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TRACE METALS IN SURFACE SEDIMENTS OF SANTA MONICA BAY

During 1978, the Coastal Water Research Project conducted a comprehensive survey of 143 stations in Santa Monica Bay to determine the distribution of animals and various sediment parameters. The results of this survey for bottom material description, infauna, biomass, volatile solids, and oxygen demand have been reported (Bascom 1979). Here, we report the measurement of nine metals in the upper 2 centimeters of sediments, at depths ranging from 10 to 300 meters. Highest metal concentrations were found at the head of Santa Monica Canyon, Redondo Canyon, and on northern Palos Verdes Shelf.

METHODS

Station locations are shown in Figures 1 and 2. Sampling methods and equipment were reported by Bascom (1979). Benthic grabs were taken with a modified Van Veen as described by Word (1976). Undisturbed surface material, the most recently settled particles, was subsampled for chemical analyses to a depth of 2 cm. The sediments were placed in plastic vials and frozen until analysis. At the time of analysis, the samples were thawed, and rocks, shells, and visible organisms were removed. The samples were then dried to a constant weight at a temperature of 80°C and manually homogenized.

The homogenized samples were subjected to hot acid digestion to dissolve the metals from the sediments. A 20-ml solution of HNO_3 and water (1:1) was added to 0.5-2.0 grams of sample in a glass-covered, 150-ml beaker. The mixture was heated to incipient boiling until about 3 ml remained; this procedure was repeated once. Then 20 ml of water and 2 ml of concentrated HCl were added, and the mixture was boiled for 20 minutes. After cooling, the digestate was filtered through acid-washed Whatman No. 40 filter paper (8-micron pore size) and diluted to 50 ml. Analytical blanks were prepared along with the sediment samples, using the same procedures and reagents.

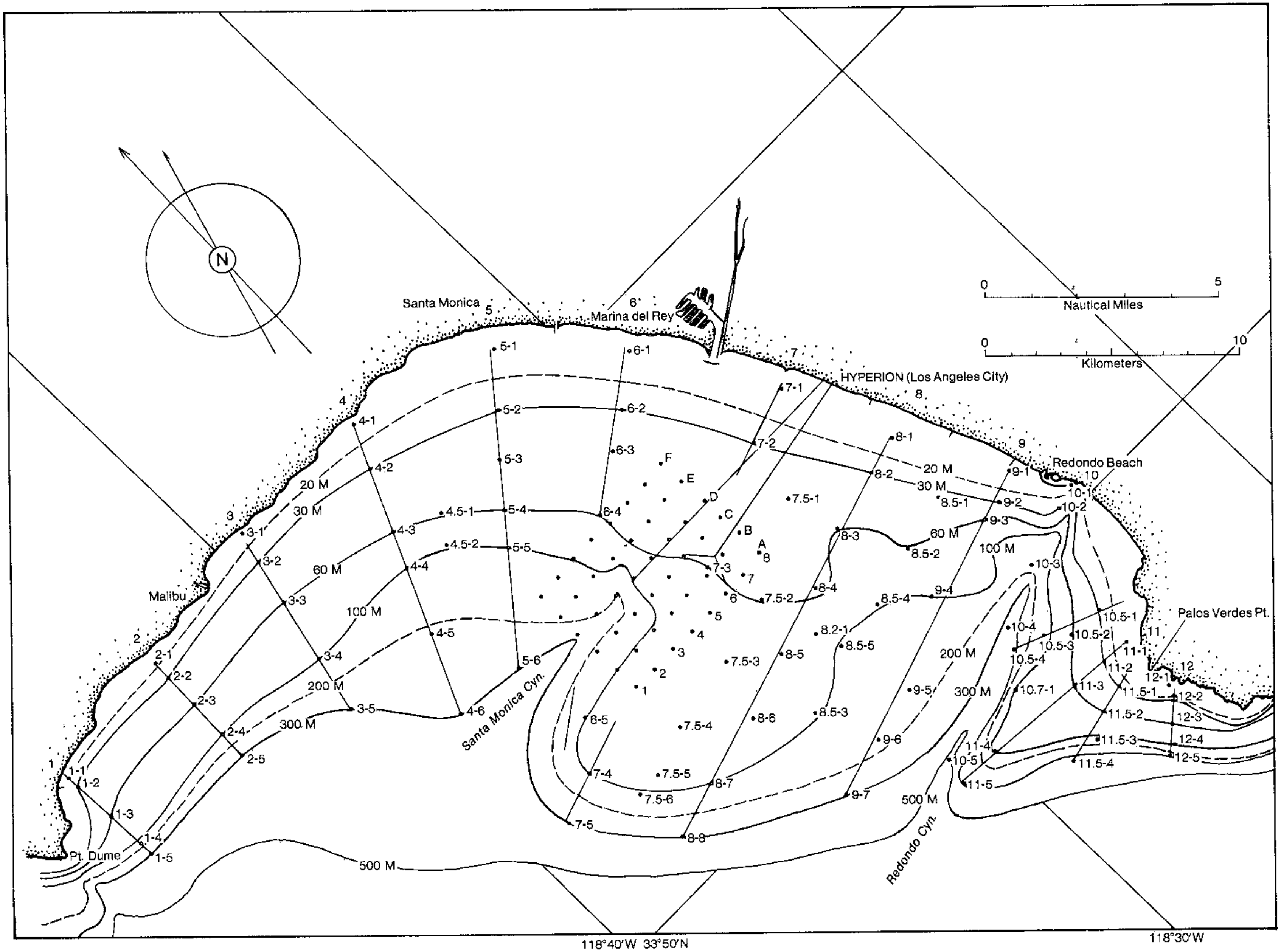

Figure 1. Station locations in Santa Monica Bay.

