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THIRD ANNUAL REPORT

DECEMBER 76 – MARCH 78

STUDIES ON THE TOXIC ELEMENTS AND ORGANIC DEGRADATION PRODUCTS IN AQUATIC BODIES AND SEDIMENTS AROUND KENNEDY SPACE CENTER (K S C) SOUTH MOSQUITO LAGOON

NASA RESEARCH GRANT NO. NSG-803

JOHN F. KENNEDY SPACE CENTER, FLORIDA

SUBMITTED BY

SAVANNAH STATE COLLEGE

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MARCH 1978

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DECEMBER 76 - MARCH 78

STUDIES ON THE TOXIC ELEMENTS AND ORGANIC DEGRADATION PRODUCTS IN AQUATIC BODIES AND SEDIMENTS AROUND KENNEDY SPACE CENTER (K S C)

-SOUTH MOSQUITO LAGOON

NASA RESEARCH GRANT NO. NSG - 803

JOHN F. KENNEDY SPACE CENTER, FLORIDA

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INTRODUCTION

This report is submitted to John F. Kennedy Space Center, NASA and is a compilation of research work performed under the NASA Research Grant NSG 803 during the third year of our study on the aquatic systems around Kennedy Space Center (KSC). The report includes a brief description of the study area, field data and analytical results of all the samples collected during the five visits to KSC up to December 17, 1977. The aquatic area selected for the third-year study is the Southern part of Mosquito Lagoon which extends from the Haulover Canal to the dead end boundary of this lagoon southwards. The area designated as '3rd Year' in Figure 1 shows the location and the surrounding parts of this area of study.

FIELD SAMPLING PROCEDURE

Study Area. The South Mosquito Lagoon is a relatively less disturbed and land enclosed water body. It extends over a distance of 12 Km from the eastern end of Haulover Canal to the south-eastern tip of this lagoon. The width of this aquatic body varies from 2.6 to 4.0 Km. The main flow of Indian River from the north to the south passes through the Haulover Canal. This southern lagoon body acts as a temporary storage trough for the excess flow of water before it gets its chance to pass through the canal. There is very little boating traffic in this area. The movement of water is caused by wind waves and the natural push of water masses to move and flow through the canal. As a result, scattered fast moving currents have been observed in this area.

The South Mosquito Lagoon is bounded by land on the east, west and south sides. The land barrier on the east side separates the lagoon from the Atlantic ocean. The southern tip of the lagoon is approximately 7.5 Km from the VAB (Vehicle Assembly Building) and the Shuttle Runway location of the Kennedy Space Center.

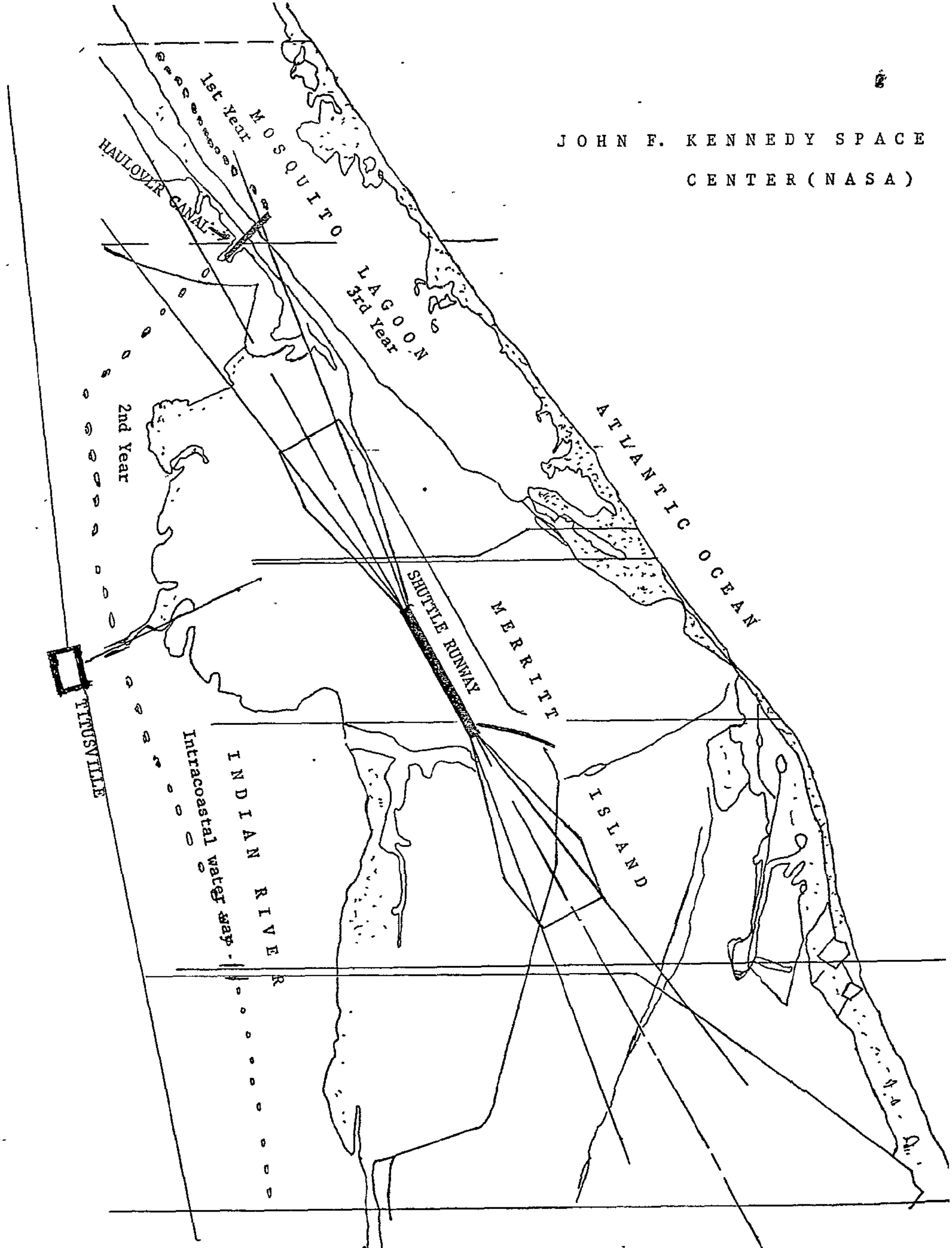

Fig. 1 MAP SHOWING STUDY AREAS

Field Trips. During this third-year study we have made five trips to KSC for the collection of study samples and for the 'on site' measurement of physical properties of the water bodies. The trips were scheduled at about two-month intervals on the following dates: February 26, 77; May 7, 77; July 16, 77; September 10, 77; December 17, 77. Eight sampling sites were selected along a traverse followed through the middle of this lagoon from the north to the south end. Since there were no marker posts in this area of lagoon, the site locations were marked on the map and the same stations were revisited by following the bearings and the distance covered by boat from the starting point. As an additional help for locating the sites, marked empty plastic bottles were left floating at each site by tying the bottle to a brick at the water bottom with a nylon rope. The chosen sites are shown in Figure 2 and the geographical co-ordinates of these sites numbered 1-SL to 8-SL (SL = South Lagoon) are as follows:

Sample Site Number	Location	
	Latitude	Longitude
1-SL	28° 44.5′ N	80° 44.6′ W
2-SL	28° 44.1′ N	80° 44.1′ W
3-SL	28° 43.5′ N	80° 43.7′ W
4-SL	28° 43.2′ N	80° 43.4′ W
5-SL	28° 42.8′ N	80° 43.1′ W
6-SL	28° 42.4′ N	80° 42.8′ W
7-SL	28° 42.1′ N	80° 42.4′ W
8-SL	28° 41.8′ N	80° 41.8′ W

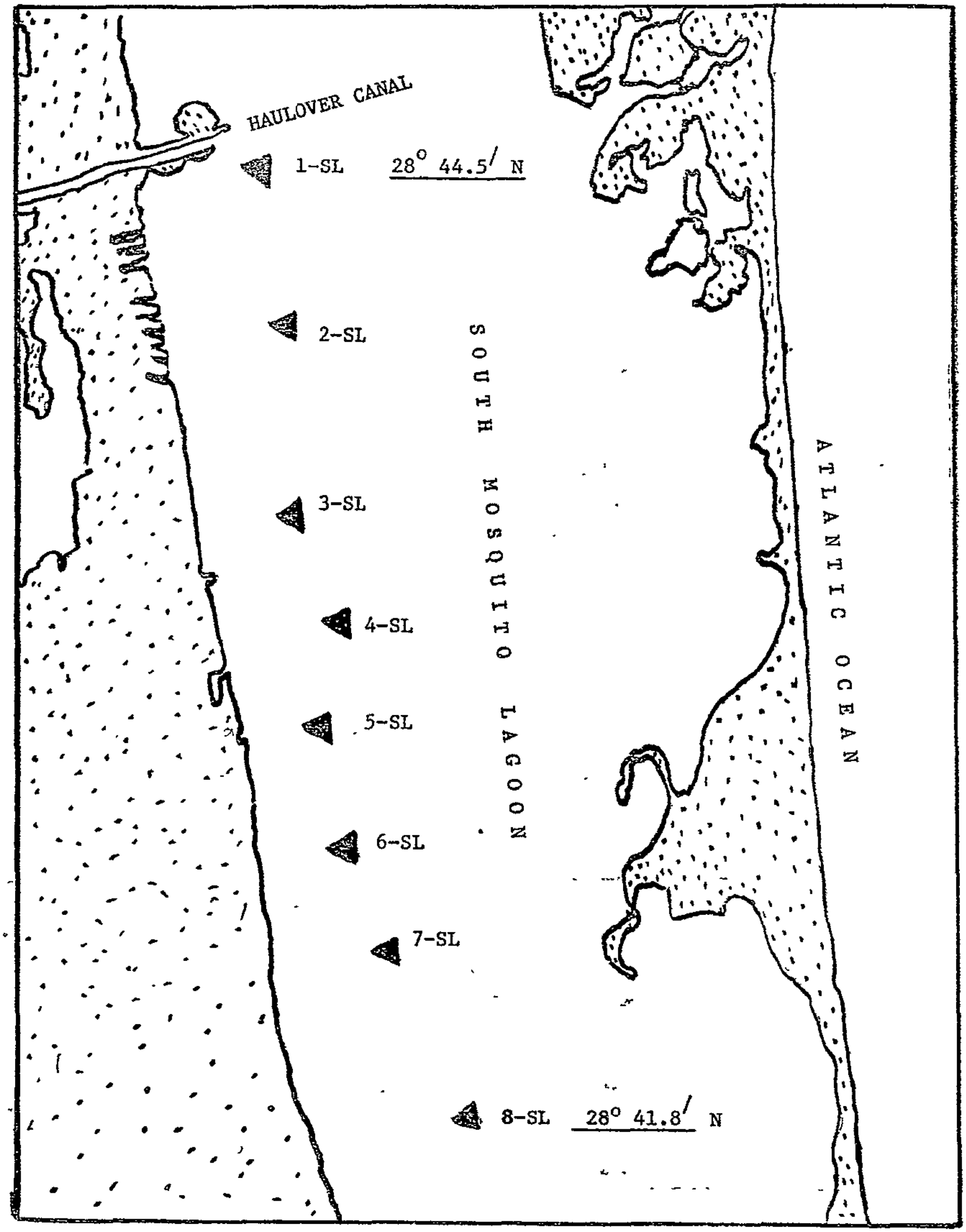

Fig. 2 SAMPLING SITES IN THE SOUTH MOSQUITO LAGOON

Collection of Water and Sediment Samples. As in the previous years, a rented boat was arranged by Mr. E. E. Perkins, NASA Technical Officer in each of our trips. The project investigators collected both water and sediment samples by using the method described in previous reports (1, 2). About three liters of water were collected in four containers (3 polyethylene bottles and one glass bottle) for various types of analyses to be performed later in the laboratory. All the water samples were collected at a depth of about one meter below the surface. The sediment samples were withdrawn by core sampler and split into two sections, the top layer 25 cm section at the top, and the bottom layer being lower 25 cm section of the core from 25 cm to 50 cm depth of the sediment strata. The top and bottom sediment samples were stored in two separate bags for each sampling site. Each bag was tied tightly and enclosed in an outer bag for protection and immediately frozen in an ice box containing dry ice obtained from KSC laboratory.

Field Observations. At each sampling site, the pH, salinity and conductivity of water were measured by using Corning Model 610A Portable pH Meter and YSI Model 33-S-C-T (Salinity-conductivity-temperature) Meter. Dissolved oxygen and temperature were measured by using Delta Model 2110 Multirange Analyzer for DO, BOD and Temperature. We had procured this new instrument for use before we made the first sampling trip this year. We are including in this report the dissolved oxygen content of the water measured at each sampling site.

The collected samples were brought back to Savannah State College for detailed analyses. In the Earth Science laboratory the sediment samples were stored in the freezer and water samples for nitrogen analysis (in glass bottles) and for microbial studies were stored in the refrigerator at 4 C until the time of analysis. The analytical data about the five collections of samples are being included in this report. The analytical methods are given on the following pages.

ANALYTICAL PROCEDURES FOR WATER SAMPLES

All the water samples were analyzed for the following inorganic elements or species: chloride, sulfate, bicarbonate, phosphorus, nitrogen, Ca, Mg, Na, K, Zn, Cd, Mn, Pb and Hg. The concentration of total solids present in water was also measured. The analytical procedures employed for the determination of all the above species except phosphorus, Pb and Hg are the same as described in the first annual report (1). Phosphorus and lead in the water samples were measured by the procedures discussed in the 2nd annual report (2). Mercury was, however determined by using our new Perkin-Elmer (Coleman) Model 50 Mercury Analyzer system. The principle and the details of the procedure for the analysis of mercury using this system are given below:

<u>Analysis of Mercury using Mercury Analyzer System</u>. In this method the mercury which may be present in the monovalent or divalent form is converted to atomic mercury. The atomic mercury is vaporized and swept through a gaseous cell in a spectrometer by a stream of air. Since the entire process takes place in a closed system there will be no loss of mercury. Mercury has a strong absorption band in the UV (ultra-violet) region. This absorbance is electrically converted into concentration which can be read from the instrument. The instrument should be calibrated beforehand with known standards of mercury. The reduction of ionic mercury into atomic mercury is carried out as follows:

A 100-ml sample of water in a BOD bottle is treated with nitric acid and sulfuric acid in the presence of potassium permanganate to oxidize all the mercury present to the mercuric (Hg^{2+}) form. The excess permanganate is reduced with hydroxylamine hydrochloride and then the mercury is reduced to metallic mercury with stannous chloride. An aerator is placed in the reduced mercury solution. A pump circulates the air to evaporate the mercury and carry it through the cell to be absorbed at 253.7 nm radiation emitted from the light source.

ANALYTICAL PROCEDURES FOR THE SEDIMENT SAMPLES

The procedures discussed in references (1, 2) have been employed for the study of sediment samples. The frozen soil samples were thawed, prepared and apportioned as before for the various types of analyses. Soil color of the samples was visually observed and the percentages of moisture and shells present in each sample were estimated. As recommended by Hesse (4) the soil pH and conductivity were measured in 1 : 1 and 1 : 5 (soil : water) dilution ratios respectively.

For the determination of inorganic nitrogen (NH_4- N and NO_3- N), 50 g of wet soil was extracted with KCl solution and the nitrogen was estimated in the extract by the steam distillation method (3).

For the measurement of water-soluble and ion-exchangeable cations in the sediments, 10 g of air-dried and sieved sample was extracted with ammonium acetate solution. In the digested extract, all the major and minor cations were determined by the atomic absorption technique except the Hg and Pb for which the methods described in the previuos section 'Water Analysis' were used.

Total inorganic phosphorus in the sediments was estimated by the method reported by Hesse (4) as follows:

One gram of <0.5 mm air-dry soil was weighed into a centrifuge tube and mixed with 10 cc of conc. HCl. It was heated on a steam bath for 10 minutes and then further 10 cc of the acid were added. The tube was allowed to stand at room temperature for 1 hour. Added 50 cc of water and centrifuged. The solution was decanted into a 100-ml volumetric flask and volume made up to the mark. Phosphorus in this extract solution was immediately determined as described before (2).

<u>Analysis of Fused Sediment Samples</u>. It was considered that the fusion analysis of selected sets of collected samples may provide the desired information about the chemical binding of certain elements. In view of this, using the method described in reference (2) the fusion analysis of 1st & 3rd collection has been completed.

