Estuarine Data Index: A Guide to Bay-Delta Research and Monitoring Programs

Volume I

Table of Contents

Introduction i

Contaminant Loading

ABAG Urban Runoff Studies 1

National Coastal Pollutant Discharge Inventory 7

Santa Clara Valley Nonpoint Source Study 12

NPDES Discharge Monitoring Database 20

Pesticide Use Reporting System 30

Sacramento Urban Runoff Monitoring Study 41

US Coast Guard Spills Data 45

Western San Joaquin Valley Hydrogeologic Studies 47

Hydrodynamics and Delta Inflow

DAYFLOW 52

Hydrodynamic Monitoring and Modeling 58

Water Resources Data 64

Sediments and Dredging

Dredge Disposal Study 86

Dredging and Permitting - Sacramento District 102

Dredging and Permitting - San Francisco District 107

Sediment Quality Survey 121

Uptake and Effects of Toxicants

California State Mussel Watch Program 142

Uptake and Effects of Toxicants, cont'd.

Chevron Deep Water Outfall Project 152

Contaminants of Concern: San Francisco Bay
and San Pablo Bay National Wildlife Refuges 163

National Status and Trends Program 168

Organic Contaminants in San Francisco Bay and
Effects on Starry Founder 176

San Francisco Bay Effluent Toxicity Study 184

Selenium Verification Study 192

South Bay Dischargers Authority Avian
Botulism Study 202

South Bay Dischargers Authority
Biological Studies 208

Striped Bass Health Index Monitoring 216

Toxicant Occurrance and Effects in Water Birds 225

Toxic Substances Monitoring Program 233

Trace Metal Accumulation in Benthos Sediments 246

Water Quality

Bioassays for Local Effects Monitoring 255

Butyltin Studies 259

Chevron Equivalent Protection Study 263

Chevron Toxicity Reduction Evaluation 275

Delta-Suisun Bay Ecological Studies 282

Local Effects Monitoring Program 295

Municipal Water Quality Investigations (formerly
Interagency Delta Health Aspects Monitoring Program) 309

Phytoplankton and Zooplankton Studies 318

Water Quality, cont'd.

Sacramento-San Joaquin Delta Water Quality Surveillance: Continuous Monitoring 325

Sacramento-San Joaquin Delta Water Quality Surveillance: Phytoplankton 328

Sacramento-San Joaquin Delta Water Quality Surveillance: Water Chemistry 336

Selenium Biogeochemical Studies 344

Shell Oil Company Effluent Toxicity Studies 351

South Bay Dischargers Authority: Water Quality 357

Spatial and Seasonal Variations of Trace Elements in South San Francisco Bay 363

Trace Element Concentrations in Seawater and Suspended Particulate Matter 367

Trace Metal Geochemistry of San Francisco Estuary 371

Urban Runoff Discharges from Sacramento, CA 375

Water Quality Monitoring Network 379

Appendix A 383

Appendix B 390

INTRODUCTION

Data and Information Management is an integral part of the Aquatic Habitat Institute 's program of evaluating the effects of water quality on the aquatic life of the San Francisco Bay-Delta. Part of that program is the maintenance of an on-line information system known as the Scientific Information Network for the Bay and Delta (SINBAD). The system was originally developed with funding from the Environmental Protection Agency's San Francisco Estuary Project and from the State Water Resources Control Board. The system is now being supported by AHI general support program funds from a variety of donors and grantors.

SINBAD contains the following databases:

The *Estuarine Data Index* (EDI) consists of detailed summaries of 70 research and monitoring programs that have been, or are presently being, conducted in the San Francisco Estuary.

The *Bay-Delta Bibliography* contains over 3,500 references about the Bay-Delta or relevant research from other estuaries.

The *Bay-Delta Hearing Testimony and Exhibits* database contains the transcripts of all testimony presented at the State Water Resource Control Board Bay-Delta Hearings.

Also part of SINBAD is an electronic "bulletin board", allowing users to exchange messages, post public inquiries, and read various bulletins and announcements.

This two volume report presents the contents of the Estuarine Data Index (EDI). Although the EDI was created for use on a computer, AHI is providing these printed reports in order to make this information available to individuals who do not have access to a computer and modem.

Each EDI project summary consists of the following sections:

General Information and Abstract: This section includes a listing of the principal investigator, conducting and funding agencies, period of record, general location, and an abstract. The abstract presents a summary of recent findings of the program, relying on the researchers own analysis for the conclusions.

Parameters: In this section the biological, chemical and physical parameters measured in the study are provided. This section also lists the taxa studies by genus and species.

Methods: This section presents summaries of sampling methods, analytical methods, and quality assurance procedures. Also included is detailed information on sampling frequency and location. Sampling sites and their geographical coordinates are listed where such information is available.

Data Storage Information and References: This section describes the format in which the data are stored, gives the storage location, and lists the contact names and phone numbers for data access. The references listed include those discussed in the summary, as well as other relevant documents.

The databases contained in SINBAD are menu-driven, keyword searchable, and available to any interested party at no charge (see the Log-on Instructions in Appendix A for more detailed information). For those without computer or modem resources, terminals which access SINBAD have been placed at Regional Water Quality Control Board locations throughout the State, the State Water Resources Control Board in Sacramento, and at the EPA office in San Francisco (See Table 1 in Appendix A for contact information). For those with modems, communications software with VT-100 emulation capability is needed to log onto the system. Additional copies of the Log-on Instructions, and public domain communications software are available from the Aquatic Habitat Institute at (415) 231-9539.

Several points regarding the EDI project summaries should be emphasized. First, although they go into some detail, the summaries are not meant to substitute for the original publications upon which they are based. Rather, they are meant to serve in enhancing coordination and communication between the scientific community, environmental managers and the public, and as a source upon which to base further inquiries. For greater detail, the publications listed in the References Section of the summary should be consulted. Second, an information source describing an on-going research program can never be current. Although each of these summaries has been verified by the Principal Investigator and is updated regularly, we still recommend that users of both the printed summaries and the computerized Estuarine Data Index consult the Principal Investigator if they desire the most up to date information.

GENERAL INFORMATION AND ABSTRACT

Program:	Association of Bay Area Governments Urban Runoff Studies
Funding Agency:	Association of Bay Area Governments Environmental Protection Agency
Principal Investigators:	Gary Silverman (419) 372-8242 University of Bowling Green Taras A. Bursztynsky (415) 464-7941 Association of Bay Area Governments
Conducting Agency:	University of California at Los Angeles RAMLT Associates - sample collection Acurex Corporation - lab analyses
Period of Record, First Study:	December 1980 to March 1981
Period of Record, Second Study:	April 1984 to March 1985
Geographic Boundaries Description:	Samples were collected in Richmond during the winter of 1980-1981; and from eight of the counties which surround the Bay from April of 1984 through March, 1985.

ABSTRACT

The Association of Bay Area Governments has undertaken three major studies of nonpoint pollution in the Bay Area. The first was conducted during 1976-1977 in conjunction with local governments, and examined runoff from 24 watersheds around the Bay. The study focused primarily upon the relationship between land uses and stormwater quality, and analyses were conducted for biochemical oxygen demand, suspended solids, total nitrogen, and total phosphorus. In addition, some samples were analyzed for trace metals and oil and grease, although the reliability of these data have been questioned (Gunther *et al.*, 1987). Drought conditions during this study period complicated interpretation of the results.

In 1981-1982 the concentration of oil and grease in urban stormwaters from a watershed in Richmond was analyzed from five sites during several storms. Flow-weighted mean concentrations were derived, and oil and grease loads were estimated. Oil and grease concentrations were found to be correlated to land use, and total oil and grease loads correlated with total rainfall.

This study was followed by an effort to estimate the loading of oil and grease to the entire Bay through sampling 15 watersheds throughout the region during 1984-1985. The results of this survey was combined with land use and precipitation data to estimate oil and grease loads. It was concluded that 1,690-5,293 metric tonnes per year of oil and grease are discharged to the Bay each year in urban runoff, depending upon the amount of precipitation.

PARAMETERS

Media Analyzed: Water

PHYSICAL PARAMETERS MEASURED

precipitation
runoff flow rate
turbidity

Other Parameters

electrical conductivity
total suspended solids
total organic carbon
total dissolved solids

CHEMICAL PARAMETERS MEASURED

Other Hydrocarbons

particulate aliphatic hydrocarbons
total aliphatic hydrocarbons particulate aromatic hydrocarbons
total aromatic hydrocarbons
particulate oil and grease
total oil and grease total soluble oil and grease
total hydrocarbons
total particulate hydrocarbons
total soluble hydrocarbons
total non-hydrocarbons
octanol
nonanol
tridecanol
tetradecanol
3,5- xylenol
3,4- xylenol
ethyl phenol
2,3,5- trimethyl phenol

PAHs

naphthalene
acenaphthylene

fluorene
phenanthrene
anthracene
pyrene
chrysene
benzo(a)anthracene
benzo(b)fluoranthene
benzo(k)fluoranthene
benzo(a)pyrene
indeno(1,2,3-c,d) pyrene
dibenz(a,h)anthracene
benzo(g,h,i)perylene
fluoranthene

MISCELLANEOUS PARAMETERS:
Land Use Categories
- Commercial property - large scale
- Commercial property - small scale
- Freeway, train and BART tracks
- Impervious non-auto (tennis courts, playgrounds)
- Industrial property
- Open land
- Parking lots
- Residential - single family
- Residential multi-family
- Undeveloped lands

METHODS

SAMPLING METHODS

Very little detail is available regarding the sampling program for the study conducted in 1976-1977. In total 563 samples were collected from 24 different watersheds in the region by local government personnel who had been trained by the U.S. Geological Survey. The extent of this training, and the specific techniques utilized, are not specified. This is partly why Gunther *et al* questioned the reliability of these data (see also Quality Assurance Testing and Reporting, below).

During 1980-81 one liter grab samples of runoff were collected several times during 7 storm events, with flow measurements made concurrently. Flow was measured using sharp- crested weirs, area-velocity measurements, and the application of Manning's formula for open channel flow. Samples were collected in locations that ensured turbulent flow or free discharge, and sample was placed in freon-washed glass containers capped according to standard methods for oil and grease analysis.

As the 1980-81 study did not show a correlation between storm phase and oil and grease concentration, 1984-1985 single grab samples were taken at several locations during storm events rather than more intensive sampling of flow and concentration. Thus, flow-weighted average concentrations could not be calculated, and "flushes" of pollutant were missed if they occurred. (The authors acknowledge that although no correlation was seen in the earlier study, other researchers have documented flushes of pollutants with changes in storm intensity).

Samples for hydrocarbon analysis were collected in one liter solvent-cleaned glass bottles, or in a stainless steel bucket and quickly transferred to a glass bottle. Additional samples were collected in polyethylene bottles for total organic carbon, turbidity, and solids analysis. All samples were cooled in ice chests in the field and kept refrigerated prior to analysis.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: A total 20 sites were sampled.

Samples were collected at 5 stations during the winter of 1980-1981 in Richmond; and at 15 stations from eight of the counties which surround the Bay from April of 1984 through March, 1985.

Seven storms were monitored during the winter of 1980-1981; samples were collected from the following areas:

1. Mouth of the watershed near the intersection of 32nd street and Griffin Avenue.
2. Safeway Distribution Center (industrial lot), adjacent to the mouth of the watershed. Samples were collected at 27th Street and Pierson Avenue.
3. Montgomery Wards parking lot near the corner of McDonald Avenue and 44th Street.
4. Regal service station on the east side of San Pablo Avenue approximately 100 feet south of the Garvin Avenue intersection.
5. Residential area at the intersection of Solano and Amador.

Samples were collected in April, July, October, November, and December of 1984, and January and March of 1985 from the following 15 stations.

1. Arroyo Viejo Creek, at Snell Street, between 75th and 76th Streets, in Oakland
2. Calabazas Creek, just south of Monroe Street, east of Calabazas Blvd. at the high school in Santa Clara
3. Castro Valley Creek, 100 yards upstream from the confluence with San Leandro Creek just east of the Hayward Civic Center
4. Colma Creek, West Orange Park in Colma, San Mateo County
5. Crandall Creek, northeast of Newark Blvd. northwest of Patterson Road, in Fremont

6. Elmhurst Creek, east of San Leandro Blvd. and north of 85th Avenue in Oakland
7. Glen Echo Creek, southeast of Broadway and southwest of Highway 580, near Richmond Blvd. in Oakland
8. Guadalupe Creek, on Almaden Avenue just north of Foxworthy Drive in San Jose
9. Matadero Creek, east of HIghway 230 and north of Page Mill Road in Palo Alto
10. Napa Creek, in the city of Napa, under the bridge at intersection of Jefferson and A Streets
11. Pine-Galindo Creek, just east of Highway 24 and south of Willow Pass Road in Concord
12. Richmond watershed, intersection of 32nd Street and Griffin
13. Sleepy Hollow Creek, Marin County
14. Sonoma Creek, just north of Boyes Springs
15. Temescal Creek, near the mouth, at 53rd Street and Horton, in Emeryville

ANALYTICAL METHODS

During 1980-81 water samples were analyzed for oil and grease using the Infrared Spectrophotometric Method (Method 413.2) described in "Methods for Chemical Analysis of Water and Wastes" (EPA, 1979). In this method, infrared absorbance of freon extracts from acidified samples is determined. It is not clear what the spectrophotometric standard was for their analysis. Selected extracts were also characterized by gas chromatography.

As part of the later study of the entire Bay Area, methods for measuring hydrocarbon concentrations were reviewed in an effort to find a method that would provide more information than standard oil and grease measurements without being much more costly. The procedure selected involved filtration, followed by extraction of the particulate and soluble fractions in methylene chloride. After drying, the samples were fractionated on a silica gel column using hexane, benzene, 1:1 chloroform/methanol, and methanol. Each of these fractions was analyzed gravimetrically and by gas chromatography.

Measurements of oil and grease, pH, specific conductivity, total organic carbon, turbidity, total non-filterable residue and total filterable residue were also made, generally following Standard Methods. Dichloromethane was used as the solvent for oil and grease extraction.

QUALITY ASSURANCE TESTING AND REPORTING

There is very little discussion of QA/QC in this work, particularly in the 1976-1977 studies. There is no discussion of the methods of analysis, or of the treatment of results below the analytical detection limit. The range of reported flow-weighted mean concentrations vary an order of magnitude for lead, cadmium, nickel, and copper; by two orders of magnitude for zinc; and by three orders of magnitude for mercury and arsenic. It is not possible to discount methodological problems as a cause of this variation, which is the major reason Gunther *et al* questioned the reliability of the 1976-77 data.

