CHAPTER 1

Introduction

Introduction

This report describes the results from the 1997 Regional Monitoring Program for Trace Substances (RMP). It is the fifth annual report from the RMP, which began in 1993, and includes data, interpretation, and synthesis from Base Program monitoring, as well as results of pilot and special studies conducted or completed in 1997. Additionally, this report includes several articles contributed by RMP investigators and other researchers. These articles provide perspective and insight on important contaminant issues identified by the RMP, and they describe results from projects that took advantage of RMP field operations. Background information about the RMP, included in previous Annual Reports, is not repeated in this report. Instead, the reader is referred to those reports where appropriate. A full description of the RMP is also included in the *RMP Program Plan* available from the San Francisco Estuary Institute (SFEI) and through our website at http://www.sfei.org.

In 1997, the list of Program Participants was expanded to seventy-seven federal, state, and local agencies and companies. Together with the San Francisco Bay Regional Water Quality Control Board (Regional Board), they participated in the RMP as funders and service providers. They also assisted in directing the RMP through input or participation on the Steering and Technical Review Committees. The RMP Participants are listed on the inside of the back cover.

RMP Objectives

Staff at the Regional Board and SFEI along with representatives of RMP participating agencies developed the Program objectives:

1. Obtain high quality baseline data describing the concentrations of toxic and potentially toxic trace elements and organic contaminants in the water and sediment of the San Francisco Estuary.
2. Determine seasonal and annual trends in chemical and biological water quality in the San Francisco Estuary.
3. Continue to develop a data set that can be used to determine long-term trends in the concentrations of toxic and potentially toxic trace elements and organic contaminants in the water and sediments of the San Francisco Estuary.
4. Determine whether water and sediment quality in the Estuary at large are in compliance with objectives established by the Basin Plan.
5. Provide a database on water and sediment quality in the Estuary which is compatible with data being developed in other ongoing studies in the system, including, but not limited to, wasteload allocation studies and model development, sediment quality objectives development, in-bay studies of dredged material disposal, Interagency Ecological Program (IEP) water quality studies, primary productivity studies, local effects biomonitoring programs, and state and federal mussel watch programs.

Monitoring Design

The RMP sampling design was based on the Bay Protection and Toxic Cleanup Program (BPTCP) Pilot Studies developed by the Regional Board (Flegal *et al*., 1994). The reasoning behind the original design, with stations located along the "spine" of the Estuary, was to include stations that, in a long-term monitoring program, would indicate spatial and temporal trends in toxicity and chemistry, determine background concentrations for different reaches of the Estuary, and assess whether there were high levels of contaminants or toxicity. Several new stations were added in 1994 to fill spatial gaps and to begin monitoring near major tributaries (SFEI, 1995). Additionally, two stations were added in 1994 in the southern-most end of

the Estuary in cooperation with the Cities of San Jose (station C-3-0) and Sunnyvale (station C-1-3) and the Regional Board as part of their National Pollutant Discharge Elimination System (NPDES) monitoring.

The RMP sampling design has provided a picture of the range of conditions found in deeper parts of the Estuary, influenced by riverine, seasonal, and daily natural processes. During the redesign process (see *Chapter 2: 1997 Review Implementation*), options for incorporating more near-shore stations, evaluating overall Estuary condition at statistically representative sites, or conducting intensive embayment studies will be explored.

Five types of samples were collected in the 1997 Base Program:

1. Conventional water quality and chemistry.
2. Aquatic bioassays.
3. Sediment quality and chemistry.
4. Sediment bioassays.
5. Transplanted, bagged bivalve bioaccumulation, survival, and condition.

Table 1.1. Parameters analyzed in water, sediment, and bivalve tissue during the 1997 sampling of the San Francisco Estuary.

