COMPLETION REPORT
B-009-LA

CHEMICAL QUALITY OF SURFACE AND SEDIMENT PORE WATER IN LOUISIANA AND MISSISSIPPI ESTUARIES

BY

JESSE O. SNOWDEN
AND
ERVIN G. OTVOS

for

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LOUISIANA WATER RESOURCES RESEARCH INSTITUTE
Louisiana State University
Baton Rouge, LA 70803

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New Orleans, Louisiana

Ervin G. Otvos, Co-Investigator
Ocean Springs, Mississippi

INTRODUCTION

The Pearl and Pascagoula are the two largest Rivers between the Mississippi and Mobile Bay, and supply much of the fresh water runoff to the brackish Mississippi Sound (Fig. 1). Between these two rivers is the Mississippi Gulf Coast, a region which, despite severe damage by Hurricane Camille in 1969 is presently undergoing a dramatic increase in population and in industrial development.

In addition to the two major rivers, there are numerous smaller streams draining into the Mississippi Sound. These are all a part of the estuarine environment, and, as waterways connecting with the Gulf of Mexico, will be under increasing urban pressure as time goes by.

There are no previous regional water quality studies, although there have been local studies of some water quality criteria. This is the first published study of interstitial sediment water chemistry in these estuaries.

The general objectives of our study were to: (1) determine the current seasonal and geographic variability in chemical quality of free and interstitial sediment water in the estuaries of the Pearl and Pascagoula Rivers, as well as some of the smaller estuaries, and (2) determine the nature of the reactions between sediments and interstitial sediment water and the effects, if any, of these reactions on water quality.

Some of these estuaries, such as Graveline and Heron Bayous exist in a relatively undisturbed state. Others, such as the Pascagoula River are already highly urbanized, and still others, such as Old Fort Bayou, Davis Bayou, and the Wolf River are somewhere in between. The data from this study will provide a current bench mark of seasonal chemical water quality, that can be correlated with the present biological productivity and hydrographic characteristics of the estuaries, which will allow quantitative determination of changes that could occur as increases in population and industry exert greater pressure in the future.

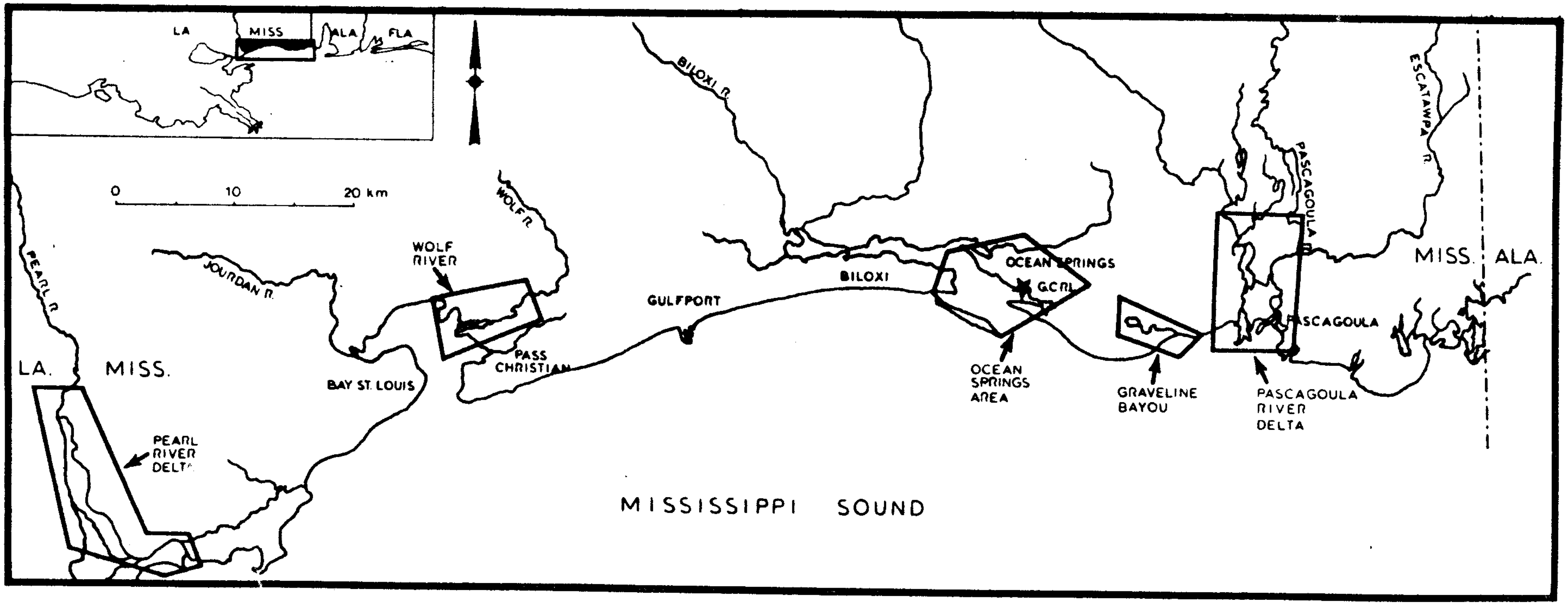

Figure 1. General Map of Mississippi Gulf Coast. Estuaries Studied in this Project Are Outlined.

MATERIALS AND METHODS

Field Procedures

Twenty-two stations were established along the salinity gradient in the estuaries of the Pascagoula River, Pearl River, Wolf River, Old Fort Bayou, Davis-Heron Bayou, Graveline Bayou, and Biloxi Bay (Fig. 1-9). Each station was visited in August-September, 1970; November, 1970; March-April and June-July 1971. Some of the stations were also sampled during July-August, 1972. The following parameters were measured in the field at each station:

1. Water depth.
2. Conductivity and salinity of surface and bottom water using a Beckman RS5-3 salinometer. The meter was calibrated just prior to each days' use against a Y.S.I. model 31 line-operated conductivity bridge, using brackish water of similar salinity to that encountered in the estuaries.
3. pH and Eh of surface and bottom water using a Beckman Model 1009 Electromate battery-operated pH meter with appropriate electrodes.
4. Dissolved oxygen of surface and bottom water, using a Y.S.I. Model 51A oxygen meter.
5. A two to three foot sediment core was collected at each station. The pH and Eh were measured at one foot intervals, and sections of the core immediately placed into portable gas-operated squeezers, modified from the design of Reeburgh (1967), to recover samples of interstitial sediment water for chemical analysis. Squeezing pressures were kept below 50 lbs. per square inch.

Laboratory Procedures

Analyses of water samples were initiated immediately after their arrival in the laboratory. Analyses for sulfate, nitrate, nitrite, and color were completed the day of collection, using reagents and colormetric methods prepared by the Hach Chemical Company (Ames, Iowa).

Chlorinity was computed from conductivity, using the Y.S.I. conductivity bridge and the emperical formulas of Pollak (1954). The major metallic ions, Sodium, Calcium, Magnesium, Potassium, and Strontium were all analyzed by atomic absorption spectroscopy, using, with slight modifications, the technique of Fishman and Downs (1966) and the Varian Techtron AA-5 Atomic Absorption Spectrophotometer. All water samples were filtered through a 0.45 micron membrane filter to remove solid particulate matter.

Surface and bottom water samples were analyzed for all of the variables discussed above. The interstitial sediment water samples were analyzed only for chlorinity and major metal ions, because insufficient sample was available for the other tests.

The sediment cores were sampled at one foot intervals, and the particle size distribution measured, using a modified Bouyoucos hydrometer technique (Snowden, 1968). The less-than-two-micron and two to five micron fractions of each core section were separated and pipetted onto glass slides and x-rayed for clay mineral determination, using the procedures outlined by Carroll (1970). The organic and total carbon content of each core section was measured gasometrically using the Laboratory Equipment Corporation (St. Joseph, Michigan) Number 577-100 carbon analyzer.

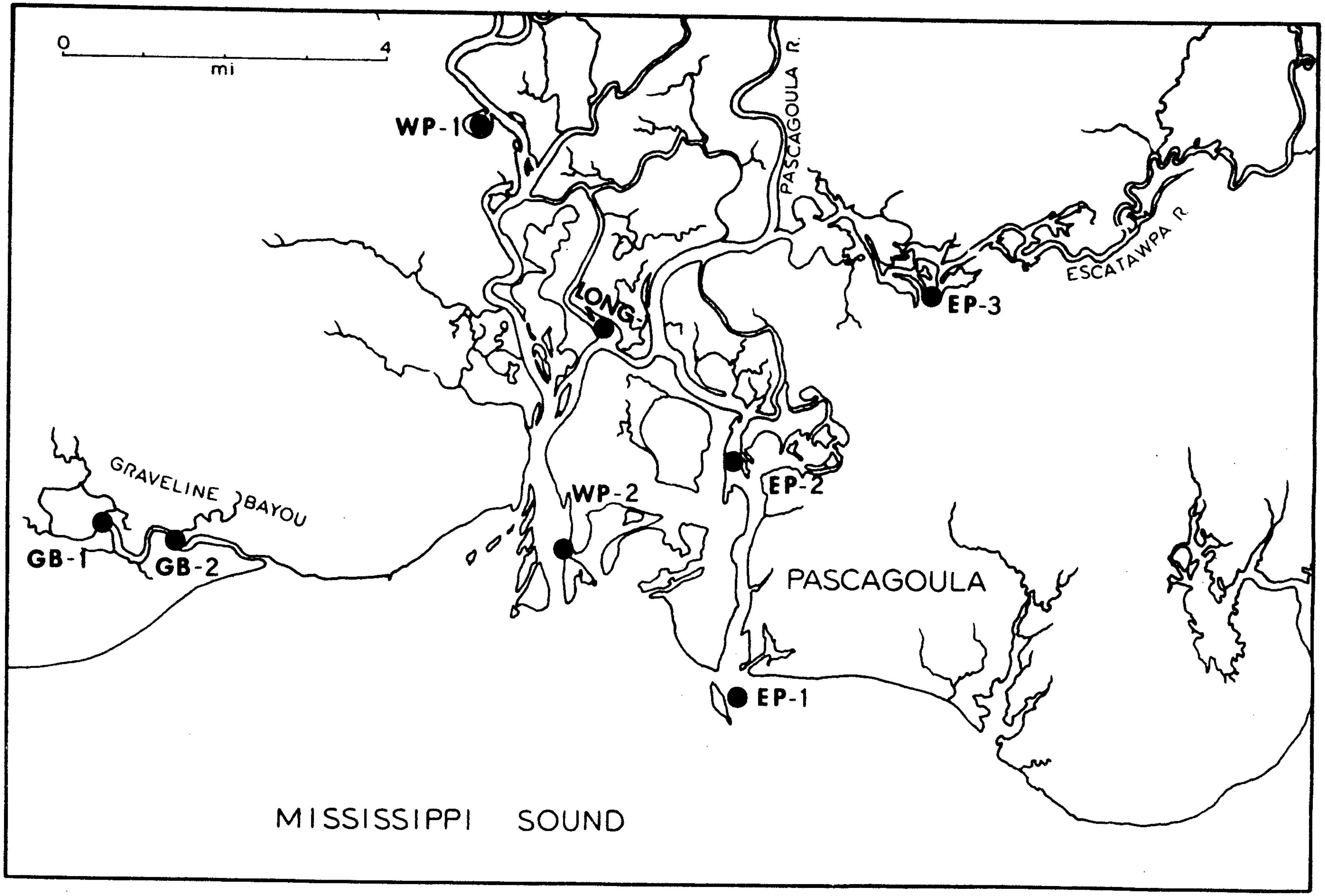

Figure 2. Pascagoula River and Graveline Bayou Stations. EP = East Pascagoula; WP = West Pascagoula; LONG = Long Bayou; GB = Graveline Bayou.

Figure 3. Aerial Photograph Looking Seaward of A Portion of the Pascagoula River Delta. Circular Lake Near Center of Photograph is Station WP-1.

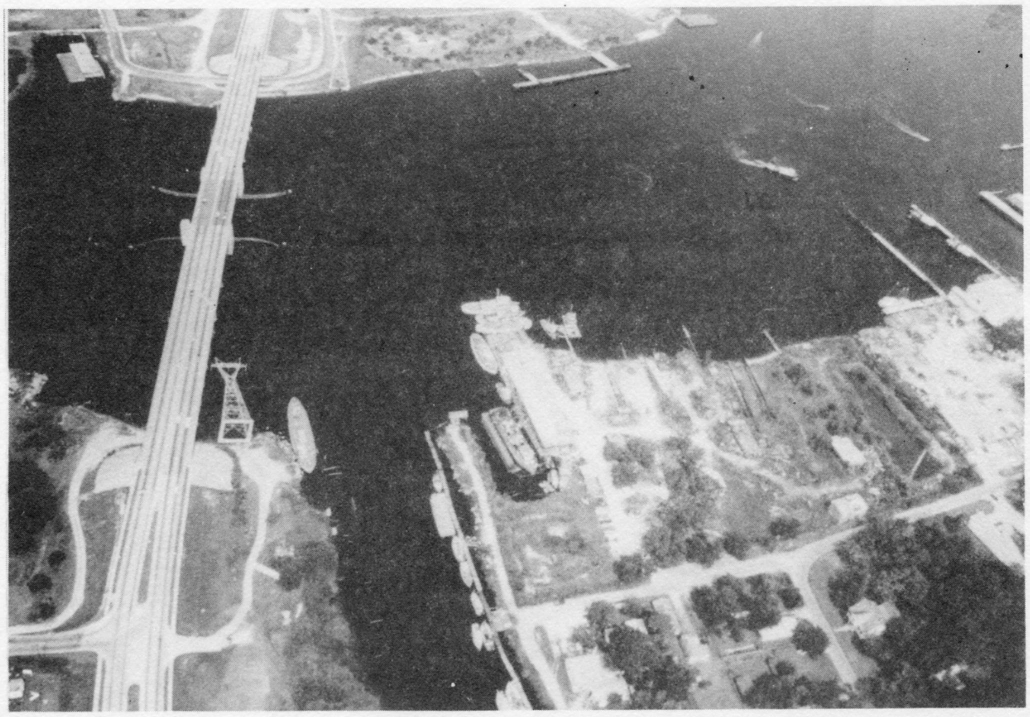

Figure 4. Aerial Photograph Showing Typical Urbanization Near Mouth of the East Pascagoula River, Between Stations EP-1 and EP-2.

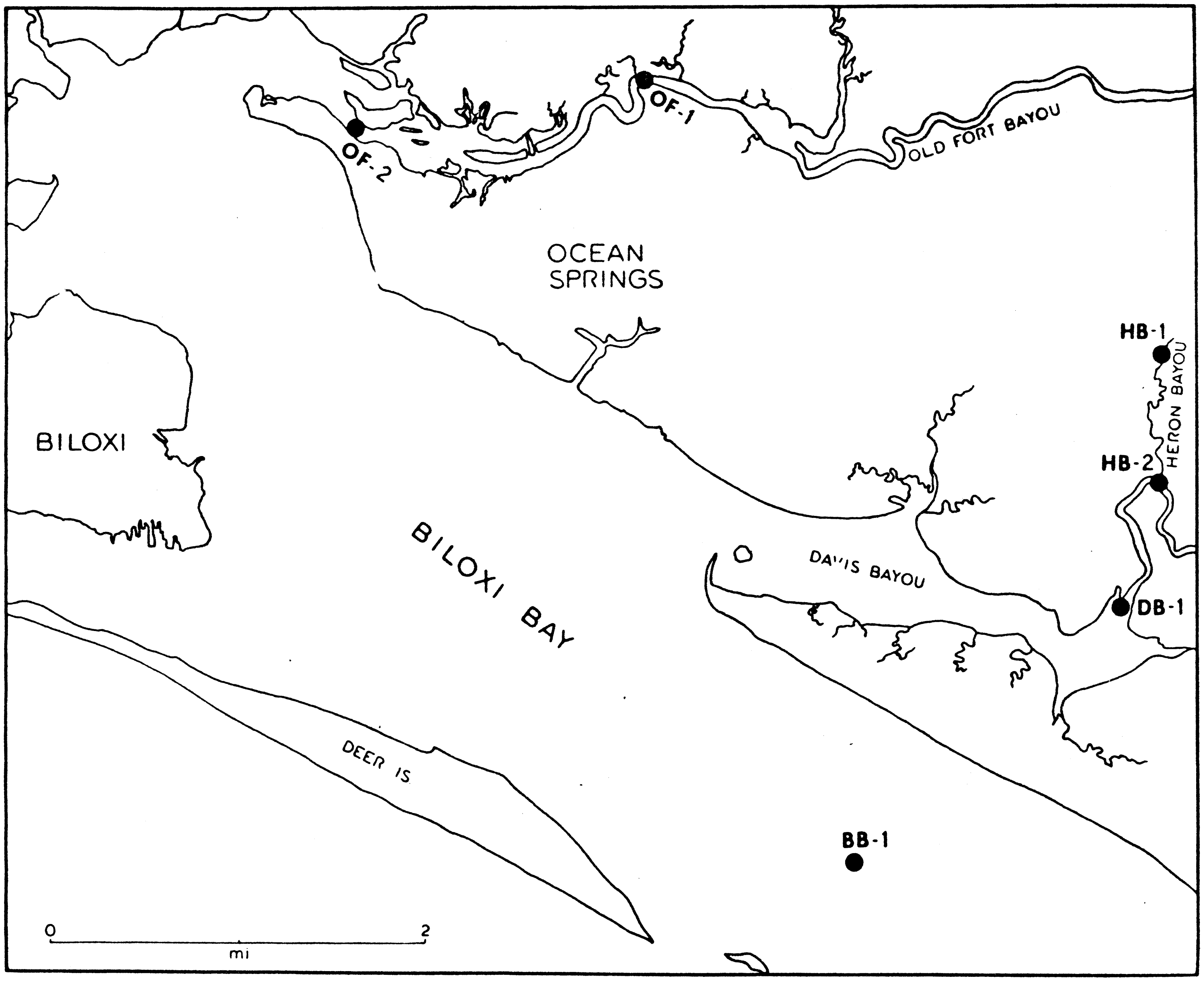

Figure 5. Ocean Springs Area Stations. DB = Davis Bayou; HB = Heron Bayou; BB = Biloxi Bay; OF = Old Fort Bayou.

Figure 6. Aerial Photograph of a Portion of Davis Bayou. Upper and Left Hand Channels are Natural. Center and Right Hand Channels Were Dredged by Real Estate Developers to Gain More Waterfront Property.

Figure 7. Heron Bayou. A Typical Small, Relatively Undisturbed Estuary. Station HB-1 is at Extreme Right of Photo.

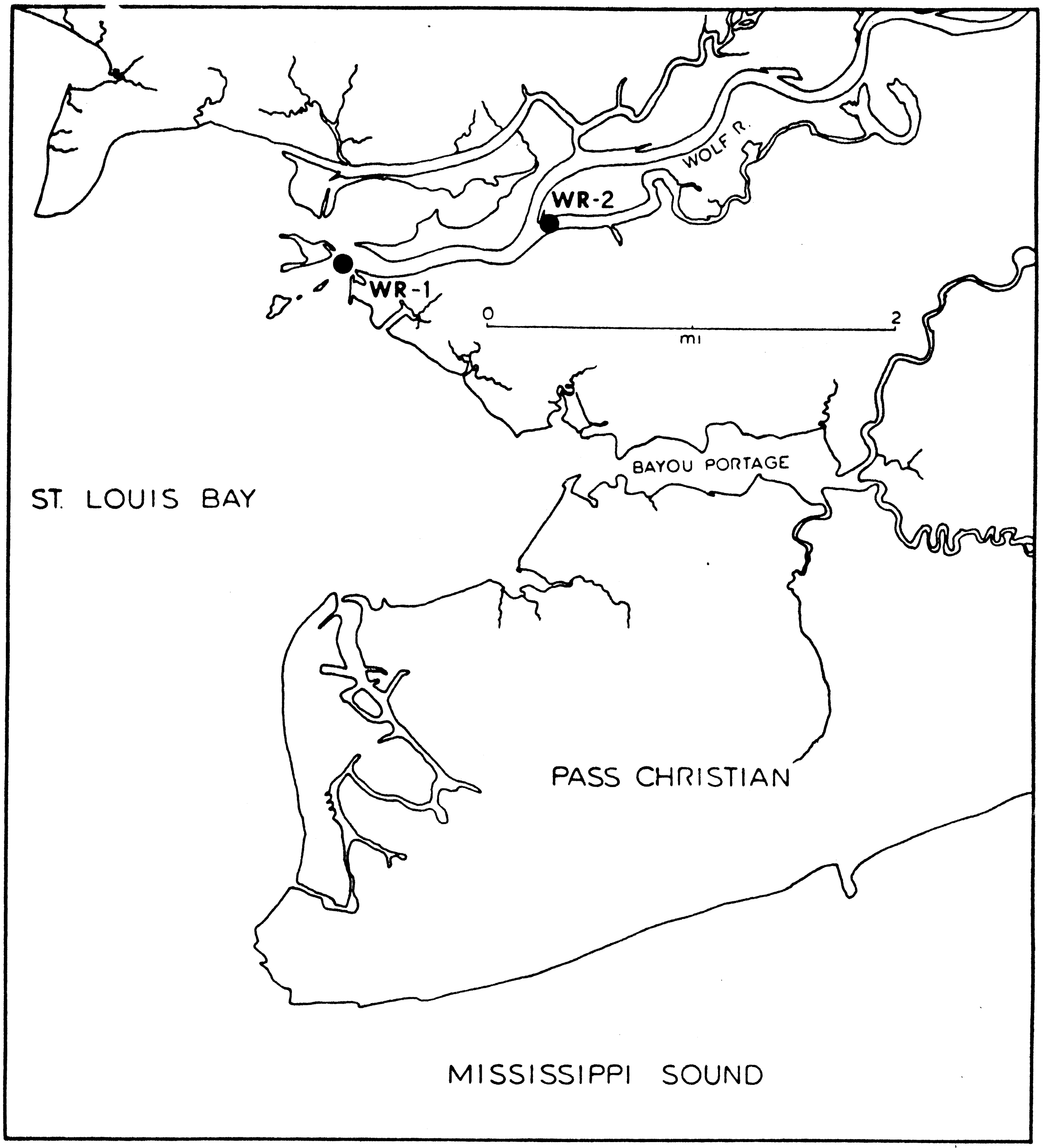

Figure 8. Wolf River Stations. Also Shown is the Eastern Half of St. Louis Bay.

