CHEMICAL ANALYSIS OF BIOLOGICAL, WATER AND SEDIMENT SAMPLES FROM THE ALTAMAHA AND A CONTROL ESTUARY

by

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The results presented in this report represent the completion of a one-year study contracted by Georgia Power Company with the Skidaway Institute of Oceanography.

The following is the final report on results of analyses of biological, water and sediment samples from the Altamaha estuary and a control estuary (St. Catherine Sound). Samples for which results are given in the following report were collected during August, 1970 and February and March, 1971.

PROCEDURES

Large volume water samples were collected every two hours for two-day periods from the two estuaries during August, 1970 and February and March of 1971. The samples were stored in polypropylene bottles to be returned to the lab for analysis. Water samples were filtered just prior to analysis in the laboratory. Sodium, strontium, iron, phosphorus and sulfur were analyzed on each of the samples collected every two hours. Sodium and strontium were analyzed by atomic absorption spectrophotometry on diluted samples. Iron and phosphorus were analyzed colorimetrically, and sulfur determinations were accomplished using a titrometric technique. All other analyses of water samples were performed on single composite samples prepared from mixing aliquots of the 24 water samples collected at each area during each sampling period. Chromium, cobalt, copper and zinc were concentrated from the composite water samples by complexation with APDC (ammonium pyrrolidine dicarbamate) followed by

extraction with MIBK (methyl isobutyl ketone). The extracting solvent was then analyzed by atomic absorption spectrophotometry. Manganese and silver were analyzed on the composite samples colorimetrically. Mercury was concentrated from the composite samples by complexation with EDTA (ethylene diamine tetracetic acid) and extraction into a dithiozone-chloroform solution. This solution was back extracted with concentrated hydrochloric acid and the mercury was then reduced using stannus chloride and aerated into a flameless atomic absorption system. All other elements were determined by neutron activation.

Biological samples were collected using otter trawls for crabs and fish and oyster rakes for oysters. Only the edible tissues of these samples were analyzed. Each sample consisted of several individual organisms in most cases. These were homogenized and aliquots were taken from this material for the separate analyses. Chromium, cobalt, copper, iron, manganese, silver, sodium, strontium and zinc were analyzed on these samples using atomic absorption spectrophotometry on solutions of the digested material following wet ashing. Phosphorus was analyzed on digested samples by colorimetric techniques. Mercury was analyzed on samples by flameless atomic absorption spectrophotometry following wet digestion. All other elements were analyzed by neutron activation of undigested samples followed by digestion, and separation and counting the irradiated isotope of the given elements.

Sediment samples were collected using a Van Veen bottom sampler. These samples were leached with a series of extracting solvents suggested by Steward Laboratories, Inc. These solvents consisted of dilute hydrochloric acid, a solution of pancreatin and a solution of triton X-100 detergent. The three leachates were combined for the analysis. Chromium, cobalt, copper, iron, manganese, silver, sodium, strontium and zinc were analyzed on the resulting solution by atomic absorption spectrophotometry. Mercury was analyzed by a flameless atomic absorption technique on the resulting solution. All other elements with the exception of phosphorus and sulfur were analyzed by neutron activation. Phosphorus and sulfur were analyzed on the untreated sediment sample since the reagents used in the preferential extraction techniques contained high concentrations of these elements. Phosphorus and sulfur determinations were accomplished by colorimetric and titrometric techniques, respectively.

RESULTS AND CONCLUSIONS

Results of the analyses of water samples from the Altamaha and St. Catherine estuaries, both in the summer and winter, are given in Tables 1 through 6. The considerable tidal variation in chemical parameters can be seen in the analyses of sodium, strontium, iron, phosphorus and sulfur both in the summer and winter at both estuaries (Tables 1 through 4). For the Altamaha estuary the average sodium and strontium

concentrations and their ranges are larger in the summer than in the winter. This probably results from both increased runoff during the winter months which dilutes the estuarine waters as well as the fact that samples taken in August were taken closer to spring tides while those taken in February were nearer neap tides. Similar variations can be observed also for the St. Catherine estuary except not quite so pronounced since the fresh water runoff into this Sound is somewhat less than the Altamaha estuary.

For both the areas studied, iron and phosphorus appear to vary not only tidally but with seasons. In both estuaries, iron is seen to be considerably higher in the winter than in the summer. This is probably due to increased runoff during the winter months. Phosphorus, on the other hand, is higher in concentration during the summer months as compared to the winter months. This phosphorus may be associated with the increased plankton population and detritus during the summer months.