A. Conventional Water Quality Parameters

Conductivity
Dissolved Organic Carbon
Dissolved Oxygen (DO)
Hardness (when salinity is <5 ‰)
pH (acidity)
Phaeophytin (a chlorophyll degradation product)
Salinity
Temperature
Total Chlorophyll-*a*
Total Suspended Solids
Dissolved Phosphates
Dissolved Silicates
Dissolved Nitrate
Dissolved Nitrite
Dissolved Ammonia

B. Sediment Quality Parameters

% Clay (<4 μm)
% Silt (4 μm–62 μm)
% Sand (63 μm–2 mm)
% Gravel (>2 mm)
% Solids
pH
Total Ammonia
Total Organic Carbon
Total Sulfide

C. Bivalve Tissue Parameters

% Moisture
Bivalve % Survival
Total Volume
Shell Volume
Dry Flesh Weight
Biological Condition Index

D. Trace elements

	Water	Sediment	Tissue
Aluminum*		•	
Arsenic	•	•	•
Cadmium*	•	•	•
Chromium	•	•	•
Copper*	•	•	•
Iron*		•	
Lead*	•	•	•
Manganese*		•	
Mercury	•	•	•
Nickel*	•	•	•
Selenium	•	•	•
Silver*	•	•	•
Zinc*	•	•	•
Dibutyltin (DBT)			•
Monobutyltin (MBT)			•
Tributyltin (TBT)			•
Tetrabutyltin (TTBT)			•

* Near-total rather than total concentrations for water. Near-total metals are extracted with a weak acid (pH < 2) for a minimum of one month, resulting in measurements that approximate bioavailability of these metals to Estuary organisms.

Table 1.1 (continued). Parameters analyzed.

E. Polycyclic Aromatic Hydrocarbons (PAHs)	Water	Sediment	Tissue
2 rings			
1-Methylnaphthalene	•	•	•
2,3,5-Trimethylnaphthalene	•	•	•
2,6-Dimethylnaphthalene	•	•	•
2-Methylnaphthalene	•	•	•
Biphenyl	•	•	•
Naphthalene	•	•	•
3 rings			
1-Methylphenanthrene	•	•	•
Acenaphthene	•	•	•
Acenaphthylene	•	•	•
Anthracene	•	•	•
Dibenzothiophene	•	•	•
Fluorene	•	•	•
Phenanthrene	•	•	•
4 rings			
Benz(a)anthracene	•	•	•
Chrysene	•	•	•
Fluoranthene	•	•	•
Pyrene	•	•	•
5 rings			
Benzo(a)pyrene	•	•	•
Benzo(b)fluoranthene	•	•	•
Benzo(e)pyrene	•	•	•
Benzo(k)fluoranthene	•	•	•
Dibenz(a,h)anthracene	•	•	•
Perylene	•	•	•
6 rings			
Benzo(ghi)perylene	•	•	•
Indeno(1,2,3-cd)pyrene	•	•	•
Alkylated PAHs			
C1-Chrysenes	•	•	•
C2-Chrysenes	•	•	•
C3-Chrysenes	•	•	•
C4-Chrysenes	•	•	•
C1-Dibenzothiophenes	•	•	•
C2-Dibenzothiophenes	•	•	•
C3-Dibenzothiophenes	•	•	•
C1-Fluoranthenes/Pyrenes	•	•	•
C1-Fluorenes	•	•	•
C2-Fluorenes	•	•	•
C3-Fluorenes	•	•	•
C1-Naphthalenes	•	•	•
C2-Naphthalenes	•	•	•
C3-Naphthalenes	•	•	•
C4-Naphthalenes	•	•	•

E. PAHs (continued)	Water	Sediment	Tissue
C1-Phenanthrenes/Anthracenes	•	•	•
C2-Phenanthrenes/Anthracenes	•	•	•
C3-Phenanthrenes/Anthracenes	•	•	•
C4-Phenanthrenes/Anthracenes	•	•	•