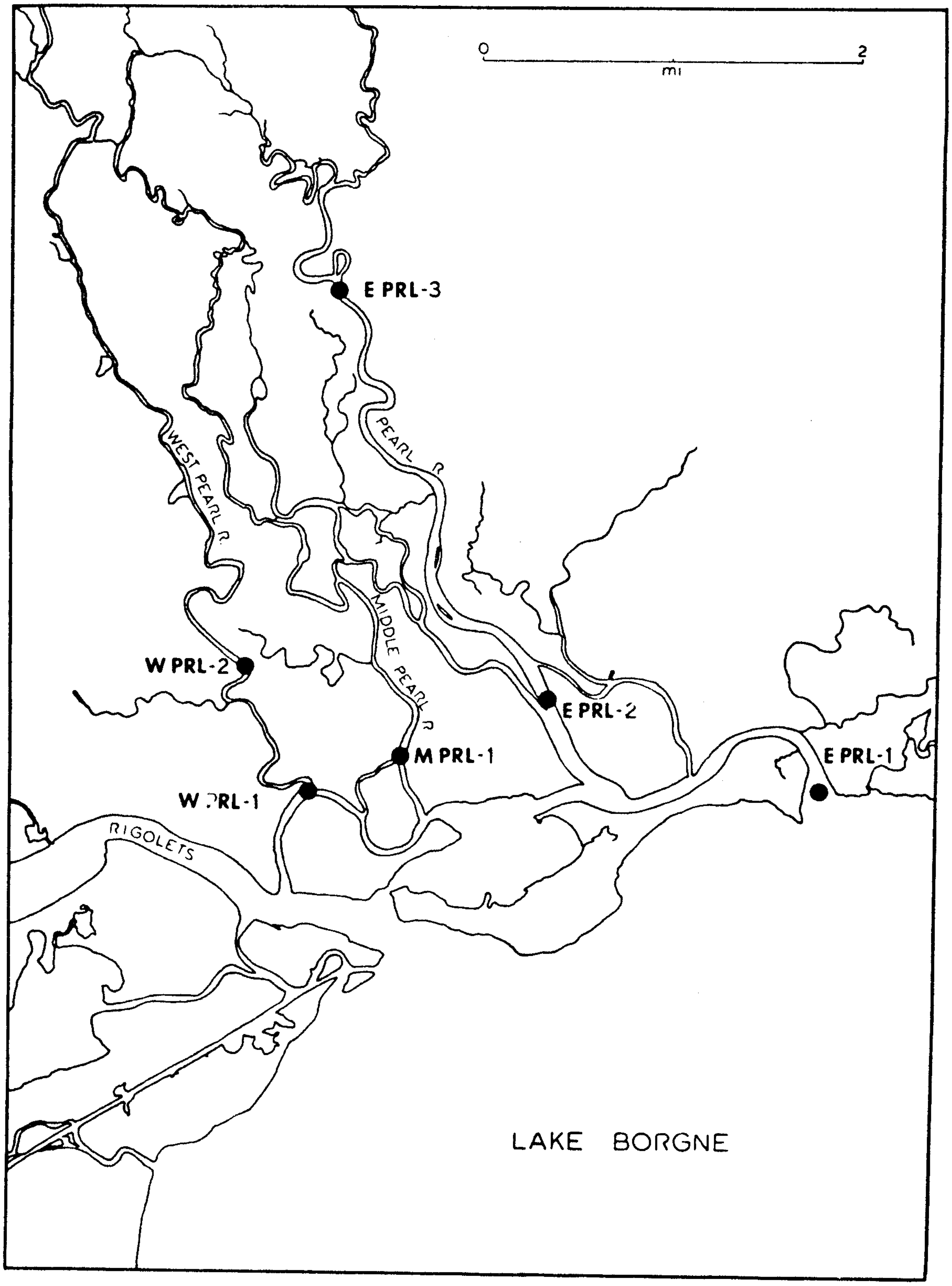

Figure 9. Pearl River Stations. At Lower Left is the Rigolets Pass, Which Separates Lake Pontchartrain from Lake Borgne.
EPRL = East Pearl; MPRL = Middle Pearl; WPRL = West Pearl.

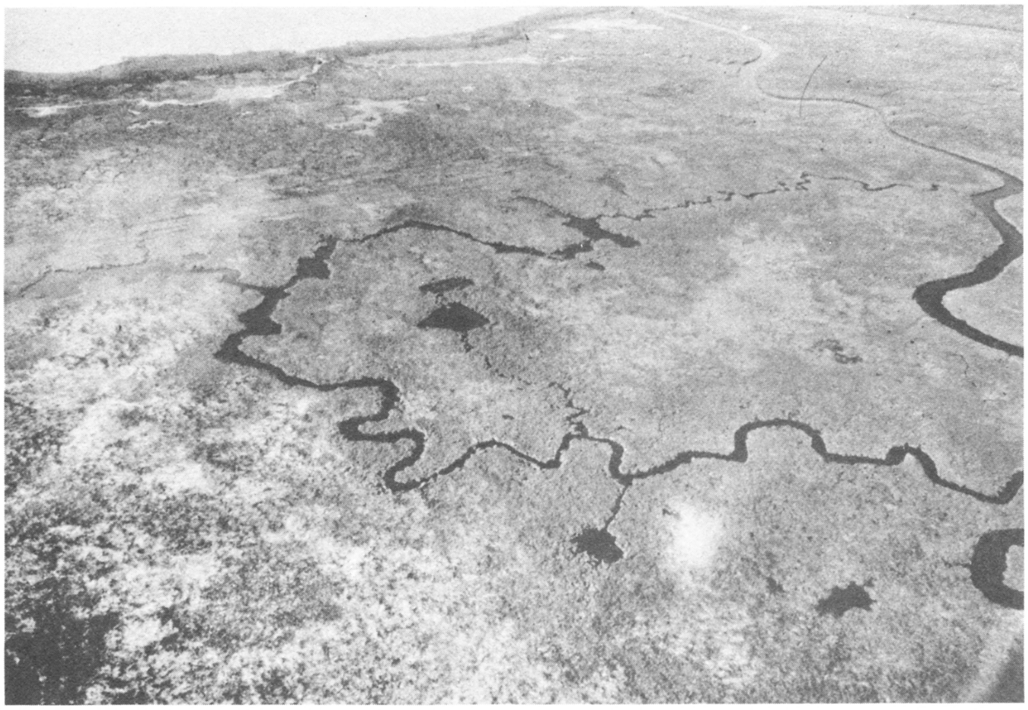

Figure 10. Aerial Photograph of A Portion of the Pearl River Delta, Showing Main Channels and Smaller Distributions.

Figure 11. Mouth of the Pearl River at the Rigolets. Dark Colored Water is a Wedge of Saline Water Being Pushed in by an Incoming Tide. Station WPRL-1 is in Upper Right.

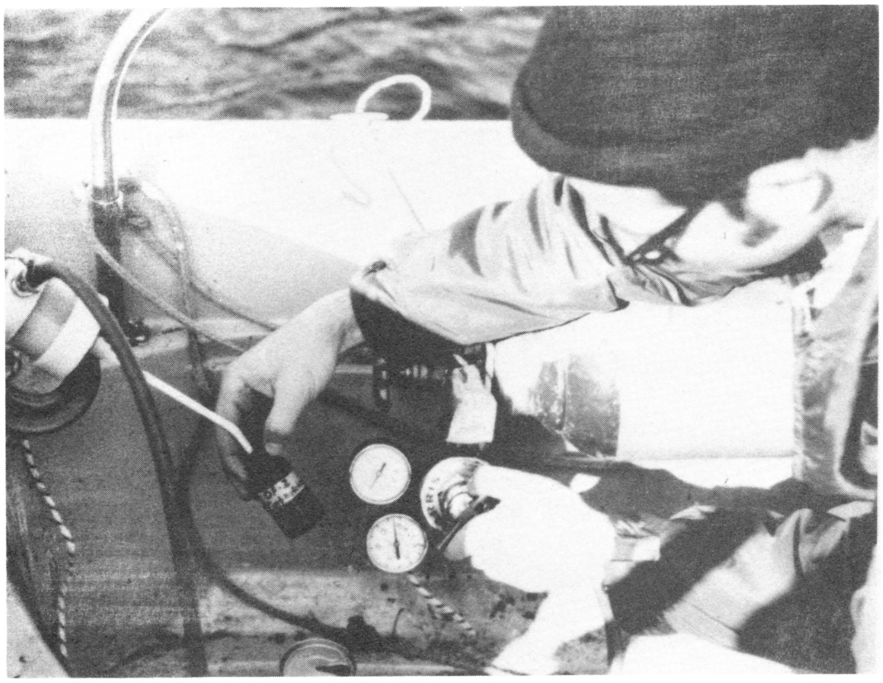

Figure 12. Operation of Portable, Gas-Operated Pore-Water Squeezer Aboard the Boston Whaler. The Design is Similar to that of Reeburgh(1967).

STATION SUMMARIES

Field Data

Table 1 is a summary, by station and date, of field physical and chemical data. The date, time of measurement, tide stage, and precipation for the month preceeding the measurement are included, as all of these factors influence the physical-chemical parameters measured. Abbreviations for tide stages are as follows: I = incoming; O = outgoing; L.I. = low incoming; L.O. = low outgoing; H.I. = high incoming; H.O. = high outgoing; I.I. = intermediate incoming; I.O. = intermediate outgoing. Negative depth figures indicate interstitial sediment water, measured in feet below the water-sediment interface.

Instruments used to measure salinity, chlorinity, pH, Eh and dissolved oxygen are discussed in the preceeding Materials and Methods section. The dynamics of specific physical and chemical factors are discussed in the sections following the presentation of individual station data.

Laboratory Data

Table 2 is a listing of the color, and the concentrations of Sulfate and Nitrate by station. There was insufficient sample of most of the interstitial sediment waters to analyze these parameters by the methods used, thus, most values are for surface and bottom water. All samples were analyzed for NO_3 and SO_4 the day of collection, as both of these ions are susceptible to post-collection changes. Mean NO_3/Cl and SO_4/Cl ratios are plotted in Figures 17-20.

Table 3 is a summary of the major metallic ion data. The concentrations of Ca, Mg, Na, K, and Sr ions are listed for each station. Both free and interstitial sediment data are included. Major ion-to-chloride ratios are also plotted in Figures 22-28.

Table 4 is a description of the sediment cores, including sand:silt: clay ratios and total organic carbon for most cores. The depth below the water-sediment interface of each core is also given.

In Figures 13-20, pH, chlorinity, NO_3/Cl and SO_4/Cl data are presented by collecting phases. Phase 1 measurements were made in August-September 1970, Phase 2 in November 1970, Phase 3 in March-April 1971, Phase IV in June 1971 and Phase IVA in July 1971.

The techniques of plotting ion-to-chloride ratios is used to eliminate "background" effects caused by variable amounts of fresh water and sea water mixing in estuaries. It also permits a quick comparison of values with the Copenhagen Standard sea water values for these ions.

TABLE 1

Field Measurements of Physical-Chemical Factors by Stations

STATIONS	DATE	TIME	TIME OF HIGH TIDE	TIME OF LOW TIDE	TIDE STAGE	PRECIP. FOR MONTH PRECEEDING (INCHES)	TEMP. (C°)	DEPTH (ft.)	SALINITY (ppt)	CHLORINITY (ppt)	pH	Eh	D.O. ppm
EP-1	8-31-70	1130	1018	1948	O.	9.01	29.08	0	11.578	6.398	7.65	+125	
EP-1	11-28-70	1345	2200	0800	I.I.	4.83	15.10	0	19.414	10.739	8.0	+ 15	
EP-1	3-6-71	1100	1906	0500	I.I.	19.37	13.10	0	0.76	0.404	7.2	+ 85	
EP-1	6-3-71	1220	0730	1724	I.O.	9.14	28.1	0	13.175	7.282	7.8	+ 35	7.4
EP-1	8-31-70	1130	1018	1948	O.	9.01	28.38	45	28.654	15.858	7.7	+125	
EP-1	11-28-70	1345	2200	0800	I.I.	4.83	13.44	45	28.338	15.683	8.0	+ 50	
EP-1	3-6-71	1100	1906	0500	I.I.	19.37	16.06	44	34.06	18.853	7.3	+220	
EP-1	6-3-71	1220	0730	1724	I.O.	9.14	24.5	45	31.936	17.676	7.7	- 70	3.2
EP-1	8-31-70	1130	1018	1948	L.O.	9.01	28.38	-0.5	30.909	17.107		-300	
EP-1	11-28-70	1345	2200	0800	I.I.	4.83	13.44	-0.5	28.432	15.735	7.1	-250	
EP-1	3-6-71	1100	1906	0500	I.I.	19.37		-0.5			6.7	-290	
EP-1	6-3-71	1220	0730	1724	I.O.	9.14	24.5	-0.5	29.441	16.294	7.1	-150	
EP-1	6-3-71	1220	0730	1724	I.O.	9.14	24.5	-1.5	29.146	16.130			
EP-2	8-31-70	1330	1018	1948	L.O.	9.01	30.08	0	4.754	2.617	7.25	+140	
EP-2	11-28-70	1315	2200	0800	I.I.	4.83	15.07	0	17.070	9.440	6.0	+ 15	
EP-2	3-6-71	1145	1906	0500	I.I.	19.37	13.70	0	0.16	0.072	7.15	- 80	
EP-2	6-3-71	1345	0730	1724	I.O.	9.14	31.9	0	3.591	1.972	7.5	- 25	6.2
EP-2	8-31-70	1330	1018	1948	L.O.	9.01	29.40	32	26.088	14.436	7.55	+120	
EP-2	11-28-70	1315	2200	0800	I.I.	4.83	14.04	25	27.202	15.054	8.1	- 50	
EP-2	3-6-71	1145	1906	0500	I.I.	19.37	14.38	28	0.33	0.166	7.0	- 50	
EP-2	6-3-71	1345	0730	1724	I.O.	9.14	25.0	28	30.134	16.678	7.6	- 25	1.3
EP-2	8-31-70	1330	1018	1948	L.O.	9.01	29.40	-0.5	28.750	15.911	6.45	-280	
EP-2	11-28-70	1315	2200	0800	I.I.	4.83	14.04	-0.5	26.276	14.540	6.6	-320	
EP-2	3-6-71	1145	1906	0500	I.I.	19.37	14.38	-0.5			7.1	-270	
EP-2	6-3-71	1345	0730	1724	I.O.	9.14	25.0	-0.5	25.228	13.960	6.5	-170	
EP-2	6-3-71	1345	0730	1724	I.O.	9.14	25.0	-1.0	27.017	14.951			
EP-2	6-3-71	1345	0730	1724	I.O.	9.14	25.0	-2.0	27.112	15.004			
EP-3	8-31-70	1455	1018	1948	I.O.	9.01	28.51	0	0.230	0.111	5.8	-225	
EP-3	11-28-70	1200	2200	0800	I.I.	4.83	14.70	0	9.285	5.127	7.4	- 90	
EP-3	3-6-71	1330	1906	0500	I.I.	19.37	13.34	0	0.09	0.033	7.1	-150	
EP-3	6-3-71	1545	0730	1724	L.O.	9.14	31.5	0	1.568	0.852	6.8	- 85	.40
EP-3	8-31-70	1455	1018	1948	I.O.	9.01	28.14	25	28.170	15.590	7.0	-322	
EP-3	11-28-70	1200	2200	0800	I.I.	4.83	16.60	35	26.092	14.438	7.8	- 90	
EP-3	3-6-71	1330	1906	0500	I.I.	19.37	13.53	38	.079	0.027	6.93	-110	
EP-3	6-3-71	1545	0730	1724	L.O.	9.14	24.0	30	26.542	14.688	7.1	-260	0.1
EP-3	8-31-70	1455	1018	1948	I.O.	9.01	28.14	-0.5	27.309	15.113	4.5	-375	
EP-3	11-28-70	1200	2200	0800	I.I.	4.83	16.60	-0.5	24.364	13.481	6.3	-375	
EP-3	3-6-71	1330	1906	0500	I.I.	19.37	13.53	-0.5	0.05	0.011	7.1	-380	
EP-3	6-3-71	1545	0730	1724	L.O.	9.14	24.0	-0.5	23.846	13.194	5.3	-320	
EP-3	6-3-71	1545	0730	1724	L.O.	9.14	24.0	-1.5	25.228	13.960			
Long-1	8-31-70	1700	1018	1948	L.O.	9.01	29.26	0	1.352	0.732	6.7	- 10	
Long-1	11-28-70	1615	2200	0800	I.I.	4.83	15.93	0	7.072	3.901	6.4	+160	

TABLE 1 (Cont'd.)

STATIONS	DATE	TIME	TIME OF HIGH TIDE	TIME OF LOW TIDE	TIDE STAGE	PRECIP. FOR MONTH PRECEEDING (INCHES)	TEMP. (C°)	DEPTH (ft.)	SALINITY (ppt)	CHLORINITY (ppt)	pH	Eh	D.O. ppm
Long-1	4-3-71	1630	1718	0318	I.I.	18.08	16.21	0	0.079	0.027	7.7	+ 90	
Long-1	6-3-71	1645	0730	1724	L.O.	9.14	25.0	0	0.693	0.367	7.2	+ 20	7.3
Long-1	8-31-70	1700	1018	1948	L.O.	9.01	28.18	23	14.787	8.175	7.25	- 30	
Long-1	11-28-70	1615	2200	0800	I.I.	4.83	14.51	23	21.258	11.761	6.6	- 90	
Long-1	4-3-71	1630	1718	0318	H.I.	18.08	16.13	20	8.408	4.641	6.4	+ 90	
Long-1	6-3-71	1645	0730	1748	L.O.	9.14	25.0	20	24.949	13.805	7.4	- 65	.4
Long-1	8-31-70	1700	1018	1948	L.O.	9.01	28.18	-0.5	18.709	10.349	7.0	-420	
Long-1	11-28-70	1515	2200	0800	I.I.	4.83	14.51	-0.5	18.372	10.161	6.9	-400	
Long-1	4-3-71	1630	1718	0318	H.I.	18.08	16.13	-0.5	5.913	3.259	6.4	-350	
Long-1	6-3-71	1645	0730	1748	L.O.	9.14	25.0	-0.5	14.109	7.800	6.9	-120	
WP-1	8-31-70	1750	1018	1948	L.O.	9.01	30.38	0	0.104	0.041	7.3	- 35	
WP-1	11-28-70	1515	2200	0800	I.I.	4.83	15.77	0	1.921	1.048	7.3	+110	
WP-1	4-3-71	1700	1718	0318	H.I.	18.08	15.82	0	0.081	0.028	6.5	+ 80	
WP-1	6-4-71	1500	0730	1748	L.O.	9.14	29.94	0	0.155	0.069	7.1	+ 70	8.6
WP-1	8-31-70	1750	1018	1948	L.O.	9.01	30.16	5	0.086	0.031	6.5	- 20	
WP-1	11-28-70	1515	2200	0800	I.I.	4.83	15.38	5	2.420	1.324	6.5	+110	
WP-1	4-3-71	1700	1718	0318	H.I.	18.08	15.65	5	0.088	0.032	7.0	+ 40	
WP-1	6-4-71	1500	0730	1748	L.O.	9.14	27.48	5	0.152	0.068	7.1	+ 90	7.9
WP-1	8-31-70	1750	1018	1948	L.O.	9.01	30.16	-0.5	0.931	0.499	6.6	-315	
WP-1	11-28-70	1515	2200	0800	I.I.	4.83	15.38	-0.5	5.400	2.975	6.8	-310	
WP-1	4-3-71	1700	1718	0318	H.I.	18.08	15.65	-0.5	4.519	2.487	6.9	-400	
WP-1	6-4-71	1500	0730	1748	L.O.	9.14	27.48	-0.5	5.169	2.847	6.8	-210	
WP-1	6-4-71	1500	0730	1748	L.O.	9.14	27.48	-1	7.432	4.101			
WP-1	6-4-71	1500	0730	1748	L.O.	9.14	27.48	-2	8.129	4.487			
WP-1	6-4-71	1500	0730	1748	L.O.	9.14	27.48	-3.0	8.573	4.733			
WP-2	8-31-70	1923	1018	1948	L.O.	9.01	29.28	0	2.384	1.304	6.5	+ 15	
WP-2	11-28-70	1430	2200	0800	I.I.	4.83	15.20	0	9.706	5.360	7.3	+ 0	
WP-2	4-3-71	1420	1718	0318	H.I.	19.37	17.05	0	0.064	0.019	7.5	+ 90	
WP-2	6-4-71	1345	0730	1748	I.O.	9.14	29.5	0	3.124	1.714	6.7	+ 35	5.9
WP-2	8-31-70	1923	1018	1948	L.O.	9.01	29.12	6	2.993	1.641	6.6	- 10	
WP-2	11-28-70	1430	2200	0800	I.I.	4.83	16.37	5	16.725	9.249	8.0	+ 10	
WP-2	4-3-71	1420	1718	0318	H.I.	18.08	17.55	4	0.065	0.019	7.6	+100	
WP-2	6-4-71	1345	0730	1748	I.O.	9.14	29.46	4.5	6.617	3.649	6.6	+ 40	3.9
WP-2	8-31-70	1923	1018	1948	L.O.	9.01	29.12	-0.5	9.327	5.150	7.2	-390	
WP-2	11-28-70	1430	2200	0800	I.I.	4.83	16.37	-0.5	15.196	8.402	7.0	-120	
WP-2	4-3-71	1420	1718	0318	H.I.	18.08	17.55	-0.5	2.033	1.109	7.2	-160	
WP-2	6-4-71	1345	0730	1748	I.O.	9.14	29.46	-0.5	9.265	5.116	7.2	-200	
WP-2	6-4-71	1345	0730	1748	I.O.	9.14	29.46	-1.0	20.639	11.418			
WP-2	6-4-71	1345	0730	1748	I.O.	9.14	29.46	-2.0	20.683	11.442			
WP-2	6-4-71	1345	0730	1748	I.O.	9.14	29.46	-3.0	19.928	10.860			
GB-1	8-27-70	1500	0706	1800	L.O.	7.66	27.52	0	5.460	3.008	6.6	+190	
GB-1	11-29-70	1215	2248	0848	I.I.	4.83	17.47	0	14.958	8.270	7.5	+ 70	
GB-1	6-5-71	1610	0800	1818	L.O.	9.14	31.91	0	10.390	5.739	7.6	+ 50	7.4
GB-1	6-29-71	1610	1212	2124	I.O.	6.32	32.07	0	18.988	10.503	7.6	- 10	6.8
GB-1	8-27-70	1500	0706	1800	L.O.	7.66	28.0	6	9.197	5.078	6.7	+ 88	

TABLE 1 (Cont'd.)

