Bayou Blue drainage. This connection is through a small canal that has been cut across the natural levees of Bayou Point au Chien.

Tray studies of the present oyster mortality are being conducted in the areas where the commercial beds are located. However, their appropriateness and application are doubtful as tray studies usually are employed to determine the expected production where beds are seeded with known quantities of oysters. In addition, the amount of mortality in the trays is not directly applicable to the oyster beds since some mortality factors, such as silting, are eliminated in the tray studies.

SUMMARY

Studies of the fauna of the Grand Bayou Blue drainage have been made for the winter months of December, January, and February. As is to be expected in the type of area under consideration, the studies show that the fauna is rather poor in numbers of individuals and species. This is especially true of the upper part of the drainage, which is much poorer in fauna than the two lower parts of the drainage.

During the winter season this paucity of fauna has a twofold cause. The first cause is the naturally low productivity of such brackish water areas and the second is the migration of many of the more mobile forms from the shallow waters of the coastal marshes to the deeper waters of the open Gulf during the winter. If the fauna of this drainage follows the pattern that is found in most waters, one would expect this winter low to be followed by a spring high.

Within the area there are two commercial enterprises based on utilization of elements of the fauna. These are fur trapping and oystering. Based on information secured from people engaged in these enterprises, their annual value is roughly estimated to be \$100,000 to \$125,000.

CHEMICAL AND BACTERIOLOGICAL SURVEY
DEC., 1954 TO NOV., 1955

INTRODUCTION

This summary report presents chemical and bacteriological data that resulted from five field trips into the Grand Bayou Blue section of Lafourche Parish, Louisiana, made from December, 1954, to November, 1955, and the correlation and interpretation of those data.

The exact locations of twenty-four sampling stations are shown on the map of the area (Fig. 2). Descriptions of the locations along with the conditions of sampling and some remarks describing generally the nature of the sediments collected at the majority of the locations are included in the text.

The first field trip covered a period from December 27, 1954, through January 14, 1955. Stations A through J were sampled on December 22, 1954, at a time of extremely low water. Natives of the area reported that waters were lower than they could recall in a lifetime. Stations K and L were sampled on December 28, 1954, after a few days of heavy rains. Samples M through S were taken on January 3, 1955, while waters were moderately high. Locations T through X were sampled on January 14, while waters were at ordinary levels.

The second field trip was made in one day, on March 19, 1955. Water levels were normal high, with fairly high winds from the southeast.

The third field trip was also completed in one day, June 25, 1955, during a period of high winds from the south and southwest. Water levels were unusually high.

The fourth field trip was made on August 2 and 3, 1955, immediately following a tropical disturbance which produced high winds and squalls throughout the area. Rain had fallen in the region for several days prior to the trip and four inches of rain was reported in Golden Meadow, Louisiana, on the morning of August 2, 1955.

The fifth field trip, which is incompletely reported here, was made during a long dry spell on October 15, 1955, while the water was at usual low levels.

This phase of the project, within necessary limitations, attempts to characterize the waters and muds of a specific area in a chemical and bacteriological way.

The following experimental determinations were made; pH, temperature, specific gravity, specific conductance, absolute turbidity, differential refractive index, total solids before and after ignition, chlorinity, dissolved oxygen, biological oxygen demand, sulfate, soluble and oxidizable forms of sulfur, type of bacteria, bacteriological count, and sulfur content of the muds. Alkalinity and total hardness were determined on the third and fourth field trips. Measurements of eH and pH were attempted on the sediments but abandoned.

Salinity, dissolved oxygen to produce saturation of the water, percentage saturation of the water with oxygen, percentage oxygen consumed by the biological demand, and the ratio of chlorinity to total solids after ignition were all further data which were calculated and reported.

All chemical and physical data are presented in tabular form in the section immediately following the description of locations and conditions of sampling. After these data, a number of graphs are presented which show the best correlations apparent from our study of the data. Our conclusions regarding the general chemical investigation of the area appear immediately after the graphical correlation of data.

Of special interest is the next section which reports the results of an intensive and augmented investigation of stations S, W, I and X.

Other than the increase in general knowledge of the area which this study has produced, the use of differential refractive index measurements may have broad application, and the geographical distribution of the ratio of chlorinity to total solids may be of considerable geochemical interest.

Many expected correlations of experimental data on the waters indicate the reliability of the data; however, we are not yet satisfied with all our methods involving the determination of sulfur and its various forms in the sediments.

The appendix presents and evaluates our experimental methods and considers the validity of the data obtained.

STATIONS AND CONDITIONS OF SAMPLING

STATION A: At the mouth of Bayou Gris-Gris on Catfish Lake, one hundred feet from southwest bank and two hundred and fifty feet from southeast bank.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
A-1	12/22/54	0745	Ebb, near low	SSW, 2 mph*	NW, slight	2-1/2 ft.	2 ft.
Remarks: Some natives of the area observed that the water at this period was lower than at any time in their memory.							
A-2	3/19/55	0850	High	S, 5-10 mph*	Negligible	2-1/2 ft.	2 ft.
Remarks: Oil wells in Catfish Lake are reported to be putting 50,000 gallons per day of bleed water into lake.							
A-3	6/25/55	0710	On rise near high	S, 8 mph*	Negligible	3 ft.	2 ft.
Remarks: Odor of H ₂ S from mud sample. Mud had a peat moss texture, high in organic material.							
A-4	8/2/55	1710	High	None	Negligible	5 ft.	3 ft.
Remarks: Sediment was gray-green, silty, organic, fairly granular but not rough. Strong H ₂ S odor.							
A-5	10/15/55	1820	Normal high	S, 0-2 mph*	Negligible	3 ft.	2-1/2 ft.
Remarks: No sediment sample taken.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION B: Across bayou (canal) from the Gulf Company pumping station at end of canal above Bayou Bouillion, approximately fifty feet from northwest bank.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
B-1	12/22/54	1010	Flow, 2 hrs. after low	SW, 5 mph*	Negligible	6 ft.	3 ft.
Remarks: None.							
B-2	3/19/55	1235	High	S, 10-20 mph*	Negligible	8 ft.	3 ft.
Remarks: This is probably a bad location for sediment samples since all canals in the area have been dredged and are not natural.							
B-3	6/25/55	1155	High	SSW, 6-7 mph*	Negligible	7 ft.	3 ft.
Remarks: Sediment was silty, low organic content with no odor of H ₂ S.							
B-4	8/3/55	1025	High	SSE, 2-4 mph*	Negligible	7 ft.	3 ft.
Remarks: Sediment was gray-green and gelatinous smooth and semifluid. No odor of H ₂ S.							
B-5	10/15/55	1000	Ebb	NW, 1-2 mph*	Negligible	7 ft.	3 ft.
Remarks: No sediment sample taken.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION C: Just in Bayou Bouillon and southwest from Gulf Company Canal by about one hundred and fifty feet, about twenty feet in the bayou from the northwest shore.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
C-1	12/22/54	1102	Flow	SW, 6-8 mph*	Negligible	2 ft.	1-1/2 ft.
Remarks: None.							
C-2	3/19/55	1340	High	S, 8-15 mph*	Negligible	9 ft.	3 ft.
Remarks: Sediment appeared to be mainly organic debris.							
C-3	6/25/55	1344	Flow toward high	SSW, 10-12 mph*	2 mph* in-land	3 ft.	2-1/2 ft.
Remarks: None.							
C-4	8/3/55	1115	High	SSE, 1-3 mph*	Negligible	5 ft.	3 ft.
Remarks: Sediment was gray-brown, silty and particulate organic matter, weak odor of H ₂ S.							
C-5	10/15/55	1015	Ebb	NW gusts to 5 mph*	NE, 1-2 mph*	9 ft.	3 ft.
Remarks: No sediment sample taken.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION D: At the mouth of Bayou Salle in the first bend of the bayou about one hundred and fifty feet south of Lake Bully Camp.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
D-1	12/22/54	1217	Flow	W, 4-5 mph*	Slight south	2 ft.	1-1/2 ft.
Remarks: Saw large blue crabs in the area.							
D-2	3/19/55	1600	High	SSW, 5-10 mph*	Negligible	6 ft.	3 ft.
Remarks: Sediment was soupy, much organic matter and a trace of H ₂ S odor.							
D-3	6/25/55	1510	High	Driving rain	Slight south	6 ft.	3 ft.
Remarks: Mud was silt with considerable organic matter. Odor of H ₂ S.							
D-4	8/3/55	1350	High	SSE, 1-3 mph*	North, slight	6 ft.	3 ft.
Remarks: Sediment was primarily organic, particulate, very fluid, with odor of H ₂ S.							
D-5	10/15/55	1045	Ebb	NW, 2 mph*	WNW, 2 mph*	5 ft.	3 ft.
Remarks: No sediment sample taken.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION E: At the fork on the upper end of Grand Bayou, approximately 30 feet from northeast shore.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
E-1	12/22/54	1311	Flow	SW, 5-6 mph*	Slight, west	4-1/2 ft.	3 ft.
Remarks: None.							
E-2	3/19/55	1530	High	SSW, 10-12 mph*	Negligible	4 ft.	3 ft.
Remarks: Sediment was gelatinous with much organic matter and odor of H ₂ S.							
E-3	6/25/55	1640	High	SSW, 3 mph*	Negligible	4-1/2 ft.	3 ft.
Remarks: Mud was silty organic material. Strong odor of H ₂ S.							
E-4	8/3/55	1255	High	SSE, 1-3 mph*	S, 1-3 mph*	5 ft.	3 ft.
Remarks: Sediment was fluid and primarily organic debris. Brown-grayish color. Considerable particulate organic matter. Odor of H ₂ S.							
E-5	10/15/55	1108	Ebb	WNW, 0-2 mph*	Negligible	4 ft.	3 ft.

Remarks: No sediment sample taken.

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION F: In Grand Bayou, above Bayou Bouillon at the mouth of the Pirogue Canal opening into the lake.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
F-1	12/22/54	1400	Flow	S, 10 mph*	Slight SW	6 ft.	3 ft.
Remarks: None							
F-2	3/19/55	1610	High	S, 8-12 mph*	Negligible	6 ft.	3 ft.
Remarks: Sediment was primarily organic matter. Odor of H ₂ S.							
F-3	6/25/55	0410	High	Driving rain from SW	Negligible	6-1/2 ft.	3 ft.
Remarks: Mud was silty and high in organic content. Medium odor of H ₂ S.							
f-4	8/3/55	1205	High	SSE, 1-3 mph* W, 1-2 mph*		8 ft.	3 ft.
Remarks: Sediment was clay with small amount of organic material. Some particulate organic matter; odor of H ₂ S.							
F-5	10/15/55	1125	Ebb	WNW, 0-5 mph*	Negligible	6-1/2 ft.	3 ft.
Remarks: Sediment appeared to be about 70% clay and 20% sand. Some organic debris and silt. Medium odor of H ₂ S.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION G: In Grand Bayou about one-half mile above Bayou Blue and at the intersection of Grand Bayou with a canal to the northeast and a small bayou to the southwest.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
G-1	12/22/54	1433	Flow	WSW, 10-12 mph*	Negligible	7-1/2 ft.	3 ft.
Remarks: None.							
G-2	3/19/55	1440	High	S, 8-12 mph*	Negligible	11 ft.	3 ft.
Remarks: Sediment was fluid with much organic debris present.							
G-3	6/25/55	1630	High	Rain from SW	Negligible	11-1/2 ft.	3 ft.
Remarks: None.							
G-4	8/3/55	1445	High	SSE, 1-3 mph*	N, 1-2 mph*	10 ft.	3 ft.
Remarks: Sediment contained considerable clay including organic debris. Gray-green in color with faint odor of H ₂ S.							
G-5	10/15/55	1148	Ebb	NW, 0-5 mph*	NW, 3 mph*	6-1/2 ft.	3 ft.
Remarks: Sediment was about 70% clay and about 20% sand. Some organic debris and silt. Medium odor of H ₂ S.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION H: At the lower end of Bayou Fallean at the point where it widens just before running into Calm Lake.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
H-1	12/22/54	1519	Flow toward full	WSW, 15 mph*	Negligible	2-1/2 ft.	2 ft.
Remarks: None.							
H-2	3/19/55	1700	High	SSW, 8-12 mph*	Negligible	3 ft.	2-1/2 ft.
Remarks: Sediment was firm.							
H-3	6/25/55	1707	High	SW, 10 mph*	Slight south	5 ft.	3 ft.
Remarks: None.							
H-4	8/4/55	0710	Slow	SW, 1-3 mph*	W, 1-2 mph*	4-1/2 ft.	3 ft.
Remarks: Sediment was gray-green firm clay with particulate organic matter, trace of H ₂ S.							
H-5	10/15/55	1255	Ebb	NW, 0-5 mph*	NE, 2 mph*	3-1/2 ft.	3 ft.
Remarks: Mud was about 90% clay and 10% sand. Little organic debris. Odor of H ₂ S.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION I: In Grand Bayou, one-fourth mile above opening to Catfish Lake and about 30 yards from west bank of bayou.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
I-1	12/22/54	1551	Flow toward full	SWS, 5-6 mph*	Negligible	8 ft.	3 ft.
Remarks: None.							
I-2	3/20/55	0710	Ebb, medium	SE, 3-5 mph*	SE, 1-2 mph*	12-1/2 ft.	3 ft.
Remarks: Sediment was black and gelatinous with some organic matter and a trace of H ₂ S.							
I-3	6/25/55	0825	Flow, toward high	SW, 8 mph*	Negligible	12 ft.	3 ft.
Remarks: Sediment had a high organic content and was peaty. Odor of H ₂ S.							
I-4	8/8/55	1800	High	None	Strong to W	12 ft.	3 ft.
Remarks: Sediment was gray, silty clay, little organic matter, combined with a gelatinous, semi-fluid. No odor of H ₂ S.							
I-5	10/15/55	0730	Ebb	NW, 1/2 mph*	W, 1 mph*	10-1/2 ft.	3 ft.
Remarks: Sediment was about 90% silt and 10% sand. Very little organic debris. Strong H ₂ S odor.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION J: At the intersection of Bayou Monnaie and Catfish Lake.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
J-1	12/22/54	1655	Near full	SSW, 8 mph*	Slight south	2 ft.	1-1/2 ft.
Remarks: None.							
J-2	3/18/55	1810	High	S, strong	Negligible	3 ft.	2 ft.
Remarks: A strong south wind made it impossible to anchor, so samples were collected while holding the boat against the wind.							
J-3	6/25/55	1955	High	SSW, 8 mph*	Negligible	3-1/2 ft.	3 ft.
Remarks: None.							
J-4	8/2/55	1735	High	None	S, slight	4 ft.	3 ft.
Remarks: Sediment was gray-black, silty and organic. Much particulate organic matter. Strong odor of H ₂ S.							
J-5	10/15/55	0648	Ebb	NW, 1/2 mph*	NW, 1/2 mph*	3 ft.	3 ft.
Remarks: Sediment was about 50% silt and 50% sand. Very little organic debris.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION K: In Bayou Blue at sharp turn to northwest (see map), twenty feet from northeast bank and 40 feet from southwest bank.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
K-1	12/28/54	1520	Flow toward full	NW, 20 mph*	Negligible	8 ft.	6 ft.
Remarks: From location K through X, water was much higher than at Station A through J, during the first field trip.							
K-2	3/19/55	1015	High	S, 10-15 mph*	Negligible	7 ft.	3 ft.
Remarks: None.							
K-3	6/25/55	0900	Flow, toward full	SW, 8-10 mph*	N, 1 mph*	10 ft.	3 ft.
Remarks: Sediment was silty with abundance of organic matter. Strong odor of H ₂ S.							
K-4	8/3/55	0750	High	None	None	11 ft.	3 ft.
Remarks: Sediment was black-brown and predominately organic matter; semi-fluid; some odor of H ₂ S.							
K-5	10/15/55	0835	Ebb	None	NW, 1/2 mph*	12-1 1/2 ft.	3 ft.
Remarks: Sediment was about 90% silt and 10% organic debris. Medium H ₂ S odor. Little sand or clay.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION L: In Bayou Blue at sharp west turn one quarter mile south of canal connecting Bayou Blue and Bayou Bouillon, exactly even with small pirogue canal and twenty feet from southwest bank and sixty feet from east bank.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
L-1	12/28/54	1623	High	WNW, 6 mph*	Negligible	6 ft.	4 ft.
Remarks: None.							
L-2	3/19/55	1015	High	S, 10-15 mph*	Negligible	7 ft.	3 ft.
Remarks: None.							
L-3	6/25/55	0957	Flow toward high	S, 8-10 mph*	Negligible	3-1/2 ft.	3 ft.
Remarks: Sediment was chiefly coarse organic matter. Strong odor of H ₂ S.							
L-4	8/3/55	0830	High	SE, 1-2 mph*	None	5 ft.	3 ft.
Remarks: Sediment was gray-green organic debris, some clay and silt, semi-fluid. Strong odor of H ₂ S.							
L-5	10/15/55	0900	Ebb	None	W, 1/2 mph*	3 ft.	3 ft.
Remarks: No sediment specimen taken.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION M: In Bayou Sevin at first turn to north off Bayou Blue. Thirty feet from north shore, twenty feet from south shore, fifty feet from east shore.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
M-1	1/3/55	0815	High	E, 15 mph*	Negligible	10 ft.	3 ft.
Remarks: None.							
M-2	3/20/55	1730	High	SSE, 10-15 mph*	N, 3 mph*	10-1 1/2 ft.	3 ft.
Remarks: Sediment was granular, some shell fragments, small amount of organic material. No H ₂ S.							
M-3	6/26/55	0710	High	SW, 10-12 mph*	Negligible	9-1 1/2 ft.	3 ft.
Remarks: None							
M-4	9/3/55	1810	High	None	S, 3 mph*	10 ft.	3 ft.
Remarks: Sediment was gray-green clay, small amount of organic material and some odor of H ₂ S.							
M-5	10/15/55	1735	Flow	S, 0-2 mph*	1-1 1/2 mph*	11 ft.	3 ft.
Remarks: No sediment specimen taken.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION N: At the entrance to Laurier Bay from Bayou Blue, one hundred feet from the east shore and seventy-five feet from the south shore.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
N-1	1/3/55	0919	High	E, 15-20 mph*	Negligible	10-1 1/2 ft.	3 ft.
Remarks: None.							
N-2	3/20/55	1600	High	SE, 20 mph*	2-5 mph*	12 ft.	3 ft.
Remarks: Sediment was granular with visible organic matter; no odor of H ₂ S.							
N-3	6/26/55	1610	Flow toward high	SW, 10 mph*	Negligible	13 ft.	3 ft.
Remarks: Sediment was silty with partially decomposed organic matter.							
N-4	8/4/55	1150	High	High	N, 1-2 mph*	13 ft.	3 ft.
Remarks: Sediment was gray-white clay with a small amount of particulate organic matter. Sediment was very firm.							
N-5	10/15/55	1710	Flow	S, 0-2 mph*	S, 1 mph*	13-1 1/2 ft.	3 ft.
Remarks: No sediment specimen taken.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION 0: In Bayou Blue at first turn to north before it enters Lake Raccourci, fifty feet from southeast shore, one hundred and fifty feet from northwest shore, and two hundred and fifty feet northeast from cut.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
0-1	1/3/55	1003	Ebb, near high	E, 15-20 mph*	Negligible	11-1/2 ft.	3 ft.
Remarks: None.							
0-2	3/20/55	1445	High	SE, 15-20 mph*	N, 2-3 mph*	18 ft.	3 ft.
Remarks: Considerable quantities of recent organic material in the sediment with some odor of H ₂ S.							
0-3	6/26/55	1530	Flow near low	SW, 10-15 mph*	Negligible	23-1/2 ft.	3 ft.
Remarks: Sediment was very fine and semi-fluid.							
0-4	8/4/55	1220	High	E, 1-3 mph*	Negligible	19 ft.	3 ft.
Remarks: Sediment was of silt and clay, some organic matter and shells in about equal proportions. Generally black-gray in color with no odor of H ₂ S.							
0-5	10/15/55	1645	Flow	SW, 0-5 mph*	SE, 3 mph*	13 ft.	3 ft.
Remarks: Sediment was approximately 90% sand and 10% silt. No organic debris.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION P: In Bayou Tete de Ours even with connecting canal to La Croix Bay. Twenty feet west of cut, sixty feet off northwest shore, fifty feet from southeast shore.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
P-1	1/3/55	1149	Ebb	E, 10 mph*	Negligible	1-1/2 ft.	1 ft.
Remarks: None.							
P-2	3/20/55	1620	High	SE, 20 mph*	Negligible	2-1/2 ft.	2 ft.
Remarks: Sediment was mostly recent organic material and was high in H ₂ S.							
P-3	6/26/55	1330	Flow near low	SW, 8-10 mph*	W, 1 mph*	2-1/2 ft.	2 ft.
Remarks: None.							
P-4	8/4/55	1120	High	NW, 1-3 mph*	N, 2-3 mph*	5 ft.	3 ft.
Remarks: Sediment was gray-brown and peat-like. Appeared to contain silt, clay, and organic matter. Some odor of H ₂ S.							
P-5	10/15/55	1606	Flow	S, 0-3 mph*	Negligible	2 ft.	0-2 ft.
Remarks: Sediment contained about 60% recent organic debris and the balance was silt. Strong odor of H ₂ S.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION Q: In the intersection of Bayou Courant and Little Grand Bay. Two hundred feet west of Bayou Courant, seventy feet from southeast shore, and forty feet from northwest shore.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
Q-1	1/3/55	1313	Ebb	E, 15 mph*	Negligible	8 ft.	3 ft.
Remarks: None.							
Q-2	3/20/55	0900	Ebb	SE, 10 mph*	Negligible	9 ft.	3 ft.
Remarks: Sediment was a smooth silty clay with a small amount of particulate organic matter.							
Q-3	6/26/55	1000	Low	SW, 5-6 mph*	NW, 1-2 mph*	4 ft.	3 ft.
Remarks: None.							
Q-4	8/8/55	0920		E, 2-4 mph*	SE, 1-2 mph*	7-1/2 ft.	3 ft.
Remarks: Sediment was green-black, appeared to contain clay, silt, organic matter, and was gelatinous. Some odor of H ₂ S.							
Q-5	10/15/55	1540	Flow	S, 0-5 mph*	SW, 1-2 mph*	11 ft.	3 ft.
Remarks: No sediment sample was taken.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION R: In the canal connecting Little Grand Bay with Bay Courant midway between southeast and northwest shores at 100 feet southwest of cut running to northwest.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
R-1	1/3/55	1429	Ebb	E, 10 mph*	Negligible	20 ft.	3 ft.
Remarks: None.							
R-2	3/20/55	1300	Med. high	SE, 10-15 mph*	Negligible	13-1/2 ft.	3 ft.
Remarks: Sediment was a smooth clay. It had a brownish surface slime and was greenish-black in color. No odor of H ₂ S.							
R-3	6/26/55	1218	Flow near low	SSW, 8-10 mph*	NW, 1-2 mph*	14-1/2 ft.	3 ft.
Remarks: The sediment was sandy with little organic matter. Some odor of H ₂ S.							
R-4	8/4/55	0950	Flow near high	E, 2-4 mph*	E, 1-2 mph*	19 ft.	3 ft.
Remarks: Sediment was a greenish-black gelatinous matter with some trace of clay, silt, sand and organic debris. There was some odor of H ₂ S.							
R-5	10/15/55	1510	Flow	S, 0-5 mph*	SW, 2 mph*	15 ft.	3 ft.
Remarks: Sediment was about 80% sand and 20% silt. Very little organic debris.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION S: In Chinoiois Pass between Chinaman Bayou and Deep Lake at steel post with Gulf can on top.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
S-1	1/14/55	1317	Flow	SE, 5-10 mph*	W, slight	14-1/2 ft.	3 ft.
Remarks: None.							
S-2	3/20/55	1017	Ebb	SE, 10-15 mph*	Negligible	14-1/2 ft.	3 ft.
Remarks: Sediment was a smooth clay with no odor of H ₂ S. There was a brown zone at the surface of the mud.							
S-3	6/26/55	1130	Flow near low	SSW, 10-12 mph*	W, 1-2 mph*	6-1/2 ft.	3 ft.
Remarks: Sediment was slightly sandy clay-silt with oyster shells. Low H ₂ S.							
S-4	8/4/55	1010	Flow near high	E, 1-2 mph*	Negligible	14 ft.	3 ft.
Remarks: Sediment was predominantly clay with some silt and organic matter. There were oyster shells and fragments, some gelatinous mud. Only slight odor of H ₂ S.							
S-5	10/15/55	1439	Flow	S, 0-5 mph*	S, 3 mph*	15 ft.	3 ft.
Remarks: Sediment was about 90% clay and 10% sand. No organic debris or odor of H ₂ S.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION T: In Bayou de la Valle, north toward Calm Lake, fifty yards northeast of bay opening and thirty feet from southeast shore.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
T-1	1/14/55	1145	Flow	SE, 5-10 mph*	Negligible	9 ft.	3 ft.
Remarks: None.							
T-2	3/19/55	1810	High	SSW, 8-10 mph*	Negligible	11 ft.	3 ft.
Remarks: None.							
T-3	6/26/55	1810	High	SW, 10-12 mph*	S, slight	10 ft.	3 ft.
Remarks: Sediment contained lots of clay with practically no silt; no odor of H ₂ S.							
T-4	8/4/55	0748	Flow toward high	SW, 1-3 mph*	Negligible	10-1/2 ft.	3 ft.
Remarks: Sediment was a gray-green approximately 50% sand and 50% silt with fine organic debris. Some odor of H ₂ S.							
T-5	10/15/55	1345	Ebb	W, 0-3 mph*	NE, 1-1/2 mph*	11 ft.	3 ft.
Remarks: None.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION U: In bayou network approximately one mile west southwest of intersection of Bayou de la Valle with Bay Courant (see map). Ten feet south of small bay and twenty feet from east shore.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
U-1	1/14/55	1230	Flow	SE, 5-10 mph*	Negligible	3 ft.	2 ft.
Remarks: None.							
U-2	3/20/55	1120	High	SE, 10-15 mph*	Negligible	4-1/2 ft.	3 ft.
Remarks: Sediment was peaty and high in organic matter. Some H ₂ S.							
U-3	6/26/55	1045	Flow near low	SSW, 6-8 mph*	S, 1-2 mph*	5 ft.	3 ft.
Remarks: Sediment was silty and high in particulate organic matter. Some odor of H ₂ S.							
U-4	8/4/55	0808	Flow, toward maximum	SW, 1-3 mph*	Negligible	4 ft.	3 ft.
Remarks: Sediment was gray-brown clay with organic debris. Low in H ₂ S.							
U-5	10/15/55	1410	Low	W, 0-3 mph*	Negligible	4-1/2 ft.	3 ft.
Remarks: No sediment sample taken.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION V: In Bayou Courant (see map) twelve feet from east shore and thirty feet from west shore in bend of bayou.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
V-1	1/14/55	1445	Flow	SE, 5-10 mph*	Negligible	3-1/2 ft.	2 ft.
	Remarks: None.						
V-2	3/20/55	0850	Ebb, near	SE, 5-8 mph*	Negligible	5 ft.	3 ft.
	Remarks: Sediment contained much particulate organic matter with some soft large granules.						
V-3	6/26/55	1800	High	SW, 5-10 mph*	None	8 ft.	3 ft.
	Remarks: Sediment was coarse with some clay and silt. No odor of H ₂ S.						
V-4	8/2/55	1830	High	None	E, slight	6 ft.	3 ft.
	Remarks: Sediment was gray-green silty and high in particulate organic matter. Some odor of H ₂ S.						
V-5	10/15/55	1756	Flow	None	SE, 2 mph*	8 ft.	3 ft.
	Remarks: No sediment sample taken.						

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION W: At cut through Bayou Pointe au Chien fourteen feet from south shore and six feet east of Bayou Pointe au Chien.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
W-1	1/14/55	1045	Flow	SE, 5-10 mph*	Negligible	6-1/2 ft.	3 ft.
Remarks: None.							
W-2	3/19/55	1730	High	SSW, 8-12 mph*	W, strong	8 ft.	3 ft.
Remarks: The canal bottom was shell; the bayou bottom was soft, some clay, some organic matter with trace of H ₂ S.							
W-3	6/25/55	1740	High	SW, 10-12 mph*	SW, 3 mph*	8-1/2 ft.	3 ft.
Remarks: Sediment was silty with some organic matter. Very little odor of H ₂ S.							
W-4	8/4/55	0728	Flow near high	SW, 1-3 mph*	Negligible	9 ft.	3 ft.
Remarks: Sediment was a gray-green silt with much fine organic debris. Some odor of H ₂ S.							
W-5	10/15/55	1320	Ebb	W, 0-5 mph*	SW, 3 mph*	7 ft.	3 ft.
Remarks: Sediment contained much organic debris. Was about 89% sand and 20% silt otherwise. Medium odor of H ₂ S.							

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION X: In Bayou Blue north of Gulf Oil's Bully Camp operation (see map).
Diagonally across V cut in the center.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
X-1	1/14/55	1735	Low	NE, 5-10 mph*	Negligible	5 ft.	3 ft.
Remarks: None.							
X-2	3/19/55	1210	High	S, 10-15 mph*	Negligible	7 ft.	3 ft.
Remarks: Sediment was a silty clay with some particulate organic matter.							
X-3	6/25/55	1054	Low	Squalls	Negligible	6-1/2 ft.	3 ft.
Remarks: Mud was silty and low in organic content. No odor of H ₂ S.							
X-4	8/3/55	0935	High	SSE, 2-3 mph*	S, 1-2 mph*	8 ft.	3 ft.
Remarks: Surface of sediment was black and the immediate underlying layer a buff brown clay with a small amount of organic matter. No odor of H ₂ S.							
X-5	10/15/55	0922	Ebb	WNW, gusts up to 5 mph*	W, 1 mph*	6 ft.	3 ft.
Remarks: Sediment was approximately 60% clay and 40% silt. Little organic debris. No H ₂ S.							

*Approximately

WATER DATA

pH (Glass versus calomel electrode)

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP	FIFTH FIELD TRIP
A	7.48	8.78	8.25	7.94	8.50
B	7.49	8.10	8.28	7.80	6.90
C	7.49	7.90	8.18	7.53	6.70
D	7.48	8.20	8.25	7.20	7.10
E	7.50	8.10	8.25	7.54	6.89
F	7.51	8.00	8.27	7.55	6.90
G	7.50	8.00	8.10	7.54	6.79
H	7.49	8.50	8.10	6.90	7.03
I	7.52	7.85	8.30	7.54	7.00
J	7.51	8.80	8.35	7.93	8.20
K	7.19	7.70	8.80	7.20	6.21
L	7.72	7.50	7.90	7.30	7.20
M	7.31	8.30	8.20	7.55	7.10
N	7.89	8.13	8.37	7.18	6.30
O	7.89	8.30	8.30	7.47	7.39
P	7.59	8.15	7.85	7.62	6.62
Q	8.31	8.85	7.95	7.70	8.40
R	8.31	8.60	8.30	7.60	8.30
S	7.50	8.19	8.30	7.58	8.20
T	7.55	7.80	7.90	7.23	6.85
U	7.36	7.75	8.00	7.31	6.75
V	7.60	8.10	8.10	7.50	7.40
W	7.59	7.40	7.95	7.35	7.40
X	7.60	7.45	8.15	7.26	7.60

WATER DATA

Temperature (°C) of water at sampling depth

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP	FIFTH FIELD TRIP
A	10.5	23.6	26.9	25.8	22.0
B	8.0	25.8	28.6	27.8	23.0
C	12.4	25.6	28.0	28.0	22.0
D	13.5	26.4	27.5	29.0	21.0
E	15.6	26.4	28.9	29.0	20.5
F	14.0	26.2	28.9	28.4	22.0
G	12.8	26.1	28.6	28.0	22.0
H	16.1	25.8	29.7	26.2	23.0
I	12.2	24.7	27.7	26.0	21.0
J	14.7	21.0	28.0	25.8	21.0
K	17.2	25.6	26.9	25.6	19.0
L	16.3	25.8	27.5	25.8	20.5
M	16.9	24.1	32.5	28.4	21.0
N	16.9	23.9	31.1	30.0	22.0
O	15.6	24.4	31.1	30.0	22.0
P	17.8	24.4	32.2	30.2	22.0
Q	18.3	23.9	30.6	28.0	23.0
R	17.8	25.0	31.2	28.2	22.5
S	12.2	23.9	31.2	28.6	22.0
T	12.2	25.8	28.9	28.0	21.5
U	12.2	23.9	31.1	28.0	21.0
V	13.9	24.4	32.2	26.0	22.0
W	9.4	25.6	29.4	27.2	21.0
X	8.9	26.1	28.6	26.2	22.0

WATER DATA

Specific Gravity 20°/20°

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP	FIFTH FIELD TRIP
A	1.016	1.011	1.020	1.009	1.005
B	1.010	1.003	1.010	1.003	1.001
C	1.010	1.011	1.013	1.005	1.003
D	1.012	1.007	1.011	1.006	1.001
E	1.011	1.007	1.012	1.005	1.003
F	1.010	1.009	1.014	1.006	1.003
G	1.010	1.013	1.018	1.009	1.001
H	1.013	1.013	1.018	1.006	1.006
I	1.012	1.013	1.018	1.008	1.007
J	1.012	1.011	1.016	1.008	1.009
K	1.003	1.013	1.014	1.006	1.002
L	1.001	1.007	1.012	1.004	1.001
M	1.011	1.013	1.016	1.010	1.003
N	1.011	1.011	1.018	1.005	1.005
O	1.007	1.013	1.020	1.008	1.007
P	1.009	1.017	1.020	1.007	1.007
Q	1.003	1.011	1.018	1.010	1.005
R	1.004	1.013	1.019	1.007	1.005
S	1.011	1.015	1.019	1.012	1.012
T	1.009	1.015	1.021	1.010	1.007
U	1.009	1.011	1.020	1.012	1.011
V	1.011	1.012	1.018	1.010	1.003
W	1.008	1.015	1.016	1.008	1.003
X	1.000	1.001	1.010	1.002	1.001

WATER DATA

Specific conductance, $\text{ohm}^{-1} \text{cm}^{-1} (\times 10^3)$, at 15°C

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	21.42	12.63	23.54	11.32
B	10.18	3.68	15.77	1.916
C	9.33	11.87	19.60	3.102
D	13.09	8.89	15.86	7.28
E	12.00	9.02	17.45	7.02
F	12.92	12.76	20.62	7.41
G	12.32	15.99	21.83	7.23
H	19.45	16.60	23.54	7.18
I	19.20	17.91	23.18	12.18
J	19.29	13.24	21.86	9.13
K	8.09	14.68	19.89	6.97
L	5.59	7.068	16.64	3.80
M	13.33	17.60	23.76	11.50
N	11.42	17.17	23.54	10.73
O	13.19	17.56	23.94	13.51
P	10.89	21.52	27.34	11.75
Q	11.38	16.47	23.94	9.96
R	13.18	19.35	23.76	11.86
S	22.63	19.44	24.27	15.15
T	16.57	18.90	23.00	12.81
U	17.46	19.00	23.73	13.69
V	13.39	16.63	23.54	13.58
W	16.57	12.80	23.73	9.31
X	1.80	1.746	14.60	1.04

WATER DATAAbsolute turbidity ($\times 10^4$)

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	0.224	0.322	0.779	3.37
B	0.118	0.508	0.328	7.10
C	0.109	0.468	0.661	1.66
D	0.128	0.332	0.357	2.54
E	0.131	0.211	0.480	1.46
F	0.106	0.213	0.479	2.18
G	0.194	0.234	1.41	2.57
H	0.220	0.234	0.224	2.26
I	0.133	0.234	0.430	4.49
J	0.208	0.207	1.13	3.29
K	0.304	0.410	0.881	1.99
L	0.165	0.269	0.891	6.97
M	0.118	0.249	0.199	1.88
N	0.176	0.254	0.161	1.73
O	0.100	0.288	0.353	2.09
P	0.176	0.410	0.209	0.73
Q	0.168	0.432	1.003	3.81
R	0.137	0.386	0.324	3.67
S	4.38	0.442	0.226	2.01
T	1.20	0.356	0.477	1.93
U	1.15	0.275	0.422	3.10
V	1.50	0.252	0.455	4.22
W	0.488	0.384	0.387	1.35
X	0.842	2.66	0.655	2.24

WATER DATA

Differential refractive index ($\times 10^4$) at 25°C.

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	28.46	23.9	43.96	16.67
B	12.44	6.35	28.37	2.66
C	12.43	21.30	38.23	5.31
D	17.30	15.50	31.57	11.38
E	16.53	14.60	32.42	8.28
F	16.62	22.40	38.44	10.30
G	16.70	28.3	33.64	18.94
H	26.16	31.1	45.53	17.21
I	21.77	32.6	44.07	20.94
J	27.27	22.4	41.38	13.28
K	9.69	25.9	36.28	13.08
L	6.38	10.9	30.21	5.73
M	20.03	33.0	44.32	18.17
N	22.14	31.3	43.80	16.52
O	19.60	31.1	44.81	21.71
P	21.23	40.4	50.49	18.07
Q	15.58	29.3	45.36	18.27
R	17.90	34.3	47.30	19.91
S	35.25	36.9	49.21	26.11
T	22.60	34.2	45.54	20.70
U	24.13	33.8	48.59	23.91
V	19.46	31.1	44.64	24.98
W	22.70	31.6	44.49	15.65
X	2.78	2.44	25.51	1.18

WATER DATATotal solids, ppm X 10⁻³, (dried at 105°C)

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP	FIFTH FIELD TRIP
A	17.5	14.82	25.48	10.08	8.38
B	7.72	3.88	17.00	1.86	1.55
C	7.56	13.67	22.20	3.41	2.61
D	10.3	9.67	18.78	7.21	3.10
E	10.4	10.15	19.24	5.37	3.58
F	10.5	14.63	23.14	6.61	2.80
G	10.2	17.95	24.83	11.72	2.98
H	16.3	21.38	27.35	10.45	6.61
I	13.7	24.0	26.44	13.23	7.57
J	16.9	14.06	25.19	8.88	8.10
K	6.28	18.15	22.04	8.19	2.64
L	4.32	6.71	17.60	3.82	2.20
M	11.9	21.93	26.68	11.99	7.99
N	13.3	25.69	26.63	10.38	11.41
O	11.6	19.68	26.68	13.43	12.96
P	12.7	29.43	30.38	12.62	12.15
Q	9.03	22.53	27.48	11.03	8.67
R	10.6	22.41	28.32	12.33	9.36
S	21.8	23.96	29.20	17.65	16.89
T	13.7	22.13	27.70	13.19	8.64
U	14.9	21.85	29.14	14.72	12.07
V	11.9	23.33	26.87	15.84	7.03
W	16.6	27.16	26.99	9.96	10.67
X	1.23	1.47	15.06	.98	8.16

WATER DATA

Total solid, ppm $\times 10^{-3}$, after ignition at 600°C. and percentage loss on ignition.

STATION	FIRST			SECOND			THIRD			FOURTH			FIFTH		
	FIELD TRIP	% LOSS	FIELD TRIP	FIELD TRIP	% LOSS	FIELD TRIP	FIELD TRIP	% LOSS	FIELD TRIP	FIELD TRIP	% LOSS	FIELD TRIP	FIELD TRIP	% LOSS	FIELD TRIP
A	15.71	10.2	12.13		18.2	23.06		9.5	8.75		13.4	7.46		21.9	
B	6.81	11.8	3.23		16.7	15.32		9.9	1.60		14.0	1.36		24.6	
C	6.82	9.8	11.27		17.6	19.96		10.1	2.92		14.4	2.25		26.4	
D	9.19	10.8	7.23		25.3	16.84		10.3	6.19		14.1	2.69		26.4	
E	9.33	8.5	8.57		15.6	17.38		9.7	4.53		15.6	3.07		28.6	
F	9.12	13.1	11.97		18.2	20.87		9.8	5.65		14.5	2.42		26.9	
G	9.04	11.4	15.20		15.3	22.39		9.8	10.12		13.6	2.55		28.7	
H	14.04	13.9	16.29		23.8	24.77		9.4	9.09		13.0	5.61		24.3	
I	12.05	12.0	17.86		25.5	23.69		10.4	11.35		14.2	6.65		24.4	
J	15.11	10.6	12.16		7.8	22.84		9.3	7.75		12.7	7.16		23.2	
K	5.61	10.7	13.91		23.5	19.55		11.3	6.94		15.3	2.28		27.4	
L	3.80	12.0	5.59		16.7	15.98		9.2	3.17		16.6	1.91		26.7	
M	10.49	11.8	17.97		18.1	24.26		9.0	10.30		14.1	7.02		24.2	
N	11.77	11.5	17.12		33.4	24.00		9.9	8.94		11.0	10.06		23.7	
O	10.07	13.2	17.01		13.6	24.06		9.8	11.67		13.1	11.47		23.0	
P	11.16	12.1	22.22		24.2	27.88		8.2	10.94		13.2	10.77		22.8	
Q	8.24	8.8	15.61		30.8	24.88		9.5	9.47		13.5	7.68		22.8	
R	9.40	11.3	18.92		15.6	25.68		9.3	10.70		13.2	8.19		25.0	
S	18.83	13.6	20.06		16.3	26.66		8.7	15.27		13.5	14.91		23.4	
T	11.55	15.7	18.66		15.7	25.02		9.7	11.30		14.3	7.52		25.7	
U	12.35	17.1	18.64		14.7	25.99		10.8	12.79		13.0	10.61		24.2	
V	9.85	17.2	17.02		27.1	24.43		9.1	13.47		15.0	6.27		21.5	
W	11.62	30.0*	17.20		36.8*	24.12		10.6	8.65		13.3	9.32		25.2	
X	1.01	17.9	1.22		17.0	13.59		9.8	0.80		20.0*	0.68		33.3*	

*Not included in the average.

WATER DATA

Chlorinity (parts per thousand)

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP	FIFTH FIELD TRIP
A	9.40	7.53	13.67	5.47	4.48
B	4.38	2.02	9.13	0.93	0.77
C	4.24	6.59	11.74	1.79	1.35
D	5.86	4.92	10.06	3.81	1.64
E	5.71	5.17	10.34	3.60	1.86
F	5.68	7.11	12.33	3.50	1.47
G	5.68	9.07	13.25	6.30	1.55
H	9.02	9.67	14.53	5.58	3.38
I	7.23	10.39	13.95	6.84	4.00
J	9.44	7.35	13.48	4.70	4.32
K	3.28	8.36	11.83	4.34	1.39
L	2.26	3.56	9.61	1.96	1.16
M	6.30	10.41	14.13	6.19	4.15
N	6.94	10.11	14.05	5.43	5.94
O	6.10	10.00	14.12	7.28	6.95
P	6.72	12.93	16.24	6.49	6.59
Q	5.00	9.33	14.59	5.73	4.62
R	5.68	11.08	14.98	6.43	4.91
S	10.80	12.00	15.43	9.09	8.73
T	6.94	11.06	14.02	6.85	4.50
U	7.22	10.88	15.48	7.58	6.28
V	6.02	9.99	14.42	7.66	3.73
W	6.72	9.98	14.10	5.62	5.59
X	0.92	0.71	8.16	0.448	0.32

WATER DATA

Ratio of chlorinity to total solids
Solids determined after ignition of the sample at 600°C.

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP	FIFTH FIELD TRIP
A	0.598 -	0.620 +	0.593 +	0.625 +	0.601 o
B	0.643 +	0.625 +	0.596 +	0.581 -	0.566*-
C	0.622 +	0.585 -	0.588 -	0.613 +	0.600 -
D	0.638 +	0.680*+	0.597 +	0.616 +	0.610 +
E	0.612 +	0.603 +	0.595 +	0.759*+	0.606 +
F	0.623 +	0.594 -	0.591 +	0.619 +	0.607 +
G	0.628 +	0.597 +	0.592 +	0.623 +	0.608 +
H	0.642 +	0.594 -	0.587 -	0.614 +	0.602 +
I	0.600 -	0.582 -	0.589 -	0.603 -	0.602 +
J	0.625 +	0.604 +	0.590 o	0.606 o	0.603 +
K	0.585 -	0.601 +	0.605 +	0.625 +	0.610 +
L	0.595 -	0.637 +	0.601 +	0.618 +	0.607 +
M	0.601 -	0.579 -	0.582 -	0.601 -	0.591 -
N	0.590 -	0.591 -	0.585 -	0.607 +	0.590 -
O	0.606 -	0.588 -	0.587 -	0.624 +	0.606 +
P	0.602 -	0.583 -	0.582 -	0.593 -	0.612 +
Q	0.607 o	0.597 +	0.586 -	0.605 -	0.602 +
R	0.604 -	0.586 -	0.583 -	0.601 -	0.600 -
S	0.574 -	0.598 +	0.579 -	0.595 -	0.586 -
T	0.601 -	0.593 -	0.584 -	0.606 o	0.598 -
U	0.585 -	0.584 -	0.596 +	0.593 -	0.592 -
V	0.611 +	0.587 -	0.590 o	0.569 -	0.595 -
W	0.578 -	0.580 -	0.585 -	0.650 +	0.600 -
X	0.911*+	0.582 -	0.600 +	0.560 -	0.471*-

*Not included in the average.

WATER DATA

Salinity, parts per thousand

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP	FIFTH FIELD TRIP
A	8.09	13.62	24.70	9.90	8.12
B	3.93	2.68	16.51	1.71	1.42
C	3.86	11.92	21.22	3.26	2.47
D	5.32	8.91	18.19	6.91	2.99
E	5.18	9.36	18.69	6.53	3.39
F	5.16	12.86	22.29	6.35	2.68
G	5.16	16.40	23.95	11.40	2.83
H	8.18	17.48	26.26	10.10	6.13
I	6.82	18.78	25.21	12.38	7.25
J	8.55	13.30	24.36	8.51	7.82
K	3.00	15.12	21.38	7.86	2.54
L	2.17	6.46	17.38	3.57	2.12
M	5.80	18.82	25.53	11.20	7.52
N	6.30	18.28	25.39	9.83	10.75
O	5.54	18.08	25.52	13.17	12.58
P	6.10	23.37	29.34	11.74	11.93
Q	4.60	16.87	26.36	10.37	8.36
R	5.16	20.03	27.07	11.64	8.88
S	9.78	21.69	27.88	16.44	15.80
T	6.30	19.99	26.42	12.39	8.16
U	6.77	19.67	27.97	13.71	11.37
V	5.47	18.06	26.06	13.86	6.76
W	6.10	18.04	25.48	10.17	10.12
X	0.46	1.31	14.76	0.84	0.61

WATER DATA

Sulfate concentration expressed as ppm sulfur

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	285	243	416	137
B	133	80	278	59
C	117	272	339	46
D	184	192	346	69
E	189	192	286	60
F	170	287	468	56
G	172	380	313	201
H	277	412	458	172
I	228	532	449	327
J	294	243	420	125
K	105	346	448	141
L	80	221	329	51
M	238	445	521	215
N	258	381	539	174
O	253	415	582	239
P	246	541	604	222
Q	163	376	505	160
R	192	506	562	200
S	443	524	737	333
T	290	481	621	222
U	315	452	589	252
V	203	460	528	299
W	298	442	499	180
X	59	30	285	48

WATER DATA

Other oxidizable forms of sulfur expressed as ppm S.