F. Synthetic Biocides	Water	Sediment	Tissue
Cyclopentadienes			
Aldrin	•	•	•
Dieldrin	•	•	•
Endrin	•	•	•
Chlordanes			
alpha-Chlordane	•	•	•
cis-Nonachlor	•	•	•
gamma-Chlordane	•	•	•
Heptachlor	•	•	•
Heptachlor Epoxide	•	•	•
Oxychlordane	•	•	•
trans-Nonachlor	•	•	•
DDTs			
o,p'-DDD	•	•	•
o,p'-DDE	•	•	•
o,p'-DDT	•	•	•
p,p'-DDD	•	•	•
p,p'-DDE	•	•	•
p,p'-DDT	•	•	•
HCHs			
alpha-HCH	•	•	•
beta-HCH	•	•	•
delta-HCH	•	•	•
gamma-HCH	•	•	•
Other			
Diazinon	•		
Mirex	•	•	•
Chlorpyrifos	•		

Table 1.1 (continued). Parameters analyzed.

G. PCBs and Related Compounds	Water	Sediment	Tissue
Hexachlorobenzene	•	•	•
PCB 008	•	•	•
PCB 018	•	•	•
PCB 028	•	•	•
PCB 031	•	•	•
PCB 033	•	•	•
PCB 044	•	•	•
PCB 049	•	•	•
PCB 052	•	•	•
PCB 056	•	•	•
PCB 060	•	•	•
PCB 066	•	•	•
PCB 070	•	•	•
PCB 074	•	•	•
PCB 087	•	•	•
PCB 095	•	•	•
PCB 097	•	•	•
PCB 099	•	•	•
PCB 101	•	•	•
PCB 105	•	•	•
PCB 110	•	•	•
PCB 118	•	•	•
PCB 128	•	•	•
PCB 132	•	•	•
PCB 138	•	•	•
PCB 141	•	•	•
PCB 149	•	•	•
PCB 151	•	•	•
PCB 153	•	•	•
PCB 156	•	•	•
PCB 158	•	•	•
PCB 170	•	•	•
PCB 174	•	•	•
PCB 177	•	•	•
PCB 180	•	•	•
PCB 183	•	•	•
PCB 187	•	•	•
PCB 194	•	•	•
PCB 195	•	•	•
PCB 201	•	•	•
PCB 203	•	•	•

Complete listings of all parameters measured in 1997 are included in Table 1.1. Methods of collection and analysis are detailed in *Appendix A*. RMP data included in this report can be obtained by contacting SFEI or by accessing SFEI's website at http://www.sfei.org.

Locations of the twenty-two RMP and two Southern Slough (C-3-0, C-1-3) sampling stations are shown on the inside of the front cover; Table 1.2 lists the station names, codes, locations, and sampling dates for all 1997 stations. Water, sediment, or bioaccumulation sampling sites with the same station name may have different station codes as they are situated at slightly different locations (latitude, longitude) due to practical considerations, such as sediment type or ability to deploy bivalves. For example, at the South Bay site, BA20 is the water station code, and BA21 is the sediment station code.

Sampling occurred during three periods in 1997: during the wet season (January–February), a period of declining Delta outflow (late April), and during the dry season (July–August). The rationale for taking seasonal "snapshots" is to relate contaminant data during hydrologically different periods of the year with higher-frequency measurements conducted by the U.S. Geological Survey, and to evaluate the influence of natural variability on the contaminant signal. As part of the RMP re-design, the use of more intensive data on tides, Delta outflow, salinity gradients, algal blooms, and other parameters will be evaluated in greater detail to minimize the natural noise around any signals of water quality improvement or degradation over time.

Not all parameters were measured at all RMP stations each sampling period. Sampling activities at each station are listed in Table 1.2. Water samples were collected at all stations during all three sampling periods; however, trace organic contaminants in water were only measured at eighteen RMP stations and at San Jose (C-3-0). Aquatic bioassays were conducted at eight RMP stations and at Sunnyvale and San Jose (C-1-3 and C-3-0) during the wet- and dry-season sampling periods.