During the 1980-81 research QA/QC was again limited. Duplicate samples were taken during one storm event, but the results of this check are not presented. Controls were included to determine the extent of retention of oil and grease on laboratory glassware, and methods were selected to minimize bias due to the loss of volatile components of oil and grease. In the 1984-85 work, standard recovery experiments were conducted and the results reported, but no other QA/QC procedures are discussed.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Information on data storage was not available.

REFERENCES

ABAG. 1982. Oil and grease in stormwater runoff. Association of Bay Area Governments, Oakland, CA.

ABAG. 1985. Evaluation of hydrocarbons in runoff to San Francisco Bay. Association of Bay Area Governments, Oakland, CA.

Gunther, A.J., J.A. Davis, and D.J.H. Phillips. 1987. An assessment of the loading of toxic contaminants to the San Francisco Bay-Delta. Exhibit #302 submitted in the Bay-Delta Hearings. Aquatic Habitat Institute. Richmond, CA.

~**Descriptors:** bay-delta; hydrocarbons; land use; spills; pollutant loading; nonpoint sources; urban run-off; salinity; oil and grease; phenol; pollutants and related parameters; pollutant sources; water pollution; water quality; water chemistry; central bay; south bay; san pablo bay; suisun bay;

GENERAL INFORMATION AND ABSTRACT

Program:	National Coastal Pollutant Discharge Inventory
Funding Agency:	National Oceanic and Atmospheric Administration
Principal Investigator:	Dan Farrow (301) 443-0453
Conducting Agency:	National Oceanic and Atmospheric Administration
Study Cost:	$2,000,000 over a six year period
Period of Record, Earliest Date:	1982
Period of Record, Latest Date:	1985
Geographic Boundaries Description:	The coastal counties of the Atlantic, the Gulf of Mexico and the West Coast of the continental U.S. are examined in this program.

ABSTRACT

The National Coastal Pollutant Discharge Inventory (NCPDI) is a database and analytical framework developed by the Strategic Assessment Branch of the National Oceanic and Atmospheric Administration. The NCPDI approximates the discharge of pollutants into estuarine and coastal waters of the United States for the base period 1980-85. The NCPDI covers three distinct geographic regions: the East Coast, the Gulf of Mexico, and the West Coast. The latter region includes the San Francisco Bay/Delta. The goal of the program is to provide pollutant discharge estimates to better identify and evaluate present and future conflicts regarding the use of coastal and oceanic resources. The NCPDI can be used as a screening tool to identify contributions of pollutant loadings from various sources to the nation's estuarine and coastal waters. All methods and assumptions used to develop the database are described in detail in a series of Methods documents.

The nine pollutant categories covered are wastewater, oxygen-demanding materials, particulate matter, nutrients, heavy metals, petroleum hydrocarbons, chlorinated hydrocarbon pesticides, pathogens, and wastewater treatment plant sludges. These categories include the toxic pollutants arsenic, cadmium, chromium, copper, iron, lead, mercury, and zinc. The source categories included are streamflows entering the coastal zone ("Upstream Sources"), point sources, urban

runoff, nonurban runoff, irrigation return flows, oil and gas operations, marine transportation operations, accidental spills, and dredging operations.

Estimates for each pollutant in each source category are made for each season of the base year and as an annual total. These estimates can be aggregated by pollutant, source category or individual source, and by different spatial or temporal combinations. Data can be summarized spatially by coastal county, USGS hydrologic cataloging units, or estuarine drainage basins. The NCPDI can be used as a screening tool for assessing the relative contributions of different pollution sources to coastal and estuarine regions under existing conditions and alternative future policies.

PARAMETERS

BIOLOGICAL PARAMETERS ANALYZED
pathogens
fecal coliform bacteria

PHYSICAL PARAMETERS MEASURED
flow parameters
wastewater volume (point sources)
runoff volume (nonpoint sources)
river discharge (upstream sources)

CHEMICAL PARAMETERS ANALYZED
Chlorinated Hydrocarbons
chlorinated hydrocarbon pesticides

Other hydrocarbons
petroleum hydrocarbons
oil and grease

Nutrients
total nitrogen
total phosphorus

Other Parameters
oxygen-demanding materials
biochemical oxygen demand
particulate matter
total suspended solids

Trace Elements
arsenic
cadmium
chromium

copper
iron
lead
mercury
zinc

MISCELLANEOUS PARAMETERS ANALYZED
accidental spills
dredging operations
irrigation return flow
marine transportation operations
nonurban runoff
oil and gas operations
pollutants in streamflow entering the coastal zone
point sources
urban runoff

METHODS

ANALYTICAL METHODS

For each of the source categories covered by the NCPDI (see Abstract), estimating pollutant discharge involved three basic steps. First, the level of a given activity for the base period (such as industrial output or land under cultivation with a specific crop) is determined. The quantity of wastewater or runoff discharged per unit of activity (or over a specific time period) is then estimated, and this is followed by a determination of the pollutant concentration in the wastewater or runoff either through the use of actual measurements or "engineering estimates" based upon the characteristics of the source. There are significant details associated with each of these calculations that are described in a series of "Source Category Methods Documents".

QUALITY ASSURANCE TESTING AND REPORTING

Quality assessments of the data used as input to the NCPDI were conducted in recognition of the influence of input data quality upon interpretation of NCPDI output. These quality assessments include discussion of the nature of source materials and the characteristics of the data in relation to their reliability and bias.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: Strategic Assessments Branch, Rockville MD
Hardware: Compaq 386 and other compatible computers
Software: RBase for DOS
Volume of Data: 20 megabytes
Quality Assurance: Internal QA/QC program

Contact for Data Retrieval:
Name: Dan Farrow

Address: Ocean Assessments Division
National Ocean Service
National Oceanic and Atmospheric Adm.
11400 Rockville Pike Room 652
Rockville MD 20852

Phone: (301) 443-0453

Who Can Access This Information: Access by request: Federal and State agencies, academic institutions, non-profit and profit organizations.

Data Availability Date: Immediately

REFERENCES

Basta, D.J., B.T. Bower, C.N. Ehler, F.D. Arnold, B.P. Chambers, and D.R.G. Farrow. 1985. The National Coastal Pollutant Discharge Inventory. Ocean Assessments Division, National Oceanic and Atmospheric Division, Rockville, MD. Prepared for Coastal Zone 85, the fourth symposium on Coastal and Ocean Management. 18 pages.

NOAA. 1987. National Coastal Pollutant Discharge Inventory: Data Summaries for San Francisco Bay Tables 2.1 to 2.3, including additional background materials regarding model input values. Strategic Assessments Branch, Ocean Assessments Division, National Oceanographic and Atmospheric Administration. Rockville, MD, 20852.

NOAA. 1987. National Coastal Pollutant Discharge Inventory: Urban Runoff Methods Document with West Coast Addendum. Strategic Assessments Branch, Ocean Assessments Division, National Oceanographic and Atmospheric Administration. Rockville, MD, 20852.

NOAA. 1987. National Coastal Pollutant Discharge Inventory: Nonurban Runoff Methods Document with West Coast Addendum. Strategic Assessments Branch, Ocean Assessments Division, National Oceanographic and Atmospheric Administration. Rockville, MD, 20852.

NOAA. 1987. National Coastal Pollutant Discharge Inventory, Irrigation Return Flow Methods Document with West Coast Addendum.
Strategic Assessments Branch, Ocean Assessments Division, National Oceanographic and Atmospheric Administration. Rockville, MD, 20852.

NOAA. 1987. National Coastal Pollutant Discharge Inventory, Point Sources Methods Document with West Coast Addendum.
Strategic Assessments Branch, Ocean Assessments Division, National Oceanographic and Atmospheric Administration. Rockville, MD, 20852.

NOAA. 1987. National Coastal Pollutant Discharge Inventory, Upstream Sources Methods Document: includes East Coast document and West Coast Addendum. Strategic Assessments Branch, Ocean Assessments Division, National Oceanographic and Atmospheric Administration. Rockville, MD, 20852.

NOAA. 1988. National Coastal Pollutant Discharge Inventory, Estimates for San Francisco Bay. Strategic Assessments Branch, Ocean Assessments Division, National Oceanographic and Atmospheric Administration. Rockville, MD, 20852. 22 pages.

Main, M.B., D.R.G. Farrow, and F.D. Arnold. 1987 Draft Document. National Coastal Pollutant Discharge Inventory, Publicly Owned Treatment works in Coastal Areas of the USA. Strategic Assessments Branch, Ocean Assessments Division, National Oceanographic and Atmospheric Administration. Rockville, MD, 20852.

Arnold, F.D., J.A. Lowe, and D.R.G. Farrow. 1987 Draft Document. National Coastal Pollutant Discharge Inventory, Analysis of Pollutant Discharges from West Coast Point Sources. Strategic Assessments Branch, Ocean Assessments Division, National Oceanographic and Atmospheric Administration, Rockville, MD, 20852.

~**Descriptors:** pollutants and related parameters; pollutant sources; bay-delta; san francisco bay; delta; chlorinated hydrocarbons; other hydrocarbons; pesticides; precipitation; point sources; urban runoff; non-urban runoff; riverine inputs; dredging and spoil disposal; atmospheric deposition; spills; sludge; irrigation return flow; san pablo bay; central bay; south bay; sediments and dredging; POTWs; refineries; nonpoint sources; bacteria; upper drainage; water quality; water pollution; development; suisun bay;

GENERAL INFORMATION AND ABSTRACT

Program: Santa Clara Valley Nonpoint Source Study

Funding Agency: Santa Clara Valley Water District, 13 cities and towns, and the County of Santa Clara

Principal Investigator: Dr. Peter Mangarella (415) 874-3022
Woodward Clyde Consultants

Conducting Agency: Woodward Clyde Consultants
Kinnetic Laboratories

Study Cost: $1,124,000

Period of Record, Earliest Date: October, 1987

Period of Record, Latest Date: July, 1989

Geographic Boundaries Description: The study area consists of the portion of Santa Clara County (approximately 720 sq. miles), which drains into South San Francisco Bay.

ABSTRACT

The Water Quality Control Plan (or Basin Plan) established by the San Francisco Bay Regional Water Quality Control Board requires that non-point source (NPS) discharges to the South Bay and the cost-effectiveness of NPS control measures be evaluated. Local governmental agencies of northern Santa Clara County (including the Santa Clara Valley Water District, 13 cities and towns, and the County) responded to these requirements by initiating the Santa Clara Valley Nonpoint Source Study in late 1987.

This study included compilation of existing data and field sampling encompassing local hydrologic and meteorologic, NPS discharge, point source discharge quality, and NPS control effectiveness and cost data. Field sampling was performed during the wet and dry seasons at land use, stream and reservoir stations. The EPA's Stormwater Management Model (SWMM) version 4 (Huber and Dickinson, 1988) was used to estimate runoff volumes for the entire valley. The model was calibrated and verified using streamflow records for the period 1974-1989.

Water quality loads were found to be directly proportional to runoff. An analysis of long term precipitation records show that, on average, there are only

about 17 major storm events per year with an average duration of 31 hours. Thus the annual nonpoint source loading is associated with relatively few, short term events. Annual flow volumes are highly variable due to changing annual meteorological conditions, and this variability is reflected in annual loads.

In general, concentrations of pollutants at land use stations were relatively uniform and did not exhibit higher loads for the first storm event of the year. Concentrations in streams were higher for the first storm event compared to later events. One hypothesis is that this is caused by the re-suspension of sediments which have been carried into the streams and settled over the dry season. Concentrations of metals in streams generally were higher (by a factor of about 2) than at land use stations for constituents that tend to be associated with suspended sediment. Thus it appears that resuspension of metals adsorbed to bottom sediment is an important process affecting stream water quality. The consistency between metals and organics concentrations detected in the sediment and the water column supports the concept that the stream sediments act as a sink for pollutants during low flow periods and a source during high flow periods.

Bioassays were performed with samples of water from land use and stream stations using *Ceriodaphnia dubia* (a water flea), *Pimephales promelas* (fathead minnow), and *Selenastrum capricornutum* (a green alga). Results showed that, during dry weather, statistically significant effects were measured in about 15% of the tests. During wet weather, about 75% of the tests showed statistically significant effects on *Ceriodaphnia* survival, whereas 15% of the tests showed significantly reduced survivability for fathead minnows.

When compared with the mean annual loads from the three Lower South Bay wastewater treatment plants, the nonpoint sources account for 60-80% of the load for chromium, copper, lead, nickel, and zinc, and about 98% of the total suspended solids. The wastewater treatment plants account for 80-97% of the nitrate-nitrogen, total Kjeldahl nitrogen, and total phosphate. Both sources contribute equally to the BOD load.

PARAMETERS

Media Analyzed: Sediment. Water.

BIOLOGICAL PARAMETERS MEASURED

fecal coliforms
streptococci
total coliforms

PHYSICAL PARAMETERS MEASURED

total suspended solids
water temperature

CHEMICAL PARAMETERS MEASURED

Chlorinated Acid Herbicides
2,4,5-T
2,4,5-TP
2,4-D
2,4-DB
dalapon
dicamba
dichloroprop
dinoseb
MCPA
MCPP

Nutrients
nitrate
nitrite
nitrogen as ammonia
total Kjeldahl nitrogen
total phosphate

Organics
semi-volatile organics (EPA Method 625-GC/MS)
volatile organics (EPA Method 624-GC/MS)

Other Hydrocarbons
oil and grease
total organic carbon

Organophosphorous Pesticides
azinphos-methyl
chlorpyrifos
coumaphos
DDVP (dichlorvos)
demeton
diazinon
dimethoate
disulfoton
EPN
ethoprop
fensulfothion
fenthion
malathion
mevinphos
monocrotophos
naled
parathion, ethyl
parathion, methyl
phorate

ronnel
sulfotepp
sulprofos
TEPP
tetrachlorvinphos
trichloronate

Other Parameters
biochemical oxygen demand
chemical oxygen demand
dissolved oxygen
pH
sediment grain size
total organic halogens

PAHs
acenaphthene
acenaphthylene
anthracene
benzo(a)anthracene
benzo(b)pyrene
benzo(b)fluoranthene
chrysene
dibenzo(a,h)anthracene
fluoranthene
fluorene
indeno(1,2,3-cd)pyrene
naphthalene
phenanthrene
pyrene

Chlorinated Hydrocarbons
aldrin
alpha-BHC
beta-BHC
delta-BHC
gamma-BHC (lindane)
gamma-chlordane
alpha-chlordane
4,4'-DDD
4,4'-DDE
4,4'-DDT
dieldrin
endosulfan I
endosulfan II
endosulfan sulfate
endrin

endrin aldehyde
heptachlor
heptachlor epoxide
methoxychlor
toxaphene
PCBs

Trace Elements
arsenic
cadmium
chromium (total)
chromium (VI)
copper
lead
mercury
nickel
selenium
silver
zinc

MISCELLANEOUS PARAMETERS
wet and dry weather toxicity bioassays

METHODS

SAMPLING METHODS

During storm events all samples (except bacteria and volatile organics) were collected in automatic samplers designed to provide a flow-composite (or event-mean-concentration) sample. Bacteria and volatile organics water samples were obtained using grab samples. All sediment samples were grab samples.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: A total of 18 stations were sampled.