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	2.5	35.2	36.8	27.8
B	0.0	41.6	65.3	2.2
C	13.9	0.0	132.5	12.8
D	7.4	10.2	11.2	76.8
E	5.2	0.0	117.1	19.5
F	9.9	21.5	0.0	67.2
G	22.5	22.7	101.8	39.7
H	25.0	35.2	124.2	51.8
I	12.7	0.0	64.9	0.0
J	14.5	0.0	71.7	25.9
K	70.3	18.6	13.7	21.4
L	44.3	0.0	45.4	2.9
M	48.0	44.8	24.6	51.5
N	52.3	57.6	20.5	57.6
O	3.7	41.6	43.2	30.1
P	19.4	25.7	82.2	48.6
Q	48.3	18.9	149.1	66.2
R	72.7	0.0	88.0	54.4
S	27.3	0.0	0.0	41.6
T	4.9	0.0	276.5	54.4
U	3.1	0.0	0.0	56.3
V	9.8	0.0	73.6	24.6
W	13.3	51.2	134.7	78.4
X	60.	28.5	52.8	19.2

WATER DATA

STATION	Alkalinity (ppm bicarbonate ion)		Alkalinity (ppm carbonate ion)		Total Hardness (expressed as ppm Calcium Carbonate)	
	Third Field Trip	Fourth Field Trip	Third Field Trip	Fourth Field Trip	Third Field Trip	Fourth Field Trip
A	268	135	90	60	44.0	26.3
B	83	113	11	0	27.3	21.1
C	234	125	10	0	18.7	14.2
D	205	157	40	0	16.7	16.0
E	205	176	55	0	16.7	11.7
F	120	140	115	0	17.3	15.0
G	170	150	50	0	20.7	43.3
H	170	151	35	0	13.7	74.6
I	191	135	50	30	37.0	26.6
J	140	139	70	31	26.0	16.9
K	202	160	43	0	14.0	49.3
L	239	145	0	0	18.4	26.6
M	25	153	30	0	23.0	47.3
N	165	145	40	0	76.1	39.0
O	144	135	33	0	28.8	34.0
P	125	140	70	0	21.0	27.3
Q	163	142	40	25	4.7	18.0
R	148	130	30	20	14.3	25.3
S	120	120	40	20	41.0	31.6
T	29	170	19	0	17.3	32.0
U	162	165	31	0	17.0	26.1
V	130	150	80	0	68.1	26.3
W	77	154	109	0	20.0	46.0
X	183	100	0	0	15.3	32.0

WATER DATA

Dissolved oxygen in ppm at field temperatures.

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	8.2	9.1	3.0	6.8
B	8.6	5.1	4.4	4.5
C	7.0	4.7	4.3	4.1
D	10.7	7.1	3.7	4.9
E	6.2	6.1	3.1	2.9
F	10.7	7.7	4.7	4.6
G	8.4	5.6	3.1	4.9
H	9.8	5.4	4.3	1.0
I	9.0	3.9	3.0	5.7
J	10.6	6.6	5.1	6.3
K	7.0	5.6	2.3	0.7
L	7.8	4.3	2.1	0.5
M	4.6	5.3	5.0	3.6
N	6.2	5.7	5.5	3.4
O	6.3	5.9	5.3	4.2
P	3.9	5.2	4.7	1.0
Q	8.4	3.0	1.9	6.0
R	9.5	2.2	4.8	3.9
S	9.1	5.4	5.2	5.9
T	7.6	5.4	4.8	1.0
U	7.8	3.6	2.2	1.0
V	9.2	1.7	4.6	3.0
W	6.9	5.8	4.5	0.6
X	4.3	3.9	2.7	0.8

WATER DATA

Theoretical ppm dissolved oxygen to produce saturation,
based on actual chlorinity and field temperatures.

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	10.9	8.2	7.3	8.1
B	11.7	8.3	7.4	8.2
C	10.7	8.0	7.3	8.1
D	10.4	8.1	7.6	7.8
E	9.8	8.1	7.3	7.8
F	10.2	7.9	7.1	7.9
G	10.4	7.8	7.0	7.7
H	9.7	7.7	6.8	8.0
I	10.6	7.8	7.1	7.9
J	9.8	8.6	7.2	8.1
K	9.8	7.8	7.4	8.1
L	10.0	8.2	7.5	8.3
M	9.6	5.5	6.6	7.7
N	9.6	7.9	6.7	7.5
O	9.8	7.9	6.7	7.4
P	9.4	7.7	6.4	7.5
Q	9.5	8.0	6.7	7.8
R	9.5	7.7	6.7	7.7
S	10.4	7.8	6.6	7.4
T	10.6	7.6	6.9	7.7
U	10.6	7.9	6.6	7.6
V	10.2	7.9	6.6	7.9
W	11.3	7.7	7.0	8.1
X	11.7	8.4	7.4	8.5

WATER DATA

Percentage saturation with regard to dissolved oxygen.

STATION	FIRST FIELD TRIP	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	75.0	111.6	41.3	84.5
B	73.3	61.2	59.7	55.2
C	65.2	59.0	59.0	50.7
D	102.7	87.8	49.0	62.9
E	63.1	75.6	42.6	37.2
F	104.6	97.2	66.1	57.9
G	80.5	72.2	44.0	63.5
H	101.3	70.0	63.1	12.4
I	85.2	50.1	42.2	71.8
J	107.7	76.8	71.3	77.7
K	71.6	71.7	31.1	8.6
L	77.9	52.4	28.2	6.0
M	47.8	95.8	75.9	46.6
N	64.7	71.9	81.8	45.2
O	64.2	74.3	79.0	56.9
P	41.4	67.5	73.2	13.4
Q	88.4	37.6	28.4	77.2
R	100.3	28.5	72.2	50.6
S	87.8	69.4	78.7	80.1
T	71.8	71.1	69.3	13.0
U	73.9	45.7	33.3	13.1
V	90.1	21.4	70.1	38.1
W	61.0	75.5	64.6	7.5
X	36.8	46.2	36.3	9.5

WATER DATA

Biological oxygen demand, ppm dissolved oxygen consumed, and percentage oxygen consumed in five days at laboratory temperatures.

STATION	FIRST FIELD TRIP	%O ₂ CONS.	SECOND FIELD TRIP	%O ₂ CONS.	THIRD FIELD TRIP	%O ₂ CONS.	FOURTH FIELD TRIP	%O ₂ CONS.
A	5.3	65	9.1	100	3.0	100	6.8	100
B	3.1	36	3.6	71	3.6	82	4.5	100
C	5.7	81	3.6	77	4.3	100	4.1	100
D	5.7	53	5.8	82	3.7	100	4.9	100
E	5.0	81	5.3	87	3.1	100	2.9	100
F	6.9	64	5.0	65	4.6	98	3.9	85
G	4.6	55	3.0	54	2.6	84	4.9	100
H	7.3	74	2.7	50	2.7	63	1.0	100
I	6.0	67	0.9	23	2.4	80	5.7	100
J	9.9	93	6.6	100	5.1	100	6.3	100
K	6.0	86	5.2	93	2.3	100	0.7	100
L	7.7	99	3.0	70	2.1	100	0.5	100
M	4.6	100	2.5	47	4.4	88	3.6	100
N	4.8	77	3.5	61	4.1	75	3.4	100
O	4.2	67	3.9	66	2.8	53	4.2	100
P	3.9	100	2.9	56	2.7	57	1.0	100
Q	4.5	54	0.9	30	1.5	79	6.0	100
R	5.1	54	1.1	50	3.4	71	3.9	100
S	2.4	26	1.2	22	2.1	40	5.9	100
T	2.2	29	2.0	37	2.8	58	1.0	100
U	4.4	56	1.6	44	0.7	32	1.0	100
V	5.2	57	1.0	59	3.8	83	3.0	100
W	1.1	16	2.0	34	2.2	49	0.6	100
X	1.8	42	2.1	54	2.6	96	0.8	100

MUD DATA

Total Sulfur expressed as weight percent of Dried Mud

STATION	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	0.32	0.30	1.57
B	4.06	0.18	2.28
C	0.95	0.42	6.24
D	2.26	0.51	11.52
E	5.06	33.33	33.23
F	2.38	4.63	13.57
G	0.25	0.26	10.64
H	0.29	6.69	1.75
I	0.90	7.72	2.77
J	0.88	4.92	7.16
K	1.18	8.50	14.00
L	1.34	0.43	15.55
M	1.82	0.44	4.54
N	0.44	0.49	0.90
O	0.04	0.35	3.78
P	0.99	5.62	6.60
Q	0.08	0.28	6.63
R	0.38	0.32	3.65
S	0.65	0.33	5.38
T	0.22	5.53	3.54
U	2.40	6.77	6.22
V	0.80	2.63	6.57
W	1.02	4.95	4.91
X	1.47	4.47	4.63

MUD DATA

Sulfate concentration expressed as percentage Sulfur in Dried
Mud (Trace is less than 0.01%)

STATION	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	0.04	0.01	0.01
B	0.35	trace	0.72
C	0.22	0.83	trace
D	0.71	1.08	0.85
E	0.62	1.67	0.84
F	0.30	1.09	0.73
G	0.05	0.18	0.18
H	0.04	1.46	1.46
I	0.12	1.32	1.00
J	0.10	0.81	0.90
K	0.13	1.55	1.71
L	1.94	1.83	1.74
M	0.29	0.29	0.28
N	0.62	0.70	0.70
O	0.12	trace	1.01
P	0.24	0.89	1.58
Q	0.38	0.55	0.26
R	0.32	trace	0.11
S	0.15	0.61	1.05
T	0.16	0.60	0.02
U	2.15	0.97	1.00
V	0.31	0.45	0.44
W	0.34	0.68	0.70
X	0.05	0.44	0.39

MUD DATA

Sulfide concentration expressed as percentage Sulfur in Dried
Mud (trace is less than 0.005%)

STATION	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	trace	0.01	0.03
B	trace	0.03	0.02
C	trace	trace	0.01
D	0.17	trace	0.05
E	0.01	0.03	0.01
F	0.01	0.02	0.01
G	0.02	0.02	trace
H	0.03	trace	0.01
I	0.04	trace	0.01
J	0.04	trace	0.01
K	0.25	trace	trace
L	0.04	trace	trace
M	0.04	0.02	trace
N	0.03	0.02	trace
O	0.02	0.02	trace
P	0.05	trace	0.01
Q	0.03	0.02	0.01
R	0.02	0.04	trace
S	trace	0.03	trace
T	0.01	0.005	trace
U	trace	0.03	trace
V	0.01	0.01	trace
W	0.03	0.05	0.01
X	0.02	0.06	0.03

MUD DATA

Free Sulfur plus Organic Sulfur expressed as weight percent of Dried Mud (obtained by subtracting percentage Sulfur equivalent of $\text{SO}_4^{=}$ + $\text{S}^{=}$ from percentage total Sulfur)

STATION	FIRST FIELD TRIP*	SECOND FIELD TRIP	THIRD FIELD TRIP	FOURTH FIELD TRIP
A	0.02	0.27	0.28	1.53
B	0.02	3.71	0.15	1.54
C	0.02	0.73	-0.41	6.23
D	0.05	1.38	-0.57	10.62
E	0.05	4.43	31.63	32.38
F	0.06	2.07	3.52	12.63
G	0.04	0.18	0.08	10.46
H	0.03	0.22	5.23	0.28
I	0.01	0.74	6.40	1.76
J	0.02	0.74	4.11	6.25
K	0.04	1.02	6.95	12.29
L	0.03	-0.13	-1.40	13.81
M	0.02	1.49	0.13	4.26
N	0.02	-0.28	-0.23	0.20
O	0.01	-0.12	0.33	2.77
P	0.04	0.70	4.73	5.01
Q	0.08	-0.38	-0.29	6.36
R	0.02	-0.01	0.28	3.54
S	0.02	0.49	-0.61	4.33
T	0.01	0.05	4.92	3.52
U	0.02	0.24	5.77	5.22
V	0.02	0.48	2.17	6.13
W	0.06	0.66	4.22	4.20
X	0.01	1.40	3.97	4.22

*Carbon disulfide soluble material only.

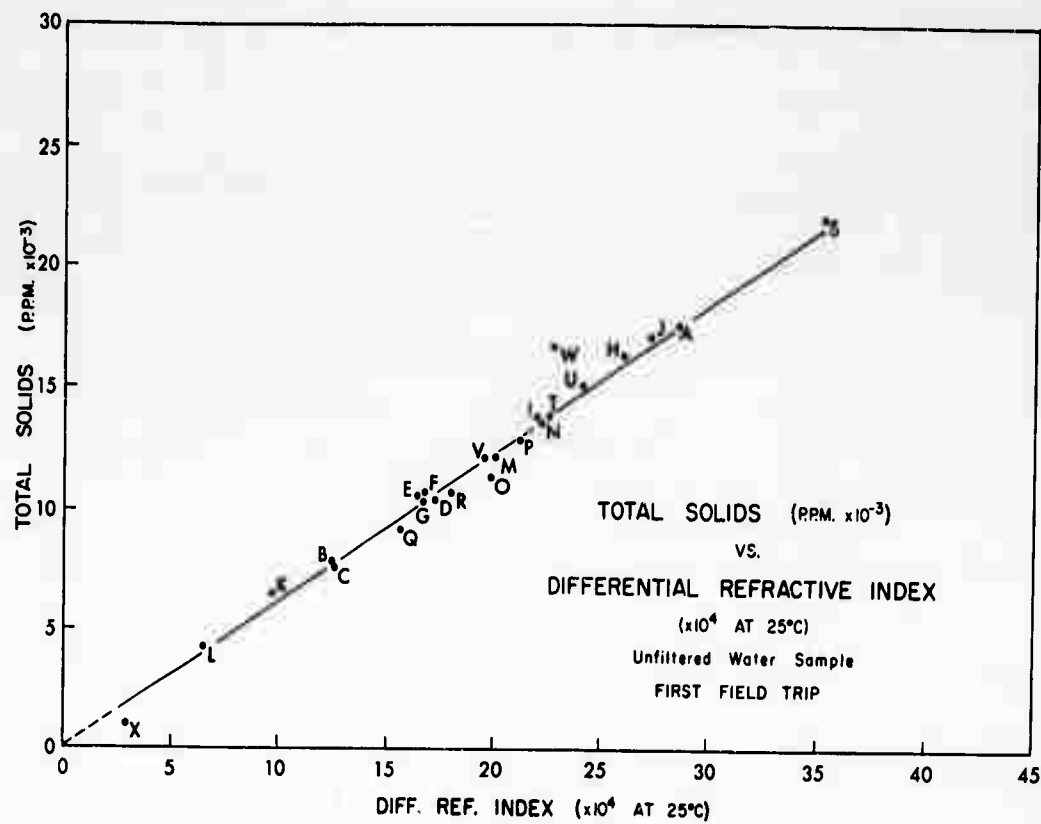


Figure 1

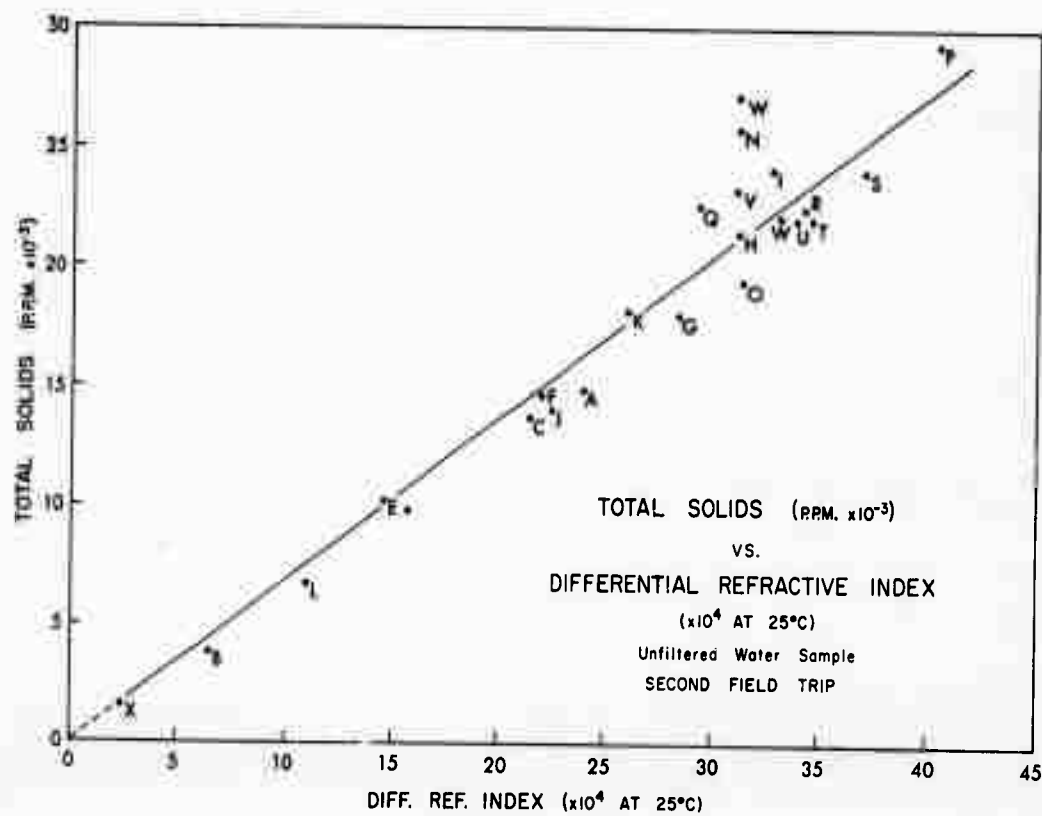


Figure 2

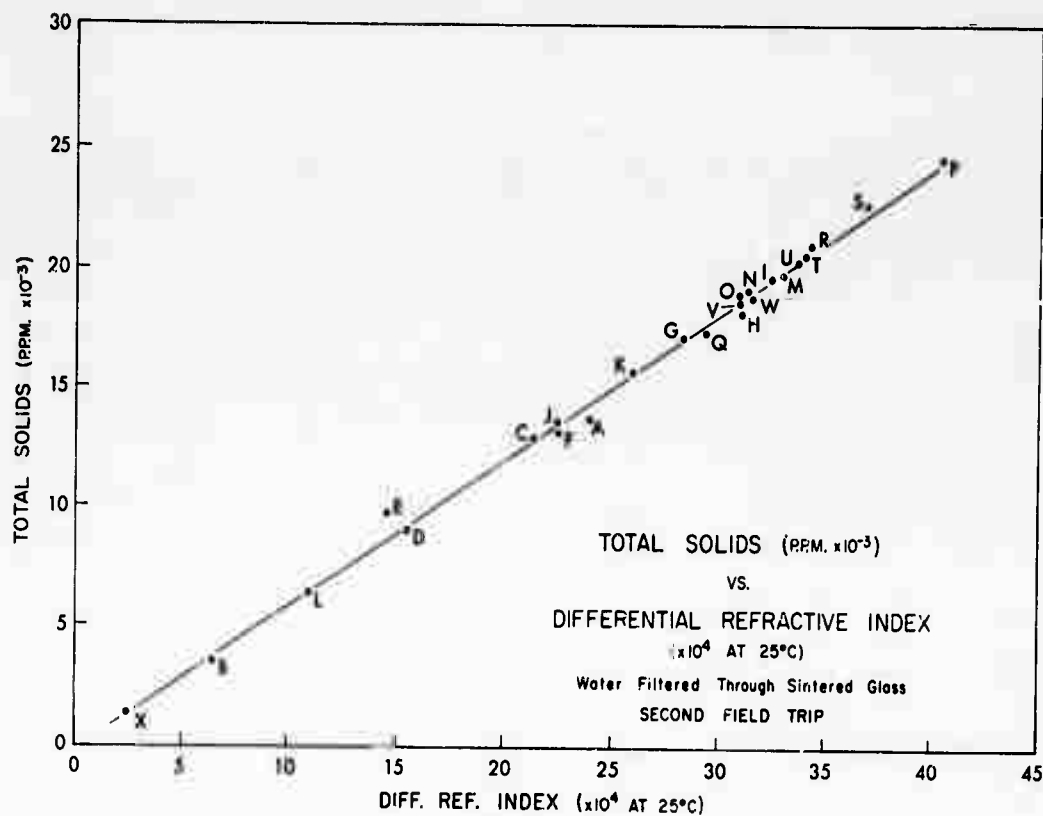


Figure 3

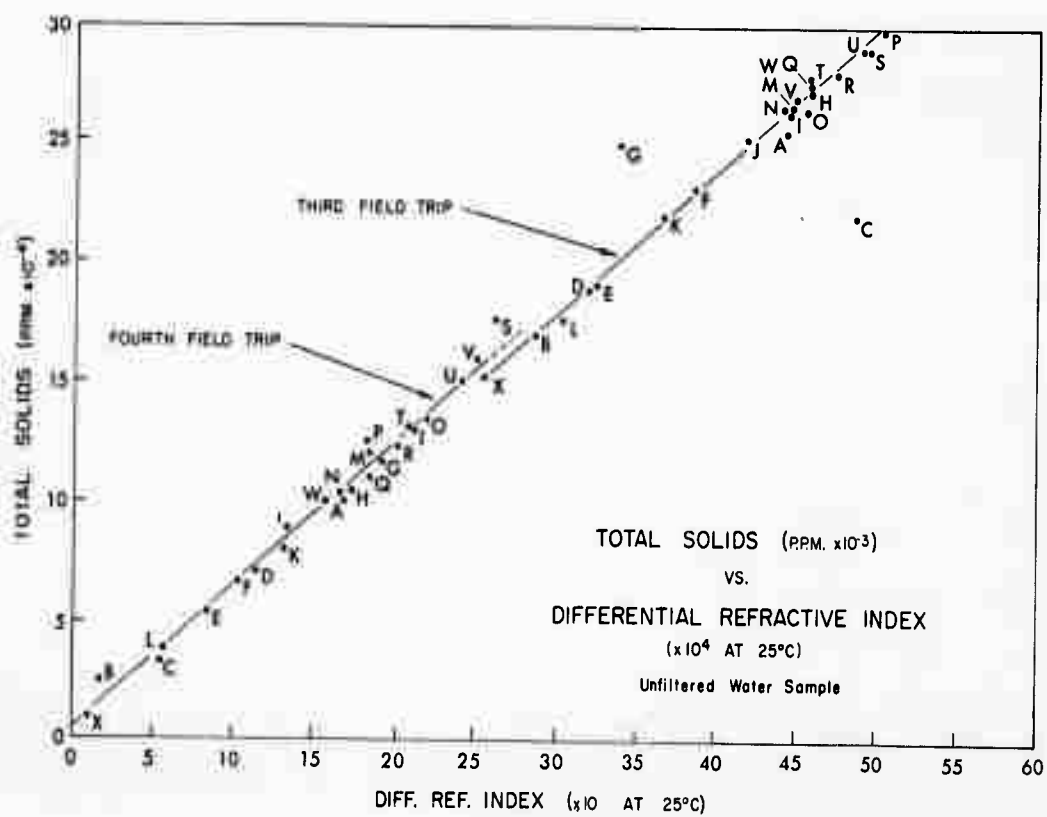
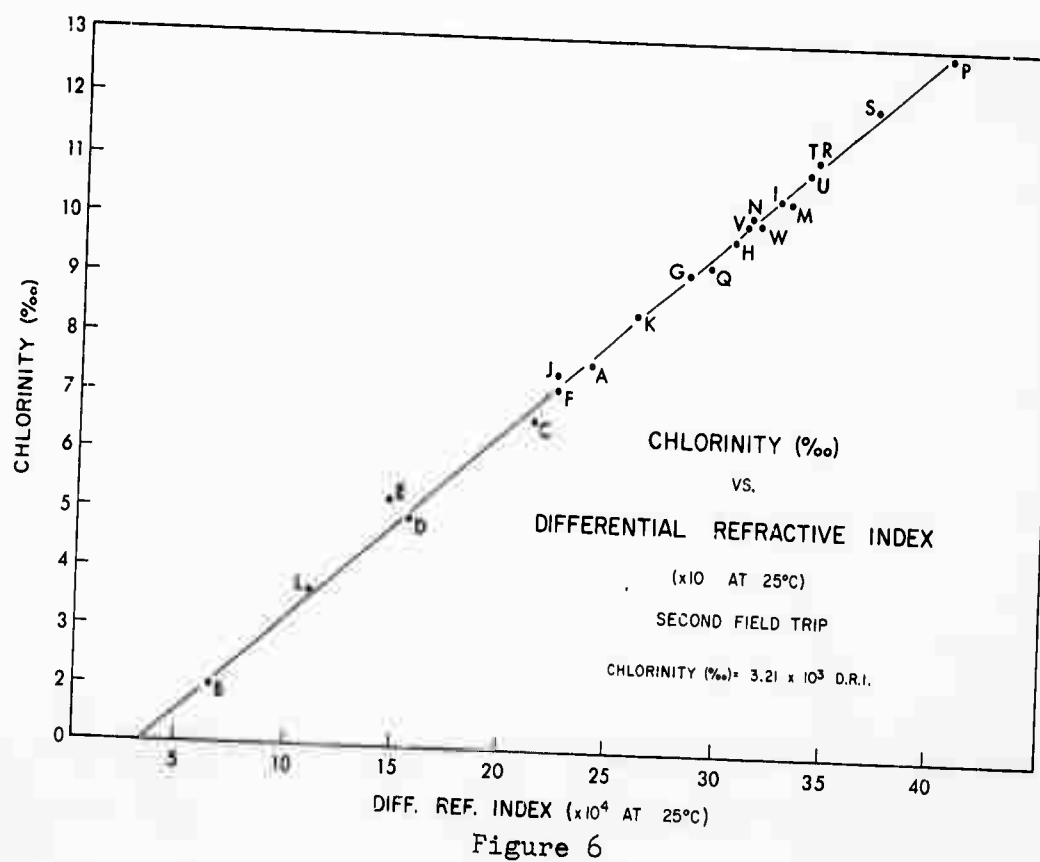
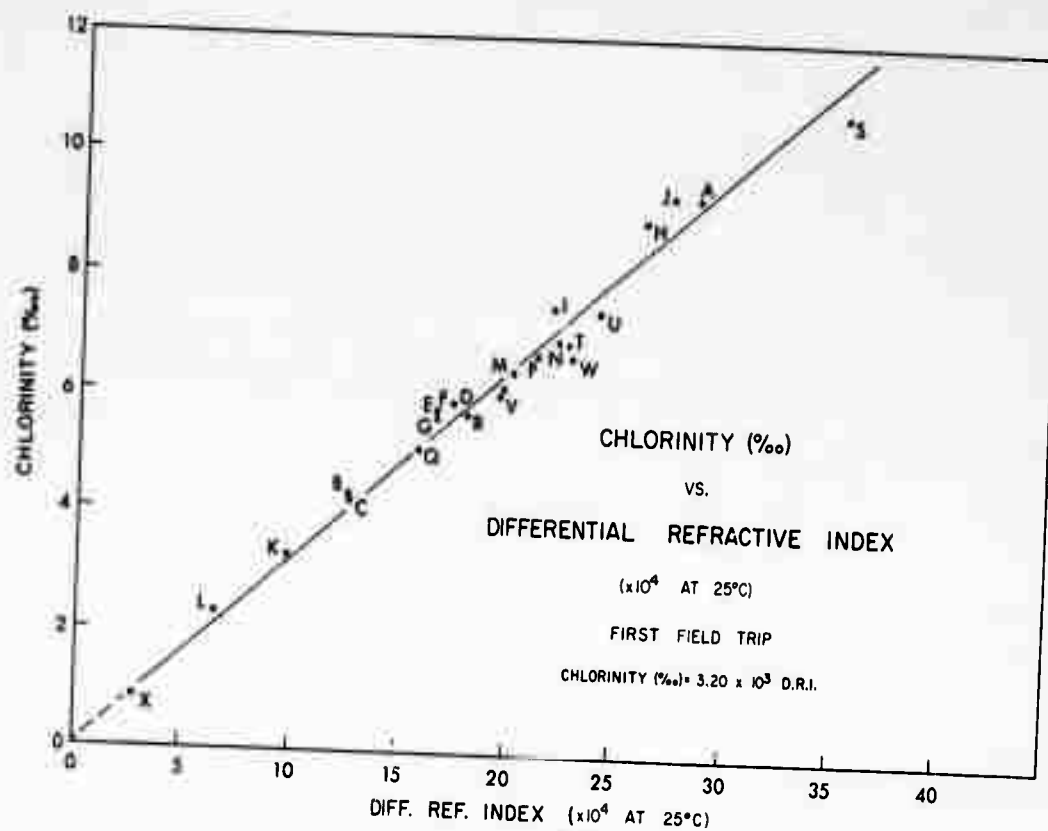


Figure 4



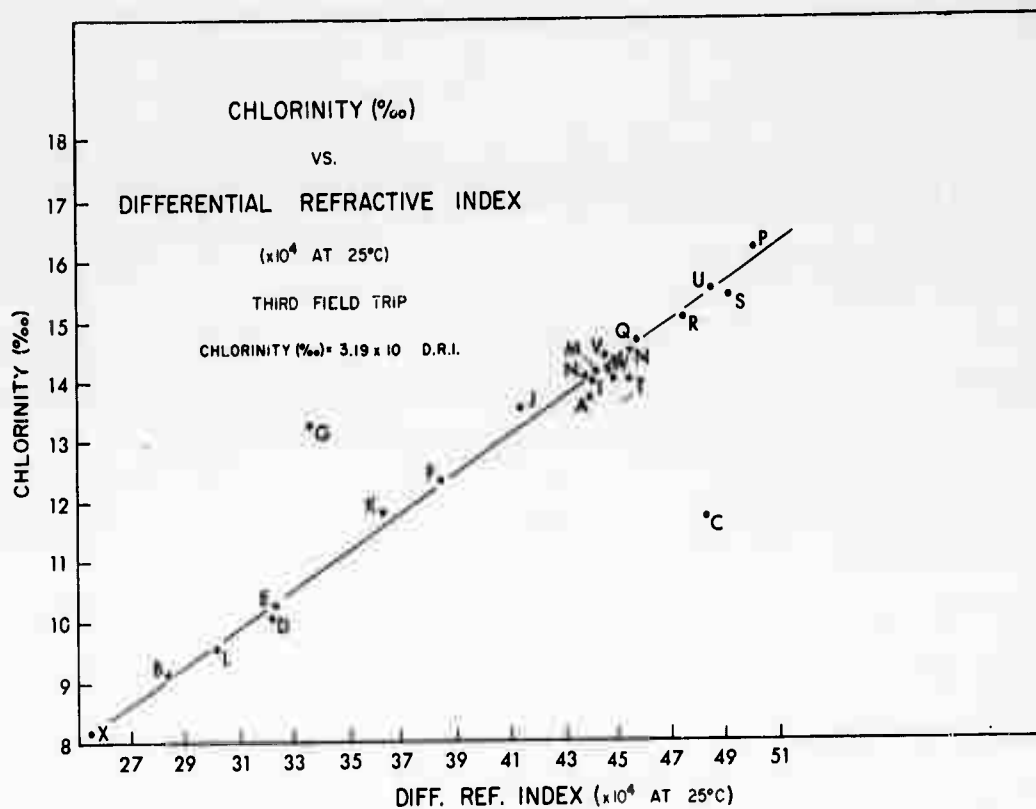


Figure 7

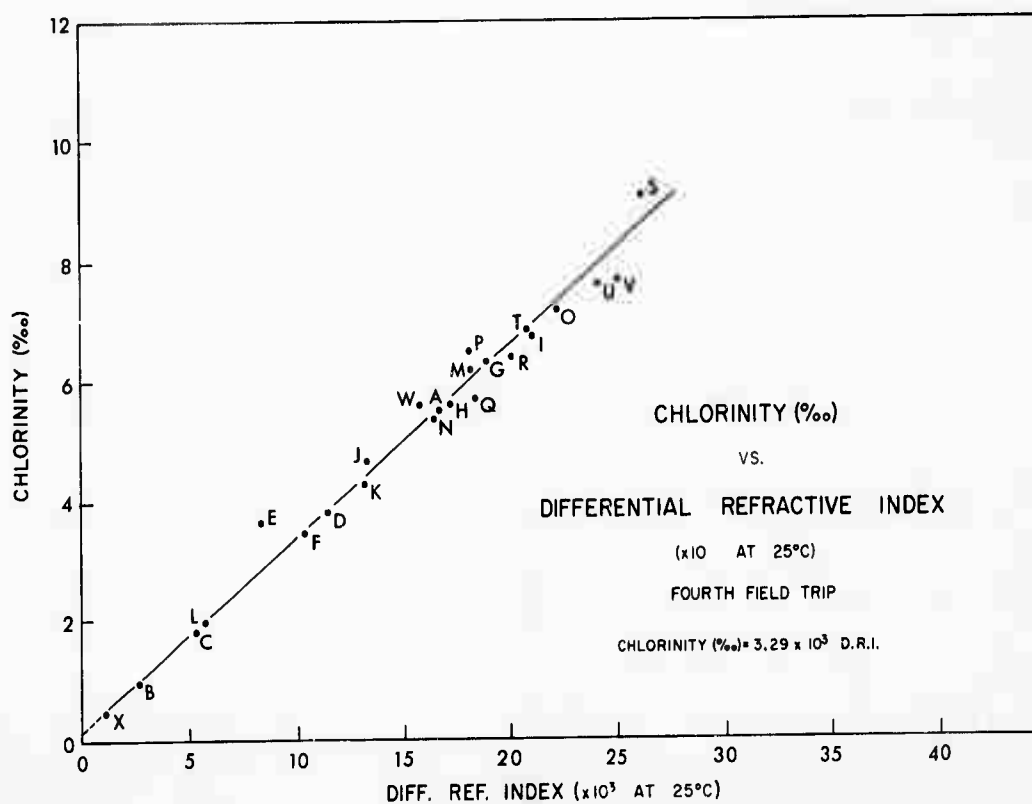


Figure 8

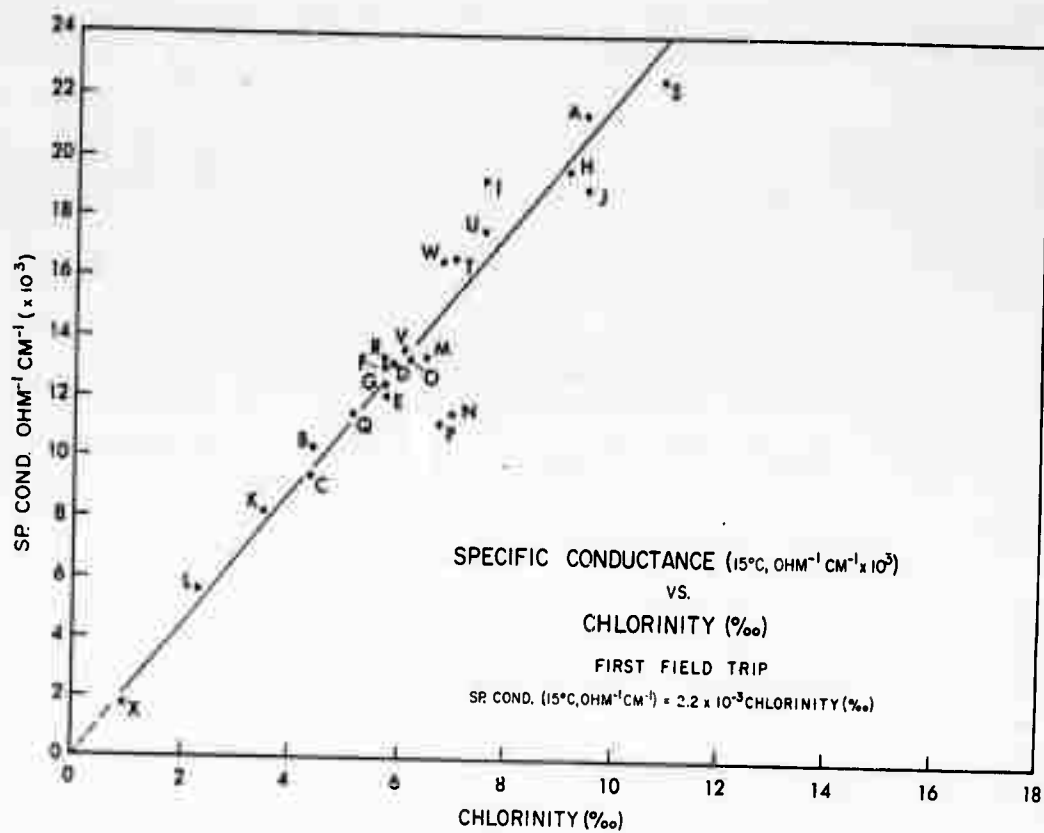


Figure 9

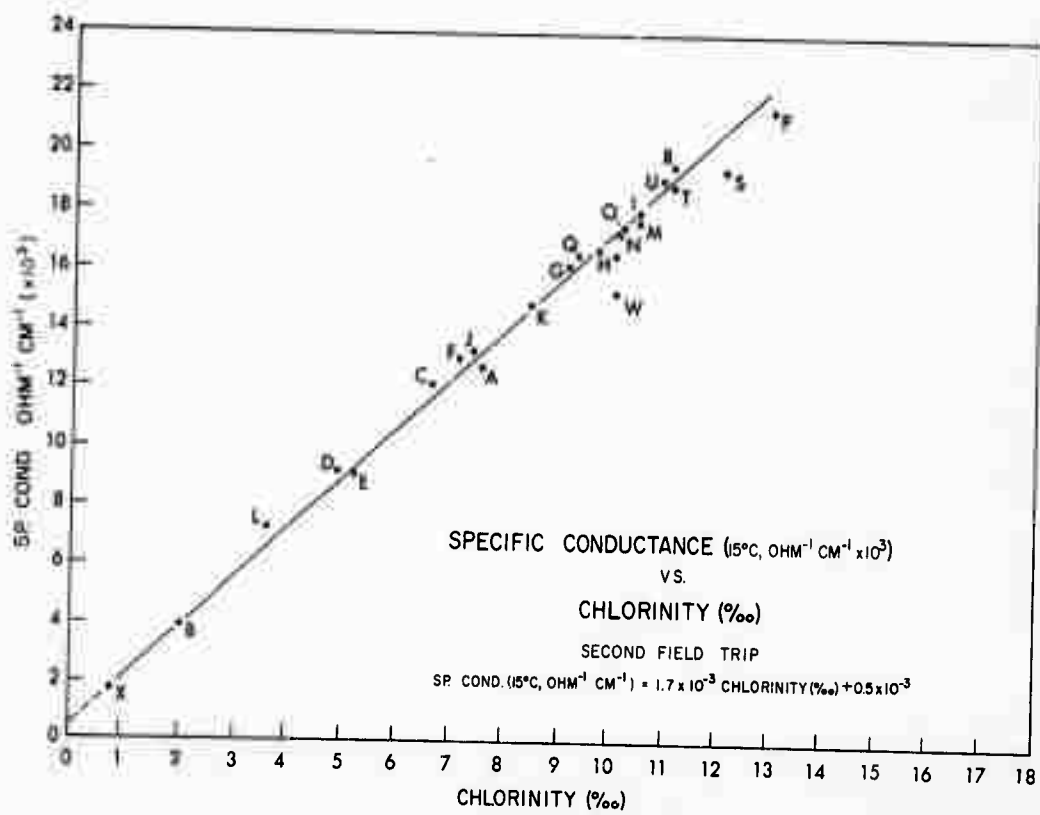


Figure 10

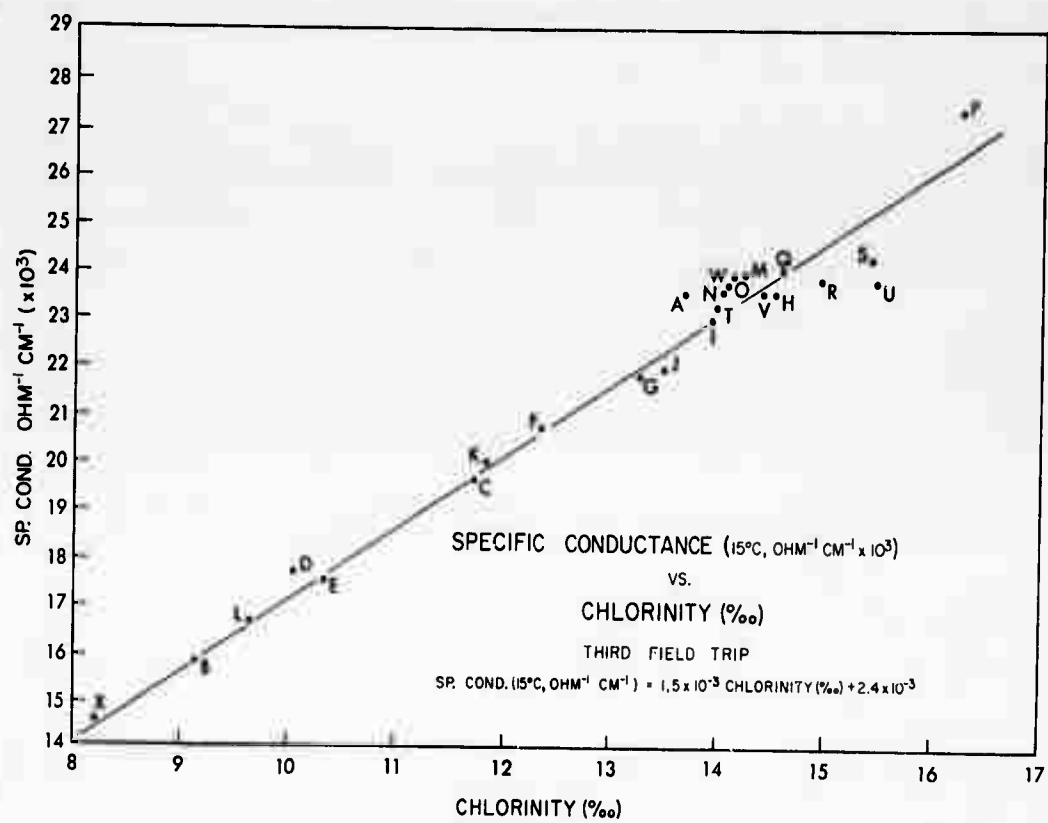


Figure 11

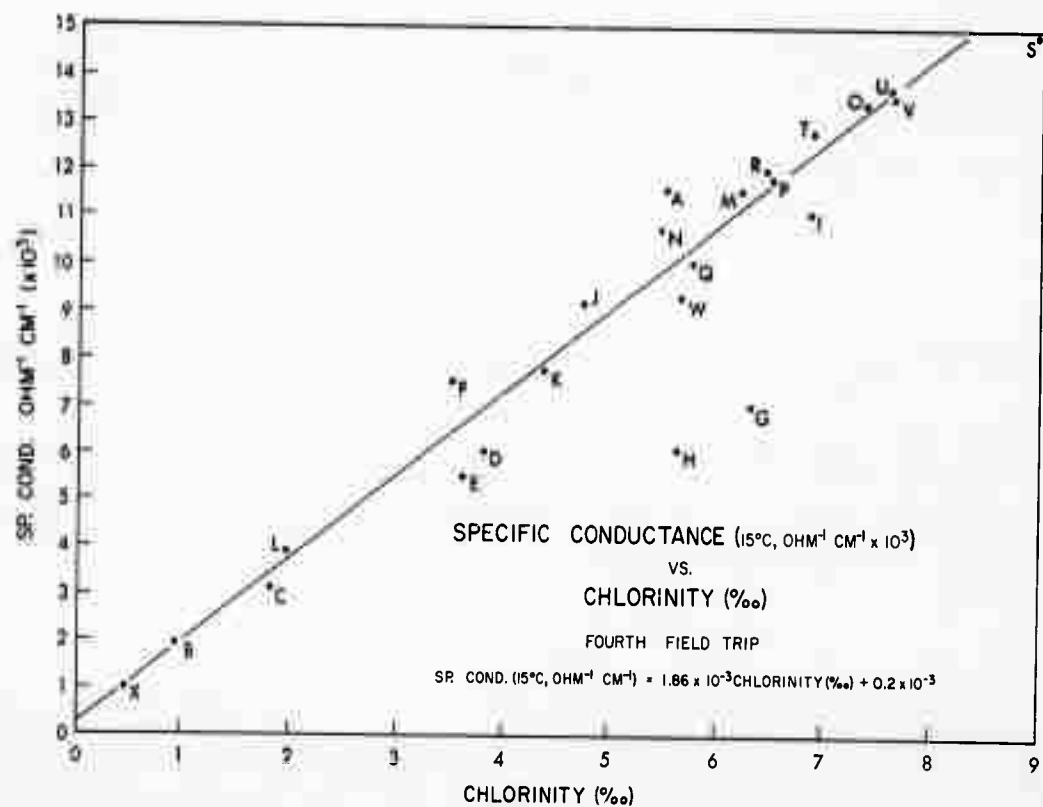


Figure 12

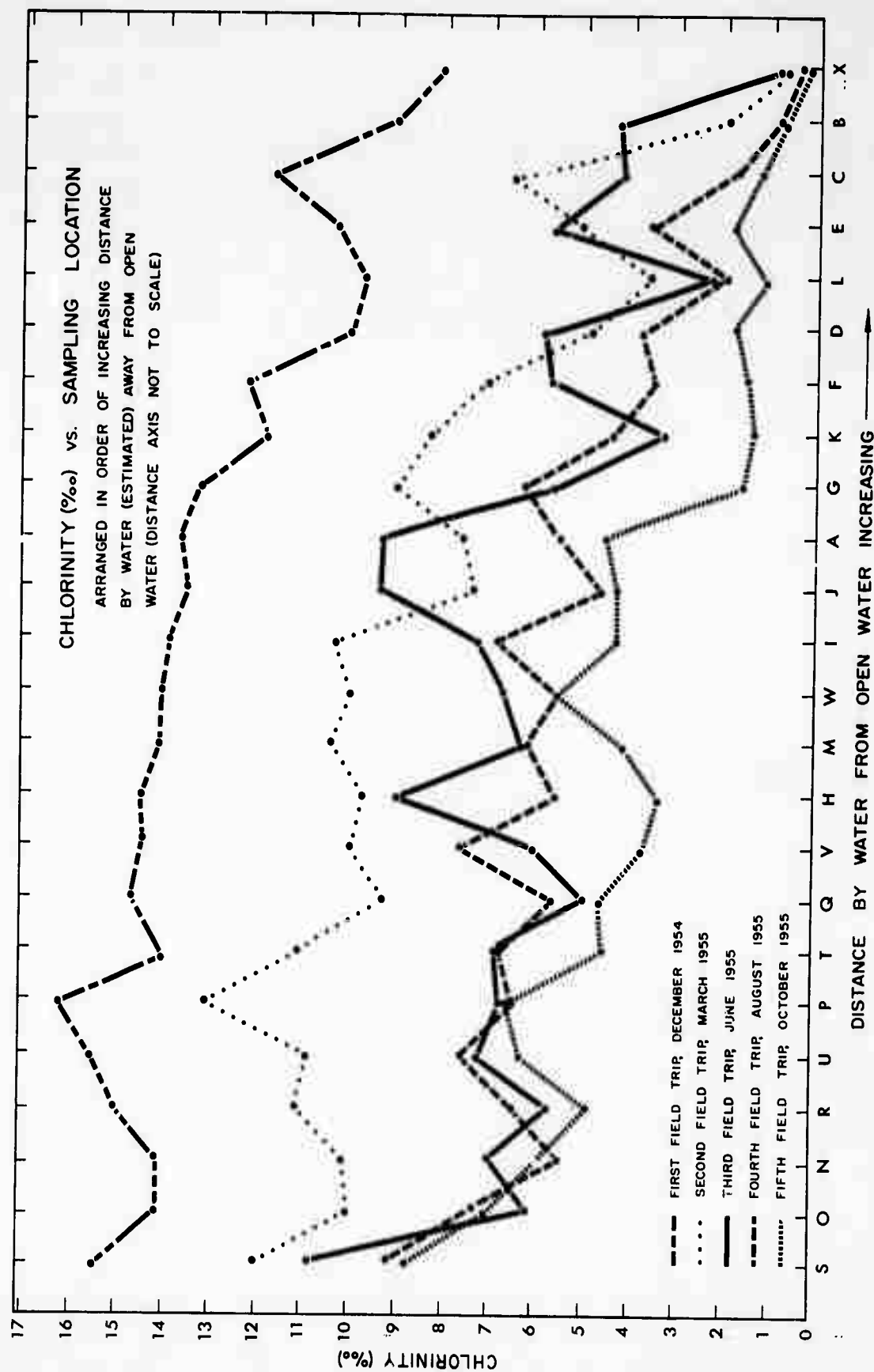


Figure 13

OBSERVATIONS AND CONCLUSIONS

For the most part, this summary has been a data report concerning some of the chemistry of the area under investigation. One calendar year was spanned with data taken at intervals of roughly two and one-half months. Except under the most unusual circumstances one should not anticipate significant variations from these data. The map of the area shows some heavy lines primarily in the north central area which indicate where levees have been constructed to dam off some of the smaller canals. If such construction continues it is possible that the drainage pattern and the ingress of sea-water may be altered sufficiently to affect the results of chemical measurements. We believe, however, that influences such as large dams, construction of new and large canals, or major storms will be required to alter significantly the year-round cycle of the chemistry of the area.