Analysis of HCl Extract of Sediment Samples. It was considered that the analysis of the sediment samples extracted by concentrated HCl may provide a comparative information relative to the data obtained from the analysis of ammonium acetate extract and the fused sediment samples. For this purpose the HCl extract of the 1st and 3rd collections of sediments prepared for the estimation of phosphorus was used. The trace metals of Mn, Zn, Cd and Cu were determined in this extract by the atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Results of Water Analyses. The data on the measurement of physical parameters and the concentrations of inorganic phosphorus and inorganic nitrogen in the water samples of five collections are included in Tables 1-SLW(a) to 5-SLW(a). The seasonal variations in the average values of measured parameters of the samples collected at the different periods are as follows:

Year 1977	I February 26	II May 7	III July 16	IV September 10	V December 17	
Surface water temp.	25.5	27.3	31.4	29.8	21.6	Degrees C
Salinity of water	2.76	3.30	3.69	3.97	3.00	%
Conductivity of water	379	478	524	469	438	in 100 uMhos
Dissolved Oxygen	7.6	7.4	5.8	6.1	6.1	mg/l
pH value at site	6.9	6.9	6.5	6.4	6.3	
Inorganic phosphorus	0.031	0.038	0.032	0.019	0.017	ppm
Inorganic Nitrogen:						
NH_4-N	0.65	0.16	0.122	0.09	0.18	ppm
NO_3-N	-0-	0.18	0.018	-0-	0.03	ppm

As compared to the previous-year study area, the surface water temperature readings of this lagoon showed relatively smaller changes during the periods of collection, the maximum being 31.4 C in July and a minimum of 21.6 C in December.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 1-SLW(a)

Data on the Measurement of the Physical Parameters and the Measured Values for Phosphorus and Inorganic Nitrogen

1st Collection* South Mosquito Lagoon

Sample #	Depth (m)	Temp. (C)	Salinity (%)	Dissolved O_2 (mg/1)	Conductivity (in 100 u Mhos)	pH (Site)	Phosphorus (ppm)	Nitrogen (ppm) NH_4-N	Nitrogen (ppm) NO_3-N
1-SL	0.61	20.5	2.61	6.9	361	6.4	0.013	0.56	-0-
2-SL	0.91	25.0	2.72	7.6	378	6.9	0.055	0.56	-0-
3-SL	0.91	25.8	2.78	7.8	380	7.0	0.023	0.56	-0-
4-SL	0.91	25.5	2.80	6.8	382	6.9	0.065	1.12	-0-
5-SL	0.91	26.0	2.80	8.0	382	7.0	0.020	0.56	-0-
6-SL	0.91	27.0	2.80	7.9	382	7.1	0.026	0.98	-0-
7-SL	1.22	27.5	2.80	7.8	382	7.1	0.020	0.42	-0-
8-SL	1.22	27.0	2.80	8.0	382	7.1	0.029	0.42	-0-
Average	0.95	25.5	2.76	7.6	379	6.9	0.031	0.65	-0-

* Samples collected on February 26, 1977.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 2-SLW(a)

Data on the Measurement of the Physical Parameters and the Measured Values for Phosphorus and Inorganic Nitrogen

2nd Collection*- South Mosquito Lagoon

Sample #	Depth (m)	Temp. (C)	Salinity (%)	Dissolved O_2 (mg/l)	Conductivity (in 100 u Mhos)	pH (Site)	Phosphorus (ppm)	Nitrogen (ppm)	
								NH_4-N	NO_3-N
1-SL	0.91	25.0	3.25	6.6	474	6.1	0.039	0.42	-0-
2-SL	1.07	26.5	3.15	6.4	456	6.4	0.029	0.42	-0-
3-SL	1.22	26.0	3.35	7.6	485	6.6	0.020	-0-	0.42
4-SL	1.22	26.0	3.35	7.9	485	7.0	0.055	0.14	-0-
5-SL	0.91	26.5	3.30	7.9	480	7.1	0.055	0.14	0.56
6-SL	0.76	27.0	3.28	8.1	474	7.3	0.042	0.14	-0-
7-SL	0.91	28.5	3.38	7.9	486	7.3	0.042	-0-	-0-
8-SL	1.22	33.0	3.38	6.6	488	7.1	0.026	-0-	0.42
Average	1.03	27.3	3.30	7.4	478	6.9	0.038	0.16	0.18

* Samples collected on May 7, 1977.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 3-SLW(a)

Data on the Measurement of the Physical Parameters and the Measured Values for Phosphorus and Inorganic Nitrogen

3rd Collection*- South Mosquito Lagoon

Sample #	Depth (m)	Temp. (C)	Salinity (%)	Dissolved O_2 (mg/1)	Conductivity (in 100 u Mhos)	pH (Site)	Phosphorus (ppm)	Nitrogen (ppm)	
								NH_4-N	NO_3-N
1-SL	0.76	31.0	3.70	6.2	530	6.1	0.067	-0-	-0-
2-SL	0.91	32.5	3.56	5.5	510	6.3	0.048	-0-	-0-
3-SL	1.22	32.5	3.68	5.5	525	6.4	0.018	-0-	-0-
4-SL	1.22	30.0	3.70	6.6	525	6.6	0.018	0.14	-0-
5-SL	1.22	31.0	3.72	6.1	525	6.7	0.048	-0-	-0-
6-SL	1.22	31.0	3.70	5.5	525	6.5	0.004	-0-	-0-
7-SL	1.22	30.0	3.72	6.2	525	6.6	0.033	-0-	0.14
8-SL	1.22	33.0	3.72	5.0	525	6.5	0.018	0.84	-0-
Average	1.12	31.4	3.69	5.83	524	6.5	0.032	0.122	0.018

* Samples collected on July 16, 1977.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 4-SLW(a)

Data on the Measurement of the Physical Parameters and the Measured Values for Phosphorus and Inorganic Nitrogen

4th Collection* - South Mosquito Lagoon

Sample #	Depth (m)	Temp. (C)	Salinity (%)	Dissolved O_2 (mg/1)	Conductivity (in 100 u Mhos)	pH (Site)	Phosphorus (ppm)	Nitrogen (PPm) NH_4-N	NO_3-N
1-SL	0.76	30.0	3.87	6.2	450	6.1	0.003	0.14	-0-
2-SL	1.22	30.0	3.90	6.2	470	6.3	0.024	-0-	-0-
3-SL	1.06	29.0	4.00	6.3	490	6.5	0.057	-0-	-0-
4-SL	1.06	29.0	4.00	6.4	450	6.6	0.015	0.14	-0-
5-SL	0.91	30.0	4.00	6.1	470	6.2	-0-	0.14	-0-
6-SL	0.76	30.0	4.00	6.2	490	6.2	0.019	-0-	-0-
7-SL	0.91	29.5	4.00	5.9	460	6.5	0.021	0.14	-0-
8-SL	1.22	31.0	4.00	5.8	470	6.6	0.012	0.14	-0-
Average	0.99	29.8	3.97	6.1	469	6.4	0.019	0.09	-0-

* Samples collected on September 10, 1977.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 5-SLW(a)

Data on the Measurement of the Physical Parameters and the Measured Values for Phosphorus and Inorganic Nitrogen

5th Collection*- South Mosquito Lagoon

Sample #	Depth (m)	Temp. (C)	Salinity (%)	Dissolved O_2 (mg/1)	Conductivity (in 100 u Mhos)	pH (Site)	Phosphorus (ppm)	Nitrogen (ppm)	
								NH_4-N	NO_3-N
1-SL	0.76	21.0	2.80	6.5	410	5.8	0.017	0.28	-0-
2-SL	0.91	21.0	2.95	6.0	435	6.0	0.029	0.56	-0-
3-SL	1.06	21.0	3.00	6.5	440	6.1	0.036	-0-	-0-
4-SL	1.22	22.0	3.02	7.0	442	6.2	-0-	0.14	0.28
5-SL	1.06	22.0	2.95	6.1	430	6.3	0.022	-0-	-0-
6-SL	0.91	22.5	3.08	5.5	448	6.4	0.024	0.28	-0-
7-SL	1.22	22.0	3.10	5.6	450	6.7	0.011	-0-	-0-
8-SL	1.22	21.5	3.10	5.6	450	6.7	-0-	0.14	-0-
Average	1.05	21.6	3.00	6.1	438	6.3	0.017	0.18	0.03

* Samples collected on December 17, 1977.

The probable reason for the smaller temperature changes is that this aquatic body is quite deep and its depth varies from 2.0 to 2.6 meters approximately. The salinity of water was maximum in September and minimum in February. On the other hand the electrical conductivity was maximum in July and minimum in the month of February. The electrical conductivity values are dependent on the temperature and salt concentration factors. With only one exception, the dissolved oxygen content of water varied according to water temperatures and the DO value was a minimum of 5.83 mg/1 at the maximum water temperature of 31.4 C in the month of July. The pH values of water varied within a narrow range of 6.3 to 6.9. This is an indication of greater production and the dissolution of CO_2 in this part of the lagoon and it keeps the pH of water relatively lower than expected.

The phosphorus concentration of water was slightly greater in the month of May and it was low in December. The ammoniacal nitrogen (NH_4-N) content was the highest in February whereas the nitrate nitrogen (NO_3-N) was the maximum in May. The high values of both the phosphorus and NO_3-N in the month of May are indicative of rapid rate of mineralization of the organic constituents of water at the ambient temperature of 27 C. As stated earlier (2) the process of decomposition and nitrification appears to be active in the month of May or even July when the water temperatures are 27.3 C and 31.4 C respectively. The activity of microorganisms seems to be optimum in these temperature ranges.

The NO_3-N was absent or present in negligible amounts in the water samples collected during February and September. The presence of high NH_4-N in water in the month of February has resulted in a slightly high pH value which may have inhibited nitrification (change of NH_4-N to NO_3-N) and thus the absence of NO_3-N.

Major Chemical Constituents of Water. Tables 1-SLW(b) to 5-SLW(b) include the results of major metals, anionic species as well as the total solids present in the water samples of five collections. The data indicate that there are small variations in the concentrations of different constituents of the samples collected from the 8 sites during each collection. However, there are appreciable differences in the chemical composition of samples of the five collection sets.

The average concentration of major cations taken from the data tables for the five collections of water samples are as follows:

1977	I February 26	II May 7	III July 16	IV September 10	V December 17	
Ca	325	467	372	344	419	ppm
Mg	1086	1350	1694	1384	1361	ppm
Na	9800	11453	6138	11419	10128	ppm
K	378	494	242	441	422	ppm
Totals:	11589	13764	8446	13588	12330	ppm

These data show that the average concentrations of Ca, Na and K in water are the maximum in late spring in May, whereas the Mg is maximum in July. The levels of Na and K are the lowest in July which makes the total concentration of cations as the minimum in this month. The Ca & Mg levels are minimum in February.

The average concentrations of anionic species and total solids are detailed as follows:

	I	II	III	IV	V	
Cl	15555	19446	22124	18270	19221	ppm
SO_4	2150	2682	3250	2808	2655	ppm
HCO_3	166	187	185	156	187	ppm
Total Solids	39523	45140	50272	50744	44681	ppm

These data reveal that the Cl and SO_4 concentrations are maximum in July and minimum in February, thus resembling the pattern of Mg concentrations.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 1-SLW(b): Concentration of Major Ions in Water

1st Collection* - South Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Cl	SO_4	HCO_3	Total Solids
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
1-SL	320	1030	9500	360	14616	2025	146.4	37370
2-SL	340	1095	10000	400	16118	2175	161.0	42376
3-SL	320	1085	9750	400	15717	2375	161.0	39022
4-SL	280	1080	9800	360	15317	2100	175.7	38852
5-SL	350	1090	9850	360	15517	2175	175.7	39553
6-SL	350	1105	10000	380	16118	2100	161.0	39796
7-SL	340	1125	10000	380	15717	2050	175.7	40154
8-SL	300	1080	9500	380	15317	2200	175.7	39066
Average	325	1086	9800	378	15555	2150	166	39523

* Samples collected on February 26, 1977.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 2-SLW(b): Concentration of Major Ions in Water

2nd Collection* - South Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Cl	SO_4	HCO_3	Total Solids
	ppm							
1-SL	466	1034	10750	496	18921	2630	175.7	43040
2-SL	466	1370	12750	484	19521	2650	175.7	44264
3-SL	466	1433	12375	484	19421	2700	190.3	47720
4-SL	467	1416	11125	488	19221	2775	190.3	44820
5-SL	466	1366	11125	484	19321	2575	175.7	45000
6-SL	467	1366	11500	500	19521	2650	190.3	47820
7-SL	468	1400	11125	520	19722	2700	190.3	43680
8-SL	467	1416	10875	496	19922	2775	205.0	44776
Average	467	1350.1	11453	494	19446.2	2682	186.7	45140

* Samples collected on May 7, 1977.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 3-SLW(b): Concentration of Major Ions in Water

3rd Collection* - South Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Cl	SO_4	HCO_3	Total Solids
	ppm							
1-SL	360	1675	6195	245	21824	3289	219.6	48920
2-SL	343	1600	5860	225	20623	3200	205.0	45420
3-SL	373	1675	6305	239	22024	3114	175.7	50220
4-SL	377	1700	6230	249	22024	3300	175.7	49820
5-SL	377	1710	5990	245	22425	3300	205.0	50740
6-SL	383	1735	6155	259	22825	3300	146.4	52280
7-SL	383	1725	6230	237	22625	3300	205.0	52760
8-SL	383	1735	6140	237	22625	3200	146.4	52020
Average	372.4	1694	6138	242	22124	3250	184.9	50272

* Samples collected on July 16, 1977.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 4-SLW(b): Concentration of Major Ions in Water

4th Collection* - South Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Cl	SO_4	HCO_3	Total Solids
	ppm							
1-SL	340	1375	11400	380	17419	2838	146.4	45424
2-SL	330	1350	11000	295	18821	2800	146.4	49704
3-SL	373	1385	11450	480	17419	2740	175.7	51056
4-SL	320	1390	11300	455	18821	2838	161.0	46572
5-SL	340	1390	11600	470	19021	3000	146.4	50688
6-SL	320	1390	11800	478	17820	3000	175.7	58084
7-SL	345	1400	11300	480	17820	2338	131.8	51884
8-SL	387	1395	11500	490	19021	2910	161.0	52540
Average	344	1384	11419	441	18270	2808	155.6	50744

* Samples collected on September 10, 1978.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 5-SLW(b): Concentration of Major Ions in Water

5th Collection* - South Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Cl	SO_4	HCO_3	Total Solids
	ppm							
1-SL	440	1390	10300	420	19021	2525	146.4	43624
2-SL	420	1370	10000	425	19421	2638	175.7	45880
3-SL	425	1340	10025	425	19221	2638	175.7	45520
4-SL	420	1375	10300	430	19421	2775	175.7	44520
5-SL	415	1360	10300	435	19221	2700	205.0	45336
6-SL	415	1355	9750	425	19221	2525	234.2	44688
7-SL	400	1360	10200	410	19021	2700	205.0	43440
8-SL	415	1335	10150	410	19221	2740	175.7	44440
Average	419	1361	10128	422	19221	2655	186.7	44681

* Samples collected on December 17, 1978.

The bicarbonate concentration varied within narrow limits, being high in May and December and low in the month of September. These HCO_3 levels corresponded closely with the Ca concentrations since the bicarbonate anion is in usual combination with calcium. The high concentration of total solids in the 4th collection (September samples) directly correlates with the maximum water salinity readings in September as well as the near maximum concentration of total metal ions in the same collection.

Trace Elements in the Lagoon Water. The data on the concentrations of six trace elements determined in the water samples of five collections are included in Tables 1-SLW(c) to 5-SLW(c). These elements exhibit less variations among the sampling sites but show greater variations on a seasonal basis in the concentrations of samples of the five periods of collection. The average trace metal concentration values of all the 8 sites for each set of samples are listed as follows:

	I	II	III	IV	V	
1977	February 26	May 7	July 16	September 10	December 17	
Mn	0.68	1.06	0.12	0.01	0.039	ppm
Zn	0.030	0.030	0.055	0.060	0.029	ppm
Cd	0.029	0.050	0.070	0.125	0.074	ppm
Cu	0.094	0.100	0.100	0.140	0.133	ppm
Pb	0.029	-0-	0.038	0.050	0.005	ppm
Hg	0.00078	0.00036	0.00035	0.00050	0.00050	ppm
Totals:	0.86278	1.24036	0.38335	0.38550	0.28050	ppm

The above data show slightly greater concentrations of Zn, Cd, Cu & Pb in the September samples while Mn and Hg are higher in May and February respectively. Zinc, Cd and Cu are in minimum concentrations in February samples of water.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 1-SLW(c): Concentration of Trace Elements in Water

1st Collection* - South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu	Pb	Hg
	ppm					
1-SL	1.28	0.030	0.03	0.09	0.0	0.0013
2-SL	0.56	0.040	0.04	0.09	0.10	0.0014
3-SL	0.90	0.023	0.04	0.09	0.0	0.0016
4-SL	0.90	0.032	0.03	0.09	0.04	0.0018
5-SL	0.72	0.026	0.04	0.09	0.03	0.00005
6-SL	0.56	0.028	0.04	0.09	0.06	0.000025
7-SL	0.24	0.028	0.01	0.09	0.0	0.000025
8-SL	0.32	0.035	0.0	0.12	0.0	0.000075
Averages:	(0.68)	(0.030)	(0.029)	(0.094)	(0.029)	(0.00078)

* Samples collected on February 26, 1977.

Table 2-SLW(c): Concentration of Trace Elements in Water

2nd Collection* - South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu	Pb	Hg
	ppm					
1-SL	1.34	0.047	0.05	0.14	0.0	0.00040
2-SL	1.76	0.042	0.08	0.12	0.0	0.00035
3-SL	1.16	0.037	0.06	0.09	0.0	0.00040
4-SL	1.54	0.035	0.04	0.10	0.0	0.00035
5-SL	0.64	0.023	0.04	0.09	0.0	0.00018
6-SL	0.98	0.028	0.05	0.09	0.0	0.00045
7-SL	0.56	0.005	0.06	0.09	0.0	0.00030
8-SL	0.48	0.019	0.05	0.09	0.0	0.00045
Averages:	(1.06)	(0.030)	(0.05)	(0.10)	(0.0)	(0.00036)

* Samples collected on May 7, 1977.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 3-SLW(c): Concentration of Trace Elements in Water

3rd Collection* - South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu	Pb	Hg
	ppm					
1-SL	0.11	0.080	0.09	0.09	0.009	0.00075
2-SL	0.11	0.051	0.04	0.09	0.020	0.00038
3-SL	0.12	0.046	0.07	0.09	0.070	0.00048
4-SL	0.10	0.035	0.07	0.09	0.048	0.00043
5-SL	0.11	0.070	0.09	0.09	0.024	0.00025
6-SL	0.11	0.056	0.07	0.11	0.091	0.00025
7-SL	0.13	0.046	0.07	0.11	0.026	0.00015
8-SL	0.14	0.054	0.09	0.11	0.018	0.00010
Averages:	(0.12)	(0.055)	(0.07)	(0.10)	(0.038)	(0.00035)

* Samples collected on July 16, 1977.

Table 4-SLW(c): Concentration of Trace Elements in Water

4th Collection* - South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu	Pb	Hg
	ppm					
1-SL	0.0	0.048	0.14	0.12	0.16	0.00012
2-SL	0.0	0.057	0.13	0.12	0.05	0.00010
3-SL	0.0	0.057	0.14	0.18	0.07	0.00088
4-SL	0.01	0.060	0.11	0.16	0.01	0.00075
5-SL	0.01	0.077	0.13	0.16	0.00	0.00063
6-SL	0.02	0.067	0.11	0.16	0.11	0.00043
7-SL	0.02	0.055	0.12	0.12	0.00	0.00025
8-SL	0.01	0.057	0.12	0.12	0.00	0.00050
Averages:	(0.01)	(0.060)	(0.125)	(0.14)	(0.05)	(0.00050)

* Samples collected on September 10, 1978.

NASA PROJECT WATER SAMPLE ANALYSIS

Table 5-SLW(c): Concentration of Trace Elements in Water

5th Collection* - South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu	Pb	Hg
	ppm					
1-SL	0.039	0.034	0.076	0.107	0.012	0.00030
2-SL	0.039	0.031	0.063	0.089	0.005	0.00028
3-SL	0.039	0.030	0.063	0.107	0.006	0.00050
4-SL	0.039	0.030	0.088	0.089	0.005	0.00012
5-SL	0.049	0.022	0.076	0.107	0.005	0.00025
6-SL	0.039	0.031	0.063	0.107	0.005	0.00050
7-SL	0.039	0.025	0.076	0.232	0.002	0.00095
8-SL	0.039	0.031	0.088	0.232	0.002	0.00065
Averages:	(0.039)	(0.029)	(0.074	(0.133)	(0.005)	(0.00050)

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* Samples collected on December 17, 1978.

This indicates a similarity of pattern of the occurrence of these elements in water. Both the Pb and Hg are either absent or in negligible concentrations in the May samples (collection II) in which the sum total of all the determined elements is at the highest level (1.24036 ppm). Manganese on the other hand is at its minimum in the September collected water samples. It is interesting to note that although the total concentration of all the six trace elements in the September samples is the 2nd minimum (0.38550 ppm) yet the concentration of the toxic elements of Cd, Pb, Cu and Zn is the maximum in this set of samples. However, these values are within the permissible limits of safety. An evaluation of the limits of toxicity in relation to these data will be presented in the final chapter of this report.