Twelve sites, 8 of which are representative of specific land uses ("landuse" stations L1-L8), and 4 of which represent an aggregate of land uses and are located in streams near the Bay ("stream" stations S1-S4), were sampled in this study. Water quality from reservoir releases (stations R1-R6) was also sampled.

The eight land use and four stream stations were sampled during 7 storm events from January 1988 through March 1989. The stream stations were sampled in January, February, March, May, July, September, November and December of 1988. Water quality from 6 regulated reservoir releases was sampled once in February of 1988. These stations are described below.

A "full suite" of potential pollutants was examined in the early stages of the study, from which a more refined list, or "reduced suite" of pollutants was developed based upon results of the initial surveys.

Land Use Stations

1. Junction Ave between Charcot and Dado Street, manhole station
2. Walsh Ave, near SPRR, manhole station
3. Intersection of Frances and Beamer Streets, north of Sunnyvale Caltrans RR station, manhole station
4. Hale Creek near Magdalena Road, SCVWD gaging station 33
5. Sunnyvale East Channel near Fremont Avenue
6. Pasetta and Williams near San Tomas Expressway and SPRR, manhole Station
7. Camp Castanoan Bridge on Stevens Creek above Stevens Creek Reservoir
8. Packwood Creek at Jackson Ranch SCVWD gaging station 57

Stream Stations

1. Calabazas Creek at Wilcox School, SCVWD gaging station 26A
2. Sunnyvale East Channel at Bayshore Frontage Road, SCVWD gaging station 74
3. Guadalupe River at San Jose, USGS gaging station 00169000
4. Coyote Creek at Montague, SCVWD gaging station 2060

Reservoir Stations

1. Below Stevens Creek Reservoir, SCVWD gaging station 44
2. Below Lexington Reservoir, SCVWD gaging station 67
3. Below Guadalupe Reservoir, SCVWD gaging station 17
4. Below Almaden Reservoir, SCVWD gaging station 16
5. Below Calero Reservoir. SCVWD gaging station 13
6. Below Anderson Reservoir, SCVWD gaging station 9

ANALYTICAL METHODS

Standard EPA methods for water analysis were used, including methods 608/8080 (organochlorine pesticides and PCBs), 624 (volatile organics), 625 (semi-volatile organics), 8100 (polynuclear aromatic hydrocarbons), 8140 (organophosphates), and 8150 (chlorinated acid herbicides).

Monitoring results were reported as event mean concentrations (EMCs), the average concentration of a pollutant in the volume of runoff or streamflow from a particular storm event. It was determined that the Santa Clara EMCs followed a lognormal distribution. The mean of the log transformed data, the best measure of central tendency, corresponds to the median of the nontransformed data. Thus, site median concentrations (SMCs) were used to compare average concentrations between sites. For mass loading estimates pooled EMCs were used to estimate the charactistics of the variable runoff quality. The mean concentration value for pollutants in the storm runoff event was calculated.

QUALITY ASSURANCE TESTING AND REPORTING

Laboratory and field duplicates were routinely performed on the reduced suite of parameters. The precision of the duplicates, an indication of the variability in the extraction and analytical procedures in the laboratory and field, is expresses as a relative percent difference (RPD). For dry weather sampling, the laboratory RPD ranged from 0 to 29% with a mean value of 6%. The wet weather RPDs were between 0 and 40% (with two exceptions) with a mean value of 16%. Wet weather RPDs for field sampling ranged from 0 to 94% with a mean of 31%. The dry weather RPDs were between 0 and 100% with a mean of 23%.

Laboratory and field blank analyses were performed to detect potential contamination. All laboratory and field blanks were generally free of contaminants.

|

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: Woodward-Clyde Consultants, Oakland
Kinnetic Laboratories, Inc., Santa Cruz
Hardware: Macintosh PC, PRIME 550, IBM PC
Software: Lotus 123, Excel, Statview 512
Quality Assurance: Data are verified against original datasheets.
Contact for Data Retrieval
Peter Mangarella
Woodward Clyde Consultants
500 12th Street
Oakland CA 94607-4014
(415) 874-3022
Access: Santa Clara Valley Water District approval required.
Data Availability Date: August 1989

REFERENCES

CH2M Hill. 1987. Santa Clara Valley nonpoint source discharge evaluation action plan. Prepared for the Santa Clara Valley Water District, Santa Clara, CA

Huber, W.C. and R.E. Dickinson. 1988. Storm Water Management Model, Version 4. U.S. Environmental Protection Agency, Environmental Research Laboratory, Office of Research and Development, Athens, GA.

Woodward-Clyde Consultants. 1989a. Draft Final Report. Santa Clara Valley Nonpoint Source Study, Vol. 1: Loads Assessment Report. Prepared for the Santa Clara Valley Water District, Santa Clara, CA.

Woodward-Clyde Consultants. 1989b. Draft Appendices. Santa Clara Valley Nonpoint Source Study, Vol. 1: Loads Assessment Report. Prepared for the Santa Clara Valley Water District, Santa Clara, CA.

~**Descriptors:** bay-delta; land use; streams; water quality; urban runoff; herbicides; pesticides; priority pollutants; south bay; toxicity testing; nonpoint sources; bacteria; cyclodienes; BHC; organophosphates; ambient testing; pollutant sources; pollutants and related parameters; water pollution; water chemistry; creeks; DDD; DDT; DDE; nonpoint pollution;

GENERAL INFORMATION AND ABSTRACT

Program: NPDES Discharge Monitoring Database

Funding Agency: California State Water Resources Control Board
US Environmental Protection Agency

Principal Investigator: Jay Davis (415) 231-9539
Aquatic Habitat Institute

Conducting Agency: Aquatic Habitat Institute

Period of Record, Earliest Date: 1984

Period of Record, Latest Date: 1987

Geographic Boundaries Description: This database includes measurements made of effluent discharges throughout the estuary, including the entire Delta and all of San Francisco Bay.

ABSTRACT

Effluent monitoring data collected as required by the National Pollutant Discharge Elimination System (NPDES) program (administered by the State Water Resources Control Board) were compiled by AHI as part of a study of pollutant mass loading to the Bay-Delta (Gunther *et al.* 1987). Monthly average toxic contaminant concentrations in effluents from all point sources in the Bay-Delta from 1984 to 1986 provided a basis for loading estimates. These data fall into two broad categories: "routine monitoring" data, which include parameters specified in each discharger's NPDES permit (most commonly trace elements); and "priority pollutant" data, gathered by municipal treatment plants and petroleum refineries. The priority pollutants include over 100 toxic volatile organics, semi-volatile organics, chlorinated pesticides, PCBs, and trace elements.

In general, three-year average loadings were computed to characterize each source. POTWs contributed 75% or more of the total point source loading (because of their correspondingly large flows) of most trace elements to the estuary. Most of the total emissions from POTWs were accounted for by the eight largest treatment plants. Among industrial discharges, petroleum refineries contribute significant flows and amounts of certain contaminants to the Bay-Delta. Refineries released most of the selenium known to be attributable to point sources, releasing amounts that were approximately equal to those carried into the estuary by the San Joaquin and Sacramento Rivers. Large loadings of chromium from a single discharger, US Steel

in Pittsburg, accounted for one-third of the total for this element from point sources during 1984-1986.

Several of the trace elements and nearly all of the synthetic organic contaminants which were monitored by point source dischargers were not well quantified analytically. Detection limits of the methods employed in determining concentrations of these substances approach or exceed the actual levels present in effluents. The general absence of results of quality control testing for chemical analyses further constrains interpretation of the data.

Data from 1987 have subsequently been incorporated by AHI into this effluent monitoring database. In work sponsored by the San Francisco Bay Regional Water Quality Control Board, the entire 4 year period of record is being made available for use on microcomputers with dBase III Plus.

PARAMETERS

Media Analyzed: Water

CHEMICAL PARAMETERS MEASURED

ORGANOCHLORINES (EPA METHOD 608)

ALDRIN
A-BHC
B-BHC
D-BHC
G-BHC
CHLORDANE
4,4' DDD
4,4' DDE
4,4' DDT
DIELDRIN
ENDOSULFAN I
ENDOSULFAN II
ENDOSULFAN SULFATE
ENDRIN
ENDRIN ALDEHYDE
HEPTACHLOR
HEPTACHLOR EPOXIDE
TOXAPHENE
PCB-1016
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254

PCB-1260
PCB-1262

POLYNUCLEAR AROMATIC HYDROCARBONS (EPA METHOD 610)
ACENAPHTHENE
ACENAPHTHYLENE
ANTHRACENE
BENZO(A)ANTHRACENE
BENZO(A)PYRENE
BENZO(B)FLUORANTHENE
BENZO(G,H,I)PERYLENE
BENZO(K)FLUORANTHENE
CHRYSENE
DIBENZO(A,H)ANTHRACENE
FLUORANTHENE
FLUORENE
INDENO(1,2,3-C,D)PYRENE
NAPHTHALENE
PHENANTHRENE
PYRENE

ORGANOPHOSPHATES (EPA METHOD 614)
AZINPHOS METHYL (GUTHION)
DEMETON (SYSTOX)
DIAZINON
DISULFOTON (DISYSTON)
ETHION
MALATHION
PARATHION ETHYL
PARATHION METHYL

PURGEABLE ORGANICS (EPA METHOD 624)
ACROLEIN
ACRYLONITRILE
BENZENE
BROMODICHLOROMETHANE
BROMOFORM
BROMOMETHANE
CARBON TETRACHLORIDE
CHLOROBENZENE
CHLOROETHANE
2-CHLOROETHYLVINYL ETHER
CHLOROFORM
CHLOROMETHANE
DIBROMOCHLOROMETHANE
1,1-DICHLOROETHANE
1,2-DICHLOROETHANE

1,1-DICHLOROETHENE
TRANS-1,2-DICHLOROETHENE
DICHLOROMETHANE
1,2-DICHLOROPROPANE
1,3-DICHLOROPROPENE
ETHYL BENZENE
1,1,2,2-TETRACHLOROETHANE
TETRACHLOROETHENE
TOLUENE
1,1,1-TRICHLOROETHANE
1,1,2-TRICHLOROETHANE
TRICHLOROETHENE
VINYL CHLORIDE
1,1-DICHLOROETHYLENE
CIS-1,3-DICHLOROPROPENE
CIS-1,3-DICHLOROPROPYLENE
METHYLENE CHLORIDE
TETRACHLOROETHYLENE
TRANS-1,2-DICHLOROETHYLENE
TRANS-1,3-DICHLOROPROPENE
TRICHLOROETHYLENE

BASE/NEUTRAL AND ACID EXTRACTABLE ORGANICS (EPA METHOD 625)

ACENAPHTHENE
ACENAPHTHYLENE
ANTHRACENE
BENZIDINE
BENZO(A)ANTHRACENE
BENZO(B)FLUORANTHENE
BENZO(K)FLUORANTHENE
BENZO(A)PYRENE
BENZO(G,H,I) PERYLENE
BENZYL BUTYL PHTHALATE
BIS(2-CHLOROETHYL)ETHER
BIS(2-CHLOROETHOXY)METHANE
BIS(2-CHLOROISOPROPYL)ETHER
BIS(2-ETHYLHEXYL)PHTHALATE
4-BROMOPHENYL PHENYL ETHER
2-CHLORONAPTHALENE
4-CHLOROPHENYL PHENYL ETHER
CHRYSENE
DIBENZO(A,H)ANTHRACENE
DI-N-BUTYLPHTHALATE
1,2-DICHLOROBENZENE
1,3-DICHLOROBENZENE
1,4-DICHLOROBENZENE
3,3-DICHLOROBENZIDINE

DIETHYL PHTHALATE
DIMETHYL PHTHALATE
2,4-DINITROTOLUENE
2,6-DINITROTOLUENE
DIOCTYLPHTHALATE
1,2-DIPHENYLHYDRAZINE
FLUORANTHENE
FLUORENE
HEXACHLOROBENZENE
HEXACHLOROBUTADIENE
HEXACHLOROCYCLOPENTADIENE
HEXACHLOROETHANE
INDENO(1,2,3-CD)PYRENE
ISOPHORONE
NAPHTHALENE
NITROBENZENE
N-NITROSODIMETHYLAMINE
N-NITROSODIPHENYLAMINE
N-NITROSODI-N-PROPYLAMINE
PHENANTHRENE
PYRENE
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN (TCDD)
1,2,4-TRICHLOROBENZENE
TRICHLOROFLUOROMETHANE
P-CHLORO-M-CRESOL
2-CHLOROPHENOL
2,4-DICHLOROPHENOL
2,4-DIMETHYLPHENOL
2,4-DINITROPHENOL
4,6-DINITRO-O-CRESOL
2-NITROPHENOL
4-NITROPHENOL
PENTACHLOROPHENOL
PHENOL
2,4,6-TRICHLOROPHENOL
2-METHYL-4,6-DINITROPHENO
4-CHLORO-3-METHYLPHENOL

CARBAMATE AND UREA PESTICIDES (EPA METHOD 632)

AMINOCARB
BARBAN
CARBARYL
CARBOFURAN
CHLORPROPHAN
DIURON
FENURON
FENURON-TCA

FLUORMETURON
LINURON
METHIOCARB
METHOMYL
MEXACARBATE
MONURON
MONURON-TCA
NEBURON
OXAMYLUR
PROPHAN
PROPOXUR
SIDURON
SWEPP
BAYGON
BENOMYL
BROMACIL
CIPC
FURADAN
IPC
SENCOR

TRACE ELEMENTS

ALUMINUM
ALUMINUM, DISSOLVED
ANTIMONY
ARSENIC
BARIUM
BERYLLIUM
CADMIUM
CHROMIUM, HEXAVALENT
CHROMIUM, TOTAL
CHROMIUM, TRIVALENT
COBALT
COPPER
LEAD
MERCURY
MOLYBDENUM
NICKEL
SELENIUM
SILVER
THALLIUM
TIN
VANADIUM
ZINC

CHLORINATED HYDROCARBONS (TICH)

A-BHC

ALDRIN
B-BHC
D-BHC
DIELDRIN
ENDRIN
G-BHC
HEPTACHLOR
HEPTACHLOR EPOXIDE
O,P'- DDD
O,P'- DDE
O,P'- DDT
P,P'- DDD
P,P'- DDE
P,P'- DDT
PCB-1242
PCB-1254
PCB-1260

NUTRIENTS
AMMONIA

OTHER PARAMETERS
CYANIDE
FORMALDEHYDE

OTHER HYDROCARBONS
OIL & GREASE
PHENOLICS

PESTICIDES
DIFOLATAN
ORTHENE
PARAQUAT
CAPTAN
TOTAL THIOCARBAMATES
EPTAM
SUTAN
VERNAM
TILLAM
ORDRAM
RO-NEET
DEVRINOL
VAPAM

METHODS

SAMPLING METHODS

Grab samples and composite samples collected over varying periods of time are taken of effluents. Techniques are prescribed by the Regional Water Quality Control Boards. Standard techniques vary for different contaminants and different classes of contaminants.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: Over 200 effluents are sampled throughout the estuary.