This moderate digestion procedure extracts most of the metals usually considered to be possibly biologically available, such as those associated with organic matter, sulfides, oxides, and adsorbed on the surface of the solids. Metals associated with the silicate minerals (part of the lithogenous fraction) essentially are not biologically available and are not extracted by this procedure (Goldberg 1954).

Analyses were performed by aspiration into an air/acetylene flame of a Varian-Techtron atomic absorption spectrophotometer (Model AA-6), equipped with a premix burner and a simultaneous background corrector. When very low concentrations were encountered, quantification was done by injection into a carbon rod atomizer. There were no significant matrix interferences in detection of the elements in question, given a sample size of up to 2 grams.

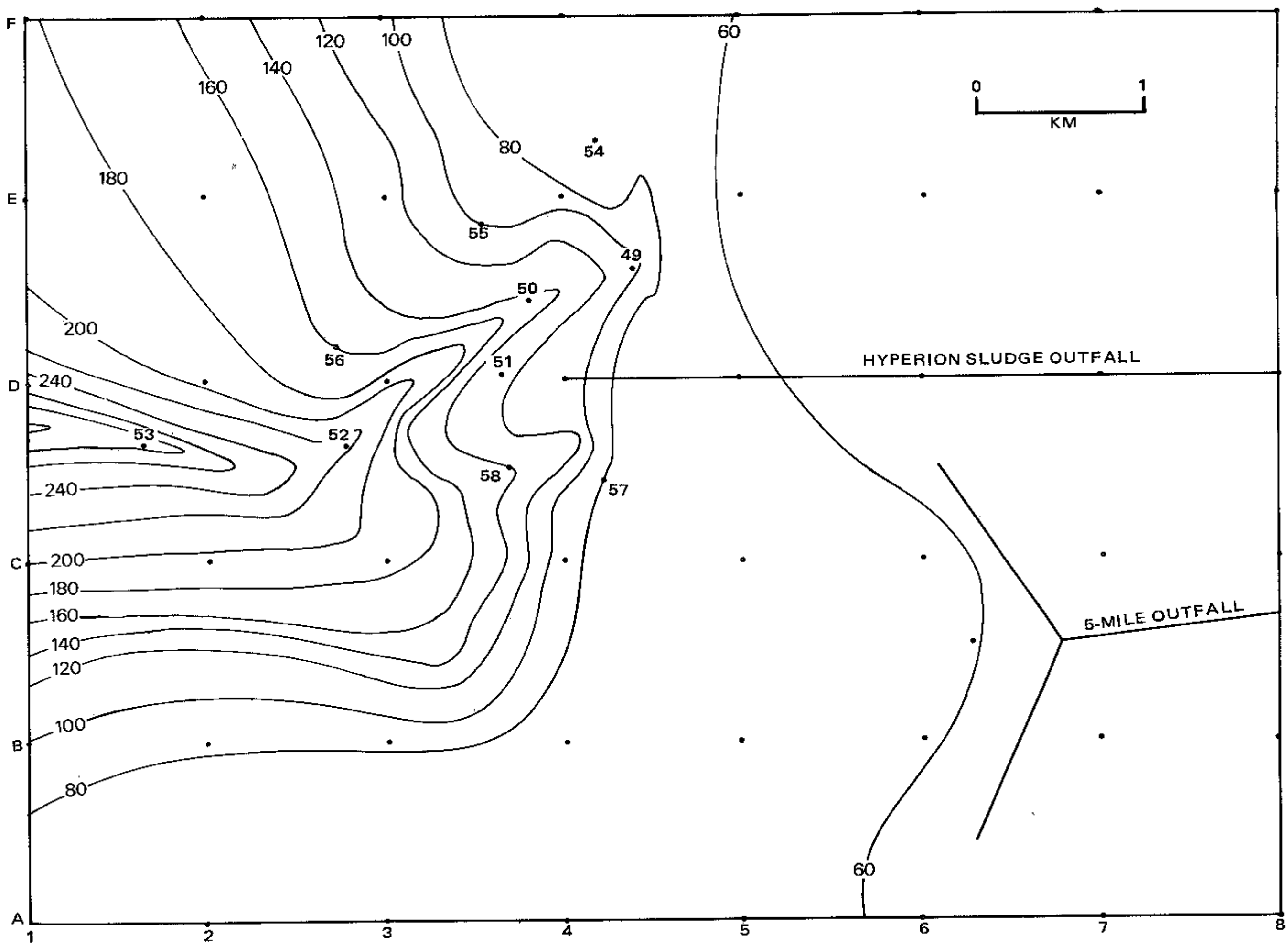

Figure 2. Station locations in the vicinity of the terminus of the Hyperion 5-mile outfall and the Hyperion sludge outfall, at the head of Santa Monica Canyon.