Sulfur variation in the Altamaha estuary are clearly a function of salinity of the water (effects of tide and runoff) for both the tidal cycle and the seasonal cycle. The sulfur concentration in the St. Catherine estuary, however, appears to change little, both during tidal changes as well as seasonal changes. This is most likely due to the fact that the sulfur originates from the effluent of a pulp mill located in the

general vicinity. The increase in sulfur from this source is so large that it probably overshadows any other effect. Of the other metals studied (Tables 5 and 6) only cesium appears to show any seasonal variation. For the Altamaha and St. Catherine estuaries, cesium is observed to decrease in concentration during the winter months.

The results of analyses of oyster samples are shown in Tables 7 and 8. Very little variation in the concentrations of the given elements can be seen except for the major elements which are expected to vary over wide ranges. The only exception to this is cesium which decreases in the oyster during the witner months following the decreasing trend in the water.

Results of analyses of crab samples (Tables 9 and 10) show very little variation in the concentration of any of the elements between samples collected in the Altamaha and St. Catherine estuaries or between samples collected during different seasons at either estuary.

Spot samples (Tables 11 and 12) of Spot 1 show a fair amount of variability in the concentration of the metals in samples collected at different times of the year, while samples collected at the same time of the year at the two different locations appear to be quite similar. This may reflect a drastic change in diet of these organisms between summer and winter.

The variability in the results of analyses of sediment samples taken at the two locations and at different times of the year most likely reflects a variation in the mineralogical composition of the sample and the concentration of organic matter. The variability in composition of the sediment samples shown in Tables 13 and 14 is probably the same that would be found in any one of the two areas studied at any time of the year.

TABLE 1

ALTAMAHA ESTUARY WATER SAMPLES
August 24-26
Sample Taken Every Two Hours for Two Days

HOUR	SODIUM ppm	STRONTIUM ppm	IRON ppb	PHOSPHORUS ppb	SULFUR ppm
10	1500	0.4	22	100	189
12	1500	0.7	26	42	162
14	7500	5.0	20	200	448
16	6900	3.8	80	62	811
18	5900	5.8	21	62	592
20	3000	3.7	12	36	311
22	2200	1.3	10	66	142
24	3600	2.0	4	60	316
2	4800	4.6	1	22	516
4	4100	4.4	1	70	493
6	4600	3.2	38	30	251
8	2600	2.6	45	16	272
10	2600	1.0	32	48	748
12	3800	3.6	44	18	602
14	6400	5.0	45	17	588
16	7200	5.2	16	20	897
18	6400	5.0	1	19	676
20	5100	3.5	10	25	651
22	3600	2.3	19	31	379
24	2600	1.4	28	39	237
2	4600	2.6	2	14	460
4	5900	4.6	1	22	372
6	4000	3.2	14	15	567
8	3500	3.5	10	14	381
Average	4327	3.3	21	43	460
Range					
High	7500	5.8	80	200	897
Low	1500	0.4	1	14	142

TABLE 2

ALTAMAHA ESTUARY WATER SAMPLES
February 17-19
Sample Taken Every Two Hours for Two Days

HOUR	SODIUM ppm	STRONTIUM ppm	IRON ppb	PHOSPHORUS ppb	SULFUR ppm
10	1200	0.5	67	20	72
12	800	1.0	65	21	148
14	600	1.1	70	25	187
16	950	0.5	60	26	106
18	440	0.3	65	18	78
20	800	1.0	54	40	135
22	1250	1.6	62	30	180
24	1800	2.1	89	16	166
2	1800	1.5	78	24	210
4	1700	1.6	81	18	210
6	1900	2.2	62	16	140
8	1500	1.6	62	15	140
10	1400	0.6	65	20	75
12	1050	1.1	85	16	68
14	1050	1.0	62	15	85
16	900	1.2	70	16	85
18	820	0.5	62	21	88
20	480	0.4	62	25	55
22	450	0.3	51	34	56
24	610	0.3	51	23	40
2	720	0.4	51	27	115
4	1400	1.4	65	23	138
6	1050	1.0	63	17	120
8	2200	1.6	66	22	121
Average	1119	1.0	65	22	117
Range					
High	1900	2.2	89	40	210
Low	450	0.3	51	15	40