Presented below are data regarding the location of some of the major POTW outfalls in the San Francisco Bay-Delta. The information has been obtained, when available, from NPDES permits filed with the San Francisco Bay Regional Water Quality Control Board. Sampling frequency for these effluents varies widely, from daily to annual. This frequency information could not be concisely presented on this Index.

POTW	Latitude	Longitude
Benicia	38-00-30	122-09-03
Calistoga	38-33-34	122-33-28
Central Contra Costa SD	38-02-44	122-05-55
Central Marin	37-56-54	122-27-23
EBDA	37-42-00	122-48-00
EBMUD	37-49-02	122-20-50
Fairfield-Suisun	38-12-33	122-03-24
Hercules-Rodeo	38-03-06	122-15-55
Las Gallinas	38-01-32	122-30-58
Napa	38-13-45	122-17-00
North Bayside	37-39-55	122-21-41
Novato-Ignacio	38-04-00	122-29-00
Palo Alto	37-27-11	122-06-36
SF Southeast	37-44-58	122-22-22
San Jose-Santa Clara	37-26-06	121-57-08
San Mateo	37-34-50	122-14-45
Sausalito-Marin	37-50-37	122-28-03
Sewage Agen. of S. Marin	37-53-40	122-28-10
South Bayside	37-33-48	122-12-55
Sonoma Valley	38-14-14	122-25-51
Sunnyvale	37-26-00	122-02-00
St. Helena	30-20-10	122-26-15

Vallejo	38-07-37	122-16-00
West County Agency	37-54-41	122-25-06
Yountville	38-24-24	122-20-27

ANALYTICAL METHODS

Standard methods are used in the analysis of these wastewaters, most of which are described in the following references: APHA (1985), "Standard Methods for the Examination of Water and Wastewater"; EPA (1982), "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater"; EPA (1983), "Methods for Chemical Analysis of Water and Wastes"; and EPA (1985), "Code of Federal Regulations". Standard techniques vary for different contaminants and different classes of contaminants.

QUALITY ASSURANCE TESTING AND REPORTING

As with the sampling and analytical methods discussed above, analytical quality assurance (QA) testing and reporting vary among dischargers and for different contaminants or classes of contaminants. The reporting of QA test results is rare. Regular QA reporting of any kind has occurred only for the organic priority pollutants, and is inconsistent in frequency and among different dischargers even for these compounds.

|

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: The data are stored locally in PC-compatible format at the Aquatic Habitat Institute in Richmond, CA, and the San Francisco Bay Regional Water Quality Control Board in Oakland, CA.

Hardware: IBM-compatible microcomputers

Software: dBase III plus

Volume of Data: Approximately 100,000 observations.

Quality Assurance: Double-entry software was used in keypunching the data. All the data were verified against original datasheets. Simple descriptive statistics were used to detect erroneous entries and outliers, which were verified or corrected.

Contact for Data Retrieval
Name: Jay Davis

Address: Aquatic Habitat Institute
1301 S. 46th St., #180
Richmond, CA 94804

Phone: (415) 231-9539

REFERENCES

Gunther, A.J., J.A. Davis, and D.J.H. Phillips. 1987. An assessment of the loading of toxic contaminants to the San Francisco Bay-Delta. Aquatic Habitat Institute. Richmond, CA. 330 pages. Cost: $24.

~**Descriptors:** pollutant sources; point sources; potws; refineries; pollutants and related parameters; bay-delta; pcbs; cyclodienes; pesticides; pahs; phthalates; chlorinated solvents; mahs; other hydrocarbons; chlorinated hydrocarbons; water quality; water chemistry; water pollution; DDD; DDE; DDT; PCB;

GENERAL INFORMATION AND ABSTRACT

Program: Pesticide Use Reporting System

Funding Agency: Department of Food and Agriculture

Conducting Agency: Department of Food and Agriculture

Period of Record, Earliest Date: 1970

Period of Record, Latest Date: Present

Geographic Boundaries Description: Data are collected throughout all of California.

ABSTRACT

The Department of Food and Agriculture maintains an inventory of pesticide use in California which tracks the application of pesticides listed as "restricted" in the California Administrative Code and nonrestricted chemicals applied by licensed pesticide applicators. Prior to 1990, nonrestricted pesticides not applied by licensed operators were not tracked, so this Pesticide Use Reporting System (PURS) reflected only a portion of total pesticide use in California. As of 1990, non restricted pesticides are also tracked. The PURS includes dates, locations, amounts of active ingredients applied, and crops.

Data grouped by pesticide and commodity are compiled in annual reports which are available to the public (DFA 1986). These reports also present annual summaries of total pesticide application by each county. As of 1990, quarterly reports by chemical are available.

PARAMETERS

BIOLOGICAL PARAMETERS MEASURED
crop type

CHEMICAL PARAMETERS MEASURED
acephate
acetophenone
acid blue 9
acid yellow 23
acifluorfen, sodium salt
acrolein
alachlor
aldicarb

aldrin
alkyl amino-3-aminopropane hydroxyacetate alkyl derived from coconut oil fatty acids
alkyl(60% C14, 30% C16, 5% C12, 5% C18) dimethyl benzyl ammonium chloride
alkyl imidazoline monocarboxylate, monosodium salt
alkylpyridines, mixed
allethrin
aluminum phosphide
ametryne
aliphatic amines
amitraz
amitrole
ammonium sulfamate
anilazine
asulam sodium salt
atrazine
azinphos-methyl
bacillus thuringiensis
barban
baythroid
bendiocarb
benefin
benomyl
bensulide
bentazon, sodium salt
benzoic acid
borax
boric acid
brodifacoum
bromacil
bromacil, lithium salt
bromadiolone
bromoxynil, butyric acid ester
bromoxynil octanoate
2-(2-butoxyethoxy)
butoxypolypropylene glycol
cacodylic acid
calcium hypochlorite
CAMA
capsicum oleoresin
captan
carbaryl
carbendazim
carbofuran
carbolic acid
carbophenothion
carboxin
beta-caryophyllene

castor oil
chloramben
chloramben, ammonium salt
chlordane
chlordimeform
chlordimeform hydrochloride
cholecalciferol
chlorflurenol, methyl ester
chlorine
chlormequat chloride
chlorobenzilate
chloroneb
chlorophacinone
chlorothalonil
chloroxuron
chloropicrin
3-chloro-p-toluidine hydrochloride
chlorpyrifos
chlorpropham
chlorsulfuron
chlorthal-dimethyl
copper
copper hydroxide
copper hydroxide-triethanolamine complex
copper naphthenate
copper oleate
copper oxide
copper oxychloride sulfate
copper salts of fatty and rosin acids
copper sodium sulfate, phosphate complex
copper sulfate (anhydrous)
copper sulfate (basic)
copper sulfate (pentahydrate)
copper-zinc sulfate complex
coumafuryl
cresylic acid
crotoxyphos
cryolite
cyanazine
cycloate
cyclohexane
cyclohexatin
cycloheximide
cypermethrin
2,4-D
2,4-D, alkanolamine salts (ethanol and isopropanol amines)
2,4-D, butoxyethanol ester

2,4-D, butoxypropyl ester
2,4-D, butyl ester
2,4-D, diethanolamine salt
2,4-D, diethylamine salt
2,4-D, dimethylamine salt
2,4-D, dodecylamine salt
2,4-D, 2-ethylhexyl ester
2,4-D, isooctyl ester
2,4-D, n-oleyl-1,3-propylenediamine salt
2,4-D, n,n-dimethyloleyl-linoleylamine salt
2,4-D, propyleneglycolbutylether ester
2,4-D, octyl ester
2,4-D, tetradecylamine salt
2,4-D, triethylamine salt
2,4-D, triisopropylamine salt
2,4-D, propyleneglycolbutylether ester
dalapon
dalapon, magnesium salt
dalapon, sodium salt
daminozide
dazomet
4(2,4-DB) butoxyethanol ester
4(2,4-DB), isooctyl ester
4(2,4-DB), dimethylamine salt
4(2,4-DB), isooctyl ester
DDVP
demeton
diazinon
dicamba
dicamba, diethanolamine salt
dicamba, dimethylamine salt
di-capryl sodium sulfosuccinate
dichlobenil
dichlone
dichloran
dichlormate
para-dichlorobenzene
1,2-dichloropropane
1,3 dichloropropene and related C-3 compounds
dichlorprop, butoxyethanol ester
diclofop methyl
dicofol
dicrotophos
dienochlor
diethatyl-ethyl
difenzoquat methyl sulfate
diflubenzuron

diiodomethyl-p-tolyl sulfone
dikegulac sodium
dimethoate
z-3,3-dimethyl-delta,beta-cyclohexaneethanol
dinitramine
dinocap
dinoseb
dinoseb, amine salt
dinoseb, ammonium salt
dinoseb, triethanolamine salt
dioxathion
diphacinone
diphenamid
diquat dibromide
disodium octaborate tetrahydrate
disulfoton
diuron
DNOC, sodium salt
dodecylammonium methanearsonate
dodecylphenoxybenzene sulfonic acid, sodium salt
dodemorph
dodine
2,4-DP, diethanolamine
DSMA
endosulfan
endothall, mono(n,n-diethylalkylamine) salt
endothall, dipotassium salt
epichlorohydrin
EPN
EPTC
ethalfluralin
ethephon
ethion
ethofumesate
ethoprop
2-(2-ethoxtethoxy) ethyl-2-benzimidazole carbamate
ethylan
ethylene dichloride
fenac, ammonium salt
fenaminosulf
fenamiphos
fenarimol
fenbutatin-oxide
fenthion
fenvalerate
ferbam
fluazifop-butyl

fluchloralin
flucythrinate
floumeturon
flurecol-methyl
fluvalinate
folpet
fonofos
formetanate hydrochloride
fosamine, ammonium salt
fosetyl-al technical
gibberellins
gibberellins, potassium salt
glyphosate, isopropylamine salt
z-11-hexadecenol
heptachlor
(z,e) 7,11 hexadecadien-1-01 acetate
(z,z) 7,11 hexadecadien-1-01 acetate
hexazinone
hydroprene
imazalil
iprodione
kinoprene
lime-sulfur
lindane
linuron
magnesium phosphide
malathion
maleic hydrazide, diethanolamine salt
maleic hydrazide, potassium salt
mancozeb
maneb
MCPA, butoxyethanol ester
MCPA, dimethylamine salt
MCPA, isooctyl ester
MCPA, sodium salt
MCPP, diethanolamine salt
MCPP, potassium salt
MCPPA
mefluidide, diethanolamine salt
mepiquat chloride
merphos
meta-cresol
metalaxyl
metaldehyde
metam-sodiam
methamidophos
methidathion

methiocarb
methomyl
methoprene
methoxychlor
methyl bromide
methyl-2,3-dichloro-9-hydroxyfluorene-9-carboxylate
methyl-2,7-dichloro-9-hydroxyfluorene-9-carboxylate
methyl isothiocyanate
methyl parathion
methylene chloride
methyl nonyl ketone
methyl parathion
metiram
metolachlor
metribuzin
mexacarbate
mevinphos
monurone
monurone-tca
monocrotophos
morpholine
MSMA
myrcene
NAA
NAA, ammonium salt
NAA ethyl ester
NAA, potassium salt
NAA, sodium salt
naled
napropamide
neburon
nicotine
4-nitropyrdine n-oxide
norea
norflurazon
octylammonium methanearsonate
octyl bicyclyheptenedicarboximide
ortho-phenylphenol, sodium salt
oryzalin
oxadiazon
oxamyl
oxycarboxin
oxydemeton-methyl
oxyfluorfen
oxytetracycline hydrochloride
oxythioquinox
paraquat dichloride

parathion
parinol
PCNB
PCP
pendimethalin
pimethalin
permethrin
phenmedipham
ortho-phenylphenol, sodium salt
phorate
phosacetin
phosalone
phosmet
phosphamidon
picloram
picloram, triisopropanolamine salt
pindone
pinene
piperalin
piperonyl butoxide, technical
pirimicarb
PMA
polymerized pinene
poly(oxyethelene(dimethylimino)ethelene(dimethyliminio)ethylene dichloride
potassium dichromate
profluralin
promalin
prometon
prometryn
propamocarb
propargite
propetamphos
propham
propoxur
propylene glycol, methyl ester
propyzamide
propyzamine
pyrazon
pyrethrins
resmethrin
ronnel
rotenone
ryanodine alkaloid
sabadilla alkaloids
sethoxydim
siduron
silvex, butoxypropyl ester

simazine
sodium cacodylate
sodium chlorate
sodium dichloro-s-triazinetrione
sodium hydroxide
sodium hypochlorite
sodium metaborate
sodium molybdate
sodium polysulfide
sodium TCA
sodium thiocyanate
streptomycin
strychnine
strychnine sulfate
sulfometuron methyl
sulfotep
sulfur
sulfuryl flouride
TCMTB
tebuthiron
temephos
TEPP
terbacil
terbutryn
terrazole
tetrachloroethylene
ethylene oxide
tetrachlorvinfos
thiabendazole
thiabendazole, hypophosphite salt
thidiazuron
thiophanate
thiophanate-methyl
thiram
2,4,5-T isooctyl ester
2,4,5-T propylene glucol butyl ester
toxaphene
triadimefon
s,s,s-tributyl phosphorotrithioate
trichlorophon
trichloro-s-triazinetrione
triclopyr
triclopyr, butooxyethyl ester
triethanolamine
trifluralin
triforine
trimethyl ether of polyethylene glycol

vegetable oil
vegetable wax
vernolate
vinclozolin
warfarin, sodium salt
xylene
xylene range aromatic solvent
2,4-xylenol
zinc chloride
zinc phosphide
zinc sulfate
zineb
ziram
1080

MISCELLANEOUS PARAMETERS MEASURED
commodity fumigation
county agricultural commodity sales
food processing plants
forage, hay and silage
industrial areas
landscape maintenance
livestock buildings
non-agricultural areas
open land
pasture/rangeland
poultry buildings
public health pest control
recreational areas - parks
regulatory pest control
residential areas
restaurants/eating establishments
soil fumigation
storage buildings, other
structural control
structural pest control

Cubic feet or acres of commodity treated - annual total
Number of applications - annual total
Pounds of active ingredient - annual total
Tons of commodity treated - annual total

METHODS

SAMPLING METHODS

Information on the methods used to gather this data was not available in the published report.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: Department of Food and Agriculture
1220 N. St., A331
Sacramento, CA

Hardware: Prime

Software: Fortran

Volume of Data: Approximately 100 - 600 megabytes per year

Quality Assurance: Varies each year. Data before 1984 is less accurate.