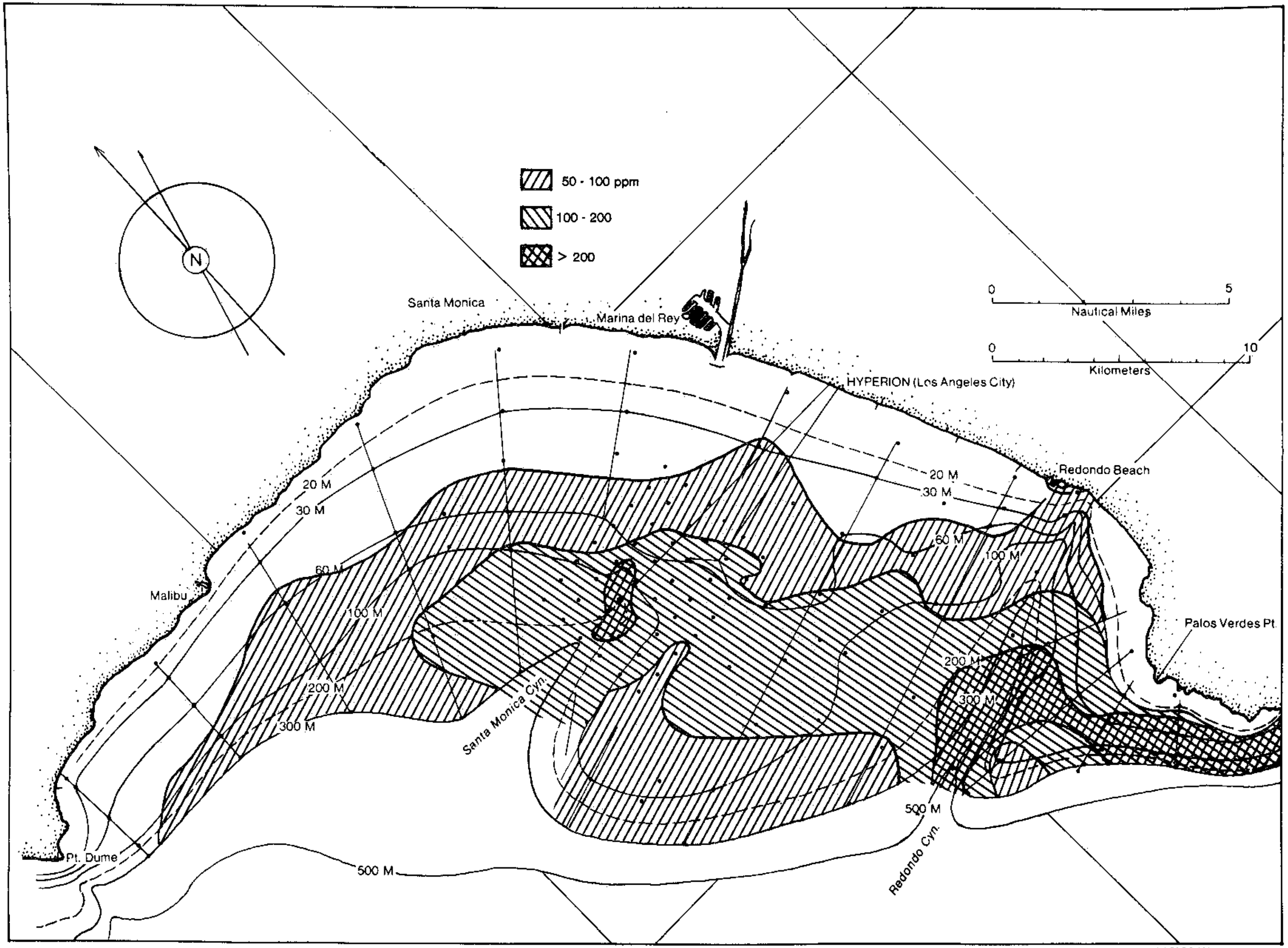

Figure 3. Concentration isopleths (mg/dry kg) of chromium in the top 2 cm of sediments in Santa Monica Bay.

