

**Analysis of Metals in Stoneroller Minnows
Collected March 13-14, 2001 from
the Bayou Creek System**

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INTRODUCTION

Stoneroller minnows (*Campostoma anomalum*) were collected March 13-14, 2001 by personnel from UK. Fish were collected from Massac Creek (MC), Big Bayou Creek (BB1A-BB9), and Little Bayou Creek (LB2, LB3, LB4). Five of the largest stoneroller minnows collected from each station were analyzed, giving a total of 55 fish from MC and Big Bayou Creek and 11 from Little Bayou Creek. Only one stoneroller minnow was found at station LB3 and, therefore, 2 creek chubs (*Semotilus atromaculatus*) were collected. Fish were analyzed for whole-body (BB) concentrations of nine metals that included silver (Ag), beryllium (Be), cadmium (Cd), chromium (Cr), copper (Cu), iron, (Fe), nickel (Ni), lead (Pb) and zinc (Zn).

MATERIALS AND METHODS

Fish collection

Fish were collected by use of a back-pack shocker and/or by seining. Stoneroller minnows were placed in plastic bags, tagged, and placed on ice (4°C) for transport to the laboratory. Fish were then stored in the freezer (-15 °C) until analyzed.

Fish Digestion

Stoneroller minnows selected for analysis were prepared according to modified procedures described by Shaw *et al.* (1998), Hogstrand *et al.* (1996), and U.S. EPA (1997). All chemicals used were ACS grade or better and all acids were TraceMetal grade. Stoneroller minnow samples were wet-weighed and placed in 50-mL Hot-Block®

digestion tubes. The samples were digested with 3.0 mL TraceMetal grade HNO₃ per gram tissue and heated to 95° C for 10 min in the Hot-Block® digestion unit. The samples were allowed to cool to room temperature and 1.0 mL of 30% H₂O₂ per gram was added to each sample followed by heat-instilling until dry. The samples were then reconstituted with 5.0 mL of 0.5% HNO₃ and filtered through a Gelman Sciences Type A/E glass fiber filter to remove suspended particulates. The filters were rinsed with 0.5% HNO₃ prior to use and filtrates were taken to a final volume of 10 mL.

Metal Analyses

Analyses of stoneroller tissue samples was performed by atomic absorption spectrophotometry (AAS), using graphite furnace atomization techniques and a Varian atomic absorption spectrophotometer (Model Spectra AA-20) equipped with a GTA-96 graphite furnace or a Perkin Elmer (Model 608) flame atomic absorption unit (U.S. EPA, 1997). All gases used were ultra pure carrier grade. Calibration curves were based on five standards. The instrument was programmed to take three readings per sample and average the absorbance. Instrument blanks (0.5 % HNO₃) and check standards were processed with all samples. Sample concentrations were then corrected for deviations from the standards and sample weights were factored into the calculations of final values.

Quality Assurance

Permanent bench records were kept of all assays and annotated as required under Good Laboratory Practices (*Federal Register*, 40 CFR, Part 160, August 17, 1989). All

printouts and graphic recordings were filed and are open for inspection. These bench records will be archived within two years after the close of the project but retrievable upon request. Chain of Custody was maintained for all samples collected.

RESULTS

Results are given in Tables 1 through 5. Table 1 includes mean metal body burden (BB) values \pm standard deviations for each station collected. Tables 2 and 3 gives metal values for each fish from each monitoring stations for Big and Little Bayou Creeks, respectively. Tables 4 and 5 include weights in grams for each specimen taken from Big and Little Bayou Creeks.

The definition of reference stations for the Bayou Creek system remains problematic. As in other studies, stations MC on the west fork of Massac Creek and upstream station on Big Bayou Creek (BB1A, BB1) are contaminated to some extent with such metals as Ag, Be, Cd, Cr and Pb (Table 1). Sources of this contamination, which appears variable over time, are under investigation. As noted earlier (Birge and Price, August 29, 2001a), there is a need to locate one or more reference sites that are free of significant pollution and comparable in habitat and hydrology to the Bayou Creek system.

As compared with metal BB values reported for stoneroller minnows collected from Big Bayou Creek in March, 2000 (Birge and Price, May 7, 2001b; Table 3), Cd and Zn BB concentrations given in Table 1 are substantially lower. This indicated a reduction in contamination in Big Bayou Creek for these two metals (*i.e.* Cd, Zn) over

the past year. However, substantial increases have occurred for other metals, including Be, Cr, Pb, Ni and, to a lesser extent, Ag and Cu. As noted in the recent study on metals in the water column, where sampling was simultaneous with these minnow collections (Birge and Price, February 4, 2002a), BB Be was substantially elevated. This included BB values ($\mu\text{g}/\text{Kg}$) of 377.3, 567.7, 369.9 and 377.0 at stations BB2, BB3, BB5 and BB6, respectively. Beryllium BB remained elevated all the way downstream to the last monitoring station (*i.e.* BB9). Below station BB6, BB values for Be ranged from 370.4 at BB8 to 289.4 at BB9. Averaging values for stations BB2 – BB9 for collections in March 2000 and 2001, the averages of mean values were 100 $\mu\text{g}/\text{Kg}$ and 347.0 $\mu\text{g}/\text{Kg}$, respectively. This represented a 3.5 fold increase in the BB of Be in the stoneroller minnow. A three fold increase in Be was observed in the analysis of water samples for the same time period (Birge and Price, February 1, 2002b).