Contact for Data Retrieval

Name: Ria Spencer/Kathy Newland

Address: Department of Food and Agriculture
Information Services
1220 N Street
Sacramento, CA 95814

Phone: (916) 324-4743

REFERENCES

DFA. 1986. Pesticide use report by commodity. Department of Food and Agriculture, Pesticide Registration and Agricultural Productivity, Sacramento, CA 95814. $10.

~**Descriptors:** bay-delta; agriculture; pollutants and related parameters; nonpoint sources; pesticides; upper drainage; chlorinated hydrocarbons; cyclodienes; triazines; carbamates; organophosphates; pyrethroids; halogenated aliphatics;

GENERAL INFORMATION AND ABSTRACT

Program:	Sacramento Urban Runoff Monitoring Study
Funding Agency:	California Regional Water Quality Control Board, Central Valley Region (CVRWQCB)
Principal Investigator:	Barry Montoya CVRWQCB (916) 361-5692
Conducting Agency:	CVRWQCB
Period of Record, Earliest Date:	9/15/86
Period of Record, Latest Date:	5/27/87
Geographic Boundaries Description:	Sacramento urban watershed drained by sump 104

ABSTRACT

An urban runoff monitoring study was conducted in Sacramento during the 1986-87 rainy season. The study was initiated to provide data for loading estimates performed in a separate report. The overall objective was to identify the periods of highest trace metal and hydrocarbon (measured as oil and grease) loads from urban runoff and correlate them with an easily measured parameter - rainfall. The conclusions are as follows:

1. A seasonal first flush of trace metals and hydrocarbons was documented in sump 104 and occurred in the first few storm events.

2. Event mean concentrations (EMCs) for trace metals and oil and grease decreased during the study period as a function of seasonal rainfall. The decline was greatest during the period corresponding to cumulative seasonal rainfall measurements of approximately four inches. An EMC is a flow-weighted concentration statistic calculated for an entire storm event to account for expected concentration and flow variations.

3. Event first-flush effects were not substantial after the first few storms of the season. Trace metal and oil and grease concentrations remained largely static throughout storm events monitored after approximately five inches of cumulative seasonal rainfall.

4. After the season's initial flush, pollutant EMCs declined to much lower levels, although for copper, lead and zinc, the levels remained above EPA water quality criteria.

5. The bulk of the detected chromium, copper, lead and zinc (58 per cent to 97 per cent) was sorbed to particulate matter larger than 30 microns.

PARAMETERS

Media Analyzed:
Water

PHYSICAL PARAMETERS MEASURED
flow
volume

CHEMICAL PARAMETERS MEASURED

Trace Elements
Arsenic
Cadmium
Cobalt
Copper
Nickel
Lead
Zinc

Other Parameters
oil and grease

METHODS

SAMPLING METHODS

Water samples were collected from Sacramento City Sump 104, a sub-surface storm drain, using the "unit volume" method. Single discrete samples were taken at increments of approximately 0.1 to 0.2 inch of rain up to a storm event total of 0.5 inch, after which the frequency was decreased to increments of approximately 0.3 to 0.5 inch of rain. A plastic bucket was lowered by rope into the sump and submerged to get a mid-depth sample. Replicates were sub-sampled from the bucket.

Metal samples were collected in one liter polyethylene bottles pre-preserved with approximately 2.5 milliters of nanograde nitric acid. Oil and grease samples were collected in one liter glass-amber bottles and acidified with sulfuric acid to a pH of less than two. Trace metal samples were analyzed within six months. All oil and grease samples were immediately chilled and transported to the laboratory and analyzed within 72 hours.

Phone: (916) 361-5692

REFERENCES

CVRWQCB. 1989. Trace metal and hydrocarbon concentration trends in urban runoff discharges from a Sacramento storm drain. Office memorandum dated 14 March. CVRWQCB Sacramento, CA.

EPA. 1983. Methods for chemical analysis of water and wastes. US EPA Environmental Monitoring and Support Laboratory, Research and Development. EPA-600/4-79-020 revised March 1983.

~**Descriptors:** bay-delta; delta; oil and grease; pollutants and other parameters; water quality; pollutant sources; nonpoint pollution; stormwater pollutant loading; precipitation;

SAMPLING FREQUENCY AND LOCATION

Frequency was based on rainfall charactistics. Sampling frequency increased with an increase in rainfall volume.

Number of Sampling Sites: 1

Locations

City Sump 104 Pumping Station, Sacramento.

ANALYTICAL METHODS

Metal analyses were performed by Anlab Laboratory, Sacramento, CA. Approved laboratory methods (EPA 1983) were followed for the analyses of heavy metals. Oil and grease was measured primarily by California Water Laboratory, Sacramento, CA and to a lesser extent by Anlab using the gravimetric (seperator funnel extraction) method for total recoverable oil and grease (EPA 1983).

Pumpage to the Sacramento River was recorded concurrently with sample collection. Pumpage data was used to calculate mass loads, event mean concentrations and runoff coefficients. Hourly rainfall data was obtained from a site approximately two to four miles from the sample site. Storm events were defined as those which were separated by at least 24 hours of no rainfall.

QUALITY ASSURANCE TESTING AND REPORTING

Replicates were collected for 100 per cent of the samples. Approximately 20 per cent of the samples were matrix spikes. Data was double checked after computer entry.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: CVRWQCB
3443 Routier Rd.
Sacramento CA 95827-3098

Hardware: MS-DOS
Software: Lotus 123
Volume of Data: 200-300K
Contact for Data Retrieval

Name: Barry Montoya
CVRWQCB
3443 Routier Rd.
Sacramento CA 95827-3098

DATA STORAGE INFORMATION:

Location: Battelle Laboratories, Columbus, Ohio

Contact for Data Retrieval:

Name: Mary Robey

Address: U.S. Coast Guard
Commandant G-MP-5
2100 Second Street S.W.
Washington, D.C. 20593
Phone: (202) 267-0452

DATA STORAGE INFORMATION

Location: National Computer Center, North Carolina
Hardware: IBM mainframe
Software: SAS
Volume of Data: 700 observations, data for the years 1984 - 1986, inclusive

Quality Assurance: Data were obtained from tapes supplied by the Coast Guard. Specific problems in relation to the quality assurance of the data are discussed in Gunther et al (referenced below).

Contact for Data Retreival:

Name: Andy Gunther
Address: Aquatic Habitat Institute
Richmond Field Station, Building 180
1301 South 46th Street
Richmond CA 94084
Phone: (415) 231-9539

References:

Gunther, A.J., J.A. Davis, and D.J.H. Phillips. 1987. An assessement of the loading of toxic contaminants to the San Francisco Bay-Delta. Aquatic Habitat Institute, Richmond, CA.

USCG. 1986. Polluting incidents in and around U.S. waters, calendar year 1983 and 1984. COMDTINST M16450.2G. Report available from the National Technical Information System, 5285 Port Royal Road, Springfield, VA 22161.

~**Descriptors:** bay-delta; pollution; oil; chemical; hazardous substance; spills; pollutant loading;

GENERAL INFORMATION AND ABSTRACT

Program: U.S. Coast Guard Spills Data

Funding Agency: U.S. Coast Guard

Principal Investigator: Marine Environmental Response Officer (415) 437-3091
U.S. Coast Guard

Conducting Agency: U.S. Coast Guard

Period of Record, Earliest Date: 1975

Period of Record, Latest Date: Present

Length of Record: 15 years

Geographic Boundaries Description: Data are kept on oil (petroleum and nonpetroleum oils) and hazardous material spills which occur in U.S. navigable waters, including the San Francisco Bay and Delta.

ANALYSES

Media Analyzed: Water.

Parameters Measured: This dataset includes spills and potential spills to the Bay and Delta involving inorganic chemicals, oil and petroleum products, and other miscellaneous organic liquids.

Discharge: Cause. Location. Material. Quantity. Source. Time of occurrance. Waterbody.

Chemical: Animal/vegetable oil. Asphalt/tar/pitch. Chemical. Crude oil. Diesel oil. Fuel oil. Gasoline. Kerosene/fuel oil. Other distillate. Other oil. Other substances. Solvents. Waste oil.

Miscellaneous:

Spill Response: Amount recovered. Cleanup cost. Cleanup party. Operation. Personnel.

Spill Penalty: Action against. Action date. Amount recovered. Appeal results. Case status. Hearing results. Initiating agency. Penalty assessed. Penalty collected.

GENERAL INFORMATION AND ABSTRACT

Program: Western San Joaquin Valley Hydrologic Studies

Funding Agency: San Joaquin Drainage Program

Principal Investigator: Robert Gilliom
U.S. Geological Survey
(916) 978-4648

Conducting Agency: US Geological Survey
US Bureau of Reclamation

Period of Record, Earliest Date: June, 1985

Period of Record, Latest Date: October,, 1989

Geographic Boundaries Description: Sampling is conducted throughout the Western San Joaquin Valley.

ABSTRACT

One facet of the program being carried out by the San Joaquin Valley Study Unit of USGS is a comprehensive hydrogeologic and geochemical study examining the sources, transport, and fate of selenium and other trace elements in the western San Joaquin Valley. Of particular relevance to the San Francisco Estuary is surface water quality data collected on the San Joaquin River at Vernalis and the Sacramento River at Freeport. This is a highly useful set of data for assessment of riverine mass transport of toxic contaminants into the estuary.

PARAMETERS

Media Analyzed: Water. Sediment.

PHYSICAL PARAMETERS MEASURED

streamflow - instantaneous

CHEMICAL PARAMETERS MEASURED

Other Hydrocarbons

purgeable organics

Other Parameters

chloride
dissolved solids
specific conductance

suspended sediment
water temperature

Pesticides
carbamates
organochlorine pesticides
organophosphorous insecticides
chlorophenoxy herbicides
triazine herbicides

Trace Elements
aluminum
arsenic
boron
cadmium
chromium
copper
iron
lead
lithium
manganese
mercury
molybdenum nickel
selenate
selenite
selenium
zinc

METHODS

SAMPLING METHODS

Temperature, and specific conductance were monitored continuously. Samples collected were analyzed for dissolved solids, major ions, nutrients, chlorophyll, and trace elements (both dissolved and total forms for most elements).
Standard USGS methods were used for sample collection.

SAMPLING FREQUENCY AND LOCATION
Number of Sampling Sites: 12

Salt Slough, Mud Slough, and the San Joaquin River at Vernalis were collected twice a month from June 1985 to October 1988, and monthly from October 1988 to October 1989. The Sacramento River at Freeport was collected twice a month from October 1986 to October 1988 then monthly till October 1989. All of the other listed stations were sampled twice monthly from June 1985 to July 1986 then monthly to October 1988. During periods of high flow, samples were collected more frequently.

In 1986 daily trace element and suspended sediment data were collected during February and March in the San Joaquin River at Vernalis. In 1985 one-time pesticide samples were collected at Vernalis.

		Latitude	Longitude
1.	Sacramento River at Freeport	38-27-15	121-29-54
2.	San Joaquin River near Stevinson Located on Highway 165, 2.5 miles south of Stevinson.	37-17-42	120-51-00
3.	Salt Slough near Stevinson Located on Highway 165, 5.8 mi south of Stevinson.	37-14-52	120-51-04
4.	San Joaquin River at Fremont Ford, near Stevinson. Located on Highway 140, 2.1 mi downstream from Salt Slough, 4.5 mi west of Stevinson, and 6.7 mi upstream from Merced River.	37-18-36	120-55-42
5.	Mud Slough near Gustine 5.0 miles east of Gustine, and 3.0 mi southeast of Highway 140.	37-15-45	120-54-20
6.	Merced River near Stevinson 4.4 mi upstream from Merced River mouth, and 5.3 mi northwest of Stevinson.	37-22-15	120-55-46
7.	San Joaquin River near Newman At Hills Ferry Bridge, 650 feet downstream from Merced River, and 3.5 mi northeast of Newman.	37-21-02	120-58-34
8.	San Joaquin river near Patterson At Los Palmas Bridge, 3.3 mi northeast of Patterson and 7.2 mi north of Crows Landing.	37-29-54	121-04-54
9.	Tuolumne River at Modesto Located at Ninth Street in Modesto, and 0.2 miles downstream from Dry Creek.	37-37-38	120-59-11
10.	San Joaquin River at Maze Road Located on Highway 132 (Maze Road), 2.7 mi upstream from Stanislaus River	37-38-24	121-13-36

and 12 miles west of Modesto.

11.	Stanislaus River at Ripon Located at railroad bridge, 1.1 mi southeast of Ripon, 15 mi upstream from mouth of Stanislaus.	37-43-47	121-06-34
12.	San Joaquin River near Vernalis Located at the Durham Ferry Bridge, 2.6 mi downstream from Stanislaus river, and 3.2 mi northeast of Vernalis.	37-40-34	121-15-55

ANALYTICAL METHODS

Current and historical stage-discharge relationship computations were used to determine exact rated discharges when measured values were not available. Water samples were analyzed for trace elements and other constituents at the USGS Laboratory in Denver, Colorado. Standard USGS methods were used for chemical determinations.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Hardware: Amdahl mainframe

Software: WATSTORE, STORET

Volume of Data: Over 160,000 parameters have been recorded.