The results of pH determinations. On the first field trip liquid samples were brought in from the field and measurements made in the laboratory. On the second and third field trips measurements were made in the field at the time of sampling. On the fourth trip, samples were quick-frozen in the field with dry ice and measurements made later in the laboratory.

The specific gravity data will plot as a linear function of total solids for each field trip but with a considerable scattering of points. The curves were not included in this report because of the necessity of better than four figure significance if the data are going to be useful.

Differential refractive index data are listed and plotted versus total solids in figures 1 through 4 and versus chlorinity in figures 5 through 8. These are some of the most interesting and significant data which were taken. The total solids in ppm can be calculated from the differential refractive index at any time of the year over the entire area if the latter is multiplied by 6×10^6 . Our data show that this is possible within a certainty of 6% on 92 out of 96 samples.

The waters on the second field trip contained a considerable amount of suspended solids, and it was necessary to filter this water through sintered glass before determining the differential refractive index. The effect of filtration on these samples is seen by comparison of figures 2 and 3. Filtration of other field trip samples did not measurably change the differential refractive index, but it would seem that for safety all samples should be filtered in such a manner if one wished to rely on this method to determine total solids. One of the most striking and perhaps surprising features of the report is the relationship

between differential refractive index and chlorinity seen in figures 5 through 8. The slopes of these curves are 3.21×10^5 with 0.04 as the average deviation for four field trips. This means that the slopes of separate calibration curves would differ from their mean throughout the year by only 1.2%. The correlation between the two properties is sufficiently high that the maximum error in applying this method for the determination of chlorinity would have been 6% and the mean error less than 2% in 92 out of 96 samples.

It must be noted, however, that theoretically, these curves should not pass through the origin since there are substances other than chloride (NaCl) contributing to the differential refractive index. If one wishes, therefore, to determine the chlorinity from a measurement of the differential refractive index, the chlorinity at one location should be determined by chemical analysis and a curve with a slope of 3.21×10^3 drawn through this point with chlorinity in parts per thousand as the ordinate and differential refractive index as the abscissa. The measurements reported here were made with green light of 589 μ in wavelength. The slope of the curves discussed above would have been different with light of different wavelength.

In their book, The Oceans, Sverdrup, Johnson and Fleming discuss the relationships between chlorinity and refractive index and give a number of references to the literature. They emphasize the dependence of the refractive index on temperature which, of course, is true. We have successfully avoided this difficulty by using a differential refractometer and determining the difference between the refractive index of our sample and that of distilled water at the same temperature. This difference has a thermal coefficient which is well outside the sensitivity of the instrument being used, probably in the eighth or ninth decimal place, whereas we are determining the difference with a precision of about 2 in the sixth decimal place.

Index of refraction measurements have never found favorable use in the determination of chlorinities because of the necessity of very precise temperature control and because of instrumental limitations. The Abbe Refractometer is read with an uncertainty of 2 in the fourth decimal place, and in our situation this would have produced errors in chlorinity of approximately 10% even with very precise temperature control. The dipping refractometer is capable of precision an order of magnitude better than the Abbe. Although it cannot be read with the precision of the differential refractometer, it could have yielded satisfactory data in this work because of the magnitude of the refractive index values over most of the chlorinity range encountered. The technique required in the use of the dipping refractometer, however, is considerably more complicated and

temperature must be controlled with extreme care.

Our differential refractive index measurements were reported at 25°, which was the mean room temperature. No effort was made to keep the temperature constant. Probably fluctuations of two or three degrees occurred during any set of determinations, and greater variations than this took place between measurements made on different field trips.

We suggest that refractive index measurements made through the application of the differential refractometer constitute an excellent method for determining chlorinity. The technique is simple, rapid, and capable of high accuracy.

The absolute turbidity measurements so far have not produced information which has been very useful. It was hoped that these data could be related to the colloid content of the waters and that the total solids might be roughly partitioned between soluble electrolytes as measured by the specific conductivity and the colloids as reflected in the absolute turbidity. Possibly because of fluctuations in the nature of the colloidal substances and the small differences in turbidities this approach has not been successful, and therefore it has been abandoned.

The data on specific conductance were plotted versus chlorinity in figures 9, 10, 11, and 12. The slopes of the curves vary in numerical value from 1.5×10^{-3} to 2.2×10^{-3} which means that conducting species other than chloride ion alter the specific conductivity to an extent depending on physical conditions in the area at the time of measurement, and perhaps on other factors presently unknown, e.g., the production of considerable quantities of bleed water into the area from producing oil wells. This also means that one could not prepare a standard conductance curve for the determination of chloride in the area on one day and expect that at some later date it would apply with better than 20-30% accuracy. The second significant observation is that, from the spread of points on a particular specific conductivity versus chlorinity plot, e.g., figure 12, apparently some locations are already under variable influences which contribute or take away conducting species other than chlorides. Under these influences other electrolytes are in variable ratio to chloride ion. If one depended on a conductivity method for chloride on any single day, he might expect average errors in the order of 10 to 15%.

The total solids-chlorinity relationship was studied very carefully. It was found that the total solids differed among stations and among field trips, and further, that the percentage loss of these solids on ignition varied among field trips but was sensibly constant within a given trip.

The average percentage loss on ignition of the solids for each field trip was:

First trip.....	12.4%
Second trip.....	19.1%
Third trip.....	9.7%
Fourth trip.....	13.8%
Fifth trip.....	24.8%

These data show the reasonably homogeneous nature of the area and that the quality and quantity of volatile matter in these solids is subject to variation with the seasons or with wind, or with egress of fresh water and ingress of gulf water. The latter effects are probably most significant and are often directly associated with changes in seasons.

The section immediately following these conclusions reports on studies especially designed to learn more about the nature of the solids.

The chlorinities were presented in tabular form and are shown again in figure 13. This figure gives a plot of chlorinity versus increasing distance by water from open water. It is included to show the general decrease in chlorinity with distance and as a convenient comparison of the variation in chlorinity among field trips. We believe that most of the small peaks common to all these curves show the effect of excess saline bleed water being dumped by producing oil wells in the vicinity of the sampling location.

The ratios of chlorinities to total solids after ignition were tabulated. After each numerical value there appeared a +, -, or o. A plus sign indicates that the value of the ratio was above the average value for all stations in the gross area for a given field trip; a minus sign indicates that the value was below the average for that field trip. An asterisk designates values not included in the calculation of the average for a given field trip. Out of a total of 120 determinations only five were excluded from consideration in determining the average value of the ratio of chlorinity to total solids for their respective field trips.

After observing that a certain station was positive or negative on the first field trip it became obvious that one should inquire as to whether that particular station consistently had this sign ascribed to it. When the values of this ratio were carefully determined for twenty-four stations on five field trips it appeared that the geographical area of the investigation could be roughly divided into a northern area where there existed a predominance of "positive" locations and a southern area in which the locations were predominantly "negative." The

dividing line is shown on the map as a curved dotted line running east and west approximately through the mid-point of the gross area. The northern area produced 43 determinations of positive stations, 14 determinations of negative stations, and 3 zero stations. The southern area produced 11 determinations of positive stations, 46 determinations of negative stations and 3 zero stations.

The average value of the ratio of chlorinity to total solids after ignition and the respective mean deviation for each field trip are shown below.

First trip.....	0.607 ± 0.016
Second trip.....	0.595 ± 0.011
Third trip.....	0.590 ± 0.005
Fourth trip.....	0.606 ± 0.014
Fifth trip.....	0.601 ± 0.005

It is of particular interest to observe that the value of the ratio of chloride to sodium chloride is 0.607 which indicates that our ignited solids are almost pure sodium chloride.

We believe that the "areas" defined above have real geochemical significance and that the line dividing them may indicate essentially the lower fringe of precipitation, principally by the polyvalent ions of the gulf water, of colloidal and surface active materials carried down by fresh water. As sea water from the Gulf of Mexico moves northward in the area, the ratio of chloride to total solids (ignited) will be lower than in an area where many of the heavier non-volatile polyvalent ions have been removed by encounter with clays and other possible colloidal substances. When sufficient combination between these types of substances has occurred, precipitation of the colloidal matter will take place with a consequent decrease in the total solids in the waters and an associated "positive" chloride to total solids ratio.

The above speculations demand more research along these lines than has been possible within the total scope of our investigations.

Salinities were calculated from the chlorinities for the convenience of the reader and were tabulated.

Both sulfate and other oxidizable forms of sulfur were determined in the waters, and the results presented; however, no correlations or interpretations based on these data seemed possible.

Alkalinities and total hardness were determined on the third and fourth field trips and tabulated. The data

available thus far indicate that no single location would be "most desirable" as a source for industrial water; however, locations C, D, E and F show promise of yielding water which would require the least treatment for industrial use.

The dissolved oxygen and biological oxygen demand data are reliable and desirable to have in a general chemical investigation of such an area. We have not succeeded, however, in correlating these data with any other measured property in the area. Subsequent work will produce a measure of the dissolved hydrogen sulfide in the waters, and it is anticipated that the biological oxygen demand may be related to the hydrogen sulfide content.

Sulfate, sulfide, free sulfur, and total sulfur were estimated in the sediments at each location and expressed in this report as weight percent of dried mud. Although considerable effort went into this phase of the work, and several methods of determination were explored, we are satisfied with the sulfide data only. Work on the general problem of establishing the partition ratios of sulfur in its various forms in these sediments is continuing in our laboratories. Further elaboration on this problem will be found in the appendix of the report.

CHEMICAL INVESTIGATION FROM FOUR SELECTED STATIONS

Preliminary studies showed the existence of excessively large amounts of solids for which no accounting could be made and strongly indicated the necessity for an investigation to characterize the dissolved solids more completely than was practical in the incomplete field surveys. The more specific knowledge gained in such an investigation should be useful in selecting methods used in general surveys and in developing correlations of a more specific nature than is possible by more general studies.

Stations S, W, I, and X were selected for this study because they are well distributed geographically, exhibit some diversity in their types of water flow, and include stations giving a wide range in total solids.

Determinations were made of pH, temperature, specific gravity, differential refractive index, turbidity, surface tension, types of cations, types of anions, types of organic material, total solids, loss of ignition, fixed residue, sodium, potassium, calcium, magnesium, iron, chloride, sulfate, and nitrate.

The correlation and interpretation of these data should prove valuable in the characterization of the waters and muds in the area under investigation.

SUMMARY OF RESULTS

Station	S	W	I	X
$\Delta n \times 10^4$	48.17	43.42	41.72	22.67
Absolute turbidity $\times 10^4$	1.45	1.67	1.39	1.79
Specific gravity (lab.)	1.021	1.019	1.018	1.011
Specific gravity (field)	1.020	1.019	1.014	1.009
Surface tension (dynes/cm.)	72.88	73.16	73.22	72.70
pH (lab.)	7.89	7.71	7.83	7.70
pH (field)	8.00	7.61	7.79	7.18
Total solids (ppm.)	29,800	27,120	26,170	14,600
Loss on ignition (ppm.)	5,026	3,822	3,716	2,990
Fixed residue (ppm.)	24,770	23,300	22,460	11,610
Sodium (ppm.)	7,904	7,308	6,908	3,712
Magnesium (ppm.)	763	673	723	395
Calcium (ppm.)	354	360	354	212
Potassium (ppm.)	224	228	212	116
Iron (ppm.)	< 1	< 1	< 1	< 1
Copper	trace	trace	trace	trace
Silver	trace	trace	trace	trace
Lead	trace	trace	trace	trace
Lithium	trace	trace	trace	trace
Strontium	trace	trace	trace	trace
Chloride (ppm.)	16,260	14,780	14,230	7,858
Sulfate (ppm.)	1,952	1,669	1,527	820
Nitrate (ppm.)	2	2	1	1
Total cations found (ppm.)	9,250	8,570	8,200	4,440
Total anions found (ppm.)	18,210	16,450	15,760	8,680
Total solids found* (ppm.)	24,460	25,020	23,960	13,120

*Total solids found does not include water of hydration present at 103° C. This figure is the sum of the total cations found and total anions found which sum appears to be very close to 90% of the total solids over all the sampling area.

COLLECTION AND HANDLING OF SAMPLES

Water samples for analysis were collected over a depth range of two to four feet, using a Foerst Water Sampler. These samples were then placed directly into polyethylene bottles and frozen by packing them with dry ice in an insulated container. The frozen samples were transferred to a freezer upon return to the University and were not thawed until they were used for analysis. In this way it was attempted to minimize changes in the samples resulting from bacterial action. At the time of sampling the pH, temperature, and specific gravity of the waters were measured and the field conditions were recorded. Conditions of sampling and data collected in the field are presented in the following table:

FIELD DATA AND CONDITIONS

Station S

Date:	June 11, 1955	Depth of water:	14 1/2 ft.
Time:	1212	Depth of sampling:	3 ft.
Temp. °F:	78.0	Current:	Slight easterly
pH:	8.00	Wind:	West, 8 mph
Specific gravity:	1.020	Tide:	Rising

Station W

Date:	June 11, 1955	Depth of water:	8 1/2 ft.
Time:	1120	Depth of sampling:	3 ft.
Temp. °F:	75.0	Current:	Slight easterly
pH:	7.61	Wind:	West, 8 mph.
Specific gravity:	1.019	Tide:	High, 6 in. above normal

Station I

Date:	June 11, 1955	Depth of water:	10 1/2 ft.
Time:	1533	Depth of sampling:	3 ft.
Temp. °F:	78.3	Current:	Slight southerly
pH:	7.79	Wind:	Northwest, 10 mph.
Specific gravity:	1.014	Tide:	High, 6 in. above normal

Station X

Date:	June 11, 1955	Depth of water:	8 1/2 ft.
Time:	1000	Depth of sampling:	3 ft.
Temp. °F:	77.9	Current:	Standstill
pH:	7.18	Wind:	West northwest, 15 mph.
Specific gravity:	1.009	Tide:	High, slightly above normal

PHYSICAL MEASUREMENTS

Differential refractive indices, n , that is, the differences between the refractive indices of the samples and that of water, were determined using green light of wave length 547 millimicrons. A Brice-Phoenix Differential Refractometer manufactured by the Phoenix Instrument Company, Philadelphia, Pennsylvania, was used for the measurements. Each sample was passed through a bronze 300 mesh sieve in order to remove coarse suspended material.

<u>Station</u>	<u>$\Delta n \times 10^4$</u>
S	48.17
W	43.42
I	41.72
X	22.67

After they were passed through the sieve, a second portion of each sample was centrifuged at 10,000 rpm. for two hours. Their differential refractive indices were then determined in the same manner as above.

<u>Station</u>	<u>$\Delta n \times 10^4$</u>
S	48.30
W	43.55
I	42.05
X	22.88

A Beckman Model G pH meter was used for the measurement of pH.

<u>Station</u>	<u>pH</u>
S	7.89
W	7.71
I	7.83
X	7.70

Specific gravities were measured by a chain gravimeter. The temperature for the measurements was 23.8° C.

<u>Station</u>	<u>Specific gravity</u>
S	1.020
W	1.019
I	1.018
X	1.011

Surface tensions were measured at 23.8° C. by the capillary rise method. These were calculated in c.g.s units of dynes per centimeter.

<u>Station</u>	<u>Surface tension</u>
S	72.88
W	73.16
I	73.22
X	72.70

Absolute turbidities were determined using green light of wavelength 547 millimicrons. A B-S Light Scattering Photometer manufactured by the Phoenix Precision Instrument Company was used for the measurements. Each sample was passed through a bronze sieve in order to remove suspended material.

<u>Station</u>	<u>Absolute turbidity x 10⁴</u>
S	1.45
W	1.67
I	1.39
X	1.79

QUALITATIVE ANALYSIS

Spectrographic techniques were used for the detection of cations because the cation concentrations in the samples were, in general, too small to apply standard wet qualitative tests. Littrow spectrograph with quartz optics, manufactured by Bausch and Lomb Optical Company, Rochester, N. Y., was used with Eastman Kodak Spectroscopic Plates, Type I-L. Water samples were evaporated to dryness, mud samples were freeze-dried, and in both cases the solid material obtained was placed in drilled National Spectroscopic Carbon Electrodes. Spectra of the samples were compared to reference spectra of Raies Ultimes powder developed at the Research Laboratories of the General Electric Company Ltd., England. Wavelengths of the lines identified were obtained from the Handbook of Chemistry and Physics, 33rd Edition, Chemical Rubber Publishing Company. Two characteristic lines were considered necessary for positive identification of an element. The lines and elements identified are listed in a table at the end of this section. The spectra are reproduced on Plates I, II, and III.

Qualitative anion analyses were made with spot tests found in Corrections, Addenda, and Suggestions for Qualitative Analysis and Analytical Chemical Separations, by Dr. Philip W. West and on the basis of communication from the latter. Chloride was indicated by a white turbidity which developed upon the addition of silver nitrate to a sample acidified with nitric acid. Sulfate was indicated by a white turbidity which developed upon the addition of barium nitrate to a sample acidified with nitric acid. The sensitivity of this test is low compared to the usual

spot test. It was necessary for this reason to concentrate the sample by evaporation. Spot tests for chromate, fluoride, ferricyanide, ferrocyanide, iodide, molybdate, nitrate, nitrite, thiocyanate, and tungstate were negative. The presence of nitrate was later confirmed and quantitatively determined by the use of a strychnidine reagent. This test will be discussed in a later section on quantitative analysis. The presence of carbonate is usually shown by the evolution of carbon dioxide gas when the sample is treated with dilute acid. This test when applied to a sample of water and to the residue after evaporation gave negative results. These tests were applied to samples S, W, I, and X.

An attempt was made to characterize the organic material present by the investigation of samples from stations S, W, I, and X after concentration by evaporation of a large part of the water from the solution. The Molisch test was used for carbohydrates, sulfosalicylic acid for proteins, 2, 4-dinitrophenylhydrazine for carbonyl groups, ceric nitrate for alcohols, a bromine in carbon tetrachloride solution for olefinic linkages, and a saturated sodium bisulfite solution for aldehydes and methyl ketones. When applied to the concentrated sample, all of these tests were negative. It was concluded that if such material was present, the concentration of organic matter was below the sensitivity limit of the tests employed.

A series of extractions were conducted. Samples from each station were evaporated to dryness and the residue was extracted with absolute alcohol. The extract was then evaporated and the extracted material was investigated. It consisted mostly of salts and had a salty taste. It gave a negative Molisch test and a negative hydroxylamine hydrochloride test for aldehydes and ketones. An infrared spectrum was obtained from a mull of this material, and will be discussed later.

A sample from each station was extracted with carbon tetrachloride and the extract evaporated. The material gave negative results when subjected to the Molisch, hydroxylamine hydrochloride, 2, 4-dinitrophenylhydrazine, and sulfosalicylic acid tests. An infrared spectrum obtained from this material will be discussed later.

A sample from each station was extracted with benzene. After the water and benzene phases had been in contact for several days an emulsion was formed in each case, the stability of which increased with decreasing salt concentration of the sample, that is, as the location of the sampling station moved progressively inland. This effect was attributed to the presence of surface active agents

which were salted out as the salt concentration increased, thus resulting in a higher concentration of surface active material in the more inland samples. The benzene extract was separated by adding salt to decrease emulsification and finally drying the separated material with calcium chloride. When a portion of the extract was evaporated to dryness no usable quantity of material was obtained.

Preliminary to spectroscopic investigation for organic matter the water samples from the stations were passed through a bronze 300 mesh sieve. The ultraviolet absorption spectra were obtained with a Beckman DK Spectrophotometer manufactured by the Beckman Instrument Company. A slight decrease in the transmission of light was noted in the ultraviolet, but there was no appreciable structure to the spectrum. The ultraviolet absorption spectra of the alcohol extracts from the solids were determined also. These spectra resembled those of the water samples closely. There was a slight decrease in light transmission but no appreciable structure. The decrease in light transmission might be caused by scattering of light by the solutions. The solids from the carbon tetrachloride extraction were put into solution in methyl cyclohexane and the absorption spectra were obtained. In this case no decrease in light transmission was encountered.

Infrared spectra were determined on the solids left upon evaporation of the alcohol and carbon tetrachloride extracts. The spectra were determined on a Perkin-Elmer Model 21 Infrared Spectrometer manufactured by the Perkin-Elmer Corporation, Norwalk, Connecticut, using a mull technique. The spectrum from the alcohol extract shows no significant absorptions. The spectrum from the carbon tetrachloride extract shows two broad absorptions, one exhibiting double maxima at 9.2 and 9.8 microns, the other a single peak at 12.5 microns. These are probably caused by aromatics. Three weak absorptions, at 3.0, 6.0, and 7.9 microns are present and may arise from amine, carboxylic acid, or hydroxyl groups. The results of the spectroscopic examination for organic material are suggestive, but not conclusive.

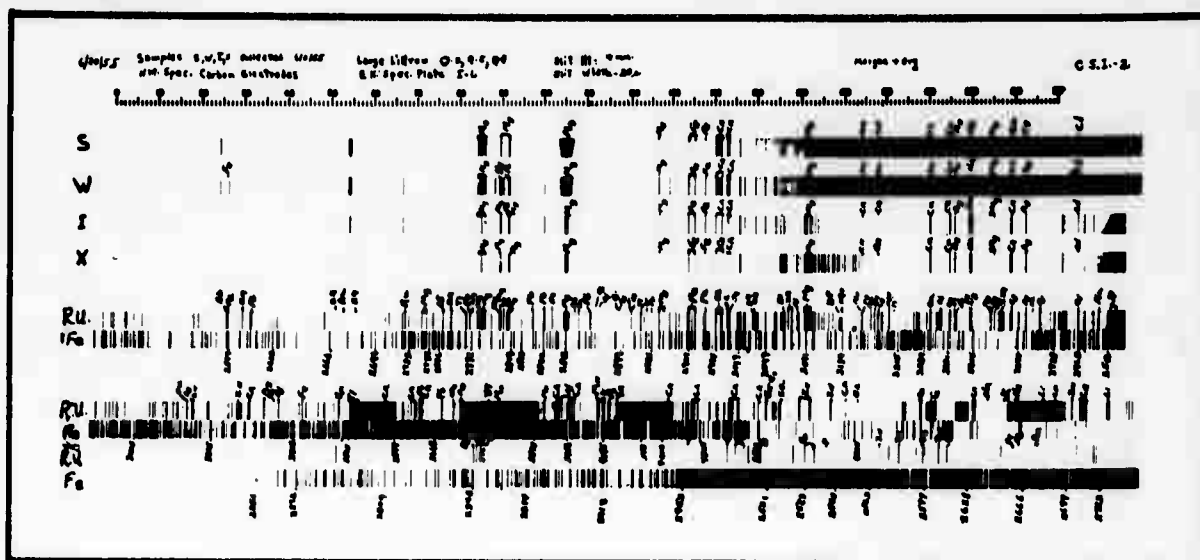
SPECTROGRAPHIC ANALYSIS OF WATER SAMPLES

<u>Element</u>	<u>Wavelength of line (Å)</u>	<u>Element</u>	<u>Wavelength of line (Å)</u>
Calcium	2994.96	Magnesium	2776.69
	2997.31		2778.29
	2999.64		2779.83
	3000.86		2781.42
	3006.86		2782.97
	3009.20		2795.53
	3158.87		2802.69
	3179.33		2852.13
	3361.92		2936.54
	3630.75		3091.08
	3644.41		3092.99
	3933.67		3096.90
	3968.47		3329.93
	4226.73		3332.15
	4298.99		3336.68
	4302.53		
	4307.74	Sodium	3302.32
	4318.65		5688.22
	4425.44		5889.93
	4434.96		5895.93
	4454.78		
	4526.98	Potassium	4044.14
	4878.13		4047.20
	5270.27		5801.96
	5598.47		5832.09
	6162.17		
	6493.78	Strontium	4077.71
			4607.34
Lithium	6103.64		
	6707.84	Copper	3247.58
			3273.96
Silver	3280.68		
	3382.89	Lead	3639.58
			3683.47
Iron	2598.37		
	2966.90		
	2973.24		
	2983.57		
	3440.61		

SPECTROGRAPHIC ANALYSIS OF MUD SAMPLES

<u>Element</u>	<u>Wavelength of line (Å)</u>
Calcium	2994.96
	2999.64
	3000.86
	3006.86
	3630.75
	3644.41
	3933.67
	3968.47
	4226.73
	4298.99
	4318.65
Magnesium	2795.53
	2802.69
	2852.13
	2936.54
	3092.99
Sodium	3302.32
	5889.93
	5895.93
Potassium	4044.14
Copper	3247.54
	3273.96
Iron	2598.37
	2966.90
	2973.24
	2983.57
	3440.61
Aluminum	3082.15
	3944.03
	3961.53
Maganese	4030.75
	4033.07
	4034.49
Zinc	2800.87
	3072.06
Silicon	2881.58

Plate I



QUANTITATIVE ANALYSIS

Procedures used for the quantitative determinations, except that for nitrate, may be found in detail in Standard Methods for the Examination of Water and Sewage, American Public Health Association. Those procedures which seemed to apply most directly to these waters were selected.

Total solids, loss on ignition, and fixed residue

Fifty milliliters of each unfiltered sample were evaporated to dryness and dried at 103° C. They were dried over-night and weighed to find the amount of total solids.

<u>Station</u>	<u>Total solids (ppm.)</u>
S	29,800
W	27,120
I	26,170
X	14,600

The residue from the determination of total solids was ignited in a muffle furnace at 600° C. for fifteen minutes and weighed. The loss on ignition was calculated in parts per million.

<u>Station</u>	<u>Loss on ignition (ppm.)</u>
S	5,026
W	3,822
I	3,716
X	2,990

The difference between the total solids and loss on ignition is termed the fixed residue.

<u>Station</u>	<u>Fixed residue (ppm.)</u>
S	24,770
W	23,300
I	22,460
X	11,610

Iron

The determination of iron depends upon the color which is developed upon the addition of thiocyanate to an iron solution. Four hundred milliliters of each sample were treated with 3 milliliters of concentrated nitric acid and a few drops of N/5 potassium permanganate and concentrated to about fifty milliliters to remove organic matter and insure the development of the proper color. The iron was precipitated with a slight excess of ammonium hydroxide, filtered, and dissolved in five milliliters of concentrated hydrochloric acid. Color comparisons were made to standards in fifty milliliter Nessler tubes. All samples contained

less than one part per million iron. This amount of iron makes an insignificant contribution to the total solids present.

Silica, calcium, and magnesium

Silica was determined by the loss in weight when silica was volatilized with concentrated sulfuric acid and hydrofluoric acid after the samples were evaporated to dryness. Twenty-five milliliter samples showed no silica present. The determinations were repeated with 200 milliliter samples with negative results. The filtrate from the determination of silica was oxidized with nitric acid and concentrated by evaporation. Treatment of the concentrated solution with ammonium hydroxide yielded no precipitate which indicated that no aluminum, iron or phosphate was present in amounts sufficient for determination. Calcium was then precipitated from the hot ammoniacal solution with a saturated solution of ammonium oxalate. The calcium oxalate was filtered, washed, ignited, and weighed as calcium oxide.

<u>Station</u>	<u>Calcium (ppm.)</u>
S	354
W	360
I	354
X	212

The filtrate from the determination of calcium was acidified and concentrated. The magnesium was precipitated with sodium ammonium phosphate, ignited, and weighed as magnesium pyrophosphate.

<u>Station</u>	<u>Magnesium (ppm.)</u>
S	763
W	673
I	723
X	395

Sodium and potassium

Samples were treated with barium chloride to precipitate the sulfate present. The barium sulfate was later used for the determination of sulfate. Treatment of the samples with barium hydroxide, ammonium hydroxide, and ammonium carbonate removed other metal ions and left the mixed chlorides of sodium and potassium in solution. The solution was evaporated, and the residue was ignited, cooled, and weighed. The mixed chlorides were converted to the mixed perchlorates by the addition of 70% C.P. perchloric acid followed by evaporation to dryness. Sodium perchlorate was separated from the potassium perchlorate by extraction with absolute alcohol. The potassium perchlorate was filtered, washed with absolute

alcohol, dried, and weighed. The potassium chloride equivalent of potassium perchlorate was subtracted from the weight of the mixed chlorides. The weights of sodium and potassium chlorides were converted to parts per million of sodium and potassium.

<u>Station</u>	<u>Sodium (ppm.)</u>
S	7,904
W	7,308
I	6,908
X	3,712

<u>Station</u>	<u>Potassium (ppm.)</u>
S	224
W	228
I	212
X	116

Sulfate

Sulfate obtained by precipitation as barium sulfate in the above procedure was ignited and weighed.

<u>Station</u>	<u>Sulfate (ppm.)</u>
S	1,952
W	1,669
I	1,527
X	820

Chloride

Chloride was precipitated from ten milliliter samples by the addition of excess silver nitrate, followed by titration of the excess silver ions by thiocyanate using a ferric ion solution as indicator. The thiocyanate solution was standardized against a 0.1000 N silver nitrate solution.

<u>Station</u>	<u>Chloride (ppm.)</u>
S	16,260
W	14,780
I	14,230
X	7,858

Nitrate

Nitrate was determined by a photometric method described by B. M. G. Zwicker and R. J. Robinson, Sears Foundation: Journal of Marine Research, Vol. V, No. 3, 214-232. The method involves measurement of the intensity of color produced by adding a strychnidine reagent to a nitrate solution. A reference curve of optical density versus concentration was constructed by using nitrate solutions of known concentrations and the nitrate

concentrations of the water samples were obtained by comparison to this reference curve.

<u>Station</u>	<u>Nitrate (ppm.)</u>
S	2
W	2
I	1
X	1

COMPARISONS WITH SEA WATER

Because of the estuarine nature of these waters, a table was compiled comparing the samples with sea water. The table does not include dissolved gases. The values for sea water were obtained from The Oceans, Sverdrup, Johnson, and Fleming, Prentice-Hall.

<u>Ion (ppm.)</u>	<u>Sea Water</u>	<u>S</u>	<u>W</u>	<u>I</u>	<u>X</u>
Chloride	18,980	16,260	14,780	14,230	7,858
Sulfate	2,649	1,952	1,669	1,527	820
Nitrate	.05-3.0	2	2	1	1
Sodium	10,556	7,904	7,308	6,908	3,712
Potassium	380	224	228	212	116
Magnesium	1,272	763	673	723	395
Calcium	400	354	360	354	212
Iron	.002- .02	< 1	< 1	< 1	< 1
Copper	.001- .01	trace	trace	trace	trace
Lead	.004	trace	trace	trace	trace
Lithium	.01	trace	trace	trace	trace
Strontium	13	trace	trace	trace	trace
Silver	.0003	trace	trace	trace	trace

CONCLUSIONS

The extremely small change in the differential refractive indices resulting from centrifugation of the samples indicates the presence of only extremely small amounts of large suspended particles. Differences in the field and

laboratory values of pH may be attributed chiefly to slight bacterial action during the time between these measurements. Differences in the field and laboratory values of specific gravity are probably caused by temperature differences, bacterial action, or more probably the greater accuracy of measurements possible in the laboratory. No conclusions can be drawn regarding surface active agents from the surface tension values because they differ only slightly from that of distilled water.

Stations S, W, I, and X appear to differ in dissolved solids only quantitatively. Muds and the waters above them differ qualitatively in the following manner. Strontium, lithium, and silver are found in the water, but not in the muds. Aluminum, manganese, zinc, and silicon are found in the muds, but not in the waters. In all stations the organic content appears to be extremely small. Impractically large volumes of samples would be required to completely characterize the organic matter present.

From 90 to 92 per cent of the solids were accounted for as sodium, potassium, magnesium, calcium, chloride, and sulfate. A large part of the material unaccounted for is water of hydration at 103° C. If all the calcium is assumed to be present in the solid as calcium sulfate, and the remaining sulfate present as the magnesium sulfate, the water of hydration of these salts at 103° C. accounts for half of the deficit in total solids. The remaining unknown material consists of other water of hydration, trace elements, and organic material. The reported loss on ignition includes water of hydration, volatile salts, carbonate if present, and organic material. There appears to be some deviation from electrical neutrality in the reported results. However, any lithium present is determined as sodium, and bromide and iodide are determined as chloride. This causes an apparent decrease in positive charge and an apparent increase in negative charge. Trace cations can also contribute to the unbalance of charge.

A number of correlations were drawn based on total solids, specific gravity, and differential refractive index which could serve as indirect determinations of total cations, total anions, sodium, and chloride. The specific gravity values used were those determined in the laboratory. Excellent linear relationships result when differential refractive index is plotted versus each of the following: total solids, specific gravity, sodium, chloride, total cations, and total anions. Good linear relationships can be observed if specific gravity is plotted versus each of the following: total solids, sodium, chloride, total cations, and total anions. Excellent linear relationships exist between total solids and each of the following:

sodium, chloride, total cations, and total anions. Since these relationships are based on only four stations, their applicability to the complete area is not yet confirmed.

APPENDIX

The following determinations were made on the water samples collected from each of the twenty-four sampling locations: hydrogen ion activity (pH), temperature, specific gravity, specific conductance, absolute turbidity, differential refractive index, total solids, chlorinity, dissolved oxygen, biological oxygen demand, sulfates, and other oxidizable forms of sulfur. The only determination made on the bottom muds collected at the same sampling locations was sulfur in its various oxidation states.

SAMPLE COLLECTION AND HANDLING

Since the water depths at the various sampling locations varied from two to twenty feet, a relatively constant sampling depth, two to four feet, was employed. A Foerst Water Sampler was utilized to collect the samples. Bottles for dissolved oxygen analysis and biological oxygen demand determinations were filled directly from the sampler. Generally two samples were collected at each station for further laboratory investigation. These samples were placed in 32 oz. polyethylene bottles; one sample was treated with 3 ml. of chloroform and the other was untreated. Mud samples were collected with an Eckman dredge, and a representative sample was placed in a 4 oz. screw cap polyethylene bottle. The samples were returned to the laboratory and stored until analyzed.

In the initial survey, four field trips were necessary to collect samples from all twenty-four sampling locations.

Unlike many chemical studies, this investigation has many associated problems which are not immediately evident. For example - the concentration of many of the possible constituents in the water and mud samples may be altered to such an extent by biological activity or changes in physical conditions during the interim between collection and analysis that the results could be impossible to evaluate.

There are essentially two ways of resolving this problem: (1) perform the analyses in the field as quickly after sampling as possible, and (2) preserve the samples in such a manner as to prevent or decrease the biological activity. The first method is impractical without a fully equipped and staffed field laboratory. Even then, the time required to perform all the analyses would extend the total

survey time to such an extent that the samples probably would not be comparable.

The second method has limited application since the ideal preservative is not known. In general the addition of any chemical agent to waters of such complexed composition may produce many changes that cannot be evaluated.

It is therefore suggested that a combination of the two methods be employed. Determinations such as dissolved oxygen, hydrogen ion activity and oxidation-reduction potential which are directly dependent upon the "field state" of the system should be made in the field. Samples for the determination of constituents which may be altered by biochemical activity should be quick frozen immediately after collection, and returned to the laboratory and stored in the frozen state until analyzed. Quick freezing will not destroy or completely stop all biochemical activity, but it will reduce it to such an extent that analyses made on samples a reasonable time after collection should give far more reliable results.

It is also suggested that the samples for a single survey be collected in the shortest feasible time period, e.g., a single two or three day field trip.

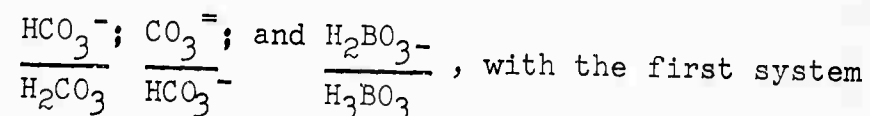
These improved procedures suggested above were carried out during the second and subsequent field surveys.

PHYSICAL MEASUREMENTS

Hydrogen Ion Activity (pH) - The pH of the water samples was determined with a Beckman Model N-2 pH meter equipped with a Beckman all-purpose glass electrode and a Beckman No. 4970 calomel reference electrode. The meter was standardized frequently with buffer solution, pH-7.00. A 50 ml. portion of the water sample collected with the Foerst Sampler was placed in a beaker, the electrodes inserted, the meter adjusted for the temperature of the water and the indicated pH was recorded.

The measured pH values in the first field survey varied from 7.19 to 8.31. In general, the values fell within the expected range.

Marine and brackish waters are buffered by the following systems:



accounting for most of the buffer action in the usual pH range of these waters. The more alkaline pH values are found in surface waters where the dissolved CO_2 may escape into the atmosphere, and its concentration is at a minimum. In deeper waters, below the euphotic zone, where the dissolved oxygen has been completely utilized, the CO_2 content is at a maximum and the pH is at its minimum. In areas where H_2S is being produced the pH values approach neutrality and may even fall in the acid range.

In the survey area, the waters are shallow and the atmosphere is in contact with water containing dissolved CO_2 . The pH values are therefore high except in the areas of low salinity or hydrogen sulfide production, in which case the pH values are low.

In view of the shallow waters of the survey area, precautions in handling samples so as to prevent the loss of dissolved CO_2 are not warranted. However, measurements should be made as quickly after collection as possible and thus prevent the loss of CO_2 as a consequence of temperature increase.

Some pH measurements were made on the muds but in view of the difficulty of interpretation of these data they were abandoned.

The problem of measuring pH in muds and soils has been studied by many groups but a truly satisfactory technique for making meaningful measurements has not been found. Most soils and muds contain fine silt and clay. For illustration, the clays can be compared roughly to finely divided ion exchange resins. These small particles are charged and when treated with an ionic solution, such as sea water, they will attract and hold ions of the opposite charge. The extent to which the charge on the clay is neutralized will depend on the charge on the clay particles, size and charge of the ions it attracts, the concentrations of the ions in the solution, the extent of hydration, etc.

In such a complexed situation, with a number of possible boundary potentials, interpretations of ordinary pH measurements are not satisfactory.

Considering the above problems and assuming that the interstitial water is in equilibrium with the solid particles, determination of pH of the interstitial water would give an average value for the environment.

If a potentiometric method is used to determine the pH and the electrodes are inserted directly into the mixture of solution and clay or silt particles, the

indicated potential (pH) will be the algebraic sum of several potentials, since the charged particles and the ionic strength of the water contained in the mud will result in a boundary potential in the contact region with KCl, and also affect the absorption of the hydrogen ions on the glass electrode.

Colorimetric methods are no better, because of color variations which result from H^+ ion gradients in the proximity of the surface of charged particles and the slight color imparted to the sample itself due to suspended matter. Samples examined under the microscope show a wide range of color from the indicator on the solid particles and that in solution.

The ideal situation would be the removal of the solid phase and determination of the pH of the liquid phase only. But all methods of separating the phases will produce a change in the composition on the interstitial water. Laboratory experiments with ion exchange resins and salt water have proven this point. It has been hypothesized that the change in concentration is produced by the membrane formed during the phase separations.

Dilution techniques, which have been used extensively by soil chemists, where the concentration of the charge particles are reduced, also give data which are highly subject to question.

In trying to evaluate pH of muds, it is desirable to know not only the instantaneous value but also the ability of the mud to maintain this value, i.e., its buffer capacity.

Preliminary experiments have indicated that a method can be developed which will give instantaneous pH and buffer capacity values of sufficient accuracy for chemical and biological applications, but the amount of time necessary to perfect and evaluate this technique is not available at present.

Temperature - The temperature of the water was determined with a mercurial Fahrenheit thermometer which can be read with an accuracy of $\pm 0.2^\circ$. Measurements were made in the field at the time water samples were collected.

Mud temperatures were determined by inserting a soil thermometer (mercurial Fahrenheit) directly into a freshly collected mud sample.

Specific Gravity - A set of hydrometers with a specific gravity scale accuracy of 0.001 were employed for this determination. Immediately after collection, a two liter

water sample was placed in a large glass cylinder. The temperature and specific gravity were determined simultaneously and the values recorded.

These specific gravity values were converted to comparable values at 20°C by the following relationship:

$$\text{Specific Gravity}_{20^{\circ}} = \text{Specific Gravity Field Temp.} \times \frac{\text{Density}_{20^{\circ}}}{\text{Density}_{\text{F.T.}}}$$

Absolute Turbidity - a B-S Light Scattering Photometer, an improved form of the apparatus originally described by R. Speiser and B. A. Brice (J. Opt. Soc. Amer., 36, 364 (1946)), was used for these determinations. The instrument constants were determined using a reference standard, working standard and neutral filters.

A water sample was introduced into the cell, which had been cleaned with a mild detergent, dried in an acetone still and polished with lens paper. Using a green filter which transmits at 547 mμ, the light transmitted at zero angle was adjusted with neutral filters to approximately that of the scattered beam at 90° in the absence of filters. Readings (galvanometer deflections) were taken at 0° and -90°. Five readings were taken at each position and the average value determined. These average values were corrected for the filters used and the absolute turbidity calculated from the constants of the instrument and the corrected readings.

This method gives relative amounts of particular matter, down through colloidal size, present in the waters. The major error in the present determinations is sample alteration prior to determination of turbidity. Preservation of samples by the addition of preservatives or quick freezing will probably affect the colloidal material present. Since samples for this determination were untreated, they were subject to possible biochemical or physical alterations between the time of sample collection and time of the laboratory determinations. At the present time a simple method of resolving this problem is not known.

Specific Conductance - The specific conductance was determined with a Leeds and Northrup Portable Conductivity - Resistivity Indicator. This instrument has a specific conductivity range of 0.012 to 0.000,001 ohm⁻¹cm⁻¹ or a specific resistance range of 80 to 10,000,000 ohm-cm and a scale accuracy of 0.3%.

The electrodes of a well-leached Washburn type conductivity cell were plated with a medium coat of platinum black, and after a thorough washing were allowed to stand for several days in contact with conductivity water.

A 0.01 N potassium chloride solution was used to determine the cell constant. The cell was washed several times with the standard potassium chloride solution and then carefully filled so as to avoid air bubbles. The cell was immersed in a thermostated water bath at $15^{\circ}\text{C} \pm 0.05^{\circ}$ and allowed to come to thermal equilibrium. Equilibrium conditions were checked by taking readings every five minutes until they were constant. This required a minimum of twenty minutes. The above procedure was repeated three times and the average value was taken as the cell constant.

Determinations on the water samples were made in a similar fashion, but with only a constant reading determined once for each sample.

Since the expected specific resistance calculated from the chlorinity of the water samples is from 80 to 800 ohms, the equipment employed is capable of giving sufficiently accurate results. However, the cell will be calibrated with 0.1 N potassium chloride instead of 0.01 N potassium chloride, since the more concentrated solution is nearer the salt concentrations of the field samples.

It is interesting to note that the specific conductances of the field samples are almost twice the values calculated from the chlorinity data by the empirical equation developed by Thomas, Thompson and Utterback¹ for sea water.

Differential Refractive Index - A Brice-Phoenix Differential Refractometer, designed for the direct measurement of the difference in refractive index between a dilute solution and its solvent, was used for this determination. The instrument has a limiting sensitivity of ± 2 in the sixth decimal place and has a range of refractive index difference of about 0.01.

A green filter transmitting at 589 mμ was used in connection with a mercury light source. Distilled water was introduced into both sides of the clean cell, and the

¹B. D. Thomas, T. G. Thompson and C. L. Utterback, "The Electrical Conductivity of Sea Water," Journal du Conseil, Conseil permanent international pour l'exploration de la mer. 9, 28-35 (1934).

slit image was aligned with the cross hair, with the cell at 0° and 180° to the incident beam. The distilled water was withdrawn from the one side of the cell, the cell dried with filter paper, and a water sample introduced. The cell was allowed to come to thermal equilibrium and the differential IR determined with the cell at 0° and at 180°. Applying the correction constant with the instrument, determined previously with standard sucrose solutions, the readings were corrected to absolute differential refractive indices.

This instrument provides an accurate and rapid method of determining the index of refraction of the water samples. Its accuracy is approximately ten times that of other instruments employed in similar studies. Since it is primarily important that the sample and reference solvent are only at thermal equilibrium, the measurements are essentially temperature independent and troublesome temperature control devices can be eliminated.

In this situation also the major problem is the preservation of samples from time of collection to time of measuring their indices of refraction. Additional studies are necessary to evaluate this possible error but it is believed to be negligible.

It is again to be noted that the value determined experimentally on the field samples is approximately twice that calculated from the empirical relationship of Utterback, Thompson and Thomas¹ for sea water.

CHEMICAL DETERMINATIONS

Total Solids - Porcelain crucibles of approximately 50 ml. capacity were dried to constant weight in an oven at 105° C. Fifty ml. water samples were placed in the crucibles and evaporated to dryness on a warm hot plate. The crucibles and residues were then dried a minimum of 48 hours in the oven and assumed to be at constant weight. All weighings were made to the nearest 0.1 mg. The total solid content was calculated from the volume of water sample and the weight of the residue.

This technique is similar to that employed in standard water analysis, but the possibility of errors was examined. Some of the solid residue obtained is crystalline and probably contains water of hydration which cannot be removed

¹C. L. Utterback, T. G. Thompson and B. D. Thomas, "Journal du conseil, Conseil permanent international pour l'exploration de la mer." 9, 35-38 (1934).

without heating to higher temperatures. Any appreciable increase in temperature would probably decompose the organic material and certain of the inorganic carbonates and halides and thus introduce additional errors in the determination.

To evaluate the above possibility, the crucible and residue, after having been weighed, were heated to 600° C. in a furnace for 15 minutes, allowed to cool to room temperature in a desiccator, then weighed again. Laboratory observations have indicated that the loss of weight upon heating at 600° can be attributed mainly to water of hydration. Very small amounts of halide salts are vaporized, and there is never much organic material present.

Chlorinity - For field surveys 5 and 6 the Mohr method as described in the ninth edition of Standard Methods for the Examination of Water and Sewage (1946) prepared by the American Public Health Association and American Water Works Association was used to determine quantitatively the presence of halides, mainly chloride. For previous field surveys the Volhard method was used as described in the same book. The Mohr method is much less time consuming and in this work, just as accurate as the Volhard method. This accounts for our change in method of analysis.

In a solution (10 to 20 ml. of sample diluted to 100 ml.) the pH of which is adjusted between the limits indicated by methyl orange and phenolphthalein indicators, and to which potassium chromate is added as an indicator, silver nitrate combines first with all the halides present, then with the chromate ion to produce an easily seen red precipitate, silver chromate. In the preliminary treatment of the sample, one ml. of 30% H₂O₂ is added to eliminate interferences by sulfite, and the volume of AgNO₃ required to turn the indicator is determined and subtracted from the final volume of AgNO₃ used in each titration.

Salinity - Salinity can be determined from the chlorinity by the following empirical relationship.

$$\text{Salinity (‰)} = 0.03 + 1.905 \times \text{Chlorinity}$$

Martin Knudsens Hydrographical Tables, which employ the above relationship, give the salinity - chlorinity relationship in tabular form and thus eliminate the necessity of mathematical calculations.

Dissolved Oxygen - Two standard 300 ml. B.O.D. bottles were filled with water directly from the Foerst Water Sampler at each sampling location. One sample served for the oxygen analysis and the other as a reagent blank. After the first trip, the oxygen analysis procedure was changed from the standard Winkler procedure to the Rideal-Steward modification

of the Winkler procedure as described in the ninth edition of Standard Methods for the Examination of Water and Sewage (1946) prepared by the American Public Health Association and American Water Works Association. In the procedure, potassium permanganate is added to the sample to oxidize the easily oxidizable organic material, then potassium oxalate is added to destroy the excess permanganate. After this treatment, the standard Winkler reagents (alkaline potassium iodide, manganous sulfate and sulfuric acid) are added respectively with automatic pipettes. The final titrations with standard sodium thiosulfate were carried out within one hour after acidification with sulfuric acid in the field. The Winkler reagents were added in the order of sulfuric acid, alkaline potassium iodide and manganous sulfate to the reagent blank, and the iodine released by interferences of one sort or another was titrated and subtracted from the vinal volume of the oxygen determinations.