Results of Sediment Analyses. As discussed in the analytical procedures in reference (2) and on page seven of this report, six types of measurements have been made on the sediment samples. These measurements are comprised of the categories (a) measurements of the physical properties, (b) the analysis of KCl extract for the estimation of ammoniacal and nitrate nitrogen, (c) the analysis of interstitial water for the concentration of trace elements, (d) the analysis of ammonium acetate extract for the cationic species, (e) the analysis of fused sediment samples for the total trace elements, and (f) the analysis of HCl extract for the estimation of total inorganic phosphorus and the extractable trace elements. The results of the various types of analyses will be discussed in the following sections:

Physical Parameters and Inorganic Phosphorus & Nitrogen. Tables 1-SLS(a) to 5-SLS(a) include the results of physical properties, inorganic phosphorus, NH_4-N and NO_3-N contents of the sediments collected from the South Mosquito Lagoon. The average calculated values of these parameters for the five collections of samples are as follows:

		I	II	III	IV	V	
1977		February 26	May 7	July 16	September 10	December 17	
Moisture	(T)	39.8	28.8	35.4	33.4	38.4	%
	(B)	36.4	31.1	29.2	34.5	37.8	%
Shells	(T)	7.1	10.3	7.3	9.0	5.9	%
	(B)	4.5	11.2	19.1	11.9	10.5	%
Color	(T)	Grayish	Light Gray	Light Gray	Light Gray	Light Gray	
	(B)	Grayish Blk,	Gray	Gray	Gray	Light Gray	
pH	(T)	7.7	7.9	8.3	7.6	8.0	
	(B)	7.7	8.0	8.4	7.6	8.0	
Conductivity	(T)	44.0	35.0	43.0	40.3	43.6	(100 uMhos)
	(B)	42.0	38.0	39.0	45.1	43.1	(" ")
Inorganic Phosphorus	(T)	4.87	2.80	3.26	2.11	3.36	ppm
	(B)	4.25	3.43	2.91	2.14	3.65	ppm
Inorganic Nitrogen:							
NH_4-N	(T)	6.45	6.78	6.83	2.48	3.75	ppm
	(B)	6.56	3.41	4.63	2.58	5.28	ppm
NO_3-N	(T)	1.11	0.23	0.36	0.25	1.08	ppm
	(B)	0.93	0.05	0.34	0.37	0.66	ppm

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 1-SLS(a): Data on the Measurement of Physical Parameters and the Measured Values of Phosphorus and Inorganic Nitrogen. 1st Collection*- South Mosquito Lagoon

Sample #	Depth (m)	Moisture (%)	% Shells in the collected sample	Color of the Sediment	pH (1:1 Ratio)	/Conductivity (in 100 u Mhos)	Phosphorus (ppm)	Inorganic Nitrogen NH_4-N	NO_3-N (ppm)
1SL-T	1.47	29.4	11.4	Gray	7.5	37	4.67	7.24	0.72
1SL-B	1.72	24.5	13.3	Gray	7.6	27	3.53	4.18	-0-
2SL-T	1.93	26.9	8.0	Grayish	7.8	28	4.33	1.07	0.36
2SL-B	2.18	26.7	9.8	Grayish	8.0	25	2.85	1.77	1.06
3SL-T	2.38	48.4	16.4	Gray	7.6	52	4.33	5.40	1.66
3SL-B	2.63	54.3	-0-	Grayish black	7.6	64	5.93	4.32	1.73
4SL-T	2.54	46.8	-0-	Grayish black	7.5	70	5.13	5.35	2.88
4SL-B	2.79	55.0	-0-	Grayish black	7.6	--	--	3.80	1.09
5SL-T	2.38	30.0	-0-	Gray	7.9	32	4.67	2.55	3.28
5SL-B	2.63	24.4	-0-	Gray	7.9	28	1.37	0.35	2.79
6SL-T	2.38	33.7	13.7	Gray	7.8	32	5.13	5.61	-0-
6SL-B	2.63	30.5	12.6	Grayish black	7.9	37	5.13	11.70	-0-
7SL-T	2.69	56.7	7.6	Grayish black	7.7	56	3.99	9.22	-0-
7SL-B	2.94	41.6	-0-	Grayish black	7.7	51	5.47	9.12	0.79
8SL-T	2.61	46.2	-0-	Grayish black	7.8	46	6.73	15.15	-0-
8SL-B	2.86	43.1	-0-	Grayish black	7.6	62	5.47	17.22	-0-
Average:									
Top (T)	2.30	39.8	7.1	Grayish	7.7	44	4.87	6.45	1.11
Bottom (B)	2.55	36.4	4.5	Grayish black	7.7	42	4.25	6.56	0.93

* Samples collected on February 26, 1977.

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 2-SLS(a): Data on the Measurement of Physical Parameters and the Measured Values of Phosphorus and Inorganic Nitrogen. 2nd Collection* - South Mosquito Lagoon

Sample #	Depth (m)	Moisture (%)	% Shells in the collected sample	Color of the Sediment	pH (1:1 Ratio)	Conductivity (in 100 u Mhos)	Phosphorus (ppm)	Inorganic Nitrogen	
								NH_4-N	NO_3-N (ppm)
1SL-T	1.77	24.6	3.3	Light gray	7.4	28	2.45	6.98	-0-
1SL-B	2.02	25.5	1.7	Gray	8.0	31	2.17	4.22	-0-
2SL-T	2.08	26.7	3.8	Light gray	8.0	34	2.45	3.54	-0-
2SL-B	2.33	31.9	5.8	Gray	7.9	39	3.35	2.22	-0-
3SL-T	2.54	36.3	5.2	Gray	7.8	47	4.80	6.11	1.86
3SL-B	2.79	35.8	9.5	Grayish black	7.8	48	8.33	4.56	-0-
4SL-T	2.38	37.2	9.0	Gray	7.8	49	1.36	6.53	-0-
4SL-B	2.63	35.9	15.8	Gray	7.8	47	2.90	3.80	-0-
5SL-T	2.08	22.0	16.1	Grayish black	8.0	29	2.17	4.78	-0-
5SL-B	2.33	31.7	10.3	Grayish black	8.0	38	1.63	2.95	-0-
6SL-T	2.08	22.2	18.7	White	8.3	22	2.17	5.47	-0-
6SL-B	2.33	29.0	13.4	Gray	8.1	34	2.72	2.89	0.36
7SL-T	2.54	23.8	15.7	Gray	8.2	32	3.08	10.02	-0-
7SL-B	2.79	25.6	13.1	Gray	8.1	27	2.90	1.76	-0-
8SL-T	2.38	37.5	10.9	Gray	8.0	41	3.89	10.78	-0-
8SL-B	2.63	33.7	19.9	Gray	8.0	43	3.44	4.87	-0-
Average:									
Top (T)	2.23	28.8	10.3	Light Gray	7.9	35	2.80	6.78	0.23
Bottom (B)	2.48	31.1	11.2	Gray	8.0	38	3.43	3.41	0.05

* Samples collected on May 7, 1977.

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 3-SLS(a): Data on the Measurement of Physical Parameters and the Measured Values of Phosphorus and Inorganic Nitrogen 3rd Collection* – South Mosquito Lagoon

Sample #	Depth (m)	Moisture (%)	% Shells in the collected sample	Color of the Sediment	pH (1:1 Ratio)	Conductivity (in 100 u Mhos)	Phosphorus (ppm)	Inorganic Nitrog NH_4-N	NO_3-N
1 SL-T	1.47	28.5	4.1	Gray	8.1	38	2.65	12.23	-0-
1 SL-B	1.72	28.5	10.3	Gray	8.0	36	2.65	4.68	0.72
2 SL-T	2.08	37.5	15.4	Gray	8.1	51	3.62	6.93	0.39
2 SL-B	2.33	42.3	16.5	Dark Gray	8.3	51	5.14	7.57	0.80
3-SL-T	2.38	53.7	6.8	Dark Gray	8.4	62	5.14	5.59	1.29
3-SL-B	2.63	39.3	21.3	Gray	8.1	58	0.99	5.46	1.17
4-SL-T	2.08	37.0	2.9	Gray	8.2	41	3.14	13.05	-0-
4-SL-B	2.33	23.1	28.2	Gray	8.3	31	-	1.72	-0-
5-SL-T	2.38	41.2	4.1	Light Gray	8.3	52	3.62	6.72	1.18
5-SL-B	2.63	25.6	10.3	Light Gray	8.7	35	3.14	1.32	-0-
6-SL-T	2.38	30.0	15.4	Grayish white	8.5	36	2.65	5.82	-0-
6-SL-B	2.63	27.1	16.5	Grayish white	8.6	36	4.65	6.76	-0-
7-SL-T	2.38	28.7	6.8	Light gray	8.5	33	3.62	2.88	-0-
7-SL-B	2.63	22.7	21.3	Light gray	8.4	32	1.66	4.29	-0-
8-SL-T	2.38	26.6	2.9	Light gray	8.5	29	1.66	1.42	-0-
8-SL-B	2.63	24.6	28.2	Grayish white	8.4	30	2.15	5.23	-0-
Average:									
Top (T)	2.19	35.4	7.3	Light gray	8.3	43	3.26	6.83	0.36
Bottom (B)	2.44	29.2	19.1	Gray	8.4	39	2.91	4.63	0.34

* Samples collected on July 16, 1977

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 4-SLS(a): Data on the Measurement of Physical Parameters and the Measured Values of Phosphorus and Inorganic Nitrogen 4th Collection* - South Mosquito Lagoon

Sample #	Depth (m)	Moisture (%)	% Shells in the collected sample	Color of the Sediment	pH (1:1 Ratio)	Conductivity (in 100 u Mhos)	Phosphorus (ppm)	Inorganic Nitrogen	
								NH_4-N	NO_3-N (ppm)
1SL-T	1.68	46.1	7.6	Gray	7.5	45.0	1.96	1.23	-0-
1SL-B	1.83	45.2	9.4	Dark Gray	7.5	48.0	1.63	2.84	-0-
2Sl-T	2.13	40.0	2.7	Gray	7.6	47.5	2.77	3.55	-0-
2SL-B	2.29	44.8	4.8	Gray	7.6	50.0	1.22	2.84	0.40
3SL-T	2.13	52.1	8.6	Dark Gray	7.5	49.5	3.42	4.26	-0-
3SL-B	2.29	41.2	9.9	Gray	7.5	55.0	2.45	2.77	-0-
4SL-T	2.29	40.6	9.1	Light Gray	7.4	50.5	1.22	4.33	-0-
4SL-B	2.44	37.5	14.6	Gray	7.4	54.5	4.65	6.16	0.38
5SL-T	1.83	23.6	9.6	Light Gray	7.6	37.5	1.63	0.69	0.98
5SL-B	1.98	31.8	5.0	Gray	7.5	42.8	3.10	1.84	1.10
6SL-T	1.22	24.6	3.3	Light Gray	7.9	32.8	3.42	3.14	-0-
6SL-B	1.37	25.7	12.4	Gray	7.8	37.5	2.45	2.46	-0-
7SL-T	2.13	22.0	15.1	Gray	7.5	36.0	2.45	1.37	1.03
7SL-B	2.29	27.9	11.3	Gray	7.5	42.0	1.63	0.72	1.08
8SL-T	2.44	17.0	15.7	Gray	7.6	23.5	0.0	1.31	-0-
8SL-B	2.59	22.0	28.0	Gray	7.6	31.0	0.0	1.02	-0-
Average:									
Top (T)	1.98	33.4	9.0	Light Gray	7.6	40.3	2.11	2.48	0.25
Bottom(B)	2.14	34.5	11.9	Gray	7.6	45.1	2.14	2.58	0.37

* Samples collected on September 10, 1977

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 5-SLS(a): Data on the Measurement of Physical Parameters and the Measured Values of Phosphorus and Inorganic Nitrogen 5th Collection* - South Mosquito Lagoon

Sample #	Depth (m)	Moisture (%)	% Shells in the collected sample	Color of the Sediment	pH (1:1 Ratio)	Conductivity (in 100 u Mhos)	Phosphorus ppm	Inorganic Nitrogen NH_4-N	NO_3-N(ppm)
1SL-T	1.69	45.3	3.8	Gray	7.8	37.5	3.45	2.05	-0-
1SL-B	1.83	38.8	11.3	Dark Gray	8.0	34.0	2.45	3.66	1.37
2SL-T	1.98	31.5	4.9	Light Gray	8.0	39.5	1.31	0.41	-0-
2SL-B	2.13	36.5	12.0	Gray	7.8	42.0	1.48	2.20	-0-
3SL-T	2.29	63.8	5.5	Gray	8.0	68.0	9.02	9.28	-0-
3SL-B	2.44	72.4	5.9	Dark Gray	7.9	68.0	7.87	12.17	-0-
4SL-T	2.44	66.3	9.6	Gray	8.1	68.0	5.57	14.96	3.32
4SL-B	2.59	50.8	5.9	Gray	7.9	68.0	5.09	19.35	-0-
5SL-T	1.98	23.8	3.3	Light Gray	8.1	32.0	2.46	1.84	1.10
5SL-B	2.13	35.7	7.8	Gray	8.3	38.0	3.45	2.61	2.17
6SL-T	1.98	22.2	7.5	Gray	7.8	39.0	2.95	0.36	1.08
6SL-B	2.13	26.1	17.5	Grayish white	8.1	30.0	3.45	1.89	-0-
7SL-T	1.98	30.2	7.5	Light Gray	8.0	30.5	0.66	-0-	2.41
7SL-B	2.13	22.4	9.6	Light Gray	7.9	34.5	1.31	-0-	0.72
8SL-T	2.13	23.9	5.3	Light Gray	8.4	34.5	1.48	1.10	0.74
8SL-B	2.29	19.7	14.4	Light Gray	8.1	30.5	4.10	0.35	1.05
Average:									
Top (T)	2.06	38.4	5.9	Light Gray	8.0	43.6	3.36	3.75	1.08
Bottom(B)	2.21	37.8	10.5	Light Gray	8.0	43.1	3.65	5.28	0.66

* Samples collected on December 17, 1977

The average moisture content of South Mosquito Lagoon sediments in the top and bottom samples varies from 28.8% in the month of May to 39.8% in February. This narrow range of variation in the moisture holding capacity indicates a uniformity of the soil texture (particle-size distribution) of these samples. The percentage of shells in the top and bottom samples of May and September is about the same; the bottom samples of July and December contain more shells than in the top layer and the February samples have more shells in the top as compared to the bottom layer. The soil color of all the samples varies only slightly from light gray to gray thus indicating low organic matter content.

The pH (1 : 1)soil-water ratio) of the five sets of sediments ranges from 7.6 to 8.4 which is typical of the soils saturated with the salts of sea water. The electrical conductivity of sediments (1 : 5 soil-water suspension) does not follow the same trend as the pH value, but its magnitude exceeds alternately in the top and bottom samples of the five sets.

The inorganic phosphorus concentration is maximum in February and minimum in September samples. There is no marked difference between the phosphorus levels of the top and bottom samples of all the collections. As in the case of phosphorus, the NH_4-N of sediments is also the highest in February and the lowest level in September. The variation between the minimum and maximum concentration of NH_4-N in the sediments occurs by a factor of 2.5 (minimum = 2.48 ppm; max. = 6.56 ppm). The NO_3-N has shown maximum value in February and a minimum in the May sediments. With few exceptions, both the ammoniacal and nitrate nitrogen concentrations are greater in the top sediments as compared to the bottom ones. As observed by Engler et al. (5) the nitrate moving downward into the more anaerobic bottom sediment layer is lost rapidly.

Trace Elements in Interstitial Water. The interstitial water was obtained from the defrozen sediments by suction filtration. It was analyzed for four trace elements of Mn, Zn, Cd and Cu. This study was undertaken to determine the distribution of the toxic elements in the water surrounding the sediment particles. The data on the estimation of these trace elements in the interstitial water are presented in Tables 1-SLS(b) to 5-SLS(b). The average concentrations of these elements in the top and bottom layer extracted interstitial water samples of five collections are listed as follows:

		I	II	III	IV	V	
1977		February 26	May 7	July 16	September 10	December 17	
Mn	(T)	0.99	1.02	0.34	0.09	0.27	ppm
	(B)	0.96	1.07	0.17	0.07	0.08	ppm
Zn	(T)	0.116	0.322	0.04	0.19	0.38	ppm
	(B)	0.185	0.067	0.07	0.12	0.08	ppm
Cd	(T)	0.03	0.05	0.19	0.19	0.10	ppm
	(B)	0.05	0.04	0.16	0.25	0.22	ppm
Cu	(T)	0.06	0.05	0.13	0.13	0.10	ppm
	(B)	0.07	0.06	0.14	0.12	0.13	ppm
Totals:	(T)	1.196	1.442	0.70	0.60	0.85	ppm
	(B)	1.265	1.237	0.57	0.56	0.51	ppm

Just like the surface water, the average concentration of Mn in the interstitial water is the maximum in May and minimum in September. The Zn content is also the maximum in May but is minimum in July. Both the Cd and Cu occur in high concentrations in July and September and are low in February and May collections. The Mn levels are slightly higher in top layer while the Zn levels vary in magnitude between top and bottom layer samples. Considering the total concentration of four elements in each collection, the top layer exceeds the bottom layer of all collections excepting in February. The sum total of these four elements is the maximum in May samples containing high Mn & Zn, and is minimum in September samples with high Cd and Cu content.