STATIONS	DATE	TIME	TIME OF HIGH TIDE	TIME OF LOW TIDE	TIDE STAGE	PRECIP. FOR MONTH PRECEEDING (INCHES)	TEMP. (C°)	DEPTH (ft.)	SALINITY (ppt)	CHLORINITY (ppt)	pH	Eh	D.O. ppm
GB-1	11-29-70	1215	2248	0848	I.I.	4.83	17.52	6	14.958	8.270	7.3	+ 50	
GB-1	6-5-71	1610	0800	1818	L.O.	9.14	32.0	7	10.353	5.719	7.5	+ 65	7.1
GB-1	6-29-71	1610	1212	2124	I.O.	6.32	30.92	7	19.072	10.550	7.4	- 50	5.7
GB-1	8-27-70	1500	0706	1800	L.O.	7.66	28.0	-0.5	12.595	6.961		-350	
GB-1	11-29-70	1215	2248	0848	I.I.	4.83	17.52	-0.5	15.117	8.358	7.0	- 20	
GB-1	6-5-71	1610	0800	1818	L.O.	9.14	32.0	-0.5	13.485	7.454	7.1	+ 50	
GB-1	6-29-71	1610	1212	2124	I.O.	6.32	30.92	-0.5	15.782	8.727	7.1	-100	
GB-1	6-5-71	1610	0800	1818	L.O.	9.14	32.0	-1	19.347	10.701			
GB-1	6-29-71	1610	1212	2124	I.O.	6.32	30.92	-1.5	19.072	10.550			
GB-1	6-5-71	1610	0800	1818	L.O.	9.14	32.0	-2	22.393	12.389	7.1	- 35	
GB-1	6-29-71	1610	1212	2124	I.O.	6.32	30.92	-3	19.410	10.737			
GB-2	8-27-70	1615	0706	1800	L.O.	7.66	28.22	0	4.853	2.672		+105	
GB-2	11-29-70	1200	2248	0848	I.I.	4.83	17.26	0	14.879	8.226	7.1	+ 75	
GB-2	6-5-71	1522	0800	1818	L.O.	9.14	31.18	0	10.463	5.780	7.2	+ 45	6.0
GB-2	6-29-71	1505	1212	2124	I.O.	6.32	30.15	0	18.235	10.086	7.1	- 40	3.8
GB-2	8-27-70	1615	0706	1800	L.O.	7.66	29.21	10	7.199	3.971		+100	
GB-2	11-29-70	1200	2248	0848	I.I.	4.83	17.33	9	14.879	8.226	7.4	+ 50	
GB-2	6-5-71	1522	0800	1818	L.O.	9.14	31.12	10	10.317	5.699	7.2	+ 35	5.8
GB-2	6-29-71	1505	1212	2124	I.O.	6.32	29.78	10	19.325	10.690	7.1	- 15	1.9
GB-2	8-27-70	1615	0706	1800	L.O.	7.66	29.21	-0.5	11.685	6.457		-340	
GB-2	11-29-70	1200	2248	0848	I.I.	4.83	17.33	-0.5	16.807	9.294	7.4	-170	
GB-2	6-5-71	1522	0800	1818	L.O.	9.14	31.12	-0.5	12.523	6.921	7.2	- 50	
GB-2	6-29-71	1505	1212	2124	I.O.	6.32	29.78	-0.5	15.782	8.727	6.3	-115	
GB-2	6-5-71	1522	0800	1818	L.O.	9.14	31.12	-1	16.346	9.039			
GB-2	6-29-71	1505	1212	2124	I.O.	6.32	29.78	-1	13.415	7.415			
GB-2	6-5-71	1522	0800	1818	L.O.	9.14	31.12	-2	17.662	9.768			
GB-2	6-29-71	1505	1212	2124	I.O.	6.32	29.78	-2	15.943	8.816	7.2	-100	
GB-2	6-5-71	1522	0800	1818	L.O.	9.14	31.12	-3	18.921	10.466	7.0	-100	
OF-1	8-28-70	1035	0728	1916	I.O.	9.01		0	0.037	0.004		+180	
OF-1	11-27-70	1400	2052	0746	I.I.	4.83	16.12	0	8.515	4.701	7.2	+ 70	
OF-1	3-5-71	1400	1728	0422	H.I.	19.37	14.60	0	0.140	0.061	6.5	+ 75	
OF-1	6-2-71	1405	0752	1834	I.O.	9.14	28.5	0	3.572	1.962	6.8	+ 95	8.1
OF-1	8-28-70	1035	0728	1916	I.O.	9.01	24.54	28	0.041	0.006		+180	
OF-1	11-27-70	1400	2052	0746	I.I.	4.83	12.18	27	12.889	7.124	7.6	+ 75	
OF-1	3-5-71	1400	1728	0422	H.I.	19.37	14.36	29	0.147	0.065	7.3	+ 65	
OF-1	6-2-71	1405	0752	1834	L.O.	9.14	26.0	23	7.467	4.120	6.4	- 50	6.0
OF-1	8-28-70	1035	0728	1916	I.O.	9.01	24.54	-0.5	5.202	2.865		-430	
OF-1	11-27-70	1400	2052	0746	I.I.	4.83	12.18	-0.5	9.487	5.239	6.9	-350	
OF-1	3-5-71	1400	1728	0422	H.I.	19.37	14.36	-0.5	3.822	2.101	6.7	-290	
OF-1	6-2-71	1405	0752	1834	L.O.	9.14	26.0	-0.5	5.783	3.187	5.5	-320	
OF-1	6-2-71	1405	0752	1834	L.O.	9.14	26.0	-1	5.359	2.952			
OF-2	8-28-70	0930	0728	1916	I.O.	9.01		0	0.057	0.015		+155	
OF-2	11-27-70	1320	2052	0746	I.I.	4.83	14.38	0	14.091	7.790	8.2	+ 60	
OF-2	3-5-71	1320	1728	0422	H.I.	19.37	12.89	0	1.212	0.655	7.2	+140	
OF-2	6-2-71	1215	0752	1834	L.O.	9.14	27.49	0	6.441	3.551	7.2	+ 65	9.3

TABLE 1 (Cont'd.)

STATIONS	DATE	TIME	TIME OF HIGH TIDE	TIME OF LOW TIDE	TIDE STAGE	PRECIP. FOR MONTH PRECEEDING (INCHES)	TEMP. (C°)	DEPTH (ft.)	SALINITY (ppt)	CHLORINITY (ppt)	pH	Eh	D.O. ppm
OF-2	8-28-70	0930	0728	1916	I.O.	9.01	25.25	18	0.067	0.021		+145	
OF-2	11-27-70	1320	2052	0746	I.I.	4.83	14.76	15	14.484	8.007	8.1	+ 80	
OF-2	3-5-71	1320	1728	0422	I.I.	19.37	12.77	15	2.175	1.188	7.1	+150	
OF-2	6-2-71	1215	0752	1834	I.O.	9.14	26.3	16	11.203	6.190	6.7	+ 40	1.8
OF-2	8-28-70	0930	0728	1916	I.O.	9.01	25.25	-0.5	4.905	2.701		-220	
OF-2	11-27-70	1320	2052	0746	I.I.	4.83	14.76	-0.5	13.779	7.617	7.1	-195	
OF-2	3-5-71	1320	1728	0422	I.I.	19.37	12.77	-0.5	3.289	1.805	7.0	-310	
OF-2	6-2-71	1215	0752	1834	I.O.	9.14	26.3	-0.5	10.024	5.537	7.3	-350	
OF-2	6-2-71	1215	0752	1834	I.O.	9.14	26.3	-1	8.658	4.780			
HB-1	8-28-70	1230	0728	1916	I.O.	9.01		0	0.041	0.006		+ 50	
HB-1	11-27-70	1415	2052	0746	I.I.	4.83	15.44	0	7.243	3.996	6.6	+ 70	
HB-1	3-5-71	1500	1728	0422	I.I.	19.37	11.18	0	0.109	0.044	6.3	+105	
HB-1	6-2-71	1600	0752	1834	I.O.	9.14	29.5	0	5.241	2.887	6.6	+ 25	3.8
HB-1	8-28-70	1230	0728	1916	I.O.	9.01	25.36	5	0.041	0.006		- 40	
HB-1	11-27-70	1415	2052	0746	I.I.	4.83	16.66	4	10.948	6.048	6.7	+ 70	
HB-1	3-5-71	1500	1728	0422	I.I.	19.37	9.93	4	0.108	0.043	6.5	+ 90	
HB-1	6-2-71	1600	0752	1834	I.O.	9.14	29.0	-1.5	5.836	3.217			6.0
HB-1	8-28-70	1230	0728	1916	I.O.	9.01	25.36	-0.5	2.869	1.573		-360	
HB-1	11-27-70	1415	2052	0746	I.I.	4.83	16.66	-0.5	9.082	5.014	6.7	-330	
HB-1	3-5-71	1500	1728	0422	I.I.	19.37	9.93	-0.5	0.940	0.504	6.5	-230	
HB-1	6-2-71	1600	0752	1834	I.O.	9.14	29.0	-0.5	6.339	3.495	6.7	-360	
HB-1	6-2-71	1600	0752	1834	I.O.	9.14	29.0	-1	5.803	3.198			
HB-2	8-28-70	1340	0728	1916	I.O.	9.01	27.14	0	0.063	0.018		+ 45	
HB-2	11-27-70	1530	2052	0746	I.I.	4.83	17.08	0	17.820	9.856	7.8	+ 60	
HB-2	3-5-71	1530	1728	0422	I.I.	19.37	12.36	0	1.912	1.042	6.7	+ 50	
HB-2	6-2-71	1700	0752	1834	I.O.	9.14	29.0	0	8.164	4.506	6.8	+ 30	7.3
HB-2	8-28-70	1340	0728	1916	I.O.	9.01	26.92	10	0.090	0.033		+ 25	
HB-2	11-27-70	1530	2052	0746	I.I.	4.83	17.36	5	22.434	12.412	7.6	+ 50	
HB-2	3-5-71	1530	1728	0422	I.I.	19.37	12.40	10	2.225	1.216	6.5	+ 90	
HB-2	6-2-71	1700	0752	1834	I.O.	9.14	29.0	4	8.234	4.545	7.2	+ 40	6.0
HB-2	8-28-70	1340	0728	1916	I.O.	9.01	26.92	-0.5	5.614	3.093		-340	
HB-2	11-27-70	1530	2052	0746	I.I.	4.83	17.36	-0.5	13.415	7.415	6.8	-350	
HB-2	3-5-71	1530	1728	0422	I.I.	19.37	12.40	-0.5	3.186	1.748	6.7	-380	
HB-2	6-2-71	1700	0752	1834	I.O.	9.14	29.0	-0.5	9.229	5.096			
HB-2	6-2-71	1700	0752	1834	I.O.	9.14	29.0	-1	11.577	6.397			
DB-1	8-28-70	1420	0728	1916	I.O.	9.01		0	0.245	0.119		- 35	
DB-1	11-27-70	1610	2052	0746	I.I.	4.83		0					
DB-1	3-5-71	1545	1728	0422	I.I.	19.37		0					
DB-1	6-2-71	1750	0752	1834	I.O.	9.14	30.0	0					
DB-1	8-28-70	1420	0728	1916	I.O.	9.01	26.94	2	0.357	0.181		- 25	
DB-1	11-27-70	1610	2052	0746	I.I.	4.83	17.58	1.5	19.241	10.643	8.0	+ 35	
DB-1	3-5-71	1545	1728	0422	I.I.	19.37	13.63	1.5	4.204	2.312	7.4	- 65	
DB-1	6-2-71	1750	0752	1834	I.O.	9.14	30.0	1.5	10.024	5.537	6.6	+ 35	7.0
DB-1	8-28-70	1420	0728	1916	I.O.	9.01	26.94	-0.5	3.788	2.082		-340	
DB-1	11-27-70	1610	2052	0746	I.I.	4.83	17.58	-0.5	16.346	9.039	7.0	-310	
DB-1	3-5-71	1545	1728	0422	I.I.	19.37	13.63	-0.5	8.094	4.467	6.9	-300	

TABLE 1 (Cont'd.)

STATIONS	DATE	TIME	TIME OF HIGH TIDE	TIME OF LOW TIDE	TIDE STAGE	PRECIP. FOR MONTH PRECEEDING (INCHES)	TEMP. (C°)	DEPTH (ft.)	SALINITY (ppt)	CHLORINITY (ppt)	pH	Eh	D.O. ppm
DB-1	6-2-71	1750	0752	1834	I.O.	9.14	30.0	-0.5	9.806	5.416	6.9	-350	
DB-1	6-2-71	1750	0752	1834	I.O.	9.14	30.0	-1	11.502	6.356			
BB-1	9-1-70	1200	1040	2016	I.O.	9.01	29.54	0	13.843	7.652	8.4	+ 50	
BB-1	11-27-70	1700	2052	0746	I.I.	4.83	14.61	0	21.557	11.926	8.0	+ 65	
BB-1	3-5-71	1620	1728	0422	I.I.	19.37	13.64	0	12.029	6.647	7.6	+ 20	
BB-1	6-5-71	1200	0728	1840	I.O.	9.14	30.03	0	15.779	8.725	7.7	+ 30	6.5
BB-1	9-1-70	1200	1040	2016	I.O.	9.01	28.80	12	17.046	9.427	8.0	+ 55	
BB-1	11-27-70	1700	2052	0746	I.I.	4.83	14.08	10	25.126	13.903	8.0	+ 50	
BB-1	3-5-71	1620	1728	0422	I.I.	19.37	12.94	10	14.424	7.974	6.5	+ 30	
BB-1	6-5-71	1200	0728	1840	I.O.	9.14	29.23	10	16.428	9.084	7.7	+ 30	6.5
BB-1	9-1-70	1200	1040	2016	I.O.	9.01	28.80	-0.5	17.293	9.564	4.0	-150	
BB-1	11-27-70	1700	2052	0746	I.I.	4.83	14.08	-0.5	36.402	12.600	7.0	-125	
BB-1	3-5-71	1620	1728	0422	I.I.	19.37	12.94	-0.5			7.1	- 50	
BB-1	6-5-71	1200	0728	1840	I.O.	9.14	29.23	-0.5	17.662	9.768		-140	
BB-1	6-5-71	1200	0728	1840	I.O.	9.14	29.23	-1	21.339	11.805			
WR-1	9-1-70	1800	1205	2202	I.O.	15.79	30.04	0	3.292	1.807	6.7	+ 30	
WR-1	11-29-70	1700	2341	1056	I.I.	6.30	16.77	0	13.648	7.544	7.7	+ 70	
WR-1	6-6-71	1400	0923	2102	I.O.	21.36	31.05	0	5.241	2.887	7.4	- 70	6.6
WR-1	6-29-71	1130	1305	2332	I.I.	8.56	28.94	0	2.150	1.174			
WR-1	9-1-70	1800	1205	2202	I.O.	15.79	29.06	22	9.703	5.359	7.2	+ 25	
WR-1	11-29-70	1700	2341	1056	I.I.	6.30	14.97	17	18.988	10.503	6.8	+ 20	
WR-1	6-6-71	1400	0923	2102	I.O.	21.36	32.51	16	5.810	3.202	7.3	+ 60	4.3
WR-1	6-29-71	1130	1305	2332	I.I.	8.56	28.94	16	15.222	8.416	7.4	- 25	2.7
WR-1	9-1-70	1800	1205	2202	I.O.	15.79	29.06	-0.5	8.840	4.881	7.2	-435	
WR-1	11-29-70	1700	2341	1056	I.I.	6.30	14.97	-0.5	13.415	7.415	7.3	-400	
WR-1	6-6-71	1400	0923	2102	I.O.	21.36	32.51	-0.5	8.552	4.721	7.4	-275	
WR-1	6-29-71	1130	1305	2332	I.I.	8.56	28.94	-0.5	8.938	4.935	6.9	- 75	
WR-1	6-6-71	1400	0923	2102	I.O.	21.36	32.51	-1	11.427	6.314			
WR-1	6-29-71	1130	1305	2332	I.I.	8.56	28.94	-1	9.010	4.975			
WR-1	6-6-71	1400	0923	2102	I.O.	21.36	32.51	-2	11.727	6.480	7.3	-260	
WR-1	6-6-71	1400	0923	2102	I.O.	21.36	32.51	-3	11.803	6.522			
WR-2	9-1-70	1720	1205	2202	I.O.	15.79	31.86	0	2.311	1.264	7.2	0	
WR-2	11-29-70	1645	2341	1056	I.I.	6.30	17.38	0	8.260	4.559	6.9	+100	
WR-2	6-6-71	1445	0923	2102	I.O.	21.36	31.33	0	5.254	2.894	7.3	+ 35	6.7
WR-2	6-29-71	1040	1305	2332	I.I.	8.56	28.15	0	1.363	0.739	6.8	- 35	6.5
WR-2	9-1-70	1720	1205	2202	I.O.	15.79	29.86	9	11.773	6.506	7.3	- 65	
WR-2	11-29-70	1645	2341	1056	I.I.	6.30	16.24	7	17.243	9.536	6.8	+ 70	
WR-2	6-6-71	1445	0923	2102	I.O.	21.36	29.31	7	5.790	3.191	7.1	+ 25	5.1
WR-2	6-29-71	1040	1305	2332	I.I.	8.56	28.68	7	14.300	7.906	7.1	- 30	3.5
WR-2	9-1-70	1720	1205	2202	I.O.	15.79	31.86	-0.5	12.075	6.673	7.0	-340	
WR-2	11-29-70	1645	2341	1056	I.I.	6.30	17.38	-0.5	10.392	5.741	6.6	+ 20	
WR-2	6-6-71	1445	0923	2102	I.O.	21.36	31.33	-0.5	8.800	4.858	7.0	-260	
WR-2	6-29-71	1040	1305	2332	I.I.	8.56	28.68	-0.5	8.397	4.635	6.9	-230	
WR-2	6-6-71	1445	0923	2102	I.O.	21.36	29.31	-1	9.229	5.096			
WR-2	6-29-71	1040	1305	2332	I.I.	8.56	28.68	-1	7.693	4.245			
WR-2	6-6-71	1445	0923	2102	I.O.	21.36	29.31	-2	9.157	5.056			

TABLE 1 (Cont'd.)

STATIONS	DATE	TIME	TIME OF HIGH TIDE	TIME OF LOW TIDE	TIDE STAGE	PRECIP. FOR MONTH PRECEEDING (INCHES)	TEMP. (C°)	DEPTH (ft.)	SALINITY (ppt)	CHLORINITY (ppt)	pH	Eh	D.O. ppm
WR-2	6-29-71	1040	1305	2332	I.I.	8.56	28.68	-2	4.682	2.577			
WR-2	6-6-71	1445	0923	2102	I.O.	21.36	29.31	-3	7.467	4.120	6.7	-175	
WR-2	6-29-71	1040	1305	2332	I.I.	8.56	28.68	-3	4.164	2.290	6.5	-160	
EPRL-1	9-2-70	1350	1305	2102	H.	15.79	29.00	0	5.673	3.126	7.5	- 15	
EPRL-1	11-25-70	1200	2117	0826	I.I.	6.30	10.67	0	4.480	2.465	7.3	+ 75	
EPRL-1	6-8-71	1600	1035	2220	I.O.	21.36	30.92	0	3.136	1.721	7.6	+ 25	7.2
EPRL-1	6-26-71	1420	1341	2514	I.O.	6.56	30.11	0	9.298	5.134	7.7	- 20	7.5
EPRL-1	9-2-70	1350	1305	2102	H.	15.79	28.94	25	13.843	7.652	7.0	0	
EPRL-1	11-25-70	1200	2117	0826	I.I.	6.30	10.26	25	6.416	3.538	7.1	+ 75	
EPRL-1	6-8-71	1600	1035	2220	I.O.	21.36	30.42	23	4.751	2.616	7.4	+ 45	3.5
EPRL-1	6-26-71	1420	1341	2514	I.O.	6.56	29.31	23	10.170	5.617	7.6	- 25	7.3
EPRL-1	9-2-70	1350	1305	2102	H.	15.79	28.94	-0.5	14.470	8.000	6.8	-210	
EPRL-1	11-25-70	1200	2117	0826	I.I.	6.30	10.26	-0.5	8.580	4.737		-280	
EPRL-1	6-8-71	1600	1035	2220	I.O.	21.36	30.42	-0.5	2.982	1.635	7.2	-165	
EPRL-1	6-26-71	1420	1341	2514	I.O.	6.56	29.31	-0.5	7.389	4.077	6.8	-110	
EPRL-1	6-8-71	1600	1035	2220	I.O.	21.36	30.42	-1	2.647	1.449	7.2	-160	
EPRL-2	9-2-70	1840	1305	2102	I.O.	15.79	28.58	0	1.589	0.863	6.6	+ 50	
EPRL-2	11-25-70	1100	2117	0826	I.I.	6.30	11.50	0	1.372	0.743	7.9	+ 75	
EPRL-2	6-8-71	1645	1035	2220	I.O.	21.36	28.72	0	0.360	0.183	7.2	+ 20	6.6
EPRL-2	6-26-71	1526	1341	2514	I.O.	6.56	29.59	0	3.074	1.686	7.2	+ 35	8.1
EPRL-2	9-2-70	1840	1305	2102	I.O.	15.79	28.50	18	10.213	5.642	6.8	+ 40	
EPRL-2	11-25-70	1100	2117	0826	I.I.	6.30	13.38	15	7.942	4.383	7.8	+ 70	
EPRL-2	6-8-71	1645	1035	2220	I.O.	21.36	28.07	18	0.818	0.436	7.2	+20	4.7
EPRL-2	6-26-71	1526	1341	2514	I.O.	6.56	28.90	18	8.158	4.503	6.9	+ 65	5.4
EPRL-2	9-2-70	1840	1305	2102	I.O.	15.79	28.50	-0.5	11.698	6.464	6.7	-270	
EPRL-2	11-25-70	1100	2117	0826	I.I.	6.30	13.38	-0.5	2.071	1.131		- 50	
EPRL-2	6-8-71	1645	1035	2220	I.O.	21.36	28.07	-0.5	1.264	0.684	7.4	-250	
EPRL-2	6-26-71	1526	1341	2514	I.O.	6.56	28.90	-0.5	1.713	0.932	6.8	- 75	
EPRL-2	6-26-71	1526	1341	2514	I.O.	6.56	28.90	-1	1.260	0.681	6.8	-150	
EPRL-2	6-26-71	1526	1341	2514	I.O.	6.56	28.90	-2	1.095	0.590			
EPRL-3	9-2-70	1730	1305	2102	I.O.	15.79	28.82	0	0.697	0.369	6.5	+ 60	
EPRL-3	11-25-70	0930	2117	0826	I.I.	6.30	12.21	0	0.357	0.181	6.95	+ 98	
EPRL-3	6-8-71	1825	1035	2220	I.O.	21.36	29.20	0	0.056	0.014	6.5	+ 40	9.7
EPRL-3	6-26-71	1650	1341	2514	I.O.	6.56	29.13	0	0.486	0.252	6.5	+ 50	5.4
EPRL-3	9-2-70	1730	1305	2102	I.O.	15.79	28.37	30	2.480	1.357	6.6	+ 60	
EPRL-3	11-25-70	0930	2117	0826	I.I.	6.30	14.14	20	2.515	1.377	7.2	+ 60	
EPRL-3	6-8-71	1825	1035	2220	I.O.	21.36	26.30	37	0.061	0.017	6.5	+ 20	6.9
EPRL-3	6-26-71	1650	1341	2514	I.O.	6.56	28.96	10	2.643	1.447	6.4	+ 60	3.1
EPRL-3	9-2-70	1730	1305	2102	I.O.	15.79	28.37	-0.5	4.113	2.262	6.6	-160	
EPRL-3	11-25-70	0930	2117	0826	I.I.	6.30	14.14	-0.5	2.266	1.239		-190	
EPRL-3	6-8-71	1825	1035	2220	I.O.	21.36	26.30	-0.5	1.579	0.858		-375	
EPRL-3	6-26-71	1650	1341	2514	I.O.	6.56	28.96	-0.5	1.078	0.581	6.3	- 50	
EPRL-3	6-8-71	1825	1035	2220	I.O.	21.36	26.30	-1	2.077	1.134	6.2	-295	
EPRL-3	6-26-71	1650	1341	2514	I.O.	6.56	28.96	-1	2.551	1.396			
EPRL-3	6-26-71	1650	1341	2514	I.O.	6.56	28.96	-2	2.442	1.336	6.2	-105	
MPRL-1	9-3-70	1415	0235	0956	I.I.	15.79	28.64	0	0.316	0.158	6.4	+ 55	

TABLE 1 (Cont'd.)