Sediment sampling was conducted during the wet- and dry-season sampling periods only. Sediment samples were collected from all RMP stations, except the Golden Gate station (BC20, this site is very deep). Sediment toxicity was measured at fourteen RMP stations and at San Jose (C-3-0) during the wet- and dry-season sampling periods. Measurements of ammonia and sulfides in sediment were also conducted in 1997 to support interpretation of sediment toxicity data.

Bivalve trace metal bioaccumulation was measured at eleven RMP stations, bivalve trace organic bioaccumulation was measured at fourteen RMP stations, and bivalve survival and condition was measured at thirteen RMP stations during the wet- and dry-season sampling periods.

Water and sediment samples were collected from the *R/V David Johnston* chartered through the University of California, Santa Cruz. Each sampling cruise started with water sampling at all RMP stations. Sediment sampling was then conducted with a separate run through the Estuary. Each complete sampling run required three to five days. Bivalve monitoring consisted of three parts: deployment of transplants from reference sites, maintenance, and retrieval. Most of this work was conducted aboard the *R/V Questuary*, owned by San Francisco State University. The California Department of Water Resources provided back-up services for bivalve cruises.

Field sampling was coordinated by Applied Marine Sciences in Livermore, California. Principal Investigators who conducted various kinds of analyses are listed in Table 1.3. Individual staff members of RMP data generators are listed in the *Acknowledgements*.

References

Flegal, A.R., R.W. Risebrough, B. Anderson, J. Hunt, S. Anderson, J. Oliver, M. Stephenson, and R. Packard. 1994. San Francisco Estuary Pilot Regional Monitoring Program: Sediment Studies. San Francisco Bay Regional Water Quality Control Board, State Water Resources Control Board.

SFEI. 1995. 1994 Annual Report: San Francisco Estuary Regional Monitoring Program for Trace Substances. Prepared by the San Francisco Estuary Institute, Richmond, CA. 339p.

Table 1.2. Summary of RMP 1997 sampling stations and activities.