For future oxygen determinations a Dorber Model D Oxygen Analyzer has been purchased. This portable polarographic instrument should give accurate results with these waters.

Biological Oxygen Demand - Samples collected in the same manner as for dissolved oxygen were kept sealed in their bottles for a period of five days at room temperature. The dissolved oxygen content was determined by the Rideal-Steward modification of the Winkler method (see foregoing paragraph) for all field trips except the first, on which the standard Winkler method was used. The difference between the dissolved oxygen determined at the time of collecting and after five days was reported as the Biological Oxygen Demand.

The standard procedure for Biological Oxygen Demand determinations requires a uniform incubation temperature. Under the present field sampling schedule, the first sample collected cannot be returned to the laboratory until at least 18 hours after collection. It is impossible to carry an incubation oven into the field. We can only point out that all samples were treated in the same manner for the period of incubation.

Sulfate - A 50 ml. portion of freshly collected water sample was placed in a flask and 50 ml. of benzdine hydrochloride solution was added with stirring. After standing for fifteen minutes the solution was filtered and the precipitate was washed on the filter paper three times with distilled water. The filter paper was carefully folded inside a second dry filter paper, labeled, and returned to the laboratory for final analysis.

At the laboratory the filter paper was placed in a flask, distilled water added, and the mixture titrated with standard sodium hydroxide solution using phenolphthalein as an indicator. The amount of sulfate was calculated from the experimental data.

Laboratory evaluation of the above procedure indicated a high degree of accuracy. The procedure is simple and easy to carry out under field conditions.

Other Oxidizable Forms of Sulfur - A 50 ml. portion of freshly collected water sample was placed in a 4 oz. bottle and 50 ml. of 30% hydrogen peroxide was added. The bottle was capped and returned to the laboratory for final analysis. In the laboratory the solution was transferred quantitatively to a flask and concentrated to 15 ml. over a blast burner. (This removed the excess peroxide which reacts with the benzidine hydrochloride reagent). The concentrated solution was diluted to approximately 50 ml. with distilled water, and the amount of sulfate was determined by the benzidine hydrochloride method. The amount of oxidizable sulfur was calculated by the difference.

This method gives accurate results since the oxidizing agent is capable of converting all forms of soluble sulfur to sulfate. The interim between collection and analysis should not produce an error in this procedure, because the hydrogen peroxide should destroy most of the biological agents which might affect the sulfur concentration.

Alkalinity was determined according to the procedure described in Standard Methods of Chemical Analysis, Vol. II, page 1429, by Scott. Samples were titrated with 0.1 N sulfuric acid to phenolphthalein and methyl orange end points, and the alkalinity calculated as hydroxyl, carbonate, and bicarbonate from the data obtained. Total alkalinity was then the sum of these values.

Total hardness was determined according to the procedure described in Standard Methods of Chemical Analysis, Vol. II, page 543, by Scott. This method utilizes a soap precipitation procedure in which a standard solution of castile soap or potassium oleate is added in measured increments to the water sample until a lather is formed which will remain unbroken for five minutes under specified conditions.

MUD SAMPLES

Extractable Sulfur - On the first field trip the mud sample was thoroughly mixed and a 2-3 gram aliquot was removed for a moisture determination. Approximately 100

grams of the sample was transferred to a Buchner funnel and the water removed by suction filtration until a solid cake resulted. (The weight of the mud sample was determined by weighing the beaker of mud before and after transferring the sample to the Buchner funnel). The solid mud cake was carefully transferred to a Waring Blender where it was extracted for five minutes with a 100 ml. portion of acetone. This mixture was returned to the Buchner funnel and the acetone removed by suction. Two additional acetone extractions were made to insure complete removal of the water. Extractable sulfur was removed by extracting in the same manner with two 100 ml. portions of carbon disulfide.

The combined CS_2 extracts were evaporated to dryness in a weighed container which was subsequently dried to constant weight in an oven. The amount of extracted material was weighed and considered as free sulfur which it appeared to be in every respect. The dry weight of the mud sample was calculated from the weight of mud extracted and the moisture determination.

This method is subject to many errors. The acetone is capable of removing a portion of the free sulfur, and the carbon disulfide will dissolve many organic sulfur compounds as well as sulfur.

Sulfur Determinations on Subsequent Field Trips - The mud samples of subsequent field surveys were frozen in the field and stored in the laboratory in the frozen condition until analyzed. The muds were then thawed out and lyophilized. This freeze-drying technique will remove 95-98% of the water without making a hard cake of the matter composing the mud sample. The wet mud and dry residues were weighed to determine the water fraction of the mud samples.

The distribution of the sulfur content of the muds among the various oxidation states of sulfur was determined by analyzing two portions of each mud sample--one portion was analyzed for sulfide content and then leached for soluble sulfate which was assumed as having been dissolved in the water of the mud and was not included as sulfur of the mud. The other portion was carried through a wet oxidation procedure using potassium permanganate (to oxidize sulfide to sulfate), nitric acid (to oxidize organic matter present to make the use of perchloric acid safe), and finally, perchloric acid (to oxidize organic and elemental sulfur to sulfate). The sulfate concentration of the filtrate of the oxidation mixture was then determined by measuring the turbidity produced in a highly diluted solution of the filtrate upon addition of BaCl_2 with a light scattering photometer. All sulfate determinations related to the muds were made with the use of

this instrument. After the proper calculations it was possible to give quantitative results for sulfide, soluble sulfate due to the presence of overlying and interstitial water, and organic and elemental sulfur as one, since they are indistinguishable by this method of analysis.

The largest source of error in this determination is obvious--the problem of getting two identical representative portions of one sample. Another source of large error is in the separation of the filtrate in the oxidation from the residues of oxidation. Here, a very finely divided residue has high potentialities for absorbing and retaining a good portion of the sulfate ions.

Sulfide analysis - A 0.5 g. sample of freeze-dried mud was placed over 1 g. of 40 mesh aluminum metal in a gas generator. This was treated with 1:1 HCl and the evolved H_2S precipitated in an ammonical solution of $CdCl_2$. The contents of the absorption column were transferred quantitatively to a titrating vessel and neutralized with 1:1 HCl. Fifty ml. of standard iodine solution was then added and this was titrated with standard thiosulfate. The amount of iodine utilized by sulfide was equal to the difference in volume required for 50 ml. of iodine solution and the titration volume.

Sulfate analysis - Sulfate was determined by a turbidimetric method employing the light scattering photometer. Two, five, or ten ml. of sample (acidified filtrate from above) were taken according to the amount of sulfate thought to be present. The aliquot was placed in a 100 ml. ground glass stoppered graduated cylinder and 15 ml. of saline solution added (245 g. of NaCl in one liter of water). This solution was made up to 100 ml. with distilled water, and one g. of solid $BaCl_2$ added. The cylinder was then shaken for one minute. A portion of this was taken and placed in a photometer cell and the 90° scattering determined. From this scattering intensity ppm sulfate was determined from a standard curve which was prepared by following the above procedure with five solutions of known sulfate concentration. Sulfate in mud samples before and after oxidation, and in the filtrate after treatment of mud with HCl was determined by this method.

BACTERIOLOGICAL INVESTIGATIONS

Arthur Novak

[For the reason that Grand Bayou Blue and similar marsh-land drainage basins may become disposal sites for effluents from sulfur mining from salt domes, the following study was conducted to determine possible biological changes that might result--Ed.]

Industrial waste disposal has always been considered a major problem, especially when an effluent is passed directly into a body of water employed for other commercial purposes. Possibilities of chemical, biological, and physical changes are infinite and vary immensely with the concentrations and the substances present in the effluent, the rapidity and repetition time of disposal, the distance from the point of disposition, the rate of addition of other pollutants from other sources, rate of flow of the river, weather changes, etc. Since such an investigation covering a multitude of variables could become too broad in scope, this study was designed to ascertain the nature of the micro-organisms now present in the water at a possible disposal site, the possible alterations they could make by their metabolic processes both before and after the addition of such an effluent and the potential danger which could be induced by these changes.

In reviewing the composition of the effluent, it can be predicted that the biological problems are likely to arise either from high salinity or the presence of sulfur compounds. Reports indicate high salt concentrations affect fish for the following reasons: (1) they consume more water in hypertonic salt solutions; (2) sodium chloride causes a decrease in the percentage of tissue fluids; (3) ingestion of salt solutions subjects fish to a modification of chemical and osmotic environment, internally and externally; and (4) ingestion of salt solutions exerts an effect on the body surface of the fish.

Recognition must also be given the rate of flow of the river which must be sufficient to afford necessary oxygen. The amount of oxygen required by any body of water for oxidation of its organic content can be measured chemically, and is referred to as the biological oxygen demand (B.O.D.). Water with a high B.O.D. indicates the presence of anaerobic conditions and will cause putrefaction and fermentation to occur, if the water is not aerated continuously. Water with a high B.O.D. but low in dissolved oxygen will likely be reflected in a marked decrease in the fish population. In many instances blame for such losses

has been placed upon industrial waste disposal until scientific tests could prove the cause to be an insufficient oxygen supply.

Considerable quantities of foreign matter entering the water can change the entire picture, and an effluent such as this paper is concerned with could favor growth of autotrophic bacteria, because it is primarily an inorganic solution. Since the aquatic environment at the disposal site is favorable for the growth of algae, which in turn would favor heterotrophic bacteria by association, the autotrophs must be considered the minority group of organisms present. High inorganic salt content effluents are not likely to increase bacterial growth near the site of disposal, because of the increase in osmotic pressure. However, halotolerant species, organisms capable of growth over a wide range of salt concentration, and halo-obligatory species, organisms requiring a high salt concentration would be favored. Yet, the dilution factor could become so high within a relatively short distance from the disposition site, that only a slight effect, if any, would be exerted. Regardless of the rate of growth, these organisms are not known to synthesize any toxic substances for higher forms of life.

Metabolism of the autotrophic sulfur bacteria must be emphasized, because the mineral effluent contains the oxidizable sulfur compounds required for their energy source. They are capable of very complex synthetic reactions, and can build high molecular weight products from simple inorganic raw materials.

Sulfur bacteria from a very heterogeneous group. They include obligate and facultative autotrophs, and may be aerobes, facultative anaerobes, or strict anaerobes. Evidence is accumulating that those organisms which are now regarded as obligate autotrophs may all be capable of growth in the presence of organic matter under certain conditions.

Organisms in this latter category have been isolated and identified. They include:

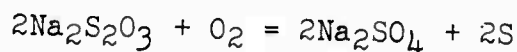
Organism	Source of Sample (See Fig. 2 for location)
<u>Thiobacillus thioparus</u>	D, E, H, S, U
<u>Beggiotoa alba</u>	E, G, R, T
<u>Thiopedia rosea</u>	C, N, Q
<u>Thiobacillus denitrificans</u>	A, D, F, H, J, L, M, O, R, T
<u>Thiothrix</u>	P, S, T
<u>Thiobacillus novellus</u>	A, C, G
<u>Thiocapsa floridana</u>	B, I, K, P
<u>Beggiotoa gigantea</u>	H, J, K, L, N
<u>Thiocystis violacea</u>	F, H, K

Numerous other organisms were isolated from these water samples, but are of little consequence to this study because their growth rates are not likely to be changed significantly upon the addition or the type of effluent being studied.

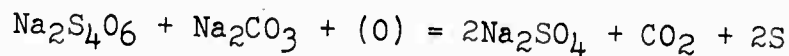
MECHANISM OF ACTION

Several types of reactions occur in cells of the sulfur metabolizing organisms that have been isolated from the samples of water. These can be summarized as follows:

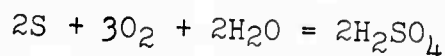
1. Some species grow under nearly neutral conditions and oxidize thiosulfate, tetrathionate or sulfides, with separation of sulfur, which is deposited outside the cells as shown below:



and tetrathionate by the reaction:

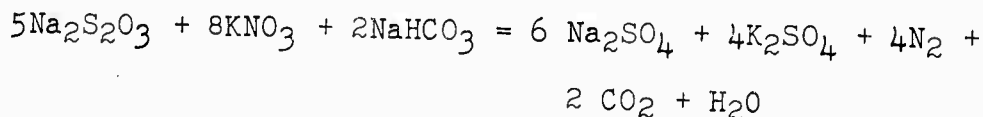


2. More complex bacteria, including Thiocystis, Beggiatoa and Thiotrix are characterized by the presence of globules of sulfur within the cells. They are obligate autotrophs which can utilize hydrogen sulfide for their growth. The hydrogen sulfide is oxidized in two stages, first to sulfur and then to sulfate.

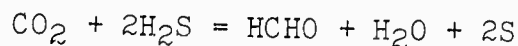


As long as hydrogen sulfide is available the organisms contain globules of sulfur, but as soon as the supply fails the sulfur is oxidized, and on its complete disappearance the cell dies.

3. Thiobacillus denitrificans oxidizes sulfur, hydrogen sulfide, thiosulfate or tetrathionate to sulfuric acid at the expense of the oxygen of nitrates. For example, thiosulfate may be oxidized as follows:



4. Sulfur bacteria found in fresh and salt water also reduce carbon dioxide with the formation of formaldehyde.



DISCUSSION

None of the compounds formed either before or after the addition of such an effluent could be produced in sufficient quantity to be considered toxic in nature. In fact, most of the reactions could prove to be beneficial in some respects. Formaldehyde that is produced is utilized by the organisms for syntheses of complex compounds required for cellular growth. Formation of small amounts of sulfuric acid is not detrimental because it aids in reducing an already excessive alkalinity. Decomposition of any hydrogen sulfide will merely remove some of this undesirable compound. This type of effluent should not constitute a major problem as far as any drastic alteration by microorganisms is concerned.

To obtain a comprehensive picture of the microbiological status of the general vicinity possible disposal sites, samples were obtained from various locations in the areas where the water could be altered in some manner by the introduction of sulfur-containing effluent. Three series of water samples were collected and transported to the laboratory for routine bacteriological analyses.

Bacterial counts were made on all samples to determine which areas appeared favorable for the growth of microorganisms. All counts were made according to standard procedures described in detail in "Methods for the Examination of Water," published in the American Public Health Association. Results are presented by Tables I, II, III, and IV.

It is obvious that numerous changes occurring daily cause rapid increases or decreases in the bacterial counts at different locations, and actual counts made any day have little significance except to show quality of the water at the time the sample was collected. Also, conditions favoring growth of some types of organisms might suddenly reverse to inhibit their growth rate while supporting increases of other microorganisms. Naturally, increases in sulfur content should favor the cultivation of sulfur-utilizing bacteria, providing other conditions are optimum, and might cause a considerable decrease in other organisms.

TABLE I

Bacterial Counts on First Series of Water Samples
(See attached map designating collection site of each sample)

Sample No.	ph	Bacterial Count Organisms/ml	Sample No.	ph	Bacterial Count Organisms/ml
A-1	7.48	2,300	M-1	7.49	6,200
B-1	7.49	1,100	N-1	7.50	3,700
C-1	7.49	4,200	O-1	7.53	3,800
D-1	7.48	6,400	P-1	7.53	1,400
E-1	7.50	2,300	Q-1	7.52	2,100
F-1	7.51	1,900	R-1	7.53	4,800
G-1	7.50	2,200	S-1	7.50	1,300
H-1	7.49	10,100	T-1	7.55	1,900
I-1	7.52	3,500	U-1	7.63	2,000
J-1	7.51	1,600	V-1	7.60	1,600
K-1	7.54	2,700	W-1	7.59	2,400
L-1	7.52	1,400	X-1	7.60	1,700

TABLE II

Bacterial Counts on First Series of Water Samples
(See attached map designating collection site of each sample)

Designation of sample	pH	No. bacteria per ml. water	Designation of sample	ph	No. bacteria per ml. water
A-2	7.33	3,720	M-2	7.25	3,000
B-2	7.22	1,750	N-2	7.17	18,400
C-2	7.14	1,260	O-2	7.17	4,210
D-2	7.33	2,230	P-2	6.80	880
E-2	7.23	6,810	Q-2	7.04	2,760
F-2	7.23	21,600	R-2	7.32	7,400
G-2	7.13	1,890	S-2	6.62	4,510
H-2	7.02	2,780	T-2	6.38	1,100
I-2	7.44	1,340	U-2	7.22	2,520
J-2	7.24	1,350	V-2	6.34	3,660
K-2	7.19	960	W-2	5.76	1,680
L-2	7.31	8,720	X-2	7.38	5,120

TABLE III

Bacterial Counts on Third Series of Water Samples
(See attached map designating collection site of samples)

Designation of sample	pH	No. bacteria per ml. water	Designation of sample	pH	No. bacteria per ml. water
A-3	7.64	1,620	M-3	7.39	720
B-3	7.11	1,220	N-3	7.33	860
C-3	7.28	2,360	O-3	7.70	4,090
D-3	7.34	970	P-3	7.73	1,900
E-3	7.65	1,860	Q-3	7.70	990
F-3	7.20	7,550	R-3	7.50	1,870
G-3	7.12	830	S-3	7.57	4,230
H-3	7.02	2,220	T-3	5.57	270
I-3	7.36	2,010	U-3	7.48	1,430
J-3	8.06	740	V-3	7.43	910
K-3	7.13	3,250	W-3	7.17	890
L-3	7.46	540	X-3	7.00	2,870

TABLE IV

Bacterial Counts on Fourth Series of Water Samples
(See attached map designating collection site of samples)

Designation of sample	pH	No. bacteria per ml. water	Designation of sample	pH	No. bacteria per ml. water
A-4	7.94	480	M-4	7.55	860
B-4	7.80	970	N-4	7.18	850
C-4	7.53	1,240	O-4	7.47	470
D-4	7.20	720	P-4	7.62	590
E-4	7.54	830	Q-4	7.70	930
F-4	7.55	650	R-4	7.60	720
G-4	7.54	570	S-4	7.58	450
H-4	6.90	440	T-4	7.23	380
I-4	7.54	1,120	U-4	7.31	910
J-4	7.93	1,010	V-4	7.50	2,100
K-4	7.20	910	W-4	7.35	880
L-4	7.30	870	X-4	7.26	1,270

GROWTH OF SULFUR UTILIZING ORGANISMS IN SAMPLES OF WATER COLLECTED

This experiment was performed to ascertain whether or not different types of autotrophic sulfur bacteria would grow and reproduce in the water samples collected at the different localities near a possible disposal site of sulfur effluent. The object was to show that suitable conditions for their cultivation were already present over the general area.

Organisms selected for this study include those which will grow under nearly neutral conditions and oxidize thiosulfate or sulfides, those characterized by the presence of globules of sulfur within the cell and use hydrogen sulfide for growth, those which oxidize sulfur, thiosulfate, or hydrogen sulfide at the expense of oxygen or nitrates, and finally those sulfur bacteria which reduce carbon dioxide with the formation of formaldehyde.

Specific strains employed include Thiobacillus thioparus, Thiobacillus denitrificans, Beggiotoa alba and Thiocystis violacea.

Individual cultures of those organisms were inoculated into water samples and incubated at 30°C for 72 hours. Microscopic examinations were made at various intervals to observe the progress of growth of each organism in each test.

Sulfur effluent was then added at a 10% level to each of the water samples and the tests repeated under the same conditions.

Results of these studies are presented in Table V. Note how most water samples already support growth of sulfur utilizing bacteria. Sulfur effluent usually fails to increase growth when added at a 10% level, and in some instances even acts as an inhibitory agent. This is probably caused by an excessive concentration of other minerals.

TABLE V
Growth of Sulfur Utilizing Bacteria in Water Samples
(See Attached Map Designating Collection Site of Samples)

Sample No.	<u>Thiobacillus thio</u> <u>parus</u>			<u>Thiobacillus denitrificans</u>			<u>Beggiotoa alba</u>			<u>Thiocystis violacea</u>		
	No addition	10% effluent added	No addition	No addition	10% effluent added	No addition	No addition	10% effluent added	No addition	No addition	10% effluent added	No addition
A-2	XX	XX	XXX	XXX	XX		X	X	XX		X	
B-2	XX	O	X	X	X		X	X	XX		X	
C-2	XXX	XX	X	X	X		O	O	XX		X	
D-2	XX	X	XXX	XXX	XX		XX	X	X		O	
E-2	X	XX	XX	XX	X		X	X	X		X	
F-2	X	X	X	X	X		X	X	XXX		X	
G-2	XXX	XXX	X	X	X		X	O	X		XX	
H-2	XX	X	XX	XX	X		X	X	X		X	
I-2	XX	XX	X	X	XX		XX	X	X		O	
J-2	X	X	X	X	XX		X	X	X		X	
K-2	X	O	X	X	O		X	XX	XX		X	
L-2	XX	X	XX	XX	X		X	X	O		X	
M-2	X	X	X	X	X		XX	X	X		X	
N-2	X	X	X	XXX	XX		X	X	X		X	
O-2	X	X	X	XXX	XX		XX	X	X		X	
P-2	XXX	X	X	XXX	X		XX	X	XX		X	
Q-2	X	X	X	X	X		X	XX	X		XX	
R-2	XX	XX	X	XX	X		X	O	O		X	
S-2	X	X	X	XX	X		XX	X	X		X	
T-2	X	O	X	XX	XX		X	XX	XX		X	
U-2	X	X	X	XX	X		X	XX	X		XX	
V-2	XXX	XXX	X	X	XX		X	O	X		X	
W-2	X	XX	X	X	O		X	X	X		X	
X-2	X	X	O	X	X		X	XX	X		X	

O.....no growth
X.....slight growth
XX.....good growth
XXX.....excessive growth

CHEMICAL SURVEY OF THE WATERS AND MUDS,
NOV., 1955-JAN., 1956

INTRODUCTION

This report is essentially an addendum to the report which covered the period, December, 1954, through November, 1955, and which was dated January, 1956. That report presented data covering the first four field trips and part of the fifth.

This report includes the remaining data from the fifth trip and continues through the 13th field trip. Bacteriological studies were not made beyond the fourth trip samples and consequently there is no bacteriological phase of this addendum report.

Field trips 6, 7, 8, and 9 were made on November 26, 1955; December 29, 1955; February 25, 1956; and March 29, 1956, respectively, and continued the same type of investigations that were carried out on previous trips. The number of stations, however, was reduced from 24 to 12. The measurement of absolute turbidity of the samples was discontinued as being an unfruitful investigation. In its place was substituted the determination of dissolved hydrogen sulfide (H_2S). Beginning with the 9th trip dissolved sulfate was determined by a turbidimetric method and beginning with the 10th trip, hardness was determined by the ethylenediaminetetracetic acid (EDTA) method. No changes other than these were made in experimental methods used in water analyses. Methods not included in previous reports will be introduced in the discussion on mud analyses for sulfur.

On the field trips 10 through 13 the number of stations was reduced to six. The dates of these trips were: April 28, 1956; June 5, 1956; June 21, 1956; and July 6, 1956, respectively. On trips 11 and 12 three different water samples were taken from as near the same location as possible and subsequently analyzed to determine what variations might exist between samples that presumably should have given identical results. On trips 10 and 13 these different samples were also taken but in the following way: one sample on location, one sample 150 ft. downstream, and the third sample 150 ft. upstream from location. This technique was employed to determine the effect of failing to return to a precise sampling location each time.

During the summer of 1957 additional personnel were utilized in our continuing efforts to quantitatively determine free sulfur and total sulfur in the sediments. Our results in this area will be discussed.

STATIONS AND CONDITIONS OF SAMPLING

STATION F: In Grand Bayou, above Bayou Bouillon at the mouth of the Pirogue Canal opening into the lake.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
F-6	11/26/55	1440	8" below normal on ebb	ENE, 0-8 mph*	W, 0-5 mph*	5.5 ft.	3 ft.
F-7	12/29/55	1000	4" below high tide, on ebb	NE, 10 mph*	SW, 0.5-1.0 mph*	9 ft.	3 ft.
F-8	2/25/56	1435	4" above normal high tide on ebb	NNE, 0-8 mph*	WNW, 0.5-5-1 mph*	7 ft.	3 ft.
F-9	3/29/56	1445	About 8" above normal on rise	N, 8-12 mph*	NE, 0.5-1 mph*	9 ft.	3 ft.

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION G: In Grand Bayou, about one-half mile above Bayou Blue and at the intersection of Grand Bayou with a canal to the northeast and a small bayou to the southwest.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
G-6	11/26/55	1500	1 ft. below normal	ENE, 0-5 mph*	NNW, 1-2 mph*	4 ft.	3 ft.
G-7	12/29/55	1025	4" below high tide, on ebb	NE, 10 mph*	WSW, 2-3 mph*	7 ft.	3 ft.
G-8	2/25/56	1500	6" above normal high on ebb	NNE, 0-5 mph*	NW, 1-2 mph*	11 ft.	3 ft.
G-9	3/29/56	1500	8-10" above normal on rise	NE, 0-5 mph*	SE, 0.5-1 mph*	8 ft.	3 ft.

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION H: At the lower end of Bayou Falteau at the point where it widens just before running into Calm Lake.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
H-6	11/26/55	1100	14" below normal on ebb	ENE, 10 mph*	N, 1.5 mph*	3 ft.	3 ft.
H-7	12/29/55	1215	18" below high	NE, 10 mph*	NE, 3 mph*	2.5 ft.	2.5 ft.
H-8	2/25/56	1130	4-6" above normal high tide on ebb	WSW, 10-12 mph* gusty	ENE, 2 mph*	4 ft.	3 ft.
H-9	3/29/56	1215	8-10" above normal	NE, 5-12 mph*	Standstill	4 ft.	3 ft.

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION I: In Grand Bayou, one-fourth mile above opening to Catfish Lake and about 30 yards from west bank of bayou.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
I-6	11/26/55	1030	14" below normal on ebb	ENE, 10-15 mph*	NW, 2-3 mph*	8-1 1/2 ft.	3 ft.
I-7	12/29/55	0740	Ebb, 3-4" below high tide	NE, gusty, 7-12 mph*	W, 1-2 mph*	10 ft.	3 ft.
I-8	2/25/56	1205	2" above normal high on ebb	WSW, 15 mph*	W, 2 mph*	12 ft.	3 ft.
I-9	3/29/56	1235	About 8" above normal on rise	NE, 0-7 mph*	E, 1-2 mph*	6.5 ft.	3 ft.

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION J: At the intersection of Bayou Monnaie and Catfish Lake.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
J-6	11/26/55	0835	14" below normal	ENE, 10-15 mph*	not noticeable	2 ft.	2 ft.
J-7	12/29/55	1750	too dark	NE, 8-12 mph*	too dark to tell	2.5 ft.	2.5 ft.
J-8	2/25/56	1604	4-6" above normal high on ebb	N, 0-5 mph*	N, 1-2 mph*	3.5 ft.	3 ft.
J-9	3/29/56	1540	About 6" above normal on ebb	NNE, 3-8 mph*	NW, 0.5 mph*	3.5 ft.	3 ft.

* Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION K: In Bayou Blue at sharp turn to northwest (see map), twenty feet from northeast bank and 40 feet from southwest bank.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
K-6	11/26/55	1325	About 1 ft. below normal on ebb	E, 0-6 mph*	NW, 1 mph*	11 ft.	3 ft.
K-7	12/29/55	0832	3-4" below high on ebb	ENE, 5-10 mph*	NW, one mph*	11 ft.	3 ft.
K-8	2/25/56	1320	4" above normal high tide on ebb	NWN, 5-10 mph*	WNW, 1 mph*	12 ft.	3 ft.
K-9	3/29/56	1330	8-10" above normal at standstill	NE, 0-5 mph*	Standstill	13 ft.	3 ft.

* Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION 0: In Bayou Blue at first turn to north before it enters Lake Raccourci, fifty feet from southeast shore, one hundred and fifty feet from northwest shore, and two hundred and fifty feet northeast from cut.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
0-6	11/26/55	1720	7" below normal on rise	none	S, 3-4 mph*	13 ft.	3 ft.
0-7	12/29/55	1630	14" below high tide	NE, 8-12 mph*	W, 1-2 mph*	11 ft.	3 ft.
0-8	2/25/56	0830	2" below high on ebb	SW, 5-10 mph*	SE, 0.5-1 mph*	15 ft.	3 ft.
0-9	3/29/56	0930	12" above normal on rise	N, 12 mph*	SE, 1-3 mph*	11.5 ft.	3 ft.

* Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION P: In Bayou Tete de Ours even with connecting canal to La Croix Bay, twenty feet west of cut, sixty feet off northwest shore, fifty feet from southeast shore.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
P-6	11/26/55	1645	6" below normal on rise	E, 0-2 mph*	E, 2 mph*	1.5 ft.	1 ft.
P-7	12/29/55	1530	21" below high tide	NE, 10-12 mph*	ENE, 0.5-1 mph*	4 ft.	3 ft.
P-8	2/25/56	0905	8" above normal high on ebb	SW, 10-15 mph* gusty	NE, 0.5-1 mph*	3 ft.	3 ft.
P-9	3/29/56	1010	About 10" above normal on rise	NE, 0-5 mph*	NE, 0-0.5 mph*	5 ft.	3 ft.

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION R: In the canal connecting Little Grand Bay with Bay Courant midway between southeast and northwest shores at 100 feet southwest of cut running to northwest.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
R-6	11/26/55	1620	About 10" below normal on rise	ENE, 0-3 mph*	SW, 3 mph*	11 ft.	3 ft.
R-7	11/29/55	1440	8" below high tide	ENE, 12 mph*	ENE, 2-3 mph*	18 ft.	3 ft.
R-8	2/25/56	0930	Above normal high on ebb	SW, 12-15 mph*	NE, 3-4 mph*	15 ft.	3 ft.
R-9	3/29/56	1035	10" above normal on rise	NE, 0-5 mph*	SW, 0.5 mph*	20 ft.	3 ft.

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION S: In Chinoils Pass between Chinaman Bayou and Deep Lake at stell post with Gulf can on top.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
S-6	11/26/55	1600	1 ft. below normal on rise	ENE, 0-6 mph*	SW, 3-5 mph*	15 ft.	3 ft.
S-7	12/29/55	1400	18" below high tide, on ebb	ENE, 8-12 mph*	ENE, 0.5-1 mph*	11 ft.	3 ft.
S-8	2/25/56	1015	8" above normal high on ebb	WSW, 5-10 mph*	ENE, 3-4 mph*	14 ft.	3 ft.
S-9	3/29/56	1110	About 12" above normal at standstill	NE, 5-12 mph*	Standstill	13 ft.	3 ft.

* Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION W: At cut through Bayou Pointe au Chien fourteen feet from south shore and six feet east of Bayou Pointe au Chien.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
W-6	11/26/55	1205	14" below normal on ebb	NE, 10-12 mph*	NE, 0.5 mph*	6 ft.	3 ft.
W-7	12/29/55	1115	18" below high	NE, 5-10 mph*	NE, 3 mph*	8 ft.	3 ft.
W-8	2/25/56	1115	6" above normal high tide on ebb	WSW, 10-12 mph* gusty	NE, 3-4 mph*	6 ft.	3 ft.
W-9	3/29/56	1150	About 8" above normal	NE, 5-12 mph*	NE, 0.5-1 mph*	8 ft.	3 ft.

* Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION X: In Bayou Blue north of Gulf Oil's Bully Camp Operation (see map).
Diagonally across V cut in the center.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
X-6	11/26/55	1400	10" below normal on ebb	NE, 0-5 mph*	NE, 2 mph*	5 ft.	3 ft.
X-7	12/29/55	0915	4" below high tide, on ebb	NE, 5-10 mph*	NE, one-half mph*	6 ft.	3 ft.
X-8	2/25/56	1355	2-4" above normal on ebb	N, 0-5 mph*	N, 0.5-1 mph*	7 ft.	3 ft.
X-9	3/29/56	1410	About 6-8" above normal at standstill	NNE, 8-10 mph*	Standstill	6.5 ft.	3 ft.

* Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION F: In Grand Bayou, above Bayou Bouillon at the mouth of the Pirogue Canal opening into the lake.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
Three samples taken in each station area: one sample on station, one 150 ft. before station, and one 150 ft. beyond station. Depth of sampling was constant.							
F-10	4/28/56	1200	3" above normal high on rise	SSE, 10-15 mph*	E, 2 mph*	6, 6.5, 5 ft.	3 ft.
F-13	7/6/56	1010	3" below normal high on rise	NNW, 0-10 mph*	NE, 1-2 mph*	3, 6.5, 5 ft.	3 ft.
Three separate samples taken on station at constant depth.							
F-11	6/5/56	1145	1" below normal high, seeming on rise	NNW, 0-8 mph*	E, 0.5-1 mph*	10ft. water, 1 ft. muck	3 ft.
F-12	6/21/56	1700	6-7" above normal high on ebb	SSW, 0-10 mph*	WSW, 0.5 mph*	7 ft.	3 ft.

* Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION G: In Grand Bayou about one-half mile above Bayou Blue and at the intersection of Grand Bayou with a canal to the northeast and a small bayou to the southwest.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
Three samples taken at constant depth in each station area: one sample on station, one 150 ft. before station, and one 150 ft. beyond station.							
G-10	4/28/56	1240	3" above normal high on rise	SSE, 10-15 mph*	E, 1-2 mph*	7, 10, 11 ft.	3 ft.
G-13	7/6/56	1035	4" below normal high on rise	NW, 0-20 mph*	SE, 2-3 mph*	10, 10, 10 ft.	3 ft.
Three separate samples taken on station at constant depth.							
G-11	6/5/56	1230	About 1" below normal high on rise	NNW, 0-5 mph*	E, 0-0.5 mph*	10 ft.	3 ft.
G-12	6/21/56	1730	6" above normal high on ebb	SSW, 0-5 mph*	W, 0-0.5 mph*	7.5 ft.	3 and 7 ft.

*Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION H: At the lower end of Bayou Balleau at the point where it widens just before running into Calm Lake.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
Three samples taken at constant depth in each station area: one sample on station, one 150 ft. before station, and one 150 ft. beyond station.							
H-10	4/28/56	0805-0910	2" above normal high tide on rise	SE, 8-12 mph*	S, 1-2 mph*	4, 5, 4 3 ft.	3 ft.
H-13	7/6/56	0705	6" below normal high on rise	WNW, 0-7 mph*	SSW, 3-4 mph*	4, 3, 5, 3 ft.	3 ft.
Three separate samples taken on station at constant depth.							
H-11	6/5/56	0830	About 1" below normal high on rise	NNW, 0-10 mph*	SSW, 2 mph*	3-4 ft.	3 ft.
H-12	6/21/56	1500	7-8" above normal high on rise	SW, 0-10 mph*	SW, 1-2 mph*	5 ft.	3 ft.

* Approximately

STATIONS AND CONDITIONS ON SAMPLING

STATION J: At the intersection of Bayou Monnaie and Catfish Lake.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
Three samples taken at constant depth in each station area: one sample on station, one 150 ft. before station, and one 150 ft. beyond station.							
J-10	4/28/56	1400	About 3" above normal on rise	SSE, 15-20 mph*	S, 0.5 mph*	All at 3.5 ft.	3 ft.
J-13	7/6/56	1150	2-3" below normal high on rise.	NNW, 0-20	SSE, 0.5-1 mph*	4, 4, 3 ft.	3 ft.
Three separate samples taken on station at constant depth.							
J-11	6/5/56	0715	About 2" below normal high tide	NNW, 0-7 mph*	Standstill	3 ft.	3 ft.
J-12	6/21/56	1810	6" above normal high on ebb	SSW, 10-15 mph*	N, 0.5 mph*	4 ft.	3 ft.

* Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION K: In Bayou Blue at sharp turn to northwest (see map), twenty feet from north-east bank and 40 feet from southwest bank.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
Three samples taken at constant depth in each station area: one sample on station, one 150 ft. before station, and one 150 ft. beyond station.							
K-10	4/28/56	0930-1000	2" above normal high tide on rise	SE, 8-10 mph*	SW, 0.5-1 mph*	5, 8, 5, -, ft.	3 ft.
K-13	7/6/56	0817	6" below normal high on rise	WNW, 0-12 mph*	W, 1-2 mph*	6, 13, 7 ft.	3 ft.
Three separate samples taken on station at constant depth.							
K-11	6/5/56	0925	About 1" below normal high	NNW, 0-10 mph*	Standstill	11 ft. water, 3 ft. muck	3 ft.
K-12	6/21/56	1550	7-8" above normal high tide on rise	SSW, 0-12 mph*	W, 0.5-1 mph*	7 ft.	3 ft.

* Approximately

STATIONS AND CONDITIONS OF SAMPLING

STATION X: In Bayou Blue north of Gulf Oil's Bully Camp Operation (see map).
Diagonally across V cut in the center.

Sample	Date	Time	Tide	Wind	Current	Water Depth	Sampling Depth
Three samples taken at constant depth in each station area: one sample on station, one 150 ft. before station, and one 150 ft. beyond station.							
X-10	4/28/56	1030-1105	1" above normal high on ebb	S, 10-15 mph*	SE, 1 mph*	5, 6, 6 ft.	3 ft.
X-13	7/6/56	0930	4" below normal high on rise	NNW, 10 mph*	W, 0-0.5 mph*	5, 6, - ft.	3 ft.
Three separate samples taken on station at constant depth.							
X-11	6/5/56	1020	Normal high tide on ebb	NNW, 0-7 mph*	N, 0-0.5 mph*	7 ft.	3 ft.
X-12	6/21/56	1630	About 6" above normal high at standstill	SSW, 0-6 mph*	Standstill	6.5 ft.	3 ft.

* Approximately

WATER DATA

pH (Glass versus calomel electrode)

Station	Field Trip							
	6th	7th	8th	9th	10th	11th	12th	13th
F	8.20	6.90	7.91	6.62	(1)	7.90	7.81	7.82
					(2)	8.00	7.81	7.82
					(3)	7.88	7.81	7.82
G	6.91	7.10	7.70	7.62	(1)	7.90	7.45	7.81
					(2)	7.99	7.45	7.81
					(3)	8.00	7.45	7.81
H	6.78	7.81	7.39	7.61	(1)	7.78	7.69	7.72
					(2)	6.69	7.69	7.62
					(3)	7.61	7.69	7.62
I	6.85	7.82	6.10	6.92				
J	7.85	7.20	8.20	6.98	(1)	8.39	8.14	8.20
					(2)	8.35	8.14	8.20
					(3)	8.50	8.14	8.20
K	6.35	7.92	7.89	6.98	(1)	7.61	7.42	7.54
					(2)	7.50	7.42	7.54
					(3)	7.49	7.42	7.54
O	8.50	6.70	7.30	8.02				
P	6.31	7.50	7.20	7.59				
R	6.80	7.20	6.70	7.99				
S	8.10	7.42	7.20	6.40				
W	6.89	6.70	7.15	7.20				
X	6.51	6.43	7.52	7.49	(1)	7.39	7.09	7.04
					(2)	7.40	7.09	7.05
					(3)	7.49	7.09	7.06

WATER DATA

Temperature of Water (°C) at Sampling Depth

Station	Field Trip								
	6th	7th	8th	9th	10th	11th	12th	13th	
F	18.0	19.0	21.0	21.7	(1)	24.6	28.9	30.8	29.9
					(2)	25.0	28.9	30.8	29.9
					(3)	25.0	28.9	30.8	29.9
G	19.0	19.0	20.1	21.7	(1)	25.0	29.2	29.4	30.1
					(2)	25.0	29.2	29.4	30.1
					(3)	24.7	29.2	29.4	30.1
H	17.5	19.0	22.1	22.2	(1)	23.9	26.2	31.7	28.6
					(2)	23.9	26.2	31.7	28.6
					(3)	23.9	26.3	31.7	28.6
I	17.1	19.0	22.0	21.7					
J	14.9	20.0	21.0	22.0	(1)	25.0	25.0	31.1	30.0
					(2)	25.1	25.1	31.1	30.0
					(3)	25.0	25.1	31.1	30.0
K	19.0	19.0	21.0	21.7	(1)	23.9	27.2	31.1	28.9
					(2)	23.8	27.3	31.1	28.9
					(3)	24.2	27.3	31.1	28.9
O	18.0	20.0	20.1	21.7					
P	18.0	20.0	21.0	22.3					
R	18.0	20.0	21.0	22.7					
S	18.0	19.0	21.0	22.2					
W	15.9	19.0	22.1	22.4					
X	19.1	19.0	20.1	20.6	(1)	25.0	27.8	29.5	28.9
					(2)	24.2	27.8	29.5	28.9
					(3)	25.0	27.8	29.5	28.9

WATER DATA

Specific Gravity

20°C/20°C

Station	6th	7th	Field Trip			10th	11th	12th	13th
			8th	9th					
F	1.003	1.005	1.001	1.003	(1)	1.004	1.005	1.002	1.002
					(2)	1.003	1.005	1.002	1.002
					(3)	1.003	1.005	1.002	1.002
G	1.003	1.005	1.003	1.005	(1)	1.005	1.003	1.001	1.002
					(2)	1.005	1.003	1.001	1.002
					(3)	1.005	1.003	1.001	1.002
H	1.005	1.009	1.003	1.006	(1)	1.007	1.012	1.003	1.003
					(2)	1.009	1.012	1.003	1.003
					(3)	1.009	1.012	1.003	1.003
I	1.006	1.011	1.005	1.007					
J	1.009	1.011	1.001	1.007	(1)	1.007	1.011	1.002	1.004
					(2)	1.007	1.011	1.002	1.004
					(3)	1.005	1.011	1.002	1.004
K	1.003	1.003	1.001	1.003	(1)	1.002	1.005	1.002	1.002
					(2)	1.001	1.005	1.002	1.002
					(3)	1.002	1.005	1.002	1.002
O	1.011	1.011	1.005	1.013					
P	1.009	1.009	1.011	1.013					
R	1.011	1.010	1.009	1.015					
S	1.019	1.015	1.009	1.017					
W	1.013	1.013	1.003	1.009					
X	1.002	1.001	1.001	1.001	(1)	1.002	1.001	1.001	1.002
					(2)	1.001	1.001	1.001	1.002
					(3)	1.002	1.001	1.001	1.002

WATER DATA

Specific Conductance

ohm⁻¹/cm³ (x 10²) at 15° C

Station	5th	6th	7th	8th	Field Trip	9th	10th	11th	12th	13th
F	1.30	1.30	1.30	1.30	1.31	(1) 1.30 (2) 1.30 (3) 1.30	1.31 1.31 1.31	1.30 1.30 1.30	1.31 1.31 1.31	
G	1.24	1.30	1.26	1.25	1.25	(1) 1.25 (2) 1.21 (3) 1.26	1.24 1.24 1.25	1.23 1.23 1.23	1.30 1.30 1.30	
H	1.94	1.93	1.93	1.95	1.93	(1) 2.00 (2) 2.00 (3) 2.01	2.00 2.01 2.00	2.02 2.02 2.02	2.00 2.00 2.00	
I	1.93	1.92	1.93	1.93	1.92					
J	1.93	1.94	1.93	1.93	1.94	(1) 1.98 (2) 1.99 (3) 2.00	1.97 1.98 1.98	1.92 1.92 1.93	2.08 2.01 2.00	
K	0.90	0.91	0.90	0.98	1.00	(1) 0.98 (2) 1.00 (3) 1.01	0.99 0.99 0.95	0.98 0.99 0.90	0.92 0.99 0.92	
O	1.30	1.40	1.40	1.31	1.40					
P	1.09	1.01	1.05	1.08	1.07					
R	1.30	1.30	1.40	1.35	1.41					
S	2.11	2.11	2.01	1.40	2.00					
W	1.66	1.70	1.71	1.71	1.70					
X	0.03	0.04	0.03	0.04	0.05	(1) 0.05 (2) 0.05 (3) 0.05	0.05 0.05 0.05	0.05 0.04 0.03	0.04 0.04 0.04	

WATER DATA

Differential Index of Refraction $\times 10^4$

Station	5th	6th	7th	8th	Field Trip 9th	10th	11th	12th	13th
F	12.45	36.45	16.70	23.50	13.50	(1) 13.81 (2) 13.87 (3) 13.95	13.42 13.45 13.62	13.21 13.21 13.21	13.28 13.42 14.10
G	17.86	32.71	16.94	28.31	17.89	(1) 18.92 (2) 18.10 (3) 18.20	18.51 18.42 18.48	18.49 18.49 18.72	19.21 20.00 21.02
H	17.29	40.02	25.06	32.46	17.19	(1) 17.29 (2) 17.30 (3) 17.30	17.30 17.30 17.30	17.21 17.22 17.21	17.82 17.82 17.91
I	20.04	45.09	23.75	32.68	19.98				
J	13.00	45.08	26.26	21.92	12.70	(1) 23.59 (2) 23.75 (3) 23.84	23.72 23.69 23.85	23.72 23.79 23.00	23.81 23.92 23.01
K	15.09	36.77	10.08	25.87	16.00	(1) 17.02 (2) 17.00 (3) 16.89	17.01 17.02 17.08	17.00 17.00 17.00	17.04 17.25 17.81
O	22.80	45.90	20.15	30.93	21.90				
P	19.05	49.04	20.78	39.89	20.00				
R	19.25	48.90	17.33	35.10	19.25				
S	25.11	50.50	37.06	35.64	26.01				
W	15.63	51.60	21.70	28.91	15.41				
X	1.08	27.00	2.44	2.58	1.80	(1) 1.84 (2) 1.89 (3) 1.82	1.84 1.89 1.81	1.82 1.79 1.95	1.92 1.87 1.82

WATER DATA

Total Solid, ppm x 10⁻³ (dried at 105° C)

Station	6th	7th	8th	Field Trip 9th		10th	11th	12th	13th
F	6.35	4.93	4.61	7.32	(1)	4.26	10.73	3.11	3.31
					(2)	5.80	10.62	3.67	3.61
					(3)	5.42	10.66	3.62	3.56
G	5.78	8.25	7.33	13.51	(1)	6.69	10.60	4.68	3.72
					(2)	4.91	10.68	4.58	3.92
					(3)	8.71	10.55	4.16	3.83
H	7.09	12.93	9.08	13.90	(1)	12.21	18.10	7.56	8.57
					(2)	12.05	18.28	7.79	8.96
					(3)	12.39	18.12	7.66	8.88
I	6.85	13.22	11.88	13.60					
J	10.92	11.46	6.93	11.69	(1)	9.26	14.42	6.70	7.45
					(2)	11.53	17.06	6.80	7.37
					(3)	4.83	16.87	6.75	7.51
K	4.20	6.64	8.24	10.14	(1)	3.38	10.90	4.78	3.80
					(2)	3.02	11.03	4.74	3.72
					(3)	3.61	9.62	4.72	3.73
O	15.16	15.40	14.16	18.53					
P	15.25	15.20	17.83	20.55					
R	14.63	16.33	15.39	19.10					
S	22.34	22.42	18.71	22.34					
W	17.04	16.34	9.14	12.15					
X	1.18	0.94	0.47	0.57	(1)	0.64	0.91	1.43	1.38
					(2)	0.73	0.90	1.46	1.23
					(3)	0.67	0.93	1.52	1.40

WATER DATA

Total Solid, ppm x 10⁻³ after Ignition at 600° C

Station	6th	7th	8th	Field Trip 9th	10th	11th	12th	13th
F	5.51	5.31	4.04	6.24	(1) 3.71 (2) 4.82 (3) 4.59	9.12 9.14 9.12	2.62 3.02 3.03	2.76 3.03 2.96
G	4.90	7.13	6.52	11.62	(1) 5.68 (2) 4.24 (3) 7.31	9.03 9.11 9.04	3.93 3.91 3.42	3.16 3.31 3.27
H	6.21	12.48	7.94	12.12	(1) 10.33 (2) 10.44 (3) 10.61	15.60 15.68 15.43	6.44 6.53 6.45	7.21 7.36 7.47
I	5.95	12.07	10.49	11.60				
J	9.48	10.08	6.18	9.89	(1) 8.04 (2) 9.91 (3) 4.23	12.82 14.75 14.80	5.76 5.75 5.71	6.26 6.40 6.37
K	3.60	5.79	7.16	8.67	(1) 2.86 (2) 2.51 (3) 2.96	9.20 9.25 8.32	4.02 3.95 3.96	3.17 3.24 3.10
O	13.46	14.76	12.43	15.89				
P	13.39	13.45	15.89	17.52				
R	12.73	14.60	13.56	16.27				
S	20.02	20.74	16.65	19.52				
W	15.04	15.29	7.77	10.35				
X	0.92	0.81	0.37	0.45	(1) 0.56 (2) 0.59 (3) 0.55	0.79 0.79 0.81	1.18 1.23 1.17	1.07 0.98 1.12