STATIONS	DATE	TIME	TIME OF HIGH TIDE	TIME OF LOW TIDE	TIDE STAGE	PRECIP. FOR MONTH PRECEEDING (INCHES)	TEMP. (C°)	DEPTH (ft.)	SALINITY (ppt)	CHLORINITY (ppt)	pH	Eh	D.O. ppm
MPRL-1	11-25-70	1330	2117	0826	I.I.	6.30	12.10	0	0.618	0.326	7.3	+ 40	
MPRL-1	6-9-71	1535	1117	2308	I.O.	21.36	29.93	0	0.094	0.035	6.8	+105	6.6
MPRL-1	6-25-71	1650	1305	2502	I.O.	6.56	31.07	0	0.799	0.426	6.9	+ 45	7.7
MPRL-1	9-3-70	1415	0235	0956	I.I.	15.79	28.67	21	8.556	4.723	7.1	+ 50	
MPRL-1	11-25-70	1330	2117	0826	I.I.	6.30	11.62	17	1.230	0.665	7.3	+ 10	
MPRL-1	6-9-71	1535	1117	2308	I.O.	21.36	29.88	22	0.108	0.043	7.0	+135	3.7
MPRL-1	6-25-71	1540	1305	2502	I.O.	6.56	29.67	17	5.620	3.097	6.8	+ 65	5.2
MPRL 1	9-3-70	1415	0235	0956	I.I.	15.79	28.67	-0.5	7.295	4.025	6.8	-270	
MPRL-1	11-25-70	1330	1117	0826	I.O.	6.30	11.62	-0.5	3.011	1.651		- 30	
MPRL-1	6-9-71	1535	1117	2308	I.O.	21.36	29.88	-0.5	0.187	0.087	7.2	-150	
MPRL-1	6-25-71	1540	1305	2502	I.O.	6.56	29.67	-0.5	1.135	0.612	7.0	- 90	
MPRL-1	6-25-71	1540	1305	2502	I.O.	6.56	29.67	-1	1.421	0.771			
MPRL-1	6-9-71	1535	1117	2308	I.O.	21.36	29.88	-1.5	0.261	0.128			
MPRL-1	6-25-71	1540	1305	2502	I.O.	6.56	29.67	-2	1.226	0.662	7.2	- 75	
MPRL-1	6-25-71	1540	1305	2502	I.O.	6.56	29.67	-3	1.801	0.981			
WPRL-1	9-3-70	1150	0235	0956	I.I.	15.79	28.28	0	0.099	0.038	6.4	- 30	
WPRL-1	11-25-70	1400	2117	0826	I.I.	6.30	11.51	0	0.086	0.031	7.3	+ 70	
WPRL-1	6-9-71	1745	1117	2308	I.O.	21.36	28.71	0	0.191	0.089	6.4	+110	10.2
WPRL-1	6-25-71	1650	1305	2502	I.O.	6.56	29.10	0	0.181	0.083	6.8	+105	5.7
WPRL-1	9-3-70	1150	0235	0956	I.I.	15.79	28.94	38	10.433	5.763	7.4	+ 15	
WPRL-1	11-25-70	1400	2117	0826	I.I.	6.30	11.70	40	6.167	3.400	7.1	+ 30	
WPRL-1	6-9-71	1745	1117	2308	I.O.	21.36	29.56	35	0.606	0.319	6.6	+ 70	8.8
WPRL-1	6-25-71	1650	1305	2502	I.O.	6.56	29.62	37	5.348	2.946	7.1	+ 90	7.6
WPRL-1	9-3-70	1150	0235	0956	I.I.	15.79	28.94	-0.5	9.703	5.359	6.5	-370	
WPRL-1	11-25-70	1400	2117	0826	I.I.	6.30	11.70	-0.5	7.369	4.066		-350	
WPRL-1	6-9-71	1745	1117	2308	I.O.	21.36	29.56	-0.5	6.828	3.766	6.6	-185	
WPRL-1	6-25-71	1650	1305	2502	I.O.	6.56	26.92	-0.5	1.654	0.900	6.4	- 10	
WPRL-1	6-9-71	1745	1117	2308	I.O.	21.36	29.56	-1	7.384	4.074			
WPRL-1	6-25-71	1650	1305	2502	I.O.	6.56	26.92	-1	3.167	1.738			
WPRL-1	6-25-71	1650	1305	2502	I.O.	6.56	26.92	-2	3.892	2.139			
WPRL-1	9-3-70	1330	0235	0956	I.I.	15.79	28.32	0	0.056	0.014	6.2	+ 10	
WPRL-1	11-25-70	1515	2117	0826	I.I.	6.30	11.50	0	0.093	0.035	6.9	+ 30	
WPRL-1	6-9-71	1350	1117	2308	I.O.	21.36	28.46	0	0.066	0.020	6.8	+ 70	5.7
WPRL-2	6-25-71	1350	1305	2502	H.	6.56	29.32	0	0.065	0.019	6.7	+ 50	6.0
WPRL-2	9-3-70	1330	0235	0956	I.I.	15.79	28.09	19	0.061	0.017	6.7	+ 20	
WPRL-2	11-25-70	1515	2117	0826	I.I.	6.30	11.49	15	0.067	0.020	7.1	+ 60	
WPRL-2	6-9-71	1350	1117	2308	I.O.	21.36	28.56	17	0.057	0.015	6.9	+ 85	4.9
WPRL-2	6-25-71	1350	1305	2502	H.	6.56	29.05	17	0.058	0.015	6.9	+360	5.4
WPRL-2	9-3-70	1330	0235	0956	I.I.	15.79	28.09	-0.5	0.099	0.038	6.5	-200	
WPRL-2	11-25-70	1515	2117	0826	I.I.	6.30	11.49	-0.5					
WPRL-2	6-9-71	1350	1117	2308	I.O.	21.36	28.56	-0.5	0.224	0.107	6.7	-170	
WPRL-2	6-25-71	1350	1305	2502	H.	6.56	29.05	-0.5	0.183	0.085	6.7	- 90	
WPRL-2	6-9-71	1350	1117	2308	I.O.	21.36	28.56	-1	0.244	0.118			
WPRL-2	6-25-71	1350	1305	2502	H.	6.56	29.05	-1	0.286	0.142			
WPRL-2	6-9-71	1350	1117	2308	I.O.	21.36	28.56	-2	0.246	0.119			
WPRL-2	6-25-71	1350	1305	2502	H.	6.56	29.05	-2	0.293	0.145	6.4	-110	

TABLE 2

Color, Sulfate, and Nitrate Data by Stations

STATIONS	DATE	TIME	DEPTH (ft.)	COLOR (APHA UNITS)	SO_4 (ppm)	NO_3 (ppm)
EP-1	8-31-70	1130	0	103	1240	.484
EP-1	11-28-70	1345	0	40	1900	
EP-1	3-6-71	1100	0	250	41	.176
EP-1	6-3-71	1220	0	80	1700	.264
EP-1	8-31-70	1130	45	60	2650	.792
EP-1	11-28-70	1345	45	40	2100	
EP-1	3-6-71	1100	44	60	2800	.440
EP-1	6-3-71	1220	45	80	1700	.264
EP-2	8-31-70	1330	0	130	390	.352
EP-2	11-28-70	1315	0	40	1450	
EP-2	3-6-71	1145	0	260	12	.220
EP-2	6-3-71	1345	0	100	210	.220
EP-2	8-31-70	1330	32	83	2750	1.188
EP-2	11-28-70	1315	25	20	2200	
EP-2	3-6-71	1145	28	290	225	.088
EP-2	6-3-71	1345	28	60	2400	.308
EP-3	8-31-70	1455	0	190	7	
EP-3	11-28-70	1200	0	90	640	
EP-3	3-6-71	1330	0	200	9	.396
EP-3	6-3-71	1545	0	250	140	.308
EP-3	8-31-70	1455	25	315	2500	
EP-3	11-28-70	1200	35	30	2400	
EP-3	3-6-71	1330	38	255	12	.528
EP-3	6-3-71	1545	30	100	1600	6.60
Long-1	8-31-70	1700	0	110	23	.[illegible]40
Long-1	11-28-70	1615	0	60	490	
Long-1	4-3-71	1630	0	195	5	.528
Long-1	6-3-71	1645	0	145	50	.352
Long-1	8-31-70	1700	23	80	1700	.704
Long-1	11-28-70	1615	23	35	2100	
Long-1	4-3-71	1630	20	120	600	.264
Long-1	6-3-71	1645	20	70	2600	.264
WP-1	8-31-70	1750	0	80	4	
WP-1	4-3-71	1700	0	185	18	.528
WP-1	6-4-71	1500	0	130	80	.176
WP-1	8-31-70	1750	5	80	4	
WP-1	4-3-71	1700	5	190	28	.660
WP-1	6-4-71	1500	5	160	290	.220
WP-2	8-31-70	1923	0	95	260	.308
WP-2	4-3-71	1420	0	195	5	.308
WP-2	6-4-71	1345	0	85	260	.220
WP-2	8-31-70	1923	6	120	300	.440
WP-2	4-3-71	1420	4	180	4	.528
WP-2	6-4-71	1345	4.5	75	480	.176
GB-1	8-27-70	1500	0	117	430	*

TABLE 2 (Cont'd.)

STATIONS	DATE	TIME	DEPTH (ft.)	COLOR (APHA UNITS)	SO_4 (ppm)	NO_3 (ppm)
GB-1	11-29-70	1215	0			0.176
GB-1	6-5-71	1610	0	120	850	0.176
GB-1	6-29-71	1610	0	30	2200	0.220
GB-1	8-27-70	1500	6	80	780	*
GB-1	11-29-70	1215	6			0.088
GB-1	6-5-71	1610	7	125	1000	0.528
GB-1	6-29-71	1610	7	110	2800	0.132
GB-2	8-27-70	1615	0	120	470	*
GB-2	11-29-70	1200	0			0.176
GB-2	6-5-71	1522	0	110	1000	0.220
GB-2	6-29-71	1505	0	180	1750	0.176
GB-2	8-27-70	1615	10	105	670	*
GB-2	11-29-70	1200	9			0.264
GB-2	6-5-71	1522	10	120	800	0.176
GB-2	6-29-71	1505	10	65	2500	0.264
OF-1	8-28-70	11035	0	120	0	*
OF-1	11-27-70	1400	0			0.176
OF-1	3-5-71	1400	0	160	8	.308
OF-1	6-2-71	1405	0	50	420	0.264
OF-1	8-28-70	1035	28	112	280	*
OF-1	11-27-70	1400	27			0.176
OF-1	3-5-71	1400	29	180	8	0.044
OF-1	6-2-71	1405	23	70	850	0.264
OF-2	8-28-70	0930	0	120	4	*
OF-2	11-27-70	1320	0			*
OF-2	3-5-71	1320	0	175	110	0.264
OF-2	6-2-71	1215	0	70	840	0.308
OF-2	8-28-70	0930	18	130	5	*
OF-2	11-27-70	1320	15			0.176
OF-2	3-5-71	1320	15	175	110	0.264
OF-2	6-2-71	1215	16	70	1700	0.220
HB-1	8-28-70	1230	0	160	0	*
HB-1	11-27-70	1415	4			0.132
HB-1	3-5-71	1500	4	170	10	0.352
HB-1	6-2-71	1600	1.5	110	1500	0.220
HB-2	8-28-70	1340	0	115	2	*
HB-2	11-27-70	1530	0			0.220
HB-2	3-5-71	1530	0	160	260	0.220
HB-2	6-2-71	1700	0	120	1800	0.176
HB-2	8-28-70	1340	10	120	3	*
HB-2	11-27-70	1530	5			0.176
HB-1	11-27-70	1415	0			0.132
HB-1	3-5-71	1500	0	160	5	0.528
HB-1	6-2-71	1600	0	105	700	0.220
HB-1	8-28-70	1230	5	165	0	*

TABLE 2 (Cont'd.)

STATIONS	DATE	TIME	DEPTH (ft.)	COLOR (APHA UNITS)	SO_4 (ppm)	NO_3 (ppm)
HB-2	3-5-71	1530	10	170	10	0.352
HB-2	6-2-71	1700	4	120	1400	0.176
DB-1	8-28-70	1420	2	130	31	*
DB-1	11-27-70	1610	1.5			0.176
DB-1	3-5-71	1545	1.5	105	280	0.308
DB-1	6-2-71	1750	1.5	160	750	0.264
BB-1	9-1-70	1200	0	120	1400	0.264
BB-1	11-27-70	1700	0			0.220
BB-1	3-5-71	1620	0	50	1700	0.176
BB-1	6-5-71	1200	0	65	2250	0.352
BB-1	9-1-70	1200	12	180	1800	0.792
BB-1	11-27-70	1700	10			0.220
BB-1	3-5-71	1620	10	65	1500	0.176
BB-1	6-5-71	1200	10	65	1950	0.220
WR-1	9-1-70	1800	0	180	240	0.088
WR-1	11-29-70	1700	0			0.176
WR-1	6-6-71	1400	0	60	340	0.264
WR-1	6-29-71	1130	0		120	0.308
WR-1	9-1-70	1800	22	113	820	0.132
WR-1	11-29-70	1700	17			0.264
WR-1	6-6-71	1400	16	85	410	0.264
WR-1	6-29-71	1130	16	45	1700	0.220
WR-2	9-1-70	1720	0	140	140	0.132
WR-2	11-29-70	1645	0			0.132
WR-2	6-6-71	1445	0	66	340	0.220
WR-2	6-29-71	1040	0	85	505	0.264
WR-2	9-1-70	1720	9	140	1200	
WR-2	11-29-70	1645	7			0.220
WR-2	6-6-71	1445	7	85	580	0.264
WR-2	6-29-71	1040	7	40	1700	0.308
EPRL-1	9-2-70	1350	0	110	430	1.628
EPRL-1	11-25-70	1200	0			0.220
EPRL-1	6-8-71	1600	0	95	290	0.264
EPRL-1	6-26-71	1420	0	60	850	0.220
EPRL-1	9-2-70	1350	25	120	1200	0.132
EPRL-1	11-25-70	1200	25			0.220
EPRL-1	6-8-71	1600	23	80	540	0.264
EPRL-1	6-26-71	1420	23	35	3000	0.220
EPRL-2	9-2-70	1840	0	140	165	0.308
EPRL-2	11-25-70	1100	0			0.308
EPRL-2	6-8-71	1645	0	189	30	0.528
EPRL-2	6-26-71	1526	0	75	230	0.308
EPRL-2	9-2-70	1840	18	90	870	0.308
EPRL-2	11-25-70	1100	15			0.352
EPRL-2	6-8-71	1645	18	149	82	0.418
EPRL-3	9-2-70	1730	0	130	53	0.132

TABLE 2 (Cont'd.)

STATIONS	DATE	TIME	DEPTH (ft.)	COLOR (APHA UNITS)	SO_4 (ppm)	NO_3 (ppm)
EPRL-3	11-25-70	0930	0			0.352
EPRL-3	6-8-71	1825	0	175	12	0.528
EPRL-3	6-26-71	1650	0	90	23	0.308
EPRL-3	9-2-70	[illegible] ~~0930~~	30	115	200	0.308
EPRL-3	11-25-70	0930	20			0.308
EPRL-3	6-8-71	1825	37	195	6	0.616
EPRL-3	6-26-71	1650	10	75	260	0.462
MPRL-1	9-3-70	1415	0	147	19	0.616
MPRL-1	11-25-70	1330	0			0.396
MPRL-1	6-9-71	1535	0	155	7	0.616
MPRL-1	6-25-71	1650	0	110	86	0.528
MPRL-1	9-3-70	1415	21	58	720	0.308
MPRL-1	11-25-70	1330	17			0.308
MPRL-1	6-9-71	1535	22	185	170	0.792
MPRL-1	6-25-71	1540	17	70	400	0.220
WPRL-1	9-3-70	1150	0	90	7	*
WPRL-1	11-25-70	1400	0			0.924
WPRL-1	6-9-71	1745	0	135	7	0.924
WPRL-1	6-25-71	1650	0	120	27	0.704
WPRL-1	9-3-70	1150	38	30	980	*
WPRL-1	11-25-70	1400	40			0.220
WPRL-1	6-9-71	1745	35	115	220	0.396
WPRL-1	6-25-71	1650	37	115	65	0.792
WPRL-2	9-3-70	1330	0	107	5	1.232
WPRL-2	11-25-70	1515	0			0.968
WPRL-2	6-9-71	1350	0	120	6	0.616
WPRL-2	6-25-71	1350	0	135	30	0.[illegible]92
WPRL-2	9-3-70	1330	19	103	3	1.232
WPRL-2	11-25-70	1515	15			0.880
WPRL-2	6-9-71	1350	17	140	9	0.792
WPRL-2	6-25-71	1350	17	115	65	0.792

* Below sensitivity of instrument (.1 ppm).

TABLE 3

Concentrations of Major Metallic Ions by Stations

STATIONS	DATE	TIME	DEPTH (ft.)	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	Sr (ppm)
EP-1	6-3-71	1220	0	158	600	4848	123	3.75
EP-1	6-3-71	1220	45	418	1387	10723	392	7.4
EP-1	6-3-71	1220	- 0.5*	352	1284	10261	397	5.1
EP-1	6-3-71	1220	- 1.5	180	1260	10210	358	4.7
EP-2	6-3-71	1345	0	48	150	1179	48	.8
EP-2	6-3-71	1345	28	365	1267	10107	351	7.05
EP-2	6-3-71	1345	- 0.5	227	998	8311	259	6.1
EP-2	6-3-71	1345	- 1.0		1126	9183	348	4.2
EP-2	6-3-71	1345	- 2.0	124	1126	8978	351	2.9
EP-3	6-3-71	1545	0	24	60	569	16	.1
EP-3	6-3-71	1545	30	339	1067	9029	331	7.8
EP-3	6-3-71	1545	- 0.5	331	1007	8157	299	5.2
EP-3	6-3-71	1545	- 1.5	200	1071	8638	338	6.2
Long-1	6-3-71	1645	0	5.9	23.1	234	9.4	0.2
Long-1	6-3-71	1645	20	325	981	8670	304	6.4
Long-1	6-3-71	1645	- 0.5	200	542	4976	195	3.4
WP-1	6-4-71	1500	0	0.9	3.0	31	1.9	.1
WP-1	6-4-71	1500	5	0.9	4.5	43	2.4	.1
WP-1	6-4-71	1500	- 0.5	89	205	2205	86	1.2
WP-1	6-4-71	1500	- 1		405	3180		1.8
WP-1	6-4-71	1500	- 2	92	482	3796	135	2.1
WP-1	6-4-71	1500	- 3	123	383	3283	115	2.2
WP-2	6-4-71	1345	0	39	140	1124	41	2.1
WP-2	6-4-71	1345	4.5	79	291	2308	86	2.0
WP-2	6-4-71	1345	- 0.5	130	469	4053	162	2.0
WP-2	6-4-71	1345	- 1	213	845	6926	259	3.2
WP-2	6-4-71	1345	- 2	246	836	6977	284	3.4
WP-2	6-4-71	1345	- 3	286	930	7644	279	
GB-1	6-5-71	1610	0	114	410	3488	119	2.8
GB-1	6-29-71	1610	0	124	772	5924	231	5.0
GB-1	6-5-71	1610	7	108	410	3693	126	2.8
GB-1	6-29-71	1610	7	207	755	5924	226	5.1
GB-1	6-5-71	1610	- 0.5	161	545	4976	181	3.2
GB-1	6-29-71	1610	- 0.5	124	636	5309	221	3.6
GB-1	6-5-71	1610	- 1	253	836	7388	289	4.9
GB-1	6-29-71	1610	- 1.5	237	815	6401	259	4.1
GB-1	6-5-71	1610	- 2	259	896	6990	294	5.4
GB-1	6-29-71	1610	- 3	284	840	6674	269	4.6
GB-2	6-5-71	1522	0	130	401	3540	122	2.9
GB-2	6-29-71	1505	0	222	755	5514	226	5.0
GB-2	6-5-71	1522	10	123	397	3642	127	3.0

TABLE 3 (Cont'd.)

STATIONS	DATE	TIME	DEPTH (ft.)	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	Sr (ppm)
GB-2	6-29-71	1505	10	175	836	6128	231	5.3
GB-2	6-5-71	1522	- 0.5	141	482	4473	161	2.3
GB-2	6-29-71	1505	- 0.5	157	708	5241	207	4.2
GB-2	6-5-71	1522	- 1	233	835	7080	279	3.1
GB-2	6-29-71	1505	- 1	132	555	4490	207	3.3
GB-2	6-5-71	1522	- 2	286	1052	8927	360	3.6
GB-2	6-29-71	1505	- 2	165	679	5378	218	4.1
GB-2	6-5-71	1522	- 3	207	772	6310	259	4.4
O -1	6-2-71	1405	0	44	147	1154	42	0.8
OF-1	6-2-71	1405	23	85	312	2513	91	2.3
OF-1	6-2-71	1405	- 0.5	52	248	2078	86	0.4
OF-1	6-2-71	1405	- 1	51	233	1508	79	0.75
OF-2	6-2-71	1215	0	75	265	1562	81	1.8
OF-2	6-2-71	1215	16	134	473	3847	102	3.1
OF-2	6-2-71	1215	- 0.5	95	414	3642	97	1.65
OF-2	6-2-71	1215	- 1	117	333	3180	116	1.5
HB-1	6-2-71	1600	0	72	211	729	64	1.6
HB-1	6-2-71	1600	1.5	71	246	4022	76	1.7
HB-1	6-2-71	1600	- 0.5	54	263	2293	91	0.8
HB-1	6-2-71	1600	- 1	41	237	2088	89	0.4
HB-2	6-2-71	1700	0	88	265	2637	93	2.3
HB-2	6-2-71	1700	4	91	278	2688	90	2.3
HB-2	6-2-71	1700	- 0.5	113	354	3406	112	1.0
HB-2	6-2-71	1700	- 1	167	465	4278	107	2.2
DB-1	6-2-71	1750	0	108	371	3232	102	2.7
DB-1	6-2-71	1750	1.5	108	371	3232	102	2.7
DB-1	6-2-71	1750	- 0.5	108	371	3282	119	2.2
DB-1	6-2-71	1750	- 1	161	465	4053	131	2.2
BB-1	6-5-71	1200	0	193	653	5233	173	4.3
BB-1	6-5-71	1200	10	193	669	5438	176	4.3
BB-1	6-5-71	1200	- 0.5	220	759	6618	235	3.5
BB-1	6-5-71	1200	- 1	253	870	7234	277	4.7
WR-1	6-6-71	1400	0	66	209	1718	67	1.3
WR-1	6-6-71	1400	16	73	221	1898	84	1.4
WR-1	6-29-71	1130	16	157	627	5036	190	4.2
WR-1	6-6-71	1400	- 0.5	114	349	3129	120	1.7
WR-1	6-29-71	1130	- 0.5	88	416	3235	125	2.3
WR-1	6-6-71	1400	- 1	165	486	4207	155	2.3
WR-1	6-29-71	1130	- 1	81	382	3405	131	1.9
WR-1	6-6-71	1400	- 2	136	503	4360	159	2.3
WR-1	6-6-71	1400	- 3	155	503	4360	164	2.4
WR-1	6-29-71	1130	0	21	90	872	27	0.3
WR-2	6-6-71	1445	0	69	210	872	69	1.3
WR-2	6-29-71	1040	0	12	53	467	18	.1
WR-2	6-6-71	1445	7	70	231	1417	74	1.4
WR-2	6-29-71	1040	7	165	568	5036	178	3.9

TABLE 3 (Cont'd.)

STATIONS	DATE	TIME	DEPTH (ft.)	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	Sr (ppm)
WR-2	6-6-71	1445	- 0.5	109	259	2434	125	1.8
WR-2	6-29-71	1040	- 0.5	97	329	2967	112	1.7
WR-2	6-6-71	1445	- 1	132	405	3540	130	2.0
WR-2	6-29-71	1040	- 1	91	308	2967	112	1.4
WR-2	6-6-71	1445	- 2	142	417	3745	127	1.8
WR-2	6-29-71	1040	- 2	74	171	1659	80	1.3
WR-2	6-6-71	1445	- 3	84	299	2667	93	1.3
WR-2	6-29-71	1040	- 3	72	158	1465	63	1.1
EPRL-1	6-8-71	1600	0	44	124	1077	42	0.8
EPRL-1	6-26-71	1420	0	93	384	3193	118	3.0
EPRL-1	6-8-71	1600	23	63	184	1667	63	1.1
EPRL-1	6-26-71	1420	23	10[illegible]	384	3466	138	3.2
EPRL-1	6-8-71	1600	- 0.5	5	81	1205	62	0.2
EPRL-1	6-26-71	1420	- 0.5	57	392	2655	104	0.9
EPRL-1	6-8-71	1600	- 1	48	79	1077	50	0.1
EPRL-2	6-8-71	1645	0	5.1	13.4	133	5.4	.1
EPRL-2	6-26-71	1526	0	34	126	1119	40	0.9
EPRL-2	6-8-71	1645	18	1.8	32.9	318	10.8	.1
EPRL-2	6-26-71	1526	18	95	325	2852	94	2.5
EPRL-2	6-8-71	1645	- 0.5	1.9	36.7	564	10.1	.1
EPRL-2	6-26-71	1526	- 0.5	16	95	539	30	0.5
EPRL-2	6-26-71	1526	- 1	12	41	539	30	0.15
EPRL-2	6-26-71	1526	- 2	11	33	573	29	0
EPRL-3	6-8-71	1825	0	1.5	1.2	8.1	1.5	.1
EPRL-3	6-26-71	1650	0	3.0	20	156	7.1	.1
EPRL-3	6-8-71	1825	37	1.4	1.3	9.9	1.6	1
EPRL-3	6-26-71	1650	10	36	117	845	34	0.6
EPRL-3	6-8-71	1825	- 0.5	32.7	55	605	34	0.2
EPRL-3	6-26-71	1650	- 0.5	12	50	394	20	.1
EPRL-3	6-8-71	1825	- 1	37.0	67	852	38	.35
EPRL-3	6-26-71	1650	- 1	56	119	934	34	0.4
EPRL-3	6-26-71	1650	- 2	60	87	722	32	.1
MPRL-1	6-9-71	1535	0	1.7	2.6	21	1.9	.1
MPRL-1	6-25-71	1650	0	5.3	33	265	12.6	.1
MPRL-1	6-9-71	1535	22	1.5	3.4	29	2.3	.1
MPRL-1	6-25-71	1540	17	76	235	1733	74	1.2
MPRL-1	6-9-71	1535	- 0.5	1.0	5.6	73	8.0	.1
MPRL-1	6-25-71	1540	- 0.5	1.1	23	423	25	.1
MPRL-1	6-25-71	1540	- 1	19.0	32	508	35	.1
MPRL-1	6-9-71	1535	- 1.5	1.5	1.1	110	8.3	.1
MPRL-1	6-25-71	1540	- 2	1.9	23	440	32	.1
MPRL-1	6-25-71	1540	- 3	10	49	679	43	.1
WPRL-1	6-9-71	1745	0	4.0	7.0	59	3.4	.1
WPRL-1	6-25-71	1650	0	1.5	5.8	55	2.8	.1
WPRL-1	6-9-71	1745	35	7.3	22	226	8.8	.1
WPRL-1	6-25-71	1650	37	72	235	1699	71	1.2

TABLE 3 (Cont'd.)