Station Name	Station Code		Type of Sample	Measurements Made	Dates Sampled			Latitude deg	min	sec	Longitude deg	min	sec
Coyote Creek	BA10		water	Q,M,O,T	1/23	4/18	7/30	37	28	20	122	3	80
	BA10		sediment	Q,M,O,T	2/5		8/14	37	28	20	122	3	80
	BA10		bioaccumulation	M,O,C	5/8		9/25	37	28	19	122	3	83
South Bay	BA20		water	Q,M,O	1/22	4/17	7/29	37	29	69	122	5	34
	BA21		sediment	Q,M,O,T	2/5		8/13	37	29	64	122	5	25
Dumbarton Bridge	BA30		water	Q,M,O	1/22	4/17	7/29	37	30	90	122	8	11
	BA30		sediment	Q,M,O,T	2/5		8/14	37	30	87	122	8	7
	BA30		bioaccumulation	M,O,C	5/8		9/25	37	30	80	122	8	8
Redwood Creek	BA40		water	Q,M,O,T	1/23	4/17	7/30	37	33	67	122	12	57
	BA40		bioaccumulation	M,O,C	5/8		9/25	37	32	82	122	11	70
	BA41		sediment	Q,M,O,T	2/5		8/13	37	33	67	122	12	62
San Bruno Shoal	BB15		water	Q,M,O	1/22	4/17	7/29	37	37	0	122	17	0
	BB15		sediment	Q,M,O,T	2/5		8/13	37	37	0	122	17	0
Oyster Point	BB30		water	Q,M,O	1/22	4/17	7/29	37	40	20	122	19	75
	BB30		sediment	Q,M,O	2/6		8/13	37	40	21	122	19	77
Alameda	BB70		water	Q,M,O	1/24	4/16	7/31	37	44	66	122	19	30
	BB70		sediment	Q,M,O,T	2/4		8/13	37	44	84	122	19	40
	BB71		bioaccumulation	M,O,C	5/8		9/25	37	41	73	122	20	38
Yerba Buena Island	BC10		water	Q,M,O	1/24	4/15	7/31	37	49	36	122	20	96
	BC10		bioaccumulation	M,O,C	5/8		9/25	37	49	12	122	20	81
	BC11		sediment	Q,M,O,T	2/4		8/12	37	49	44	122	20	93
Golden Gate	BC20	*	water	Q,M,O	1/25			37	51	81	122	32	20
			water	Q,M,O		4/16		37	51	81	122	32	20
			water	Q,M,O			8/1	37	51	81	122	32	20
Horseshoe Bay	BC21		sediment	Q,M,O,T	2/4		8/12	37	49	98	122	28	43
	BC21		bioaccumulation	M,O,C	5/10		9/26	37	49	87	122	28	65
Richardson Bay	BC30		water	Q,M	1/24	4/15	8/1	37	51	81	122	28	66
	BC32		sediment	Q,M,O	2/4		8/12	37	51	82	122	28	72
Point Isabel	BC41		water	Q,M	1/24	4/15	7/31	37	53	30	122	20	55
	BC41		sediment	Q,M,O	2/4		8/12	37	53	34	122	20	55
Red Rock	BC60		water	Q,M,O	1/24	4/15	7/31	37	55	0	122	26	0
	BC60		sediment	Q,M,O,T	2/4		8/12	37	55	0	122	25	97
	BC61		bioaccumulation	Q,M,O	5/9		9/26	37	55	70	122	28	13
Petaluma River	BD15		water	Q,M,O,T	1/28	4/22	8/5	38	6	66	122	29	0
	BD15		sediment	Q,M,O	2/1		8/9	38	6	66	122	29	0
	BD15		bioaccumulation	M,O,C	5/9		9/26	38	6	77	122	30	5
San Pablo Bay	BD20		water	Q,M,O	1/28	4/22	8/5	38	2	92	122	25	19
	BD20		bioaccumulation	M,O,C	5/9		9/26	38	2	72	122	25	71
	BD22		sediment	Q,M,O	2/1		8/9	38	2	86	122	25	24
Pinole Point	BD30		water	Q,M,O,T	1/28	4/22	8/5	38	1	48	122	21	65
	BD30		bioaccumulation	M,O,C	5/9		9/26	38	1	0	122	22	5
	BD31		sediment	Q,M,O	2/1		8/9	38	1	49	122	21	71
Davis Point	BD40		water	Q,M,O	1/28	4/22	8/5	38	3	12	122	16	62
	BD40		bioaccumulation	M,O	not deployed		9/24	38	3	26	122	15	63
	BD41		sediment	Q,M,O,T	2/1		8/9	38	3	11	122	16	65
Napa River	BD50		water	Q,M,O,T	1/29	4/23	8/6	38	5	79	122	15	2
	BD50		sediment	Q,M,O,T	2/1		8/9	38	5	79	122	15	61
	BD50		bioaccumulation	M,O,C	5/9		9/24	38	4	84	122	14	82
Pacheco Creek	BF10		water	Q,M	1/29	4/24	8/6	38	3	9	122	5	80
	BF10		sediment	Q,M,O	1/31		8/8	38	2	85	122	5	66
Grizzly Bay	BF20		water	Q,M,O,T	1/29	4/23	8/6	38	6	96	122	2	31
	BF20		bioaccumulation	M,O,C	5/10		9/24	38	6	49	122	3	37
	BF21		sediment	Q,M,O,T	1/31		8/8	38	6	97	122	2	35
Honker Bay	BF40		water	Q,M	1/29	4/23	8/6	38	4	0	121	56	0
	BF40		sediment	Q,M,O	1/31		8/8	38	4	0	121	55	0
Sacramento River	BG20		water	Q,M,O,T	1/30	4/24	8/7	38	3	56	121	48	59
	BG20		sediment	Q,M,O,T	1/31		8/8	38	3	36	121	48	63
	BG20		bioaccumulation	M,O,C	5/10		9/27	38	3	58	121	47	50
San Joaquin River	BG30		water	Q,M,O,T	1/30	4/24	8/7	38	1	40	121	48	45
	BG30		sediment	Q,M,O,T	1/31		8/8	38	1	36	121	48	44
	BG30		bioaccumulation	M,O,C	5/10		9/27	38	1	27	121	48	32
San Jose	C-3-0		water	Q,M,O,T	1/23	4/18	7/30	37	27	85	121	1	60
	C-3-0		sediment	Q,M,O,T	2/6		8/14	37	27	72	121	58	53
Sunnyvale	C-1-3		water	Q,M,T	1/23	4/18	7/30	37	26	8	122	0	64
	C-1-3		sediment	Q,M	2/6		8/14	37	26	13	122	0	67
Standish Dam†	BW10		water	Q,M,O	2/8	4/10	8/2	37	27	10	121	55	45
	BW10		sediment	Q,M,O	2/8		8/7	37	27	20	121	55	45
Guadalupe River†	BW15		water	Q,M,O	2/8	4/8	8/2	37	25	34	121	1	60
	BW15		sediment	Q,M,O	2/8		8/7	37	25	33	121	58	47