TABLE 3

ST. CATHERINE SOUND ESTUARY WATER SAMPLES
August 26-28
Sample Taken Every Two Hours for Two Days

HOUR	SODIUM ppm	STRONTIUM ppm	IRON ppb	PHOSPHORUS ppb	SULFUR ppm
12	6400	5.3	1	16	718
14	6600	5.5	1	46	1110
16	6600	5.2	1	43	1380
18	7200	5.0	28	43	1180
20	6900	5.2	26	15	1420
22	8400	5.3	4	31	1800
24	7500	4.5	1	39	452
2	7500	4.3	1	27	920
4	8600	5.4	1	47	1720
6	8400	5.0	1	54	963
8	7200	5.3	1	47	1270
10	6900	5.2	12	45	1450
12	8100	6.0	1	52	885
14	7200	5.5	1	100	495
16	7800	5.7	1	64	1040
18	7800	6.0	1	59	648
20	7800	6.0	1	97	1140
22	7800	5.4	1	90	1240
24	7800	5.7	6	75	1110
2	7500	5.2	1	140	1000
4	7500	5.3	7	97	1240
6	8400	5.5	4	125	1330
8	8100	5.5	1	87	1400
10	8000	5.2	1	85	1350
Average	7583	5.3	4	63	1135
Range					
High	8600	6.0	28	140	1800
Low	6400	4.3	1	15	495

TABLE 4

ST. CATHERINE SOUND ESTUARY WATER SAMPLES
March 16-18
Sample Taken Every Two Hours for Two Days

HOUR	SODIUM ppm	STRONTIUM ppm	IRON ppb	PHOSPHORUS ppb	SULFUR ppm
12	5750	4.9	84	45	1150
14	6250	4.9	850	71	920
16	6150	5.2	170	58	700
18	6250	4.9	158	40	1000
20	4400	3.4	158	37	700
22	6150	4.9	216	72	500
24	6250	4.8	148	44	1300
2	6000	4.7	138	38	1150
4	6700	5.2	136	42	1200
6	6700	4.9	82	30	1200
8	6950	4.9	99	30	1300
10	6800	4.9	66	22	1200
12	7200	5.3	86	37	1100
14	7550	5.2	130	34	1000
16	6250	4.8	610	44	——— *
18	6700	4.7	780	43	———
20	6250	4.7	730	30	———
22	6250	4.8	610	24	———
24	6000	4.9	495	35	———
2	6150	4.8	690	32	———
4	6150	4.8	690	69	———
6	6000	4.9	690	62	———
8	6550	5.3	700	69	———
10	7100	4.9	650	58	———
Average	6354	4.8	381	44	1030
Range					
High	7550	5.3	850	72	1300
Low	4400	3.4	66	22	500

*samples contaminated

TABLE 5

WATER SAMPLES
August 1970

	Altamaha Estuary ppm	St. Catherine Sound Estuary ppm
Barium	5×10^{-2}	4×10^{-2}
Cerium	1×10^{-3}	8×10^{-4}
Cesium	5×10^{-4}	5×10^{-4}
Chromium	1.4×10^{-3}	1.1×10^{-3}
Cobalt	7×10^{-4}	5×10^{-4}
Copper	3×10^{-3}	2.5×10^{-3}
Iodine	5×10^{-2}	4×10^{-2}
Iron*	2.1×10^{-3}	4.4×10^{-3}
Manganese	7×10^{-3}	1.5×10^{-3}
Molybdenum	4×10^{-4}	3×10^{-4}
Neodymium	$<10^{-4}$	$<10^{-4}$
Niobium	$<10^{-4}$	$<10^{-4}$
Phosphorus*	4.4×10^{-2}	6.3×10^{-2}
Ruthenium	$<10^{-4}$	$<10^{-4}$
Silver	2×10^{-4}	1.5×10^{-4}
Sodium*	4.3×10^{3}	7.6×10^{3}
Strontium*	3.3	5.3
Sulfur*	4.6×10^{2}	1.1×10^{3}
Zinc	8.8×10^{-3}	1.4×10^{-2}
Zirconium	$<10^{-4}$	$<10^{-4}$
Mercury	1.8×10^{-4}	2.0×10^{-4}