WATER DATA

Percentage Weight Loss on Ignition Total Solids

Station	6th	7th	8th	Field Trip 9th	10th	11th	12th	13th
F	13.1	10.4	12.4	14.8	(1) 12.9 (2) 10.9 (3) 15.3	15.0 13.9 14.4	15.7 17.8 16.3	16.6 16.1 16.8
G	15.3	13.6	11.1	14.0	(1) 13.7 (2) 13.6 (3) 16.1	14.8 14.7 14.3	16.1 14.5 17.8	15.3 15.6 14.7
H	12.5	3.51	12.2	12.8	(1) 15.4 (2) 13.4 (3) 14.4	13.8 14.2 14.8	14.9 16.2 15.7	15.9 17.9 15.8
I	13.1	8.73	11.7	14.8				
J	13.2	12.0	10.8	15.4	(1) 13.2 (2) 14.0 (3) 12.4	11.1 13.5 12.3	14.0 15.5 15.3	16.0 13.2 15.2
K	14.3	12.8	13.1	14.6	(1) 15.2 (2) 17.1 (3) 18.1	15.6 16.1 13.5	15.9 16.6 16.1	16.6 15.5 16.7
O	11.2	4.13	12.2	14.2				
P	12.2	11.5	10.9	14.8				
R	13.0	10.6	11.9	14.8				
S	10.4	7.49	11.0	12.6				
W	11.8	6.38	15.0	14.8				
X	18.2	13.7	21.3	20.8	(1) 11.9 (2) 19.1 (3) 17.4	13.6 13.1 13.1	17.5 15.9 22.8	22.4 20.0 19.5

WATER DATA

Chlorinity (parts per thousand)

Station	Field Trip								
	6th	7th	8th	9th		10th	11th	12th	13th
F	3.31	3.17	2.23	4.09	(1)	2.23	5.51	2.08	1.67
					(2)	2.93	5.50	1.87	1.79
					(3)	2.83	5.52	1.89	1.79
G	2.94	4.27	3.77	6.98	(1)	3.56	5.47	2.41	1.93
					(2)	2.46	5.48	2.40	2.00
					(3)	4.42	5.46	2.42	2.00
H	3.77	6.86	4.51	7.16	(1)	6.24	9.28	3.93	4.38
					(2)	6.23	9.29	3.98	4.46
					(3)	6.35	9.29	3.95	4.55
I	3.60	7.03	6.07	6.95					
J	5.78	6.09	3.60	4.35	(1)	4.72	7.47	3.52	3.85
					(2)	6.00	8.81	3.52	3.87
					(3)	2.44	8.82	3.52	3.88
K	2.17	3.52	4.28	5.25	(1)	1.74	5.62	2.46	1.94
					(2)	1.60	5.61	2.45	1.94
					(3)	1.83	4.94	2.45	1.89
O	7.88	8.04	7.32	8.05					
P	8.05	7.98	9.22	8.26					
R	7.57	7.57	7.97	9.62					
S	11.54	6.29	9.65	11.38					
W	8.85	8.36	4.62	6.25					
X	0.53	0.39	0.13	0.19	(1)	0.29	0.40	0.70	0.67
					(2)	0.30	0.41	0.72	0.64
					(3)	0.31	0.40	0.73	0.65

WATER DATA

Ratio of Chlorinity to Total Solids (600°)

Station	6th	7th	8th	Field Trip 9th	10th	11th	12th	13th
F	0.601+	0.597+	0.552-	0.656+	(1) 0.601+ (2) 0.608+ (3) 0.616+	0.604+ 0.602+ 0.605+	0.794* 0.619+ 0.624+	0.605- 0.591- 0.605-
G	0.600+	0.599+	0.578-	0.601-	(1) 0.627+ (2) 0.580- (3) 0.605+	0.606+ 0.601+ 0.604+	0.613+ 0.614+ 0.708*	0.611+ 0.604- 0.612+
H	0.607+	0.550-	0.568-	0.591-	(1) 0.604+ (2) 0.597+ (3) 0.598+	0.595- 0.592- 0.602+	0.610- 0.609- 0.612	0.607- 0.606- 0.609-
I	0.605+	0.582+	0.579-	0.599-				
J	0.610+	0.604+	0.582+	0.440*	(1) 0.587- (2) 0.605+ (3) 0.577-	0.583- 0.597 0.596-	0.611- 0.612 0.616+	0.615+ 0.605- 0.609
K	0.603+	0.608+	0.598+	0.605+	(1) 0.608+ (2) 0.637+ (3) 0.618+	0.611+ 0.606+ 0.594-	0.612 0.620+ 0.619+	0.612+ 0.599- 0.610+
O	0.585-	0.545-	0.589+	0.507*				
P	0.601+	0.593+	0.580-	0.471*				
R	0.595	0.518-	0.588+	0.581-				
S	0.576-	0.303*	0.579-	0.583-				
W	0.588-	0.547-	0.594+	0.604				
X	0.576-	0.481*	0.351*	0.422*	(1) 0.518- (2) 0.508* (3) 0.564-	0.506* 0.519* 0.494*	0.593- 0.585- 0.624+	0.626+ 0.653+ 0.580-
Avg.	0.595	0.574	0.581	0.604	0.597	0.584	0.612	0.609

*Not included in average

WATER DATA

Salinity (parts per thousand)

Station	6th	7th	8th	Field Trip 9th	10th	11th	12th	13th
F	6.00	5.75	4.06	7.41	(1) 4.06 (2) 5.32 (3) 5.14	9.98 9.96 9.99	3.78 3.41 3.44	3.04 3.26 3.26
G	5.34	7.74	6.83	12.63	(1) 6.46 (2) 4.47 (3) 8.01	9.90 9.92 9.89	4.38 4.36 4.40	3.51 3.64 3.64
H	6.83	12.41	8.17	12.95	(1) 11.29 (2) 11.28 (3) 11.49	16.78 16.80 16.80	7.12 7.21 7.16	7.94 8.08 8.24
I	6.53	12.72	10.99	12.57				
J	10.46	11.02	6.53	7.88	(1) 8.55 (2) 10.86 (3) 4.43	13.51 15.93 15.95	6.38 6.38 6.38	6.98 7.02 7.03
K	3.95	6.38	7.76	9.51	(1) 3.17 (2) 2.92 (3) 3.33	10.17 10.16 8.95	4.47 4.45 4.45	3.53 3.53 3.44
O	14.25	14.54	13.24	14.56				
P	14.56	14.43	16.67	14.94				
R	13.69	13.69	14.42	17.39				
S	20.86	11.38	17.45	20.57				
W	16.00	15.12	8.37	11.31				
X	0.98	0.73	0.26	0.37	(1) 0.55 (2) 0.57 (3) 0.59	0.75 0.77 0.75	1.29 1.32 1.34	1.23 1.18 1.20

WATER DATA

Sulfate* (ppm)

Station	Field Trip									
	5th	6th	7th	8th	9th		10th	11th	12th	13th
F	507	498	475	521	541	(1)	506	542	510	520
						(2)	570	543	510	562
						(3)	520	542	520	575
G	525	595	550	584	572	(1)	562	524	525	542
						(2)	1325	532	550	532
						(3)	304	547	562	547
H	802	901	900	901	900	(1)	604	708	604	892
						(2)	2110	1802	692	847
						(3)	1125	1249	655	863
I	680	704	695	687	685					
J	890	905	895	899	892	(1)	472	892	800	800
						(2)	1090	899	800	820
						(3)	520	904	800	815
K	300	250	288	298	301	(1)	408	478	520	500
						(2)	400	542	520	500
						(3)	750	502	520	510
O	750	748	749	749	752					
P	720	701	698	728	715					
R	574	600	575	589	602					
S	1025	1450	1201	1133	1013					
W	900	895	850	859	904					
X	104	175	122	152	163	(1)	238	400	238	250
						(2)	260	400	250	247
						(3)	250	408	250	238

*For 6th, 7th, and 8th Field Trips, sulfate was determined by the benzidine sulfate method. For the remaining trips, sulfate was determined by light scattering.

WATER DATA

Oxidizable Sulfur* (ppm)

Station	5th	6th	7th	8th	Field Trip 9th	10th	11th	12th	13th
F	40.0	29.7	30.2	40.9	39.2	(1) 40.4 (2) 41.2 (3) 49.8	48.4 48.5 48.4	49.8 41.2 40.4	0 40.4 0
G	50.7	69.4	73.4	78.4	75.8	(1) 76.2 (2) 75.5 (3) 90.1	76.3 75.4 75.8	75.8 75.8 75.8	74.9 75.8 74.9
H	56.2	74.5	69.8	57.9	62.9	(1) 69.4 (2) 69.2 (3) 69.4	74.2 74.9 75.8	74.9 76.3 75.8	45.8 41.7 41.7
I	0	0	0	0	45.8				
J	2.71	3.17	40.7	48.9	32.8	(1) 0 (2) 5.70 (3) 0	0 0 8.27	0 0 0	0 0 0
K	4.56	13.4	19.7	22.5	19.2	(1) 19.8 (2) 19.4 (3) 20.0	20.4 20.9 20.1	20.7 20.9 20.7	26.7 41.7 26.7
O	43.2	45.4	41.5	41.6	41.7				
P	26.8	59.4	60.7	25.7	26.7				
R	89.0	0	89.7	0	0				
S	0	0	0	59.0	67.2				
W	39.8	38.7	37.4	38.9	37.4				
X	20.5	20.9	19.9	20.5	20.7	(1) 20.9 (2) 22.0 (3) 21.0	20.0 19.4 19.8	20.9 20.4 20.9	20.9 20.9 20.9

*For 6th, 7th, and 8th Field Trips, sulfate was determined by the benzidine sulfate method. For the remaining trips, sulfate was determined by light scattering.

WATER DATA

Alkalinity (ppm)

HCO_3^-

Station	5th	6th	7th	8th	Field Trip 9th	10th	11th	12th	13th
F	135.0	141.0	149.0	119.5	150.0	(1) 96.5 (2) 104.5 (3) 110.5	142.5 142.5 146.0	110.5 114.5 114.0	155.0 155.0 152.5
G	145.0	152.5	157.5	109.5	152.2	(1) 108.0 (2) 111.5 (3) 110.0	152.5 153.5 153.0	101.5 118.5 218.5	146.0 169.0 149.0
H	150.0	150.0	170.0	109.0	172.0	(1) 118.0 (2) 115.0 (3) 120.0	165.0 167.0 170.5	119.5 120.0 61.5	175.0 110.5 159.5
I	162.5	152.5	165.0	110.5	154.0				
J	155.0	279.0	160.0	85.5	162.0	(1) 95.0 (2) 125.0 (3) 92.0	165.0 155.0 170.0	110.0 110.0 115.5	132.5 76.5 145.0
K	120.0	150.0	358.0	105.5	174.0	(1) 95.5 (2) 99.5 (3) 87.5	179.0 160.0 175.0	116.5 119.0 117.5	162.0 170.0 160.5
O	150.0	255.5	170.0	115.0	163.0				
P	192.5	205.0	175.0	120.0	193.0				
R	145.0	165.5	167.5	125.0	168.5				
S	123.0	96.0	160.0	122.5	102.0				
W	152.5	185.0	177.0	105.5	169.0				
X	110.0	115.0	140.5	95.5	87.0	(1) 81.5 (2) 83.0 (3) 85.0	136.5 110.0 110.0	87.5 92.5 89.0	104.0 91.0 105.0

WATER DATA

Alkalinity (ppm)

CO_3^{--}

Station	Field Trip									
	5th	6th	7th	8th	9th	10th	11th	12th	13th	
F	0	0	0	0	0	(1) 0 (2) 0 (3) 0	0	0	0	0
G	0	0	0	0	0	(1) 0 (2) 0 (3) 0	0	0	0	0
H	0	0	0	0	0	(1) 0 (2) 0 (3) 0	0	0	0	0
I	0	0	0	10.0	0					
J	0	0	0	20.0	0	(1) 20.0 (2) 25.0 (3) 25.0	0	0	0	25.0 69.0 0
K	0	0	0	0	0	(1) 0 (2) 0 (3) 0	0	0	0	0
O	0	0	0	0	0					
P	0	0	0	0	0					
R	0	0	0	0	0					
S	30.0	34.0	0	0	0					
W	0	0	0	0	0					
X	0	0	0	0	0	(1) 0 (2) 0 (3) 0	0	0	0	0

WATER DATA

Hardness (ppm)

CaCO₃ *

Station	5th	6th	7th	Field Trip 8th 9th+	10th	11th	12th	13th
F	23.9	37.6	35.3	39.5	(1)			
					(2)			
					(3)			
G	24.7	26.7	31.7	25.1	(1)			
					(2)			
					(3)			
H	19.3	27.3	26.0	20.1	(1)			
					(2)			
					(3)			
I	26.0	28.6	28.7	20.7				
J	14.0	20.6	35.3	28.2	(1)			
					(2)			
					(3)			
K	21.3	38.7	26.7	41.9	(1)			
					(2)			
					(3)			
O	41.1	41.1	57.3	18.0				
P	33.0	42.5	36.7	37.7				
R	45.0	48.7	31.3	47.5				
S	29.0	46.0	56.3	62.0				
W	19.3	33.0	34.7	29.7				
X	21.3	26.4	30.0	24.7	(1)			
					(2)			
					(3)			

SEE FOLLOWING TABLE

*Determined by soap method.

+Determination omitted this trip because EDTA was not available.

WATER DATA

Hardness *

Station	Field Trip							
	10th		11th		12th		13th	
	CaCO ₃	MgCO ₃	CaCO ₃	MgCO ₃	CaCO ₃	MgCO ₃	CaCO ₃	MgCO ₃
F (1)	22.80	61.99	45.75	179.12	18.30	68.69	21.45	61.99
(2)	23.10	61.99	47.25	181.53	18.00	68.94	23.55	66.16
(3)	22.80	61.00	46.50	180.26	18.45	68.94	20.25	67.05
G (1)	25.05	68.18	48.15	187.73	22.80	85.39	22.50	70.84
(2)	25.80	69.32	46.50	188.11	23.25	85.39	24.00	67.05
(3)	26.70	68.56	47.25	188.11	23.25	85.39	24.00	67.30
H (1)	37.80	156.99	69.30	305.88	32.85	141.81	36.00	160.15
(2)	39.15	146.61	69.30	312.71	32.70	144.46	33.00	140.42
(3)	39.15	141.81	71.10	312.20	28.65	152.94	37.65	147.88
J (1)	30.00	115.12	69.15	278.30	45.15	140.42	33.60	115.75
(2)	30.15	116.13	72.00	298.54	45.45	141.05	35.25	128.40
(3)	31.35	113.85	64.95	281.84	46.05	141.05	31.50	116.38
K (1)			49.65	189.62	23.55	91.46	29.85	71.98
(2)			50.25	198.10	23.70	91.46	29.40	70.46
(3)			52.20	194.18	23.85	92.09	24.45	73.12
X (1)	13.80	36.94	13.65	21.76	17.25	9.99	12.00	22.14
(2)	14.70	35.93	11.85	19.99	18.00	24.79	12.75	25.30
(3)	15.00	25.30	13.80	23.28	18.30	24.92	11.25	31.63

* Determined by EDTA method.

WATER DATA

Dissolved O₂ at Field Temperature (ppm)

Station	Field Trip									
	5th	6th	7th	8th	9th		10th	11th	12th	13th
F	4.9	1.9	6.5	6.2	7.3	(1)	6.7		7.0	
						(2)	6.0		7.3	
						(3)	5.9		7.6	
G	4.0	5.0	6.1	6.3	6.3	(1)	6.2			
						(2)	6.3			
						(3)	5.8			
H	5.1	3.2	6.9	7.5	6.9	(1)	7.8	6.7	8.0	
						(2)	7.8	7.3	7.8	
						(3)	7.3	7.9	7.9	
I	4.8	4.8	8.9	7.8	5.8					
J	5.9	3.8	9.6	6.5	5.1	(1)	6.2	8.4		
						(2)	6.2	8.5		
						(3)	5.6	8.5		
K	1.7	1.0	6.8	6.7	5.7	(1)	6.7	6.5	7.0	
						(2)	6.6	6.3	7.3	
						(3)	6.7	7.0	6.7	
O	7.0	3.3	9.7	7.8	4.3					
P	4.0	1.7	9.8	4.8	6.0					
R	7.1	2.7	9.9	6.8	6.6					
S	7.7	4.2	9.5	7.4	6.7					
W	5.6	6.0	6.9	7.8	6.9					
X	3.0	4.2	6.4	5.5	4.0	(1)	4.8	6.9	6.5	
						(2)	5.4		6.5	
						(3)	5.5		6.7	

WATER DATA

Theoretical ppm Oxygen to Produce Saturation at
Field Chlorinity and Temperature*

Station	Field Trip									
	5th	6th	7th	8th	9th	10th	11th	12th	13th	
F	8.94	9.44	9.28	9.03	8.72	(1)	8.45	7.65	7.65	7.82
						(2)	8.39	7.65	7.67	7.82
						(3)	8.39	7.65	7.67	7.82
G	8.93	9.29	9.17	9.04	8.47	(1)	8.33	7.63	7.89	7.80
						(2)	8.43	7.65	7.89	7.80
						(3)	8.26	7.66	7.89	7.80
H	8.63	9.56	8.93	8.69	8.44	(1)	8.25	7.73	7.39	7.73
						(2)	8.25	7.73	7.39	7.73
						(3)	8.25	7.73	7.39	7.73
I	8.72	9.57	8.92	8.55	8.47					
J	8.55	9.72	8.85	8.92	8.69	(1)	8.25	7.48	7.55	7.65
						(2)	8.13	7.36	7.55	7.65
						(3)	8.43	7.36	7.55	7.65
K	9.43	8.99	9.23	8.85	8.62	(1)	8.63	7.90	7.63	7.93
						(2)	8.63	7.90	7.63	7.93
						(3)	8.62	7.94	7.63	7.93
O	8.47	8.99	8.67	8.73	8.37					
P	8.50	8.98	8.67	8.42	8.36					
R	8.65	9.03	8.70	8.54	8.10					
S	8.32	8.65	8.99	8.37	8.08					
W	8.73	9.23	8.79	8.67	8.54					
X	8.79	9.52	9.53	9.27	9.21	(1)	8.60	8.19	7.90	8.03
						(2)	8.75	8.19	7.90	8.03
						(3)	8.60	8.19	7.90	8.03

* O_2 ppm = 1.42857 x O_2 ml/l

WATER DATA

Percentage Saturation with Regard to Dissolved O₂ *

Station	Field Trip									
	5th	6th	7th	8th	9th	10th	11th	12th	13th	
F	54.8	20.1	70.1	68.7	8.37	(1) 79.3		91.5		
						(2) 71.5		95.2		
						(3) 70.4		99.2		
G	44.8	53.8	66.6	69.7	74.3	(1) 74.4				
						(2) 74.7				
						(3) 70.3				
H	58.0	33.5	77.3	86.4	81.8	(1) 94.5	86.7	108.2		
						(2) 94.5	94.5	105.6		
						(3) 88.5	102.3	106.9		
I	55.0	50.2	99.8	91.2	68.5					
J	69.0	39.1	108.4	72.9	58.7	(1) 75.2	112.3			
						(2) 76.3	115.4			
						(3) 66.4	115.4			
K	18.1	11.1	73.7	75.7	66.1	(1) 77.7	82.3	91.8		
						(2) 76.5	79.7	95.7		
						(3) 77.8	88.2	87.8		
O	83.6	36.7	111.8	89.4	51.3					
P	47.1	18.9	113.0	57.0	71.8					
R	82.1	29.9	113.7	79.7	81.5					
S	92.6	48.6	105.7	88.4	82.9					
W	64.2	65.0	78.5	89.8	81.8					
X	34.2	44.1	67.2	59.4	43.4	(1) 55.8	84.3	82.3		
						(2) 61.7		82.3		
						(3) 63.9		84.8		

*Blank spaces shown for 11th, 12th, and 13th Field Trips resulted from instrumental failure

WATER DATA

Biological Oxygen Demand *

Station	Field Trip									
	5th	6th	7th	8th	9th		10th	11th	12th	13th
F	3.9	1.7	0.2	1.5	2.9	(1)	1.9	—	3.5	—
						(2)	1.5	—	4.0	—
						(3)	0.2	—	3.0	—
G	3.4	3.7	0.5	1.5	1.1	(1)	1.9	—	—	—
						(2)	1.6	—	—	—
						(3)	1.8	—	—	—
H	4.9	1.7	0.6	2.3	2.4	(1)	2.1	2.0	2.0	—
						(2)	2.1	2.3	2.5	—
						(3)	1.4	1.7	3.4	—
I	4.6	3.8	1.2	4.2	2.5					
J	5.9	3.5	4.6	4.5	2.4	(1)	3.9	3.2	—	—
						(2)	3.9	3.7	—	—
						(3)	2.7	4.8	—	—
K	1.7	0.9	0.7	0.7	1.2	(1)	2.2	3.2	2.5	—
						(2)	3.0	3.0	3.3	—
						(3)	2.4	3.1	2.9	—
O	4.7	1.6	1.5	4.1	0.5					
P	3.5	1.6	3.1	1.1	2.6					
R	4.6	0.6	3.6	0.1	1.8					
S	4.5	0.9	0.8	1.0	1.8					
W	3.5	4.3	1.2	3.0	2.7					
X	2.0	1.9	0.3	0.7	0.8	(1)	0.3	2.5	3.5	—
						(2)	0.9	—	4.0	—
						(3)	0.2	—	4.2	—

*Blank spaces shown for 11th, 12th, and 13th Field Trips resulted from instrumental failure.

WATER DATA

Percentage Oxygen Consumed *

Station	Field Trip									
	5th	6th	7th	8th	9th		10th	11th	12th	13th
F	80	89	3	24	40	(1)	28		50	
						(2)	25		55	
						(3)	3		39	
G	85	74	8	24	17	(1)	31			
						(2)	25			
						(3)	31			
H	96	77	9	31	35	(1)	27	30	25	
						(2)	27	32	32	
						(3)	19	22	43	
I	96	79	13	54	43					
J	100	92	48	69	47	(1)	63	38		
						(2)	63	44		
						(3)	48	56		
K	100	90	10	10	21	(1)	33	49	36	
						(2)	45	48	45	
						(3)	36	44	43	
O	67	48	15	53	12					
P	88	94	32	23	43					
R	65	22	36	1	27					
S	58	21	8	14	27					
W	63	72	17	38	39					
X	67	45	5	13	20	(1)	6	36	54	
						(2)	17		62	
						(3)	4		64	

*Blank spaces shown for 11th, 12th, and 13th Field Trips resulted from instrumental failure.

WATER DATA

Corrected Dissolved H₂S Data

H₂S in ppm

Station	Field Trip								
	6th	7th	8th	9th	10th	11th	12th	13th	
F	22.1	9.4	33.2	25.3	(1)	65.3	18.6	66.4	12.6
					(2)	67.5	12.8	69.1	13.9
					(3)	90.7	12.8	70.0	16.2
G	28.8	18.9	31.9	27.7	(1)	67.5	153.0	66.0	138.1
					(2)	70.5	153.5	69.0	141.0
					(3)	95.8	153.0	65.5	147.3
H	30.6	45.9	30.6	33.3	(1)	64.5	132.6	51.0	121.0
					(2)	68.4	133.5	56.0	118.5
					(3)	68.4	133.1	54.0	146.0
I	51.0	46.9	28.9	27.7					
J	25.5	12.3	29.4	17.7	(1)	69.6	140.3	62.7	117.0
					(2)	68.4	140.3	81.4	117.4
					(3)	117.3	140.2	86.4	121.5
K	22.1	52.6	26.0	19.1	(1)	139.7	156.9	121.4	161.2
					(2)	68.4	140.7	121.9	163.4
					(3)	69.2	138.2	141.0	196.2
O	52.7	13.1	31.1	21.4					
P	30.6	7.5	31.1	18.2					
R	6.8	44.6	31.5	16.3					
S	35.7	44.1	28.2	26.2					
W	18.7	45.9	31.1	30.6					
X	3.4	18.7	34.5	27.7	(1)	116.9	121.2	66.4	121.5
					(2)	67.5	123.3	71.4	121.5
					(3)	112.2	123.3	81.4	104.6

OBSERVATIONS AND CONCLUSIONS

Water Studies

In the report for the period, Dec., 1954 to Nov., 1955, a number of graphs were presented showing data correlations. Although we continued taking mainly the same type of data included in that report, the validity of the data and methods seem well established. Consequently, this report is primarily concerned with the presentation of data in the continuous characterization of the area and observations on the reproducibility of sampling. The data are not presented in any form other than tabular.

The results of field trips 10, 11, 12, and 13 are of particular interest for they help to answer the most important question, "How well do such data as were taken in the area of investigation really characterize the area and how reliable are the data?" On trips 11 and 12 three different water samples were taken from as near the same location as possible and subsequently analyzed to determine what variations might exist between samples that presumably should have given identical results. On trips 10 and 13 three different samples were also taken but in the following way: one sample on location, one sample 150 ft. downstream, and the third sample 150 ft. upstream from location. Most variations observed among three samples taken at the same location were within experimental error but variations lying outside experimental error should reflect real variations in the quantity being measured.

On such significant data as chlorinity, total solids, loss on ignition, and dissolved H_2S at stations G, J, and K there were variations among samples as great as 18% from the mean of the results for three samples taken from the same location. A mean deviation of 7% would include 90% of the results in these four types of determinations.

When samples were taken on locations 150 feet upstream and 150 feet downstream the variations between some of them were quite pronounced. These data are shown for field trips 10 and 13. When the same data are compared, i.e., chlorinity, total solids, loss on ignition, and dissolved H_2S , we observe variations from the mean at stations G, J, and K up to 52%.

The above observations bring us to the important conclusion that a single sample taken within 150 feet upstream or down from the correct location might differ from another taken along the same line by 70% or more. The anticipated difference, however, would be of the order

of 20%. Our data indicate that 82% of all samples taken in such a manner as described above should differ in the respects mentioned by less than 20%.

We do not feel that we have enough data of the kind taken on field trips 10, 11, 12, and 13 to subject them to rigorous statistical analysis, however, the data do indicate the above conclusions.

Beginning with the 10th field trip, hardness was determined by the EDTA method.

EDTA Procedure for Hardness. The ammonia buffer procedure described in Standard Methods for the Examination of Water, Sewage, and Industrial Wastes (1) was used for the total hardness determination. This method uses the sodium salt of 1-(1-hydroxy-2-naphthylazo)-5-nitro-2-naphthol-4-sulfonic acid (trade names: Eriochrome Black T, Pontachrome Black TA, Omega Chrome Black S, and a few others) as an indicator for the end point of the titration. This indicator forms a colored complex with magnesium and since the calcium-EDTA complex is more stable than the magnesium complex, calcium is sequestered first, then magnesium. Thus only the cations calcium and magnesium are reported as total hardness.

A second titration using the same procedure above, except that ammonium purpurate (2) (trade name: Murexide) instead of Eriochrome Black T was used as an indicator, was carried out to determine the hardness due to calcium alone. Thus the total hardness value can be resolved into hardness due to Ca^{++} and hardness due to Mg^{++} .

On the basis of the EDTA method applied to six stations in the more northern portion of the area it appears that they should be ranked in order: X, F, G, K, J, H of Fig. 2 as sources for industrial water with the latter station being the least desirable. Any other station lying north of F would probably be more desirable since it will have a higher fresh water content.

The determination of dissolved H_2S was included in this later work with the expectancy that there might be some correlation with biological oxygen demand. However, there appeared to be no correlation between dissolved H_2S and any other parameter.

Procedure for Dissolved H_2S . Two hundred milliliters of sample water collected in the field was treated with fifty milliliters of 0.1 N ammoniacal cadmium chloride solution and brought to the laboratory in brown bottles. This treatment removed the dissolved sulfide

from solution and further biological activity was arrested by the high pH of the final solution. The brown bottles were used to prevent photochemical decomposition of the cadmium sulfide. Later in the year, zinc acetate was substituted for cadmium chloride since the zinc sulfide is more stable to light.

In the laboratory the sulfide precipitate was filtered from the field solution and the filter paper and precipitate transferred to a 250 ml. Erlenmeyer flask which contained approximately one gram of zinc and 50 ml. of distilled water. The flask was then attached to a West condenser by means of a rubber stopper and the condenser mixture was connected to a gas absorption column containing 50 ml. of zinc or cadmium solution. (One absorption column was found to be sufficient). About 25 ml. of concentrated hydrochloric acid was rapidly blown (by mouth through a tube connected to a separatory funnel mounted on top of the condenser) into the flask. Then the mixture was vigorously refluxed 15-20 minutes during which time the hydrogen produced by the zinc and acid swept the H_2S out of the apparatus. The absorbent solution was then quantitatively transferred to a 250 ml. Erlenmeyer flask and stoppered with a rubber stopper through which was placed a 60 ml. separatory funnel and a glass tube to which a rubber hose and clamp were affixed. The flask was evacuated with an aspirator through the glass tube and then sealed by the clamp. Then the solution in the flask was made acid to phenolphthalein and 50 ml. of approximately 0.05 N iodine solution was sucked into the flask through the separatory funnel. The flask was vigorously shaken, then the excess iodine titrated with standard sodium thiosulfate using starch indicator. The equivalence of the iodine solution in terms of thiosulfate is determined and the calculation of the determined H_2S is as follows:

$$(\text{ml. thiosulfate} \quad 50 \text{ ml. } I_2 - \text{ml. thiosulfate required for excess } I_2)$$

(Normality of thios.)

$$\frac{(\text{milliequivalent wt. } H_2S) \times 10^6}{\text{Volume of sample in ml.}} = \text{ppm } H_2S.$$

MUD SAMPLES

In the summer of 1956 an extensive laboratory study was conducted on the analyses for total sulfur, sulfide, and free sulfur in Louisiana coastal muds. The

determination of total sulfur was approached by reduction of all sulfur to sulfide, with subsequent determination of the sulfide by evolution of H_2S . Various processes for this reduction were studied and applied without marked success. The problem of the determination of total sulfur in natural sediments is beset with adversity....samples appear to agree and then, for no reason, to be at variance. One then wonders whether it is the method or the sample.

Subsequent research conducted by us has indicated that a reduction method is a poor one for total sulfur. Experiments with a pure compound such as K_2SO_4 yielded sulfur recoveries of 90% or better. However, when the method was applied to mud samples, the endpoint of the iodometric titration became very indefinite. This indicated the presence of an interfering substance or substances. At this point this phase of the investigation was dropped because analytical methods of more immediate concern had to be developed. As a result we still do not have a reliable reduction method for determining the total sulfur content of our mud samples.

It appears that reproducible results for total sulfur in muds can be obtained by combustion using a Leco furnace which converts all the sulfur to SO_2 which is absorbed in $KI-HCl$ solution and titrated with KIO_3 .

This laboratory had access to a suitable furnace for one day and was able to get the following results for total sulfur in some mud samples.

Sample	Location	Trip	% S (all forms)
1	N	4	0.05
2	I	4	0.92
3	V	4	1.21
4	X	4	1.24
5	U	4	1.69
6	S	4	0.87
7	W	3	1.26

Three separate determinations on sample N₁ yielded identical values of 0.05% S. The reproducibility of the Leco furnace method is good, however, time did not permit a test for accuracy by adding known amounts of elemental sulfur or of sulfur containing compounds to the samples.

At the high operating temperature of the Leco furnace some of the chloride salts present in the mud samples can be converted to the metallic oxide of the cation and chlorine gas or oxides of chlorine in the

presence of oxygen. The chlorine gas reacts with the KI in the absorbent solution releasing I_2 which in turn oxidizes SO_2 to SO_4^{--} and thereby introduces a serious error in the determination. In such a situation the determinations on an individual homogeneous mud sample will be reproducible but not accurate.

Progress was made in the development of a colorimetric method for determining free sulfur, though the applicability of the method to natural sediments is still not certain. Since our method has not been used actually to determine free sulfur in the muds it is suggested that this should be attempted using the following procedure.

Take mud samples of about 0.1 gram, take duplicate samples of the same size with known quantities of sulfur added, and add to these an excess of reagent great enough to provide a full reaction mixture. If possible, add about the same amount of reagent to each sample. Place these in test tubes and heat them with slight swirling in an oil bath at $210^\circ C$. for exactly ten minutes. After cooling the samples, extract them with benzene until the blue color is completely removed, then filter the extracts into 25 ml. volumetric flasks (if the thioketone absorbs on the filter paper, it can easily be washed on through with benzene). Make up the final volume of extract to 25 ml. (it may be necessary to reduce this to 10 if there is only a small amount of sulfur in the samples). Measure the absorbance of the thioketone solutions obtained using the Beckman DU Spectrophotometer. Read the amount of sulfur present from the standard curve. The sulfur added should be accounted for. The per cent sulfur in the sample can then easily be calculated. If difficulties arise, the use of ultraviolet light or peroxides in the reaction should be attempted.

REFERENCES

1. Standard Methods for the Examination of Water, Sewage, and Industrial Wastes, American Public Health Assoc., Inc., 10th Edition, New York, p. 115.
2. West, Philip W. Louisiana State Engineering Experiment Station Bulletin, Series No. 23, 48 (1952).

ECOLOGICAL STUDIES IN TIMBALIER BAY
LOUISIANA, JAN.-OCT., 1957

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ABSTRACT

During the period from January, 1957, through October, 1957, ten field trips were made into the area of Timbalier Bay, Louisiana. On each trip samples were taken for chemical analysis, Foraminifera counts, and plankton counts at some or all of twenty sampling stations in the area.

The study was undertaken as a preliminary investigation toward identifying possible chemical parameters which might control the ecology of the embayed waters of coastal Louisiana. Diverse chemical data were collected and correlated with meteorological changes in the area and data obtained by the paleontologist and the biologist participating in the investigation.

Analysis of the data shows the following: (1) Chlorinity, total solids and salinity of the bay vary according to the amount of rainfall between field trips and in addition, vary with the relative location of the stations with regard to fresh water drainage discharge. (2) The major portion of the fresh water runoff enters the bay on the eastern side and moves across the bay in a WSW direction. (3) The optimum temperature for biological activity in the bay is somewhere between 23 and 30° C. (4) That total salinity of the water is not a primary limiting factor in the bionomics of the bay. (5) The life in the bay seems to be dependent upon land for its nutrient supply and (6) that the preference for a certain portion of the bay bottom (considered as sampling stations in the above analysis) by a genus of Foraminifera is controlled by something other than the gross nutrients received by that small portion of the bottom.

The most probable inorganic nutrients, phosphate phosphorous, and nitrate-nitrite nitrogen, were studied in this program but the results indicate that they are not of primary importance. However, we may be misled in this conclusion for there are no simple means of determining how much of the nitrogen and phosphorous is metabolically available to the organisms.

PREFACE

Ecological Studies in Timbalier Bay represents a joint effort by members of several departments at Louisiana State University. Cooperating in the project through the Coastal Studies Institute were the departments of Geology, Chemistry, and Zoology and Entomology, each department supporting, yet always serving as constructive critic to the others.

Most of the workers participating in this study had gained previous valuable experience through participation in a similar program for two years prior to the work reported here. During that time a chemical and biological study had been conducted on the waters and bottoms in the geographical area just north of Timbalier Bay. Resulting reports constitute the first sections of this volume.

Two principal factors contributed to the decision to go into Timbalier Bay proper and to launch a more extensive investigation there. A reasonably complete ecological study of any area would require some knowledge of the area draining into it; this information we already had from the previous study. The second factor influencing the decision to move the investigation southward was that in the brackish waters of the previous study, the water was too saline for life which normally inhabits fresh water and not sufficiently saline for the salt water organisms. By centering our activities farther south into Timbalier Bay proper the population of many forms of life increased. It was worthwhile to study also that sampling stations could be selected to tie into the northern area previously studied.

The biological data included in this report were obtained, interpreted, and presented by Dr. Richard T. Gregg, of the L. S. U. Department of Zoology and Entomology.

The data on the ecological study of foraminifera by Robert P. Waldron has been the subject of a separate report;¹ however, some of his data have been included and assimilated here as they seemed significant and pertinent.

¹Waldron, Robert P., a seasonal and ecological study of the foraminifera from Timbalier Bay, Louisiana, 71 p., Jan., 1958, a thesis submitted in partial fulfillment of the requirements for the M. S. degree; on file in the Louisiana State University Library.

INTRODUCTION

The present study was undertaken as a preliminary investigation toward identifying possible chemical parameters which might control the bionomics of the embayed waters of Coastal Louisiana. Relatively few studies of this type have been undertaken, i.e. studies in which samples for chemical analysis and specimens for biological study were collected simultaneously. If one or more chemical parameters could be established, a more detailed understanding of the complex food chain in the bays and possibly a new and more useful set of environmental boundaries could be provided. Since very little is known about the ecology of the Foraminifera, this latter possibility could provide new clues for the paleontologist.

The exact locations of twenty sampling stations are shown on the map of the area, Fig. 14. The appendix gives detailed locations of stations, along with the conditions of sampling.

The first field trip was made on January 9-10, 1957, with fairly high winds from the south and southwest. The water level was slightly below normal. Stations 26, 27, and 30 were not sampled because of high northerly winds and rain accompanying a passing cold front on the afternoon of January 10, 1957. Approximately 5 inches of rain fell in the area during December, 1956.

The second field trip was made on January 29-30, 1957. Approximately 0.3 inches of rain fell between this and the first field trip and the water level was at its minimum level with calm to moderate wind velocities from the S and SE.

The third field trip was made on March 13-14, 1957 during beautiful cool weather, slight winds from the E and a normal water level. Approximately 3.6 inches of rain fell in the interim between the second and third field trip. The analyses for carbohydrates, nitrate-nitrite nitrogen, and phosphate phosphorous were begun on the samples of this trip.

The fourth field trip was made on May 8-9, 1957, with 14 inches of rain falling prior to this trip. On this trip all the forms of aquatic life, micro and macro, which were to be found through field trip 7, were found in recordable numbers. Cloudy weather accompanied by high winds from the E and SE prevailed throughout the field sampling. Water levels were normal.

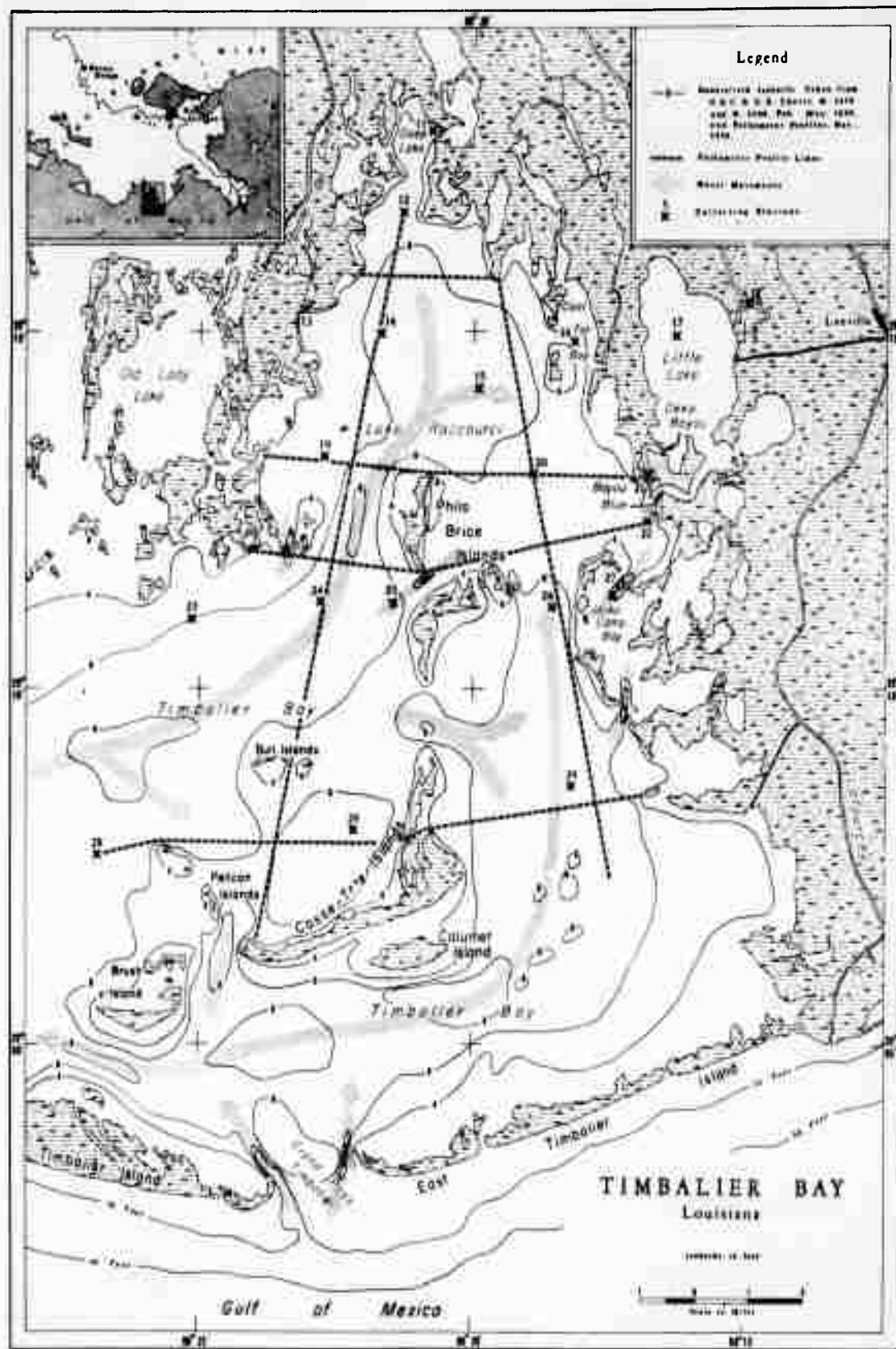


Figure 14 Sampling stations (Chemistry) in Timbalier Bay.

Moderate wind velocities from the S and SW prevailed during the fifth field trip which was made on May 30-31, 1957. Approximately 1 inch of rain fell before this field trip. The water level was above normal.

Field trip 6, June 19-20, 1957, was marked by a large increase in total count of aquatic organisms. Slight to moderate S, SE wind velocities were recorded and the water level reached its maximum height on this field trip. This trip was preceded by approximately 8 inches of rain in the area.

During field trip 7, July 15-16-17, fair weather with calm waters and winds prevailed. Approximately 2.3 inches of rain fell prior to this trip. Only chlorinity data were taken on this trip. There was insufficient time to process the other samples.

On field trips 8, 9, and 10, made in August, September, and October, respectively, only mud samples for Foraminifera counts and water samples for chlorinity were taken.

Tide levels are indicated as normal, above normal or below normal only. This is because, in the coastal marshes of Louisiana, wind direction, velocity and duration have a great effect on the actual water level than the lunar cycle. The difference between the minimum and maximum water levels recorded during this program was approximately 2.5 feet.

The following experimental determinations were made: pH, temperature, chlorinity, sulfate, total solids--before and after ignition at 500° C., Eh, and alkalinity. All the above analyses were completed on 20 stations from field trips 1 through 6. Chlorinity determinations and salinity calculations were completed through the samples of field trip 10. Carbohydrate, nitrate-nitrite nitrogen, and phosphate phosphorous were analysed in both surface and bottom water samples from field trip 3 through 6. Sulfide was spot checked on the field trips, but was not present in the waters. Silicate silicon was determined on samples of field trips 5 and 6.

All chemical and physical data are presented in tabular form in the appendix of this report. Specialized presentation of data is limited to those data which are of greater interest in the discussion of the results of this research program.

Differences in such things as chlorinity, nitrate-nitrite nitrogen, phosphate phosphorous, carbohydrates, and in some physical measurements, were so small as to be

negligible between surface and bottom waters at the same station.

FIELD PROGRAM

The area studied covers approximately 70 square miles and includes Lake Raccourci, Little Lake, and the upper half of Timbalier Bay.

In October 1956, the area was reconnoitered in a small skiff. A more intensive field survey was conducted in a larger boat in November, during which time preliminary bottom profiles were recorded with a fathometer.

The twenty stations shown on the map were established in December. Each station was marked with a set of canes 15 to 20 feet in length to expedite location of the station on subsequent field trips. Locations of the various stations were established by determining with a sextant the two angles between three reference points of known location. The reference points selected were objects such as channel lights, water tanks, lighthouse camps, and tank batteries which were located accurately on the chart. The two angles were set on corresponding arms of a three armed protractor, and on passing the center line of each arm through the corresponding reference points, the station location was obtained at the vertex.

Early in January, the field sampling program was started with subsequent trips made at approximately one month intervals through July 1957. A total of seven field trips were made on which samples for complete chemical analysis were taken.

BOTTOM PROFILES. During the field reconnaissance period information regarding the bottom topography was needed to lay out the sampling stations. The charts available gave very little information on channels or clues to the drainage pattern of the area. At a later date additional fathometer traverses were made to complete the coverage of the study area. The various traverses are shown on the map. No channels were found. The bottom of the bay is flat with water depth ranging from about 5-8 feet over the major portion of the bay and reading a maximum of 10-11 feet at station 30.

FIELD SAMPLING EQUIPMENT. Most of the equipment used in the field was simple and easily obtained or constructed. Only the construction of the self-flushing water sampler and the coring device required machine shop facilities.

A well aged -3° to 50° centigrade thermometer with 0.2° subdivisions was used to determine the temperature of the waters.

The sounding line was a 0.5 inch Manila line weighted at one end and marked every six inches with colored twine.

The pH and Eh measurements were made with a pair of Beckman Model N portable pH meters. One meter was equipped with a Calomel reference electrode and a glass electrode and the other meter was equipped with a Calomel reference electrode and platinum electrode. All four electrodes were mounted in a single large rubber stopper which fit the top of a polyethylene beaker. This arrangement essentially made possible the measurement of pH and Eh simultaneously on the same water sample. A buffer solution of pH-7 was used to set and frequently check the meter used for pH measurements. The condition of the Eh electrodes was checked by adding a small amount of quinhydrone to a portion of buffer solution pH-7, and by comparing the meter readings to the value of Eh calculated for that temperature.

Two-and-one-half gallon polyethylene bottles were used to collect surface water samples.

Bottom water samples were collected in one of two samplers. The first sampler was a single glass stoppered BOD bottle with a flat lead weight attached to the bottom of the bottle. A simple twine bridle was used to raise and lower the sampler. A second line was attached to the glass stopper. A second sampler which carried five BOD bottles was used for collection at most field stations. The self-flushing feature of this sampler made possible the collection of samples of dissolved gas analysis. The base of the sampler was a heavy circular brass plate with a one inch in diameter brass stud center in an upright position. A vertical rim around the circumference of the plate held the BOD bottles tightly against each other and the center stud, thus, automatically positioning the bottles. The brass top plate was secured to the base by a brass eye bolt which screwed into the center stud. Five rubber washers, spaced to fit the mouths of the BOD bottles, were cemented to the lower side of the top plate. These washers cushioned the bottles and formed an air tight seal. Copper tubing was used to join the mouths of the various bottles. The tubing, which soldered to the top plate, was so arranged that water entering the sampler was conducted to the bottom of the 1st bottle. When this bottle was filled the overflow was conducted to the bottom of the next bottle. This process was repeated until all bottles were joined. The air escape port, which was considerably smaller than the connecting tubes (to prevent

back flow), was located above the mouth of the 5th bottle. In operation the 1st sample bottle was flushed with four times its volume of water, thus providing a reliable field sample.