Averaging data for the same stations, BB of Cr in stoneroller minnows increased between March, 2000 and March 2001 by more than a factor of 2. The averages of mean values per station were 2249.5 and 4725.6 $\mu\text{g}/\text{Kg}$ for years 2000 and 2001. For the same stations (*i.e.* BB2 – BB9), Pb concentrations ($\mu\text{g}/\text{Kg}$) in the stoneroller minnow ranged from 612.8 (BB4) to 5442.8 (BB3) with an average value per station of 3031.4 (*i.e.* 3.03 ppm). This was more than a 2.5 fold increase over BB values for Pb reported for collections in March, 2000. Similar results were obtained for Ni. The average value per station (*i.e.* BB2 – BB9) was 7070.1 $\mu\text{g}/\text{Kg}$ and this represented an increase in stoneroller minnow BB of 3.7, as compared with data reported for March, 2000. Results were more variable for Ag and Cu. Highest values ($\mu\text{g}/\text{Kg}$) for these metals were 111.7

(BB7) and 11828.4 (BB8). Both of these metals were elevated within and below the effluent receiving zone in Big Bayou Creek. The average values ($\mu\text{g}/\text{Kg}$) of BB silver per station for BB2 – BB9 was 61.0 compared to 57.0 observed for minnows collected in March, 2000. However, higher values for Ag BB were found in the 2001 collection at stations BB4 – BB7. These values ranged ($\mu\text{g}/\text{Kg}$) from 83.9 at BB4 to 111.7 at BB7.

Concerning Little Bayou Creek, all metals except Zn were higher in BB concentrations at station LB2 than reported for March 2000. For example, Ag BB was 19.0 $\mu\text{g}/\text{Kg}$ in March 2000 and 64.1 $\mu\text{g}/\text{Kg}$ one year later (Table 1). The BB value ($\mu\text{g}/\text{Kg}$) for Be increased from 28.0 in March 2000 to 197.1 in March 2001. The mean BB value for Pb increased from 982.0 $\mu\text{g}/\text{Kg}$ to 1186.3 $\mu\text{g}/\text{Kg}$ over this one year interval. This trend also held true for station LB3, except BB concentrations were somewhat less for Cu and Pb than in March 2000. Data for individual assays per station are given in Tables 2 and 3 for Big and Little Bayou Creeks. As noted above, weight measurements for individual minnows are given by collecting stations in Table 4.

The possible extent to which upstream contamination may have affected the Bayou Creek system is under consideration and a search for dump sites will be undertaken in the near future. However, it appears probable that metal contamination from the abandoned bridge site on the unnamed tributary and effluent 009 affected conditions at stations BB2 and BB3. In addition, the elevated concentrations at stations MC and BB1 often were appreciably higher than those reported for stations BB3 and/or BB4. This supports the contention that contamination at and below stations BB5

originated from the PGDP area. This assumption is based on the substantial increases in metal BB in minnows taken from the lower stations (Table 1).

Table 1. Mean metal concentrations \pm standard deviations in stoneroller minnows from the Bayou Creek system, collected March 13-14, 2001¹.

Station	Wt. of body - gut (g)	Wt. of gut (g)	Wt. of body + gut (g)	Avg. % gut out of whole Body	Avg. whole body plus gut concentration ($\mu\text{g}/\text{Kg}$) per station ²								
					Ag	Be	Cd	Cr	Cu	Fe ³	Pb	Ni	Zn ³
MC	2.384	0.277	2.661	11.41	26.22	399.92	185.77	3389.43	1415.85	3555.56	3603.49	7574.78	75.57
	1.323	0.122	1.432	3.21	2.87	113.75	139.50	1301.77	1306.15	1354.69	1382.84	1780.02	27.33
BB1A	3.500	0.597	4.097	14.19	10.44	668.03	118.24	1842.17	4706.65	5979.36	3937.52	7099.63	73.17
	0.746	0.246	0.969	3.03	3.97	259.36	63.44	907.21	1029.11	581.06	778.06	1224.51	11.74
BB1	5.477	0.520	5.997	8.97	37.88	290.59	154.04	2868.24	5357.48	4017.13	1975.53	5656.45	65.39
	1.020	0.101	0.988	2.75	19.81	156.52	95.79	1751.91	1744.07	1987.16	1028.84	1796.92	3.16
BB2	3.113	0.384	3.497	11.22	30.10	377.34	89.73	1501.82	2884.16	4124.76	3666.57	6393.68	54.50
	0.924	0.106	1.011	1.74	11.29	101.66	24.24	381.61	1812.50	1712.70	892.53	1801.31	10.89
BB3	3.006	0.427	3.433	12.67	11.11	567.72	90.93	2824.13	10395.03	7739.95	5442.81	9677.57	112.88
	1.358	0.167	1.520	1.55	4.97	199.74	35.28	1018.84	3007.89	2413.34	1919.90	1580.41	11.55
BB4	10.589	0.528	11.117	4.80	83.94	78.10	242.58	2154.65	7827.76	743.21	612.76	2070.47	64.45
	2.353	0.103	2.445	0.52	17.56	60.73	163.52	2490.04	7415.86	216.09	357.26	900.41	16.46
BB5	5.413	0.532	5.944	9.21	97.17	369.92	148.78	9144.06	8604.68	4395.17	3287.28	7030.29	94.63
	1.091	0.083	1.091	2.53	22.73	211.37	55.53	5506.32	5589.19	3049.57	2208.21	4182.09	10.98

¹ Standard deviations given below the means.

² Whole body metal concentrations including gut.

³ Fe and Zn are given in $\mu\text{g}/\text{g}$.

Table 1, continued. Mean metal concentrations \pm standard deviations in stoneroller minnows from the Bayou Creek system, collected March 13-14, 2001¹.