*average values

TABLE 6

WATER SAMPLES
February-March 1971

	Altamaha Estuary ppm	St. Catherine Sound Estuary ppm
Barium	2×10^{-2}	3×10^{-2}
Cerium	3×10^{-3}	7×10^{-4}
Cesium	2×10^{-6}	6×10^{-5}
Chromium	8×10^{-4}	1.2×10^{-3}
Cobalt	4×10^{-4}	7.5×10^{-4}
Copper	5.4×10^{-3}	3.4×10^{-3}
Iodine	2×10^{-2}	3×10^{-2}
Iron*	6.6×10^{-2}	3.8×10^{-1}
Manganese	1.9×10^{-2}	7.8×10^{-3}
Molybdenum	2×10^{-4}	2×10^{-4}
Neodymium	$< 10^{-4}$	$< 10^{-4}$
Niobium	$< 10^{-4}$	$< 10^{-4}$
Phosphorus*	2.2×10^{-2}	4.4×10^{-2}
Ruthenium	$< 10^{-4}$	$< 10^{-4}$
Silver	2.2×10^{-4}	5×10^{-5}
Sodium*	1.1×10^{3}	6.3×10^{3}
Strontium*	1.0	4.8
Sulfur*	1.2×10^{2}	1.0×10^{3}
Zinc	1.2×10^{-2}	3.8×10^{-3}
Zirconium	$< 10^{-4}$	$< 10^{-4}$
Mercury	1.7×10^{-4}	1.8×10^{-4}

*average values

TABLE 7

OYSTER SAMPLES
August 1970

	Altamaha Estuary	St. Catherine Sound Estuary
% Ash	3.0	5.3
% Moisture	89.3	87.2
	ppm Wet Weight	ppm Wet Weight
Barium	0.70	0.90
Cerium	0.004	0.006
Cesium	0.011	0.011
Chromium	0.45	0.79
Cobalt	0.44	0.68
Copper	16.8	15.5
Iodine	1.5	3.6
Iron	57.5	54.9
Manganese	5.4	4.7
Molybdenum	0.41	0.39
Neodymium	<0.04	<0.06
Niobium	<0.01	<0.01
Phosphorus	1576.	1536.
Ruthenium	0.02	0.15
Silver	1.4	0.9
Sodium	325.	285.
Strontium	21.0	21.5
Sulfur	2500.	2000.
Zinc	370.	215.
Zirconium	<0.30	<0.30
Mercury	0.30	0.24

TABLE 8

OYSTER SAMPLES
February-March 1971

	Altamaha Estuary	St. Catherine Sound Estuary
% Ash	1.6	5.3
% Moisture	90.1	86.7
	ppm Wet Weight	ppm Wet Weight
Barium	0.80	0.70
Cerium	0.12	0.10
Cesium	0.005	0.003
Chromium	0.41	0.35
Cobalt	0.21	0.18
Copper	7.9	4.9
Iodine	1.0	0.9
Iron	34.	45.
Manganese	1.1	2.2
Molybdenum	0.42	0.29
Neodymium	<0.05	<0.04
Niobium	<0.01	<0.01
Phosphorus	1480.	1300.
Ruthenium	0.02	0.02
Silver	1.5	1.4
Sodium	2010.	3800.
Strontium	2.5	0.16
Sulfur	2400.	2200.
Zinc	210.	130.
Zirconium	<0.3	<0.2
Mercury	0.09	0.20

TABLE 9

CRAB SAMPLES
August 1970

	Altamaha Estuary	St. Catherine Sound Estuary
% Ash	3.5	3.7
% Moisture	76.3	85.4
	ppm Wet Weight	ppm Wet Weight
Barium	0.8	0.7
Cerium	0.003	0.008
Cesium	0.02	0.02
Chromium	1.1	0.7
Cobalt	1.1	0.93
Copper	18.1	12.4
Iodine	0.35	0.40
Iron	8.3	11.1
Manganese	2.2	1.8
Molybdenum	0.23	0.20
Neodymium	<0.04	<0.04
Niobium	<0.01	<0.01
Phosphorus	1580.	1793.
Ruthenium	<0.0003	<0.0004
Silver	3.2	2.6
Sodium	2550.	4940.
Strontium	17.2	2.9
Sulfur	985.	1180.
Zinc	67.5	35.9
Zirconium	<0.35	<0.30
Mercury	0.017	0.08