The sample was lowered and raised by a line, which was attached to the eye bolt by means of a snap swivel. A rubber stopper fitted with a lanyard was used to seal the air escape port until the sampler was on the bottom.

The coring device was a fifteen foot wooden pole attached to a split collar fitted with a t-bolt. This collar fit over the upper end of a 2 1/2 foot section of a 2 1/2 inch plastic tubing and could be securely tightened so that the plastic tube became an extension of the pole. A removable ball type valve fit the top of the plastic tube. It consisted of two large brass washers separated by a two inch thick rubber washer, the diameter of which was slightly smaller than the inside of the plastic tube. The rubber washer could be compressed and caused to press tightly against the inside of the tube by tightening the four brass machine screws that join the two washers. A rubber ball that seats in the upper washer was attached to a large lead washer by a length of chain which was passed through the valve assembly. Water pressure opened the valve during its descent; prior to ascent the lead weight caused the ball to become seated.

FIELD SAMPLING AND SAMPLE HANDLING. Once the boat was securely anchored on station sampling was begun. Wind velocity and direction were estimated and recorded. The polyethylene bucket was used to collect a surface sample. Surface water temperature was measured and recorded. A beaker full of sample was removed for pH and Eh measurement, which were made as quickly as possible. The following portions of surface sample were removed: approximately 12 ounces in a 16-ounce screw capped bottle, a full 16-ounce bottle, a full 4-ounce bottle, and 50 ml. pipetted into an alkalinity bottle. During the early trips portions were removed for the sulfide analysis.

The bottom water sampler was lowered over the side, and the stopper was withdrawn. After approximately five minutes the sampler was brought aboard, and the top plate was removed. The temperature was taken as quickly as possible, followed by removal of a portion from the 1st bottle for pH and Eh measurements. The remainder of the 1st bottle was used for a 50 ml. alkalinity sample and as a part of the 12-ounce sample. Bottle No. 2 was used to complete the 12-ounce sample. After filling the salinity bottle the remainder of the water was poured

into the 16-ounce bottle. Usually a portion of the 3rd bottle was needed to complete the 16-ounce sample.

All bottles were checked for proper labels. The alkalinity, salinity, and 16-ounce sample bottles were stored in an upright position in their respective field boxes. The 12-ounce sample, the one which would be used for phosphate, nitrate, and carbohydrate analysis, was immediately packed in an upright position in the dry ice chest to be quickly frozen.

Bottom samples were collected with the coring device. After forcing the plastic coring tube into the bottom sediment it was brought to surface. The push pole and the valve assembly were removed. A plunger was inserted in the cutting end of plastic tube, and the core was extruded upward. The uppermost one inch layer was removed with a spatula and transferred to a plastic bag. The bag was sealed, placed in a one pint frozen food carton, labeled and stored in the dry ice chest.

LABORATORY PROGRAM

Laboratory work was commenced early in September 1956. Approximately six weeks were spent in equipping the laboratory, standardizing methods, and orienting the workers in the field. A literature survey necessary to find, evaluate, and develop methods of chemical analysis was started the latter part of October, but the work was delayed by preparation for field work.

As the various procedures were decided upon the required chemicals and laboratory equipment were obtained. After a laboratory evaluation of a given procedure, necessary modifications were made, and the procedure was standardized. Any additional chemicals, apparatus or field sample bottles necessary were obtained and the analysis was added to the program. In most cases a minimum of one month was required to evaluate, standardize, and add an analytical procedure to the study.

Several additional analytical procedures were in the process of being worked out when the program terminated. Two of these analyses were delayed several months because necessary chemical reagents were not available locally and orders incurred considerable delay. A summary of these prepared procedures will be given at the end of this section.

PROCEDURES

Chlorinity (o/oo). A slight modification of the standard Knudsen method of determining chlorinity was employed.

Since Knudsen burettes or pipettes were not available, a precision burette with 1/20 ml. subdivision and a 15 ml. pipette with a stopcock feature similar to the Knudsen model were used. A motor driven stirrer was used in place of hand stirring, and with some practice the operator achieved a standard procedure of stirring. In all other ways the Knudsen procedure was followed.

Salinity (o/oo). Hydrographical Tables of Knudsen were used to convert chlorinity values to salinity values. These tables are based upon the universally accepted equation, relating salinity and chlorinity - $S = 0.030 + 1.8050 C_l$ where salinity and chlorinity values are in parts per thousand (o/oo).

Alkalinity - (Milliequivalents per liter). A procedure worked out by Anderson and Robinson (1946) was used to determine the alkalinity of the water samples. The term alkalinity is defined as being the number of milliequivalents of hydrogen ion neutralized by 1 liter of sea water at 20°C. In this procedure a carefully measured volume of standard hydrochloric acid solution was treated with an accurately known volume of water sample, and after a thorough mixing the pH was determined with a pH meter which was equipped with a calomel reference electrode and a glass electrode.

Using the following relationship the hydrogen ion activity, C_{H^+} f_{H^+} , was calculated from the measured pH value:

$$pH = -\log C_{H^+} f_{H^+}$$

Upon division of the hydrogen ion activity value by an interpolated value of f_{H^+} worked out by Anderson and Robinson, which is chlorinity dependent, the hydrogen ion concentration was obtained. This value was used in the equation developed by Thompson and Bonner (1931) to complete the calculation.

$$\begin{aligned} \text{Alkalinity} &= \frac{1000}{\text{Ml. of Sample}} \times (\text{Ml. of HCl} \times N \text{ HCl}) - \\ &\quad \frac{1000}{\text{Ml. of Sample}} \times (\text{Ml. of Sample} + \text{Ml. of HCl}) \\ &\quad \times (C_{H^+}). \end{aligned}$$

The 50 ml. volume of water sample and 15 ml. of approximately 0.01N hydrochloric acid were worked out experimentally so that the pH of the resulting solution would be between 3.0 and 4.0. This range is a desirable

one in which the f_{H+} has the minimum amount of deviation throughout the chlorinity range of 2 to 29 grams halide per liter.

With the above volumes and the actual normality of the hydrochloric acid used, 0.00997N, the above equation reduces to simple form:

$$\text{Alkalinity} = (2.991) - (1300) \times (C_{H+})$$

In actual practice a table of C_{H+} values was calculated so that from the pH meter reading and chlorinity value of the sample, the value of C_{H+} was immediately obtained. It was a simple matter to quickly complete the calculation and arrive at the desired results.

The larger part of the alkalinity determination was conducted in the laboratory. Four dozen brown 4 ounce screw-cap bottles were acid aged by filling with dilute hydrochloric acid solution, pH3 (approximately), and allowing them to stand several weeks. Just prior to a field trip, into each clean, dry bottle was pipetted a 15.00 ml. portion of standard hydrochloric acid solution. The bottles were tightly capped and stored upright in their field cases. At each station in the field a 50 ml. sample of surface and bottom water were added to the appropriate bottles. Again the bottles were tightly capped and returned to their field cases. As soon as practical after returning to the laboratory, the pH of each sample was determined. A buffer solution of pH4 was used to set the pH meter. Frequent checks with the buffer solution were made during the determination.

Carbohydrates (Milligrams per liter of sucrose equivalent).

The colorimetric procedure of Lewis and Rakestraw (1955) was used to determine the amount of material responding to a carbohydrate reagent. Anthrone was used as the reagent rather than N-ethyl carbozale because anthrone is a more stable reagent, and reaction conditions are more easily controlled. Consequently, it is capable of giving more reliable results.

The anthrone reagent was prepared by dissolving one gram of anthrone in one liter of concentrated sulfuric acid. It was stored in a glass stoppered bottle in the dark under refrigeration. A freshly prepared solution was allowed to age overnight before using. Although the preparation is supposedly stable for one week, the mixture was discarded after the fifth day.

Sucrose was used as the primary standard. A stock solution containing 50 mg. sucrose per liter was prepared

by placing 500 mg. of analytical reagent grade sucrose in a one liter volumetric flask, filling to mark with distilled water, and diluting 50 ml. of this solution to 500 ml. with distilled water to which several drops of saturated mercuric chloride solution had been added as a preservative. This solution was good for about one week if stored under refrigeration. Standard solutions were prepared by diluting the stock solution - for example - 20 ml. of stock solution was diluted to 100 ml. with distilled water to give a standard solution containing 10 mg. of sucrose per liter. From five to nine standard solutions ranging in sucrose concentration from 1 to 10 mg./l were used to establish the reference curve.

A Bausch and Lomb Spectronic "20" colorimeter with a one inch absorption test tube was used to determine the optical density of the solutions and samples at a wavelength of 625 millimicrons.

The procedure used was the following: 7.5 ml. of standard solution or a filtered sample from the frozen portion was transferred to a 60 ml. glass stoppered bottle. Anthrone reagent, 15 ml., was slowly added with as little mixing as possible to form two discrete layers. The bottle was stoppered, and the solutions were thoroughly mixed and immediately placed in a pan of water which was maintained at room temperature. A reagent blank was prepared with distilled water. The colorimeter was allowed to warm up, and the dark current was zeroed. Between 15 and 25 minutes after the addition of the anthrone reagent the samples were ready for measurement. After the instrument was zeroed with the reagent blank, optical density measurements were made on the standard solutions and samples. Reference curves were determined daily by plotting optical density values against the corresponding sucrose concentrations (in mg. per liter), for the standard solutions. Straight lines with slopes ranging from 25 to 33 were obtained. Reference curves were usually the results of three sets of standard solutions, one run before the sample, one run in the middle of the sample run, and one run following the samples. The slope of the curve was determined and was used to convert the optical density reading of the samples to mg. per liter, sucrose equivalents.

In distilled water, this method is reported to be sufficiently reproducible to limit the error to less than 5%. However, there is a salt error which decreased this accuracy in saline water. It would be possible to correct for the salt error by making a series of reference curves at various salinities and then using the curve corresponding to the salinity of the field sample.

This suggestion was not carried out since it is time consuming, and a high degree of accuracy was not believed necessary for this initial survey.

Nitrate-Nitrite Nitrogen (Microgram atoms, per liter).
Reduced strychnine (strychnidine) a colorimetric reagent for nitrates and nitrites was first used in sea water analysis by Harvey (1926). Zwicker and Robinson (1944) improved the reagent employed by Harvey and changed the procedure to a photometric method. This latter procedure, as recently modified by Marvin (1955), was used in this study to obtain an estimation of the nitrate-nitrite nitrogen concentrations.

The strychnidine reagent was prepared by dissolving 0.3 millimoles (0.092 g.) of the reagent in one liter of nitrate-free, concentrated sulfuric acid. An acid aged glass-stoppered pyrex bottle was used to store the reagent, which was stable for several months if stored in the dark.

Standard nitrate solutions for the preparation of reference curves, were prepared from a stock solution of sodium nitrate in a distilled water solution of 25 c/oo chlorinity. The stock solution, containing 500 microgram atoms $\text{NO}_3 - \text{NO}_2 \text{ N}$ per liter, was prepared by dissolving 0.8501 grams of dry, analytical reagent grade sodium nitrate in enough distilled water, which contained sufficient c.p. sodium chloride to give 25 o/oo chlorinity, to make one liter; 25 ml. of this solution was diluted to 500 ml. with more 25 o/oo chlorinity water which contained several drops of saturated mercuric chloride solution as a preservative. This solution was stable for about a week when stored under refrigeration. Sets of standard solutions (five to nine samples to a set) containing from 1 to 10 microgram atoms $\text{NO}_3 \text{ N}$ per liter were prepared by diluting 0.5 to 5 ml. portions of stock solution to 250 ml. with 25 o/oo chlorinity water.

A Bausch and Lomb Spectronic "20" colorimeter equipped with 1/2 inch absorption test tubes was used to measure the optical density of the reaction mixtures at a wavelength of 525 millimicrons.

Samples used in this analysis were taken from the frozen portion of the field sample. One milliliter was withdrawn with a transfer pipette from a thoroughly mixed, freshly thawed sample bottle, and placed in a 10 ml. pyrex test tube. This aliquot was diluted with exactly 2 ml. of distilled water, followed 3 ml. of strychnidine reagent. The acid reagent was allowed to slowly run down the inside of the test tube, which was tilted to a 45° angle, so that it formed a layer under the diluted water sample. This precaution prevented boiling of the

sample during the addition of the strychnidine. Mixing was achieved by gently pouring the contents of the test tube into a 15 ml. test tube and back again, only once. Immediately the reaction mixture was placed in the dark where it remained for four hours before measuring the absorbancy.

The colorimeter was turned on and allowed to warm up for fifteen minutes before it was used. The dark current was set at infinity on the optical density scale. A reagent blank, prepared from strychnidine reagent and distilled water containing 25 o/oo chlorinity, and aged for four hours, was used to set the instrument at 0 on the optical density scale.

The colored sample solutions were transferred to the absorption cell, and the optical density was determined. Standard samples were analysed in the same manner, with one set being run before and one set after the field samples. Average values for the standard samples were used to plot optical density against microgram atoms of nitrate-nitrite nitrogen per liter. The slope value from the standard solution curve was used to convert instrument readings for the samples into nitrate-nitrite nitrogen concentrations.

This is another analytical procedure subject to a "salt" error, but with the utilization of standard nitrate solutions mixed with 25 o/oo chlorinity water this error has been minimized.

Phosphate Phosphorus (Microgram atoms per liter). An estimate of the inorganic phosphate phosphorus was made by the Molybdenum blue method. The method is an empirical one which includes the equivalent of any arsenate that is present and any acid soluble particulate phosphate.

Various procedures for this analysis have been reported by a number of investigators, Robinson and Thompson (1948), and Wooster and Rakestraw (1951). Features of these last two publications were combined to give the procedure used in this study. Quick freezing of samples at the time of collection as advocated by Collier and Marvin (1953), was employed to preserve the samples until they were analysed. The acid molybdate reagent was prepared by dissolving 9.75 grams of analytical reagent grade ammonium molybdate in 225 ml. of distilled water; the resulting solution was diluted with a mixture of 165 ml. of concentrated sulfuric acid and 525 ml. of distilled water, which had been cooled to room temperature. A one liter glass stoppered, acid aged, pyrex bottle was used to store the reagent. After the initial 48 hours this

reagent was relatively stable for several months.

Stannous chloride solution was prepared by dissolving 2.1 grams of reagent grade, granulated (20 mesh) tin metal in 22 ml. of reagent grade concentrated hydrochloric acid. Several hours were required for the solution, after which the acid solution was diluted to 200 ml. with distilled water. Several pieces of mossy tin were added, and the reagent was stored in a glass-stoppered bottle under a protective layer of toluene.

Several liters of approximately 0.28 N sulfuric acid in distilled water were prepared for use as a solvent in the preparation of stock phosphate standards. The stock solution was prepared by diluting 1.3609 grams of dry, analytical reagent grade monobasic potassium phosphate to one liter with 0.28 N sulfuric acid. Ten milliliters of this solution was diluted to one liter with a portion of the diluted sulfuric acid which had been saturated with chloroform. The resulting solution, which is good for several weeks if refrigerated, contained 100 microgram atoms of phosphate phosphorus per liter. Sets of standard phosphate solutions, ranging from 0.2 to 1.0 microgram atoms $\text{PO}_4 - \text{P}$ per liter were prepared by diluting 1 to 5 ml. of the stock solution to 500 ml. with distilled water.

A Fisher Electrophotometer fitted with 60 ml. absorption cells was used to measure the color intensity. A suitable filter was used that transmitted at 700 millimicrons which is the absorption maximum of the molybdenum blue complex.

Shortly before the analysis was started, the water samples were thawed, thoroughly mixed, filtered through a quantitative paper, and allowed to reach room temperature. One hundred milliliter portions of sample or standard solution were carefully measured in a graduated cylinder and transferred to a pyrex flask. Acid molybdate reagent, 4.5 ml., was added from a graduated pipette, and while the contents of the flask were swirled, 3 drops of stannous chloride solution were introduced. Between 15 and 25 minutes later, a portion of the mixture was transferred to a 60 ml. absorption cell, and its color intensity was measured. Distilled water was used in the other cell as a reference solution, but a reagent blank prepared with distilled water was run to ascertain if a correction need be applied to sample and standard solution readings.

A curve showing transmittancy as microgram atoms $\text{PO}_4 - \text{P}$ per liter was made from the set of standard solutions, which were run before and after the samples.

The slope of the resulting straight line was used to convert the instrument readings for the samples into phosphate-phosphorus concentrations.

The color development in this procedure is temperature and time dependent. Consequently, precautions were observed to keep a run at a fairly even temperature, and that the time intervals from the addition of the stannous chloride until the instrument was read were as uniform as possible.

Silicate (Microgram atoms silicate silicon per liter). The procedure published by Robinson and Thompson (1948) was used to determine the dissolved silicate in the waters. By this method silicate is converted by molybdate to a yellow-colored compound which is probably the heteropoly acid $\text{H}_8\text{Si}(\text{Mo}_2\text{O}_7)_2$.

The samples were collected in sea water-aged amber bottles and frozen in the field with dry ice. In the laboratory the freshly thawed samples were filtered and a 50 ml. portion of sample treated with 0.25 ml. 6N sulfuric acid and 0.5 ml. ammonium molybdate reagent (10 gms. of $(\text{NH}_4)_6\text{Mo}_7\text{O}_{24} \times 4\text{H}_2\text{O}$ dissolved in 100 ml. distilled water) in a 125 ml. pyrex Erlenmeyer flask. The transmittance at 410 millimicrons was measured using a 25 mm. round cell in a Bausch and Lomb Spectronic "20" colorimeter not less than 10 minutes or later than one hour after addition of the molybdate reagent.

The concentrations of the sample were determined by comparing their transmittancies with a reference curve which had been prepared with a sodium silicate solution standardized by the gravimetric method. This method used perchloric acid for the dehydrating acid as described in the tenth edition of Standard Methods for the Examination of Water and Sewage. (1955).

Sulfate (Milligram atoms sulfate sulfur per liter). The sulfate concentration in the first two field trip samples was determined by the turbidimetric method described in the tenth edition of Standard Method for the Examination of Water and Sewage (1955) prepared by the American Public Health Association and American Water Works Association. A light scattering photometer was used to measure the transmittance and also the scattering of light by the turbid solution at 90° to the incident light beam. A study was made to determine if the turbidimetric or the nephelometric method was more accurate. Both methods have a maximum error of about $\pm 10\%$ of the sulfate concentration.

In the meantime Bertolacini and Barney II (1957) published a colorimetric method employing barium chloranilate as the color developing reagent. The principle of the method is that upon the addition of solid barium chloranilate to a 50% ethanol solution containing sulfate, barium sulfate precipitates with the resultant release of an equivalent amount of chloranilic acid which is measured colorimetrically. The procedure outlined by Bertolacini and Barney II (1957) was modified slightly to suit our needs.

Two milliliters of sample were passed through an ion exchange column 8 mm. I.D. and containing 2 1/2 gms. dry weight of Dowex 50 x 8 resin of 200-400 mesh. (This amount of resin was sufficient for the removal of all cations from 10 ml. of sample before regeneration, but not more than 6 ml. of sample was passed through between regenerations with 8 M. HCl). The sample was washed through the column with distilled water in three washings of 2-3 ml. The total effluent volume was increased to about 25 ml., pH adjusted to pH4 using a Beckman Model N-2 pH meter, and 10 ml. of buffer solution (0.05M $\text{KHC}_8\text{H}_4\text{O}_4$) added. The adjusted sample was transferred to a 100 ml. volumetric flask, 50 ml. of ethanol and about 0.3 gm. barium chloranilate crystals added and after cooling, the solution was brought up to volume, shaken well and allowed to stand overnight to eliminate the necessity of filtering out the excess reagent and precipitated barium sulfate. The following morning 25 ml. of the sample was pipetted into a 25 mm. round cell, and optical density was measured with a Bausch and Lomb Spectronic "20" colorimeter.

The concentrations of the samples was determined by comparing their optical densities to a reference curve prepared by using reagent grade sodium sulfate as a standard. The reported accuracy of this method is $\pm 1\%$.

Barium chloramilate was prepared by reacting several liters of 0.1% aqueous chloranilic acid solution with an equal volume of 5% aqueous varium chloride solution and allowed to stand overnight to permit proper ageing of the crystals.

Chloranilic acid was prepared from chloranil by the procedure of Stenhouse (1870).

Sulfide. The colorimetric method described in the tenth edition of Standard Methods for the Examination of Water and Sewage (1955) was applied, without modification, to these waters. This method is based on the reactions which take place under suitable conditions between para-aminodimethylaniline, ferric chloride, and sulfide ion resulting in the formation of methylene blue. Ammonium

phosphate is added prior to color comparisons to remove the color due to the presence of ferric ion.

Care was taken not to aerate the sample and a 7.5 ml. portion was pipetted into each of two test tubes. The test tubes were approximately 125 mm. long and 15 mm. in outside diameter. One half milliliter of para-aminodimethylaniline, dissolved in sulfuric acid, was added to one test tube and 0.5 ml. 1:1 H_2SO_4 added to the second tube. Then 0.1 ml. or 2 drops, of ferric chloride solution was added. The tubes were closed with the thumbs and inverted slowly twice. If sulfide is present, a blue color occurs immediately in the first tube and color development is complete in one minute. After 1 to 5 minutes 1.6 ml. ammonium phosphate solution was added to each tube and the solution mixed. The color is stable for about 2 hours.

The concentration of the sulfide present was determined by adding dropwise a standard solution of methylene blue, for which the sulfide equivalency per drop was known, to the second tube until the color intensities were the same.

This method was taken to the field, but at no time was sulfide found in these waters.

Total Solids (o/oo). Porcelain crucibles of approximately 50 ml. capacity were dried to constant weight in an oven at $105^{\circ}C$. Fifty ml. water samples were placed in the crucibles and evaporated to dryness on a warm hot plate. The crucibles and residues were then dried a minimum of 48 hours in the oven and assumed to be at constant weight. All weighings were made to the nearest 0.1 mg. The total solid content was calculated from the volume of water sample and the weight of the residue.

This technique is similar to that employed in standard water analysis, but the possibility of errors was examined. Some of the solid residue obtained is crystalline and probably contains water of hydration which cannot be removed without heating to higher temperatures. Any appreciable increase in temperature would probably decompose the organic material and certain of the inorganic carbonates and halides and, thus, introduce additional errors in the determination.

To evaluate the above possibility, the crucible and residue, after having been weighed, were heated to $600^{\circ}C$. in a furnace for 15 minutes, allowed to cool to room temperature in a dessicator, then weighed again. Laboratory observations indicated that the loss of

weight upon heating at 600° can be attributed mainly to water of hydration. Very small amounts of halide salts are vaporized, and there is never much organic material present.

PROPOSED PROCEDURES

Proteins. A procedure reported by Feigl (1954) is a simple and quick qualitative test for protein. This test should prove to be very useful if the protein content of the bay waters is high enough to react with the reagent. The principle underlying this analysis is the "protein error" of an indicator which is strongly affected by protein.

A 0.1% solution of the potassium salt of tetrabromophenolphthalein ethyl ester in alcohol is used as the test reagent. Several drops of water sample are mixed on a spot plate with several drops of reagent. Upon acidification with a couple of drops of 0.2 N acetic acid a blank test turns yellow, while the color remains deep blue if protein is present. The color may be green if only a small amount of protein is present.

Sensitivity of the test is less than 1 microgram, with an average of about 0.6 micrograms.

Alpha Amino Acids. A photometric procedure for the quantitative determination of Alpha Amino acids as reported by Moore and Stein (1948) appears adaptable to water sample analysis. Ninhydrin, purified by recrystallization, is used as the test reagent. The color produced by the reaction of ninhydrin with the NH_2 group is rendered reproducible by the incorporation of stannous chloride. To speed up the analysis, test tubes (100 x 15 mm) selected for their optical properties are used as reaction vessels. The reaction is carried out at pH 5 at 100°C. Color intensity is measured at a wave length of 570 millimicrons by use of a colorimeter.

Details for the selection of test tubes, purification of ninhydrin, preparation of stannous chloride and citrate buffer solutions are given in the above reference, as well as a detail account of the analytical procedure.

The alpha amino acid concentrations may not be sufficiently high in the bay waters to react with ninhydrin, therefore, a procedure to concentrate the amino acids may have to be worked out. A second consideration is possible interference from other substances in the field sample which would make it necessary to treat the samples prior to analysis.

Copper. The method for determining copper in sea water published by Chow and Thompson (1952) was in the process of being applied to these waters when this project terminated. This method used sodium diethyldithiocarbamate as the color forming reagent and the resulting copper diethyldithiocarbamate is extracted into xylene and measured colorimetrically at 436 millimicrons.

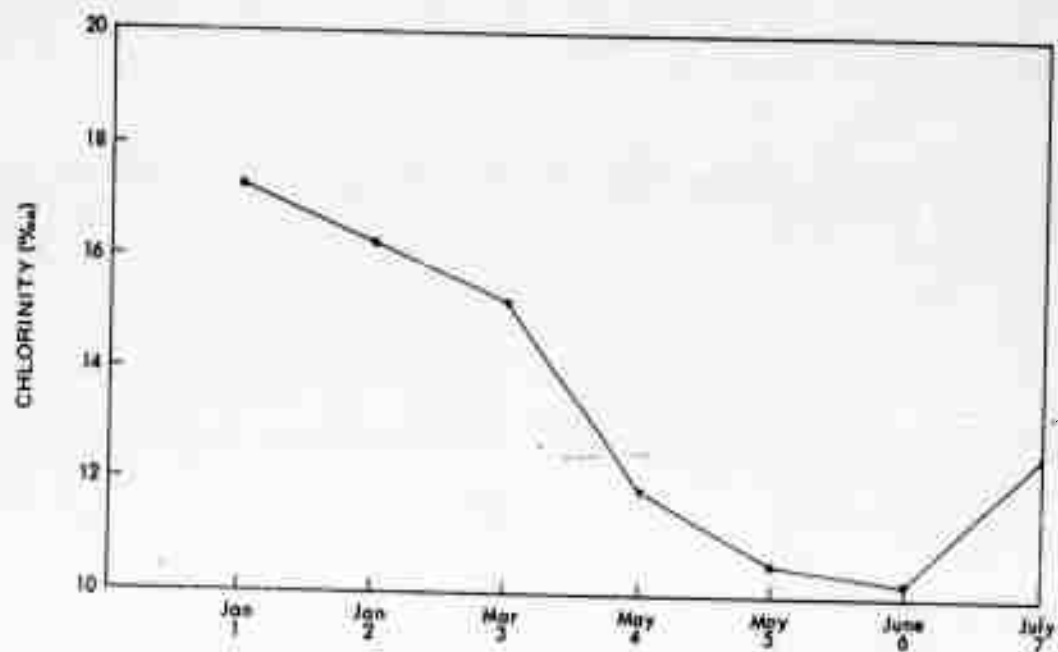
DISCUSSION OF DATA

From the chemical data the following plots were made; sulfate versus carbohydrate, sulfate versus phosphate as phosphorous, sulfate versus nitrate-nitrite nitrogen (hereafter called simply nitrogen), phosphorous versus chlorinity, carbohydrate versus Eh, carbohydrate versus phosphorous, carbohydrate versus salinity, nitrogen versus salinity, and sulfate versus salinity. The points on all the above graphs were scattered and the stations did not hold their relative positions on the graphs for successive field trips. This implied that the concentrations of the ions being measured are independent of each other and the chemical parameters other than chlorinity, total solids and the calculated salinity at the individual stations are independent of their relative locations. Typical chlorinity, total solids and temperature data are shown graphically in Figs. 15 and 16.

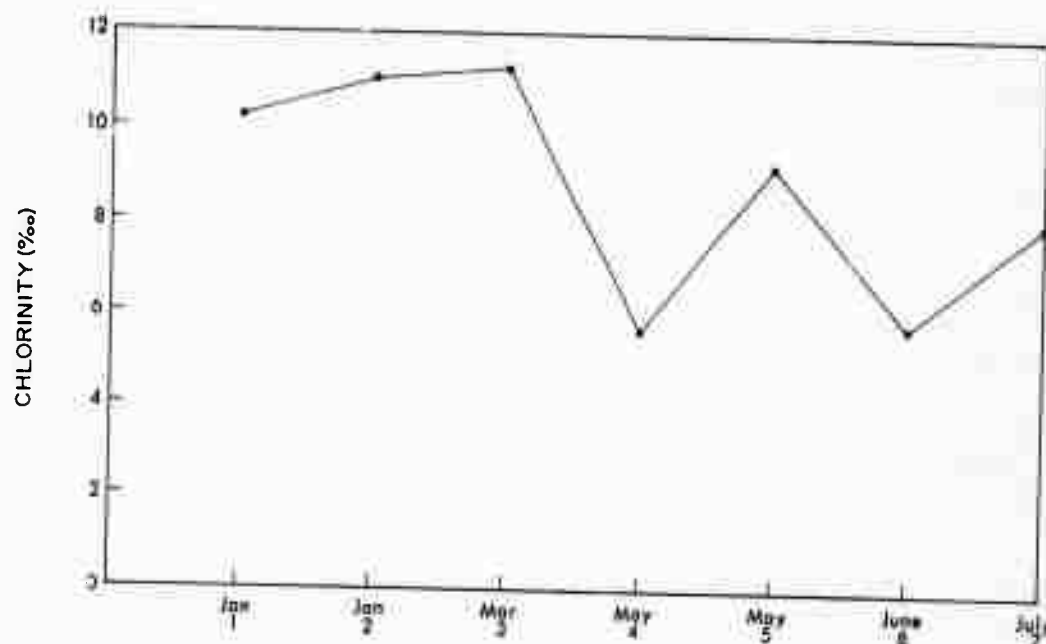
The data were then plotted on maps to determine if any unique chemical conditions were created in sections of the bay by heavy rainfall or increased salinity due to Gulf water being driven in by strong Southwest winds, or perhaps that sections of the bay remained unaffected by these natural changes.

Chlorinity, total solids, and salinity of the bay vary according to the amount of rainfall between field trips and in addition, vary with the relative location of the stations with regard to fresh water drainage discharge. The salinities range from 10 to 33 o/oo. The major portion of the fresh water run-off enters the bay on the eastern side and moves across the bay in a WSW direction. This is reflected by the constant East-West salinity gradient in the bay. East Timbalier Island forms a barrier which prevents direct southerly drainage into the Gulf of Mexico.

Carbohydrate, nitrogen, and phosphorous do not present any distribution pattern, but occur at all stations. Carbohydrate increased at all 20 stations on the fifth field trip, nitrogen increased at 14 stations on the fourth field trip and phosphorous increased at 10 stations on the fourth field trip and at 14 stations



Typical Chlorinity vs. Field Trip Number (Time in Year) for Stations 28, 29, and 30.
(Data for Station 29)



Typical Chlorinity vs. Field Trip Number (Time in Year) for All Stations except
Numbers 28, 29, and 30. (Data for Station 17)

Figure 15

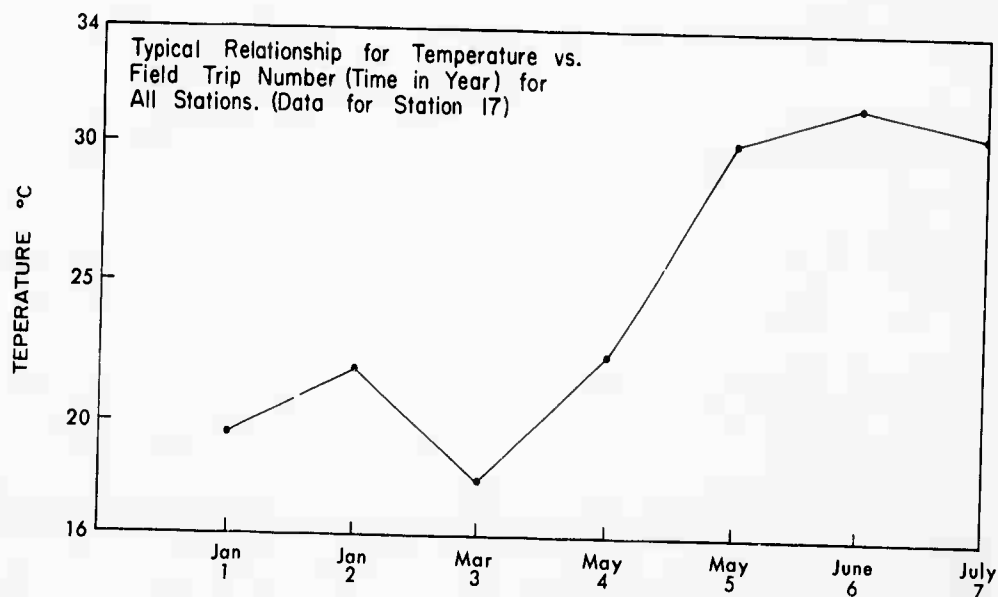
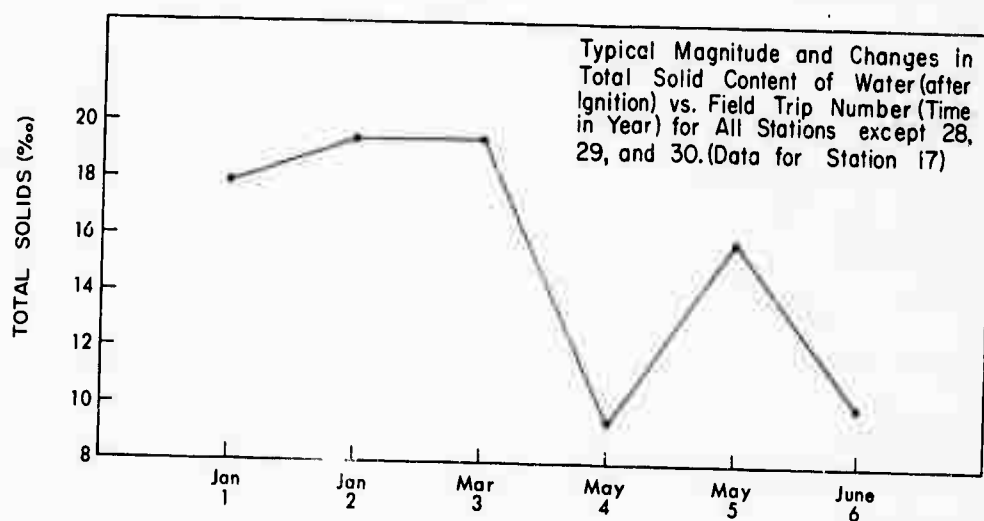
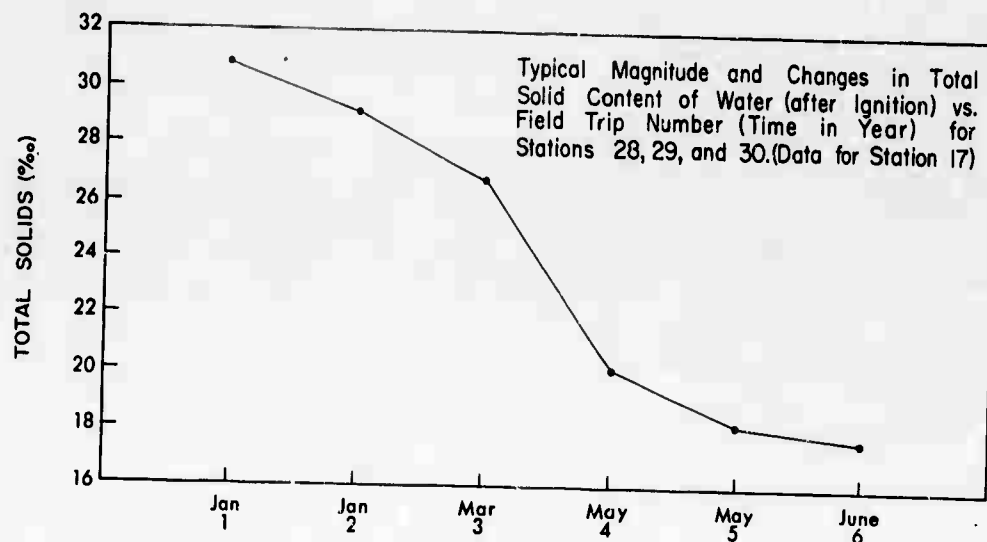


Figure 16

on the sixth field trip. Throughout the period of these analyses, from the third through the sixth field trip, nitrogen and phosphorous did not show any trend, while carbohydrate increased continually.

All stations except 28, 29, and 30 were affected by rainfall as shown by a sharp decrease in salinity following a period of heavy precipitation. Stations 28, 29, and 30 appeared to be unaffected by individual periods of rain, but seem to show a cyclic variation in salinity from a high in the winter to a low in the summer.

The concentration differences of such things as chlorinity, nitrate-nitrite nitrogen, phosphate phosphorous, carbohydrate, and the differences of some physical measurements in surface and bottom waters were so small as to be negligible.

Thus from the chemical data taken in this investigation it does not appear to be possible to characterize any given station, however, large areas and perhaps the entire bay have been partially described chemically. The Foraminifera population seem to indicate regular characteristic differences between stations in a much more satisfactory way than do the chemical data. Details are shown in the Appendix, Table I.

FORAMINIFERA POPULATION

Population counts were made of living foraminifera contained in the upper half inch of cores taken in plastic tubes with a diameter of 2.75 inches. Analysis of the data shows that the population of Foraminifera at a given station is almost totally dependent on the amount of fresh water (presumably carrying nutrients) received from the land drainage. The productivity of different genera at the various stations is also dependent on some other unknown factors once the nutrient requirements are apparently met. Perhaps this factor is controlled by the type of bottom, but the mud composition at all stations except, 13, 20, and 28 is qualitatively similar, containing mainly silt with clay and sand. Stations 13, 20, and 28 contain mainly sand with clay and silt with a high percentage of dead Mytilus shells.

When the productivity of the Foraminifera is considered at each station, it is seen that some stations are more productive than others. Stations 20, 16, 12, and 13 are the most populous while 26 and 29 are the least. It is very interesting to note the sharp demarcation in productivity between groups of stations. The higher and lower productivity levels vary greatly from the median. This means that there should be some

other measurable distinguishing characteristics of these extreme stations.

If it is assumed that the populations at the stations are entirely dependent upon fresh water drainage, a drainage pattern for the bay can be drawn from the population data alone, Fig. 17. Upon comparison with a drainage pattern drawn from the salinity data of field trip 4; Fig. 18¹ it is obvious that the patterns are almost identical.

Stations 20, 16, 13, and 12, the most productive stations, are located approximately the same distance from drainage exits and stations 26 and 27 have almost the same relation to drainage exits as stations 20 and 16, but are the four least productive stations. The poor populations of stations 11 and 21 may possibly be explained on the basis that they are in passes and the relatively rapidly moving water is not conducive to Foraminifera growth. However, the explanation could also be that the Foraminifera do not utilize the nutrients brought in by the fresh water directly, but that they feed upon some organisms which depends upon these nutrients. If that is the case, the low populations of stations 11 and 21 could be explained because it takes time for the organisms to take advantage of the dissolved nutrients, and develop an abundant population to serve as food for the Foraminifera. Thus stations in the immediate vicinity of the fresh water discharge will not be benefited (stations 11 and 21) but stations some distance from the exit points will. This is the case for stations 12, 13, 16, and 20. They are about a mile from their fresh water source. However, the low populations of stations 26 and 27 appear to be anomalous. Salinity data show that both stations receive fresh water; neither station, however, responds to the assumed nutrient supply. Stations 14, 15, 19, and 23 are similarly located from the standpoint of fresh water discharge and if dilution of nutrients is considered, would be expected to have lower populations than stations 20, 16, 13, and 12, but higher than stations farther from land. This is true. Station 29 is well shielded from a fresh nutrient supply by Casse-Tete Island and has one of the lowest populations. Thus it is suggested that if the bay had no nutrient supply from land, it would be able to support only a Foraminifera population similar to station 29.

¹Salinity data of field trip 4 was selected because of the clearer drainage pattern produced by the heavy influx of fresh water.



Figure 17 Foraminifera Population gradients.

Drainage pattern of bay drawn by assuming that all nutrients are washed into bay by rain water, and that total foraminifera populations at the stations are dependent on the gross nutrients received by the stations. Dilution of the nutrients by bay water is considered the independent variable.

The stations were next studied with regard to relative abundance and variety of species of Foraminifera present and the effects of the chemical and physical variations of the environment on these populations. The changes in population of three genera (selected because of their occurrence at all stations and on almost all field trips) between field trips were observed and increases of 100 per cent or more over the previous field trip noted. (see Appendix, Table II). From this information the field trips on which conditions were optimum for reproduction and growth for the three genera under consideration can be determined for each station. It may be noted that on field trip 4 (April) 21 out of 27 stations had a peak of maximum population and on field trip 8 (August) 13 out of 15 stations had a recurring secondary peak. The remaining stations had peaks sporadically and do not seem to follow a pattern which might be correlated to some measured environmental variation. Thus, the period of maximum productivity occurred during March (Field trip 4) when the temperature of the waters began to rise above the winter low. The reason for the reoccurring peak in August (Field trip 7-8) will not be hazarded. It does not seem feasible that the August peaks were caused by additional nutrients being released into the waters by the decaying bodies of microorganisms which have exhausted their food supply since there is a constant influx of nutrients from land. This program was not extended over a period long enough to determine if this is a reproduction cycle.

To determine the selectivity of environment by the Foraminifera, the productivity of each of the three genera was determined at each station; Appendix, Table III, and the field trip on which the maximum population increase occurred was noted. Station 13 seems to be the most favored by Ammotium as 30.2% of the Ammotium and only 3.8% of the Elphidium and 5.6% of the Streblus populations occur there. (These percentages are of the total live count of that genera for all field trips). The stations, collectively or singly, do not hold their order of productivity for the three genera. It seems clear that the gross amount of nutrients received by a station is not the factor determining the preference of a given genus of Foraminifera for that station.

It is also of interest to notice the order of occurrence of the peaks of maximum population increase for each genus at the stations, for example the genus Elphidium; Appendix, Table II. On field trip 2 (February) station 13 had its maximum population increase. On field trip 3 (March) stations 12, 16, and 19 had their maximum increase. On field trip 4 (April) stations 14,

15, 20, 24, 25, 26, and 30 had their maximum increase. It is true that this pattern is not very clearly defined, however, it is worthy of consideration and could mean that the nutrients brought in by a short period of heavy precipitation on land work their way slowly down the bay and benefit the stations as they reach them. This is consistent with the belief that the bionomics of the bay is dependent on the land, that the bay alone could not support the population that it does but would generally be similar to station 29. There is no abrupt increase in population at station 29 on any field trip. In the spring station 29 builds up a certain population and maintains that population until the cold of winter decreases reproduction and growth permitted by warmer temperatures. The other fauna found floating in the waters of the bay also indicate dependence on nutrients from land.

PLANKTON

The factors which seem to influence the abundance of floating plankton are temperature and rainfall. See Appendix, Table IV and Figs. of the appendix for graphical information concerning plankton distribution. Prior to field trip 4 there seemed to be negligible quantities of micro and macro fauna in the bay. The average temperature of the water was about 20°C., and very little rain had fallen between field trips 1 and 3. Between field trip 3 (March) and 4 (April) fourteen inches of rain fell. On field trip 4 the temperature began to rise to an average 22 to 23°C. and total plankton count increased by 300-400%. Between field trips 4 (April) and 5 (May) very little rain fell, but the temperature of the bay waters was reaching the maximum of about 30-31°C. A slight general decrease in plankton was recorded. Thus it seems that the biological activity of the bay is controlled by the temperature to the extent that at low temperatures the organisms are inactive but at higher temperatures they are unhindered. But here again it seems that nutrients from land are the limiting factor of productivity as demonstrated by the increase in population between field trips 4 and 5. The data of field trip 6 again demonstrate the effect of rainfall on the bay. Eight inches of rain fell between field trips 5 (May) and 6 (June). The temperature was almost constant, but the recorded plankton population increased 200-300%. Some forms continued to increase through field trip 7 (July), while others decreased sharply by the seventh field trip. Perhaps these forms exhausted their particular nutrient from the gross nutrients washed into the bay.

The abrupt variations in plankton population had no direct measurable effect on the fish, which were apparently dependent on the shrimp larvae which arrived in the bay between field trips 3 and 4 (March and April). Stomach contents of the fish were 99% shrimp and shrimp larvae. The stomach contents of the shrimp indicate feeding on algae or organic detritus. The shrimp and fish could be found in greatest numbers in the bay from the fourth through the seventh field trips. This then infers that the fish of the bay depend upon shrimp for food; the shrimp depend upon the algae, and the algae depend upon nutrients which are apparently washed into the bay from the land by rain. For this chain of biological events to occur, however, the temperature must be favorable, that is somewhere between 23 and 30°C.

CONCLUSIONS

In conclusion, the above analysis of the data shows these things: (1) the optimum temperature for biological activity in the bay is somewhere between 23 and 30°C., (2) that total salinity of the water is not a primary limiting factor in the bionomics of the bay, (3) the life in the bay seems to be dependent upon land for its nutrient supply and (4) that the preference for a certain portion of the bay bottom (sampling stations in the above analysis) by a genus of Foraminifera is controlled by something other than the gross nutrients received by that small portion of the bottom.

From the above conclusion then, it appears that future work should be directed toward developing methods for the extraction, separation, identification of the nutrients brought into the bay by the rain water and identification of the various micro-organisms with a particular nutrient or nutrients. The inorganics considered most probable as nutrients, phosphate phosphorous and nitrate-nitrite nitrogen, were studied in the above program but the results indicate that they are not of primary importance. However, we may be misled in this conclusion for there are no simple means of determining how much of the nitrogen and phosphorous is metabolically available to the organisms. This then leaves the organic nutrients.

It is realized that the insufficiency of present knowledge of some biochemical processes and the difficulties in identifying and analyzing small amounts of complex biologically active organic compounds preclude a simple, straightforward approach to the problem. To illustrate this, no one has been able to culture a colony of micro-organisms in artificial sea water. However, upon the injection of organic material into the

artificial water (Allen and Nelson 1910) the cultures were successfully grown thus demonstrating the importance of organic substances. Harvey (1933 and later) showed the importance of accessory factors, the presence of iron and manganese, in the growth of some marine diatoms. To further point out the importance of the organic constituents Wilson (Wilson and Armstrong 1951, 1952, 1954) demonstrated that the eggs and larvae of the sea urchin would grow more satisfactorily in water from the Celtic Sea than in English Channel water. It is significant that these waters can be distinguished by characteristic species of *Sagitta*. Perhaps the presence of *Sagitta* or some unknown conditions associated with *Sagitta* are beneficial to the sea urchin. The beneficial qualities of the water deteriorated on standing at room temperature therefore it is possible that the differences between the waters are due only to the organic content. In view of the above, then, it would be impractical to attempt to identify the extracted organic substances down to the individual compounds. It is believed that extremely useful information could be obtained by simply developing standardized separation procedures for the extracted organic substances by which the gross extract can be separated into several fractions which may be given arbitrary designations. Then these fractions should be identified with as many of the most abundant genera of micro-organisms present as practically possible as to whether the fraction is detrimental, indifferent, or beneficial to the organisms. Then a field program should be conducted to determine how the relative and absolute availability of these fractions vary in the body of water under investigation, and correlate their variance with the population variance of the microorganisms. Finally the fractions of greatest interest may be singled out for more extensive fundamental research.