Quality Assurance: Accuracy of recorded entries is checked at several phases of data processing. Questionable results are re-analyzed. Outliers are verified.

Contact for Data Retrieval

Name: Bob Gilliom

Address: USGS
Water Resources Division
2800 Cottage Way, Room W2234
Sacramento CA 95825

Phone: (916) 978-4648

Data Availability Date: Data from June 1985 to April 1987 are in STORET and are available upon request. Data from April 1987 are in review and QA, and will be released in early 1989.

REFERENCES

Gilliom, R.J. 1986. Selected water-quality data for the San Joaquin river and its tributaries, California, June to September 1985. USGS Open-File Report 86-74.

Shelton, L.R. and L.K. Miller. 1988. Water-quality data, San Joaquin Valley, California, 1985-1987. USGS Open-File Report.

Shelton, L.R. and L.K. Miller. 1990. Water-quality data, San Joaquin Valley, California, 1987-1989. USGS Open-File Report.

~**Descriptors:** agricultural drainage; salinity; herbicides; drinking water; contaminant loading; bay-delta; delta; upper drainage; flow; pollutants and related parameters; non-urban runoff; pollutant sources; suspended particulate matter; hydrology and flow; water chemistry; water quality; water pollution; hydrology and flow; chlorinated hydrocarbons; delta inflow; riverine inputs; rivers;

GENERAL INFORMATION AND ABSTRACT

Program:	DAYFLOW
Funding Agency:	Department of Water Resources
Principal Investigators:	Kamyar Guivetchi (916) 445-5157 Sheila Greene (916) 323-8978
Conducting Agency:	Department of Water Resources
Period of Record, Earliest Date:	1955
Period of Record, Latest Date:	Present
Geographic Boundaries Description:	Model boundaries are the Sacramento River at Freeport, the San Joaquin River at Vernalis, and Chipps Island.

ABSTRACT

DAYFLOW is a computer program developed by the California Department of Water Resources (DWR) in 1978 as a tool for determining historical Delta boundary hydrology. The DAYFLOW program presently provides the best estimate of historical mean daily flows at several points in the Delta, including: past Chipps Island into San Francisco Bay (net Delta outflow); through the Delta Cross Channel and Georgiana Slough; and past Jersey Point. The program also provides a valuable summary of the data used as input, such as streamflows, water project exports, water diversions within the Delta, and precipitation. Historical hydrologic data from 1955 to the present are available. DAYFLOW output is used extensively in studies conducted by DWR, the California Department of Fish and Game, and other agencies and private consultants.

The accuracy of DAYFLOW output is determined by the DAYFLOW computational scheme and the accuracy and limitations of the input data. The input data include the principal Delta stream inflows, Delta precipitation, Delta exports, and Delta gross channel depletions (consumptive use within the Delta). These input data include both measured and estimated values collected from a number of different sources. All calculations are performed using daily data.

PARAMETERS

MISCELLANEOUS PARAMETERS

Contra Costa Canal exports

Central Valley Project exports
Delta Cross Channel and Georgiana Slough flow estimate
Eastern Delta inflow
effective delta inflow for striped bass survival
effective percent of Western/Central Delta water diverted
gross Delta channel depletions (consumptive use)
interior Delta flow estimates
miscellaneous diversions
miscellaneous streamflows
net Delta channel depletions
net Delta outflow estimate at Chipps Island
Delta precipitation runoff estimate
percent of flows diverted
State Water Project export
total Delta exports and diversions/transfers
total Delta inflow
Yolo bypass flow

METHODS

SAMPLING FREQUENCY AND LOCATION

Half of the sites used to supply data which is input into the model are obtained from continuous monitoring stations maintained by the US Geological Survey and the US Bureau of Reclamation. These stations are described below, and numbered 1 through 5. The rest of the nodes are used to calculate daily flow at various areas throughout the Bay and Delta; these stations are described in numbers 6 through 10. When it could be obtained, the drainage area for the sampling stations was included in the description.

		Latitude	Longitude
1.	Sacramento River at Freeport Left bank 600 ft downstream from drawbridge at Freeport, 11 miles south of Sacramento. Drainage area indeterminate. Prior to October 1979, samples were collected on the Sacramento River at Sacramento, 1,000 feet upstream from I St. Bridge, 0.5 mile downstr from the American River. Drainage area 23,502 miles. USGS measurements of mean daily flow and USBR calculated flow.	38-27-15	121-29-54
2.	San Joaquin River near Vernalis Left bank 12 feet downstream from Durham Ferry bridge, 2.6 miles downstream from Stanislaus River, and 3.2 miles NE of	37-40-34	121-15-55

Vernalis. Drainage area 13,536 miles. USGS measurements of mean daily flow. USBR instantaneous flow at 6 a.m. reading at Vernalis.

3.	Mokelumne River at Woodbridge Right bank at Woodbridge, 0.4 mile downstream from county Hwy bridge, 0.5 mile downstream from am and canal intake of Woodbridge Irrigation District. Drainage area 661 miles. USGS measurements of mean daily flow.	38-09-31	121-18-09
4.	Cosumnes River at McConnell Downstream side of Hwy 99 bridge, 0.2 mi S of McConnell, 1 mile downstream from Deer Creek 7 miles north of Galt. Drainage area 724 mi USGS measurements of mean daily flow. Sampled at McConnell until October 1982. Sampling now occurs on the Cosumnes River at Michigan Bar, a stream gage station operated by USGS.	38-21-29	121-20-34
5.	Yolo Bypass near Woodland Left bank 300 ft upstream from the Sacramento-Woodland RR bridge, 6 miles upstr from the Sacramento Bypass, 6 miles downstream from Fremont Weir, 7 mi E of Woodland.	38-40-40	121-38-35
6.	Delta Cross Channel and Georgiana Slough DWR calculated daily flow in the Delta Cross channel and Georgiana Slough. Calculations are based on the daily operation of the Cross channel gates and a series of equations, which use the flow of the Sacramento River at Freeport as a variable.	38-15-00	121-30-00
7.	Contra Costa Canal Pumping plant No. 1, 0.7 mile east of Oakley, 2.6 miles NW of Knightsen. USBR computations of pumped daily flow.	37-59-44	121-42-03
8.	Clifton Court Forebay Intake to Clifton Court Forebay, 5.5	37-49-50	121-33-09

miles SE of Byron. DWR computations of mean daily flow. Prior to 1971, Ca. Aqueduct of Delta Pumping Plant; Location was 4.5 mi S of Byron. Prior to Nov. 1969, water was diverted via Italian Slough.

9.	Delta-Mendota Canal Tracy Pumping Plant at intake to canal, 6 miles SE of Byron, 10 miles NW of Tracy. USBR computation of pumped daily flow.	37-47-45	121-35-05
10.	Chipps Island DWR computed total daily Delta outflow.	38-02-47	121-55-02

11. Bear Creek - Lodi. A DWR stream gage.

12. Calaveras River - below New Hogan Reservoir. A DWR stream gage.

13. Dry Creek - Galt. A USGS stream gage.

14. French Camp Slough - French Camp. A DWR stream gage.

15. Sacramento Weir Spill

16. South Fork Putah Creek - Solano Lake Diversion Included from October 1985; previously at Davis.

17. Stockton Diverting Canal. A DWR stream gage which was discontinued in October, 1986.

18. Stockton Fire Station #4. National weather service precipitation gage.

19. Central Valley Project. Data collected from USBR operations records.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: Research Triangle Park, North Carolina

Hardware: IBM mainframe

Software: STORET, SAS, RBASE System V

Volume of Data: approximately 240,000 records

Contact for Data Retrieval

Sheryl Baughman
Chair of the Interagency Data Management
Technical Committee
Bureau of Reclamation
2800 Cottage Way Rm W-2137
Sacramento CA 95825-1898
(916) 978-5290

or

Phil Daniels
Data Management Office
State Water Resources Control Board
(916) 322-4515

or

Kamyar Guivetchi	Sheila Greene
Dept of Water Resources	
Central District	
3251 S Street	
Sacramento CA 95825-1898	
(916) 445-5157	(916) 323-8978

Access: Public information

Data Availability Date: Immediately

REFERENCES

"DAYFLOW Program Documentation and DAYFLOW Data Summary User's Guide." Available from the Department of Water Resources, Central District. Sacramento, CA. Contact Kamyar Guivetchi, (916) 445-5157.

DWR. STORET DAYFLOW database documentation. Available from the Department of Water Resources, Central District. Sacramento, CA. Contact Kamyar Guivetchi, (916) 445-5157 or Sheila Greene, (916) 323-8978.

DAYFLOW data summary for water years 1955-56 through 1983-84. Available from the Department of Water Resources, Central District. Sacramento, CA. Contact Kamyar Guivetchi, (916) 445-5157.

DWR. Annual DAYFLOW data summary update reports. Available from the Department of Water Resources, Central District. Sacramento, CA. Contact Sheila Greene (916) 323-8978.

DWR. Summary documentation of several existing data bases of historical delta hydrology. Available from the Department of Water Resources, Central District. Sacramento, CA. Contact Kamyar Guivetchi, (916) 445-5157.

Greene, S. 1988. DAYFLOW data summary for water year 1987. Available from the Department of Water Resources, Central District. Sacramento, CA. Contact Sheila Greene, (916) 323-8978.

Greene, S. 1988. DAYFLOW data summary update documentation for water year 1987. Available from the Department of Water Resources, Central District. Sacramento, CA. Contact Sheila Greene, (916) 323-8978.

Report location: Department of Water Resources, Central District, 3251 S Street, Sacramento, CA, 95816.

~**Descriptors:** hydrodynamics and modelling; water diversion; hydrologic data; precipitation; delta; bay-delta; sacramento-san joaquin delta; delta outflow; hydrology and flow; delta inflow; net channel depletion; west delta; east delta; north delta; south delta;

GENERAL INFORMATION AND ABSTRACT

Program:	Hydrodynamic Monitoring and Modeling
Funding Agency:	U.S. Geological Survey NOS/NOAA State Water Resources Control Board Department of Water Resources
Principal Investigators:	Jeff Gartner Ralph Cheng U.S. Geological Survey (415) 354-3360
Conducting Agency:	U.S. Geological Survey NOS/NOAA
Period of Record, Earliest Date:	August, 1978
Period of Record, Latest Date:	Present
Geographic Boundaries Description:	Data are collected throughout San Francisco Bay.

ABSTRACT

During 1979 and 1980, a comprehensive tidal-current survey of San Francisco Bay was conducted jointly by the National Ocean Survey/National Oceanic and Atmospheric Administration (NOS/NOAA) and the US Geological Survey (USGS). Each of these agencies had already initiated significant hydrodynamic monitoring programs in the Bay, and their combined efforts produced an extensive set of measurements of currents and tidal elevations. This dataset represents the first detailed sampling of the spatial variation of the flows within the Bay. After completion of this joint study, USGS continued to collect hydrodynamic data at selected locations in the Bay. Data generated in these studies are useful in contributing to an improved understanding of water circulation and mixing in the Bay, improved tide and tidal-current predictions, and the calibration and verification of mathematical and physical models of the estuary.

Analyses of these data have been conducted by USGS, and by researchers at the University of California at Berkeley (UCB) under contract to the State Water Resources Control Board. USGS has focused on analysis of both velocity and tidal elevation data. A five-part report presents all of the data generated in the joint study (1979-1980) (Cheng and Gartner 1984). Other reports (see References) document analysis of data collected in subsequent years. Included in these reports are tabulations of RMS current speed, principal current direction, tidal form number, results from harmonic analysis; Eulerian residual currents computed using a

vector-averaging technique; and time- series plots of current speed and direction, salinity, and temperature. Meteorology data are documented in Gartner and Cheng (1983).

Cheng and Gartner (1985) describe a detailed harmonic analysis of tides and tidal currents in South San Francisco Bay. Among the findings of that study were that the principal direction and magnitude of tidal currents are well correlated with basin bathymetry, and residual circulation patterns in the summer months differ from those in winter months due to the influence of the prevailing westerly summer wind.

Denton and Hunt (1986) of UCB conducted an analysis of all of the data generated by the joint study, particularly concerning themselves with mechanisms of pollutant dispersion in the Bay. The hydrodynamic circulation in Suisun Bay and San Pablo Bay is typical of a predominantly progressive wave in a partially mixed estuary with spatial variations in frictional resistance. The hydrodynamics of the South Bay are more closely related to a standing wave with non-uniform bathymetry. The circulation in Central San Francisco Bay is determined by tidal forcing through the Golden Gate and the exchanges with the South Bay at the Bay Bridge and San Pablo Bay to the north. Delta outflow plays an important role in the northern reach in setting up longitudinal and transverse gravitational circulation. The effect of Delta outflow in setting up residual currents in the Central Bay and South Bay tends to be small compared to the net circulations set up by other effects such as tidal pumping. The difference in phases of the flows along different interconnecting channels in Suisun Bay leads to tidal trapping which acts to increase the dispersion of pollutants. A simple flushing model based on current and conductivity data has been developed and calibrated.

PARAMETERS

PHYSICAL PARAMETERS MEASURED

air temperature
atmospheric pressure
conductivity
current speed
current direction
irradiance
water level observations
water temperature
wind direction
wind speed - average and maximum

METHODS

SAMPLING METHODS

Field measurements of current speed and direction, and water temperature and conductivity were collected by *in situ* current meters at 124 stations from 1978 to 1986. Up to four current meters were deployed at the stations in the deeper parts of the Central Bay, but there was generally only one meter at each station in the shallows. The USGS used Endeco-174 current meters, which recorded current speed and direction, and water temperature and conductivity at two minute intervals. Records were retrieved by individual meters for 2 to 6 weeks. NOS/NOAA used Aanderaa RCM-4 current meters which also measured pressure variations resulting from changes in the tidal elevation. These meters recorded data at 10 minute intervals. Aanderaa meters were deployed for 15 to 29 days.

Water-level data were also recorded by NOS/NOAA during this study period. Data from 34 stations located around the perimeter of the Bay are discussed in Cheng and Gartner (1984). Water levels were recorded at 6 minute intervals and later averaged to hourly values for analysis. Meteorological data were collected at four locations from 1979-1981. These data were recorded at 20 minute intervals using Aanderaa remote weather stations. Data were averaged to hourly values for archiving.