STATIONS	DATE	TIME	DEPTH (ft.)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
WPRL-1	6-9-71	1745	- 0.5	85	299	2405	86.5	1.8
WPRL-1	6-25-71	1650	- 0.5	10	48	628	26	.1
WPRL-1	6-9-71	1745	- 1	61	282	2821	94	1.5
WPRL-1	6-25-71	1650	- 1	61	119	1157	40	0.4
WPRL-1	6-25-71	1650	- 2	46	189	1464	55	1.0
WPRL-2	6-9-71	1350	0	0.76	0.9	9.3	1.3	.1
WPRL-2	6-25-71	1350	0	1.03	1.0	11	1.3	.1
WPRL-2	6-9-71	1350	17	0.4	0.8	7.4	1.3	.1
WPRL-2	6-25-71	1350	17	3.1	1.0	11	1.5	.1
WPRL-2	6-9-71	1350	- 0.5	56.7	18	44	4.9	0.3
WPRL-2	6-25-71	1350	- 0.5	8.6	11	29	3.7	.1
WPRL-2	6-9-71	1350	- 1	23	8.0	47	3.6	.1
WPRL-2	6-25-71	1350	- 1	17	12.0	67	3.9	.1
WPRL-2	6-9-71	1350	- 2	11	11	49	3.8	.1
WPRL-2	6-25-71	1350	- 2	13	12.0	71	2.2	.1

* Negative depth values refer to feet below the water-sediment interface.

TABLE 4

Sediment Core Data

STATIONS	DATE	TIME	CORE LENGTH (INCHES)	INCHES BELOW INTERFACE	SAND %	SILT %	CLAY %	TOTAL ORGANIC CARBON %
EP-1	11-28-70	1345	6	6	4.0	36.4	59.6	
EP-1	3-6-71	1100	6	6	32.8	23.2	44.0	
EP-1	6-3-71	1220	18	6	0.10	25.6	74.3	2.34
EP-1	6-3-71	1220	18	18	26.80	29.5	43.7	1.34
EP-2	3-6-71	1145	6	6	4.1	40.7	55.2	
EP-2	6-3-71	1345	24	6	0.80	49.5	49.7	2.85
EP-2	6-3-71	1345	24	12	3.8	32.6	63.6	3.32
EP-2	6-3-71	1345	24	24	6.0	30.8	63.2	3.12
EP-3	11-28-70	1200	6	6	-	-	49.9	
EP-3	3-6-71	1330	6	6	-	-	56.6	
EP-3	6-3-71	1545	18	6	0.10	39.0	60.9	0.54
EP-3	6-3-71	1545	18	18	4.0	55.8	40.2	14.07
Long-1	11-28-70	1515	6	6	17.1	48.2	34.7	
Long-1	4-3-71	1630	6	6	26.5	37.3	36.2	
Long-1	6-3-71	1645	6	6	38.8	32.0	29.2	2.12
WP-1	11-28-70	1515	6	6	1.1	47.3	51.6	
WP-1	4-3-71	1700	6	6	6.2	51.3	42.5	
WP-1	6-4-71	1500	36	6	0.44	39.9	59.7	2.49
WP-1	6-4-71	1500	36	12	0.4	37.8	61.8	0.53
WP-1	6-4-71	1500	36	24	0.7	48.2	52.1	1.90
WP-1	6-4-71	1500	36	36	0.4	54.2	45.4	1.81
WP-2	11-28-70	1430	6	6	31.0	32.2	36.8	
WP-2	6-4-71	1345	36	6	20.0	24.4	55.6	1.95
WP-2	6-4-71	1345	36	12	72.0	16.3	11.7	1.[illegible]
WP-2	6-4-71	1345	36	24	85.6	9.3	5.1	0.40
WP-2	6-4-71	1345	36	36	84.4	6.4	9.2	0.37
GB-1	11-29-70	1215	6	6	5.1	44.5	50.4	
GB-1	6-29-71	1610	36	6	8.80	48.0	44.2	1.14
GB-1	6-5-71	1618	24	12	-	-	38.6	
GB-1	6-29-71	1610	36	18	1.60	59.8	38.6	1.07
GB-1	6-29-71	1610	36	36	20.4	45.5	34.1	0.88
GB-2	11-29-70	1200	6	6	84.2	9.5	6.3	
GB-2	6-5-71	1522	36	6	51.0	8.4	40.6	1.21
GB-2	6-29-71	1505	24	6	36.7	-	-	1.60
GB-2	6-5-71	1522	36	12	26.6	45.1	28.3	0.86
GB-2	6-29-71	1505	24	12	17.6	-	-	1.87
GB-2	6-5-71	1522	36	24	25.6	41.8	32.6	0.89
GB-2	6-29-71	1505	24	24	58.4	-	-	0.45
OF-1	11-27-70	1400	6	6	50.4	31.9	17.7	
OF-1	3-5-71	1400	6	6	39.8	35.5	24.7	
OF-1	6-2-71	1405	12	6	74.4	14.1	11.5	1.32

TABLE 4 (Cont'd.)

STATIONS	DATE	TIME	CORE LENGTH (INCHES)	INCHES BELOW INTERFACE	SAND %	SILT %	CLAY %	TOTAL ORGANIC CARBON %
OF-1	6-2-71	1405	12	12	69.0	13.8	16.6	0.75
OF-2	11-27-70	1320	6	6	-	-	52.2	
OF-2	3-5-71	1320	6	6	1.10	42.9	56.0	
OF-2	6-2-71	1215	12	6	0.3	45.7	54.0	2.73
OF-2	6-2-71	1215	12	12	0.3	36.2	63.5	2.74
HB-1	11-27-70	1415	6	6	37.0	41.2	21.8	
HB-1	3-5-71	1500	6	6	65.5	13.1	21.4	
HB-1	6-2-71	1500	6	6	1.0	41.9	56.4	6.35
HB-2	11-27-70	1530	6	6	26.3	36.4	36.8	
HB-2	3-5-71	1530	6	6	1.9	33.4	64.6	
HB-2	6-2-71	1700	12	6	8.0	30.0	62.0	3.18
HB-2	6-2-71	1700	12	12	59.0	16.3	24.7	1.81
DB-1	11-27-70	1610	6	6	23.4	35.2	41.4	
DB-1	3-5-71	1545	6	6	10.5	50.6	48.9	
DB-1	6-2-71	1750	12	6	50.4	26.3	23.3	1.65
DB-1	6-2-71	1750	12	12	11.6	43.4	45.0	1.58
BB-1	11-27-70	1700	6	6	4.1	30.9	65.0	
BB-1	6-5-71	1200	12	6	6.0	26.4	67.6	1.95
BB-1	6-5-71	1200	12	12	0.3	24.0	75.7	0.47
WR-1	11-29-70	1700	6	6	-	-	50.7	
WR-1	6-6-71	1400	36	6	-	-	30.0	
WR-1	6-29-71	1130	12	6	20.4	-	-	5.00
WR-1	6-6-71	1400	36	12	-	-	22.8	
WR-1	6-29-71	1130	12	12	42.0	-	-	2.83
WR-2	11-29-70	1645	6	6	11.2	47.1	41.7	
WR-2	6-6-71	1445	36	6	-	-	56.6	
WR-2	6-29-71	1040	36	6	7.6	-	-	2.42
WR-2	6-6-71	1445	36	12	-	-	-	
WR-2	6-29-71	1040	36	12	28.8	-	-	1.53
WR-2	6-6-71	1445	36	24	-	-	20.2	
WR-2	6-29-71	1040	36	24	58.0	-	-	1.65
WR-2	6-6-71	1445	36	36	-	-	13.2	
WR-2	6-29-71	1040	36	36	61.4	-	-	0.73
ERPL-1	11-25-70	1200	6	6	-	-	16.6	
ERPL-1	6-8-71	1600	12	6	-	-	12.2	
ERPL-1	6-26-71	1420	6	6	81.8	-	-	0.74
ERPL-2	11-25-70	1100	6	6	20.6	54.7	24.7	
ERPL-2	6-8-71	1645	6	6	-	-	16.2	
ERPL-2	6-26-71	1526	24	6	55.6	-	-	0.60
ERPL-2	6-26-71	1526	24	12	24.0	46.4	29.6	0.55
ERPL-2	6-26-71	1526	24	24	41.6	-	-	0.46
ERPL-3	9-2-70	1730	6	6	-	-	-	
ERPL-3	11-25-70	0930	6	6	41.0	38.3	20.7	
ERPL-3	6-8-71	1825	12	6	-	-	30.7	
ERPL-3	6-26-71	1650	24	6	25.2	-	-	4.98

TABLE 4 (Cont'd.)

STATIONS	DATE	TIME	CORE LENGTH (INCHES)	INCHES BELOW INTERFACE	SAND %	SILT %	CLAY %	TOTAL ORGANIC CARBON %
ERPL-3	6-8-71	1825	12	12	-	-	37.6	
ERPL-3	6-26-71	1650	24	12	24.0	-	-	4.59
ERPL-3	6-26-71	1650	24	24	7.2	-	-	2.69
MPRL-1	9-3-70	1415	6	6	-	-	-	
MPRL-1	11-25-70	1330	6	6	-	-	45.3	
MPRL-1	6-9-70	1535	18	6	-	-	57.8	
MPRL-1	6-25-70	1540	36	6	3.6	-	-	2.22
MPRL-1	6-25-71	1540	36	12	9.2	-	-	2.24
MPRL-1	6-9-71	15[illegible]5	18	18	-	-	-	
MPRL-1	6-25-71	1540	36	24	5.6	-	-	2.05
MPRL-1	6-25-71	1540	36	36	11.2	-	-	0.39
WPRL-1	9-3-70	1150	6	6	-	-	-	
WRPL-1	11-25-70	1400	6	6	15.2	41.5	43.3	
WPRL-1	6-9-71	1745	12	6	-	-	20.8	
WPRL-1	6-25-71	1650	24	6	9.6	-	-	1.87
WPRL-1	6-9-71	1745	12	12	-	-	25.4	
WPRL-1	6-25-71	1650	24	12	9.6	-	-	1.48
WPRL-1	6-25-71	1650	24	24	-	-	-	1.30
WPRL-2	9-3-70	1330	6	6	-	-	-	
WPRL-2	11-25-70	1515	6	6	-	-	53.7	
WPRL-2	6-9-71	1350	24	6	-	-	14.3	
WPRL-2	6-25-71	1350	24	6	14.8	-	-	0.15
WPRL-2	6-9-71	1350	24	12	-	-	30.6	
WPRL-2	6-25-71	1350	24	12	10.0	-	-	2.03
WPRL-2	6-9-71	1350	24	24	-	-	42.0	
WPRL-2	6-25-71	1350	24	24	5.8	-	-	0.8

RESULTS AND DISCUSSION

Sediments

In the cores collected during this study, the sediments are heterogeneous, ranging from sandy (84%) to clayey (76%) (cf. Table 4). There was some sampling bias toward clay-rich sediments, as these are the ones with the highest cation-exchange capacity and in which the greatest reactivity with interstitial water would be expected. Total organic contents are also variable. However, except for one anomolously high sample (EP-3), which is located just downstream from a municipal garbage dump, they vary only between 0.15 and 6.35 percent.

There is a significant clay mineral facies change across the study area. Table 5 below shows the mean clay mineral ratios in the Pascagoula River-Graveline Bayou cores, the Old Fort-Davis-Heron Bayou cores, and the Pearl River cores.

TABLE 5

Mean Clay Mineral Ratios

Clay Mineral	Pearl River	Davis-Heron-Old Fort Bayou	Pascagoula River Graveline Bayou
Smectite	47	40	25
Kaolinite	41	50	66
Illite (mica)	12	10	9

The higher smectite content of the Pearl River sediments would give them theoretically higher exchange capacity than the more kaolinitic Pascagoula River sediments. Indeed, most of the major cation/chlorinity ratios do deviate more from sea water values in the Pearl River than in the other estuaries, as will be seen in the discussion of these ions.

pH

Table 1 and Figures 13 and 14 show that pH values generally increase from surface to bottom water, due to wedging of alkaline sea water under the more acid river water. Below the sediment-water interface, the pH decreases sharply in most cores. This decrease in pH below the sediment water interface is typical of estuarine and marine environments. Similar results were reported by Brooks, Presley, and Kaplan (1968) off the coast of Southern California, by Friedman and Gavish (1970) in several Long Island Sound environments, and by Siever, Beck and Berner (1965) in cores from six different areas of the Atlantic and Pacific Oceans. There are numerous other examples in the literature.

The decrease in pH is accompanied by a decrease in redox potential (Eh), a decrease in SO_4 and an increase in H_2S and hydrotroilite ($FeS \cdot nH_2O$). Reduction of sulfate has often been proposed as the chief mechanism of pH-lowering in marine and estuarine environments (Friedman and Gavish, (1970). Sulfate reductase enzymes were identified in several cores collected for this study (Guilbault, G. G., 1972, personal communication), additional evidence for the importance of sulfate reduction on the sediment pH.

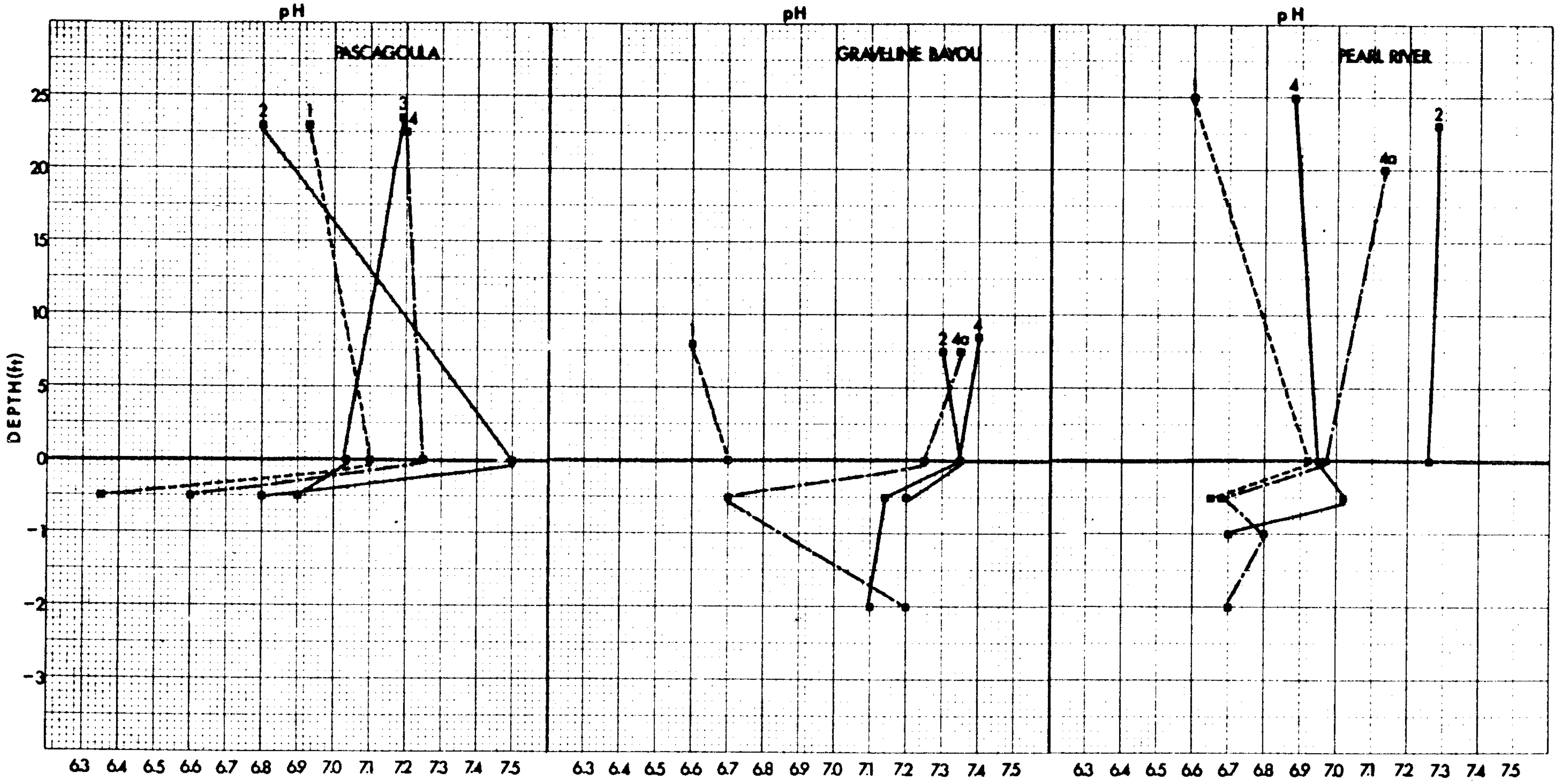

Figure 13. Mean pH of Surface Water, Bottom Water, and Interstitial Sediment Water in the Pascagoula River, Graveline Bayou, and Pearl River. Dashed Horizontal Line Represents the Water-Sediment Interface. Numbers 1-4a Refer to Different Dates of Measurement (see text).

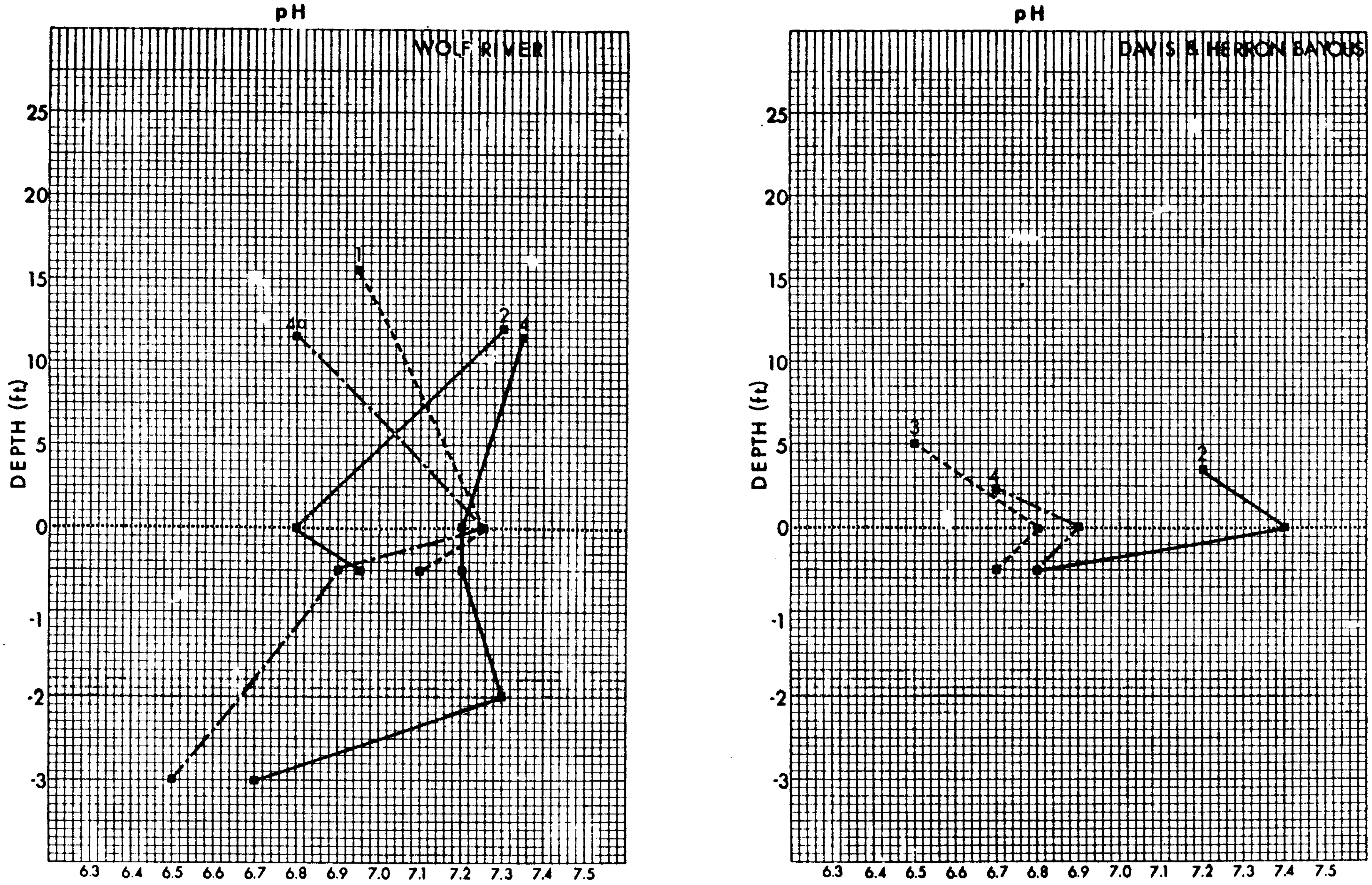

Figure 14. Mean pH of Surface Water, Bottom Water, and Interstitial Sediment Water in the Wolf River and Davis-Heron Bayous. Dashed Horizontal Line Represents the Water-Sediment Interface. Numbers 1-4a Refer to Different Dates of Measurement (see text).

Eh

Above the water-sediment interface Eh values are usually, but not always, positive. Below the water-sediment interface, there is a sharp decrease in Eh in all of the cores, and most are strongly reducing, with some Eh values as low as -420mv (Table 1). The low Eh conditions are accompanied by lowering of dissolved oxygen content (to near zero below the water-sediment interface) and the reduction of sulfate to sulfides, as discussed in the pH section above. Similar reducing conditions in estuarine and marine sediments are widely reported in the literature, for example Brooks, Presley, and Kaplan (1968), and Friedman and Gavish (1970). The Eh values in this study are lower than most reported from the east and west coasts, probably due to the warmer climate and greater bacterial activity in these sediments. This thesis is supported by similarly low Eh readings reported in Barataria Bay sediments by Valentine and McCleskey (1956).

Chlorinity

Although there is considerable seasonal variation in the chlorinity of the estuaries studied, the bottom water is nearly always more saline than the surface water. Chlorinity profiles run at several times of the year indicate that all of the estuaries in this study, with the exception of Graveline Bayou, are Schubel and Pritchard's (1972) Type B estuaries. Type B estuaries are river-dominated (as opposed to tide-dominated) and are partially mixed vertically. Graveline Bayou, which has proportionally less fresh water inflow, is a vertically homogeneous Type C estuary during most of the year.