RESULTS AND DISCUSSION

Concentrations of silver, cadmium, chromium, copper, iron, manganese, nickel, lead, and zinc have thus far been determined. The results are listed in Table 1. Baseline metal concentrations at a depth of 60 meters from 28 pristine coastal sites throughout the Southern California Bight were measured in 1977 (Word and Mearns 1979); these are summarized below:

	Median	Range
Silver	0.20	0.06-1.7
Cadmium	0.33	0.1-1.4
Chromium	22	6.5-43
Copper	8.3	2.8-31
Nickel	12	1.6-35
Lead	6.1	2.7-12
Zinc	43	9.8-62

Iron and manganese, which are relatively constant in the Bay, have little gradient with proximity to point discharges. Chromium concentrations are plotted in Figures 3 and 4 enabling one to viualze their distribution. Chromium is illustrated because this metal is highly associated with wastewater particulates discharged into the Bay and does not readily desorb in seawater (Rohatgi and Chen 1975; Lu and Chen 1977; Jan and Young 1978). With the exception of lead, the rest of the metals had distribution patterns similar to that of chromium. The lead distribution (Figure 5) reflects the fact that its predominant source is not only submarine wastewater outfalls, but also terrestrial aerial fallout transported by surface runoff to nearshore regions via storm drainage channels (Huntzicker et al. 1975; Young and Jan 1977).

Most of the Bay at a depth of 60 meters had somewhat higher concentrations than control values reported by Word and Mearns (1979). Very high values were confined to the head of Santa Monica Canyon, site of the City of Los Angeles sludge outfall. The adjacent Palos Verdes Shelf had values similar to those measured in 1975 (Hershelman et al. 1977). Elevated values were also detected in Redondo Canyon; presumably, the source of these is the wastewater discharges from the outfalls of the Los Angeles County Sanitation District off Palos Verdes, some 20 km down coast. The head of Redondo Canyon impinges nearshore at King Harbor. Additional study of this area would be useful in evaluating inputs from the harbor and movements of wastewater particles in this canyon.

The Project's Trace Metal Laboratory is in the process of completing analysis of samples from 300 stations extending sediment measurements southward to the U.S.-Mexico border.

Table 1. Concentrations (mg/dry kg) of nine metals in surficial (0-2 cm) sediments of Santa Monica Bay, 1978.