SAMPLING FREQUENCY AND LOCATION

Number of Stations: 4 meteorological stations and 124 current meter stations were established.

Between August and December of 1978 current meter data were collected at 7 stations which were located near the Oakland-Bay bridge in Central Bay, in Suisun Bay, and as far north as the confluence of the Sacramento and San Joaquin Rivers. Deployment periods were approximately 4 to 5 weeks (Gartner and Cheng, 1981).

Between February 1979 and December of 1980 current meter data were collected at 97 stations throughout San Francisco Bay. Normal deployment periods for the current meters lasted between 15 and 35 days. Water level observations from 34 stations in San Francisco Bay were also collected.

During the survey of 1979-1980 current meters were deployed at 22 stations in the Suisun Bay Region, 11 stations in San Pablo Bay, 38 in Central Bay, and 26 stations in the South Bay. Water level data were collected at 9 stage stations located around the perimeter of Suisun Bay, 6 around San Pablo Bay, 11 around Central Bay, and 8 around South Bay.

Between November 1979 and September 1981 weather data was collected at 4 remote weather stations which were located in South Bay, (2 stations), San Pablo Bay, and Suisun Bay. Measurements included average and maximum wind speed, wind direction, air temperature, atmospheric pressure, and irradiance.

Additional current meter data were collected in 1981-1983 at seven stations in the South Bay, and in 1984 and 1985 at four stations in the Sacramento and San Joaquin River Delta near the confluence of the two rivers. All four current meters were placed near the west side of the Sacramento and San Joaquin Delta near Kimball Island and Antioch. One of these current meters was located north of the Stockton ship channel, two were located mid-estuary just south of the ship channel, and the fourth was located near the Antioch-side shoreline.

During 1985 one additional station was located in the South Bay near San Bruno Shoal, and in 1986 eleven stations were established in Suisun and San Pablo Bays.

QUALITY ASSURANCE TESTING AND REPORTING

Accuracy specifications for the two types of current meters deployed are given in Cheng and Gartner (1984). Instruments were periodically recalibrated during the 10 year study period. Specifications for the meteorological instruments can be found in Gartner and Cheng (1983) and specifications for the tide gauges are presented in Welch *et al.* (1985).

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location:	Sacramento, CA
Hardware:	PRIME computer
Software:	FORTRAN
Quality Assurance:	Each record contains information indicating the quality of the data on a scale of 1 to 5. The Aanderaa current meter data were checked by NOS/NOAA before release to USGS. USGS examined the Endeco data. Some portions of obviously bad data were removed from records and minor editing of spurious values done. The user should be aware of the quality of data from examination of time series plots and from the quality of data codes included in the data fields.
Contact for Data Retrieval	USGS
Address:	2800 Cottage Way Sacramento CA 95825
Phone:	(916) 978-4648

REFERENCES

Cheng, R.T. and J.W. Gartner. 1985. Harmonic analysis of tides and tidal currents in South San Francisco Bay, California. Estuarine, Coastal and Shelf Science 21: 57-74.

Cheng, R.T. and J.W. Gartner. 1984. Tides, tidal and residual currents in San Francisco Bay, California; results of measurements, 1979-1980: Parts I-V, Description of data. USGS Water Resources Investigations Report 84-4339. Part I 72 pages; Part II 231 pages; Part III 368 pages; Part IV 757 pages; Part V 319 pages.

Denton, R.A. and J.R. Hunt. 1986. Currents in San Francisco Bay: Final Report. Report No. UCB/HEL-86/01. Department of Hydraulic and Coastal Engineering, U.C. Berkeley. Berkeley, CA. (Also cited as: SWRCB Publication No. 86-7 WR California State Water Resources Control Board. Sacramento, CA.)

Gartner, J.W. 1986. Tidal and residual currents near the confluence of the Sacramento and San Joaquin Rivers, California: Results of measurements, 1984-1985. USGS Water Resources Investigations Report 86-4025. 42 pages.

Gartner, J.W. and R.T. Cheng. 1981. Observations from moored current meters in San Francisco Bay, 1978. USGS Open-File Report 82-153. 91 pages.

Gartner, J.W. and R.T. Cheng. 1983. Observations from remote weather stations in San Francisco Bay, California 1979-1981. USGS Open-File Report 83-269. 120 pages.

Gartner, J.W. and R.A. Walters. 1986. Tidal and residual currents in South San Francisco Bay, California, Results of Measurements, 1981-1983. USGS Water Resources Investigations Report 86-4024. 148 pages.

Gartner, J.W. and B.T. Yost. 1988. Tides, tidal and residual currents in Suisun and San Pablo Bays, California, Results of measurements, 1986. USGS Water Resources Investigations Report 88-4027. 95 pages.

Welch, J.M., J.W. Gartner, and S.K. Gill. 1985. San Francisco Bay area circulation survey 1979-1980. NOS Oceanographic Circulation Survey Report No.7. 180 pages.

Report Location

For viewing:

USGS Library
345 Middlefield Road
Menlo Park CA 94025

For purchase:
Books and Open File Reports
US Geological Survey
Federal Center Bldg 810
P.O. Box 25425
Denver CO 80225

~**Descriptors:** bay-delta; hydrology and flow; hydrodynamics and modelling; currents; tides; delta outflow;

GENERAL INFORMATION AND ABSTRACT

Program:	Water Resources Data
Funding Agency:	U.S. Geological Survey U.S. Army Corps of Engineers U.S. Bureau of Reclamation U.S. Department of the Interior
Principal Investigator:	Pete Antilla (916) 978-4633 U.S. Geological Survey
Conducting Agency:	U.S. Geological Survey California Department of Water Resources Pacific Gas and Electric Company Sacramento Municipal Utility District Nevada and Oroville-Wyandotte Irrig Dsts Placer and Yuba County Water Agencies
Period of Record, Earliest Date:	The major rivers, the San Sacramento and the San Joaquin, have been monitored since 1948 and 1922, respectively.
Period of Record, Latest Date:	Present
Geographic Boundaries Description	The entire catchment of the Bay and Delta is monitored.

ABSTRACT

The U.S. Geological Survey (USGS) collects surface water data throughout California to assess the quantity and distribution of surface water resources. The data include records of stage, discharge, and water quality of streams, and other water bodies and aquifers. Numerous major and minor streams that flow into the San Francisco estuary are monitored. Sediment discharge and temperature are also monitored at selected stations. In addition, water quality parameters (such as trace elements, nutrients, radioactive particles, and certain standard parameters) are measured at selected stations statewide, including 4 in the Bay-Delta, as part of the National Stream Quality Accounting Network (NASQAN).

Annual reports are published that present monitoring data collected at all of the stations throughout California. The most recent of these covers water year 1986 (October 1985 through September 1986) (USGS 1988). Daily average flows are presented, along with temperature, sediment, and chemical data. These publications are simply data reports, so minimal analysis of the data is provided.

PARAMETERS

Media Analyzed: Water

BIOLOGICAL PARAMETERS MEASURED
fecal coliforms
fecal streptococci bacteria

PHYSICAL PARAMETERS MEASURED
barometric pressure
gage height
groundwater levels
instantaneous streamflow
records of water quality in selected observations wells
sediment concentrations
sediment discharge
stage, discharge and water quality of streams, lakes, and reservoirs
suspended sediments

CHEMICAL PARAMETERS MEASURED
alkalinity
biological oxygen demand
chloride
dissolved oxygen
dissolved solids
fluoride
hardness - calcium carbonate and non-carbonate
pH
sediment particle size
silica
sodium
sodium adsorbtion ratio
solids residue at 180 degrees C
specific conductance
turbidity
water temperature
Nutrients
dissolved nitrogen-ammonia

nitrogen
nitrogen-ammonia organic total

Trace Elements
aluminum
arsenic
barium
berylium
cadmium
chromium
cobalt
copper
iron
lead
lithium
magnesium
manganese
mercury
molybdenum
nickel
ortho-phosphorus
phosphorus - total and dissolved
selenium
silver
strontium
sulfate
vanadium
zinc

MISCELLANEOUS PARAMETERS ANALYZED

average discharge
drainage area
extremes of published records
period of record

METHODS

SAMPLING METHODS

Stage and discharge of streams and stage and contents of lakes and reservoirs throughout California are measured and recorded. In 1984, for example, this program included hydrologic data for 478 continuous streamflow stations established by USGS. Included in the reports describing these data are measurements made by cooperating parties, such as the Department of Water Resources. Water quality data are collected at a subset of the stations where hydrological data are collected. Standard USGS methods of collection of hydrologic and water quality data are used, as described in the series "Techniques of Water Resources Investigations of the United States Geological Survey" (see USGS 1988 for the full list of references).

Number of Sampling Sites:
Sampling Location and Frequency:

Streamflows are computed on a daily basis at all locations. Temperature, sediment, and turbidity are measured daily at a few locations. Chemical data are recorded quarterly at selected sites.

	Latitude	Longitude
Colma Creek at South San Francisco Ca	37 39 14	122 25 31
Spruce Branch at South San Francisco Ca	37 38 46	122 25 15
Redwood Creek at Redwood City, Ca	37 26 58	122 13 57
Sharon C Nr Menlo Park CA	37 25 45	122 13 02
San Francisquito Crk below Ladera Damsite	37 24 24	122 12 11
San Francisquito C T Nr Stanf U CAL	37 24 43	122 11 52
Los Trancos CA Nr Stanford Univ CA	37 23 20	122 11 10
Los Trancos C Trib Nr Stanf U CA	37 24 18	122 11 09
Las Trancos C at Stanford U CA	37 24 44	122 11 35
Lagunita Ca at Stanfrod U CA	37 25 05	122 11 15
San Francisquito C at Stanford U CA	37 25 24	122 11 18
San Francisquito C at Menlo Park, CA	37 26 35	122 10 30
San Frnacisquito C at Palo Alto, CA	37 27 10	122 08 20
Matadero C at Palo Alto CA	37 25 18	122 08 04
Stevens Creek Reservoir nr Monte Vista CA	37 17 55	122 04 34
Stevens Creek nr Cupertino, CA	37 18 20	122 04 25
Permanente Cr Nr Monte Vista, CA	37 20 00	122 05 13
West Fork Permanente Cr Nr Monte Vista, CA	37 19 59'	122 05 58
Almaden Reservoir at New Almaden CA	37 09 54	121 49 39
Arroyo Calero Trib nr New Almaden, CA	37 10 40	121 47 28
Calero Reservoir nr New Almaden, CA	37 11 00	121 47 82
Alamito Creek nr New Almaden, CA	37 13 21	121 51 00
Alamitos Cr nr Edenvale, CA	37 14 08	121 52 08
Guadalupe Reservoir nr New Almaden, CA	37 11 57	121 52 42
Guadalupe C at Guadalupe, CA	37 13 02	121 54 35
Guadalupe R at Almtos Rchg Fac at San Jose, CA	37 14 51	121 52 08
Ross Creek at San Jose, CA	37 14 56	121 54 45
Ross C Bl Jarvis Rd Nr San Jose, CA	37 15 48	121 53 08
Lake Elsman nr Los Gatos, CA	37 07 51	121 55 47
Lake Elsman nr Los Gatos Ca	37 07 51	121 55 47

Los Gatos C AB Lexington Re nr Los Gatos, CA	37 10 02	121 58 43
Lexington Reservoir Nr Los Gatos, CA	37 12 06	121 59 17
Los Gatos Creek at Los Gatos, CA	37 13 03	121 59 11
Los Gatos C BL Los Gatos, CA	37 14 00	121 58 23
Los Gatos C at Lark a At Los Gatos, CA	37 15 07	121 57 48
Los Gatos C at Lincoln Ave at San Jose, CA	37 18 45	121 54 12
Guadalupe River at San Jose, CA	37 20 04	121 53 54
Saratoga Creek at Saratoga, CA	37 15 16	122 02 18
Garrod Ranch Rg Nr Saratoga, CA	37 16 38	122 03 36
Galabazas C Trib at Mt Eden Road nr Saratoga Road	37 16 09	122 03 36
Calabazas C at mterd nr Saratoga, CA	37 16 03	122 03 31
Calabazas C tr3 at mterd nr Saratoga, CA	37 15 54	122 03 19
Calabazas C TR4 at mterd nr Saratoga, CA	37 15 54	122 03 18
Calabazas C TR5 at Prc Rd nr Saratoga, CA	37 15 54	122 03 10
Calabazas C at Vregna nr Saratoga, CA	37 16 00	122 03 04
Prospect C at Saratoga Golf Course nr Saratoga	37 17 09	122 03 14
Prospect C at MRA La nr Saratoga, CA	37 17 38	122 02 34
Prospect C TR nr Saratoga, CA	37 17 38	122 02 34
Calabazas C at Rnbo Dr nr Cupertino, CA	37 18 03	122 01 32
Coyote Creek nr Gilroy, CA	37 04 40	121 29 36
Coyote Lake nr San Martin, CA	37 07 06	121 32 55
Coyote C Bl Coyote Res nr San Martin, CA	37 07 23	121 33 06
Las Animas C bl San Felipe C nr Madrone, CA	37 12 45	121 39 26
Anderson Lake nr Madrone, CA	37 09 56	121 37 42
Coyote C bl Leroy Anderson DM nr Madrone, CA	37 09 54	121 37 56
Coyote Creek nr R Madrone, CA	37 10 06	121 38 55
Coyote C at Coyote, CA	37 13 45	121 44 20
Laguna Seca nr Coyote, CA	37 11 55	121 44 25
Coyote C nr Edenvale, CA	37 16 15	121 47 47
Coyote C at San Jose, CA	37 21 00	121 52 25
Upper Penitencia Creek at San Jose, CA	37 23 43	121 49 38
Laguna Creek at Irvington, CA	37 32 10	121 57 35
Alameda C nr Sunol, CA	37 30 50	121 48 10
Arroyo Hondo Near San Jose, CA	37 27 42	121 46 06
Calaveras C nr Sunol, CA	37 29 45	121 49 05
Alameda Cr Trib No 2 nr Warm Springs, CA	37 31 15	121 50 49
Alameda Cr Trib No 1 nr Warm Springs, CA	37 31 14	121 50 48
San Antonio C nr Sunol, CA	37 34 39	121 51 24
Alameda C at Sunol, CA	37 35 15	121 53 21
Big Canyon Cr nr Dublin, CA	37 43 15	121 56 25
Alamo C at Dublin, CA	37 42 05	121 55 05
Alamo Canal nr Pleasanton, CA	37 41 10	121 54 54
DSRSD (VCSD) Wasteway nr Pleasanton	37 41 09	121 54 53
Tassajero C nr Pleasanton, CA	37 42 00	121 52 40