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 1-SLS(b)

Concentration of Trace Elements in Interstitial Water of Sediments

1st Collection*- South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu
	ppm			
1SL-T	0.96	0.234	0.04	0.06
1SL-B	1.16	0.014	0.06	0.06
2SL-T	1.24	0.140	0.05	0.06
2SL-B	0.78	0.035	0.05	0.06
3SL-T	2.10	0.014	0.01	0.06
3SL-B	0.72	0.733	0.03	0.06
4SL-T	0.56	0.040	0.03	0.06
4SL-B	0.64	0.367	0.05	0.09
5SL-T	0.98	0.026	0.04	0.09
5SL-B	1.34	0.033	0.05	0.09
6SL-T	0.64	0.056	0.03	0.06
6SL-B	0.98	0.005	0.05	0.06
7SL-T	0.74	0.021	0.05	0.00
7SL-B	1.14	0.084	0.06	0.06
8SL-T	0.74	0.395	0.0	0.06
8SL-B	0.88	0.207	0.01	0.06
Averages:				
Top (T)	0.99	0.116	0.03	0.06
Bottom (B)	0.96	0.185	0.05	0.07

* Samples collected on February 26, 1977

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 2-SLS(b)

Concentration of Trace Elements in Interstitial Water of Sediments

1st Collection* - South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu
	ppm			
1SL-T	0.98	0.009	0.04	0.0
1SL-B	0.64	0.019	0.05	0.06
2SL-T	0.98	1.121	0.06	0.06
2SL-B	0.98	0.044	0.01	0.06
3SL-T	1.16	0.047	0.05	0.06
3SL-B	1.06	0.023	0.04	0.06
4SL-T	0.88	0.028	0.05	0.06
4SL-B	1.44	0.026	0.04	0.00
5SL-T	0.400	0.028	0.04	0.00
5SL-B	0.72	0.060	0.01	0.06
6SL-T	1.34	1.302	0.08	0.06
6SL-B	1.64	0.037	0.10	0.12
7SL-T	1.06	0.005	0.05	0.06
7SL-B	0.98	0.014	0.04	0.06
8SL-T	1.34	0.014	0.03	0.09
8SL-B	1.06	0.302	0.06	0.09
Averages:				
Top (T)	1.02	0.322	0.05	0.05
Bottom (B)	1.07	0.067	0.04	0.06

* Samples collected on May 7, 1977

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 3-SLS(b)

Concentration of Trace Elements in Interstitial Water of Sediments

3rd Collection*- South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu
	ppm			
1SL-T	0.24	0.01	0.18	0.11
1SL-B	0.25	0.23	0.22	0.08
2SL-T	0.24	0.01	0.17	0.11
2SL-B	0.11	0.14	0.17	0.11
3SL-T	0.50	0.04	0.19	0.11
3SL-B	0.18	0.05	0.22	0.25
4SL-T	0.18	0.02	0.21	0.11
4SL-B	0.07	0.01	0.19	0.10
5SL-T	1.04	0.01	0.17	0.11
5SL-B	0.23	-	-	-
6SL-T	0.19	0.00	0.19	0.25
6SL-B	0.11	0.01	0.15	0.17
7SL-T	0.09	0.08	0.19	0.11
7SL-B	0.18	0.08	0.20	0.17
8SL-T	0.23	0.16	0.19	0.13
8SL-B	0.23	0.06	0.15	0.21
Averages:				
Top (T)	0.34	0.04	0.19	0.13
Bottom (B)	0.17	0.07	0.16	0.14

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* Samples collected on July 16, 1977

NAS PROJECT SEDIMENT SAMPLE ANALYSIS

Table 4-SLS(b)

Concentration of Trace Elements in Interstitial Water of Sediments

4th Collection*- South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu
	ppm			
1SL-T	0.14	1.14	0.19	0.17
1SL-B	0.02	0.04	0.17	0.12
2SL-T	0.19	0.05	0.30	0.16
2SL-B	0.12	0.10	0.35	0.17
3SL-T	0.11	0.05	0.18	0.12
3SL-B	---	0.18	-	-
4SL-T	0.14	0.06	0.17	0.12
4SL-B	-	-	-	-
5SL-T	0.03	0.05	0.16	0.12
5SL-B	-	-	-	-
6SL-T	0.02	0.06	0.17	0.12
6SL-B	0.10	0.09	0.34	0.19
7SL-T	0.03	0.06	0.21	0.12
7SL-B	0.05	0.27	0.20	0.12
8SL-T	0.02	0.05	0.17	0.12
8SL-B	0.05	0.04	0.17	0.00
Averages:				
Top (T)	0.09	0.19	0.19	0.13
Bottom (B)	0.07	0.12	0.25	0.12

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* Samples collected on September 10, 1977

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 5-SLS(b)

Concentration of Trace Elements in Interstitial Water of Sediments

5th Collection* - South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu
	ppm			
1Sl-T	0.38	0.04	0.10	0.04
1SL-B	-	0.38	0.25	0.11
2SL-T	0.28	0.04	0.10	0.04
2SL-B	0.08	0.04	0.14	0.06
3SL-T	0.38	1.21	0.09	0.09
3SL-B	0.14	0.03	0.14	0.05
4SL-T	0.52	0.02	0.08	0.11
4SL-B	0.04	0.02	0.16	0.13
5SL-T	0.30	0.03	0.13	0.09
5SL-B	-	0.09	0.58	0.14
6SL-T	0.30	0.03	0.13	0.09
6SL-B	-	0.09	0.30	0.32
7SL-T	0.16	0.04	0.10	0.14
7SL-B	0.06	0.10	0.15	0.18
8SL-T	0.02	0.10	0.09	0.21
8SL-B	0.05	0.01	0.06	0.04
Averages:				
Top (T)	0.27	0.38	0.10	0.10
Bottom (B)	0.08	0.08	0.22	0.13

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* Samples were collected on December 17, 1977

Water-Soluble and Ion-Exchangeable Metals in Sediments. The data on the concentration of water-soluble and exchangeable metals in the sediments obtained by the analysis of ammonium acetate extract have been included in Tables 1-SLS(c) to 5-SLS(c). These data show lower concentrations of Na and Mg in the sediments than in the corresponding samples of surface water from the same sites. The concentration of Ca in the sediments is about 20 - 30 times greater than the Ca content of ambient water. This is primarily due to the rapid rate of precipitation of calcium from water and its high exchange capacity to be held by the sediment particles. The K content of sediments did not show wide variation from the K content of water. The average values of major cations in the sediments of five collections from the South Mosquito Lagoon are listed as follows:

1977		I February 26	II May 7	III July 16	IV September 10	V December 17	
Ca	(T)	11133	9444	8747	8191	5939	ppm
	(B)	8733	7878	8991	7791	7203	ppm
Mg	(T)	912	846	900	916	850	ppm
	(B)	854	974	725	966	988	ppm
Na	(T)	4406	3582	4800	3729	4370	ppm
	(B)	4006	3706	3628	4216	4470	ppm
K	(T)	385	262	289	244	321	ppm
	(B)	335	295	231	287	377	ppm
Totals:	(T)	16836	14134	14737	13080	11480	ppm
	(B)	13928	12853	13575	13260	13038	ppm

The average concentrations of water-soluble and exchangeable Ca and K in the top layer sediments were maximum in February while those of Na and Mg were maximum in July and September samples respectively. The minimum concentration of Ca occurred in December, but K content was minimum in September sediments. The Ca content of sediments decreased systematically from February to December in the five sets of samples. Both the Na and Mg were minimum in May collected samples. The Mg concentration of sediments is relatively uniform and shows much less variations among the five collections.

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 1-SLS(c)

Concentration of Water-Soluble and Ion-Exchangable Metals in Sediments@

1st Collection*- South Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Mn	Zn	Cd	Hg	Cu	Pb
			ppm							
1SL-T	9932	600	3750	280	2.8	25.0	0.25	0.025	1.20	1.26
1SL-B	8266	366	2300	180	0.7	23.5	1.63	0.050	1.10	1.17
2SL-T	10060	532	3000	230	3.5	35.0	0.26	0.028	1.65	1.24
2SL-B	11732	500	2500	190	3.9	24.8	0.26	0.055	1.20	1.16
3SL-T	8732	1332	5800	600	6.10	22.7	0.19	0.075	1.60	1.18
3SL-B	9064	1132	5700	285	6.60	23.7	0.13	0.039	1.20	-
4SL-T	8466	1166	5200	470	6.60	24.7	0.13	0.018	1.20	1.05
4SL-B	8132	1400	6300	695	8.40	24.6	0.19	0.025	1.60	1.07
5SL-T	11080	532	2800	220	4.80	24.8	0.19	0.054	1.90	1.17
5SL-B	7132	400	1700	160	0.80	21.0	0.06	0.023	0.95	0.88
6SL-T	12932	766	5100	320	2.10	23.0	0.19	0.085	0.95	0.95
6SL-B	9800	732	3550	310	1.70	23.3	0.19	0.028	0.95	1.35
7SL-T	14932	1100	4900	550	7.0	21.8	0.26	0.020	1.10	1.51
7SL-B	7466	1232	4800	475	5.30	24.5	0.13	0.055	1.10	0.44
8SL-T	12932	1266	4700	405	7.0	23.8	0.13	0.018	1.20	1.18
8SL-B	8266	1066	5200	380	4.4	25.3	0.50	0.052	1.30	1.29
Averages:										
Top (T)	11133	912	4406	385	5.0	25.1	0.20	0.040	1.35	1.19
Bottom (B)	8733	854	4006	335	4.0	23.9	0.39	0.041	1.18	0.92

*samples collected on February 26, 1977

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 2-SLS(c)

Concentration of Water-Soluble and Ion-Exchangable Metals in Sediments[@]

2nd Collection* - South Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Mn	Zn	Cd	Hg	Cu	Pb
		ppm								
1SL										
1SL-T	10250	600	2930	177	2.68	13.4	0.39	0.007	1.29	0.58
1SL-B	9625	700	3173	212	1.51	14,6	0.39	0.005	1.72	0.74
2SL-T	5575	740	3535	202	1.70	16.0	0.11	0.011	1.93	0.38
2SL-B	5000	932	3563	267	1.80	11.8	0.28	0.014	1.22	0.64
3SL-T	11750	1166	4870	371	3.26	13.4	0.17	0.012	1.29	0.61
3SL-B	5750	1266	4925	398	2.43	12.8	0.22	0.009	1.43	0.69
4SL-T	7000	1256	4758	398	2.68	13.3	0.34	0.019	1.29	0.86
4SL-B	4925	1300	4813	542	2.14	20.6	0.22	0.016	1.15	0.83
5SL-T	8075	720	2930	177	1.46	13.10	0.22	0.011	1.72	0.67
5SL-B	6075	966	3415	282	1.12	22.4	0.11	0.0	1.79	0.74
6SL-T	10575	466	2033	129	1.17	11.7	0.34	0.018	1.36	0.67
6SL-B	8575	834	3283	255	1.12	14.2	0.28	0.051	1.57	0.50
7SL-T	15750	720	2948	210	2.05	12.4	0.78	0.049	1.43	0.18
7SL-B	13500	732	2575	202	1.61	13.7	0.67	0.0	1.65	0.79
8SL-T	8575	1100	4648	332	2.73	15.2	0.45	0.0	1.15	0.86
8SL-B	9575	1066	3900	300	1.85	14.2	0.34	0.002	1.15	0.79
Averages:										
Top (T)	9444	846	3582	262	2.22	13.6	0.35	0.032	1.43	0.80
Bottom (B)	7878	974	3706	295	1.70	15.5	0.31	0.012	1.46	0.72

* Samples collected on May 7, 1977

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 3-SLS(c)

Concentration of Water-Soluble and Ion-Exchangable Metals in Sediments[@]

3rd Collection* - South Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Mn	Zn	Cd	Hg	Cu	Pb
			ppm							
1SL-T	7125	734	4100	222	1.78	10.80	1.30	0.295	1.39	0.43
1SL-B	8750	734	3350	221	1.02	11.55	1.00	0.526	1.25	0.76
2SL-T	9000	1066	5450	327	2.84	9.65	0.60	0.526	1.25	1.06
2SL-B	11250	1134	5750	367	2.16	9.30	0.70	1.154	1.11	1.59
3SL-T	4625	1400	8450	560	2.38	10.80	0.35	0.397	1.11	1.00
3SL-B	6875	934	4300	323	2.16	10.60	0.40	0.244	1.04	0.18
4SL-T	7825	734	3950	249	1.82	10.75	0.35	0.282	1.25	0.81
4SL-B	8575	466	2200	144	1.08	10.70	0.40	0.269	1.25	0.95
5SL-T	11375	1134	5800	315	6.47	11.95	0.75	0.269	1.67	0.88
5SL-B	9075	466	2900	143	1.14	10.40	0.35	0.282	1.04	1.11
6SL-T	11375	666	3500	214	1.19	11.15	0.45	0.372	1.11	0.62
6SL-B	8750	700	3475	221	1.36	10.90	0.40	0.208	1.11	0.76
7SL-T	8325	766	3300	238	1.36	11.40	0.10	0.305	1.39	0.61
7SL-B	8325	666	3350	218	2.04	10.70	0.45	0.337	1.81	0.70
8SL-T	10325	700	3850	188	2.44	10.50	0.50	1.619	1.11	0.83
8SL-B	10325	700	3700	211	2.16	11.70	0.45	0.529	1.25	0.78
Averages:										
Top (T)	8747	900	4800	289	2.76	10.9	0.55	0.508	1.29	0.78
Bottom (B)	8991	725	3628	231	1.64	10.7	0.52	0.444	1.23	0.85

* Samples collected on July 16, 1977

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 4-SLS(c)

Concentration of Water-Soluble and Ion-exchangable Metals in Sediments@

4th collection*-SSouth Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Mn	Zn	Cd	Hg	Cu	Pb
		ppm								
1SL-T	14750	1000	5000	220	2.34	13.35	0.80	0.27	1.90	1.25
1SL-B	8425	1125	4888	348	1.44	11.85	0.60	0.16	1.55	0.24
2SL-T	7075	1300	5800	384	2.77	12.55	0.43	0.14	1.95	0.27
2SL-B	7000	1100	4850	332	2.50	11.50	0.40	0.16	1.55	0.0
3SL-T	7125	1200	5000	386	2.87	11.85	0.35	0.27	1.65	0.40
3SL-B	8575	1250	5400	360	2.66	12.25	0.55	0.14	1.95	0.0
4SL-T	8125	1050	4973	282	3.94	12.05	0.43	0.19	1.75	0.0
4SL-B	5550	1375	5150	416	3.03	11.70	0.43	0.19	1.75	0.0
5SL-T	8500	725	3500	168	1.65	12.85	0.55	0.11	1.75	0.03
5SL-B	5425	825	3938	268	0.85	12.80	0.35	0.05	1.75	0.0
6SL-T	6825	575	2950	144	0.91	12.10	0.43	0.08	1.90	0.0
6SL-B	7175	800	3785	224	1.70	12.35	0.50	0.03	1.75	0.0
7SL-T	5425	800	4073	196	1.23	12.70	0.95	0.10	1.75	0.02
7SL-B	10675	800	3440	218	1.49	13.05	0.60	0.07	1.75	0.0
8SL-T	7700	675	3035	168	1.97	13.45	0.40	0.04	1.90	0.0
8SL-B	9500	450	2275	128	2.18	12.45	0.50	0.03	1.75	0.02
Averages:										
Top (T)	8191	916	3729	244	2.21	12.68	0.54	0.15	1.82	0.24
Bottom (B)	7791	966	4216	287	1.98	12.24	0.49	0.10	1.73	0.03

@ Sediments extracted with 1 N Ammonium Acetate Solution

* Samples collected on September 10, 1977

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 5-SLS(c)

Concentration of Water-Soluble and Ion-exchangable Metals in Sediments[@]

5th Collection[*] - South Mosquito Lagoon

Sample #	Ca	Mg	Na	K	Mn	Zn	Cd	Hg	Cu	Pb
		ppm								
1SL-T	7000	960	4700	370	4.14	17.9	0.32	0.0	2.15	1.02
1SL-B	6000	1120	5300	430	1.28	4.1	0.38	0.24	2.32	0.97
2SL-T	5960	600	3320	210	1.97	20.8	0.25	0.06	3.40	1.25
2SL-B	10800	960	4080	344	2.17	18.7	0.32	0.19	3.46	-
3SL-T	8100	1600	7760	650	4.69	3.1	0.32	0.18	3.04	0.94
3SL-B	7500	1580	7600	672	4.19	12.2	0.32	0.13	2.68	0.89
4SL-T	3200	1360	8240	604	6.65	5.0	0.19	0.11	2.41	0.72
4SL-B	4960	1240	5680	470	2.17	1.0	0.13	0.12	2.59	0.62
5SL-T	3400	5580	3020	200	1.09	1.6	0.32	0.19	3.22	-
5SL-B	3200	940	4200	370	0.74	5.6	0.70	0.13	2.86	0.60
6SL-T	4040	480	2320	150	0.79	18.9	0.51	0.07	2.95	0.98
6SL-B	7840	800	3500	296	0.74	2.8	1.01	0.11	3.40	0.15
7SL-T	6440	700	3200	224	1.19	3.2	0.76	0.12	3.13	0.77
7SL-B	5920	660	2900	224	0.59	2.8	0.57	0.12	2.86	0.91
8SL-T	5000	520	2400	160	1.04	3.1	0.88	0.12	2.50	0.80
8SL-B	11400	600	2500	208	0.99	2.4	0.95	0.12	2.77	0.82
Averages:										
Top (T)	5939	850	4370	321	2.70	9.2	0.44	0.11	2.85	0.93
Bottom (B)	7203	988	4470	377	1.61	6.2	0.55	0.15	2.87	00.62

[@] Sediments extracted with 1 N Ammonium Acetate Solution

[*] Samples collected on December 17, 1977

The sum total of cations in the top-layer sediments has shown a general decrease from the 1st to the 5th collection. Another interesting observation is that although the total major cations in the July collection of surface water are 8446 ppm (ref. page 15), yet the comparative total cationic concentration in the sediments of the same month is 14737 and 13575 ppm in the top and bottom layers respectively. This shows that the release of cations from the sediments is not readily caused by the slight dilution in the ambient water.

As reported earlier (2) Zn is the predominant element present among the trace metals of sediments. However, the Zn level of sediments of the South Mosquito Lagoon is much greater than the Zn level of Indian River sediments. The Zn content is maximum in February samples and it is somewhat constant at a low level in the other four collections. The average values of six water-soluble and exchangeable trace elements determined in the sediments of each of the five collections are tabulated as follows:

		I	II	III	IV	V	
1977		February 26	May 7	July 16	September 10	December 17	
Mn	(T)	5.00	2.22	2.76	2.21	2.70	ppm
	(B)	4.00	1.70	1.64	1.98	1.61	ppm
Zn	(T)	25.10	13.60	10.90	12.68	9.20	ppm
	(B)	23.90	15.50	10.70	12.24	6.20	ppm
Cd	(T)	0.20	0.35	0.55	0.54	0.44	ppm
	(B)	0.39	0.31	0.52	0.49	0.55	ppm
Hg	(T)	0.040	0.032	0.508	0.150	0.110	ppm
	(B)	0.041	0.012	0.444	0.100	0.150	ppm
Cu	(T)	1.35	1.43	1.29	1.82	2.85	ppm
	(B)	1.18	1.46	1.23	1.73	2.87	ppm
Pb	(T)	1.19	0.80	0.78	0.24	0.93	ppm
	(B)	0.92	0.72	0.85	0.03	0.62	ppm
Totals:	(T)	32.880	18.432	16.788	17.640	16.230	ppm
	(B)	30.431	19.702	15.384	16.570	12.000	ppm

The tabulation of average values of trace elements found in the sediments shows that the maximum average concentrations of Mn, Zn and Pb in both the top and bottom-layer sediments occurred in the February collection. The minimum levels of these elements were observed in the September or December samples (collections IV and V). Cadmium and Hg had the highest concentration in July but their minimum levels were found in February or May sediments (collections I & II). Copper was distinctly high in December and low in July samples.

The top and bottom samples of sediments do not differ markedly in their concentrations of Zn, Cu and Pb. With only a few minor variations, the Cd and Hg levels are nearly the same in both the strata of sediments. Manganese in general is somewhat lower in the bottom layer than in the top layer. This fact of Mn distribution has been observed consistently during the last year (2) and this year's study. The phenomenon of this nature may explain the formation of manganese nodules in the sea beds.

The total concentration of all the six trace elements is the highest in the February sediments and their total value is nearly constant at a much lower level in the other four collections. This kind of pattern is largely determined by the Zn concentration of sediments. It is also noticeable that excepting the December sediments (collection V), there is no significant difference between the total trace element content of top and bottom layer samples.