Below the water-sediment interface, chlorinities always change, but may be either higher or lower than the bottom water chlorinity. Time is needed for water to diffuse through the sediments. Therefore, the interstitial water chlorinity may represent a seasonal average. Interstitial water chlorinities do change, however, from season-to-season as the chlorinity profiles (Figures 15 and 16) clearly show. Rate of chlorinity change in interstitial water is probably a function of sediment permeability as well as ground water migration. Complete chlorinity data for the study is given in Table 1.

Nitrate and Nitrite

Because of its intimate relationship with various biological cycles, the nitrogen content of rivers, estuaries, and the ocean is highly variable. Nitrogen exists in several forms, as NH_4^+, NO_2^-, NO_3^-, in organic compounds, and as free N_2, according to Horne (1969). Nitrate and Nitrite were both analyzed in the surface and bottom water of the estuaries in this study. Although few interstitial water samples were large enough for NO_3 - NO_2 analysis, the ones that were analyzed showed a marked decrease from the bottom water, which is compatible with Richards (1965) three important chemical features of an anoxic (reducing) environment:

1. Concurrent with the disappearance of oxygen, denitrification and disappearance of NO_2^- and NO_3^-.
2. Reduction of sulfate ions and production of H_2S.
3. Lowering of the redox potential (Eh) with, consequently, reduced removal of organic materials.

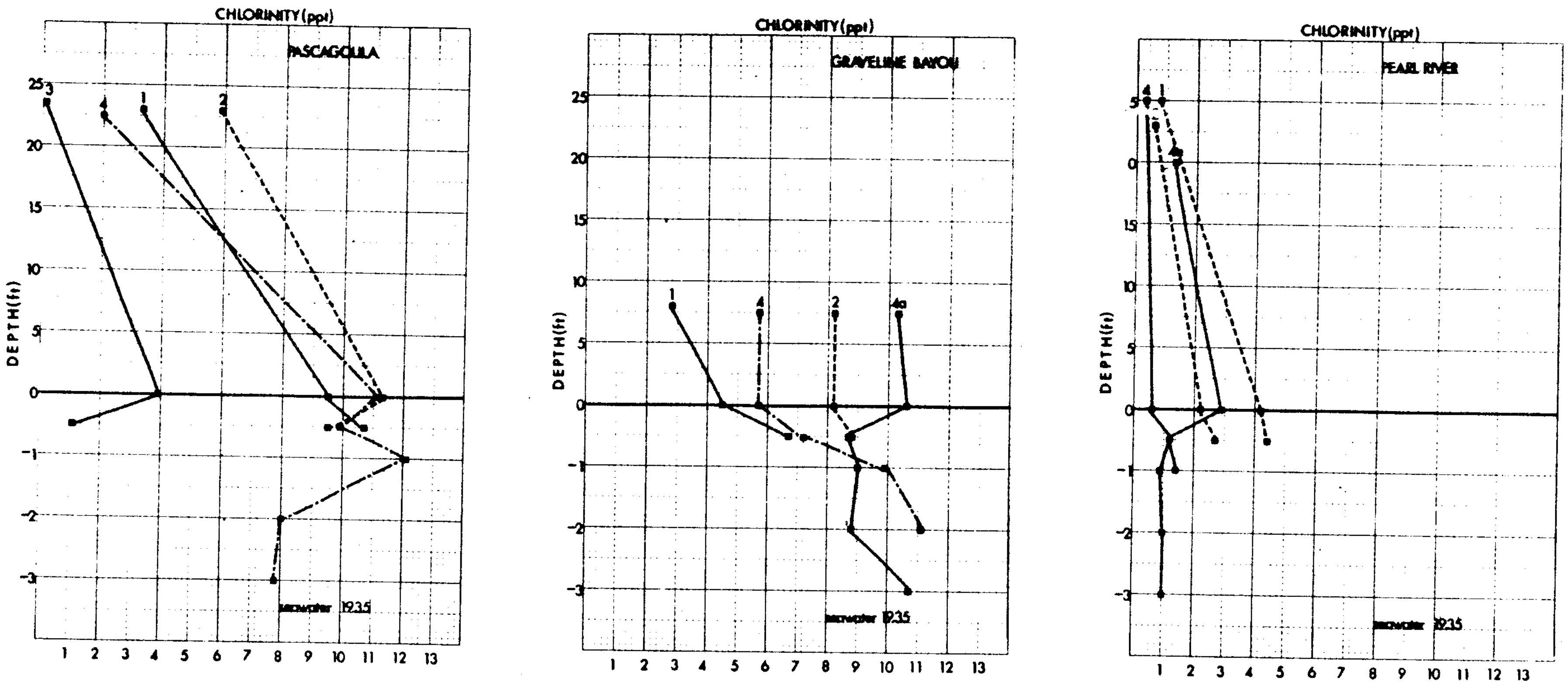

Figure 15. Mean Chlorinity (parts per thousand) of Surface Water, Bottom Water, and Interstitial Sediment Water in the Pascagoula River, Graveline Bayou, and Pearl River. Dashed Horizontal Line Represents the Water-Sediment Interface. Numbers 1-4a Refer to Different Dates of Measurement (see text).

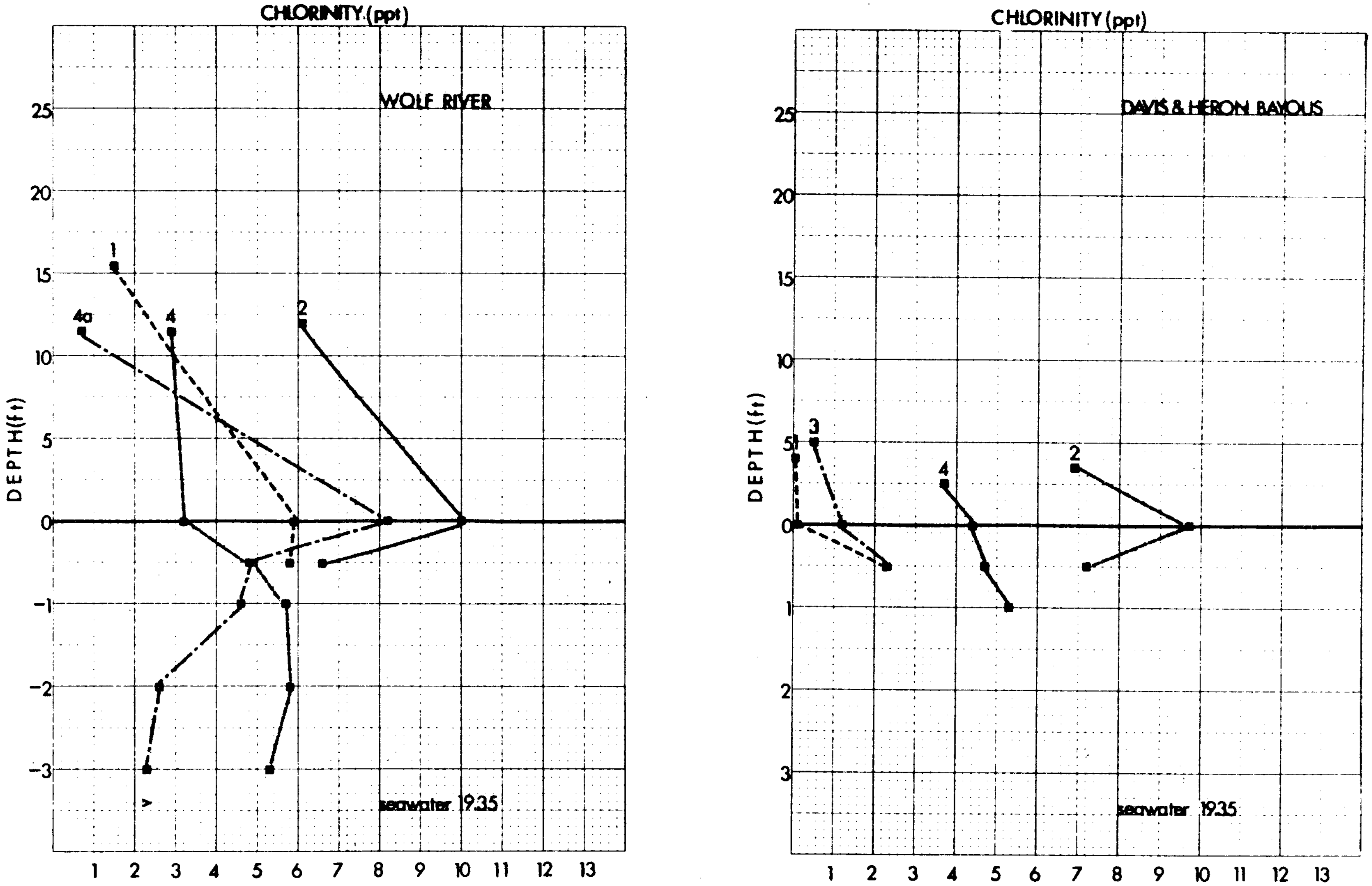

Figure 16. Mean Chlorinity (parts per thousand) of Surface Water, Bottom Water, and Interstitial Sediment Water in the Wolf River and Davis-Heron Bayous. Dashed Horizontal Line Represents the Water-Sediment Interface. Numbers 1-4a Refer to Different Dates of Measurement (see text).

Complete data is presented in Table 2. NO_2 values are not listed because they were consistently very low compared to NO_3, and always paralleled to NO_3 concentrations. A more instructive way of looking at the NO_3 data is in the graphs of NO_3/Cl ratios (Figures 17 and 18). This technique removes the sea water "background" and permits identification of ions from other sources. As the NO_3 ion is one of the primary pollution-indicator ions, it is especially important to identify its source. NO_3/Cl ratios are very low in Graveline Bayou, Davis-Heron, and and Fort Bayous and the Wolf River. These are the smaller estuaries, where there is less industrialization and urbanization. Both the Pearl and Pascagoula Rivers had much higher NO_3/Cl levels, although the Pascagoula readings were unusually high only during the March, 1971 measurement period. The salinity was unusually low then due to greater fresh water runoff (Table 1). The Pearl River estuary, which receives a considerably higher fresh water discharge than the other estuaries in this study, had consistently high NO_3/Cl readings. The average NO_3 concentrations of the Pearl River stations in this study were, in fact, very close to the published average NO_3 concentrations of the Mississippi River-- 1.54 ppm (Horne, 1969).

The major source of NO_3 in both the Pearl and Pascagoula estuaries is the fresh water runoff component, as shown by the inverse relationship between NO_3/Cl ratios and salinity. There are two probable sources of excess nitrates in the Pearl and Pascagoula rivers: (1) use of nitrate fertilizers within the drainage basin and (2) raw and treated sewage from cities and towns upstream. The Pearl River is known to receive large quantities of municipal sewage from Jackson, Mississippi and Bogalusa, Louisiana, as well as from smaller communities along its course. The Pascagoula River receives less municipal sewage, but effluents from the Moss Point City garbage dump, a Menhaden (fish) processing plant, and a large Kraft paper mill all enter the Escatawpa River, a tributary to the Pascagoula, near station EP-3 (Figure 2), where the highest nitrate concentration (6.6 ppm) of the project was recorded.

Although NO_3 - NO_2 levels are not extremely high in any of the estuaries studied, the NO_3/Cl ratios are up to 100 times higher in the Pearl and Pascagoula Rivers than the regional background, apparently due entirely to human activity. The association of nitrates with sewage pollution, and the discovery that infants are particularly sensitive to NO_3 - NO_2 poisoning (Federal Water Pollution Control Administration 1968) warrants a close watch be kept on nitrate levels in all rivers, and sources of extra nitrates be identified, and, if possible, eliminated.

Sulfate

Mean SO_4/Cl ratios range from slightly lower to more than seven times higher than the Copenhagen standard sea water value of 0.14. As in the case of nitrates, most of the anomalously high values were found in the two largest estuaries, the Pearl and Pascagoula Rivers. However, most of the high SO_4/Cl readings were from the bottom water only, during times of low salinity and high fresh water runoff. In contrast, the high nitrate concentrations were found throughout the water column. The concentration of sulfates in the bottom water indicates that, during periods of high runoff, there is stirring of bottom sediments and the oxidation of sulfides. The low chlorinities at these times allow even a small increase in SO_4 to affect the SO_4/Cl ratios (Table 1, Figures 19 and 20).

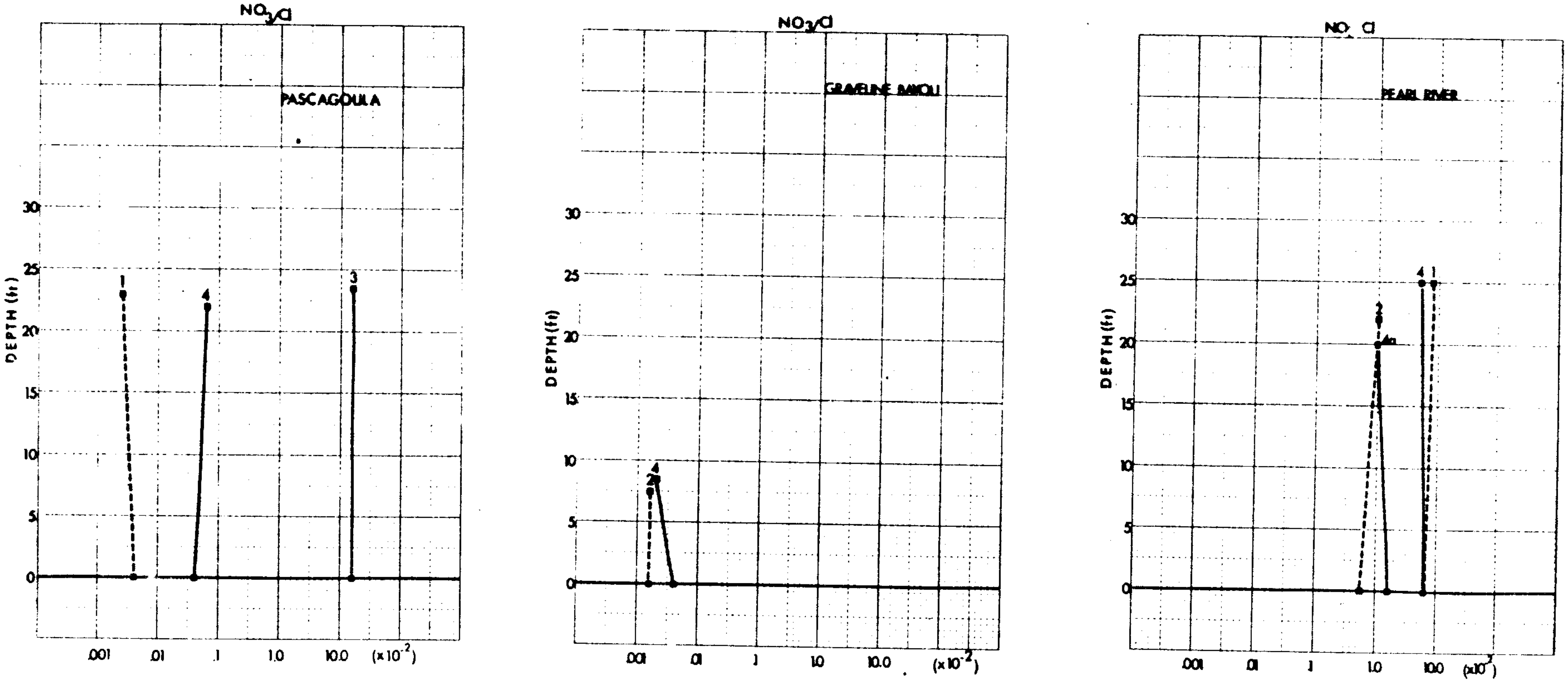

Figure 17. Mean NO_3/Cl Ratios of Surface Water and Bottom Water in the Pascagoula River, Graveline Bayou, and Pearl River. Heavy Horizontal Line Represents the Water-Sediment Interface. Numbers 1-4a Refer to Different Dates of Measurement (see text).

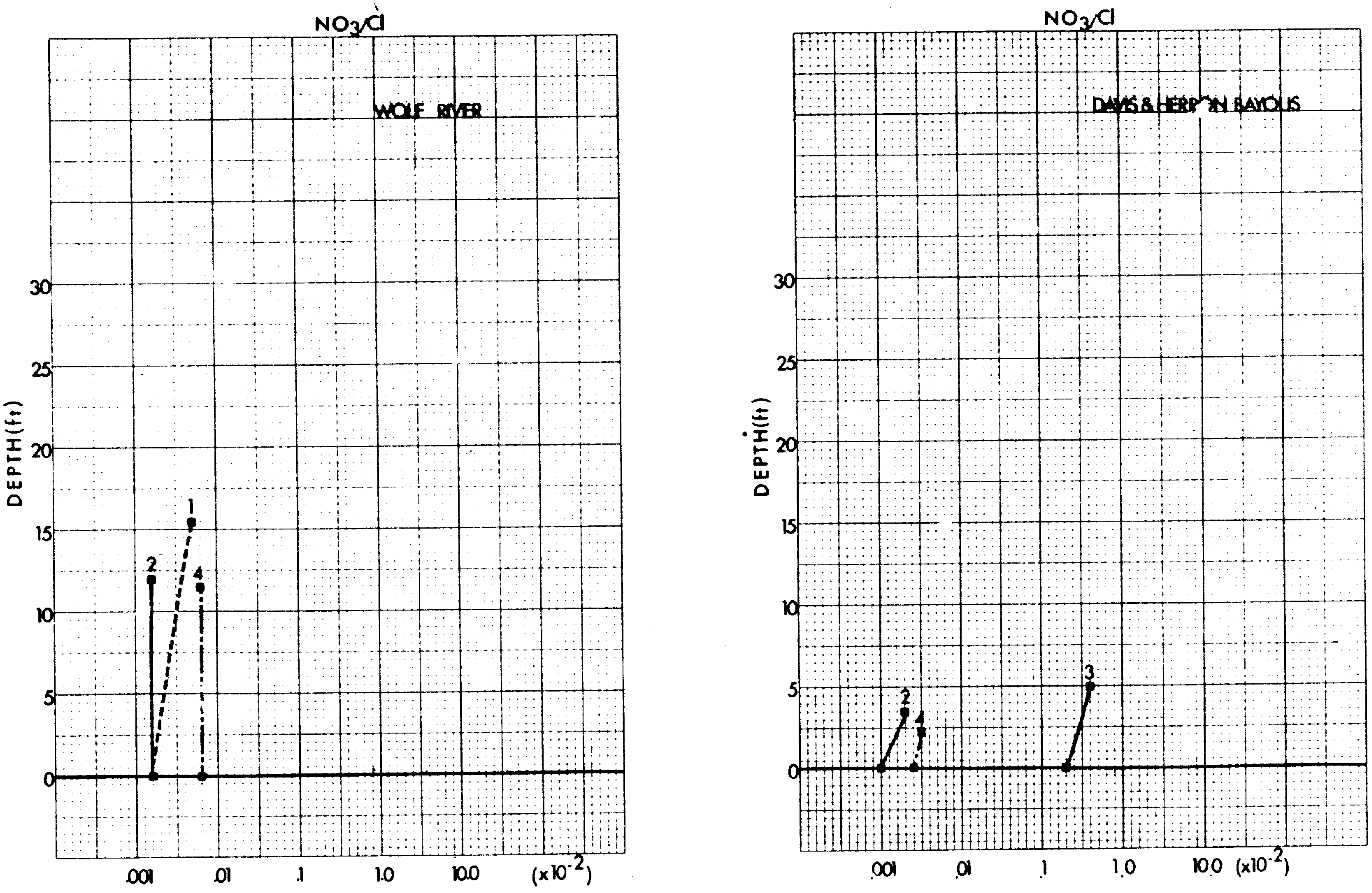

Figure 18. Mean NO$_3$/Cl Ratios of Surface Water and Bottom Water in the Wolf River and Davis-Heron Bayous. Heavy Horizontal Line Represents the Water-Sediment Interface. Numbers 1-4a Refer to Different Dates of Measurement (see text).

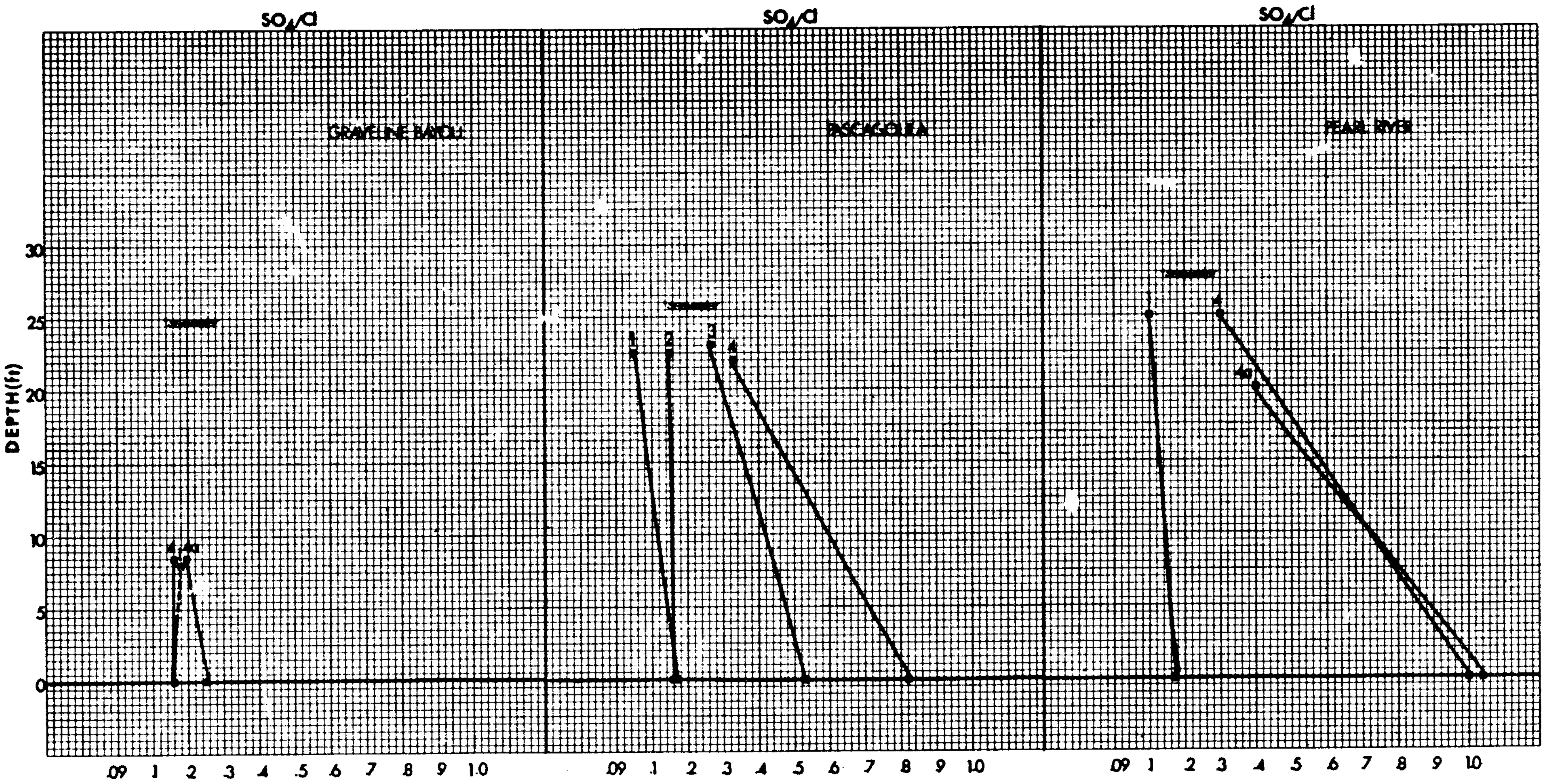

Figure 19. Mean SO_4/Cl Ratios of Surface Water and Bottom Water in the Pascagoula River, Graveline Bayou, and Pearl River. Heavy Horizontal Line Represents the Water-Sediment Interface. Numbers 1-4a Refer to Different Dates of Measurement (see text).