Station	Wt. of body - gut (g)	Wt. of gut (g)	Wt. of body + gut (g)	Avg. % gut out of whole Body	Avg. whole body plus gut concentration ($\mu\text{g}/\text{Kg}$) per station ²								
					Ag	Be	Cd	Cr	Cu	Fe ³	Pb	Ni	Zn ³
BB6	4.136	0.546	4.683	10.99	88.39	377.09	107.92	9012.55	8689.70	4035.98	2571.88	7763.61	89.68
	2.304	0.391	2.678	3.67	38.16	136.17	49.87	3617.93	6839.49	1386.63	801.67	1854.23	12.15
BB7	4.102	0.544	4.646	12.40	111.74	346.26	150.68	6921.06	9194.54	4228.43	2630.32	7469.06	76.39
	1.129	0.050	1.159	3.47	25.43	61.20	42.79	3208.18	4021.40	1200.46	627.47	2288.86	14.55
BB8	2.873	0.295	3.168	10.20	39.07	370.43	117.04	3363.64	11828.43	3830.26	3678.27	8289.65	88.23
	1.406	0.076	1.457	3.07	10.53	139.36	55.70	1243.01	3157.75	1963.32	669.49	2411.40	11.35
BB9	3.133	0.273	3.407	8.33	24.45	289.43	133.38	2883.16	11256.66	3100.49	2360.93	7866.61	78.16
	1.216	0.131	1.322	2.76	9.96	160.01	81.26	1743.25	11590.96	1562.04	2390.92	3564.81	22.17
LB2	5.456	0.698	6.154	11.22	64.12	197.12	91.70	13342.38	9151.79	2070.28	1186.34	4845.60	80.57
	1.651	0.275	1.897	1.71	22.08	33.21	31.20	7197.67	5539.05	823.68	178.56	1172.62	20.78
LB3	3.075	0.239	3.314	6.91	62.57	128.29	616.48	3086.71	10769.55	1948.42	626.28	1972.69	88.58
	2.712	0.261	2.966	1.94	54.60	145.71	772.07	1336.38	482.05	1105.26	504.09	2513.67	36.66
LB4	3.920	0.379	4.299	8.83	182.71	212.42	96.77	9373.74	8368.68	1539.00	1768.60	3561.99	56.06
	0.482	0.073	0.521	1.35	100.09	91.32	22.20	9855.03	2814.39	708.19	700.69	1409.42	8.25

¹ Standard deviations given below the means.

² Whole body metal concentrations including gut.

³ Fe and Zn are given in $\mu\text{g}/\text{g}$.

Table 2. Metal concentrations in whole body and gut from stoneroller minnows from Big Bayou Creek, collected March 13-14, 2001.

Station	Date	Sample	Ag Conc. ($\mu\text{g}/\text{Kg}$)			Be Conc. ($\mu\text{g}/\text{Kg}$)			Cd Conc. ($\mu\text{g}/\text{Kg}$)		
			Body	Gut	Body+gut	Body	Gut	Body+gut	Body	Gut	Body+gut
MC	031401	SR1	13.73	12.31	26.03	37.63	373.94	411.57	26.04	123.91	149.95
MC	031401	SR2	16.46	13.39	29.85	33.56	396.46	430.03	27.05	363.95	391.00
MC	031401	SR3	12.47	13.70	26.17	35.18	168.05	203.23	22.04	61.34	83.38
MC	031401	SR4	<31.65	22.82	22.82	17.76	455.80	473.56	<31.65	<118.11	N.D.
MC	031401	SR5	<18.41	<18.41	N.D.	18.82	462.39	481.21	118.73	<78.95	118.73
BB1A	031301	SR1	<10.52	10.26	10.26	16.52	360.72	377.24	<10.52	70.11	70.11
BB1A	031301	SR2	<9.57	7.09	7.09	32.78	848.96	881.74	12.81	68.21	81.02
BB1A	031301	SR3	<10.35	6.45	6.45	26.32	400.00	426.32	31.61	98.22	129.83
BB1A	031301	SR4	8.10	8.01	16.11	28.42	920.67	949.08	17.30	68.75	86.05
BB1A	031301	SR5	<6.87	12.32	12.32	19.83	685.91	705.75	15.93	208.25	224.18
BB1	031301	SR1	15.19	11.30	26.49	26.66	364.39	391.05	23.64	34.68	58.32
BB1	031301	SR2	32.79	19.86	52.65	23.87	<43.73	23.87	96.91	106.59	203.50
BB1	031301	SR3	6.51	11.81	18.32	10.67	405.50	416.16	105.95	187.75	293.70
BB1	031301	SR4	12.74	52.05	64.78	31.86	269.95	301.80	28.63	103.48	132.11
BB1	031301	SR5	19.49	7.67	27.16	39.17	280.92	320.09	26.29	56.29	82.57
BB2	031301	SR1	<19.92	10.86	10.86	28.83	188.66	217.50	<19.92	<68.18	N.D.
BB2	031301	SR2	18.78	16.20	34.99	42.33	380.64	422.97	19.12	66.18	85.31
BB2	031301	SR3	20.85	9.11	29.97	34.84	310.19	345.03	17.80	39.67	57.47
BB2	031301	SR4	21.82	13.24	35.06	30.14	451.56	481.70	11.02	93.17	104.19
BB2	031301	SR5	26.62	13.01	39.63	31.23	388.26	419.50	13.06	98.90	111.96

Table 2, continued. Metal concentrations in whole body and gut from stoneroller minnows from Big Bayou Creek, collected March 13-14, 2001.