It is also important to point out that the total concentration of all the determined trace elements is about 20 - 30 times greater in the air-dry sediments in contrast to the concentrations observed in the surface and interstitial water samples (ref. p. 21 & 32). This reveals the mechanism and the capacity with which these toxic elements are held by the sediment particles.

Total Trace Metals in Sediments by Fusion Analysis. The results of fusion analysis indicating the total concentration of trace elements in the South Mosquito Lagoon sediments of the 1st and the 3rd collections are presented in Tables 1-SLF(d) and 2-SLF(d).

The data in these tables reveal that the total content of Mn is the highest of all the trace elements in collection I while the total Cu content is the highest in collection III. All the trace elements in these two collections of sediments range according to their decreasing order of total concentrations as follows:

Collection I : Mn, Cu, Zn, Cd, Pb, & Hg.
Collection III: Cu, Mn, Cd, Zn, Pb, & Hg.

Disregarding the order of concentrations, the data suggest that a major fraction of the elements of Mn, Cu and Cd is fixed in the crystal lattice of the mineral particles and these elements are released in the process of fusion analysis. This conclusion may be justified when the data for fusion analysis are compared with the data for the water-soluble and exchangeable fraction of these elements.

The total Cd and Cu contents are high in both the sets of sediments analyzed. It is not clear why the total Zn content in the 3rd collection turned out to be less than the water-soluble and exchangeable Zn fraction.

The concentration of total Hg is greater in the 3rd collection than in the 1st, while the total Pb is less in the 3rd collection sediments as compared to the 1st collection. The total contents of both Hg & Pb are greater than the corresponding concentrations of water-soluble and exchangeable Hg & Pb (ref. p. 44). It reveals that a portion of these two elements is also bound in the crystal lattice of the soil mineral despite the fact that the total content of these toxic elements is very low in the sediment-water system.

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 1-SLF(d)

Total Concentration of Trace Elements in Fused Sediments

(1st Collection* - South Mosquito Lagoon

Sample #	MN	Zn	Cd	Hg	Cu	Pb
	ppm					
1SL-T	51.5	22.0	24.5	0.216	27.5	0.04
1SL-B	38.6 m	33.0	23.5	0.216	25.0	0.02
2SL-1	66.9	38.0	29.4	0.152	21.3	4.13
2SL-B	49.7	30.0	24.4	0.398	30.0	9.6
3SL-T	68.6	48.0	21.6	2.076	42.5	1.87
3SL-B	61.7	47.0	18.6	0.066	51.5	4.00
4SL-T	65.2	39.0	17.6	0.066	58.8	0.14
4SL-B	48.0	65.3	36.8	0.108	131,9	2.67
5SL-T	32.6	41.0	16.7	0.060	72.5	3.60
5SL-B	42.9	31.0	21.6	0.028	30.0	2.93
6SL-T	32.6	31.0	23.5	0.028	21.3	3.40
6SL-B	36.0	32.0	21.6	0.016	21.3	1.20
7SL-T	51.5	42.0	21.6	0.398	42.5	2.93
7SL-B	61.7	40.0	21.6	0.028	21.3	1.87
8SL-T	80.6	43.0	26.5	0.066	36.3	0.14
8SL-B	73.8	35.0	23.5	0.072	27.5	4.93
Averages:						
Top (T)	56.2	38.0	22.7	0.383	40.3	2.03
Bottom (B)	51.6	39.2	24.0	0.117	42.3	3.40

* Samples collected on February 26, 1977

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 2-SLF(d)

Total Concentration of Trace Elements in Fused Sediments

3rd Collection*- South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Hg	Cu	Pb
	ppm					
1SL-T	18.0	8.6	18.4	1.076	39.8	2.48
1SL-B	17.0	6.8	18.4	0.308	36.2	4.10
2SL-T	21.0	10.5	21.0	0.538	29.0	4.64
2SL-B	17.0	5.5	21.0	0.0	29.0	1.58
3SL-T	18.0	5.5	13.2	0.109	29.0	0.74
3SL-B	42.0	8.0	30.3	0.77	25.4	2.78
4SL-T	27.0	12.0	21.0	2.783	25.4	2.45
4SL-B	14.0	4.0	13.2	1.462	29.0	1.97
5SL-T	21.0	4.3	10.5	1.154	29.0	1.45
5SL-B	20.0	4.3	10.5	0.076	25.4	1.32
6SL-T	18.0	4.3	17.1	0.076	25.4	0.16
6SL-B	17.0	3.7	13.2	0.0	25.4	1.22
7SL-T	22.0	13.6	18.4	0.0	43.5	0.48
7SL-B	15.0	6.8	13.2	0.924	18.1	0.94
8SL-T	29.0	11.1	30.3	0.819	21.7	2.36
8SL-B	17.0	2.5	9.2	2.460	29.0	0.0
Averages:						
Top (T)	21.8	8.8	18.7	0.849	30.4	1.85
Bottom (B)	19.9	5.2	16.1	0.78	27.2	1.74

---

* Samples collected on July 16, 1977

Total Trace Metals in Sediments by HCl Extract Analysis. For the total analysis of a soil by chemical procedures, all the elements have to be brought into solution. Two main methods of achieving this are 'Fusion of the soil with subsequent digestion of the melt' and 'Digestion of the soil with strong acids'. It is not possible to recommend one method as better than the other as the suitability of either depends on the elements to be determined (4). For the determination of every element, it would be necessary to prepare portions of soil sediment sample in more than one manner.

The total analysis gives a better idea of trace element availability due to greater range of concentration of trace elements in different soils. From this point of view, the analysis of strong HCl extract of the sediment samples of the 1st and the 3rd collections of South Mosquito Lagoon was performed. The results are included in Tables 1-SLH(e) and 2-SLH(e).

The data indicate that Mn is the most abundant trace element in the sediments followed by Zn and then Cu or Cd. The Mn values from the HCl extract analysis seem fairly compareable with the Mn values from Fusion analysis. The Zn values are more logical and consistent in this HCl procedure than the other one. The total Cd values in this analysis also appear reasonable. However, the total Cu values cause some doubt about this procedure since Cu is quite high in the 1st collection and is rather low in the 3rd collection of sediments. The total Cu values obtained by fusion analysis are markedly high in both the collections of sediments analyzed.

On the whole, the'HCl Extraction' procedure appears to give better results about the total trace elements in these sediments. Further investigations are proposed to be undertaken to confirm this finding.

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 1-SLH(e)

Concentration of Trace Elements in HCl Extract of Sediments

1st Collection* - South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu
	ppm			
1SL-T	24.3	31.5	9.5	24.0
1SL-B	19.9	18.5	16.2	14.0
2SL-T	19.9	35.1	21.6	18.0
2SL-B	28.7	35.7	13.5	22.0
3SL-T	68.4	27.4	17.6	34.0
3SL-B	79.5	27.4	6.8	28.0
4SL-T	92.7	30.7	24.3	60.0
4SL-B	-	-	-	-
5SL-T	24.3	28.3	13.5	42.0
5SL-B	22.1	17.6	5.4	14.0
6SL-T	24.3	28.3	8.1	14.0
6SL-B	28.7	25.9	10.8	22.0
7SL-T	118.1	40.8	13.5	24.0
7SL-B	66.2	26.2	2.7	18.0
8SL-T	79.5	28.0	8.1	14.0
8SL-B	92.7	32.7	9.5	18.0
Averages:				
Top (T)	64.5	27.7	12.3	28.8
Bottom (B)	48.3	26.3	9.3	19.4

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* Samples collected on February 26, 1977

NASA PROJECT SEDIMENT SAMPLE ANALYSIS

Table 2-SLH(e)

Concentration of Trace Elements in HCl Extract of Sediments

3rd Collection* – South Mosquito Lagoon

Sample #	Mn	Zn	Cd	Cu
	ppm			
1SL-T	24.0	16.0	3.1	0.0
1SL-B	29.7	19.9	3.1	1.5
2SL-T	29.7	19.0	4.6	3.1
2SL-B	45.7	20.6	3.1	3.1
3SL-T	52.6	21.5	6.1	3.1
3SL-B	43.4	17.4	6.1	3.1
4SL-T	25.1	15.4	4.6	3.1
4SL-B	-	-	-	-
5SL-T	36.6	7.7	9.2	3.1
5SL-B	13.7	15.4	6.1	3.1
6SL-T	20.6	19.3	7.7	3.1
6SL-B	18.3	17.7	4.6	3.1
7SL-T	22.9	16.1	3.1	0.0
7SL-B	25.1	15.8	12.2	0.0
8SL-T	27.4	12.9	1.6	1.5
8SL-B	25.1	19.9	12.2	3.1
Averages:				
Top (T)	29.9	16.0	5.0	2.1
Bottom (B)	28.7	18.1	6.8	2.4

---

* Samples were collected on July 16, 1977

Results of Microbiological Studies. The microorganisms were isolated by pre-enrichment and enrichment techniques, and were identified by biochemical tests. Among the factors tested, temperature exerted the most significant effect. The highest counts of single bacterial isolates or mixed cultures occurred in samples incubated at 18 or 25 C. Microbial floral composition was also affected by elemental composition of the sediments, especially during late spring or early summer. In particular, the elevation of levels of toxic elements such as cadmium caused a reduction in microbial counts. Results also suggest a possibility of the occurrence of bacteriolytic activity since the bacterial load was generally low ($\leq 10^5$/ml).

Microorganisms constitute a vital link in the biogeochemical cycling of nutrients in the aquatic ecosystem. In our studies of water and sediment samples from Haulover Canal, Mosquito Lagoon and the Indian River around Kennedy Space Center (Florida), the following organisms have been identified by the above methods:

Bacteria: 1. *E. coli* 2. *Pseudomonas aeruginosa* 3. *Clostridium perfringens*
4. *Staphylococcus aereus* 5. *Bacillus* species

During the extension period of this project, these five strains of bacteria identified in the aquatic samples are being studied by using the Pyrolysis-Gas-Liquid-Chormatography (PGLC) technique. The pyrograms of the isolated organisms will be compared with the standard reference cultures by using the same technique and the similar parameters on the gas chromatograph. Since these studies are still in progress, their results are proposed to be included in the next year report.

EVALUATION OF RESULTS AND CONCLUSIONS

(A) General Trends in the Concentration of Major and Minor Constituents of South Mosquito Lagoon Water. The aquatic system of South Mosquito Lagoon is a contiguous part of the North Mosquito Lagoon. The south-ward flow of water is prevented by the land barrier at its terminus and then the water tends to reverse its direction north-ward to pass through the Haulover Canal and resume the general flow with the Indian River. Although there is practically no boating traffic through this enclosed lagoon, yet the water mass appears to be well-mixed due to the two-way movement as well as the localized currents.

In this apparently homogeneous water body no significant variations occurred among the water characteristics of samples from different collection sites. However, there were prominent seasonal variations in the composition of water samples of the five collections. For a general representation of the data, the concentrations of a given element in the samples collected on the same day of each collection were averaged. Figure 3 is a plot of the pH and salinity versus the period of collection since February, 1977. The upper curve shows the correlation between pH and time and the lower one shows the relation between salinity and time. The pH of water is relatively uniform, but the salinity shows a maximum in September. High water temperature and low rainfall in September seem to be the causes for high salinity during this period.

Water temperature affects the shape of dissolved oxygen curve. The optimum temperature for the decomposition of organic wastes by microorganisms ranges from 25 to 30 C. In addition, oxygen is less soluble at high temperatures, so oxygen levels in rivers receiving organic wastes have the lowest oxygen concentrations during the months of July and August (6). In this lagoon study the temperature of water ranged from 21.6 to 31.4 C and the minimum dissolved oxygen (DO) of 5.8 mg/liter was present in the maximum water temperature of July.

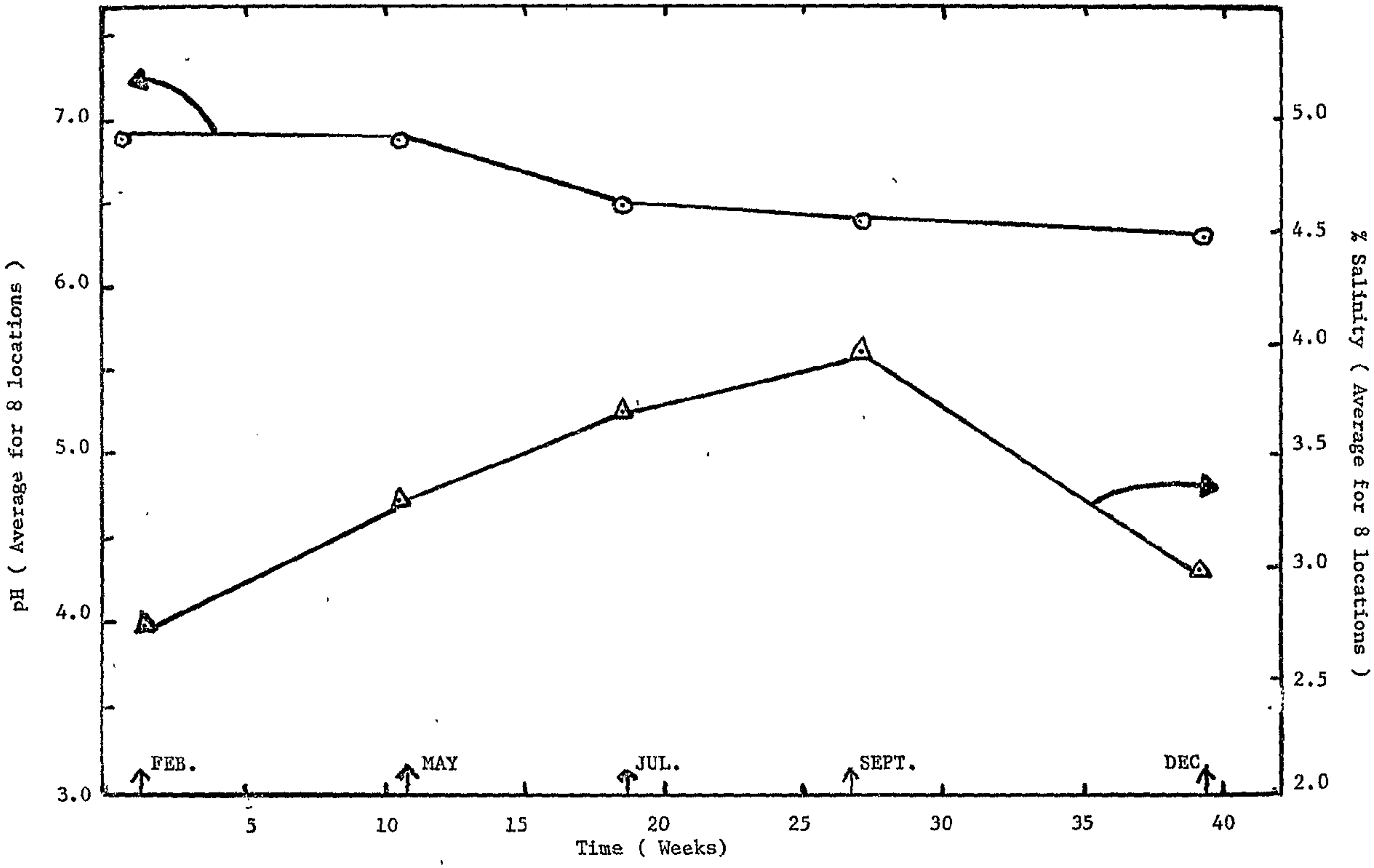

FIGURE 3 SEASONAL VARIATION IN THE AVERAGE VALUES FOR pH AND SALINITY FOR EIGHT LOCATIONS IN WATER SAMPLES

Figure 4 shows the variation in the average values of concentrations of Cl, SO_4, HCO_3 and P as a function of sampling times. Of these constituents, Cl and SO_4 show a maximum concentration level in the 3rd collection made in July; HCO_3 is at the maximum level in May, July and December (2nd, 3rd & 5th collections); while the P is at the highest concentration in the spring samples of May. The maximum concentration levels of Cl and SO_4 may be attributed to the high mobility of these ions in the ambient high temperature of water in July. The bicarbonate concentration is a function of the solubility of CO_2 at the varying temperatures as well as the rate of decomposition of organic wastes.

Inorganic phosphorus and nitrogen are added to the lagoon water by the decomposition of organic waste material and by the nutrients carried through surface run off from the surrounding land. The phosphorus values are low and tend to vary by a small factor of two from the minimum to the maximum. Alberts et al. (7) reported the decrease of phosphorus from 0.62 ppm (20 ug atoms P/liter) in fresh water of Peace River (Florida) entering the estuary where it decreased to 0.02 ppm phosphorus in 3.2% salt water. The P values in the South Mosquito Lagoon water ranged from 0.017 to 0.038 ppm.

Jaworski et al. (8) reported 0.1 to 0.2 ppm NH_4-N and 0.1 to 0.3 ppm NO_3-N in the saline estuary of Potomac River during August 17 - 22, 1968, water temperature being 27.5 C. The NH_4-N values in the lagoon water in our study ranged from 0.09 to 0.65 ppm whereas the NO_3-N was either absent or was present in negligible concentrations. This indicates the lesser amounts of the addition of organic wastes coupled with the slower rate of nitrification.

In Figure 5 the seasonal variations in the average concentrations of major cations are depicted. Except for Mg, the major cations show the maximum concentration in late spring in May. The maximum for Mg is in July which seems to be associated with the maximum for SO_4 and Cl.