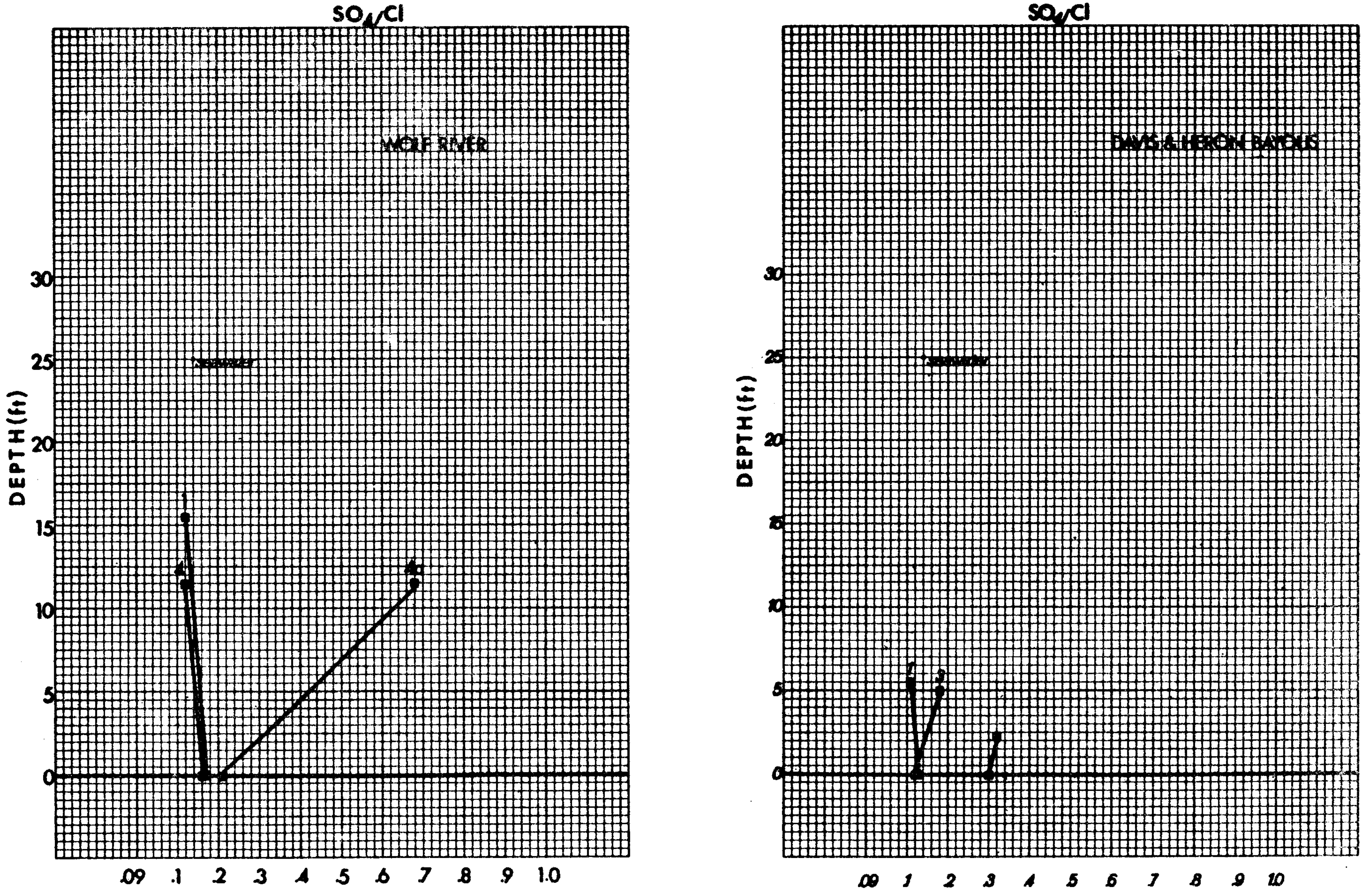

Figure 20. Mean SO_4/Cl Ratios of Surface Water and Bottom Water in the Wolf River and Davis-Heron Bayous. Heavy Horizontal Line Represents the Water-Sediment Interface. Numbers 1-4a Refer to Different Dates of Measurement (see text).

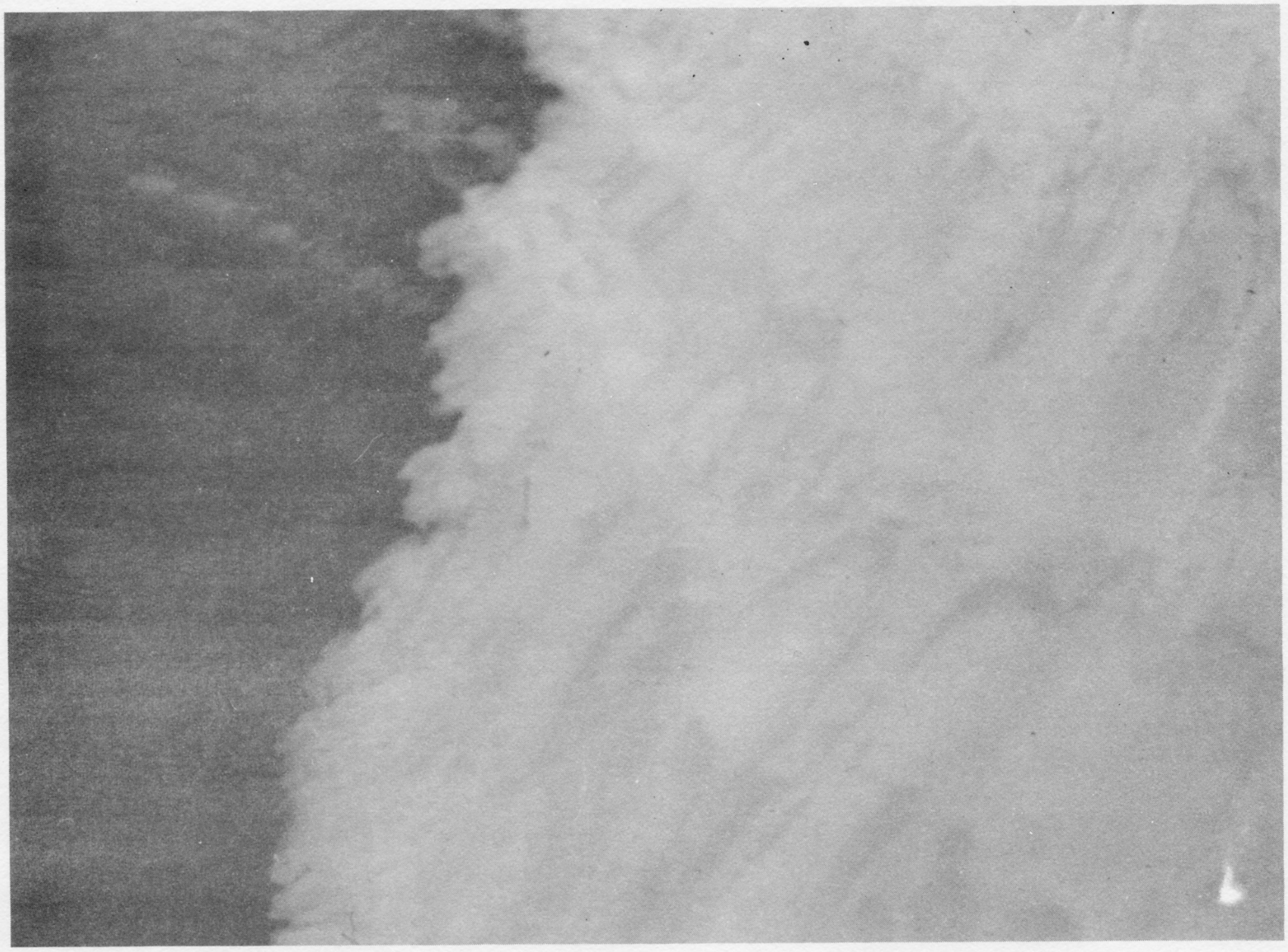

Figure 21. Treated Effluent From International Paper Company's Moss Point Plant Entering the Escatawpa River, Near Station EP-3. Clearer Normal River Water is on Left; Turbid Effluent on Right.

Kraft paper mill effluents are pumped into both the Pearl and Pascagoula Rivers (at Bougalusa, Louisiana and Moss Point, Mississippi). These effluents, which contain sulfites and various organic compounds, do not measurably affect sulfate concentrations in the rivers. Although these treated effluents add measurable color and odor to the water (Figure 21), there is no evidence from this study that they affect the inorganic chemistry of the water significantly.

Below the sediment-water interface, there is a marked decrease in $SO_4^=$ concentration, which is reflected by an increase in H_2S and precipitated sulfides, especially hydrotroilite ($FeS \cdot nH_2O$).

According to Horne (1969) sulfate reduction begins after the dissolved oxygen level has fallen below 0.11 ml/l and all the NO_3^- and NO_2^- has been consumed. The reaction below is considered typical:

$$(CH_2O)_{106}(NH_3)_{16}H_3PO_4 + 53SO_4^{-2} \rightarrow 106CO_2 + 53S^{-2} + 16NH_3 + 106H_2O + H_3PO_4$$

with consequent production of H_2S and NH_3. In a study of O^{18} in SO_4^{-2}, Lloyd (1967) found the O^{18} is <u>not</u> in equilibrium with sea water, leading to the conclusion that the sulfur cycle in the sea must be so rapid that equilibrium is not established. At least two sulfate reductase enzymes were isolated from a sediment core taken at station EP-3, indicating the bacterial mechanism for sulfate reduction.

The variability of the sulfate ion, compared to the other major ions in Mississippi Sound has been demonstrated in previous studies (Snowden, 1961; Moore and Snowden, 1967). The mechanism for this variability is thought to be (1) bacterial (enzyme) reduction of SO_4^{-2} to S^{-2} below the water-sediment interface, and occasionally in the lower water column, and (2) reoxidation of S^{-2} to SO_4^{-2} when the sediment is stirred by oxygenated waters, during storms and periods of increased fresh water runoff.

Calcium

Whole estuary averages for Ca/Cl ratios for the Phase IV collecting period (June 1971) were calculated and graphed against depth, as shown in Figure 22. Complete calcium analyses are listed in Table 3. Mean Ca/Cl ratios were close to Copenhagen sea water values, except for the surface water in Pearl River, which was significantly higher, and the bottom water in Davis-Heron Bayou, which was significantly lower. During this phase, the surface water in Pearl River was very low salinity, thus, the Ca/Cl ratio is closer to the fresh water value than the sea water value.

The lowering of the Ca/Cl ratio in the bottom water in Davis-Heron Bayou, and in the upper interstitial sediment water in the Pearl and Pascagoula River cores is probably related to the initial reduction of sulfates. Presley and Kaplan (1968) noted this phenomenon in cores off the Southern California coast, and showed that the reduction of sulfate produces HCO_3^- ions (see reaction under the sulfate discussion above) which equilibrate $CaCO_3$. This relationship derived from the best fit plot of Presley and Kaplan's (1968) data is:

$$^{m}Ca^{+2} = 3.6 + 1.25\,^{m}SO_4$$

Virtually all studies of clay minerals in sea water (Powers, 1957; Potts, 1959; Carroll and Starkey, 1960) have shown that calcium-rich fresh water clays tend to lose exchangeable calcium in favor of sodium, magnesium, and potassium. Field studies by Friedman and Gavish (1970) show Ca/Cl ratio increases in interstitial water from clay-rich sediments from several environments. The increase in the Ca/Cl ratio in the

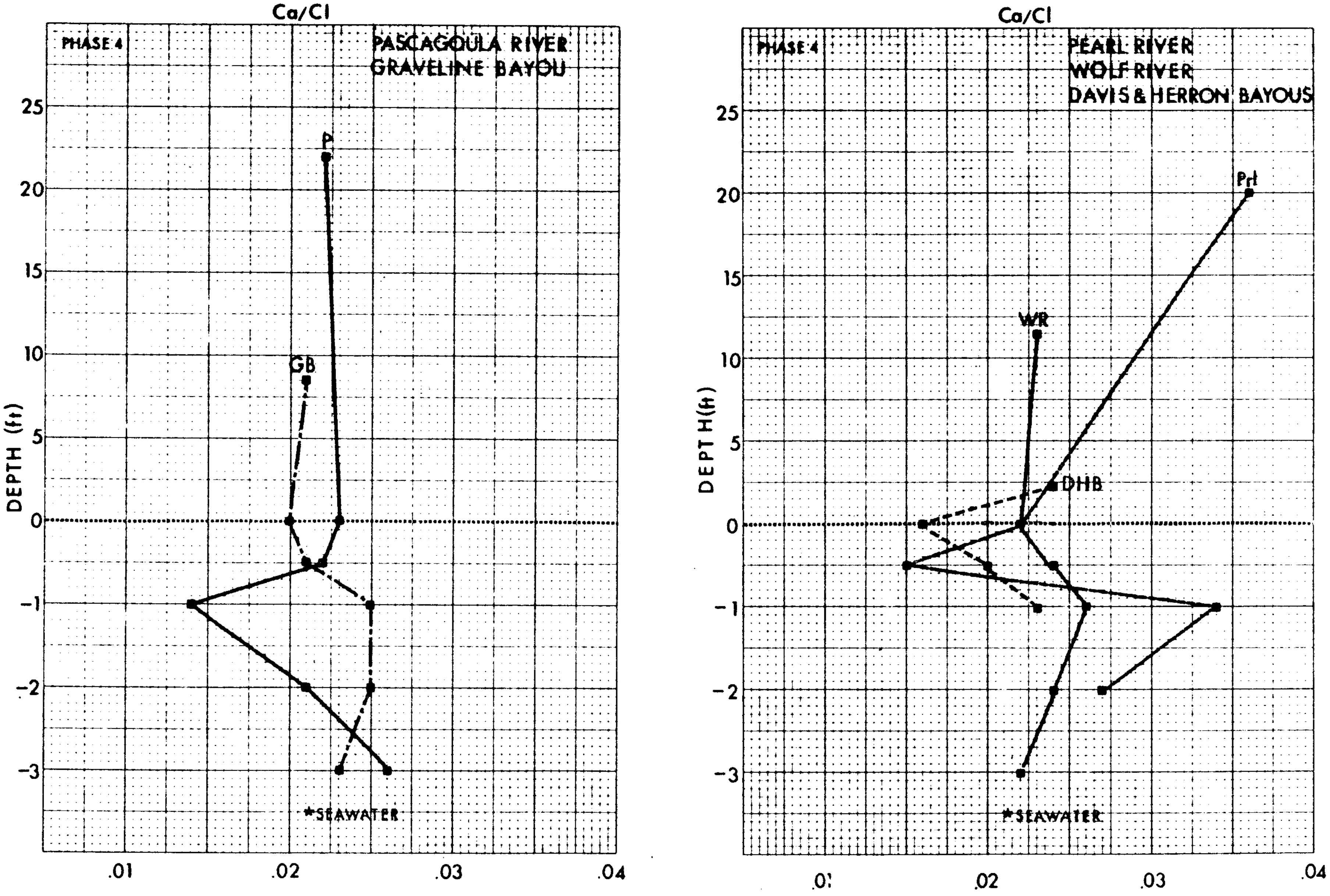

Figure 22. Mean Ca/Cl Ratios of Surface Water, Bottom Water, and Interstitial Sediment Water. Dashed Horizontal Line Represents the Water-Sediment Interface.

Pascagoula and Pearl River interstitial water below the one-foot horizon, and the general increase in Ca/Cl in the other cores is thought to be a reflection of this ion-exchange reaction. The smectite-rich Pearl River interstitial water showed considerably more variability in Ca/Cl, probably due to its higher exchange capacity.

Bischoff, Greer, and Luistro (1970) noted a temperature-of-squeezing effect on calcium concentration, which caused a 4.9% depletion when samples were warmed to room temperature prior to squeezing. Our core samples were squeezed on board the boat immediately following collection at low pressure (25-50 pounds per square inch) at temperatures very close to in situ. Thus, the temperature-of-squeezing effect should be negligible.

Murthy and Ferrell (1972), in a study of dredge samples in Barataria Bay, found that squeezing out interstitial water at 100 pounds per square inch yielded calcium values that were higher than values obtained by water-dilution methods of interstitial water extraction, especially when the samples were refrigerated prior to squeezing. This technique warrants further study on core samples from greater depths.

In any event, there seems to be a need for technique standardization among those studying interstitial water geochemistry and sediment diagenesis resulting from reactions between sediments and interstitial water.

Magnesium

Although some of the mean Mg/Cl ratios from interstitial water were lower than the overlying bottom water, as reported from most other studies (Powers, 1957; Siever, Beck, and Berner, 1965, Brooks, Presley, and Kaplan, 1968, and Friedman and Gavish, 1970), most were not. As Figure 23 shows, most of the interstitial Mg/Cl values are higher than sea water values. In fact, there is a linear relationship between Mg/Cl ratio and chlorinity in the Phase IV samples (Figure 24). This relationship is very similar to that reported by Ferrell and Brooks (1971) from Lake Pontchartrain and Maurepas sediments.

Long term exposure to sea water has been shown to cause absorption of Mg^{+2} by three-layer clays (Potts, 1959; Carroll and Starkey, 1960).

Ion exchange into interlayer positions and into the octahedral layer have both been suggested. Drever (1971) showed a positive correlation between Mg^{+2} depletion and SO_4^{-2} reduction, similar to the Ca^{+2} and SO_4^{-2} relationship discussed previously. However, in the majority of samples analyzed during this study, the mechanism seems to be simple ion exchange, with Mg^{+2} being replaced on clay surfaces and released into the interstitial water. Bischoff, Greer and Luistro's (1970) temperature-of-squeezing effect resulted in an apparent depletion of magnesium, the opposite of our Mg-enriched values.

Ca/Mg ratios are close to sea water values, with the exception of the upper interstitial water from the Pearl and Pascagoula Rivers, which are Ca-depleted, and the deeper interstitial water from Pearl River, which is Mg-depleted (Figure 25).

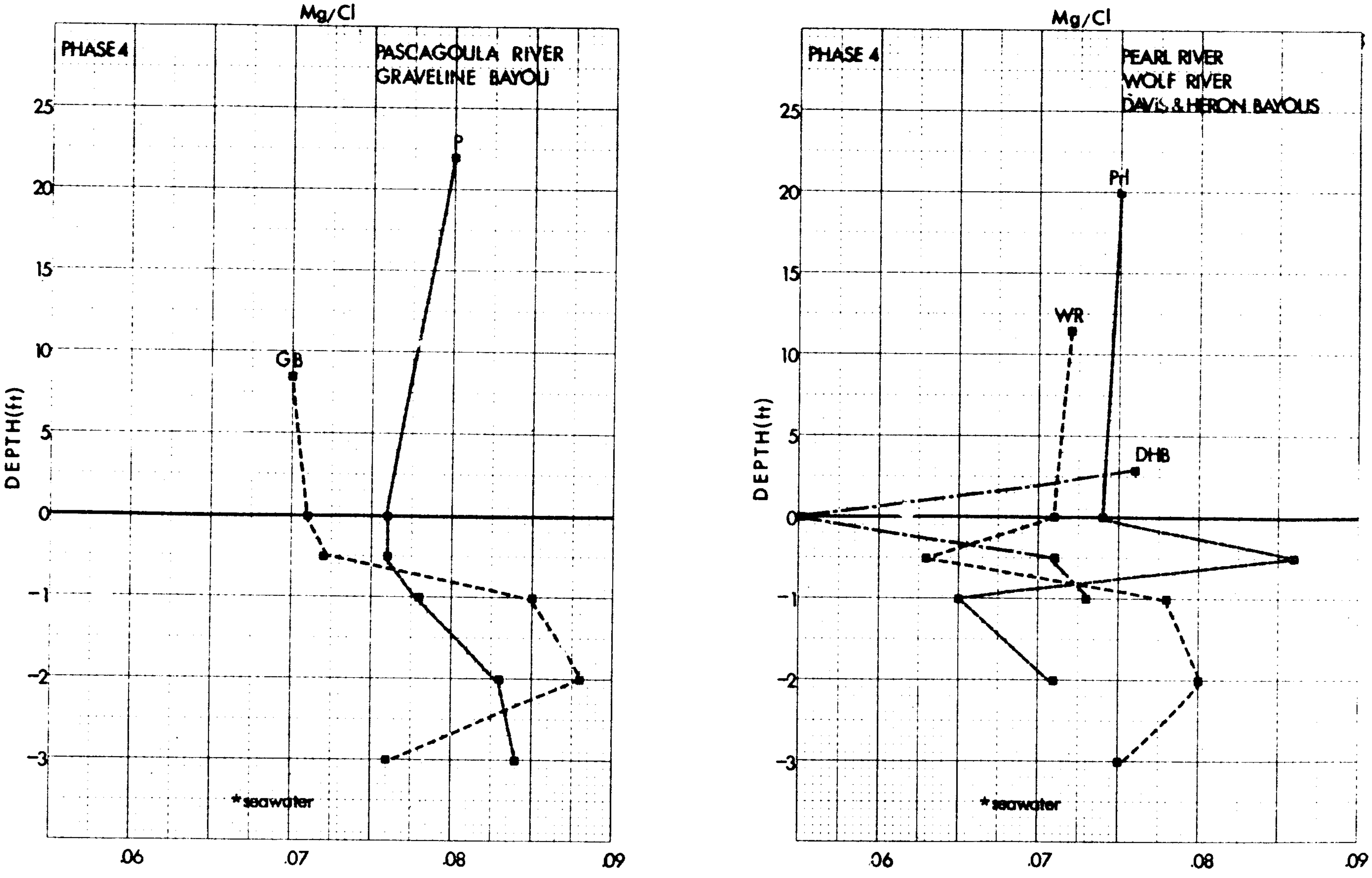

Figure 23. Mean Mg/Cl Ratios of Surface Water, Bottom Water, and Interstitial Sediment Water. Dashed Horizontal Line Represents the Water-Sediment Interface.