Station	LORAN-C Position LOP 1	LOP 2	Depth (m)	Ag	Cd	Cr	Cu	Fe*	Mn	Ni	Pb	Zn
Santa Monica Bay												
1-1	28128.5	41224.9	11	0.05	0.73	11	1.8	0.54	54	7.6	3.2	15
1-2	28128.2	41222.5	29	0.86	0.95	27	19	2.7	227	38	14	66
1-3	28127.4	41218.5	60	0.46	0.55	34	11	1.7	106	21	11	42
1-4	28126.9	41215.3	107	—**	—	—	—	—	—	—	—	—
1-5	28126.5	41214.4	310	0.68	1.1	50	17	2.0	138	24	7.4	55
2-1	28138.4	41208.0	10	0.07	1.1	13	2.8	1.2	96	6.8	4.0	22
2-2	28137.9	41206.2	30	0.22	0.27	29	8.6	2.0	120	30	7.9	46
2-3	28137.0	41203.8	60	1.5	0.59	45	16	2.3	133	28	13	59
2-4	28136.3	41200.4	102	—	—	—	—	—	—	—	—	—
2-5	28135.5	41198.5	305	1.1	0.68	69	17	2.3	136	19	7.8	65
3-1	28149.1	41191.0	10	0.06	0.55	18	4.7	1.1	106	15	5.7	37
3-2	28148.0	41189.5	30	0.29	1.3	29	19	2.7	227	38	14	66
3-3	28146.2	41187.6	60	1.6	1.1	52	25	2.6	174	37	16	72
3-4	28144.0	41184.5	100	1.5	0.48	54	21	2.3	96	24	15	54
3-5	28141.9	41181.5	300	1.5	0.94	68	30	2.4	160	32	14	72
4-1	28159.3	41171.4	11	0.11	0.05	11	5.0	0.98	83	11	5.1	22
4-2	28157.4	41170.5	31	0.89	0.98	32	10	2.0	140	22	7.2	49
4-3	28154.1	41169.1	60	1.7	0.15	50	18	1.6	96	24	19	57
4-4	28152.3	41168.9	96	1.7	0.03	56	24	2.1	90	16	13	55
4-5	28149.0	41167.8	208	2.6	1.2	102	52	1.9	177	32	16	93
4-6	28145.0	41166.5	307	3.4	0.91	69	32	2.4	177	34	4.7	72
4.5-1	28157.2	41161.0	60	1.9	0.38	55	22	2.1	91	19	3.9	60
4.5-2	28155.4	41160.5	100	1.9	0.53	66	32	2.0	93	12	6.5	61
5-1	28168.5	41148.8	11	0.01	0.36	20	5.9	1.2	129	15	15	36
5-2	28165.0	41150.2	31	0.73	0.45	31	12	1.5	106	16	17	48
5-3	28162.0	41151.5	47	1.7	0.40	49	18	1.9	121	13	22	62
5-4	28159.2	41152.6	60	2.7	0.72	90	23	1.8	90	21	9.3	45
5-5	28156.8	41153.6	98	5.7	1.4	117	68	1.4	93	22	30	77
5-6	28149.8	41156.5	290	3.1	1.9	113	61	2.0	176	32	20	97
6-1	28172.5	41129.6	10	0.18	0.29	22	6.5	1.2	104	14	26	44
6-2	28169.0	41132.8	30	0.66	0.30	28	9.7	1.2	85	13	18	41
6-3	28166.6	41135.5	40	1.6	0.53	39	16	1.5	99	15	20	49
6-4	28161.6	41139.5	59	4.3	2.8	73	47	1.1	89	14	23	79
6-5	28149.4	41148.8	100	0.73	0.40	26	14	1.3	38	8.5	6.4	31
7-1	28174.8	41109.8	11	0.10	0.04	9.7	2.3	0.74	43	3.2	16	14
7-2	28170.8	41115.6	30	2.8	0.77	53	25	1.7	135	18	33	73
7-3	28164.0	41124.9	60	7.2	3.8	118	64	1.6	116	19	26	113
7-4	28145.5	41150.5	101	0.84	0.78	59	19	2.6	61	12	10	48
7-5	28142.0	41155.2	301	0.98	0.94	70	19	2.9	165	16	7.6	62
7.5-1	28168.3	41114.0	49	3.0	0.70	68	29	2.1	138	7.5	35	70
7.5-2	28161.4	41120.9	59	5.2	2.1	138	79	1.8	137	12	27	92
7.5-3	28156.8	41128.8	70	2.5	0.90	111	61	2.8	232	5.9	31	87
7.5-4	28151.2	41136.7	78	0.99	2.5	96	42	2.5	146	47	14	90
7.5-5	28148.3	41141.7	83	3.1	1.3	84	37	2.6	123	40	11	76
7.5-6	28145.8	41144.9	110	0.73	0.39	39	15	1.9	52	11	11	34
8-1	28175.2	41096.2	12	0.12	0.13	18	3.2	0.92	83	7.1	8.5	20
8-2	28172.5	41100.6	30	0.61	0.48	27	7.2	0.93	86	9.0	15	31
8-3	28168.0	41107.2	58	1.7	0.56	48	18	1.1	95	13	16	42
8-4	28163.7	41112.8	59	5.3	1.1	108	55	1.8	172	19	24	83
8-5	28158.8	41120.0	73	5.6	1.0	141	65	2.3	229	19	28	99
8-6	28154.0	41126.5	76	3.2	0.97	126	46	2.3	165	18	24	77
8-7	28148.7	41134.5	102	0.98	0.94	70	19	2.9	165	16	7.6	62
8-8	28144.8	41140.0	300	1.1	0.62	71	22	2.9	177	8.1	8.4	67
8.2-1	28161.0	41114.7	66	5.8	4.7	155	64	2.1	150	16	27	94
8.5-1	28171.7	41097.0	43	ND†	0.05	36	13	1.3	84	12	0.8	40
8.5-2	28168.9	41098.9	64	2.9	1.2	88	25	1.9	128	14	22	71
8.5-3	28156.1	41117.7	97	2.9	1.5	113	33	4.1	138	12	18	76
8.5-4	28164.7	41105.9	99	5.6	3.0	163	57	2.3	160	18	34	100
8.5-5	28161.0	41110.5	102	6.9	2.4	179	69	2.4	169	20	32	113
9-1	28176.5	41181.5	11	0.16	0.13	18	3.2	1.0	95	8.4	8.4	21
9-2	28174.5	41084.2	28	0.60	0.45	29	8.7	1.0	82	9.8	14	33
9-3	28173.0	41086.5	58	1.3	0.74	46	16	1.2	102	14	22	53
9-4	28165.7	41097.0	99	2.1	0.51	74	28	1.8	107	12	19	69
9-5	28160.5	41103.9	140	4.5	1.3	149	66	2.4	211	28	35	117
9-6	28156.5	41110.0	168	2.0	1.0	95	38	2.2	206	21	21	86
9-7	28152.4	41116.0	303	1.1	0.94	66	28	2.1	207	16	13	68

*Percent

**Rocks, no sample.

†No data, sample solution lost.