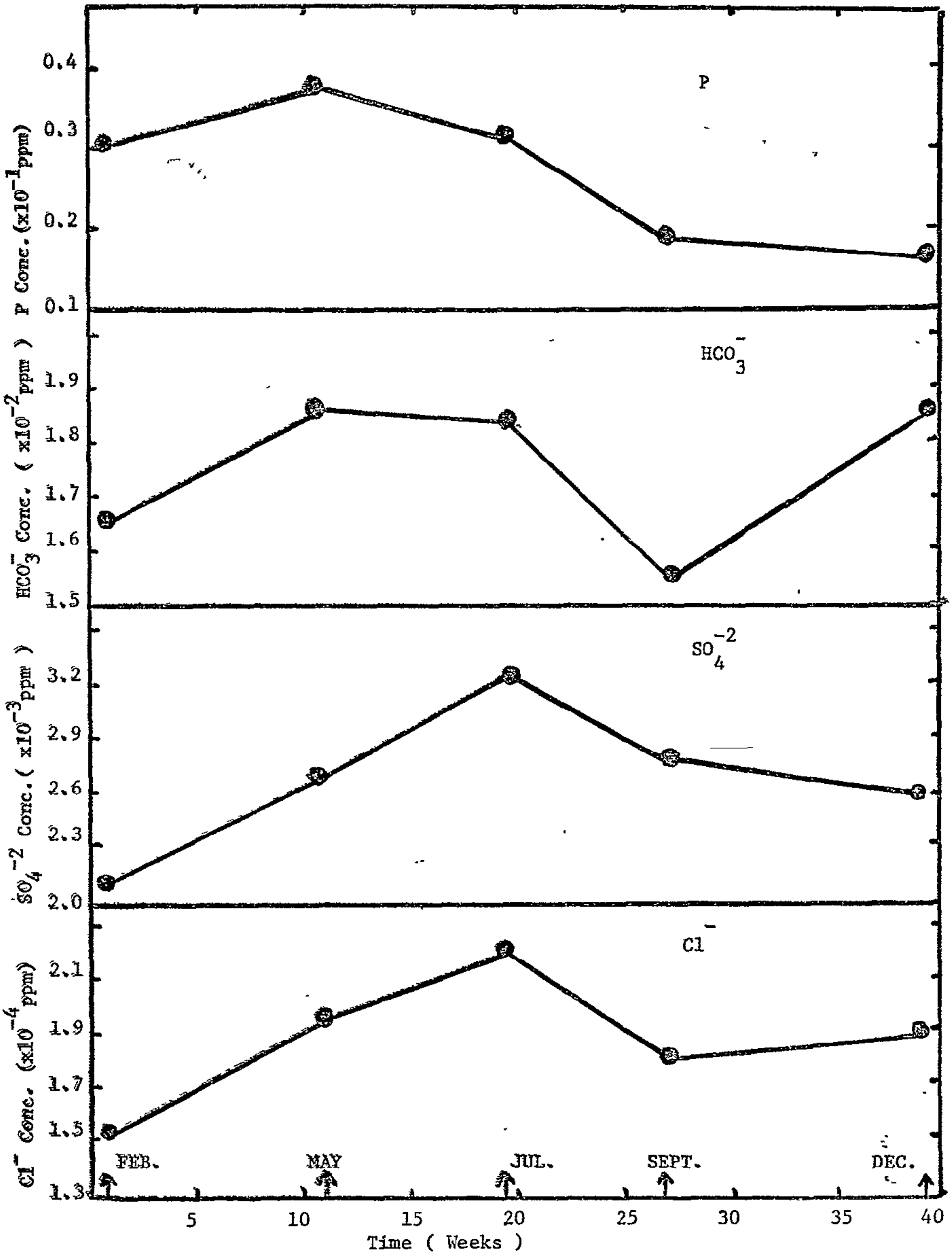

FIGURE 4. SEASONAL VARIATION IN THE AVERAGE VALUES OF CONC. OF Cl$^-$, SO$_4^{-2}$, HCO$_3^-$ AND P FOR EIGHT LOCATIONS IN WATER SAMPLES

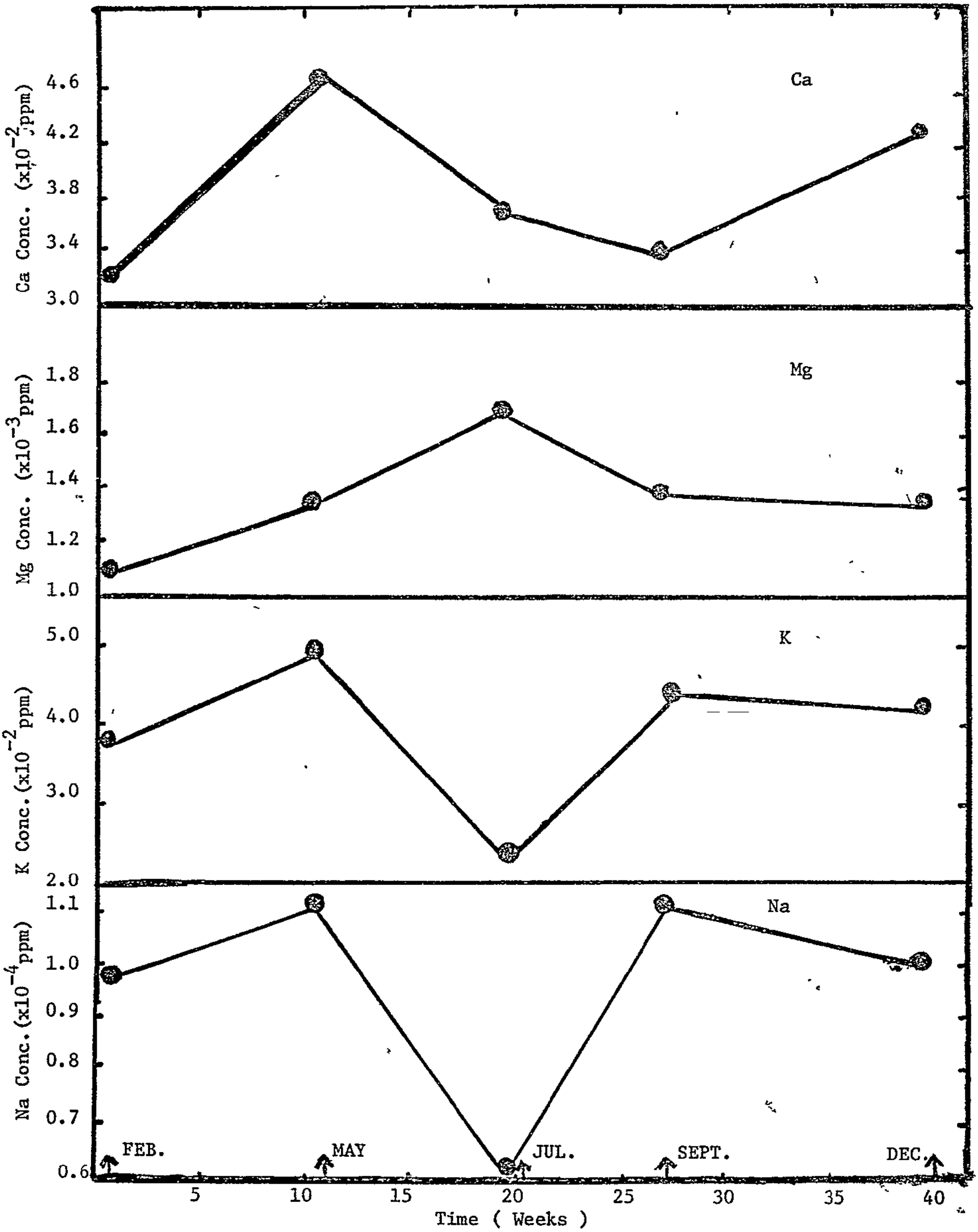

FIGURE 5 SEASONAL VARIATIONS IN THE AVERAGE VALUES OF CONC. OF MAJOR CATIONS IN WATER SAMPLES

Other seasonal concentration variations in the occurrence of maxima and minima as well as the variations from one period to the other for the various major ions may be attributed to the variations in temperature, amount of precipitation and biological activity. The concentrations of the major chemical constituents in the South Mosquito Lagoon water arrange in the decreasing order as follows: Cl, Na, SO_4, Mg, K, Ca, HCO_3

This order to a great extent resembles the order of these ionic concentrations in a seawater at 3.5% salinity with the exception that in the seawater the Ca is slightly more than the K (9). The major elements of Na, K, Mg and Ca are essential for the growth of organisms (10).

Toxic Trace Elements in South Mosquito Lagoon Water. Figure 6 is a plot of the average concentrations of Zn, Mn, Cd and Pb in the five collections of water samples as listed on page 21 of this report. The data for Cu and Hg in water have not been plotted. All of six trace metals can be pollutants and can be toxic at certain concentration levels. Toxicologists are concerned primarily with adverse responses in individual human subjects or in individuals of domesticated species of animal. In contrast, the ecologist is more concerned with the survival of a population. The difference in viewpoints is further complicated by the hierarchy of biological organization and structure, each level of which has its own unique complexities. Among the impacts of pollution on communities, population and organisms, acute toxicity affects survival of individuals, but there are also many chronic, sublethal effects of pollution. A pollutant may affect the genetics of a population or the behavior of organisms, such as their migration or their breeding behavior. Some pollutants may be biostimulatory at low concentrations or inhibitory at high concentrations.

Sea water is a highly complex mixture of all the elements known, and there are consequently a number of chemical problems which must be understood in order

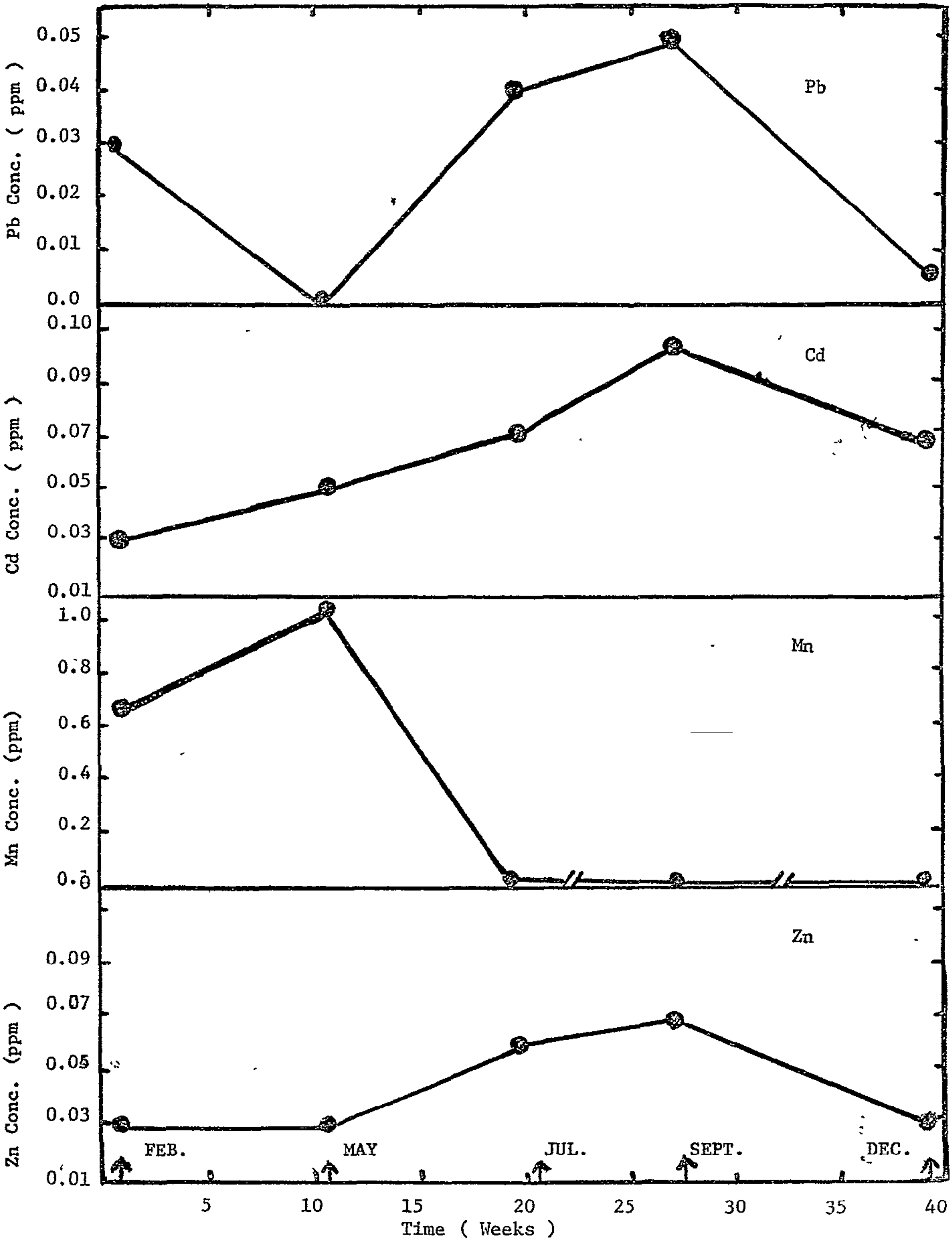

FIGURE 6. SEASONAL VARIATIONS IN THE AVERAGE VALUES OF CONC. OF SELECTED TRACE ELEMENTS IN WATER SAMPLES

to evaluate the impact of pollutants. Anything added may form complexes, may undergo chemical reactions, may suffer alteration of valence states, may be sorbed into particulate matter, or may be sedimented to the bottom, where, although removed from the aqueous phase, it may still have impacts on the sea bed populations. These physical or chemical processes can greatly modify the direct effect of the pollutant on the ecosystem.

Interconnecting all these parts of the ecosystem, there are problems of synergism and antagonism. It means that two different pollutants may aid or may oppose each other's action on living organisms. The receiving capacity of any aquatic system is determined by the physical process of circulation and mixing. The term 'receiving capacity' refers to the amount of pollutant addition without any serious deleterious effects upon the organism in the environment. The determination of receiving capacity and the ultimate export of a pollutant from the system requires monitoring to make correct predictions.

Ketchum (11) compared the toxicity of eleven elements in Table 3.2 of his paper with available estimates of concentrations found in sea water.

Table 3.2. Toxic Heavy Metals of Importance in Marine Pollution Based on Their Sea WATER Concentration and Toxicity. (Bostwick H. Ketchum)

Element	Seawater concentration (ug / liter)		Toxicity (ug/liter)	Ratios	
	A	B	C	A/C	B/C
Mercury	0.2	0.05	0.1	2	0.5
Cadmium	0.1	0.05	0.2	0.5	0.25
Silver	0.3	0.1	1	0.3	0.1
Nickel	7	2	2	3.5	1
Selenium	0.09	0.45	5	0.018	0.09
Lead	0.03	0.03	10	0.003	0.003
Copper	3	3	10	0.3	0.3
Chromium	0.5	0.6	10	0.05	0.06
Arsenic	2.6	2.3	10	0.26	0.23
Zinc	10	5	20	0.5	0.25
Manganese	2	2	20	0.1	0.1

The ratio of concentration divided by toxicity shows how close the sea water concentration is to the amount considered to pose a risk, though minimal, of deleterious effects. For Hg, concentration in column A of Table 3.2 (Ketchum) suggests that sea water already contains twice as much mercury as should be permitted. From these data Ni appears to be more of a problem, with sea water concentration being equal to three times greater than the acceptable toxic level. It is well known that methyl mercury is more toxic than the ionic form. Both Goldberg et al. (12) and Riley and Chester (13) list mercuric chloride or a chloride complex ($Hg\,Cl_2$ or $HgCl_4^{2-}$) and ionic nickel (Ni^{2+}) as the most probable species of these elements in sea water. Recent studies (Brewer and Spencer, 14) have shown that considerable variation exists in the results of different analysts or analytical methods for heavy metals in sea water.

Following a similar approach as that of Ketchum (11) we have shown the toxicity ratios for the minimum and maximum concentrations of six heavy metals determined in the South Mosquito Lagoon water in Table 6 below:

TABLE 6: Minimum and Maximum Concentrations* of Toxic Heavy Metals in South Mosquito Lagoon Water and their Toxicity.

Element	Lagoon water concentration¢ (ug / liter)		Toxicity(ug/liter)	Ratios	
	A (Minimum)	B (Maximum)	C@	A/C	B/C
Mercury	0.15	0.92	0.1	1.5	9.2
Cadmium	50.6	87.6	0.2	253	438
Lead	2.2	64.6	10	0.22	6.46
Copper	95.8	156.4	10	9.58	15.64
Zinc	26.6	55.6	20	1.33	2.78
Manganese	172	648	20	8.6	32.4

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* Min. and Max. values selected from each of the Table 1-SLW(c) to 5-SLW(c) and averages calculated for the five collections of water samples.

¢ Concentrations changed from ppm (parts per million or milligrams per liter) to ug/1 (micrograms per liter).

@ Toxicity values taken from Table 3.2 (Ketchum).

It is clear from Table 6 that the calculated toxicity ratios of heavy metals in the South Mosquito Lagoon water are quite high. Only the minimum ratios for Hg, Pb and Zn provide a fair comparison with the ratios given in Table 3.2 (Ketchum). The concentration values and the corresponding toxicity ratios for Cd, Cu and Mn are abnormally high. During our determinations, we were mindful about the high values obtained for these metals by the flame atomization procedure. For a fair comparison with the values obtained by other investigators, different techniques of estimation involving solvent extraction and flameless atomization need to be considered in future studies. In our estimations of heavy metals, we had employed mainly the flame atomic absorption spectrophotometer method because the graphite furnace attachment for the flameless atomization was not available. Likewise, the Ni values for the Indian River water estimated last year (2) by flame atomic absorption were rather high.

Mercury and Pb values for the lagoon water are in better agreement with those reported by other workers and the published values (9, 11). These two metals were estimated by different methods of solvent extraction and measurement (Ref. Analytical Procedures of this report and 2.) Hence it is very important that the toxicity values listed in Table 6 be used with extreme caution. On the basis of these arbitrary values we cannot say that the concentrations of Cd, Cu and Mn and even Hg, Pb and Zn in the South Mosquito Lagoon water exceed the safety limits and pose a potential hazard. The toxicity concentrations given in Table 3.2 (Ketchum) must also be looked with caution. For instance, most plant species and animals can tolerate high concentrations of manganese. The maximum permissible amounts of Mn in air for male mine workers for an 8-hour day has been set at the level of 5 mg/m^3 (15). Under normal conditions the dietary Mn intake of man is approximately 3 mg/day. Of this only one percent is retained by the body. How much of Mn a man may be getting from saltwater fish, requires investigation.

It is equally important to point out that the values derived in Table 6 may not be considered as insignificant. These values clearly indicate the seasonal as well as the locational variations in the range of concentrations of toxic metals in the water samples of the study area. The data point out as to when a particular element is in extremely low concentrations and when it assumes high levels to cause any concern. For example in Table 1-SLW(c) of 1st collection, the concentrations of Cd and Pb range from zero to 40 and 60 ug/1 respectively among the eight sampling sites. In Table 2-SLW(c) of 2nd collection (in May), the Pb was completely absent in all of the samples. In Table 4-SLW(c) of 4th collection (in September), the Mn level varied from zero to 10 ug/1.

Because of the unique susceptibility of manganese oxides to dissolution with decreasing redox potentials, the concentration of dissolved Mn in natural waters and in soil solutions usually fluctuates more than does the concentration of other first-transition series of elements. According to Slowey (16) the concentration of Mn in marine waters ranges from 0.00004 to 0.016 ppm. Many of our values of Mn reported for the South Mosquito Lagoon water fall in the upper limit of this range.

It is clear that we need to know much more about concentrations, distributions, speciation, and toxicity of these elements, before final conclusions can be reached about the hazard they represent to the marine ecosystem around Kennedy Space Center. More long-term evaluations are needed by way of monitoring these water bodies at least twice a year for the levels of the toxic metals.

(B) <u>General Trends in the Concentration of Major and Minor Cations in the Interstitial Water and the Ion-Exchangeable Fraction of Sediment Samples of South Mosquito Lagoon</u>. The interstitial water represents a transition phase between the solid sediment particles at the bottom and the surface water. Looking at the results of four trace elements of Mn, Zn, Cd and Cu in the interstitial water in Tables 1-SLS(b) to 5-SLS(b) and the averages listed on page 32, it may be inferred that the precipitation action and the binding capacity of the sediments interact differently with these metals. In general, Mn and Zn levels are greater in the interstitial water as compared to to their levels in the surface water of the same sites (comparison of data on pages 21 and 32 of this report). Cadmium and Cu however, are either nearly the same in both phases of water or the interstitial water has somewhat lesser concentrations of these elements. For a proper understanding of the precipitation (or sedimentation) characteristics of these heavy metals in the aquatic bodies, it is pertinent to consider their distribution in the interstitial water phase around the sediment particles.