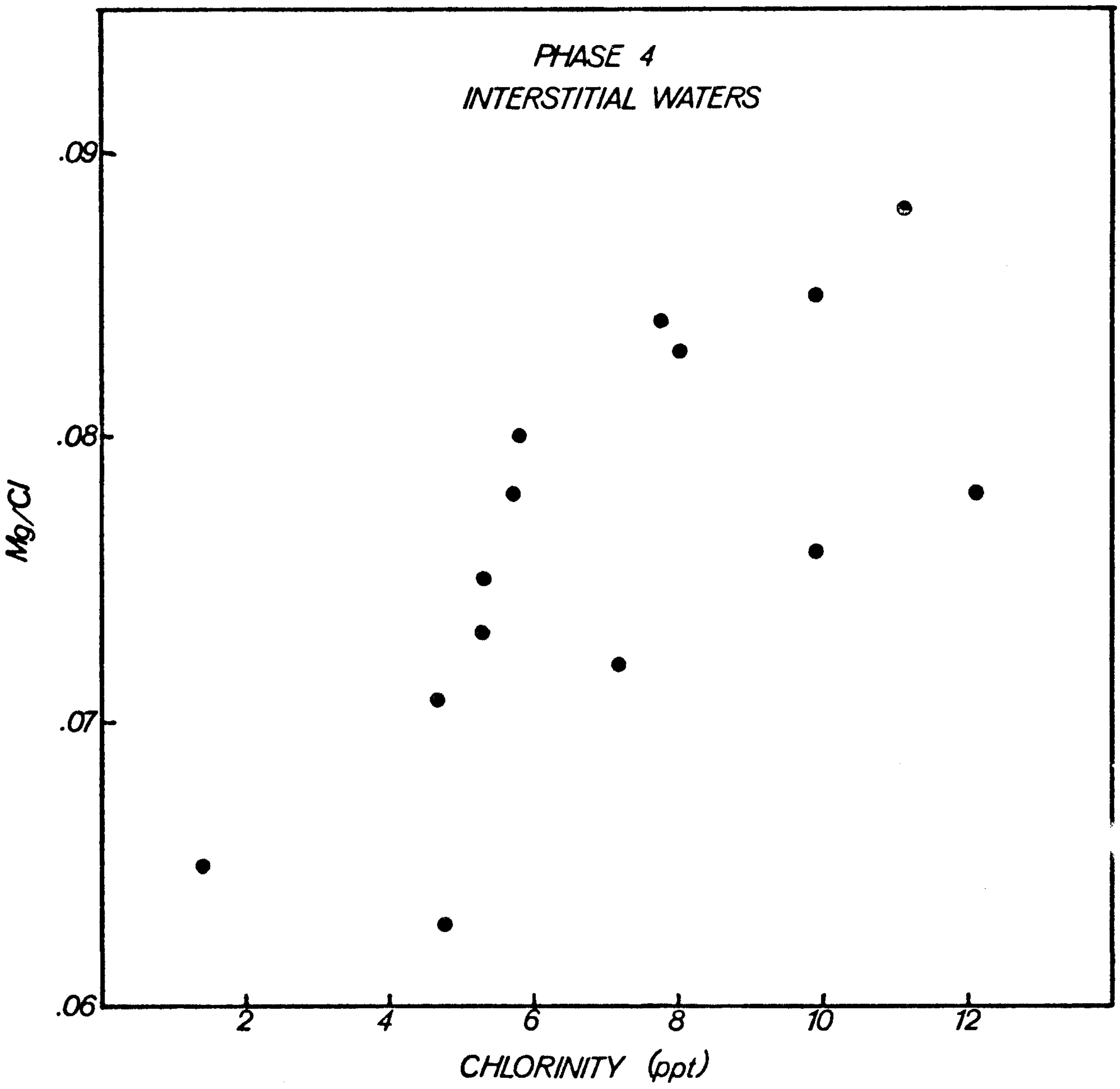

Figure 24. Mean Chlorinity Plotted Against Mean Mg/Cl Ratios For Phase IV Stations.

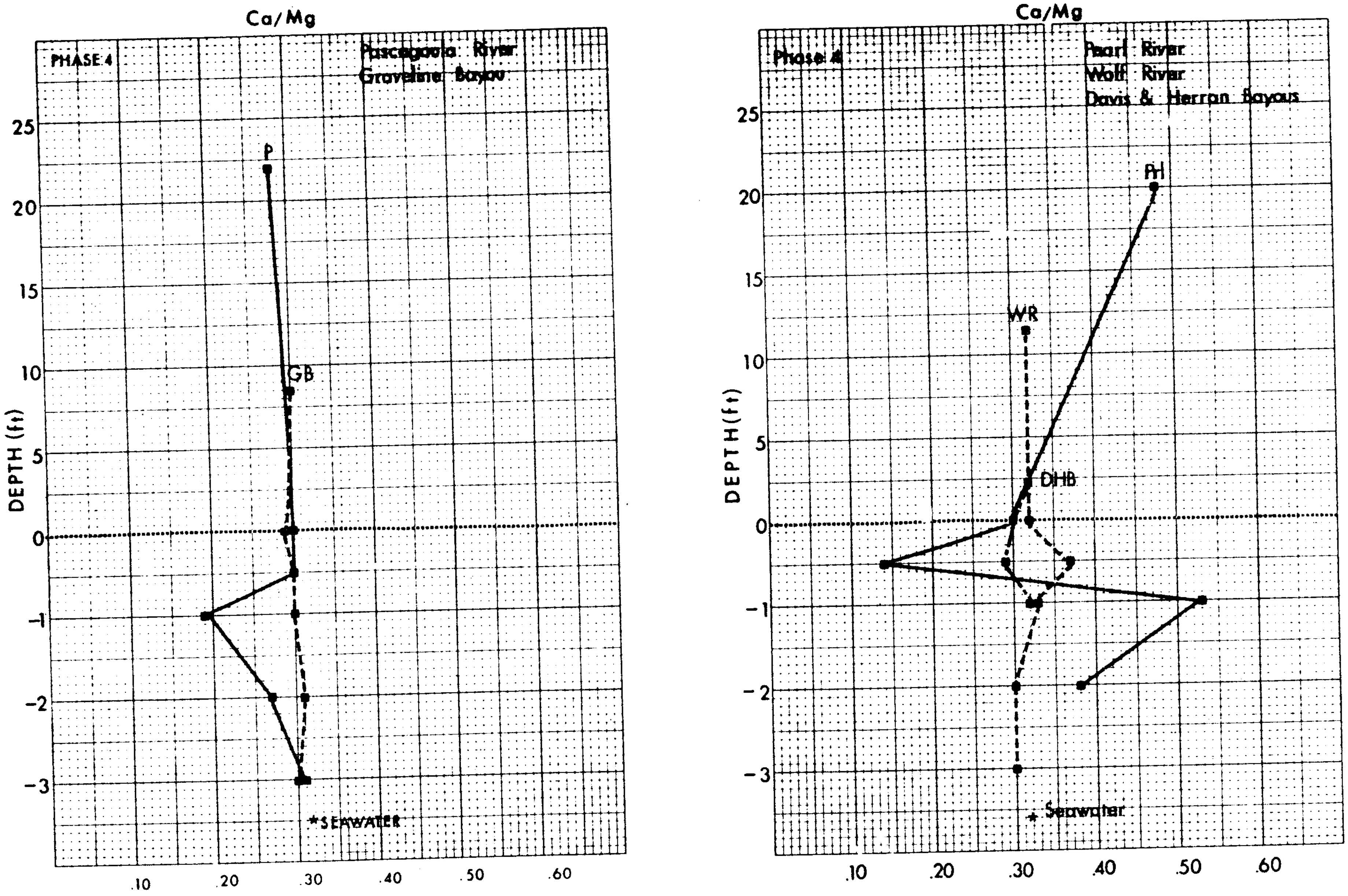

Figure 25. Mean Ca/Mg Ratios of Surface Water, Bottom Water, and Interstitial Sediment Water. Dashed Horizontal Line Represents the Water-Sediment Interface.

Potassium

There is a very slight enrichment of K^+ as compared to the K/Cl values for sea water (Figure 26). The greatest deviation from Copenhagen standard sea water values, however, are found in the surface water from the Wolf River which is 2.5 times more enriched and the bottom water from Davis-Heron Bayous, which is slightly depleted (Figure 26). We know of no reason for K^+ enrichment of Wolf River surface water. Local use of a soluble potassium fertilizer is a possibility, although the nitrate values were not correspondingly high. The K-depletion in Davis-Heron bottom waters is probably due to organic acid complexing.

Sodium

Mean Na/Cl values increased slightly in the interstitial water of all stations tested (Figure 27). This is contrary to findings by Friedman and Gavish (1970) in transitional environments, and the experimental data of Potts (1959) and Carroll and Starkey (1960), in which sodium is absorbed by clay minerals, chiefly in exchange for calcium.

There are at least two possible explanations for this sodium enrichment: (1) at the low salinities of most of these stations, Na^+ is not preferrentially absorbed, as it is at higher salinities, and (2) effect of a pressure artifact, as reported by Murthy and Ferrell (1972), which increases the Na^+ content of interstitial during the squeezing operation. During this project, the squeezing pressures were kept low (under 50 pounds per square inch) so this effect should have been minimized. Also, since our data is being compared chiefly to other squeezed interstitial water values, for example, Friedman and Gavish (1970), the higher Na/Cl values reported here are thought to be significant.

Surface water Na/Cl values from the Wolf River were anomalously low (Figure 27) just as the K/Cl values from this station (Figure 26) were anomalously high.

Strontium

The mean Sr/Cl ratios decreased sharply below the water-sediment interface (Figure 28). This finding closely resembles the strontium depletion profiles reported by Friedman and Gavish (1970), and demonstrates the strongest trend of any ion studied. The only major variations are: (1) the greater strontium depletion in the high-smectite Pearl River cores and (2) an anomalously high Sr/Cl ratio in surface waters of Davis and Heron Bayous. The greater depletion in Pearl River cores is almost certainly due to the higher cation exchange capacity of those sediments, and it indicates that cation exchange with clay minerals is the chief mechanism of strontium depletion. As of now, we have no explanation for the high Sr/Cl ratios of Davis-Heron Bayous' surface water.

The evidence from this and other studies has strong implications concerning the fate of radioactive Sr^{90} in estuaries and in the ocean. Sr^{90} is a particularly troublesome isotope, as it replaces calcium in bone structure and other organic sites. However, it appears that estuarine sediments do have considerable ability to remove strontium ions from the system.

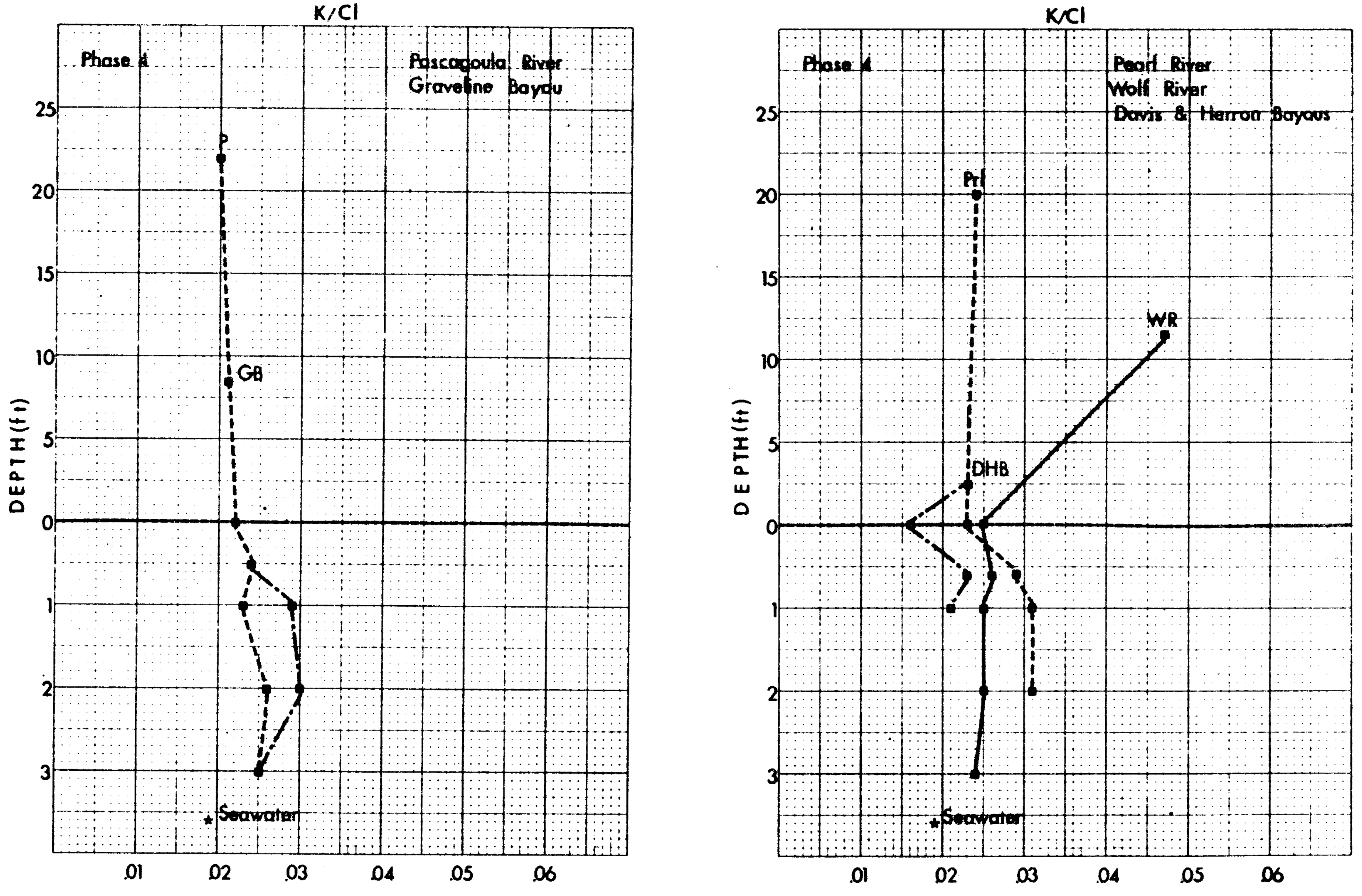

Figure 26. Mean K/Cl Ratios of Surface Water, Bottom Water, and Interstitial Sediment Water. Dashed Horizontal Line Represents the Water-Sediment Interface.

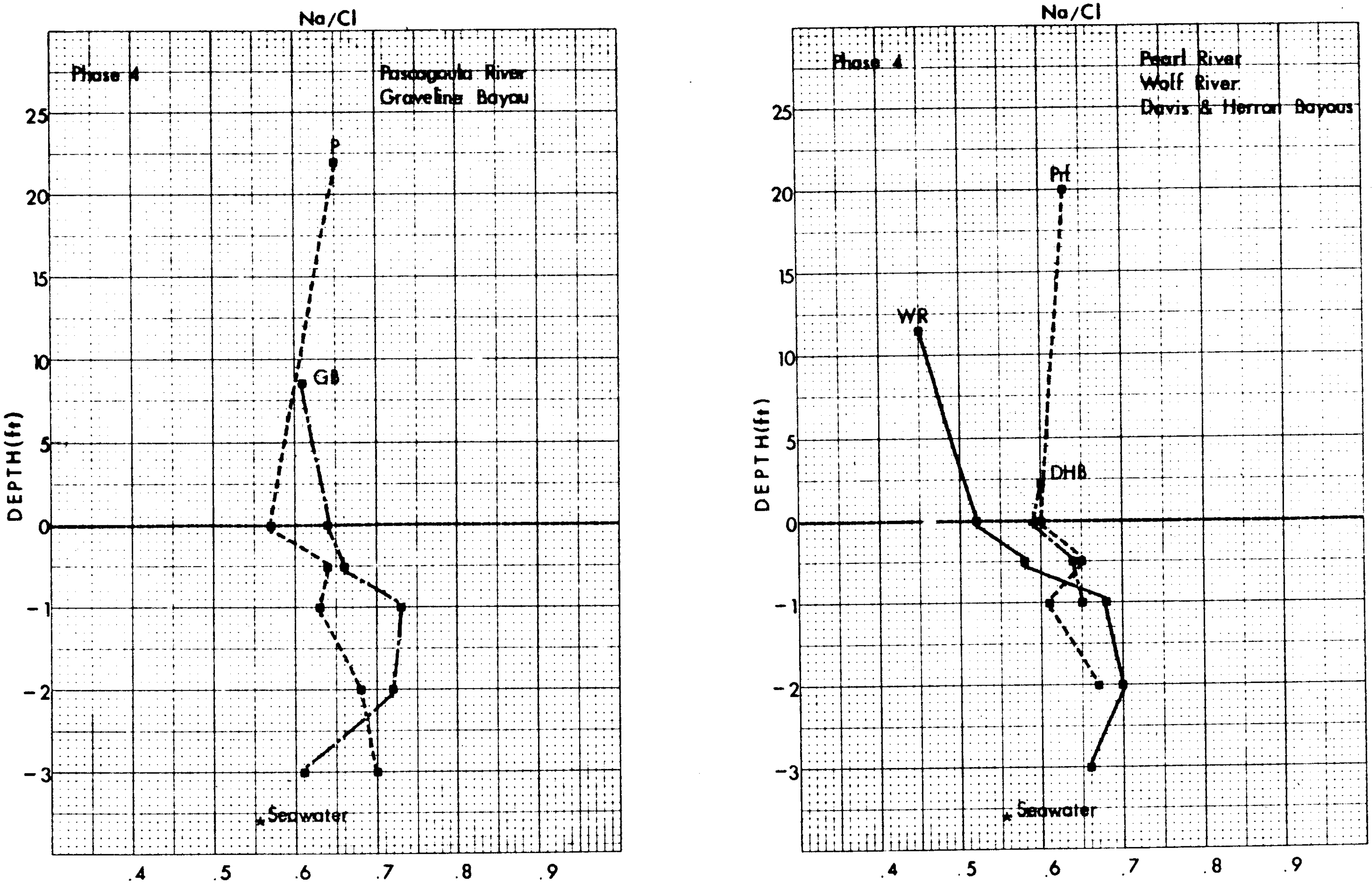

Figure 27. Mean Na/Cl Ratios of Surface Water, Bottom Water, and Interstitial Sediment Water. Dashed Horizontal Line Represents the Water-Sediment Interface.

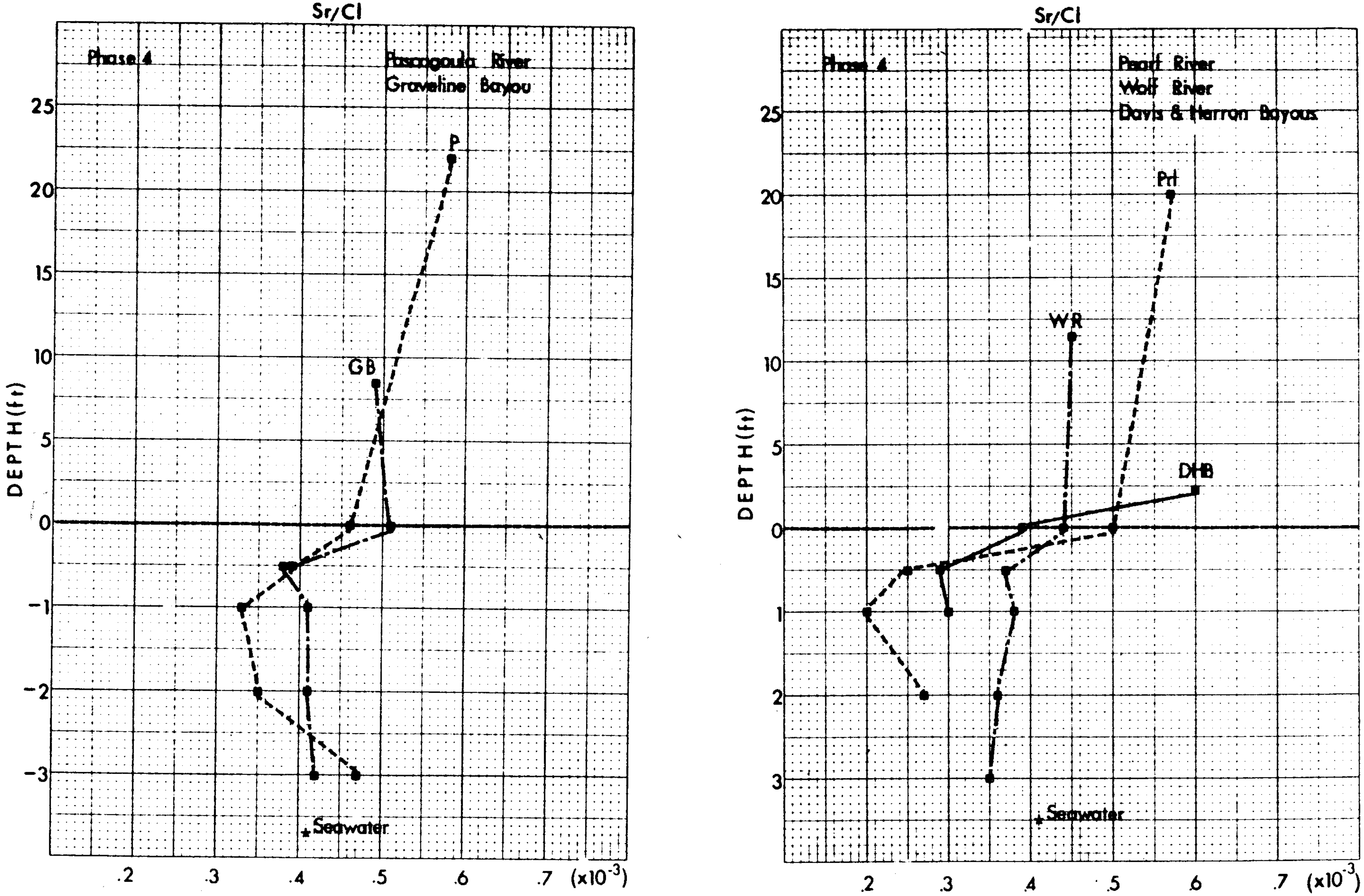

Figure 28. Mean Sr/Cl Ratios of Surface Water, Bottom Water, and Interstitial Sediment Water. Dashed Horizontal Line Represents the Water-Sediment Interface.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

As the result of this study, we have reached the following conclusions:

(1) There is considerable seasonal variability in the major ion concentrations (salinity) in the estuaries studied, which correlates directly with rainfall and runoff patterns.

(2) All of the estuaries studied, with the exception of Graveline Bayou, are fresh water dominated Type B estuaries, using Schubel and Prichard's (1972) classification. Estuaries of this type are characterized by a rather sharp vertical salinity gradient, although there is partial mixing of fresh and saline water. Graveline Bayou during most of the year is a Type C estuary, which is more tidally dominated, and is well-mixed vertically.

(3) The water quality in these estuaries is generally good and dissolved oxygen values are generally normal. However, almost all of the Pearl River stations had nitrate-levels that were higher than regional background, and were, in fact, comparable to Mississippi River values. During times of maximum fresh water runoff, some Pascagoula River stations also recorded higher than regional normal nitrate levels. The source of excess nitrates is invariably the fresh water fraction, rather than the saline water fraction of the estuaries.

(4) The Escatawpa River, a tributary of the Pascagoula, shows all of the chemical effects of severe chronic/organic pollution: (a) unusually high nitrate; (b) very low dissolved oxygen concentrations; (c) reducing (negative Eh) conditions in the water column; (d) strong H_2S odor in the water, and (e) anomalously high organic content in the upper sediment. The chief sources of pollution are believed to be effluents from the Moss Point city dump, and a Menhaden (fish) processing plant. Although a large Kraft paper mill is pouring effluents into the river that disagreeably affect its odor and turbidity, the chemical quality is not very much affected.

(5) Interstitial water ion ratios were different in nearly every case from the overlying water. These chemical changes below the sediment-water interface are caused chiefly by (a) oxidation or reduction of sulfates and nitrates and (b) metal ion exchange between the water and clay minerals. Sometimes there is interaction between these two processes, as in the case of calcium. Some of the ion-exchange reactions, such as magnesium, are affected by differences in concentration of that ion, whereas others, such as strontium, at least within the limits found in these estuaries, were not. Different amounts of exchange were found between the high-smectite Pearl River sediments and the lower smectite eastern sediments, for most of the ions studied.

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(6) The pressure artifact described by Murthy and Ferrell (1972) should be taken into account for future interstitial water studies. The significance of this effect on cores from greater depth also needs to be studied.

RECOMMENDATIONS

We recommend the following:

(1) All sources of nitrates in the Pearl and Pascagoula Rivers be geographically determined and efforts made to reduce them. In addition to being an indicator of other pollution, such as fecal coliform from sewage, nitrates are plant nutrients that could seriously affect the ecology of the estuaries.

(2) Local, Regional, and National Authorities should make every effort to stop pollution of the Escatawpa River. Proper waste treatment by the industries and municipalities along this relatively short segment of river (see Figure 2) should be easy to implement and monitor. International Paper Company has indicated that they plan additional effluent treatment for their Escatawpa River plant in the near future.

(3) Real Estate and industrial development along all estuaries be carefully planned in terms of protecting chemical water quality. This study shows that the smaller estuaries have good water quality that should be maintained. Regional water quality standards should be established and regorously enforced. It will be far easier to prevent water pollution now than to clean it up in the future.

(4) Standard methods for the study of interstitial sediment water be adopted, similar to the standard methods now in use for water and wastewater. The zone below the water-sediment interface is a chemically active habitat for many life forms, and may be nearly as important as the free water above.

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