Table 1 continued

Station	LORAN-C Position LOP 1	LOP 2	Depth (m)	Ag	Cd	Cr	Cu	Fe*	Mn	Ni	Pb	Zn
10-1	28177.5	41073.5	49	3.4	1.7	103	39	2.3	196	28	69	119
10-2	28175.8	41076.2	50	2.3	0.93	63	23	1.5	126	18	35	70
10-3	28171.5	41082.6	186	2.6	1.4	81	36	1.5	147	18	26	72
10-4	28167.2	41088.3	368	4.4	2.4	191	74	2.5	219	28	44	132
10-5	28158.0	41101.4	552	1.4	1.5	273	27	1.6	285	18	15	70
10.5-1	28171.0	41075.0	33	0.48	1.0	41	9.1	1.0	218	12	11	42
10.5-2	28168.7	41079.8	66	2.2	1.3	119	42	1.9	200	20	30	86
10.5-3	28167.9	41083.5	165	3.4	2.6	174	66	2.1	218	24	45	126
10.5-4	28166.0	41088.5	387	4.1	2.4	226	83	2.7	223	32	47	134
10.7-1	28163.7	41089.3	106	—	—	—	—	—	—	—	—	—
11-1	28169.9	41072.8	11	—	—	—	—	—	—	—	—	—
11-2	28168.0	41076.1	30	0.28	3.4	39	5.4	1.2	182	12	11	54
11-3	28165.6	41081.0	62	3.9	2.1	167	60	1.9	217	18	40	115
11-4	28159.5	41093.9	105	1.7	1.2	71	28	2.3	95	10	21	85
11-5	28156.6	41099.9	301	1.1	1.8	134	35	6.0	122	23	17	89
11.5-1	28167.0	41075.3	46	2.7	4.7	136	60	2.0	196	26	51	145
11.5-2	28165.0	41078.2	70	5.2	6.6	344	154	2.1	233	28	91	267
11.5-3	28163.2	41081.1	173	2.5	4.4	202	83	2.2	242	22	53	163
11.5-4	28161.2	41084.5	366	2.9	4.4	186	85	2.4	262	25	44	169
12-1	28168.5	41068.5	11	—	—	—	—	—	—	—	—	—
12-2	28168.0	41068.0	30	0.17	0.97	25	4.9	0.49	427	4.8	8.0	22
12-3	28166.7	41069.5	62	7.4	8.8	627	238	2.7	271	46	138	265
12-4	28165.5	41070.0	102	3.1	5.5	224	99	3.0	211	23	71	235
12-5	28164.5	41070.9	312	3.9	9.4	260	214	2.3	251	31	69	278
Santa Monica Bay Inner Grid												
A1	28152.2	41141.1	80	—	—	—	—	—	—	—	—	—
A2	28153.9	41137.8	80	2.6	0.81	118	43	4.6	148	22	22	82
A3	28155.6	41134.6	76	5.1	0.94	121	74	2.7	171	18	30	82
A4	28157.3	41131.5	70	6.9	1.1	126	80	0.9	113	16	36	78
A5	28159.0	41128.4	62	7.5	1.9	111	79	1.3	98	15	32	89
A6	28160.7	41125.4	61	5.1	2.2	83	57	1.4	84	14	26	66
A7	28162.4	41122.2	58	6.7	2.8	107	65	1.4	105	16	27	95
A8	28164.1	41119.2	57	5.8	2.3	98	54	1.5	113	16	23	97
B1	28152.7	41143.2	138	1.6	0.75	63	24	4.8	83	11	13	61
B2	28154.4	41139.9	84	1.6	0.64	72	31	2.3	76	11	19	64
B3	28156.1	41136.7	80	2.6	0.82	92	55	2.2	94	13	30	76
B4	28157.8	41133.6	77	5.6	1.7	101	88	1.5	122	16	36	84
B5	28159.4	41130.4	65	7.6	3.6	112	79	1.3	96	16	34	107
B6	28161.2	41127.3	62	8.7	3.8	146	95	1.6	101	22	39	106
B7	28162.9	41124.2	61	6.3	8.7	153	90	1.9	111	27	28	120
B8	28164.6	41121.1	55	3.5	1.3	70	34	1.3	96	12	16	68
C1	28153.2	41145.3	240	6.2	2.4	128	64	2.1	178	23	27	109
C2	28154.9	41142.1	217	18	12	253	150	2.0	185	32	66	256
C3	28156.5	41138.8	191	24	19	360	244	2.1	178	40	91	345
C4	28158.3	41135.6	89	—	—	—	—	—	—	—	—	—
C5	28160.0	41132.5	68	11	6.1	140	102	1.3	104	18	44	150
C6	28161.7	41129.4	62	14	7.2	201	140	1.7	100	29	52	169
C7	28163.3	41126.5	58	5.9	3.3	104	69	1.7	105	21	29	100
C8	28165.1	41123.2	53	4.5	0.91	78	38	1.6	117	16	21	78
D1	28153.7	41147.4	210	5.9	4.2	142	91	2.1	167	27	35	120
D2	28155.4	41144.2	195	8.3	5.8	152	94	1.9	167	23	35	137
D3	28157.1	41140.9	201	7.5	44	895	617	2.3	180	87	212	777
D4	28158.8	41137.7	95	14	14	207	204	0.89	82	42	95	121
D5	28160.5	41134.6	65	10	8.4	151	115	1.5	112	19	44	168
D6	28162.2	41131.4	60	8.6	4.8	130	86	1.6	100	22	34	121
D7	28163.9	41128.3	54	4.8	1.6	79	43	1.5	108	15	21	82
D8	28165.6	41124.9	50	3.4	0.79	52	28	1.4	105	14	18	66
E1	28154.2	41149.4	195	9.2	3.7	149	81	1.8	156	22	34	127
E2	28159.9	41146.2	173	12	11	193	165	1.9	155	29	58	212
E3	28157.6	41143.1	132	13	9.9	186	130	1.3	99	26	56	189
E4	28159.3	41139.8	95	—	—	—	—	—	—	—	—	—
E5	28161.0	41136.6	60	4.6	3.7	85	57	1.1	84	14	25	95
E6	28162.7	41133.5	57	4.7	2.6	76	52	1.4	87	17	23	80
E7	28164.4	41130.4	51	4.3	1.1	84	44	1.6	94	15	24	68
E8	28166.1	41127.3	45	3.4	1.0	63	31	1.7	110	19	24	66