The cations that are bound to the surface of the sediment particles are leached out by an exchange reaction during the ammonium acetate extraction. In this fraction the trace elements may be accumulated by adsorption on the particles and their sedimentation as well as by the downward trapping of the precipitates of the metallic oxides into the sediments. A comparison between average values of major and minor cations in water (pages 15 & 21) and the values of these cations in the sediments (pages 38 & 44) reveals the differences of great magnitudes.

Figure 7 is a plot of the average concentrations of four metals, Ca, Zn, Cd, and Pb as a function of collection times in the top and bottom sediment samples. It is seen from these graphs that both the Ca and Zn levels decrease with time of collection, maximum being in February and minimum in December. Cadmium concentration in sediments has consistently increased with time. The Pb values remained about the same over the entire year except that it was the minimum in September sediments (4th collection). There are no distinct differences between the concentrations of metal ions in the top and bottom sediments. This indicates the fresh addition of sediments with adsorbed cations and the slow movement of these metals to the lower layer.

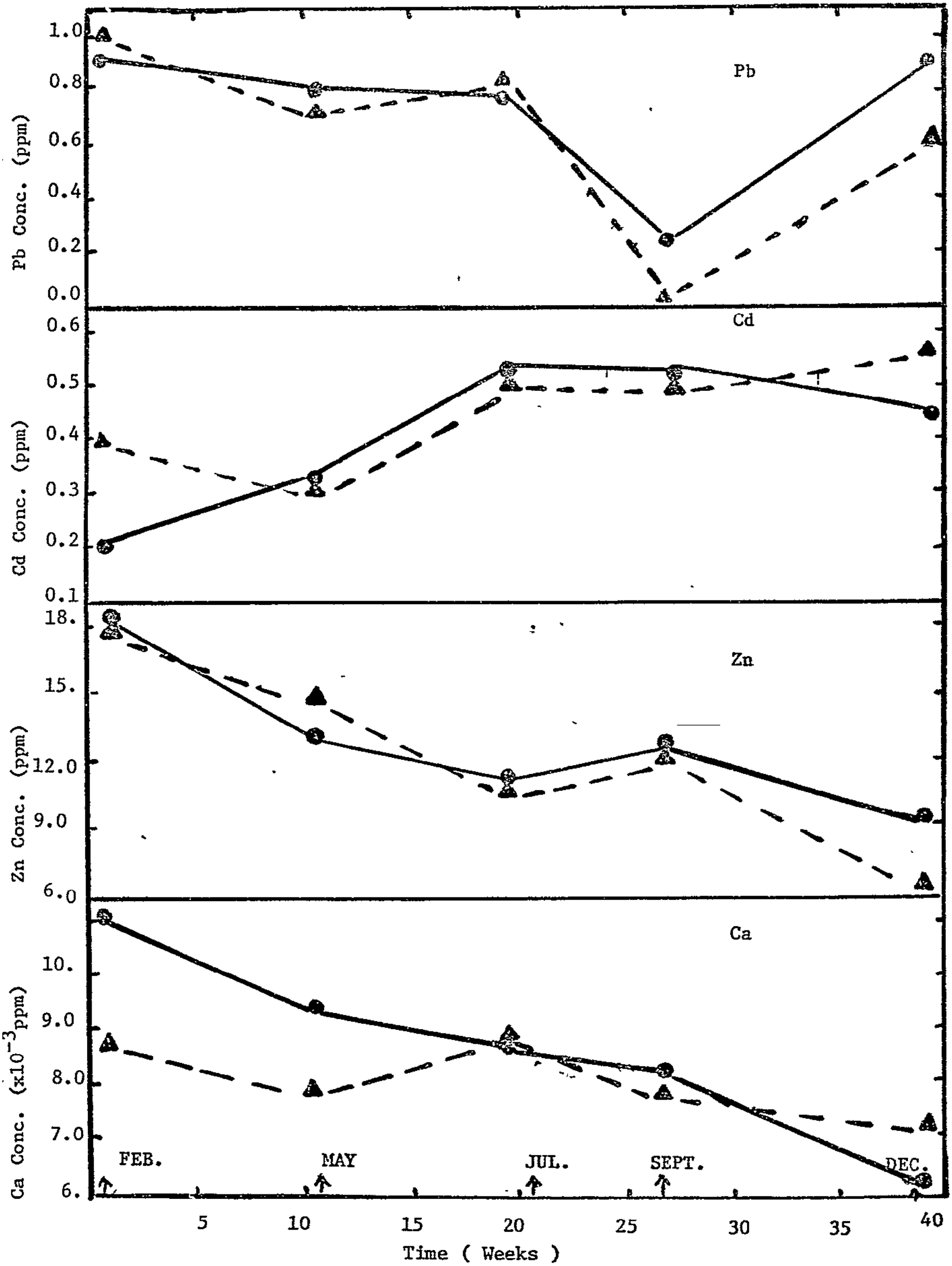

FIGURE 7. SEASONAL VARIATION IN THE AVERAGE VALUES OF CONC. OF SURFACE BOUND CATIONS IN SEDIMENTS (___ Top Portion; --- Bottom Portion)

In order to get a better idea of the relative sedimentation rates of these metals we have normalized their concentrations in both the sediment and water phases against the K concentration selected as the reference element in each phase. The sedimentation ratios were calculated by dividing the normalized values of exchangeable metals in the sediment with the normalized values of these metals in water. Table 7 lists the average normalized values of Ca/K, Zn/K, Cd/K and Pb/K respectively in the water and sediment fractions, and their sedimentation ratios as well. It can be seen from this table that the values of $(Ca/K)_W$ are approximately uniform for the five collections within the range of 0.78 to 1.539 while these values for other metals vary significantly. This is in fair agreement with our observations stated in the 1st and 2nd annual reports (1, 2). This signifies the fact that appreciable changes in the concentrations of trace metals, especially the transition metals do occur in the different periods of sample collection as affected by a variety of physical, chemical and biological factors. However, there is a significant variation in the values for $(Ca/K)_S$ in the five collections of sediment samples probably due to staggering values of calcium estimation caused by the mixture of fine pieces of shells in the samples.

Depending upon the replacing power of the major cations in the exchange reaction and the relative mass effect of their concentration in the surface water, the concentrations of major cations as obtained by the analysis of the ammonium acetate extract of the sediment range as follows:

$$Ca > Na > Mg > K$$

In Figure 8 the average values of $(M/K)_S$ / $(M/K)_W$ where M refers to Ca, Zn, Cd and Pb, are plotted as a function of collection time. The figure shows the maximum sedimentation rates for Ca in May and September; for Zn and Cd in May; and for Pb in December. It is noteworthy that the sedimentation ratios can be arranged in the decreasing order as: Zn $>$ Ca $>$ Cd. These ratios for Pb are quite variable, but most values are apparently greater than those for calcium.

Table 7 : Average Values for $(M/K)_W$ and $(M/K)_S$ and for $(M/K)_S/(M/K)_W$ for the Top and Bottom Portions of the Sediment for the Entire Aquatic System (South Mosquito Lagoon) at each collection Time*

Colln. No. and Sediment Portion		$(Ca/K)_W$	$(Zn/K)_W$ $\times 10^5$	$(Cd/K)_W$ $\times 10^5$	$(Pb/K)_W$ $\times 10^5$	$(Ca/K)_S$	$(Zn/K)_S$ $\times 10^2$	$(Cd/K)_S$ $\times 10^3$	$(Pb/K)_S$ $\times 10^3$	$\frac{(Ca/K)_S}{(Ca/K)_W}$	$\frac{(Zn/K)_S}{(Zn/K)_W}$	$\frac{(Cd/K)_S}{(Cd/K)_W}$	$\frac{(Pb/K)_S}{(Pb/K)_W}$
1	(T)	0.859	7.93	7.60	7.60	28.92	6.5	0.52	3.09	33.64	819.6	6.83	40.6
	(B)					26.07	7.1	1.16	2.75	30.34	893.0	15.20	35.5
2	(T)	0.945	6.07	10.12	0.0	36.05	5.2	1.34	3.05	38.15	856.0	13.24	- -
	(B)					26.71	5.3	1.05	2.44	28.26	873.0	10.38	- -
3	(T)	1.539	22.70	28.93	15.7	30.27	3.8	1.90	2.70	19.67	167.4	6.67	17.19
	(B)					38.92	4.6	2.25	3.68	25.29	202.6	7.78	23.44
4	(T)	0.780	13.60	28.3	11.33	33.57	5.2	2.21	0.98	43.03	382.3	7.77	8.65
	(B)					27.15	4.3	1.70	0.10	34.80	316.2	6.00	0.88
5	(T)	0.992	6.87	17.5	1.18	18.50	2.7	1.37	2.89	18.65	393.0	7.82	244.0
						19.11	1.6	1.46	1.64	19.26	232	8.34	138.98

---

* $(M/K)_W$ is the ratio of the concentration of a given metal to that of K in water samples

$(M/K)_S$ is the ratio of the concentration of a given metal to that of K in the ion-exchangable fraction of the sediment (Ammonium Acetate Extract)

The average concentration for the metals were obtained by summing the concentration of all of the water samples and in sediment samples the average concentration was obtained by summing the concentration of all of the sediment samples (Top and Bottom separately) separately from eight locations

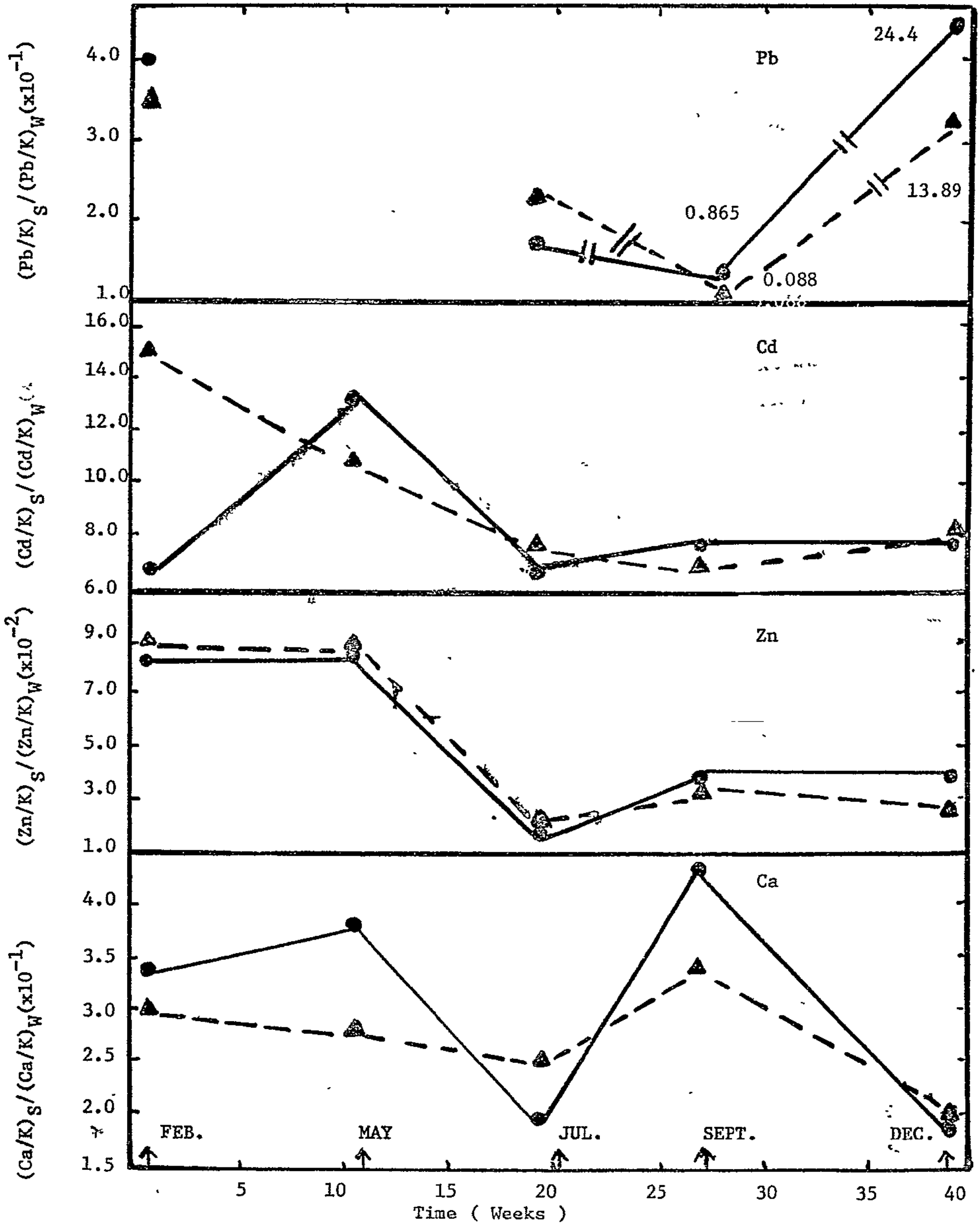

FIGURE 8. SEASONAL VARIATION IN SEDIMENTATION OF A FEW METALS RELATIVE TO POTASSIUM (_ Top Portion; ---- Bottom Portion) ; Average conc, of lead for 2nd collection is zero and hence the data points for second collection missing.

(C) Relation between Water-Soluble, Surface-Bound, and Internally-Bound Trace Elements in South Mosquito Lagoon. Just like the Indian River study (2), an attempt was made to determine the distribution of trace metals in the aquatic system of South Mosquito Lagoon. Without considering the possible presence of heavy metals as organic complexes or chelates in this water body, a simplified approach was adopted to determine their distribution among three phases, namely (a) the water-soluble fraction, (b) water-soluble but surface-bound or exchangeable cations, and (c) internally bound cations. It was assumed that the water-soluble fraction comes off with the interstitial water and the surface-bound cation is released through the cation exchange process by the ammonium acetate extraction. This fraction may also contain about 20 - 30% of the cationic content in the interstitial water because of the moisture content of the suction-filtered sediment samples which were used, after drying, for the ammonium acetate extraction. However, this amount was considered negligible in comparison with the relatively large concentration of cations in the sediments.

Four cations, namely Zn, Mn, Cd and Cu were chosen for the above study. Among the 8 sampling locations, the concentrations of a given metal were averaged over the five collections for each sample location. This was done with the data from the interstitial water analysis, and the analysis of ammonium acetate extract. The fusion extract data of only the 1st collection was used as an indication of the total concentration of the internally bound and surface-bound cations. The concentration of internally bound cations was obtained by subtracting the concentration of surface-bound cations (ammonium acetate extractable) from the total concentration. The percent distribution of each cation in each fraction was computed by using the following equation (2, p.79):

$$\% E_i = \frac{C_i}{C_{I.B.} + C_{S.B.} + C_{W.S.}} \times 100$$

where $\% E_i$ is the percent of the element or cation in the i'th fraction and C_i is that in the same fraction.

The results of these computations for the four elements of Zn, Mn, Cd and Cu are summarized in Tables 8 and 9.

The data in these ~~tables~~ indicate that the total trace element content in the sediment and interstitial water together (composite of all the fractions) for the four elements falls in the order of: Mn > Zn > Cu > Cd. It may be pointed out that the total content of these elements in the Indian River was in the decreasing order of Mn, Cd, Zn and Cu (Ref. 2 p. 79). The tables also show that except for Zn, more than 90% of each of the Mn, Cu and Cd elements exists in the internally bound fraction. In the case of Zn, a significant fraction is found as surface-bound species. With the exception of a few sampling sites, less than one percent of the total of each trace element content is observable in the interstitial water.

Figure 9 shows the relation between water-soluble, surface-bound and internally bound Zn for 16 samples (top and bottom layers). A triangular set of co-ordinates in which each apex represents 100% of the indicated type of zinc was used for plotting the data. It is seen from this figure that Zn is mostly distributed between surface-bound and internally bound forms. As reported last year (2) similar diagrams were not drawn for other elements since more than 90% of these elements were found in the internally bound fraction and therefore, all the points would be clustered near one apex.

It is rather encouraging to find the confirmation of our previous observations (2) that the toxic elements of Cd, Mn and even Cu appear only as an insignificant fraction in the interstitial water. Unlike Zn, these three elements seem to concentrate in the inner lattice of sediment particles, thus making them more difficult to be released to the surrounding water during turbulations and resuspension of the sediments. It will be interesting to study the release of these elements by various extracting reagent solutions.

Table 8: Percent Distribution of Zinc and Manganese among Water-soluble, Surface-bound and Internally-bound Fraction of Sediments Collected from Eight Locations[*]- South Mosquito Lagoon

	Zinc				Manganese			
Sample	Zinc total (ppm)	Zinc % I. B.	Zinc % S. B.	Zinc % W. S.	Manganese total (ppm)	Manganese % I. B.	Manganese % S. B.	Manganese % W. S.
1SL-T	22.29	26.5	72.2	1.3	52.04	93.7	5.3	1.0
1SL-B	33.14	60.0	39.6	0.4	39.12	95.6	3.0	1.4
2SL-T	38.29	49.1	49.1	1.8	67.49	95.3	3.8	0.9
2SL-B	30.07	49.2	50.6	0.2	50.11	94.2	5.0	0.8
3SL-T	48.27	73.8	25.6	0.6	69.45	93.2	5.6	1.2
3SL-B	47.2	69.3	30.3	0.4	62.23	93.2	6.0	0.8
4SL-T	39.03	65.9	34.0	0.1	65.66	92.7	6.6	0.7
4SL-B	65.41	78.9	21.0	0.1	48.55	91.9	6.9	1.2
5SL-T	41.03	68.5	31.3	0.2	33.07	89.2	9.3	1.5
5SL-B	31.06	53.3	46.5	0.2	43.36	96.8	2.1	1.1
6SL-T	31.29	50.0	49.1	0.9	33.11	94.7	3.7	1.6
6SL-B	32.05	60.2	39.7	0.1	36.57	94.8	3.6	1.6
7SL-T	42.04	70.6	29.3	0.1	51.92	94.2	4.9	0.9
7SL-B	40.11	67.4	32.3	0.3	61.48	95.5	3.8	0.7
8SL-T	43.14	69,1	30.6	0.3	81.07	95.0	3.7	1.3
8SL-B	35.12	62.0	37.6	0.4	74.25	96.3	3.1	0.6

---

*D

* Data from five collections were averaged to compute the percent distribution except the fusion samples of which data from 1st collection were used .