We wish to speculate on the value of information gained from research in this field. The sensitivity of some microorganisms to certain organic constituents in sea water has been shown to be extremely high. Their productivity often is entirely dependent on the availability of these organic substances whatever grosser nutrients are available (Hamilton, Hutner, and Provasoli, 1952). The possibility arises, therefore, of initiating a chain reaction of biological events by adding to natural waters organic substances likely to encourage a desirable sequence and to suppress undesirable types. (Note that the shrimp and shrimp larvae arrived in the bay coincident with a tremendous increase in plankton population which was preceded by very heavy rainfall in the surrounding area.) Since no additional nutrients are involved, and the quantities of material may be

relatively small, this possibility may lead to practical methods of controlling some forms of aquatic life (Johnston, 1955). Thus, the study of organic substances in the waters is at least indirectly relevant to fishery problems. In time, some compounds may be shown to be directly relevant --perhaps by favoring or hindering the development of fish eggs or larvae, or even by affecting the adult life of mollusca and true fish. One example may be found in the observation of Collier, et al., (1953) that the active feeding of oysters is related to the concentration of "carbohydrates" in the sea water. Another lies in the results of fish behavior studies. It has been suggested that salmon may be able to distinguish the products of one organism from another, even at great dilutions, and perhaps thereby the waters of one stream from others (Lissman, 1954). In one instance Hasler and Wisby (1951) have tracked down the characteristic odor of the "home" waters of a fish to a volatile aromatic substance.

Geologically, the ecological study of the Foraminifera and other benthic organisms is a direct contribution to the knowledge of sedimentary environments, thus permitting the paleontologist to draw conclusions regarding the conditions prevalent at the time of deposition of a sedimentary sample. This may be an aid to the oil industry in finding stratigraphic traps.

TABLE I

Sampling Stations and Conditions at Time of Sampling

Station 11. In the mouth of Chinois Pass in the northeastern end of Deep Lake N 29° 17' 40" Lat., W 90° 21' 45" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/9/57	1435	-normal	S 15-20	7	1/2 , 6 1/2
2	1/29/57	1337	low	SE 5-10	6	1/2 , 5 1/2
3	3/13/57	1140	normal	E 5-10	6 1/2	1/2 , 6
4	5/8/57	1120	normal	E 15	6 1/2	1/2 , 6
5	5/30/57	1755	+normal	S 5	7	1/2 , 6 1/2
6	6/19/57	1910	high	E 5-7	7	1/2 , 6 1/2
7	7/15/57	1755	normal	SW 5-10	7	1/2 , 6 1/2

Station 12. At the northern end of Lake Raccourci 0.5 mile south of Deep Lake N 29° 17' 40" Lat., W 90° 21' 45" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/9/57	1535	-normal	SW 20+	7	1/2 , 6 1/2
2	1/29/57	1300	low	S 5-10	5 1/2	1/2 , 5
3	3/13/57	1115	normal	E 5	5 1/2	1/2 , 5
4	5/8/57	1053	normal	E 15	6 1/2	1/2 , 6
5	5/30/57	1735	+normal	S 5	6	1/2 , 5 1/2
6	6/19/57	1855	high	SE 5-10	6	1/2 , 5 1/2
7	7/17/57	1535	normal	WNW 5	6	1/2 , 5/2

* -normal indicates below normal; +normal indicates above normal.

TABLE I (continued)

Sampling Stations and Conditions at Time of Sampling

Station 13. Center of mouth of Grand Bayou Felicity
N 29° 14' 12" Lat., W 90° 23' 08" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/9/57	1630	-normal	SSW 15	6	1/2 , 5 1/2
2	1/29/57	1435	low	SE 10	5	1/2 , 4 1/2
3	3/13/57	1225	normal	E 5	5 1/2	1/2 , 5
4	5/8/57	1300	normal	ESE 20	5 1/2	1/2 , 5
5	5/31/57	1055	+normal	SE 0-5	6 1/2	1/2 , 6
6	6/19/57	1630	high	SE 5-10	6	1/2 , 5 1/2
7	7/17/57	1409	normal	N 5	6	1/2 , 5 1/2

Station 14. Lake Raccourci, 1.4 miles east-southeast of mouth of Grand Bayou Felicity
N 29° 14' 55" Lat., W 90° 21' 42" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/9/57	1710	-normal	S 10	7	1/2 , 6 1/2
2	1/29/57	1405	low	S 10	6 1/2	1/2 , 6
3	3/13/57	1305	normal	E 5-10	6 1/2	1/2 , 6
4	5/8/57	1220	normal	ESE 20	6 1/2	1/2 , 6
5	5/31/57	1005	+normal	SE 0-5	6 1/2	1/2 , 6
6	6/19/57	1650	high	SE 5-10	7	1/2 , 6 1/2
7	7/17/57	1445	normal	NW 5	6 1/2	1/2 , 6

* -normal indicates below normal; +normal indicates above normal.

TABLE I (continued)

Sampling Stations and Conditions at Time of Sampling

Station 15. Lake Raccourci, 1.5 miles west of southern opening to Coal Tar Bay.

N 29° 14' 15" Lat., W 90° 19' 55" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/10/57	0955	-normal	SW 5-8	6	1/2 , 5 1/2
2	1/29/57	1130	low	SE 10-15	5 1/2	1/2 , 5
3	3/13/57	1035	normal	E 5-10	6	1/2 , 5 1/2
4	5/8/57	0950	normal	E 20	6 1/2	1/2 , 6
5	5/31/57	0935	+normal	SE 0-5	8	1/2 , 7 1/2
6	6/19/57	1745	high	SE 5-10	7	1/2 , 6 1/2
7	7/17/57	1550	normal	NW 3-5	6 1/2	1/2 , 6

Station 16. Center of Coal Tar Bay.

N 29° 14' 50" Lat., W 90° 18' 16" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/9/57	1320	-normal	S 15-20	5	1/2 , 4 1/2
2	1/29/57	1045	low	S 10-15	4	1/2 , 3 1/2
3	3/13/57	0955	normal	E 5	4	1/2 , 3 1/2
4	5/8/57	1020	normal	E 20	4 1/2	1/2 , 4
5	5/30/57	1705	+normal	S 5	5	1/2 , 4 1/2
6	6/19/57	1825	high	SE 5-10	5	1/2 , 4 1/2
7	7/15/57	1705	normal	SW 5-10	5	1/2 , 4 1/2

* -normal indicates below normal; +normal indicates above normal.

TABLE I (continued)

Sampling Stations and Conditions at Time of Sampling

Station 17. In Little Lake northwest-central opposite mouth of Bayou Blue
N 29° 14' 55" Lat., W 90° 16' 12" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/9/57	0940	-normal	SW 15+	5	1/2 , 4 1/2
2	1/29/57	0935	low	SE 10-15	4	1/2 , 3 1/2
3	3/13/57	0835	normal	E 2-5	4	1/2 , 3 1/2
4	5/8/57	0825	normal	E 20	4 1/2	1/2 , 4
5	5/30/57	1605	+normal	S 5-10	5 1/2	1/2 , 5
6	6/19/57	1320	high	SE 5-10	5 1/2	1/2 , 5
7	7/15/57	1625	normal	SW 5-10	5 1/2	1/2 , 5

Station 18. In sharp turn of Bayou Blue 1/2 mile from mouth at Little Lake
N 29° 15' 25" Lat., W 90° 14' 55" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/10/57	0800	-normal	SW 5	6	1/2 , 5 1/2
2	1/29/57	0845	low	SE 10-15	7 1/2	1/2 , 7
3	3/13/57	0750	normal	Calm	7	1/2 , 6 1/2
4	5/8/57	0740	normal	E 15	11 1/2	1/2 , 11
5	5/30/57	1500	+normal	SW 5-10	9	1/2 , 8 1/2
6	6/19/57	1300	high	SE 5-10	13	1/2 , 12 1/2
7	7/15/57	1530	normal	SW 5-10	9	1/2 , 8 1/2

* -normal indicates below normal; +normal indicates above normal.

TABLE I (continued)

Sampling Stations and Conditions at Time of Sampling

Station 19. Lake Raccourci, 1.95 miles west of northern tip of Philo Brice Islands.

N 29° 13' 14" Lat., W 90° 22' 45" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/10/57	1030	-normal	W 5	5	1/2 , 4 1/2
2	1/29/57	1510	low	SSE 10	5	1/2 , 4 1/2
3	3/13/57	1350	normal	E 5-10	5	1/2 , 4 1/2
4	5/8/57	1420	normal	ESE 25	5 1/2	1/2 , 5
5	5/31/57	1215	+normal	SE 5-10	6	1/2 , 5 1/2
6	6/19/57	1550	high	SE 5-10	5 1/2	1/2 , 5
7	7/16/57	1600	normal	W 15-20	5 1/2	1/2 , 5

Station 20. Lake Raccourci, 1.85 miles east of northern tip of Philo Brice Islands.

N 29° 13' 03" Lat., W 90° 18' 56" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/10/57	0925	-normal	SSW 5-8	5	1/2 , 4 1/2
2	1/29/57	1555	low	SSE 10	6	1/2 , 5 1/2
3	3/14/57	0825	normal	calm	5 1/2	1/2 , 5
4	5/8/57	0920	normal	E 15	6	1/2 , 5 1/2
5	5/31/57	0800	+normal	SE 1-2	6 1/2	1/2 , 5 1/2
6	5/19/57	1510	high	SE 5-10	7	1/2 , 5 1/2
7	7/16/57	1650	normal	W 5-10	6 1/2	1/2 , 6

* -normal indicates below normal; +normal indicates above normal.

TABLE I (continued)

Sampling Stations and Conditions at Time of Sampling

Station 21. Near southern bank of Deep Bayou mouth
N 29° 12' 57" Lat., W 90° 16' 53" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/9/57	1220	-normal	SW 15-20	9	1/2 , 8 1/2
2	1/29/57	1010	low	SE 10-15	10	1/2 , 9 1/2
3	3/13/57	0925	normal	E 10	6	1/2 , 5 1/2
4	5/8/57	0850	normal	E 15	4	1/2 , 3 1/2
5	5/30/57	1630	+normal	S 5-10	5 1/2	1/2 , 5
6	6/19/57	1405	high	SE 5-10	9	1/2 , 3 1/2
7	7/16/57	0925	normal	NW 1-2	4 1/2	1/2 , 4

Station 22. In Lake Raccourci 1/2 mile below Bayou Blue outlet connecting to Little Lake
N 29° 12' 20" Lat., W 90° 16' 50" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/10/57	0845	-normal	SW 5-8	4 1/2	1/2 , 4
2	1/29/57	1700	low	SSE 5	5	1/2 , 4 1/2
3	3/14/57	1035	normal	S 2-3	4 1/2	1/2 , 4
4	5/8/57	1720	normal	E 10-15	4 1/2	1/2 , 4
5	5/31/57	0830	+normal	SE 1-2	6	1/2 , 5 1/2
6	6/19/57	1420	high	SE 5-10	5 1/2	1/2 , 5
7	7/16/57	0940	normal	NW 1-2	5	1/2 , 4 1/2

* -normal indicates below normal; +normal indicates above normal.

TABLE I (continued)

Sampling Stations and Conditions at Time of Sampling

Station 23. Approximately 1 mile south of the western portion of
Formation Islands.
N 29° 11' 02" Lat., W 90° 25' 19" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/10/57	1230	-normal	SW 2-3	6	1/2 , 5 1/2
2	1/30/57	1030	low	SSE 3-5	5	1/2 , 4 1/2
3	3/13/57	1515	normal	E 5	6 1/2	1/2 , 6
4	5/9/57	1250	normal	E 10	7	1/2 , 6 1/2
5	5/31/57	1400	+normal	SE 15+	8	1/2 , 7 1/2
6	6/20/57	1135	high	SE 5-10	7	1/2 , 6 1/2
7	7/16/57	1400	normal	S 5-10	6 1/2	1/2 , 6 1/2

Station 24. 0.9 mile south of the eastern-most island of Formation Islands.
N 29° 11' 10" Lat., W 90° 23' 03" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/10/57	1155	-normal	SW 2-3	6 1/2	1/2 , 6
2	1/30/57	1000	low	SSE 3-5	5 1/2	1/2 , 5
3	3/13/57	1440	normal	E 5-10	6 1/2	1/2 , 6
4	5/9/57	1320	normal	E 5-10	7 1/2	1/2 , 7
5	5/31/57	1330	+normal	SE 10-15	8	1/2 , 7 1/2
6	6/20/57	1050	high	SE 5-10	8	1/2 , 7 1/2
7	7/16/57	1420	normal	SW 5-10	7 1/2	1/2 , 7

* -normal indicates below normal, +normal indicates above normal.

TABLE I (continued)

Sampling Stations and Conditions at Time of Sampling

Station 25. 0.6 mile southwest of pass between Philo Brice Islands
N 29° 11' 06" Lat., W 90° 21' 30" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/10/57	1105	-normal	SW 5	6	1/2 , 5 1/2
2	1/30/57	0915	low	SSE 2-5	5 1/2	1/2 , 5
3	3/14/57	0855	normal	calm	6	1/2 , 5 1/2
4	5/8/57	1520	normal	ESE 20	6 1/2	1/2 , 6
5	5/31/57	1245	+normal	SE 10-15	8	1/2 , 7 1/2
6	6/20/57	1015	high	SE 5-10	7	1/2 , 6 1/2
7	7/16/57	1505	normal	SW 5-10	7	1/2 , 6 1/2

Station 26. About midway between eastern tip of Philo Brice Islands and islands flanking Jacko Camp Bay
N 29° 11' 8" Lat., W 90° 18' 48" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	- - -	- -	- - -	- - -	- - -	- - -
2	1/30/57	1345	low	SSE 3-5	6	1/2 , 5 1/2
3	3/14/57	0925	normal	calm	5 1/2	1/2 , 5
4	5/8/57	1610	normal	ESE 20-25	6 1/2	1/2 , 6
5	5/31/57	1635	+normal	SE 10-15	7 1/2	1/2 , 7
6	6/20/57	0925	high	SE 5-10	7 1/2	1/2 , 7
7	7/16/57	1035	normal	NW 1-3	7	1/2 , 6 1/2

* -normal indicates below normal; +normal indicates above normal.

TABLE I (continued)

Sampling Stations and Conditions at Time of Sampling

Station 27. North-central Jacko Camp Bay.
N 29° 07' 52" Lat., W 90° 22' 09" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	- - -	- -	- - -	- - -	- - -	- - -
2	1/30/57	1630	low	SSE 10-15	4	1/2 , 3 1/2
3	3/14/57	1010	normal	S 0-2	4	1/2 , 3 1/2
4	5/8/57	1655	normal	ESE 15	4	1/2 , 3 1/2
5	5/31/57	1655	+normal	SE 15-20	5	1/2 , 4 1/2
6	6/19/57	1445	high	SE 10-15	5	1/2 , 4 1/2
7	7/16/57	1000	normal	NW 1-3	4 1/2	1/2 , 4

Station 28. 1.25 miles west of northernmost island of Pelican Islands.
N 29° 07' 48" Lat., W 90° 26' 46" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/10/57	1305	-normal	calm	7	1/2 , 6 1/2
2	1/30/57	1110	low	SSE 2-4	6	1/2 , 5 1/2
3	3/13/57	1558	normal	E 5-10	7 1/2	1/2 , 7
4	5/9/57	1130	normal	E 10	8	1/2 , 7 1/2
5	5/31/57	1440	+normal	SE 10	8	1/2 , 7 1/2
6	6/20/57	1225	high	SE 5-10	8	1/2 , 7 1/2
7	7/16/57	1320	normal	S 5	7 1/2	1/2 , 7

* -normal indicates below normal, +normal indicates

TABLE I (continued)

Sampling Stations and Conditions at Time of Sampling

Station 29. 0.9 mile west-southwest of bayou crossing Casse Tete Islands.
N 29° 07' 52" Lat., W 90° 22' 09" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	1/10/57	1420	-normal	N 20-25	6 1/2	1/2 , 6
2	1/30/57	1155	low	SSE 2-4	5 1/2	1/2 , 5
3	3/13/57	1645	normal	E 5-10	6	1/2 , 5 1/2
4	5/9/57	1040	normal	E 10	7	1/2 , 6 1/2
5	5/31/57	1515	+normal	ESE 15	7	1/2 , 6 1/2
6	6/20/57	1600	high	S 10-15	7	1/2 , 6 1/2
7	7/16/57	1155	normal	NW 1-2	7	1/2 , 6 1/2

Station 30. About midway between northern tip of Casse Tete Island and
Deville Island which extends out past mainland.
N 29° 08' 33" Lat., W 90° 18' 16" Long.

<u>Trip No.</u>	<u>Date</u>	<u>Time</u>	<u>Water Level*</u>	<u>Wind (mph approx)</u>	<u>Water Depth (ft)</u>	<u>Sampling Depths (ft)</u>
1	- - -	- -	- - -	- - -	- - -	- - -
2	1/30/57	1315	low	SSE 3-5	6	1/2 , 5 1/2
3	3/13/57	1725	normal	E 10	7 1/2	1/2 , 7
4	5/9/57	0940	normal	E 10-15	7 1/2	1/2 , 7
5	5/31/57	1600	+normal	SE 10	7 1/2	1/2 , 7
6	6/20/57	0830	high	SE 5	7 1/2	1/2 , 7
7	7/16/57	1115	normal	NW 1-3	7 1/2	1/2 , 7

* -normal indicates below normal, +normal indicates above normal.

TABLE II

Precipitation in the Houma, Golden Meadow and Grand Isle
Area of Louisiana from December, 1956, to July, 1957

<u>Field Trip</u>	<u>Date</u>	<u>Approximate Precipitation in Inches between Field Trips</u>
1	January 9-10	5.4
2	January 29-30	0.3
3	March 13-14	3.6
4	May 8-9	14.2
5	May 30-31	1.1
6	June 13-20	8.2
7	July 15, 16, 17	2.3

Data obtained from U. S. Weather Bureau Climatological Reports
on Louisiana.

TABLE III
Temperature °C*

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
11	19.7	18.1	22.7	30.0	30.0	31.1				
	19.7	22.3	18.4	23.0	29.8	29.8	31.1	32.0	29.4	23.5
12	19.4	22.5	17.9	22.4	30.5	30.0	31.1			
	19.4	22.0	18.0	23.2	30.4	30.0	29.8	30.6	29.7	23.5
13	20.0	22.1	18.2	23.8	30.0	30.2	32.4			
	20.0	22.1	18.2	23.8	28.8	29.4	31.8	30.1	30.0	21.6
14	19.4	22.1	18.2	22.8	28.8	30.2	31.0			
	19.4	21.9	18.0	23.4	28.4	29.8	30.8	29.7	28.4	22.6
15	19.7	21.4	17.6	22.0	29.0	30.4	20.8			
	20.0	21.3	17.5	22.4	28.4	30.0	30.8	29.7	29.0	23.5
16	20.0	22.0	17.8	22.8	30.4	30.6	31.6			
	20.0	22.0+	17.8	23.4	30.3	30.4	31.3	33.0	29.1	24.2
17	19.4	22.2	18.2	22.5	30.4	31.6	31.2			
	- -	22.1	18.2	23.4	30.1	30.2	31.1			
18	20.0	21.9	17.8	22.0	31.8	31.6	31.3			
	20.0	21.8	18.1	22.8	29.6	30.2	31.0			
19	20.0	22.0	18.2	23.6	29.8	30.6	32.6			
	20.0	19.9	18.2	23.6	29.6	30.2	31.2	30.2	29.0	22.4
20	20.0	22.3	18.7	21.8	28.4	30.6	31.3			
	20.0	22.3	18.7	22.2	28.0	30.0	30.8	29.6	28.5	24.1
21	20.0	21.8	18.0	22.2	30.2	31.6	31.0			
	20.0	22.0	17.9	22.5	30.5	30.1	- -	29.6	28.5	24.1
22	20.3	24.0	20.8	23.3	28.8	31.0	31.2			
	20.3	23.9	20.2	23.0	28.2	30.0	30.5			
23	20.3	21.8	18.6	23.2	30.2	30.6	33.2			
	20.3	21.8	18.3	23.2	29.7	29.8	31.1	29.4	29.5	23.1

* Upper values are for top samples and lower values for bottom samples.

TABLE III (continued)

Temperature °C*

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
24	20.2	21.5	18.4	23.6	30.0	30.4	32.8			
	20.0	21.5	18.1	23.4	30.1	29.6	30.6	29.8	28.8	23.0
25	20.0	21.6	19.4	23.6	29.6	30.1	31.9			
	- -	21.6	19.0	23.8	29.4	- -	30.4	29.4	28.4	22.7
26	- -	23.5	19.7	23.6	30.6	29.6	31.8			
	- -	24.0	19.4	23.6	30.2	30.0	31.0		28.4	24.0
27	- -	23.2	20.9	24.0	29.6	31.6	31.3			
	- -	23.1	20.1	23.7	29.4	30.3	30.0		28.5	24.5
28	20.4	22.0	19.9	23.4	29.6	30.8	32.8			
	20.4	22.5	19.6	23.4	29.4	30.0	31.4	29.4	28.4	23.2
29	20.6	22.5	19.2	23.3	30.0	31.2	32.3			
	20.6	23.0	19.2	23.3	29.6	30.8	31.2		27.4	23.8
30		22.5	19.0	23.1	30.0	30.0	31.4			
		23.5	19.0	23.0	29.4	30.0	30.6		27.3	23.2

* Upper values are for top samples and lower values are for bottom samples.

TABLE IV
pH of Waters*

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
11	8.3 8.3	8.1 8.1	7.7 7.8	7.9 7.9	7.9 7.8	7.8 7.9	8.0 8.0	7.9	8.0	8.0
12	8.4 8.4	8.2 8.2	7.9 7.9	7.9 7.9	7.9 7.9	8.0 8.0	7.8 7.9	7.7	8.1	8.2
13	8.2 8.2	8.2 8.2	7.9 7.9	8.0 8.0	8.1 8.0	8.1 8.1	8.0 8.0	8.0	8.2	8.3
14	8.2 8.3	8.2 8.2	7.9 7.9	7.9 8.1	8.1 8.1	8.1 8.2	8.0 8.0	8.0	8.2	8.2
15	8.1 8.2	8.2 8.2	7.9 8.0	8.0 8.1	8.1 8.1	8.2 8.2	8.1 8.1	8.2	8.1	8.2
16	8.1 8.2	8.1 8.1	7.8 7.8	8.1 8.1	8.1 8.1	8.1 8.1	8.2 8.1	8.0	8.2	8.2
17	8.2 8.2	8.0 8.0	7.9 7.9	7.9 7.9	7.9 8.2	7.8 7.5	8.0 8.0			
18	7.9 7.8	7.8 7.7	7.4 7.7	7.6 7.6	7.7 7.8	7.6 7.6	7.9 8.0			
19	8.0 8.1	8.2 8.2	7.9 8.0	8.0 8.1	8.1 8.2	8.2 8.2	8.1 8.1	8.2	8.0	8.1
20	8.1 8.1	8.2 8.2	8.0 8.1	8.2 8.2	8.0 8.0	8.2 8.1	8.1 8.2	8.2	8.2	8.3
21	8.4 8.5	8.1 8.1	7.9 8.1	8.0 8.1	8.0 8.0	8.2 8.1	7.9 7.9	8.4	8.1	7.2
22	8.0 7.9	8.1 8.1	7.8 8.0	7.9 7.8	7.7 7.8	8.0 8.0	8.0 7.9			
23	8.0 8.0	8.1 8.1	7.9 7.9	8.2 8.1	8.2 8.2	8.1 8.0	8.1 8.0	7.8	8.2	8.1

* Upper values are for top samples and lower values are for bottom samples.

TABLE IV (continued)

pH of Waters*

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
24	8.1	8.2	8.0	8.1	8.2	8.2	8.0			
	8.1	8.2	7.9	8.2	8.2	8.2	7.9	7.7	8.1	8.2
25	8.1	8.0	8.1	8.0	8.2	8.2	7.9			
	8.0	8.0	8.1	8.1	8.2	8.1	7.8	8.0	8.1	8.2
26	-	8.2	8.1	8.0	8.1	8.1	8.1			
	-	8.2	8.1	7.9	8.1	8.2	7.8		8.0	8.2
27	-	8.2	8.0	8.0	8.0	8.2	8.0			
	-	8.2	8.1	8.3	8.3	8.1	7.8		8.1	8.1
28	8.1	8.1	8.2	8.5	8.4	8.1	8.0			
	8.0	8.1	8.2	8.4	8.4	7.9	8.2	8.0	8.4	8.2
29	8.0	8.3	8.1	8.3	8.3	8.4	7.9			
	8.0	8.2	8.2	8.4	8.3	8.2	8.1		8.2	8.2
30	-	8.2	8.2	8.3	8.1	8.3	8.0			
	-	8.3	8.1	8.3	8.2	8.3	8.1		8.1	8.0

* Upper values are for top samples and lower values are for bottom samples.

TABLE V

Eh (mv.) of Waters*

Station Number	Number of Field Trip on Which Sample was Taken									
	1	2	3	4	5	6	7	8	9	10
11	376 385	316 319	- -	474 462	343 336	321 322	238 216		36	91
12	376 376	330 323	- -	480 444	346 340	325 327	263 227		11	67
13	364 364	332 337	- -	479 449	362 359	322 322	242 246		51	100
14	382 376	341 340	- -	486 449	362 332	319 316	318 257		68	71
15	358 364	321 321	- -	474 450	359 350	315 316	302 274		48	71
16	352 385	298 303	- -	480 443	334 340	317 317	276 198		95	79
17	406 394	281 297	- -	474 461	332 331	312 308	213 208			
18	- 442	270 290	- -	474 468	329 328	286 297	279 213			
19	370 361	332 337	- -	491 443	359 343	320 316	293 246		55	103
20	364 370	329 358	- -	480 456	356 341	313 320	270 255		79	53
21	352 400	296 311	- -	468 456	332 344	317 311	251 226		39	24
22	370 382	361 352	- -	432 444	339 317	315 316	225 226			
23	361 376	356 356	- -	414 414	353 349	335 327	298 222		105	103

* Upper values are for top samples and lower values are for bottom samples.

All values are positive.

TABLE V (continued)

Eh (mv.) of Waters*

Station Number	Number of Field Trip on Which Sample was Taken									
	1	2	3	4	5	6	7	8	9	10
24	358	350	-	431	363	337	265			
	376	349	-	389	348	331	223		37	95
25	367	367	-	497	358	329	252			
	367	350	-	473	343	321	229		66	89
26	-	355	-	449	363	298	264			
	-	353	-	461	356	311	279		13	11
27	-	352	-	443	368	307	249			
	-	347	-	521	361	310	247		45	67
28	375	345	-	437	340	341	221			
	363	336	-	401	340	326	201			127
29	-	353	-	438	355	342	245			
	-	351	-	426	347	327	204		53	67
30	-	352	-	408	368	226	274			
	-	353	-	402	353	249	266		30	127

* Upper values are for top samples and lower values for bottom samples.

All values are positive.

TABLE VI
Alkalinity meq./l*

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
11	2.42 2.42	2.43 2.43	2.27 2.24	1.85 1.80	2.24 2.24	2.31 2.24				
12	2.40 2.43	2.43 2.44	2.27 2.26	1.85 1.96	2.27 2.31	2.28 2.28				
13	2.43 2.44	2.44 2.44	2.24 2.27	1.88 1.96	2.08 2.04	2.24 2.31				
14	2.43 2.48	2.44 2.45	2.22 2.30	1.74 1.80	2.15 2.09	2.24 2.24				
15	2.41 2.44	2.44 2.44	2.24 2.24	1.91 1.85	2.04 2.04	2.22 2.27				
16	2.42 2.44	2.42 2.43	2.24 2.26	1.96 2.00	2.13 2.21	2.31 2.27				
17	2.42 2.42	2.43 2.45	2.20 2.20	1.98 2.02	2.22 2.28	2.26 2.24				
18	2.42 2.43	2.44 2.46	2.22 2.21	2.15 2.15	2.45 2.37	2.32 2.35				
19	2.40 2.41	2.44 2.45	2.24 2.27	1.96 2.00	2.04 2.04	2.29 2.17				
20	2.42 2.45	2.44 2.44	2.20 2.26	1.96 2.00	2.13 2.00	2.23 2.28				
21	2.44 2.46	2.41 2.42	2.20 2.15	2.01 2.03	2.22 2.21	2.27 2.28				
22	2.43 2.45	2.43 2.43	2.20 2.13	2.01 2.03	2.17 2.24	2.25 2.37				
23	2.42 2.44	2.44 2.44	2.09 2.20	1.74 1.80	2.00 1.90	2.00 1.95				

* Upper values are for top samples and lower values are for bottom samples.

TABLE VI (continued)

Alkalinity meq./*

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
24	2.41	2.44	2.13	1.96	2.00	2.02				
	2.41	2.44	2.20	1.96	1.95	1.96				
25	2.40	2.44	2.27	1.96	1.90	2.13				
	2.45	2.45	2.32	2.00	2.00	2.09				
26	-	2.41	2.24	2.00	2.04	2.13				
	-	2.46	2.24	2.09	2.02	2.02				
27	-	2.42	2.17	1.98	2.17	2.37				
	-	2.42	2.18	2.03	2.13	2.37				
28	2.44	2.26	2.19	1.90	1.85	2.05				
	2.42	2.27	2.20	2.00	1.85	2.09				
29	2.43	2.41	2.27	1.90	1.80	2.00				
	2.44	2.41	2.31	2.00	1.85	2.00				
30	-	2.29	2.26	1.90	1.91	2.03				
	-	2.40	2.30	2.00	1.91	2.02				

* Upper values are for top samples and lower values are for bottom samples.

TABLE VII
Chlorinity o/oo*

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
11	11.30	12.01	12.12	9.29	10.49	8.38	8.66			
	11.28	12.16	12.12	9.37	10.49	8.47	8.67	6.32	9.34	7.12
12	11.97	12.50	12.88	9.54	10.67	8.76	8.63			
	11.96	12.83	13.01	9.54	10.67	8.77	8.63	6.93	9.46	6.80
13	13.12	12.38	12.87	10.29	11.44	9.92	9.89			
	13.30	12.39	12.88	10.40	11.54	9.92	9.90	8.89	10.13	7.80
14	12.45	12.40	13.38	10.81	11.29	9.82	8.41			
	12.48	12.41	13.65	10.79	11.29	9.91	8.40	9.16	10.95	7.57
15	12.41	13.63	13.58	10.78	11.18	9.30	9.54			
	12.42	13.62	14.60	10.76	11.19	9.30	9.55	9.28	11.38	7.95
16	5.29	13.51	13.27	9.76	10.56	8.87	9.04			
	11.61	13.49	13.26	9.82	10.59	8.90	9.03		10.04	7.01
17	10.21	11.34	11.38	5.65	9.29	5.68	8.03			
	10.21	11.37	11.35	5.63	9.24	6.14	8.04			
18	9.02	11.21	10.46	5.49	8.07	5.61	7.80			
	9.03	11.15	10.84	5.50	8.57	5.68	7.81			
19	12.78	13.22	14.13	10.31	12.47	10.11	10.61			
	12.81	13.23	14.10	10.28	12.47	10.11	10.61	9.38	12.27	9.01
20	12.18	14.22	13.65	9.77	11.27	9.15	9.50			
	13.49	14.23	13.72	9.77	11.28	9.15	9.50	10.06	12.82	8.11
21	12.08	12.62	12.07	7.03	9.94	6.86	8.63			
	12.17	12.77	12.16	7.16	9.74	8.21	8.64	7.52	10.80	6.60
22	11.65	15.85	11.95	7.10	9.58	8.03	8.93			
	12.03	15.87	12.60	7.02	9.77	8.19	9.00			
23	15.90	13.46	15.00	10.61	12.28	10.62	12.02			
	16.05	14.12	14.93	10.62	12.28	10.67	12.61	13.74	14.45	10.21

* Upper values are for top samples and lower values are for bottom samples.

TABLE VII (continued)

Chlorinity o/oo*

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
24	14.41	13.39	14.60	9.90	12.52	10.25	11.43			
	14.52	13.43	14.61	10.16	12.53	10.37	11.40	13.04	14.48	10.38
25	13.28	15.09	14.39	10.05	11.70	9.95	10.86			
	14.06	15.13	14.52	10.04	12.10	10.04	10.99	11.89	14.03	10.34
26	-	16.21	13.59	9.25	11.06	9.66	10.11			
	-	16.22	13.60	9.25	11.01	9.88	11.13		15.30	8.12
27	-	16.53	13.05	7.69	10.87	8.20	9.17			
	-	16.54	13.06	7.58	10.85	8.89	9.68		14.31	7.18
28	18.09	16.81	16.82	13.53	10.30	9.42	14.23			
	18.09	16.81	16.76	13.52	10.30	10.04	15.92	16.98	16.99	12.28
29	17.30	16.46	15.18	11.83	10.50	10.26	12.37			
	17.28	16.51	15.15	12.67	10.17	10.26	14.79		15.51	11.68
30	-	16.64	14.94	11.99	10.43	9.55	12.09			
	-	16.67	14.83	12.66	10.44	9.93	13.97		16.44	10.93

* Upper values are for top samples and lower values are for bottom samples.

TABLE VIII
Salinity o/oo*

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
11	20.43	21.71	21.91	16.80	18.96	15.16	15.66			
	20.39	21.98	21.91	16.94	18.96	15.32	15.68	11.44	16.89	12.88
12	21.64	22.59	23.28	17.32	19.29	15.84	15.61			
	21.62	23.19	23.53	17.32	19.29	15.86	15.61	12.54	17.10	12.30
13	23.71	22.38	23.26	18.60	20.68	17.94	17.88			
	24.04	22.39	23.28	18.80	20.86	17.94	17.90	16.24	18.31	12.99
14	22.50	22.41	24.18	19.54	20.41	17.76	15.21			
	22.56	22.43	24.67	19.51	20.41	17.92	15.19	16.56	19.75	13.69
15	22.43	25.63	24.54	19.49	20.21	16.82	17.25			
	22.45	25.61	26.38	19.45	20.23	16.82	17.27	16.78	20.57	14.39
16	9.58	24.42	23.98	17.65	19.09	16.04	16.35			
	20.99	24.38	23.96	17.76	19.14	16.09	16.33		18.15	12.68
17	18.46	20.50	20.57	10.23	16.80	10.28	14.52			
	18.46	20.55	20.52	10.19	16.71	11.11	14.54			
18	16.31	20.26	18.91	9.94	14.60	10.16	14.11			
	16.33	20.16	19.60	9.96	15.50	10.28	14.13			
19	23.10	23.89	25.53	18.64	22.54	18.28	19.18			
	23.15	23.91	25.48	18.59	22.54	18.28	19.18	16.96	22.18	16.29
20	22.01	25.70	24.67	17.66	20.37	16.55	17.18			
	24.38	25.72	24.79	17.66	20.39	16.55	17.18	18.19	23.17	14.67
21	21.83	22.81	21.82	12.72	17.96	12.41	15.61			
	22.00	23.08	21.98	12.95	17.61	14.85	15.63	13.60	19.52	11.94
22	21.06	28.64	21.60	12.85	17.32	14.52	16.15			
	21.74	28.68	22.77	12.70	17.66	14.81	16.28			
23	28.73	24.33	27.11	19.18	22.20	19.20	21.73			
	29.00	25.52	26.98	19.20	22.20	19.29	22.79	24.83	26.11	18.46

* Upper values are for top samples and lower values are for bottom samples.

TABLE VIII (continued)

Salinity o/oo*

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
24	26.04	24.20	26.38	17.90	22.63	18.53	20.66			
	26.24	24.27	26.40	18.37	22.65	18.75	20.61	23.57	26.17	18.78
25	24.00	27.27	26.00	18.17	21.15	17.99	19.63			
	25.41	27.34	26.24	18.15	21.87	18.15	19.87	21.49	25.35	18.69
26		29.29	24.56	16.73	19.99	17.47	18.28			
		29.31	24.58	16.73	19.90	17.86	20.12		27.65	14.69
27		29.87	23.59	13.91	19.65	14.83	16.58			
		29.88	23.60	13.71	19.61	16.08	17.50		25.86	12.99
28	32.68	30.37	30.39	24.45	18.62	17.03	25.72			
	32.68	30.37	30.28	24.43	18.62	18.15	28.77	30.68	30.70	22.20
29	31.26	29.74	27.43	21.38	18.98	18.55	22.36			
	31.22	29.83	27.38	22.90	18.39	18.55	26.73		28.03	21.11
30		30.07	27.00	21.67	18.86	17.27	21.85			
		30.12	26.89	22.88	18.87	17.95	25.25		29.70	19.76

* Upper values are for top samples and lower values are for bottom samples.

TABLE IX

SO₄⁼ Content of Waters* (mg. atoms sulfur/liter)

Station Number	**1	**2	3	4	5	6	7	8	9	10
11	28.4 30.7	23.6	25.2	21.3	20.9	17.7				
12	31.3 30.8	24.1 26.5	22.3	25.1	21.6	21.8				
13	33.2 34.3	22.8 24.5	23.6	20.6	21.8	20.9				
14	31.4 32.0	26.1 24.4	23.4	21.0	22.3	19.3				
15	30.7 31.7	27.7 29.0	22.2	21.8	22.3	18.7				
16	39.4 29.3	28.5 27.1	23.6	20.6	21.0	18.0				
17	26.5 27.7	23.5 23.2	22.2	17.3	20.6	18.0				
18	23.6 23.8	24.2 24.9	21.5	13.1	19.0	12.4				
19	31.3 32.6	28.8 28.2	23.1	20.9	22.8	25.2				
20	30.5 33.3	31.1 30.6	22.8	20.2	21.8	21.3				
21	30.0 30.4	30.1 26.5	25.5	17.4	21.0	18.7				
22	30.6 30.0	33.3 32.8	23.6	18.0	20.6	18.7				
23	39.3 40.5	30.1	25.5	21.9	23.3	22.0				

* Upper values are for top samples and lower values are for bottom samples.

**Determined by turbidimetric method, and 3-6 determined by Ba Chloranilate method.

TABLE IX (continued)

SO₄⁼ Content of Waters* (mg. atoms sulfur/liter)

Station Number	Number of Field Trip on Which Sample Was Taken									
	**1	**2	3	4	5	6	7	8	9	10
24	34.4 35.1	26.5 27.1	23.6	20.9	22.9	23.1				
25	32.4 33.6	31.0 31.1	23.6	21.0	22.9	21.0				
26		33.2 33.4	23.3	20.6	22.2	21.7				
27		34.1 35.3	23.6	18.9	21.7	18.0				
28	45.7 46.3	34.2 34.3	25.2	22.3	21.5	21.3				
29	43.9 44.2	33.7 35.2	25.4	24.2	21.7	21.7				
30		35.2 34.0	24.5	23.1	21.7	20.6				

* Upper values are for top samples and lower values are for bottom samples.

**Determined by turbidimetric method, and 3-6 determined by Ba Chloranilate method.

TABLE X
Carbohydrates
mg/l*

Station Number	1	2	3	4	5	6	7	8	9	10
11	-	-	1.9	2.3	3.4	5.2				
	-	-	6.4	2.0	3.1	4.3				
12	-	-	3.1	1.9	3.6	4.4				
	-	-	3.0	2.2	3.1	5.2				
13	-	-	2.5	1.8	2.3	8.0				
	-	-	2.2	1.8	3.0	5.3				
14	-	-	1.9	1.4	2.8	4.5				
	-	-	1.9	1.4	3.0	4.1				
15	-	-	2.1	1.2	2.9	3.1				
	-	-	1.7	1.6	2.6	3.9				
16	-	-	1.6	1.9	3.6	4.3				
	-	-	2.3	1.9	3.3	6.6				
17	-	-	1.9	2.2	3.9	4.4				
	-	-	2.1	2.3	3.8	4.7				
18	-	-	1.5	1.9	3.6	4.5				
	-	-	2.5	2.1	3.8	3.3				
19	-	-	1.7	1.3	2.9	3.5				
	-	-	1.7	1.0	3.0	3.5				
20	-	-	1.2	1.5	4.6	3.9				
	-	-	1.4	1.7	3.3	3.4				
21	-	-	1.2	2.3	4.2	5.6				
	-	-	1.4	2.1	4.2	3.9				
22	-	-	1.5	2.1	3.8	4.1				
	-	-	1.5	1.9	3.8	3.0				
23	-	-	1.2	0.7	1.7	2.8				
	-	-	1.8	0.7	1.7	2.0				

* Upper values are for top samples and lower values for bottom samples.

TABLE X (continued)

Carbohydrates

mg/l*

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
24	-	-	0.9	1.2	1.7	4.3				
	-	-	1.1	1.2	2.0	3.1				
25	-	-	0.9	1.7	2.4	3.7				
	-	-	1.0	1.7	1.4	3.2				
26	-	-	0.8	1.3	2.1	3.1				
	-	-	1.1	1.0	2.6	2.1				
27	-	-	1.0	1.6	2.2	3.9				
	-	-	0.9	2.0	2.0	4.3				
28	-	-	0.6	0.9	2.4	3.5				
	-	-	0.5	1.0	2.3	2.4				
29	-	-	0.8	1.4	2.8	2.7				
	-	-	0.9	0.8	2.4	2.8				
30	-	-	1.0	1.3	2.2	2.7				
	-	-	0.9	1.0	2.7	2.3				

* Upper values are for top samples and lower values are for bottom samples.

TABLE XI
Nitrate-Nitrite Nitrogen*

ug - atm/l

Station Number	Number of Field Trip on Which Sample was Taken									
	1	2	3	4	5	6	7	8	9	10
11	-	-	1.2	1.2	0.8	0.6				
	-	-	1.0	0.8	0.5	-				
12	-	-	0.8	3.8	1.0	-				
	-	-	1.2	0.7	-	0.5				
13	-	-	0.9	1.0	0.9	0.6				
	-	-	0.8	0.7	1.0	0.4				
14	-	-	0.5	3.3	1.0	0.5				
	-	-	0.4	0.9	0.9	0.3				
15	-	-	0.6	0.8	1.2	0.3				
	-	-	0.9	1.0	1.0	0.1				
16	-	-	1.6	1.1	0.6	0.4				
	-	-	1.1	0.7	0.9	0.2				
17	-	-	1.4	0.7	1.2	0.4				
	-	-	0.7	1.0	0.7	0.5				
18	-	-	0.9	0.8	0.9	0.4				
	-	-	0.9	0.6	1.0	0.5				
19	-	-	1.3	0.8	0.9	0.1				
	-	-	0.4	1.1	0.9	2.7				
20	-	-	0.5	3.8	0.9	0.5				
	-	-	0.6	0.8	0.7	0.4				
21	-	-	0.6	1.3	0.8	0.3				
	-	-	0.6	1.2	0.8	0.4				
22	-	-	0.4	1.3	0.9	0.3				
	-	-	0.3	1.5	1.0	0.4				
23	-	-	0.6	1.6	0.6	1.4				
	-	-	1.5	1.4	1.0	0.2				

* Upper values are for top samples and lower values are for bottom samples.

TABLE XI (continued)
Nitrate-Nitrite Nitrogen*

ug - atm/l

Station Number	1	2	3	4	5	6	7	8	9	10
24	-	-	0.7	1.1	1.5	0.4				
	-	-	0.5	1.0	0.8	0.5				
25	-	-	0.7	1.7	1.4	0.3				
	-	-	0.4	1.0	0.3	1.0				
26	-	-	0.8	0.7	0.9	0.1				
	-	-	0.4	0.3	1.2	0.1				
27	-	-	0.5	1.6	1.0	2.1				
	-	-	0.5	1.4	1.2	0.3				
28	-	-	0.3	1.8	1.2	0.1				
	-	-	0.4	2.8	1.2	0.5				
29	-	-	0.4	1.8	0.7	0.3				
	-	-	0.7	4.7	1.0	0.3				
30	-	-	0.4	1.5	1.2	3.8				
	-	-	0.7	2.6	0.9	2.4				

* Upper values are for top samples and lower values are for bottom samples.

TABLE XII
Phosphate Phosphorus*
ug - atm/l

Station Number	1	2	3	4	5	6	7	8	9	10
11	-	-	0.33	0.46	0.41	0.41				
	-	-	0.45	0.40	0.30	0.30				
12	-	-	0.42	0.46	0.75	0.42				
	-	-	0.78	0.38	0.71	0.37				
13	-	-	0.55	0.26	0.35	0.40				
	-	-	0.47	0.42	0.08	0.39				
14	-	-	0.49	0.38	0.41	0.38				
	-	-	0.60	0.31	0.35	0.35				
15	-	-	0.53	0.89	0.41	0.43				
	-	-	0.26	0.19	0.43	0.39				
16	-	-	0.08	0.41	0.62	0.41				
	-	-	0.87	0.42	0.51	0.37				
17	-	-	0.44	0.44	0.51	0.74				
	-	-	0.56	0.58	0.52	0.56				
18	-	-	0.77	1.34	0.19	0.88				
	-	-	0.67	0.80	0.52	0.59				
19	-	-	0.65	0.22	0.26	0.45				
	-	-	0.32	0.54	0.23	0.38				
20	-	-	0.18	0.32	0.37	0.40				
	-	-	0.25	0.49	0.24	0.43				
21	-	-	0.41	0.75	0.58	0.73				
	-	-	0.37	0.49	0.49	0.57				
22	-	-	0.44	0.59	0.45	0.60				
	-	-	0.27	0.41	0.41	0.67				
23	-	-	0.18	0.13	0.09	0.31				
	-	-	0.45	0.23	0.07	0.30				

* Upper values are for top samples and bottom values are for bottom samples.

TABLE XII (continued)

Phosphate Phosphorus*

ug - atm/l

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
24	-	-	0.16	0.30	0.11	0.33				
	-	-	0.24	0.23	0.13	0.33				
25	-	-	0.29	0.22	0.20	0.31				
	-	-	0.26	0.22	0.21	0.33				
26	-	-	0.24	0.27	0.02	0.41				
	-	-	0.28	0.23	0.16	0.49				
27	-	-	0.34	0.32	0.04	0.47				
	-	-	0.12	0.28	0.24	0.63				
28	-	-	0.24	0.24	0.00	0.33				
	-	-	0.34	0.16	0.03	0.23				
29	-	-	0.24	0.23	0.15	0.56				
	-	-	0.45	0.28	0.10	0.37				
30	-	-	0.29	0.31	0.88	0.41				
	-	-	0.24	0.24	0.12	0.29				

* Upper values are for top samples and lower values for bottom samples.

TABLE XIII

Silica Content of Waters*

Number of Field Trip on Which Sample Was Taken

Station Number	5	6	Station Number	5	6
11	34.6 30.9	39.2 28.3	21	41.0 39.5	34.7 37.7
12	46.7 38.0	34.5 35.7	22	39.0 31.2	35.7 35.7
13	24.2 23.0	18.7 30.8	23	5.0 6.5	25.2 16.8
14	22.2 22.8	29.0 28.0	24	3.0 3.5	30.2 27.3
15	25.2 21.0	31.5 29.7	25	3.7 19.1	29.7 25.0
16	39.2 36.2	25.8 21.2	26	18.1 19.3	29.0 20.4
17	46.0 45.8	34.7 34.5	27	25.2 20.7	33.2 40.0
18	49.4 48.0	36.3 30.2	28	8.4 8.7	6.7 10.4
19	20.6 15.5	35.3 34.5	29	18.2 15.7	11.7 12.8
20	25.5 31.6	29.0 28.3	30	13.3 15.5	14.4 20.3

* Upper values are for top samples and lower values are for bottom samples.

TABLE XIV
Total Solids* (Dry at 105°C) (o/oo)

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
11	22.13	24.27	23.90 23.98	17.77	21.12	16.25				
12	23.12	25.66	25.48 25.21	18.29	21.58	16.95				
13	27.95	24.48	25.54 24.90	19.87	23.13	19.49				
14	24.46	24.07	26.83 17.06	20.88	22.60	19.01				
15	24.08	26.77	27.19 27.11	20.91	22.63	18.11				
16	22.65	26.84	26.31 26.10	18.77	21.36	17.36				
17	20.04	22.03	22.33 22.03	10.85	18.68	11.14				
18	17.43	21.57	20.51 21.07	10.58	16.22	10.92				
19	24.98	26.48	28.41 27.77	20.05	25.17	19.89				
20	23.73	27.98	27.30 26.79	19.05	22.73	17.77				
21	23.76	24.47	24.05 23.59	14.01	19.58	13.53				
22	22.78	31.02	23.96 24.60	13.61	19.23	15.59				
23	31.53	26.61	30.25 29.85	20.92	24.76	20.76				

* Upper values are for top samples and lower values are for bottom samples.