*Percent.

continued

Table 1 continued

	LORAN-C Position												
Station	LOP 1	LOP 2	Depth (m)	Ag	Cd	Cr	Cu	Fe*	Mn	Ni	Pb	Zn
F1	28154.7	41151.4	185	12	3.3	182	105	1.7	141	24	42	127
F2	28156.4	41148.3	147	9.3	5.2	193	121	1.7	116	24	44	140
F3	28158.1	41145.1	96	8.2	4.1	119	84	1.2	83	18	34	111
F4	28159.8	41141.9	63	3.7	2.1	69	44	0.96	74	9.9	18	70
F5	28161.5	41138.7	58	3.8	2.6	70	40	1.2	95	11	17	73
F6	28163.2	41135.6	53	3.3	1.1	67	35	1.3	90	12	17	53
F7	28164.9	41132.4	50	3.8	1.3	72	37	1.5	92	15	19	61
F8	28166.6	41129.3	42	2.0	0.57	46	20	1.5	93	15	21	51
49	28159.7	41137.8	111	6.6	74	1,200	947	1.8	129	152	336	1,390
50	28158.7	41139.2	153	10	72	1,160	881	1.8	127	157	292	1,380
51	28158.2	41138.8	136	42	97	1,140	1,310	1.6	111	219	374	1,760
52	28156.6	41140.9	198	46	39	646	512	2.1	168	79	180	683
53	28154.6	41144.5	246	8.2	17	303	272	2.6	218	47	86	343
54**	28159.6	41140.2	73	7.7	4.6	116	77	1.3	83	14	30	114
55	28158.3	41140.5	87	8.9	6.4	136	88	1.1	73	17	38	121
56	28156.8	41142.2	160	13	9.7	274	120	1.9	124	22	45	181
57	28158.8	41135.5	78	8.2	5.3	105	75	1.3	84	13	28	107
58	28158.5	41137.1	66	15	14	219	119	1.5	117	20	57	226

*Percent.