Table 9: Percent Distribution of Cadmium and Copper among Water-soluble, Surface-bound and Internally-bound Fraction of Sediments Collected from Eight Locations* - South Mosquito Lagoon

	Cadmium				Copper			
Sample	Cadmium total (ppm)	Cadmium % I. B.	Cadmium % S. B.	Cadmium % W. S.	Copper total (ppm)	Copper % I. B.	Copper % S. B.	Copper % W. S.
1SL-T	24.61	97.1	2.5	0.4	27.58	93.9	5.8	0.3
1SL-B	23.65	96.0	3.4	0.6	25.09	93.3	6.3	0.4
2SL-T	29.54	98.4	1.1	0.5	21.39	90.0	9.6	0.4
2SL-B	24.54	97.8	1.6	0.6	30.09	94.0	5.7	0.3
3SL-T	21.70	98.2	1.3	0.5	42.59	95.7	4.1	0.2
3SL-B	18.71	97.7	1.7	0.6	51.58	96.6	3.2	0.2
4SL-T	17.71	97.7	1.6	0.7	38.89	95.7	4.1	0.2
4SL-B	36.91	99.0	0.7	0.3	31.98	98.7	1.3	0.0
5SL-T	16.80	97.0	2.4	0.6	72.58	97.1	2.8	0.1
5SL-B	21.73	98.0	1.4	0.6	30.10	94.1	5.6	0.3
6SL-T	23.62	97.9	1.6	0.5	21.42	91.7	7.7	0.6
6SL-B	21.74	97.1	2.2	0.7	21.47	91.0	8.2	0.8
7SL-T	21.72	96.8	2.6	0.6	42.59	95.7	4.1	0.2
7SL-B	21.73	97.2	2.2	0.6	21.42	90.9	8.5	0.6
8SL-T	26.60	97.9	1.8	0.3	36.42	95.4	4.3	0.3
8SL-B	23.-9	97.3	2.3	0.4	27.58	93.8	5.9	0.3

* Data from five collections were averaged to compute the percent distribution except the fusion samples of which data from 1st collection were used.

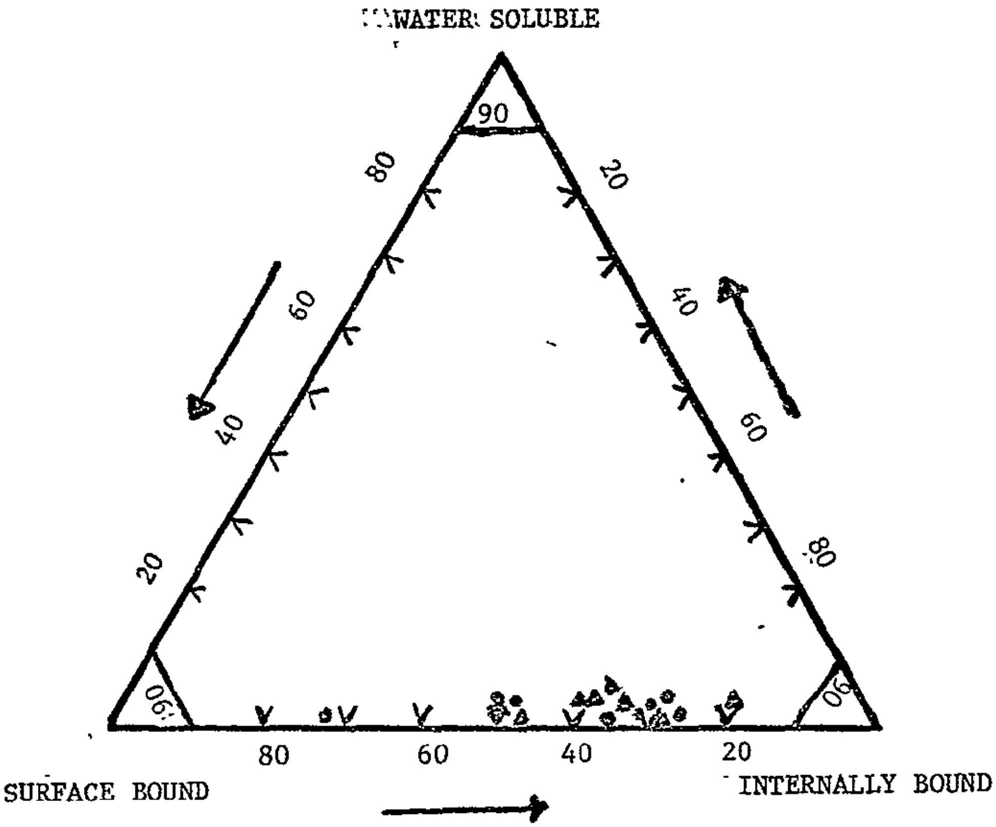

FIGURE 9. RELATION BETWEEN WATER-SOLUBLE, SURFACE-BOUND AND INTERNALLY BOUND ZINC CONC. FOR EIGHT LOCATIONS (AVERAGE FOR % COLLECTIONS) ● Top Portion; ▲Bottom Portion; Concentrations are expressed in percentages; Percentage of the three total 100%; Arrow shows the decrease in percentage

(SOUTH MOSQUITO LAGOON SEDIMENTS)

(D) Comparative Release of Zinc, Manganese, Cadmium and Copper from the South Mosquito Lagoon Sediments. Keeping in view the percent distribution of Zn, Mn, Cd and Cu among the different binding states, we have compared the extractability (release) of these elements by concentrated hydrochloric acid (conc. HCl) and normal ammonium acetate solution (N Am. Act.), from the sediment samples. The calculated comparative data derived from the previous tables are given in Tables 10 and 11.

It is seen from these tables that major portions of Mn and Zn (above 60% of the total) are released from the sediment by extraction with conc. HCl. Cadmium and Cu are released about equally (above 40% of total) by conc. HCl treatment. With ammonium acetate extraction of the sediment about 38% of total Zn, about 5% of total of Cu and Mn each, and nearly 2% of the total Cd are released. Ammonium acetate extraction brings out only that fraction of these elements which is held on the exchange sites of the sediment minerals and the organic matter particles mixed with them. On the other hand, the conc. HCl treatment, seems to break much of the mineral lattice and brings into solution major portions of these elements. A simplified version of the average release values of these elements from the top and bottom layer sediments looks as follows:

	Zn	Mn	Cd	Cu
% release by conc. HCl -----	62.0	68.7	41.8	40.9
% release by Am. Acetate ---	38.0	4.8	1.9	5.4

These results have a significant bearing on the situation under which the toxic elements may be released into the natural environment. The results also confirm the observation made by Saward (17) that the sediment contains a pool of adsorbed metals and can be involved in their recycling into the environment. Symeonides and McRae (18) in their estimations found that the mean levels of Cd from the Cd-treated soils by different extracting solutions were : 39.5 ppm in 1N Ammonium acetate extract; 60.3 ppm in 0.05 N EDTA extract; 70.8 ppm in 1N HCl extract; and 70.9 ppm in Hydrofluoric Acid extract (Total Cd).

Table 10:Comparison of the Extractabilities of Zinc and Manganese from Sediments Collected from Eight Locations by Hydrochloric Acid and Ammonium Acetate Solutions* - South Mosquito Lagoon

Sample	Zinc total@ (ppm)	Zinc HCl Extr.+ (ppm)	% Zinc HCl Extr.	% Zinc Am. Act. Extr.¢	Manganese total@ (ppm)	Manganese HCl Extr.+	% Manganese HCl Extr.	%Manganese Am. Act. Extr.¢
	Zinc				**Manganese**			
1SL-T	22.29	23.8	--	72.2	52.04	24.2	46.5	5.3
1SL-B	33.14	19.2	57.9	39.6	39.12	24.8	63.4	3.0
2SL-T	38.29	27.0	70.5	49.1	67.49	24.8	36.7	3.8
2SL-B	30.07	28.1	93.4	50.6	50.11	37.2	55.1	5.0
3SL-T	48.27	24.5	50.8	25.6	69.45	60.4	87.0	5.6
3SL-B	47.2	22.4	47.5	30.3	62.23	61.5	98.4	6.0
4SL-T	39.08	23.0	58.9	34.0	65.66	58.9	89.7	6.6
4SL-B	65.41	-	-	21.0	48.55	-	-	6.6
5SL-T	41.03	18.0	43.8	31.3	33.07	30.5	92.2	9.3
5SL-B	31.06	21.9	70.5	46.5	43.36	17.9	41.3	2.1
6SL-T	31.29	23.8	76.1	49.1	33.11	22.5	68.0	3.7
6SL-B	32.05	21.8	68.0	39.7	36.57	23.5	64.3	3.6
7SL-T	42.04	28.5	67.8	29.3	51.92	70.5	36.2	4.9
7SL-B	40.11	21.0	52.4	32.3	61.48	45.7	74.3	3.8
8SL-T	43.14	20.5	47.5	30.6	81.07	53.5	66.0	3.7
8SL-B	35.12	26.3	74.9	37.6	74.25	58.9	79.3	3.1
Averages:								
Top (T)	38.12	23.6	59.3	40.2	56.72	39.3	69.4	5.4
Bottom (B)	39.27	23.0	66.4	37.2	51.92	38.5	68.0	4.2

@ These values were taken from Table ; + Average of data from 1st and 3rd collections;¢ These values were taken from Table

Table 11: Comparison of the Extractabilities of Cadmium and Copper from Sediments Collected from Eight Locations by Hydrochloric Acid and Ammonium Acetate Solutions - South Mosquito Lagoon

Sample	Cadmium				Copper			
	Cadmium total (ppm)@	Cadmium HCl Extr. (ppm)+	% Cadmium HCl Extr.	% Cadmium Am. Act. Extr.¢	Copper total (ppm)@	Copper HCl Extr. (ppm)+	% Copper HCl. Extr.	% Copper Am. Act. Extr.¢
1SL-T	24.61	6.3	25.6	2.5	27.58	12.0	43.5	5.8
1SL-B	23.61	9.7	41.0	3.4	25.09	7.8	31.1	6.3
2SL-T	29.54	13.1	60.2	1.1	21.39	10.6	49.6	9.6
2SL-B	24.54	8.3	33.8	1.6	30.09	12.6	41.9	5.7
3SL-T	21.70	11.9	54.8	1.3	42.59	18.6	43.7	4.1
3SL-B	18.71	6.5	34.7	1.7	51.58	15.6	30.2	3.2
4SL-T	17.71	14.5	81.9	1.6	38.89	31.6	81.3	4.1
4SL-B	36.01	-	-	0.7	31.98	-	-	1.3
5SL-T	16.80	11.4	67.9	2.4	72.58	27.6	38.0	2.8
5SL-B	21.73	5.8	26.7	9.4	30.10	8.6	28.6	5.6
6SL-T	23.62	7.9	33.4	1.6	21.42	8.6	40.1	7.7
6SL-B	21.74	7.7	35.4	2.2	21.47	12.6	58.7	8.2
7SL-T	21.72	8.3	38.2	2.6	42.59	12.0	28.2	4.1
7SL-B	21.73	7.5	34.5	2.2	21.42	9.0	42.0	8.5
8SL-T	26.60	4.9	18.4	1.8	36.42	17.3	20.0	4.3
8SL-B	23.59	10.9	46.2	2.3	27.58	10.6	38.4	5.9
Averages:								
Top (T)	22.7	9.8	47.6	1.9	37.93	16.0	43.1	5.3
Bottom (B)	24.05	8.1	36.0	1.9	29.92	11.0	38.7	5.6

@ These values were taken from Table ; + Average of data from 1st and 3rd collections; ¢ These values were taken from Table

SUMMARY AND COMMENTS

In the foregoing the results of our 3rd-year study conducted on the South Mosquito Lagoon water and sediments have been discussed. In the 1st-year study we had reported about Haulover Canal and North Mosquito Lagoon, and the 2nd-year report dealt with the Indian River study. The current report marks the conclusion of sampling activities in the aquatic bodies around Kennedy Space Center as was initially proposed in this project. It primarily includes the discussion of physical and chemical characteristics of water and sediments. By using the standard culture techniques, much of the work on the study of microorganisms in these water bodies was done during the first and second years of this project. During the third year efforts were devoted for the publication of microbial work that had been previously done. One paper entitled "Cultural factors affecting the growth of mixed cultures of bacteria in water samples collected from Indian River, Florida" has been published in the March-June, 1978 issue of Science of Biology Journal. Reprints of this paper will be supplied when available. Another paper entitled "Seasonal distribution of pollution indicator and pathogenic bacteria in water and sediment samples collected from Haulover Canal and Mosquito Lagoon around the Kennedy Space Center" has been recently submitted for publication in the same journal.

In the extension year (4th year) of this project efforts are mainly concentrated on the study of microorganisms by using the pyrolysis- gas-liquid-chromatography. The results and achievements of this work in progress will be reported next year and that will wind up the work undertaken in this project. During this remaining period earnest efforts will also be made to write up a number of manuscripts about the enormous data generated on the physical and geochemical properties of these water bodies for publication in the scientific journals. The scientific papers we have planned to write will deal with the "Interactions of metal ions" and "Geochemical cycling of the toxic elements".

In this report the project investigators would like to express their gratitude to the NASA authorities at Kennedy Space Center for providing this valuable opportunity to undertake these studies through NASA Grant NSG 803. Our sincere thanks also go to Mr. E. E. Perkins, NASA Technical Officer for his many useful and timely suggestions about the project work and for providing sampling facilities in the field. Since the beginning of this project in September, 1974, we have made a considerable progress in our thinking, approach to the problem, and the laboratory techniques. However, we have still a long way to go since the scientific work is continuous and ever-expanding. In the case of environmental studies, we must always keep up with the developing situations.

Some of the conclusions derived in our 3-year study of the water bodies around Kennedy Space Center may be summarized as follows:

1. The three water bodies, (i) Haulover Canal and North Mosquito Lagoon; (ii) Indian River; and (iii) South Mosquito Lagoon are somewhat different from each other in their physical, chemical and biological characteristics. These differences are probably due to their geographic and physiographic situations despite the fact that these are contiguous areas and are parts of main stream of the Indian River through which Intracoastal Waterway runs.
2. There are definite seasonal and locational variations in the major and minor constituents of water and sediments.
3. These water bodies are like estuaries, but considering the salinity, conductivity and other chemical constituents, their water composition is very much similar to the seawater composition.
4. There are definite periods of occurrence of the maximum and minimum concentration levels of the various chemical constituents of both the water and the sediments. The maximum level in most cases occurs in early or late spring (March to May) and sometimes in June or July. These periods may not recur at the same time from year to year.

5. The concentration levels of both the inorganic phosphorus and the inorganic nitrogen are low in the surface water but are relatively higher in the sediments indicating sedimentation and adsorption. The sediments contain relatively high NH_4-N and negligible amounts of NO_3-N.

6. The concentration levels of major constituents in the surface water fall in the decreasing order as: $Cl > Na > SO_4 > Mg > K > Ca > HCO_3$

7. The concentrations of major metal ions in the water and sediments can be arranged in the decreasing order as: $Na > Mg > K > Ca$ in water.
   $Ca > Na > Mg > K$ in sediments.

   This change in order is the resultant effect of the distinct sedimentation and adsorption characteristics of these elements attached to the sediments.

8. The decreasing concentration order of trace elements in water is:
   (a) $Mn > Cu > Cd > Zn > Pb > Hg$ in South Mosquito Lagoon water.
   (b) $Ni > Cu > Mn > Cd > Zn > Pb$ Hg in Indian River water.

9. The concentration values of trace elements in the interstitial water are generally greater as compared to those of the surface water, thus indicating the concentration effects in the interphase between the sediments and water.

10. The concentration levels of ion-exchangeable trace elements in the sediments may be arranged as: $Zn > Mn > Cu > Pb > Cd > Hg$ *

11. The total concentration of trace elements in the sediments may be arranged in the decreasing order as: $Mn > Zn > Cu > Cd$

12. The sedimentation ratios of the metal ions may be arranged in the decreasing order as: $Zn > Ca > Cd$ (Sedimentation rate of Pb may be greater than Cd).

13. The calculated minimum toxicity ratios for the heavy metals in water may be arranged as: $Cd > Cu > Mn > Hg > Zn > Pb$ (The values in the table to be considered arbitrary pending future investigations on this subject).

* Orders based on the data from South Mosquito Lagoon unless oterwise stated.

In addition to the summary of 13 conclusions already listed, many more inferences are possible from the results of our study. Each of these conclusions will be brought out in the appropriate manuscripts for publication purposes. As stated earlier in this report, some of our values of the toxic elements obtained by the flame atomic absorption spectrophotometer technique seem to be high relative to those reported in literature. However, these values have been obtained consistently by our method of estimation over a period of three years. Furthermore, the seasonal variations in the concentration levels of toxic metals clearly suggest that there is a periodic release (dissociation) of these elements into the ambient water surrounding the sediments, for recycling. To arrive at realistic predictions of the possible build-up of any or all of these trace elements in these aquatic bodies, regular future monitoring will be necessary by collecting samples at least twice a year.

We had observed most of the required precautions in our analytical procedures. However, it is necessary to further improve the precision and accuracy of measurements by eliminating sampling errors, using high quality glassware and reagents, improving the purity of laboratory air and deionized water, and by proper preparation of samples for analysis. It will be essential to compare the various methods of estimations of trace elements and define the toxicity levels that may be useful for making predictions. If our method of estimation continues to provide consistent values in the future samples while indicating any variations, then it may be desirable to define the limits of toxicity on these values versus the values obtained by other laborious and time-consuming methods.

Ketchum (11) in his article, presented the estimates of the rate of mobilization of various toxic heavy metals whether produced by combustion of fossil fuels and reaching the sea via the atmosphere, or reaching the sea in river transport including the addition to the river by man and natural weathering.

When the estimate for the mobilization of each metal is divided by the concentration of that metal considered to pose minimal risk of deleterious effect, a 'Relative Critical Index' is derived. This index gives the volume of water which would receive an annual increment of the element equal to the toxicity concentration at the given rate of mobilizations.

In order to prepare indexes reflecting future trends we suggest that a comprehensive study be undertaken on the geochemical cycling of the toxic elements in the ecosystem of Merritt Island. Such a study should include the periodic distribution of the heavy metals in the soil, vegetation (natural and cultivated), marine animals (fish etc.), estuarine water and sediments. To our knowledge, no systematic study of this kind has been done in the coastal area. The chemistry and mobility of the heavy metals in the estuaries are quite complex. Many of the researchers have studied only one or two of the toxic elements in such aquatic systems. For instance, Baier (19) reported the lead distribution in the Cape Fear River Estuary. He found low Pb levels in water (some values compare well with our data), but reported considerably higher values for total Pb in the underlying sediments.

In the light of the above observations, the initiation of a comprehensive study of the toxic metals on the Merritt Island housing the Kennedy Space Center, is not only desirable but rather an essential entity. Such a project can be a model study for the estuaries and coastal islands around the world. The study may include at least five elements such as Hg, Cd, Ni, Cu and Zn, most frequently ranked as being of high potential hazard in order of toxicity. In addition, Pb, Cu and Mn should also be studied to make up a list of eight elements out of the 11 considered by Ketchum for the marine environment (11).

We may conclude this report by stating that the work carried out in this project has furnished not only valuable data and conclusions, but it has also opened up new avenues and ideas for further research needed by mankind.

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