M = trace elements
O = trace prgamocs
* location dependent on salinity
T = toxicity (aquatic and/or sediment)
Q = water and/or sediment quality
C = bivalve condition index
† Estuary Interface Pilot Station

Table 1.3. 1997 RMP contractors and principal investigators.

Field Logistics	Dr. Bob Spies and Dr. Andrew Gunther Applied Marine Sciences, Livermore, CA
BADA Program Manager	Mr. David Tucker City of San Jose, Environmental Services Dept., CA
Trace Element Chemistry	Dr. Russ Flegal, UC Santa Cruz, CA Dr. Eric Prestbo, Brooks-Rand, Seattle, WA
Trace Organic Chemistry	Dr. Bob Risebrough, Bodega Bay Institute, CA Dr. José Sericano, Texas A&M University, TX Dr. Walter Jarman, UC Santa Cruz, CA
Sediment Trace Metals and Trace Organics	Mr. Bill Ellgas East Bay Municipal Utility District, Oakland, CA
Water Hardness	Ms. Lynda Taylor Union Sanitary District, Fremont, CA
Water Toxicity Testing	Dr. Scott Ogle Pacific Eco-Risk Laboratories, Martinez, CA
Sediment Toxicity Testing	Mr. John Hunt and Mr. Brian Anderson Marine Pollution Laboratory, Granite Canyon, CA
Bagged Bivalve Sampling	Mr. David Bell Applied Marine Sciences, Livermore, CA
Bivalve Trace Metals	Mr. Jim Salerno City and County of San Francisco, CA
Bivalve PAHs and PCBs	Mr. Bhupinder Dhaliwal Central Contra Costa Sanitary District, Martinez, CA
USGS Water Quality	Dr. James Cloern, USGS, Menlo Park, CA
USGS Sediment Transport	Dr. David Schoellhamer, USGS, Sacramento, CA
Pilot Study on Benthic Macrofauna	Dr. Bruce Thompson San Francisco Estuary Institute, Richmond, CA Ms. Heather Peterson Dept. of Water Resources, Sacramento, CA
Fish Contamination Pilot Study	Dr. Jay Davis San Francisco Estuary Institute, Richmond, CA Ms. Karen Taberski SF Bay Regional Water Quality Control Board, Oakland, CA Mr. Russ Fairey Moss Landing Marine Laboratory, Moss Landing, CA
Estuary Interface Pilot Study	Dr. Rainer Hoenicke San Francisco Estuary Institute, Richmond, CA Mr. Dane Hardin Applied Marine Sciences, Livermore, CA