TABLE XIV (continued)
Total Solids* (Dry at 105°C) (o/oo)

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
24	28.36	26.47	28.91 28.79	19.41	25.30	20.22				
25	26.20	29.85	29.56 28.66	19.76	23.62	19.44				
26		32.01	26.78 26.73	18.07	22.20	18.84				
27		33.34	25.90 25.64	15.75	21.97	15.96				
28	35.66	33.37	33.39 32.77	26.42	20.75	18.38				
29	34.05	32.69	30.58 29.78	23.06	21.42	20.14				
30		33.43	29.22 29.12	23.55	21.11	18.91				

* Upper values are for top samples and lower values are for bottom samples.

TABLE XV

Total Solids after Ignition* (o/oo)

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
11	19.42	20.76	21.05 20.60	15.67	18.07	14.22				
12	20.66	21.74	22.45 22.47	16.22	18.48	14.93				
13	22.64	21.45	22.32 22.35	17.71	19.81	17.23				
14	21.64	20.78	23.39 13.38	18.71	19.44	16.64				
15	21.33	23.85	23.53 23.70	16.62	19.44	16.08				
16	19.92	23.45	23.07 22.74	16.84	18.15	14.38				
17	17.88	19.57	19.71 19.74	9.52	15.86	9.60				
18	15.35	19.21	18.11 18.58	9.31	13.62	9.43				
19	22.35	23.10	24.57 24.19	17.70	21.41	17.47				
20	21.18	25.03	23.63 24.02	16.73	19.50	15.75				
21	21.13	21.77	20.94 21.10	12.16	16.79	11.66				
22	20.44	27.89	20.86 22.14	12.08	16.28	13.59				
23	27.76	23.23	26.52 26.24	18.46	21.35	18.38				

* Upper values are for top samples and lower values are for bottom samples.

TABLE XV (continued)

Total Solids after Ignition* (o/oo)

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
24	25.03	23.41	25.67 25.28	17.06	21.70	17.86				
25	23.18	26.65	25.17 24.74	17.50	20.32	17.30				
26		28.77	23.74 23.64	15.84	19.00	16.64				
27		28.84	22.85 22.35	12.88	18.76	14.05				
28	31.79	29.41	29.54 29.10	23.41	17.82	16.32				
29	30.39	29.15	26.65 26.58	20.25	18.28	17.68				
30		29.39	26.25 26.06	20.99	18.11	16.66				

* Upper values are for top samples and lower values are for bottom samples.

TABLE XVI
Weight Loss on Ignition* (o/oo)

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
11	2.71	3.50	2.86 3.38	2.10	3.05	2.03				
12	2.46	3.92	3.03 2.74	2.07	3.10	2.01				
13	5.31	3.03	3.22 2.56	2.16	3.32	2.26				
14	2.82	2.59	3.45 3.68	2.17	3.17	2.36				
15	2.74	2.92	3.66 3.40	2.29	3.19	2.03				
16	2.74	3.38	3.25 3.37	1.93	3.21	2.09				
17	2.16	2.46	2.62 2.30	1.33	2.82	1.54				
18	2.08	2.36	2.40 2.49	1.27	2.60	1.60				
19	2.63	3.38	3.83 3.57	2.35	3.77	2.42				
20	2.54	2.96	3.77 2.77	2.32	3.23	2.01				
21	2.63	2.70	3.10 2.49	1.86	2.79	1.97				
22	2.34	3.13	3.10 2.46	1.53	2.95	2.00				
23	3.76	3.38	3.73 3.61	2.46	3.41	2.39				

* Upper values are for top samples and lower values are for bottom samples.

TABLE XVI (continued)

Weight Loss on Ignition* (o/oo)

Station Number	Number of Field Trip on Which Sample Was Taken									
	1	2	3	4	5	6	7	8	9	10
24	3.33	3.06	3.24 3.51	2.35	3.60	2.36				
25	3.01	3.19	3.39 3.92	2.26	3.40	2.14				
26		3.31	3.05 3.09	2.23	3.19	2.21				
27		4.50	3.05 3.29	1.87	3.21	1.91				
28	3.88	3.95	3.85 3.67	3.02	2.94	2.06				
29	3.67	3.54	3.93 3.20	2.81	3.15	2.46				
30		4.03	2.97 3.05	2.57	3.00	2.25				

* Upper values are for top samples and lower values are for bottom samples.

APPENDIX

TABLE I

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	2	8	27	15	30	30	47	52	38	97
<i>Ammonastuta salsa</i>	1M									
<i>Ammonaculites crassus</i>			1S		3S	1S			1L	
<i>A. subcatenulatus</i>			1M			1M		2S	4S	13M
<i>Ammonium dilatatum</i>			2S		1S					
<i>A. fragile</i>			3S		1M	5M	2M			4M
<i>A. salsum</i>										
<i>Arenoparella mexicana</i>	1S	2M	7S	1S	6S	5S	15S	4M	6M	26M
<i>Bolivina striatula</i>			1S			1S	1S	1S		
<i>Elphidium gunteri</i>										
<i>E. limosum</i>			2S	1S	5S	1S	3S	4S	2M	6S
<i>E. matagordani</i>			1S						1M	
<i>E. poeyanum</i>				1S		1S	1S	1S		2S
<i>Gaudryina exilis</i>	1M									
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>										
<i>Miliammina fusca</i>			1S	3S	1S		2S	3S	1S	2S
<i>Quinqueloculina</i> cf. <i>Q. lamarckiana</i> .										
<i>Q. rhodiensis</i>										1S
<i>Streblus parkinsoniana</i>	1S	3S	7S	7S	11M	11S	17S	20S	12S	25S
<i>S. tepida</i>			1S	1S	2S	5S	3S	16S	11S	18S
<i>Trochammina comprimata</i>							1S			
<i>T. inflata</i>										
<i>T. macroscens</i>										
								1S		

Populations of living Foraminifera from station 11, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
MONTH	9	18	27	99	48	119	188	129	119	120
TOTAL	1M									1M
<i>Ammonastuta salsa</i>	1M	1S	2L	2M			1M	6M	3M	3M
<i>Ammonaquilites crassa</i>		1M	2M				1S	2S	1S	5S
<i>A. subcatenulatus</i>					4M					
<i>Ammonium dilatatum</i>			1M							
<i>A. fragile</i>				2M		15L	15M	8M	1S	5M
<i>A. salsum</i>		2M	6M	10S	6M	25M	21M	24M	5M	17S
<i>Arenoparella mexicana</i>						4S	2S	1S	2S	1S
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>										
<i>E. limosum</i>	2S	6S	7S	9S	6S	2S	7S	9S	2S	10S
<i>E. matagordani</i>			32S	6M	1S		3S	1S	1S	
<i>E. poeyanum</i>		1S		3S	3S	1S	7S	3S	4S	1S
<i>Gaudryina exilis</i>	1S		2S	9S					2S	1S
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>			1S			1S				
<i>Miliammina fusca</i>			1M	1S			7S	4S	1M	
<i>Quinqueloculina</i> cf. <i>Q. lamarckiana</i>	1S	3M	4M	13S	5S	1M	6S	9S	1S	1M
<i>Q. rhodiensis</i>										
<i>Streblus parkinsoniana</i>							1S	1S		
<i>S. tepida</i>	4M	5S	27S	37S	21S	53S	97S	52S	58S	49S
<i>Trochammina comprimata</i>			5S	8S	2S	12S	19S	8S	37S	26S
<i>T. inflata</i>					1S	1S	1S	1S		
<i>T. macroscens</i>										
					1S					1M

Populations of living Foraminifera from station 12, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

MONTH
TOTAL

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	57	47	46	336	127	132	50	63	119	31
	1M						1M			
<i>Ammodontostoma salsa</i>	2M	6S	2S	1S		1S				
<i>Ammodontostoma cressus</i>		2M	7M	3S	4M	1L	1S	1S		
<i>A. subcostatum</i>	3S	2S	7S			4S	6M	7S	2S	
<i>Ammodontostoma dilatatum</i>	2M		2M	280M	83M	114M	12M	35M	17M	1M
<i>A. fragile</i>	4S	1S	1S				1S		1S	
<i>A. salem</i>										
<i>Arenoporella mexicana</i>	6S	13S	9S	8S	10S		6S	2S	8S	
<i>Bolivina striatula</i>		4S	4S	2S			2S			
<i>Elphidium gunteri</i>			3S	3S		1S	1S	1S		
<i>E. limosum</i>										
<i>E. matagordianum</i>										
<i>E. poeyanum</i>										
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>										
<i>Milliammina fusca</i>	17S	6S	4M	1S		2M	2M			
<i>Quinqueloculina cf. Q. lamarkiana</i>	1M			4S	2S		2S	2M		
<i>Q. rhodiensis</i>										
<i>Streblus parkinsoniana</i>	1S									
<i>S. tepida</i>	11S	4M	8M	9S	8S	4M	10S	10S	75S	15S
<i>Trochammina comprimata</i>	4S	7S	5S	21S	9S	4S	6S	6S	20S	6S
<i>T. inflata</i>	2S	2S	1M							
<i>T. macroscena</i>	3S						1S			

Populations of living Foraminifera from station 13, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	3	14	41	33	40	123	67	15	140	56
<i>Ammoastuta salsa</i>										
<i>Ammobaculites crassus</i>							1M			
<i>A. subcatenulatus</i>					2S	1M	3S	1S	1M	
<i>Annotium dilatatum</i>										
<i>A. fragile</i>			4M		8M	46L	15M	4S	1M	
<i>A. salsum</i>			3S		1M	24M	25M	10M		
<i>Arenoparella mexicana</i>										
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>										
<i>E. limosum</i>	1S	4S	8S	20S	1S	2S	1S			4S
<i>E. matagordanus</i>				2S						
<i>E. poeyanum</i>			2S	2S		1S			1S	1S
<i>Gaudryina exilis</i>				1S						
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>										
<i>Miliammina fusca</i>						2S	1S			
<i>Quinqueloculina</i> cf. <i>Q. lamarckiana</i> .										
<i>Q. rhodiensis</i>										1S
<i>Streblus parkinsoniana</i>										
<i>S. tepida</i>	2M	10S	21S	25S	24S	47S	20S		135S	49M
<i>Trochammina comprimata</i>			3S	3S	4S		1S		2S	1S
<i>T. inflata</i>										
<i>T. macroscens</i>										

Populations of living Foraminifera from station 14, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	44	16	65	66	79	35	123	40	43	47
<i>Ammonastuta salaa</i>							1S			
<i>Ammonaculites crassus</i>										
<i>A. subcatenulatus</i>										
<i>Ammonium dilatatum</i>			3M		4S	2S	3S			
<i>A. fragile</i>	1M			1S	2S	8M	51M			
<i>A. salaa</i>			1S		2S	2S	4M	1M		
<i>Arenoparella mexicana</i>										
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>	1S	1S	2S	9S	1S	1L	1S			1S
<i>E. limosum</i>			12S	1S			1M			
<i>E. matagordani</i>	38S	10S	3S	44S	53	7S	13S	24S	3S	25S
<i>E. poeyanum</i>			4S		1S		1S	1S	1S	
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>										
<i>Millammina fusca</i>	1M		7M	2M	7M		1S	3S		
<i>Quinqueloculina</i> cf. <i>Q. lamareckiana</i> .										
<i>Q. rhodiensis</i>										
<i>Streblus parkinsoniana</i>	3S	5S	24S	9S	54S	14S	44S	11S	39S	21S
<i>S. tepida</i>			9S		3S	1S	1S			
<i>Trochammina comprimata</i>										
<i>T. inflata</i>										
<i>T. macroscens</i>										

Populations of living Foraminifera from station 15, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	28	48	274	207	111	50	156	103	30	42
<i>Ammonstute salsa</i>					1M					
<i>Amnobaaculites crassus</i>					1M	1L	2M			
<i>A. subcatenulatus</i>		1S		2M						
<i>Ammotium dilatatum</i>			1M	4M	40M	11M	5M	2S		1S
<i>A. fragile</i>	8S	2S	1M	1M	5S	6S	3S	7S	3S	1S
<i>A. salsum</i>	3S	1S	2M	2M	18M	17M	111M	76M	6M	
<i>Arenoporella mexicana</i>										
<i>Belivina striatula</i>										
<i>Elphidium gunteri</i>										
<i>E. limosum</i>										
<i>E. matagordanus</i>										
<i>E. poeyanum</i>										
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>										
<i>Miliammina fusca</i>										
<i>Quinqueloculina</i> cf. <i>Q. lamarckiana</i>										
<i>Q. rhodiensis</i>										
<i>Streblus parkinsoniana</i>										
<i>S. tepida</i>										
<i>Trochammina comprimata</i>										
<i>T. inflata</i>										
<i>T. macroscens</i>										

Populations of living Foraminifera from station 16, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	11	9	19	30	41	114	65	33	84	91
<i>Ammonastuta sales</i>					1L			2S		1M
<i>Ammonaculites crassus</i>										
<i>A. subcastenulatus</i>										
<i>Ammonium dilatatum</i>			1S			52M	4M	9M		
<i>A. fragile</i>					2S			3S		
<i>A. salsum</i>	1S		1S	2M	5S	1M	3M			1S
<i>Arenoporella mexicana</i>				1S	1S					
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>	8S	6M	9S	13S	6S	13S	9M	2S	4S	
<i>E. limosum</i>			2S			1S				
<i>E. metagordanum</i>					6S	2S	1S			
<i>E. poeyanum</i>			1M	3S			1S			
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manillaensis</i>							1M			
<i>H. wilberti</i>		1M			1M	2S	1S	1M	1M	
<i>Miliammina fusca</i>					2S					
<i>Quinqueloculina</i> cf. <i>Q. lamareckiana</i>										
<i>Q. rhodiensis</i>							1S			
<i>Streblus parkinsonians</i>	1S	2M	6M	13M	19M	33S	41S	11S	68S	89M
<i>S. tepida</i>	1S					3S	6S	2S	9S	1S
<i>Trochammina comprimata</i>						1S				
<i>T. inflata</i>					1S					1S
<i>T. macroscens</i>										

Populations of living Foraminifera from station 19, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
MONTH	10	34	55	120	302	109	213	154	26	40
<i>Ammonastute sales</i>										
<i>Ammonaculites crassus</i>										
<i>A. subcatenulatus</i>										
<i>Ammonium dilatatum</i>										
<i>A. fragile</i>										
<i>A. salsum</i>										
<i>Arenoparella mexicana</i>										
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>										
<i>E. limosum</i>										
<i>E. matagordanus</i>										
<i>E. poeyanum</i>										
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>										
<i>Miliammina fusca</i>										
<i>Quinqueloculina</i> cf. <i>Q. lamarekiana</i>										
<i>Q. rhodiensis</i>										
<i>Streblus parkinsoniana</i>										
<i>S. tepida</i>										
<i>Trochammina comprimata</i>										
<i>T. inflata</i>										
<i>T. macroscena</i>										

Populations of living Foraminifera from station 20, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	2	5	16	14	5	17	48	93	18	103
<i>Ammonostuta salsa</i>		1L								
<i>Ammonosculites crassus</i>										
<i>A. subcatenulatus</i>								4S		2S
<i>Ammonotium dilatatum</i>							2S	2M	1S	
<i>A. fragile</i>										
<i>A. salsum</i>	1L		3M			1S				
<i>Arenoparella mexicana</i>			1M				16S	1S		1S
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>		2S		4S		2S		3S		5S
<i>E. limosum</i>		1S		1S	1S			2S		
<i>E. matagordianum</i>	1S	1S	2S			6S		3S		
<i>E. poeyanum</i>			1S	1S		1S				2S
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>							2QM	2S		
<i>Miliammina fusca</i>			1S	2S					1S	
<i>Quinqueloculina</i> cf. <i>Q. lamarckiana</i> .										
<i>Q. rhodiensis</i>										
<i>Streblus parkinsoniana</i>			2S	6S	1S	4S	11S	42S	8S	87S
<i>S. tepida</i>			6S		3S	3S		33S	6S	6S
<i>Trochammina comprimata</i>										
<i>T. inflata</i>										
<i>T. macroscens</i>									1S	

Populations of living Foraminifera from station 21, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
MONTH	80	11	11	17	24	143	40	100	109	49
TOTAL										
<i>Ammonastuta salsa</i>								1M		
<i>Ammonastulites crassus</i>								1M		
<i>A. subcastenulatum</i>					2S	2S	3S	5S	2S	
<i>Ammonium dilatatum</i>	1L	1S	1L		3M	3M	2M	2M		
<i>A. fragile</i>							2S	5S		
<i>A. salum</i>	1S				1S			4S	1S	
<i>Arenoporella mexicana</i>										
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>	6S	6S	6S	1S	2S	17S	8S	15S	7S	11S
<i>E. limosum</i>					1S	1M		1S		
<i>E. matagordani</i>	2M				2S	3S		2S	3S	1S
<i>E. poeyanum</i>	1M	1S			1S	4S	1S	3S		1M
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>						1S				
<i>Miliammina fusca</i>									1S	
<i>Quinqueloculina</i> cf. <i>Q. lamareckiana</i>						1L			1L	
<i>Q. rhodiensis</i>									2S	
<i>Streblus parkinsoniana</i>	8S		3M	1M	2S	68S	18S	46S	60S	23S
<i>S. tepida</i>	6S	2S		14S	10S	42S	6S	14S	27S	13S
<i>Trochammina comprimata</i>	1S	1S	1S						4S	
<i>T. inflata</i>				1L				1S		
<i>T. macroscens</i>								1L		

Populations of living Foraminifera from station 23, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	14	17	16	43	39	37	41	129	99	23
<i>Ammonastuta salsa</i>	1M									
<i>Ammonaculites crassus</i>										
<i>A. subcatenulatus</i>						1L		1M	1S	
<i>Ammonium dilatatum</i>										
<i>A. fragile</i>										
<i>A. salsum</i>	1S		3M	1S	2S	1S	2M			
<i>Arenoporella mexicana</i>			3S	1S	1S	1S	1S	2S		
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>	10S	10S	2S	16S	12S		5S	6S	5S	3S
<i>E. limosum</i>	1S			1S		2S	1S	1S	1M	
<i>E. matagordianum</i>		1S	1S			2S		5S	4S	1S
<i>E. poeyanum</i>	1S			3S				2S		
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>			2S		3S	1S	1S	2S		
<i>Miliammina fusca</i>	1S									
<i>Quinqueloculina</i> cf. <i>Q. lamarckiana</i>										
<i>Q. rhodiensis</i>								1S		
<i>Streblus parkinsoniana</i>		2S	1M	15S	11S	21S	28S	84S	79S	17M
<i>S. tepida</i>				6S	3S	7S	3S	25S	9S	2S
<i>Trochammina comprimata</i>		2S	2S		2S	1S				
<i>T. inflata</i>					3S					
<i>T. macroscens</i>		1S	2S		3S					

Populations of living Foraminifera from station 24, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	33	36	47	263	21	45	45	46	59	57
<i>Ammonastuta sales</i>		1M								
<i>Ammonaculites cressus</i>				1S						
<i>A. substenulatus</i>		9S	1M	8S	4S	3S				2M
<i>Ammonotium dilatatum</i>										
<i>A. fragile</i>				1S						
<i>A. salsum</i>							1S			
<i>Arenoparella mexicana</i>										
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>		19S	15S	30S	243S	9S	21S	4S	1S	5S
<i>E. limosum</i>										6S
<i>E. matagordianum</i>			2S	1S	2S		4S	3S		1S
<i>E. poeyanum</i>		1S		3S	1S					1S
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>		2S	2S		1S	1S				
<i>Miliammina fusca</i>										
<i>Quinqueloculina</i> cf. <i>Q. lamarckiana</i>										1S
<i>Q. rhodiensis</i>		1M	14S	3M	16S	4S	10S	31S	41S	50M
<i>Streblus parkinsoniana</i>		1S	1S	2S	1S	11S	4S	1S	1S	2S
<i>S. tepida</i>										
<i>Trochammina comprimata</i>										
<i>T. inflata</i>										1M
<i>T. macroscena</i>										

Populations of living Foraminifera from station 25, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	20	26	44	16	9	8	9	9	53	
<i>Ammonoastuta salsa</i>										1M
<i>Ammonobaculites crassus</i>										
<i>A. subcatenulatus</i>			4M							
<i>Ammotium dilatatum</i>		8M	7M		1S					
<i>A. fragile</i>				1M						
<i>A. salsum</i>			5S			1S				
<i>Arenoparella mexicana</i>										
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>		7S	7S	34S	8S	2S		2S	16S	
<i>E. limosum</i>										
<i>E. matagordanus</i>		1S	1S		4S	4S	1S		2S	
<i>E. poeyanum</i>		2S	1S	1S		1S			6S	
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>										
<i>Miliammina fusca</i>			1S						1S	
<i>Quinqueloculina</i> cf. <i>Q. lamarckiana</i> .										
<i>Q. rhodiensis</i>									1S	
<i>Streblus parkinsoniana</i>				5S	2S		5S	5S	9S	
<i>S. tepida</i>				3S	1S	1S	2S	2S	17S	
<i>Trochammina comprimata</i>		2S								
<i>T. inflata</i>										
<i>T. macroscens</i>										

Populations of living Foraminifera from station 26, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	11	71	81	51	46	79	8	10		
<i>Ammoastuta salsa</i>										LM
<i>Ammobaculites crassus</i>										
<i>A. subcatenulatus</i>			LM	1S			2M			
<i>Annotium dilatatum</i>	4M	35M		3S	3S					
<i>A. fragile</i>	2S	1M	1S	2S	1S	2S				2S
<i>A. salsum</i>		17M	57M	38M	41M	71M				3S
<i>Arenoparella mexicana</i>										
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>										
<i>E. limosum</i>			1S							1S
<i>E. matagordanus</i>			1S	8S	3S					
<i>E. poeyanum</i>				2S						
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>			1S			1S				
<i>Miliammina fusca</i>	3S	12S	3S		1S	3S				
<i>Quinqueloculina</i> cf. <i>Q. lamarckiana</i> .										
<i>Q. rhodiensis</i>										
<i>Streblus parkinsoniana</i>	2S	2S	9S	4S			2S	4S		
<i>S. tepida</i>				1S			1S	3S		
<i>Trochammina comprimata</i>										
<i>T. inflata</i>										
<i>T. macrosens</i>										

Populations of living Foraminifera from station 27, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	43	12	32	19	41	144	26	69	43	42
<i>Ammonastuta salsa</i>										
<i>Ammonaculites crassus</i>										
<i>A. subcatenulatus</i>										
<i>Ammonium dilatatum</i>										
<i>A. fragile</i>										
<i>A. salsum</i>										
<i>Arenoporella mexicana</i>										
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>										
<i>E. limosum</i>										
<i>E. matagordani</i>										
<i>E. poeyanum</i>										
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>										
<i>Millammina fusca</i>										
<i>Quinqueloculina</i> cf. <i>Q. lamarckiana</i> .										
<i>Q. rhodiensis</i>										
<i>Streblus parkinsoniana</i>										
<i>S. tepida</i>										
<i>Trochammina comprimata</i>										
<i>T. inflata</i>										
<i>T. macroscens</i>										

Populations of living Foraminifera from station 28, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	27	24	45	43	51	20	12	6	6	7
<i>Ammonatuta salaa</i>										
<i>Ammonaculites crassus</i>										
<i>A. subcastenulatus</i>										
<i>Ammonium dilatatum</i>	3S	2S	16M	4L	15M	5M	1M			
<i>A. fragile</i>						5S				
<i>A. saalum</i>										
<i>Arenoparella mexicana</i>										
<i>Bolivina striatula</i>										
<i>Elphidium gunteri</i>	17S	14S	14S	21S	20S	5S	4S	1S	1S	1S
<i>E. limosum</i>										
<i>E. matagordanus</i>		3S	6S	2S	2S	2S	2S		1S	
<i>E. poeyanum</i>	3S	2S	4S	9S	3S		1S			1M
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>						1S				
<i>Millammina fusca</i>										1S
<i>Quinqueloculina</i> cf. <i>Q. lamarckiana</i>					1S					
<i>Q. rhodiensis</i>										
<i>Streblus parkinsoniana</i>	2S	2S	4S	5S	4S	2S	3S	3S	3S	3S
<i>S. tepida</i>	2S	1S	1S	2S	6S		1S	1S	1S	1S
<i>Trochammina comprimata</i>										
<i>T. inflata</i>										
<i>T. macroscens</i>										

Populations of living Foraminifera from station 29, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE I (continued)

MONTH	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
TOTAL	38	35	73	15	19	66	53	33		
<i>Ammonastuta salsa</i>										1M
<i>Ammonaculites crassus</i>										
<i>A. subcatenulatus</i>										
<i>Ammonium dilatatum</i>										
<i>A. fragile</i>			8M	2S	2S					
<i>A. salsum</i>										2S
<i>Arenoparella mexicana</i>										
<i>Bolivina striatula</i>							2S			
<i>Elphidium gunteri</i>										
<i>E. limosum</i>	29S	23S	41S	6S	5S	9S		12S	7S	
<i>E. matagordamum</i>										
<i>E. poeyanum</i>	2S	3S	5S	1S	1S	7S				
<i>Gaudryina exilis</i>										
<i>Haplophragmoides manilaensis</i>										
<i>H. wilberti</i>										
<i>Miliammina fusca</i>										
<i>Quinqueloculina</i> cf. <i>Q. lamareckiana</i> .										
<i>Q. rhodiensis</i>										
<i>Streblus parkinsoniana</i>	5M	12S	2M	11M	22M			16S	5S	
<i>S. tepida</i>	1S	1S	13S	4S	2S	26S		21S	21S	
<i>Trochammina comprimata</i>										
<i>T. inflata</i>										
<i>T. macroscens</i>										

Populations of living Foraminifera from station 30, showing average sizes. Small (S) = (less than 0.177mm); medium (M) = (between 0.177 and 0.250mm); large (L) = (greater than 0.250mm).

TABLE II

Month	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
Trip	2	3	4	5	6	7	8	9	10
ANMOTIUM	26	11*	12*	11	11	11*	13*		11*
	27	12	13	13	12*	15*	19*		12*
		13	27*	14	13*	16*	23*		
		14		15	14*				
		25*		16*	19*				
		26*		20					
		29*		23					
		30*		27*					
				29*					
ELPHIDIUM	12	12*	14*	23	16*	12*	15*	16*	13*
	13*	14	15*	28	20*	13*	16	26	15*
	14	15	19*		21*	15	20*	30*	26*
	20	16*	20*		23*	30*	21*		
	26*	19	24*		25*		23*		
	30*	20	25*		28*		24*		
		25	26*				28*		
		28*	27*						
		29	29*						
			30*						
STREBULUS	11	11	12*	11*	11	11	11*	12*	11*
	14	12	13*	15*	12	12*	21*	13*	16*
	15	13	14	19	14*	13	24*	14*	19*
	20	14	16*	20*	21	15*	25	15*	20*
	25*	15*	19	28	23*	19*	28*	16	21*
	30	16	20	29*	24	20*		19	26*
		19	23*		25	23		23*	27*
		20	24*		28*	24		25*	
		21*	25*		30	25		26	
		28	26*			26*		27	
		29	27*			30*		29	
			28					30*	
			29						
			30*						

* population peak for station on field trip

Stations and field trips on which increases of 100 per cent, or more, occurred in foraminiferal populations of genera listed.

TABLE II; SUMMARY

Field trip -----	2	3	4	5	6	7	8	9	10
Stations with increase of population	14	28	27	16	20	18	15	15	12
Stations with peaks of population	4	11	21	8	13	12	13	9	12
Stations with continuing increase of population	10	17	6	8	7	6	2	6	0

The greatest biological activity of the year is indicated by populations of the fourth field trip when 21 out of 27 stations reached a population peak. A minor upswing was found on the eighth field trip, also on the tenth field trip.

TABLE III

Grouping of Stations According to Genus Productivity

Total live counts

Ammotium = 2004

Elphidium = 2186

Streblus = 4354

<u>Station</u>	<u>% Ammotium</u>	<u>Station</u>	<u>% Elphidium</u>	<u>Station</u>	<u>% Streblus</u>
13	30.2	25	12.4	20	18.6
		16	11.2		
		28	10.2		
16	16.8	15	9.7	12	11.9
27	10.4	20	8.4	14	8.0
14	9.6	30	7.0	23	8.3
12	8.8	29	6.3		
		12	6.3	24	7.2
11	4.5			19	7.0
15	4.3	19	4.5		
19	4.3	23	4.8	13	5.6
		24	4.4	15	5.5
20	2.3	26	4.6	21	5.0
29	2.5			25	5.5
		14	2.3	28	4.9
		13	3.8		
23	1.4	11	1.5	11	4.0
25	1.4	21	1.8	30	3.7
26	1.1				
				16	2.0
21	0.6	27	0.7		
24	0.6			26	1.2
30	0.7			29	1.0
28	0.4			27	0.6

TABLE IV

Stations	11	14	19	24	29
Trip 3	247		65	30	168
Trip 4	698	348	399	225	507
Trip 5	808	322		177	413
Trip 6	751	1107	920	573	2166
Trip 7	1599	1863	588	1063	613

Total Plankton per Liter, Timbalier Bay

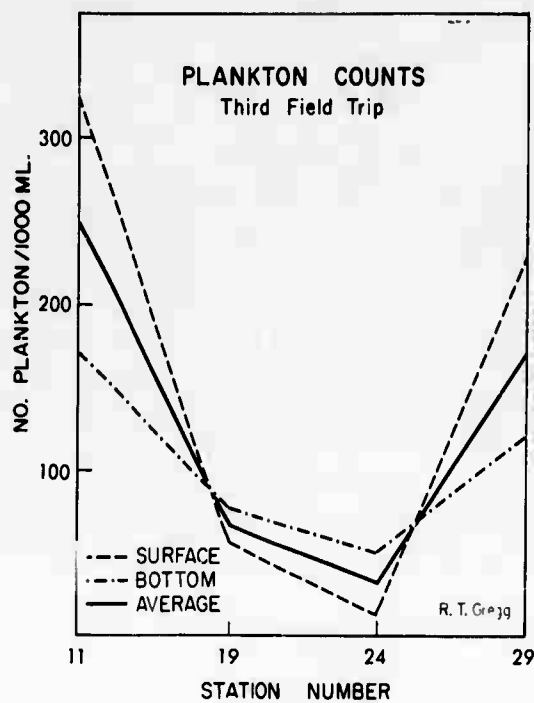


Figure 19

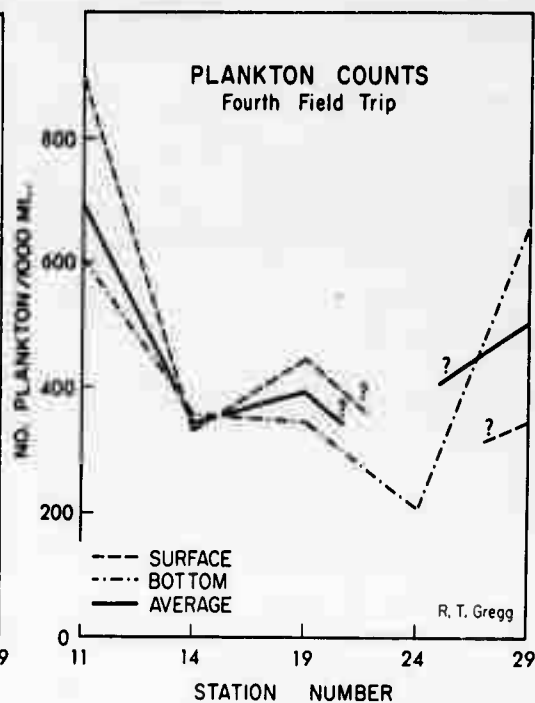


Figure 20

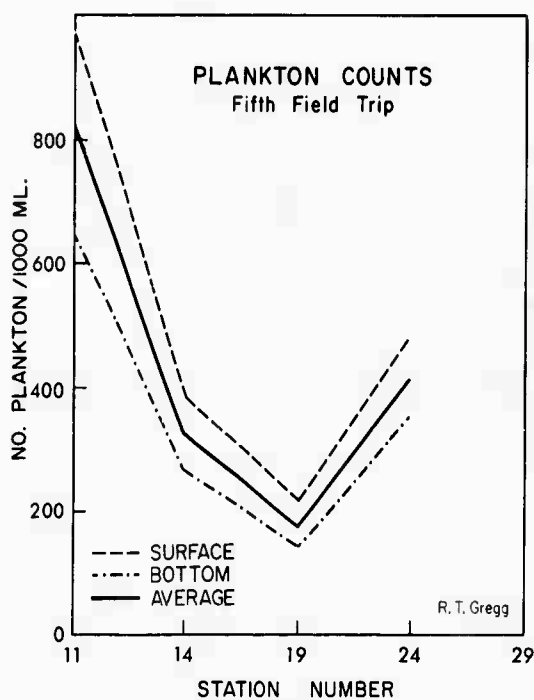


Figure 21

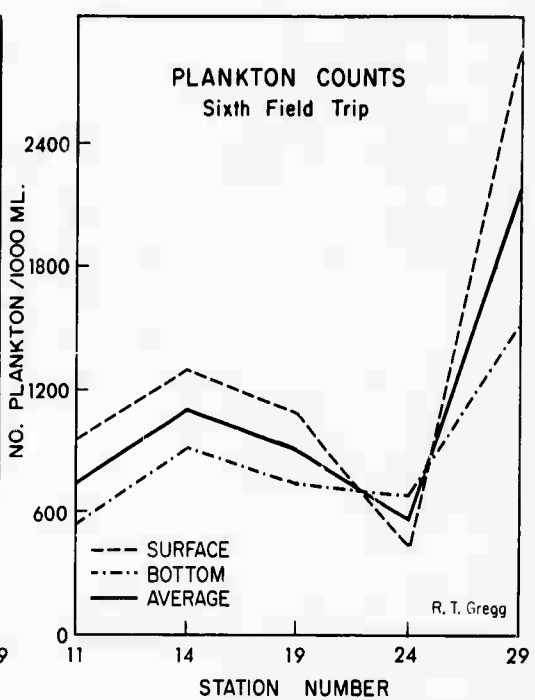


Figure 22

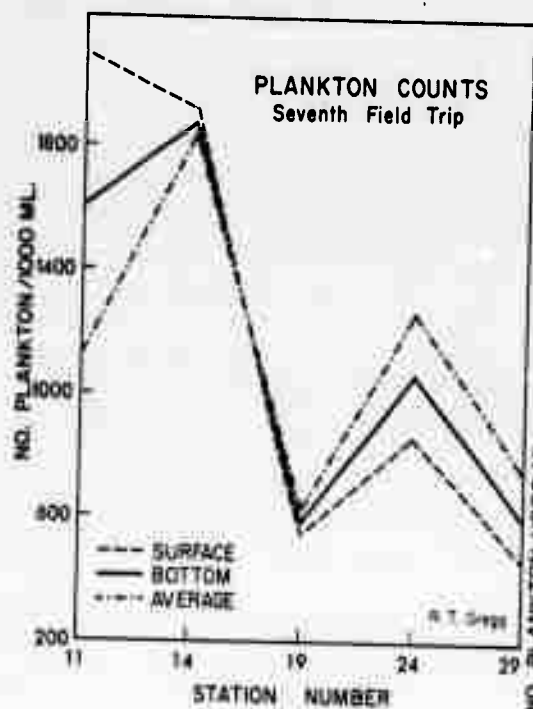


Figure 23

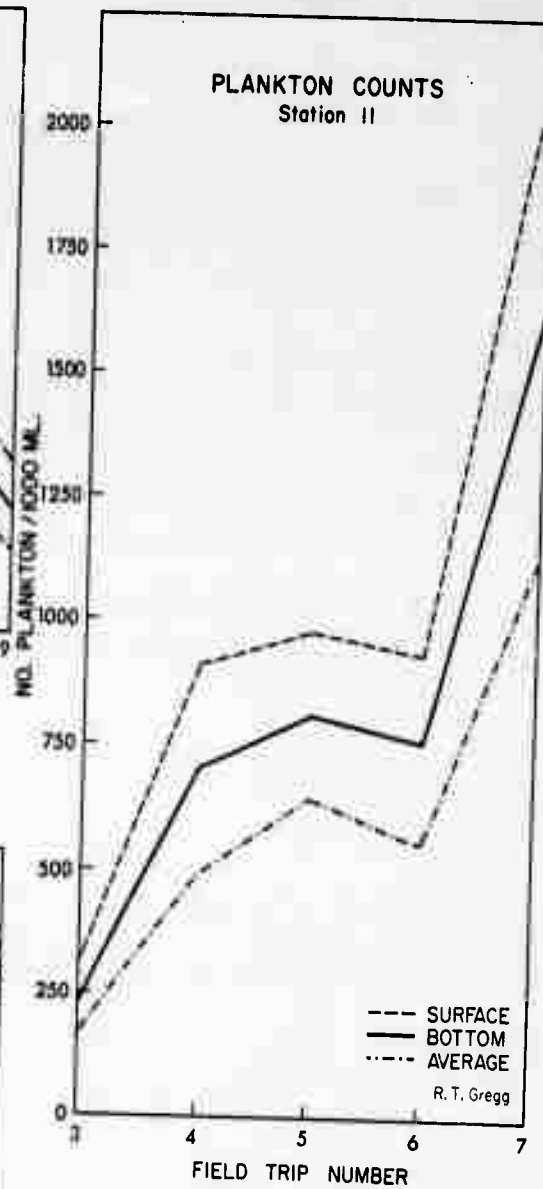


Figure 24

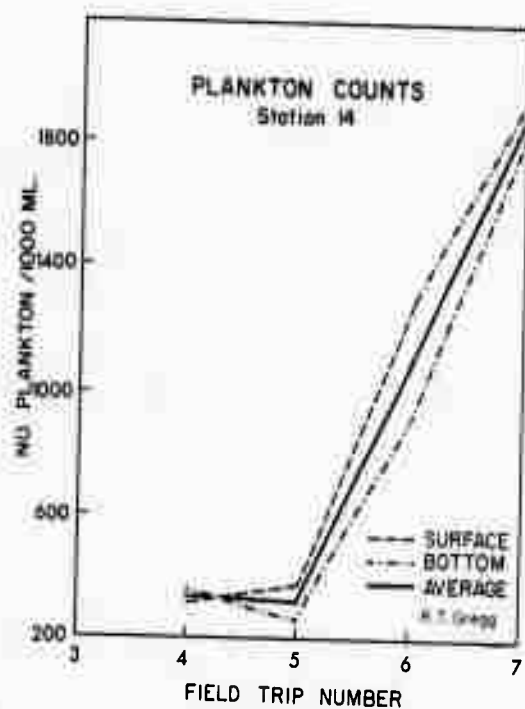


Figure 25

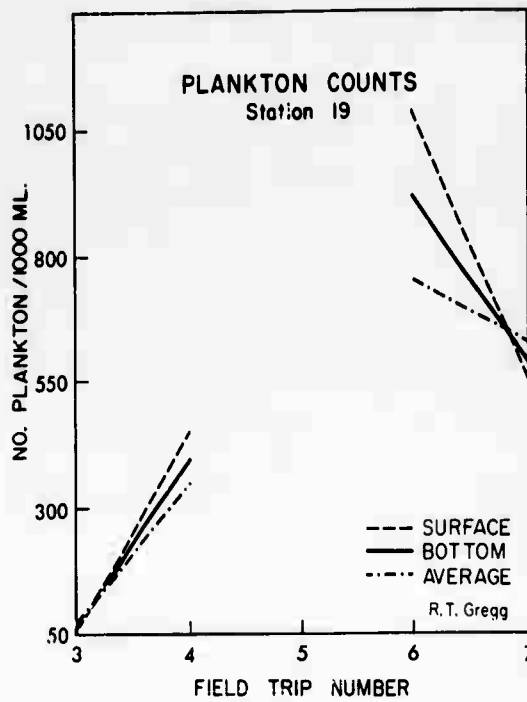


Figure 26

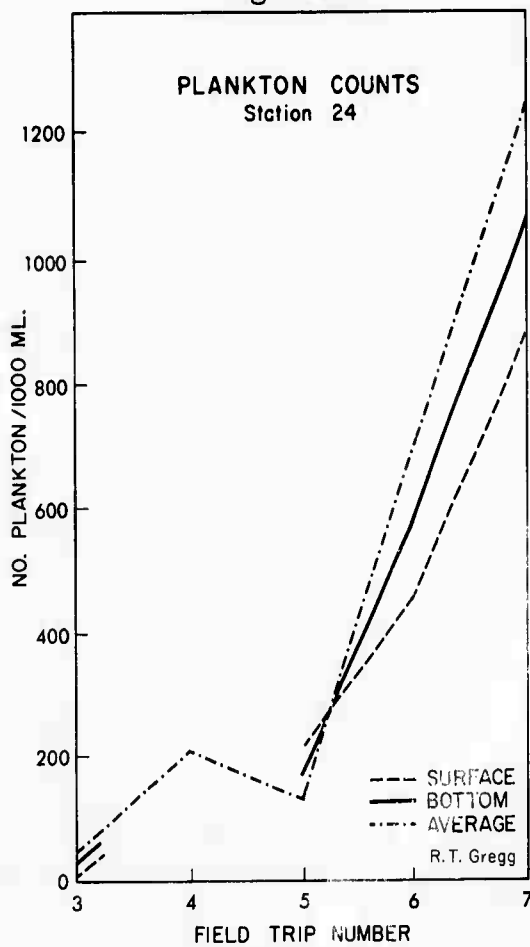


Figure 27

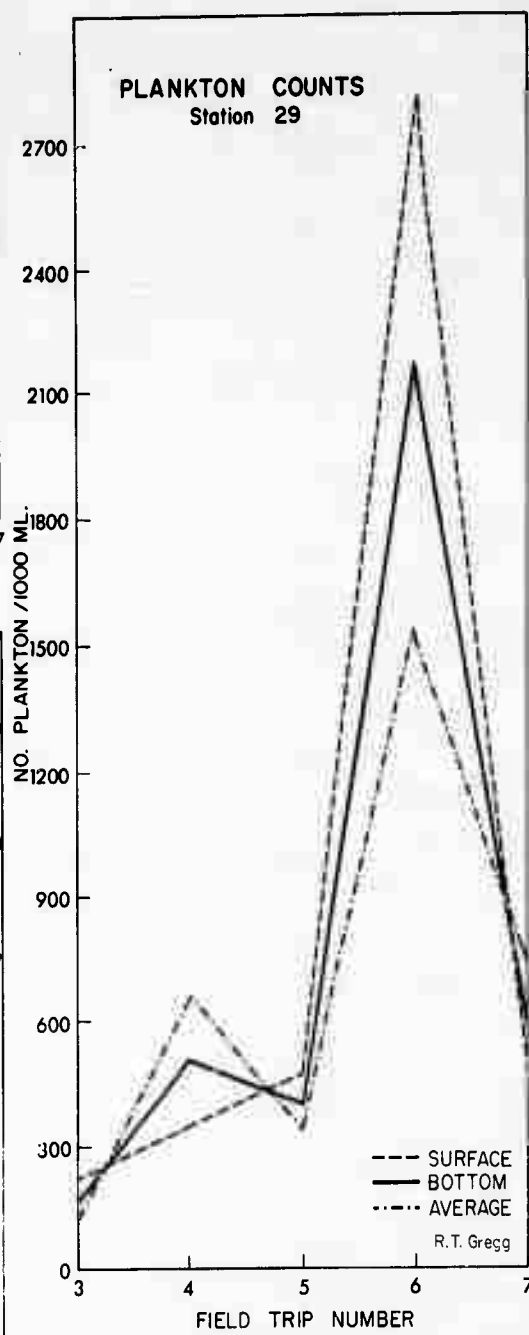


Figure 28

REFERENCES

- Allen, E. J. and Nelson, W. E., 1910. On the artificial culture of marine plankton organisms, J. Mar. Biol. Ass. U. K., Vol. 8, pp. 421-74.
- Anderson, D. N. and Robinson, Rex J. Rapid Electrometric Determination of the Alkalinity of Sea Water. Industrial and Eng. Chem. Anal. Ed. 18 767-73 (1946).
- Bertolacini, R. J. and Barney II, J. E., 1957. Anal. Chem. 29, 281 (1957).
- Chow, T. J. and Thompson, T. G., 1952. J. Marine Res. Vol. XI, No. 2, pp. 125-137 (1952).
- Collier, A. and Marvin, K. T. Stabilization of the Phosphate Ratio of Sea Water by Freezing. U. S. Fishing Bulletin, No. 79 (1953).
- Collier, A., Ray, S. M., Magnitzky, A. W., and Bell, J. O., 1953. Effect of dissolved organic substances on oysters. Fish. Bull. U. S., Vol. 54, pp. 167-85.
- Feigl, F. Spot Test, Vol. II, Organic Application. Elsevier, New York, 1954.
- Hamilton, L. D., Hutner, S. H., and Provasoli, L., 1952. The use of Protozoa in analysis. Analyst, Vol. 77, pp. 618-25.
- Harvey, H. W. (1926) Nitrates in the Sea. J. Marine Biol. Assoc. U. K. 14 71-88 (1926).
- Harvey, H. W., 1933. On the Rate of Diatom Growth. J. Mar. Biol. Ass. U. K., Vol. 19, pp. 253-76.
- _____, 1939. Substances Controlling the Growth of a Diatom. Ibid, Vol. 23, pp. 499-520.
- _____, 1936. The Supply of Iron to Diatoms. Ibid, Vol. 22, p. 206.
- _____, 1944. Manganese and the Growth of Phytoplankton. Ibid, Vol. 26, p. 562.
- Harvey, H. W. The Estimation of Phosphate and of Total Phosphorus in Sea Water. J. Marine Biol. Assoc., 27, 337-59 (1948).
- Hasler, A. D., and Wisby, W. J., 1951. Discrimination of Stream Odors by Fishes and its Relation to Parent Stream Behavior. Am. Nat., Vol. 85, pp. 223-38.

- Johnston, R., 1955. Biologically Active Compounds in the Sea. J. Mar. Biol. Ass. U. K., Vol. 34, pp. 185-95.
- Knudsen, Martin, 1901. Hydrographical Tables. G. E. C. Gad., Copenhagen, 63 pp, 1901. Reprinted by Tutein og Koch, Copenhagen, 1953.
- Lewis, G. J., Jr. and Rakestraw, H. W. Carbohydrates in Sea Water. J. Marine Research 14, 253-8 (1955).
- Lissman, H. W., 1954. Direction Finding in Fish. Advac. Sci., Vol. 11, pp. 69-71.
- Marvin, K. Notes on the Precision of a Modified Routine Nitrate-Nitrite Analysis. J. Marine Research 14, 79-87 (1955).
- Moore, S. and Stein, W. H. Photometric Ninhydrin Method for Use in the Chromatography of Amino Acids. Journal of Biological Chemistry, 176, 367-88 (1948).
- Robinson, R. J. and Thompson, T. G. 1948. J. Marine Res. Vol. VII, No. 1, pp. 49-55.
- _____ The Determination of Phosphates in Sea Water. Ibid. Vol. VII, pp. 33-41.
- Standard Methods for the Examination of Water and Sewage 1955, American Public Health Association, Inc., New York, New York.
- Stenhouse, J. (1870). J. Chem. Soc. 23, 6-14 (1870).
- Thompson, T. G. and Bonnar, R. U. Ind. Eng. Chem. Anal. Ed. 3, 393-5 (1931).
- Wilson, D. P., 1951. A Biological Difference between Natural Sea Waters. J. Mar. Biol. Ass. U. K., Vol. 30, pp. 1-20.
- Wilson, D. P., and Armstrong, F. A. J., 1952. Further Experiments on Biological Differences between Natural Sea Waters. Ibid, Vol. 31, pp. 335-49.
- _____ 1954. Biological Differences between Sea Waters; Experiments in 1953. Ibid, Vol. 33, pp. 347-60.
- Wooster, W. S. and Rakestraw, N. W. The Estimation of Dissolved Phosphate in Sea Water. J. Marine Research 10, 91-100 (1951).
- Zwicker, B. M. G. and Robinson, R. J. The Photometric Determination of Nitrate in Sea Water with a Strychnidine Reagent. J. Marine Research 5, 214-32 (1944).

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