**54 through 58 sampled in 1980.

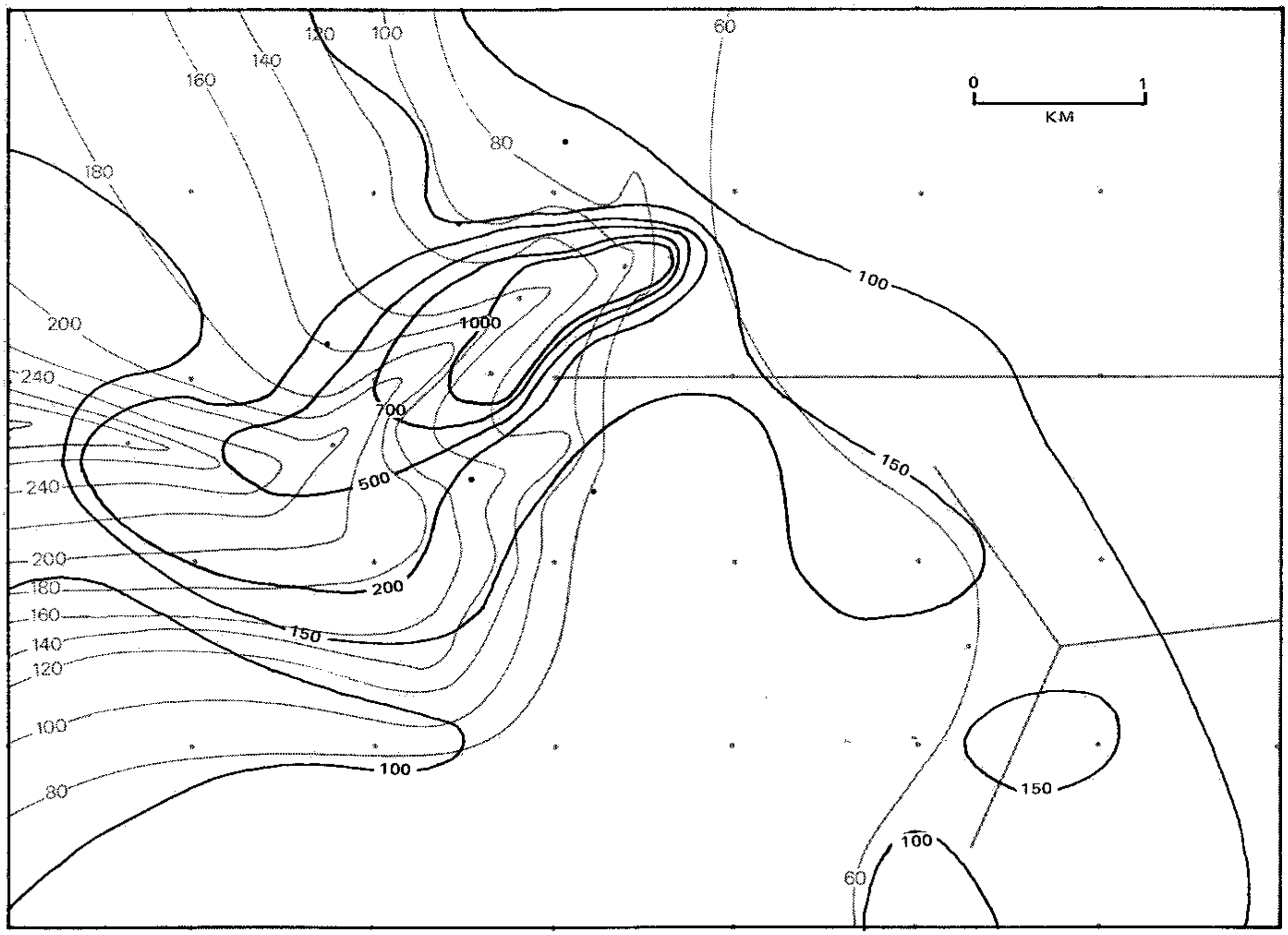

Figure 4. Concentration isopleths (mg/dry kg) of chromium in the top 2 cm of sediments at the head of Santa Monica Canyon.

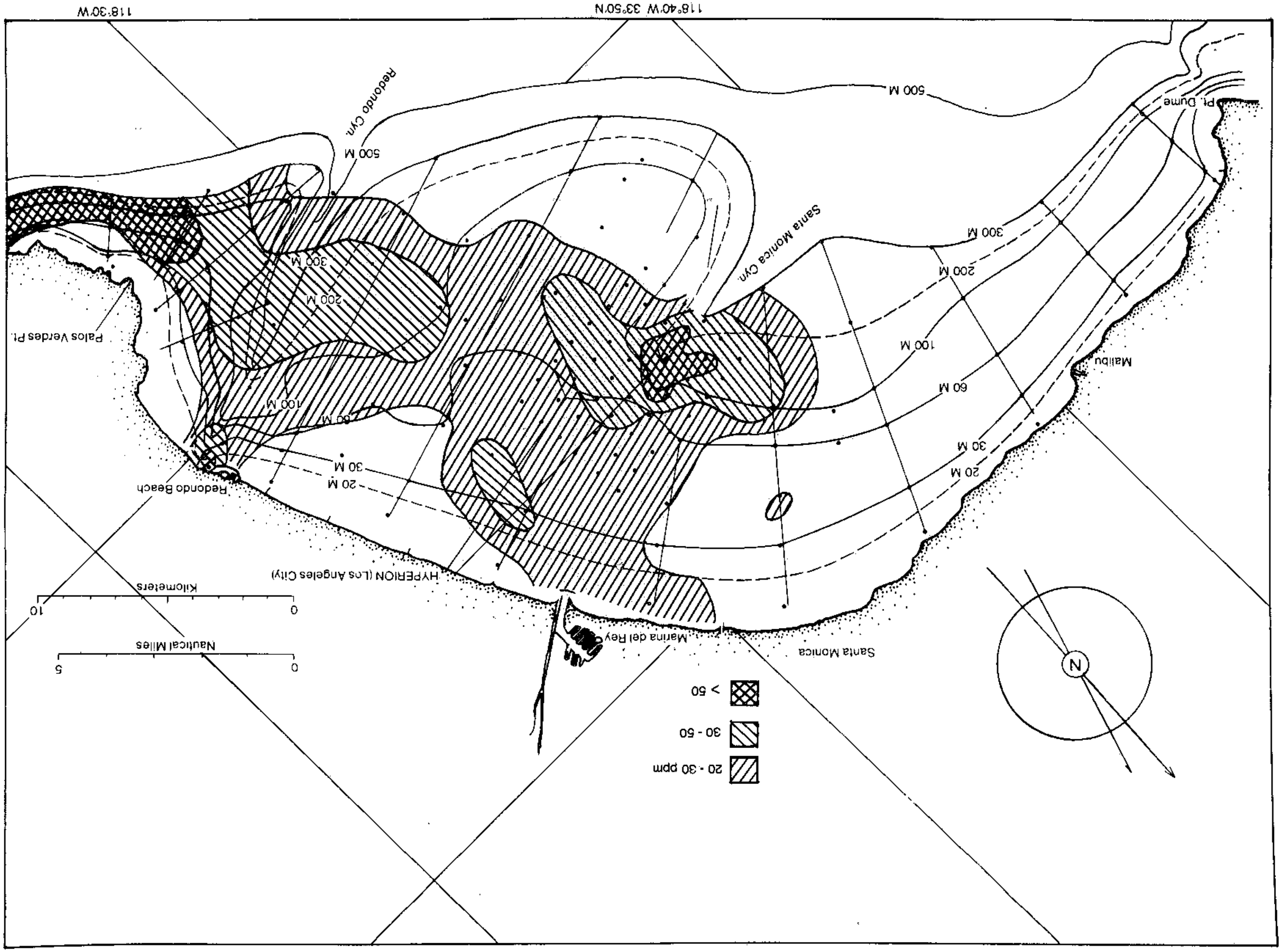

Figure 5. Concentration isopleths (mg/dry kg) of lead in the top 2 cm of sediments in Santa Monica Bay.

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