Station	Date Sample	Ag Conc. ($\mu\text{g}/\text{Kg}$)			Be Conc. ($\mu\text{g}/\text{Kg}$)			Cd Conc. ($\mu\text{g}/\text{Kg}$)		
		Body	Gut	Body+gut	Body	Gut	Body+gut	Body	Gut	Body+gut
BB3	031301 SR1	<18.06	<18.06	N.D.	32.20	779.34	811.54	<15.87	152.80	152.80
BB3	031301 SR2	<13.12	16.65	16.65	13.57	639.69	653.26	<13.12	65.20	65.20
BB3	031301 SR3	<18.63	<18.63	N.D.	35.12	387.82	422.94	19.82	55.51	75.33
BB3	031301 SR4	9.64	8.89	18.53	35.83	605.16	640.99	21.21	63.60	84.81
BB3	031301 SR5	<14.95	7.03	7.03	32.23	277.65	309.87	<14.95	76.52	76.52
BB4	031301 SR1	40.91	51.37	92.27	96.18	80.45	176.62	49.80	103.85	153.65
BB4	031301 SR2	24.59	58.54	83.13	40.66	45.97	86.63	31.38	102.48	133.85
BB4	031301 SR3	34.75	31.31	66.06	26.23	<34.64	26.23	25.78	87.21	112.99
BB4	031301 SR4	43.80	65.19	109.00	31.03	<36.23	31.03	30.54	283.78	314.32
BB4	031301 SR5	28.22	41.02	69.24	24.99	45.01	70.00	25.63	472.44	498.08
BB5	031301 SR1	78.52	40.19	118.71	38.80	605.28	644.08	23.68	207.61	231.30
BB5	031301 SR2	65.95	30.16	96.11	32.86	105.01	137.87	28.44	114.36	142.80
BB5	031301 SR3	63.34	31.93	95.27	28.05	302.61	330.66	14.86	70.04	84.90
BB5	031301 SR4	49.37	65.22	114.59	35.21	488.45	523.66	14.84	153.41	168.25
BB5	031301 SR5	25.18	36.00	61.19	20.60	192.74	213.34	25.77	90.89	116.67
BB6	031301 SR1	30.69	46.00	76.68	47.48	338.34	385.83	25.01	117.28	142.28
BB6	031301 SR2	97.60	35.84	133.44	37.27	382.70	419.97	18.49	100.91	119.40
BB6	031301 SR3	91.36	32.13	123.49	34.70	121.67	156.37	20.81	<81.52	20.81
BB6	031301 SR4	31.30	29.32	60.62	64.31	329.35	393.66	31.93	106.53	138.46
BB6	031301 SR5	34.81	12.90	47.70	64.22	465.40	529.62	32.88	85.76	118.64

Table 2, continued. Metal concentrations in whole body and gut from stoneroller minnows from Big Bayou Creek, collected March 13-14, 2001.

Station	Date	Sample	Ag Conc. ($\mu\text{g}/\text{Kg}$)			Be Conc. ($\mu\text{g}/\text{Kg}$)			Cd Conc. ($\mu\text{g}/\text{Kg}$)		
			Body	Gut	Body+gut	Body	Gut	Body+gut	Body	Gut	Body+gut
BB7	031301	SR1	54.68	24.16	78.84	23.21	327.98	351.19	22.23	89.51	111.74
BB7	031301	SR2	103.32	23.49	126.80	31.33	275.59	306.91	19.90	99.82	119.72
BB7	031301	SR3	102.15	24.63	126.78	41.16	228.23	269.39	21.20	113.32	134.52
BB7	031301	SR4	117.08	18.94	136.02	34.05	342.29	376.34	22.48	150.17	172.64
BB7	031301	SR5	65.31	24.95	90.27	32.25	395.21	427.46	17.99	196.77	214.76
BB8	031301	SR1	28.11	16.36	44.47	51.35	545.80	597.15	26.64	145.51	172.15
BB8	031301	SR2	33.46	15.61	49.07	49.16	348.44	397.60	32.59	117.81	150.40
BB8	031301	SR3	22.38	19.57	41.95	27.00	268.36	295.36	<15.29	47.84	47.84
BB8	031301	SR4	19.58	18.67	38.25	36.81	288.49	325.30	40.07	57.71	97.78
BB8	031301	SR5	<19.51	21.59	21.59	21.43	215.29	236.72	<19.51	<83.33	N.D.
BB9	031401	SR1	19.78	10.53	30.32	56.00	109.63	165.63	35.42	<92.59	35.42
BB9	031401	SR2	12.14	10.36	22.49	49.57	132.60	182.18	32.43	77.66	110.08
BB9	031401	SR3	<25.38	8.48	8.48	36.74	456.85	493.58	<25.38	242.18	242.18
BB9	031401	SR4	20.77	13.62	34.39	45.88	127.48	173.36	23.56	69.37	92.93
BB9	031401	SR5	16.47	10.12	26.59	49.07	383.33	432.40	21.28	165.00	186.28

Table 2, continued. Metal concentrations in whole body and gut from stoneroller minnows from Big Bayou Creek, collected March 13-14, 2001.