TABLE 10

CRAB SAMPLES
February-March 1971

	Altamaha Estuary	St. Catherine Sound Estuary
% Ash	2.0	1.9
% Moisture	83.9	80.4
	ppm Wet Weight	ppm Wet Weight
Barium	0.7	0.7
Cerium	0.09	0.08
Cesium	0.07	0.03
Chromium	0.63	0.66
Cobalt	0.30	0.16
Copper	4.9	9.2
Iodine	0.30	0.27
Iron	3.9	5.1
Manganese	2.9	3.0
Molybdenum	0.20	0.30
Neodymium	<0.02	<0.02
Niobium	<0.01	<0.01
Phosphorus	1500.	1250.
Ruthenium	<0.001	<0.001
Silver	1.3	2.4
Sodium	4100.	940.
Strontium	1.1	0.41
Sulfur	1000.	720.
Zinc	32.	38.
Zirconium	<0.6	<0.8
Mercury	0.02	0.05

TABLE 11

SPOT SAMPLES
August 1970

	Altamaha Estuary	St. Catherine Sound Estuary
% Ash	3.6	4.0
% Moisture	79.3	80.0
	ppm Wet Weight	ppm Wet Weight
Barium	0.08	0.05
Cerium	0.18	0.19
Cesium	0.009	0.01
Chromium	0.77	0.98
Cobalt	0.29	0.34
Copper	0.8	2.9
Iodine	1.0	1.8
Iron	16.9	15.9
Manganese	2.4	2.7
Molybdenum	0.004	0.052
Neodymium	< 0.02	< 0.02
Niobium	< 0.01	< 0.01
Phosphorus	3840.	4380.
Ruthenium	< 0.0004	< 0.0001
Silver	0.90	2.6
Sodium	850.	508.
Strontium	1.3	0.54
Sulfur	1760.	1600.
Zinc	9.2	6.9
Zirconium	<0.30	<0.30
Mercury	0.11	0.14

TABLE 12

SPOT SAMPLES
February-March 1971

	Altamaha Estuary	St. Catherine Sound Estuary
% Ash	1.0	1.5
% Moisture	80.9	79.5
	ppm Wet Weight	ppm Wet Weight
Barium	0.05	0.07
Cerium	0.01	0.015
Cesium	0.0004	0.0006
Chromium	1.4	0.6
Cobalt	1.0	0.12
Copper	0.8	1.3
Iodine	1.2	0.9
Iron	67.	55.
Manganese	0.02	0.08
Molybdenum	0.01	0.01
Neodymium	<0.02	<0.02
Niobium	<0.01	<0.01
Phosphorus	3200.	3900.
Ruthenium	<0.01	< 0.01
Silver	2.6	1.5
Sodium	690.	1500.
Strontium	0.1	2.1
Sulfur	1500.	1800.
Zinc	57.	11.
Zirconium	<0.30	<0.30
Mercury	0.10	0.15

TABLE 13

SEDIMENT SAMPLES EXTRACT
August 1970

	Altamaha Estuary	St. Catherine Sound Estuary
	ppm Wet Weight	ppm Wet Weight
Barium	<10.0	<10.0
Cerium	1.7	1.1
Cesium	0.62	0.004
Chromium	0.45	0.45
Cobalt	0.4	0.5
Copepr	0.45	0.30
Iodine	0.1	0.1
Iron	106.	36.
Manganese	225.	74.
Molybdenum	0.22	0.03
Neodymium	<0.6	<0.6
Niobium	<0.01	<0.01
Phosphorus	(390.)	(460.)
Ruthenium	<0.005	<0.005
Silver	0.26	0.98
Sodium	3130.	10000.
Strontium	8.1	10.5
Sulfur	(580.)	(620.)
Zinc	52.	43.
Zirconium	< 5.	< 5.
Mercury	0.28	0.14

TABLE 14

SEDIMENT SAMPLES EXTRACT
February-March 1971

	Altamaha Estuary	St. Catherine Sound Estuary
	ppm Wet Weight	ppm Wet Weight
Barium	<10.	<10.
Cerium	1.0	0.8
Cesium	0.5	0.3
Chromium	1.4	0.3
Cobalt	1.5	1.1
Copper	1.1	0.3
Iodine	0.2	0.1
Iron	200.	220.
Manganese	47.	5.5
Molybdenum	0.05	0.10
Neodymium	<0.6	<0.6
Niobium	<0.01	<0.01
Phosphorus	(500.)	(400.)
Ruthenium	<0.005	<0.005
Silver	1.2	2.9
Sodium	9500.	4000.
Strontium	13.	19.
Sulfur	(430.)	(350.)
Zinc	100.	14.
Zirconium	<5.0	<5.0
Mercury	0.10	0.09