Station	Date	Sample	Cr Conc. (µg/Kg)			Cu Conc. (µg/Kg)			Fe Conc. (µg/g)		
			Body	Gut	Body+gut	Body	Gut	Body+gut	Body	Gut	Body+gut
MC	031401	SR1	283.66	2819.46	3103.12	626.90	3061.40	3688.29	9.76	4526.89	4536.65
MC	031401	SR2	165.46	2820.21	2985.67	671.84	<2038.04	671.84	14.67	4227.23	4241.90
MC	031401	SR3	143.05	1414.93	1557.98	510.54	<2727.27	510.54	9.43	1381.96	1391.39
MC	031401	SR4	296.36	4363.51	4659.87	888.88	<5905.51	888.88	59.19	3003.07	3062.26
MC	031401	SR5	328.18	4312.31	4640.49	1319.69	<3947.37	1319.69	153.53	4392.08	4545.61
BB1A	031301	SR1	51.82	1646.55	1698.37	1266.13	3038.85	4304.98	45.18	6055.61	6100.79
BB1A	031301	SR2	<47.85	2077.34	2077.34	659.78	3594.49	4254.27	7.56	6401.04	6408.60
BB1A	031301	SR3	66.01	2201.94	2267.95	762.38	3137.25	3899.63	56.52	6566.80	6623.32
BB1A	031301	SR4	77.46	301.74	379.20	645.98	3932.18	4578.16	72.88	5201.27	5274.15
BB1A	031301	SR5	290.20	2497.79	2787.99	1070.41	5425.79	6496.20	171.15	5318.80	5489.95
BB1	031301	SR1	87.65	5359.87	5447.53	1227.88	2053.11	3280.99	23.05	4042.20	4065.25
BB1	031301	SR2	85.49	990.48	1075.97	4049.78	3515.76	7565.54	15.41	936.17	951.58
BB1	031301	SR3	69.90	3728.42	3798.32	1758.41	4270.80	6029.21	18.41	6444.29	6462.71
BB1	031301	SR4	<27.09	2200.08	2200.08	4137.92	1868.12	6006.04	20.01	4637.29	4657.31
BB1	031301	SR5	<37.92	1819.29	1819.29	1916.27	1989.33	3905.61	15.84	3932.97	3948.81
BB2	031301	SR1	<99.60	1515.03	1515.03	<498.01	<3409.09	N.D.	<9.96	1542.41	1542.41
BB2	031301	SR2	<41.40	1230.46	1230.46	608.81	1912.40	2521.21	2.41	4331.52	4333.93
BB2	031301	SR3	57.97	1055.52	1113.50	547.02	<1820.39	547.02	64.17	3583.51	3647.68
BB2	031301	SR4	62.13	2035.79	2097.93	1130.94	3658.36	4789.30	67.94	6086.72	6154.67
BB2	031301	SR5	<47.57	1552.18	1552.18	1059.17	2619.93	3679.10	19.88	4925.25	4945.12

Table 2, continued. Metal concentrations in whole body and gut from stoneroller minnows from Big Bayou Creek, collected March 13-14, 2001.

Station	Date	Sample	Cr Conc. (µg/Kg)			Cu Conc. (µg/Kg)			Fe Conc. (µg/g)		
			Body	Gut	Body+gut	Body	Gut	Body+gut	Body	Gut	Body+gut
BB3	031301	SR1	<79.37	4545.32	4545.32	1295.15	11362.29	12657.44	17.35	10463.50	10480.85
BB3	031301	SR2	<65.59	2875.22	2875.22	2207.14	10889.53	13096.67	36.38	9684.15	9720.52
BB3	031301	SR3	<38.71	2058.92	2058.92	2862.63	8836.13	11698.77	22.85	6816.51	6839.36
BB3	031301	SR4	<30.18	2537.79	2537.79	1068.60	7294.79	8363.39	16.74	7182.28	7199.01
BB3	031301	SR5	<74.74	2103.39	2103.39	1362.36	4796.53	6158.88	24.12	4435.90	4460.02
BB4	031301	SR1	43.66	1211.01	1254.66	3010.95	1188.64	4199.59	14.57	650.75	665.31
BB4	031301	SR2	37.38	6562.94	6600.32	1013.34	1550.22	2563.56	11.59	616.60	628.19
BB4	031301	SR3	42.10	786.66	828.77	2041.95	9172.82	11214.77	13.27	786.13	799.40
BB4	031301	SR4	49.24	1047.16	1096.40	2696.30	16615.64	19311.93	25.99	1063.95	1089.94
BB4	031301	SR5	39.48	953.60	993.08	1024.97	823.98	1848.95	9.24	523.96	533.20
BB5	031301	SR1	64.11	17869.39	17933.50	736.15	3094.51	3830.66	29.51	6999.74	7029.25
BB5	031301	SR2	61.17	4047.55	4108.72	4393.22	1198.22	5591.44	10.94	1129.06	1140.00
BB5	031301	SR3	94.63	5249.54	5344.17	1438.04	9659.42	11097.46	43.41	2016.45	2059.86
BB5	031301	SR4	46.87	10574.25	10621.12	2861.74	2354.63	5216.38	61.10	8030.52	8091.61
BB5	031301	SR5	131.18	7581.61	7712.79	6071.74	11215.72	17287.46	82.64	3572.50	3655.14
BB6	031301	SR1	47.97	9827.07	9875.04	4666.97	2087.00	6753.97	16.93	5769.57	5786.50
BB6	031301	SR2	61.23	9022.70	9083.93	1793.20	16732.08	18525.28	30.38	4216.35	4246.72
BB6	031301	SR3	46.41	5737.97	5784.38	1811.21	10864.02	12675.23	17.62	1908.51	1926.13
BB6	031301	SR4	40.96	5728.09	5769.04	1815.03	1170.20	2985.23	27.25	4327.69	4354.94
BB6	031301	SR5	33.27	14517.08	14550.35	1457.84	1050.98	2508.82	23.51	3842.08	3865.59

Table 2, continued. Metal concentrations in whole body and gut from stoneroller minnows from Big Bayou Creek, collected March 13-14, 2001.

Station	Date	Sample	Cr Conc. ($\mu\text{g}/\text{Kg}$)			Cu Conc. ($\mu\text{g}/\text{Kg}$)			Fe Conc. ($\mu\text{g}/\text{g}$)		
			Body	Gut	Body+gut	Body	Gut	Body+gut	Body	Gut	Body+gut
BB7	031301	SR1	419.70	5602.18	6021.88	2118.27	7808.34	9926.61	57.00	4343.64	4400.64
BB7	031301	SR2	33.84	4924.86	4958.70	2648.74	9036.78	11685.52	15.55	3277.51	3293.07
BB7	031301	SR3	55.82	5090.62	5146.43	2893.93	9827.81	12721.73	14.58	2944.53	2959.11
BB7	031301	SR4	51.94	5824.60	5876.54	1827.18	7362.82	9190.00	31.63	4443.89	4475.52
BB7	031301	SR5	52.27	12549.46	12601.73	858.80	1590.03	2448.83	29.09	5984.73	6013.82
BB8	031301	SR1	<36.18	5581.16	5581.16	2193.58	6586.20	8779.78	44.88	6767.22	6812.10
BB8	031301	SR2	<32.44	2882.85	2882.85	1994.39	6670.61	8665.00	22.51	4731.34	4753.85
BB8	031301	SR3	<76.45	2682.12	2682.12	3232.89	12390.84	15623.73	26.54	2893.52	2920.06
BB8	031301	SR4	<71.57	2763.24	2763.24	4616.07	9697.33	14313.40	78.60	2678.26	2756.86
BB8	031301	SR5	<97.53	2908.84	2908.84	3669.95	8090.28	11760.23	13.74	1894.67	1908.41
BB9	031401	SR1	<50.03	1858.58	1858.58	1405.46	30259.88	31665.35	23.08	2589.35	2612.43
BB9	031401	SR2	<39.06	1423.75	1423.75	<195.31	3913.07	3913.07	6.38	1600.34	1606.72
BB9	031401	SR3	<126.90	4072.24	4072.23	1255.30	6881.88	8137.18	52.28	4378.70	4430.98
BB9	031401	SR4	<46.01	1697.09	1697.09	2763.06	5491.77	8254.83	36.40	1760.63	1797.04
BB9	031401	SR5	<34.20	5364.15	5364.15	315.26	3997.61	4312.87	12.86	5042.40	5055.26

Table 2, continued. Metal concentrations in whole body and gut from stoneroller minnows from Big Bayou Creek, collected March 13-14, 2001.

Station	Date	Sample	Pb Conc. (µg/Kg)			Ni Conc. (µg/Kg)			Zn Conc. (µg/g)		
			Body	Gut	Body+gut	Body	Gut	Body+gut	Body	Gut	Body+gut
MC	031401	SR1	402.35	1498.95	1901.30	2991.24	6506.66	9497.90	23.53	40.05	63.57
MC	031401	SR2	347.23	3013.29	3360.51	2296.32	6309.94	8606.27	28.61	42.80	71.41
MC	031401	SR3	1317.48	1430.30	2747.78	3034.47	1855.61	4890.08	18.99	19.36	38.36
MC	031401	SR4	696.76	4444.44	5141.20	968.15	5893.93	6862.09	56.63	48.43	105.05
MC	031401	SR5	738.03	4128.65	4866.68	1276.07	6741.49	8017.56	60.71	38.76	99.47
BB1A	031301	SR1	1109.89	3304.32	4414.20	1001.62	4911.48	5913.10	41.45	37.06	78.52
BB1A	031301	SR2	1299.84	3214.26	4514.10	1645.49	7446.42	9091.91	26.32	36.85	63.18
BB1A	031301	SR3	1077.96	3455.47	4533.43	1436.58	5899.42	7335.99	28.85	33.50	62.35
BB1A	031301	SR4	1360.18	2023.67	3383.86	1349.44	5124.72	6474.16	37.43	33.84	71.27
BB1A	031301	SR5	1050.81	1791.19	2841.99	1155.15	5527.84	6683.00	31.56	59.00	90.56
BB1	031301	SR1	306.62	2279.99	2586.61	2092.47	3878.70	5971.17	40.06	25.19	65.25
BB1	031301	SR2	229.48	<874.64	229.48	1253.15	1281.94	2535.09	29.55	37.00	66.55
BB1	031301	SR3	162.85	2576.49	2739.34	602.40	6534.39	7136.79	26.96	40.46	67.42
BB1	031301	SR4	270.20	1608.35	1878.54	2179.10	4103.02	6282.12	24.98	42.73	67.72
BB1	031301	SR5	354.20	2089.50	2443.70	2595.31	3761.79	6357.10	31.74	28.26	60.00
BB2	031301	SR1	1050.56	1519.78	2570.34	1781.24	2446.68	4227.92	38.36	27.41	65.77
BB2	031301	SR2	355.45	2882.26	3237.71	2010.82	4443.04	6453.86	16.53	21.70	38.23
BB2	031301	SR3	1490.43	3507.37	4997.81	1825.33	3141.35	4966.68	35.19	22.72	57.91
BB2	031301	SR4	1212.59	2480.92	3693.51	1434.60	6658.33	8092.93	20.22	40.99	61.21
BB2	031301	SR5	1682.07	2151.44	3833.51	1995.32	6231.67	8226.99	17.98	31.41	49.39

Table 2, continued. Metal concentrations in whole body and gut from stoneroller minnows from Big Bayou Creek, collected March 13-14, 2001.

Station	Date	Sample	Pb Conc. (µg/Kg)			Ni Conc. (µg/Kg)			Zn Conc. (µg/g)		
			Body	Gut	Body+gut	Body	Gut	Body+gut	Body	Gut	Body+gut
BB3	031301	SR1	1857.52	6684.77	8542.29	2284.03	10211.62	12495.64	34.68	92.69	127.38
BB3	031301	SR2	599.66	5334.20	5933.86	1050.69	7892.40	8943.09	26.15	84.73	110.88
BB3	031301	SR3	379.54	3984.73	4364.28	2632.68	6190.85	8823.53	32.83	71.10	103.93
BB3	031301	SR4	379.34	4345.01	4724.35	2659.83	6513.59	9173.43	29.77	70.54	100.30
BB3	031301	SR5	1350.63	2298.65	3649.28	2407.14	6545.00	8952.14	45.21	76.69	121.89
BB4	031301	SR1	34.53	790.86	825.39	637.86	1304.18	1942.04	24.73	32.79	57.52
BB4	031301	SR2	48.52	603.24	651.76	685.30	1699.00	2384.30	19.75	29.63	49.37
BB4	031301	SR3	36.59	<692.84	36.59	608.07	<1732.10	608.07	30.25	25.91	56.16
BB4	031301	SR4	64.78	909.22	973.99	722.90	2281.05	3003.95	46.01	45.43	91.45
BB4	031301	SR5	45.15	530.93	576.08	686.64	1727.31	2413.96	24.02	43.71	67.72
BB5	031301	SR1	856.89	4418.19	5275.08	822.24	10845.34	11667.58	22.59	78.69	101.28
BB5	031301	SR2	110.54	846.55	957.09	860.29	2775.64	3635.93	37.65	42.66	80.31
BB5	031301	SR3	168.40	1757.62	1926.02	722.93	3569.17	4292.10	31.75	53.77	85.52
BB5	031301	SR4	434.56	5551.08	5985.64	799.76	10740.98	11540.74	26.96	78.17	105.13
BB5	031301	SR5	167.44	2125.12	2292.57	620.33	3394.76	4015.09	50.74	50.18	100.93
BB6	031301	SR1	620.27	2676.66	3296.92	1115.54	7447.68	8563.22	45.13	53.64	98.77
BB6	031301	SR2	227.47	3344.48	3571.96	708.74	7453.10	8161.85	31.92	71.41	103.33
BB6	031301	SR3	151.31	1878.54	2029.85	638.69	3896.26	4534.95	33.60	50.46	84.06
BB6	031301	SR4	420.96	1719.37	2140.32	1136.33	7158.76	8295.08	22.66	49.98	72.64
BB6	031301	SR5	768.00	1052.35	1820.34	721.61	8541.35	9262.96	30.46	59.12	89.58

Table 2, continued. Metal concentrations in whole body and gut from stoneroller minnows from Big Bayou Creek, collected March 13-14, 2001.

Station	Date	Sample	Pb Conc. (µg/Kg)			Ni Conc. (µg/Kg)			Zn Conc. (µg/g)		
			Body	Gut	Body+gut	Body	Gut	Body+gut	Body	Gut	Body+gut
BB7	031301	SR1	348.81	2232.99	2581.80	569.40	7179.50	7748.90	25.69	46.01	71.69
BB7	031301	SR2	215.18	1621.05	1836.23	668.96	4593.82	5262.79	19.94	47.07	67.02
BB7	031301	SR3	482.28	1983.70	2465.97	861.38	4515.17	5376.54	51.00	50.81	101.81
BB7	031301	SR4	399.04	2283.14	2682.18	744.55	7400.75	8145.30	20.76	46.36	67.12
BB7	031301	SR5	602.70	2982.72	3585.42	688.08	10123.69	10811.77	18.06	56.24	74.30
BB8	031301	SR1	516.85	3914.55	4431.40	3220.47	8248.71	11469.18	44.82	45.28	90.10
BB8	031301	SR2	592.41	3650.29	4242.70	3130.90	6612.85	9743.75	35.04	44.95	79.99
BB8	031301	SR3	1149.52	1870.69	3020.21	2240.10	5518.47	7758.57	29.53	44.60	74.13
BB8	031301	SR4	1638.32	2068.38	3706.70	2819.44	4500.18	7319.61	45.69	48.51	94.20
BB8	031301	SR5	872.54	2117.79	2990.33	1801.38	3355.76	5157.15	46.46	56.25	102.71
BB9	031401	SR1	539.64	<1851.85	539.64	3275.59	2043.30	5318.88	37.46	42.50	79.96
BB9	031401	SR2	475.26	1195.06	1670.32	2874.38	3344.01	6218.40	13.48	41.83	55.31
BB9	031401	SR3	1577.23	4693.95	6271.18	3234.92	10594.82	13829.74	46.93	67.45	114.38
BB9	031401	SR4	477.65	<1408.45	477.65	2990.34	2492.09	5482.43	36.90	36.27	73.16
BB9	031401	SR5	477.17	2368.69	2845.86	3146.53	5337.05	8483.57	16.13	51.84	67.96

Table 4. Results from the weights of whole body with gut removed, weight of gut, and combined weights for stoneroller minnows collected from Big Bayou Creek. Samples were collected March 13-14, 2001.

Station	Date	Sample	Wt. of Whole Body - Gut (g)	Wt. of Gut (g)	Wt. of Body + Gut (g)	Percent gut out of Whole Body
MC	03/14/01	SR1	3.128	0.424	3.552	11.94
MC	03/14/01	SR2	3.751	0.368	4.119	8.93
MC	03/14/01	SR3	3.118	0.275	3.393	8.10
MC	03/14/01	SR4	0.948	0.127	1.075	11.81
MC	03/14/01	SR5	0.977	0.190	1.167	16.28
		Mean	2.384	0.277	2.661	11.41
		±	1.323	0.122	1.432	3.21
BB1A	03/13/01	SR1	2.851	0.499	3.350	14.90
BB1A	03/13/01	SR2	3.135	0.337	3.472	9.71
BB1A	03/13/01	SR3	2.899	0.450	3.349	13.44
BB1A	03/13/01	SR4	4.251	0.937	5.188	18.06
BB1A	03/13/01	SR5	4.364	0.762	5.126	14.87
		Mean	3.500	0.597	4.097	14.19
		±	0.746	0.246	0.969	3.03
BB1	03/13/01	SR1	6.646	0.577	7.223	7.99
BB1	03/13/01	SR2	6.090	0.343	6.433	5.33
BB1	03/13/01	SR3	5.155	0.552	5.707	9.67
BB1	03/13/01	SR4	5.538	0.543	6.081	8.93
BB1	03/13/01	SR5	3.956	0.586	4.542	12.90
		Mean	5.477	0.520	5.997	8.97
		±	1.020	0.101	0.988	2.75
BB2	03/13/01	SR1	1.506	0.220	1.726	12.75
BB2	03/13/01	SR2	3.623	0.495	4.118	12.02
BB2	03/13/01	SR3	3.568	0.412	3.980	10.35
BB2	03/13/01	SR4	3.714	0.348	4.062	8.57
BB2	03/13/01	SR5	3.153	0.446	3.599	12.39
		Mean	3.113	0.384	3.497	11.22
		±	0.924	0.106	1.011	1.74

Table 4, continued. Results from the weights of whole body with gut removed, weight of gut, and combined weights for stoneroller minnows collected from Big Bayou Creek. Samples were collected March 13-14, 2001.

Station	Date	Sample	Wt. of Whole Body - Gut (g)	Wt. of Gut (g)	Wt. of Body + Gut (g)	Percent gut out of Whole Body
BB3	03/13/01	SR1	1.890	0.284	2.174	13.06
BB3	03/13/01	SR2	2.287	0.410	2.697	15.20
BB3	03/13/01	SR3	3.875	0.500	4.375	11.43
BB3	03/13/01	SR4	4.971	0.672	5.643	11.91
BB3	03/13/01	SR5	2.007	0.267	2.274	11.74
		Mean	3.006	0.427	3.433	12.67
		±	1.358	0.167	1.520	1.55
BB4	03/13/01	SR1	12.038	0.569	12.607	4.51
BB4	03/13/01	SR2	10.079	0.563	10.642	5.29
BB4	03/13/01	SR3	9.973	0.433	10.406	4.16
BB4	03/13/01	SR4	7.317	0.414	7.731	5.36
BB4	03/13/01	SR5	13.538	0.661	14.199	4.66
		Mean	10.589	0.528	11.117	4.80
		±	2.353	0.103	2.445	0.52
BB5	03/13/01	SR1	3.951	0.622	4.573	13.60
BB5	03/13/01	SR2	6.823	0.565	7.388	7.65
BB5	03/13/01	SR3	5.149	0.409	5.558	7.36
BB5	03/13/01	SR4	5.064	0.492	5.556	8.86
BB5	03/13/01	SR5	6.077	0.570	6.647	8.58
		Mean	5.413	0.532	5.944	9.21
		±	1.091	0.083	1.091	2.53
BB6	03/13/01	SR1	3.012	0.547	3.559	15.37
BB6	03/13/01	SR2	3.012	0.234	3.246	7.21
BB6	03/13/01	SR3	2.398	0.184	2.582	7.13
BB6	03/13/01	SR4	4.163	0.605	4.768	12.69
BB6	03/13/01	SR5	8.097	1.162	9.259	12.55
		Mean	4.136	0.546	4.683	10.99
		±	2.304	0.391	2.678	3.67

Table 4, continued. Results from the weights of whole body with gut removed, weight of gut, and combined weights for stoneroller minnows collected from Big Bayou Creek. Samples were collected March 13-14, 2001.

Station	Date	Sample	Wt. of Whole Body - Gut (g)	Wt. of Gut (g)	Wt. of Body + Gut (g)	Percent gut out of Whole Body
BB7	03/13/01	SR1	4.764	0.552	5.316	10.38
BB7	03/13/01	SR2	4.933	0.521	5.454	9.55
BB7	03/13/01	SR3	2.141	0.480	2.621	18.31
BB7	03/13/01	SR4	4.411	0.617	5.028	12.27
BB7	03/13/01	SR5	4.259	0.551	4.810	11.46
		Mean	4.102	0.544	4.646	12.40
		±	1.129	0.050	1.159	3.47
BB8	03/13/01	SR1	4.146	0.378	4.524	8.36
BB8	03/13/01	SR2	4.624	0.317	4.941	6.42
BB8	03/13/01	SR3	1.962	0.334	2.296	14.55
BB8	03/13/01	SR4	2.096	0.265	2.361	11.22
BB8	03/13/01	SR5	1.538	0.180	1.718	10.48
		Mean	2.873	0.295	3.168	10.20
		±	1.406	0.076	1.457	3.07
BB9	03/14/01	SR1	2.998	0.162	3.160	5.13
BB9	03/14/01	SR2	3.840	0.412	4.252	9.69
BB9	03/14/01	SR3	1.182	0.161	1.343	11.99
BB9	03/14/01	SR4	3.260	0.213	3.473	6.13
BB9	03/14/01	SR5	4.386	0.419	4.805	8.72
		Mean	3.133	0.273	3.407	8.33
		±	1.216	0.131	1.322	2.76

Table 5. Results from the weights of whole body with gut removed, weight of gut, and combined weights for stoneroller minnows collected from Little Bayou Creek. Samples were collected March 14, 2001.

Station	Date	Sample	Wt. of Whole Body - Gut (g)	Wt. of Gut (g)	Wt. of Body + Gut (g)	Percent gut out of Whole Body
LB2	03/14/01	SR1	4.415	0.456	4.871	9.36
LB2	03/14/01	SR2	3.420	0.453	3.873	11.70
LB2	03/14/01	SR3	7.443	0.860	8.303	10.36
LB2	03/14/01	SR4	6.754	1.089	7.843	13.88
LB2	03/14/01	SR5	5.246	0.634	5.880	10.78
		Mean	5.456	0.698	6.154	11.22
		±	1.651	0.275	1.897	1.71
LB3	03/14/01	SR1	5.961	0.536	6.497	8.25
LB3	03/14/01	CC1	0.579	0.049	0.628	7.80
LB3	03/14/01	CC2	2.684	0.132	2.816	4.69
		Mean	3.075	0.239	3.314	6.91
		±	2.712	0.261	2.966	1.94
LB4	03/14/01	SR1	4.050	0.349	4.399	7.93
LB4	03/14/01	SR2	3.339	0.295	3.634	8.12
LB4	03/14/01	SR3	4.391	0.357	4.748	7.52
LB4	03/14/01	SR4	4.330	0.488	4.818	10.13
LB4	03/14/01	SR5	3.489	0.407	3.896	10.45
		Mean	3.920	0.379	4.299	8.83
		±	0.482	0.073	0.521	1.35

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