Arroyo Mocho nr Livermore, CA	37 37 35	121 42 13
Arroyo Mocho at Livermore, CA	37 40 37	121 48 48
Arroyo Las Positas Above Livermore, CA	37 41 40	121 42 49
Altamont Creek nr Livermore, CA	37 43 23	121 43 41
Arroyo Las Positas at Livermore, CA	37 42 00	121 46 22
Arroyo Las Positas Nr Livermore, CA	37 41 52	121 48 15
Livermore Treatment Plant #1 nr Livermore	37 41 47	121 48 35
Livermore Treatment Plant #2 nr Livermore	37 41 50	121 49 42
Arroyo Las Positas at Elch Rd nr Pleasanton	37 41 49	121 50 54
Arroyo Mocho nr Pleasanton, CA	37 41 26	121 52 20
Tassajara Creek nr Pleasanton, CA	37 41 57	121 52 41
Arroyo de La Laguna AB AV nr Pleasanton, CA	37 39 46	121 54 19
Arroyo Valle Bl Lang Cn nr Livermore, CA	37 33 41	121 40 58
Arroyo Valle nr Livermore, CA	37 37 24	121 45 28
Arroyo Valle Trib nr Livermore, CA	37 38 45	121 47 55
Arroyo Valle at Pleasanton, CA	37 40 02	121 52 54
Arroyo de La Laguna at Verona, CA	37 37 36	121 52 55
Arroyo de La Laguna nr Pleasanton, Ca	37 36 55	121 52 50
Vallecitos C at Sunol, CA	37 35 42	121 52 51
Sinbad C at Suno, CA	37 35 41	121 53 07
Stonybrook C nr Niles, CA	37 35 54	121 56 51
Alameda Creek nr Niles, CA	37 35 14	121 57 35
Alameda Cr Trib nr Niles, CA	37 35 15	121 57 40
San Francisco Release at Niles re at Niles	37 34 55	121 57 35
Kaiser Pit at Niles, CA	37 34 08	121 58 56
Shinn Pit at Niles, CA	37 34 12	121 59 15
The Lake at Newark, CA	37 33 14	122 32 06
Crandall Cr nr Centerville, CA	37 43 10	122 01 45
Alameda C nr Decoto, CA	37 35 15	122 02 15
Dry Creek at Union City, CA	37 36 22	122 01 22
Patterson C at Union City, CA	37 35 09	122 02 50
Alameda Creek at Union City, CA	37 35 46	122 03 15
San Lorenzo Cr abv Don Castro Res nr CV, CA	37 41 42	122 02 38
Cull C TR No.4 AB Cull C R nr Castro Valley	37 45 02	122 03 21
Cull Creek Ab Cull C RE nr Castro Valley	37 43 04	122 03 12
Cull Creek BL Cull C Dam nr Castro Valley	37 42 08	122 03 15
San Lorenzo Creek at Hayward, CA	37 41 11	122 03 44
Castro Valley Creek at Castro Valley, CA	37 42 42	122 03 45
Castro Valley C at Knox St at Castro Valley, CA	37 40 56	122 04 44
Castro Valley Creek at Hayward, CA	37 40 48	122 04 46
San Lorenzo Creek at San Lorenzo, CA	37 41 03	122 08 20
Peralta C at Oakland, CA	37 46 59	122 13 06
Temescal C ab Lk Temescal at Oakland, CA	37 50 38	122 13 35
Caldecott C at Lk Temescal at Oakland, CA	37 50 48	122 13 40

Wildcat C at Vale Road at Richmond, CA	37 57 12	122 20 14
Wildcat Creek at Richmond, CA	37 57 41	122 21 33
San Pablo C nr San Pablo, CA	37 56 40	122 15 45
San Pablo C at San Pablo, CA	37 58 00	122 21 24
Rheem Creek at San Pablo, CA	37 58 38	122 21 10
Pinole C at Pinole, CA	37 58 21	122 14 43
Arroyo Del Hambre nr Martinez, CA	37 58 10	122 10 05
Arroyo Del Hambre at Martinez, CA	38 00 12	122 07 44
San Ramon Creek at San Ramon, CA	37 46 23	121 59 37
San Ramon Creek at Walnut Creek, CA	37 52 38	122 02 52
Walnut C at Walnut Creek, CA	37 54 21	122 03 22
Walnut Creek at Concord, CA	37 56 43	122 02 55
Little Pine C nr Alamo, CA	37 53 06	121 58 36
Avenal Creek Nr Avenal, CA	35 51 15	120 07 34
Stoker Canyon Creek nr Devils Den, CA	35 46 20	120 10 15
Cullinciscan Creek at Kecks Corner, CA	35 39 57	120 04 56
Bitterwater Creek nr Lost Hills, CA	35 33 40	120 02 25
Poso Creek nr Oildale, CA	35 30 50	118 54 17
Mon Canyon Creek nr Oildale, CA	35 31 45	118 58 25
White R nr Calif Hot Springs, CA	35 50 12	118 43 42
Coho Creek nr White River, CA	35 49 50	118 51 35
White River nr Ducor, CA	35 48 53	118 55 42
Dear C nr Calif Hot Springs, CA	35 52 45	118 40 42
Deer Creek nr Fountain Springs, CA	35 56 30	118 49 19
Deer Cr Diversion nr Terra Bella, CA	35 59 27	118 59 06
Pacific Gas & Electric Conduit nr Springville	36 11 11	118 39 47
PG&E Tule r PH nr Springville, CA	36 09 48	118 42 21
NF of MF Tule R Bl Hossack C nr Springville	36 11 22	118 39 49
Nf of MF Tule R nr Springyville, CA River only	36 10 29	118 41 41
NF or MF Tule R nr Springville Total Flow	36 10 29	118 41 41
Winding Creek near Camp Nelson, CA	36 09 35	118 40 30
SF of MF Tule R nr Springville, CA	36 09 39	118 42 19
SCE Co Tule R CD nr Springville, CA	36 09 00	118 42 00
MF Tule R AB Springvile, CA	36 09 00	118 44 56
MF Tule R AB Springfield (Tot. Flow)	36 09 00	118 44 56
Bear C nr Springville, CA	36 12 09	118 45 37
NF Tule R at Springville, CA	36 08 22	118 48 15
Tule River Div Nr Springville, CA	36 05 58	118 52 10
Tule River nr Springvillle, CA	36 06 02	118 52 07
Combined Flow of Tule R Div ditch and Tule R	36 06 02	118 52 07
Wardlow Cr nr Springville, CA	36 05 29	118 52 58
Tule R nr Porterville, CA	36 04 48	118 54 30
SF Tule R nr Porterville, CA	36 01 50	118 46 54
South Fork Tule River nr Success, CA	36 02 33	118 51 24

Pioneer Ditch Below Success Dam	36 03 34	118 55 22
Success Lake nr Success, CA	36 03 40	118 55 18
Tule River Bl Success Dam, CA	36 03 23	118 55 22
Tule River Tributary nr Success, CA	36 03 27	118 54 48
Tule R at Worth Br nr Porterville, CA	36 02 24	118 56 14
Frazier Creek nr Strathmore, CA	36 08 33	118 57 18
Lewis Creek nr Lindsay, CA	36 11 11	118 59 46
MF Kaweah R No. 3 Conduit nr Potwisha, Camp	36 30 36	118 47 48
MF Kaweah R nr Potwisha Camp (River only)	36 30 46	118 47 25
MF Kaweah R nr Potwisha Camp (Total Flow)	36 30 46	118 47 25
Emerald Lake Outflow nr Giant Forest, CA	36 35 54	118 40 32
Marble Fork Kaweah R No. 3 Conduit at Potwisha	36 31 10	118 48 00
Marble Fk Kaweah at Potwisha, CP River only	36 31 08	118 48 03
Marble Fk Kaweah at Potwisha CP Total Flow	36 31 08	118 48 03
MF Kaweah Tributary nr Hammond CA	36 29 35	118 49 30
Franklin C nr Hammond, CA	36 25 50	118 35 00
White Chief C nr Hammond, CA	36 26 00	118 35 20
EF Kaweah R BL Eagle C nr Hammond, CA	36 26 44	118 35 38
Spring C nr Hammond, CA	36 26 40	118 35 50
EF Kaweah R AB Monarch Creek nr Hammond, CA	36 27 01	118 35 40
Monarch Creek nr Hammond, CA	36 27 09	118 35 37
EF Kaweah R BL Monardh C nr Hammond, CA	36 27 09	118 35 56
Mosquito C nr Hammond, CA	36 27 00	118 37 00
EF Kaweah River Bl Mosquito C nr Hammond	36 27 05	118 37 04
EF Kaweah R At SEQ National Park Bndry nr Hammond	36 27 30	118 39 11
Atwell Creek AB Mineral King Hwy nr Hammond	36 27 57	118 40 30
Redwood Creek AB Mineral King Hwy nr Hammond	36 27 14	118 42 10
Squirrel Creek BL Mineral King Hwy nr Hammond	36 26 36	118 46 00
Crunigen Creek BL Mineral King Hwy nr Hammond	36 26 55	118 16 18
East Fork Kaweah River Conduit Nr Three Rivers	36 27 05	118 47 15
East Fork Kaweah River Near Three Rivers, CA	36 27 05	118 47 15
EF Kaweah River Nr Three Rivers, CA	36 27 05	118 47 15
Dorst Creek nr Kaweah Camp, CA	36 38 45	118 48 15
NF Kaweah R at Kaweah, CA	36 29 25	118 55 12
Kaweah River at Three Rivers, CA	36 26 38	118 54 09
SF Kaweah R nr Three Rivers, CA	36 22 30	118 51 20
South Fork Kaweah River at Three Rivers	36 25 00	118 54 48
Kaweah R nr Three Rivers, CA	36 24 24	118 57 12
Lemoncove Ditch Below Terminus Dam, CA	36 24 55	119 00 22
Lake Kaweah nr Lemoncove, CA	36 24 53	119 00 07
Foothill Ditch Below Terminus Dam, CA	36 24 48	119 00 47
Kaweah R BL Terminus Dam, CA	36 24 51	119 00 42
Antelope Creek at Woodlake, CA	36 24 50	119 06 31
Dummy Station 210950 + 210930 + 210850 Eq This	36 24 51	119 00 42

Dry Creek nr Lemoncove, CA	36 26 51	119 01 38
Kaweah R at Mck Point nr Lemoncove, CA	36 23 20	119 02 40
Cottonwood C ab Collier C nr Elderwood	36 32 33	119 06 40
Cottonwood Creek nr Elderwood, CA	36 31 47	119 07 33
Sand Creek nr Orange Cove, CA	36 37 36	119 14 48
Cooper Creek nr Cedar Grove, CA	36 47 56	118 34 47
South For, Kings River At Cedar Grove, CA	36 47 25	118 40 08
Sheep CReek at Cedar Grove, CA	36 47 08	118 40 34
Lewis Creek nr Cedar Grove, CA	36 48 14	118 41 29
Grizzly Creek nr Cedar Grove, CA	36 48 10	118 44 35
SF Kings R nr Cedar Grove, CA	36 48 25	118 44 55
Kings R nr Hume, CA	36 50 50	118 53 50
Kings River AB NF nr Timmer, CA	36 51 48	119 07 24
NF Kings R BL Meadowbrook, CA	37 04 53	118 51 43
Fleming C nr Blackcap Mountain, CA	37 05 55	118 51 40
Post Corral C nr Blackcap Mtn, CA	37 06 25	118 53 45
Helms C at Sand Meadows, CA	37 05 50	118 58 20
Courtright Reservoir nr Nelson Mtn, CA	37 04 40	118 58 05
Helms C BL Courtright Dam, CA	37 04 35	118 58 04
Wishon Reservoir nr Cliff Camp, CA	37 00 20	118 58 00
NF Kings R BL Wishon RE, CA	37 00 05	118 58 20
NF Kings R nr Cliff Camp, CA	36 59 38	118 58 49
Rancheria C nr Smith Meadow, CA	36 57 05	118 58 15
Teakettle C at S3 nr Pat Mtn, CA	36 57 40	119 01 35
Teakettle C TRib No.7 nr Pat Mtn, CA	36 57 45	119 01 20
Teakettle C Trib No.2 nr Pat Mtn, CA	36 57 35	119 02 00
Teakettle C Trib No.2A nr Pat Mtn, CA	36 57 25	119 01 50
Teakettle C Trib No.1 nr Pat Mtn, CA	36 57 00	119 01 10
NF Kings R BL Rancheria Creek, CA	36 55 40	119 00 30
Haas Ph nr Balch Camp, CA	36 55 40	119 01 00
Black Rock Res nr Balch Camp, CA	36 55 13	119 01 20
NF Kings R BL Balch Div DM, CA	36 54 10	119 03 00
Balch PH nr Fresno (No1 & No2 comb) CA	36 54 36	119 05 12
Dinkey Cr Siphon Fish Release at Balch Camp	36 54 29	119 07 27
NF Kings R AB Dinkey C at Balch Camp, CA	36 54 12	119 07 14
Rock C at Dinkey Creek, CA	37 05 24	119 09 39
Dinkey Creek at Dinkey Meadow nr Shaver Lake	37 02 50	119 08 52
Deer C BL East Fork, CA	37 00 10	119 03 50
Dinkey C at Mouth, CA	36 55 00	119 08 00
NF Kings R BL Dinkey C nr Balch Camp, CA	36 52 47	119 07 40
Combined flow Kings R AB NF and NF Kings R	36 52 29	119 08 27
Kings River LB NF nr Trimmer, CA	36 52 29	119 08 27
Combined Flow Kings R BL N F and Kings R PP	36 52 29	119 08 27
Kings R Powerhouse nr Balch Camp, CA	36 51 06	119 10 12

Big C nr Tollhouse, CA	37 02 00	119 14 00
Big Creek above Pine Flat Res Near Trimmer	36 54 59	119 14 37
Sycamore Creek AB Pine Flat Res nr Trimmer	36 55 13	119 18 32
Pine Flat Lake nr Piedra, CA	36 49 58	119 19 29
Kings R BL Pine Flat Dam, CA	36 49 50	119 20 07
Mill Creek nr Piedra, CA	36 49 05	119 20 25
Kings River at Piedra Bridge nr Piedra PO	36 49 01	119 22 56
Kings R at Piedra, CA	36 49 00	119 20 06
Bear Mountain Creek nr Squaw Valley, CA	36 43 52	119 16 53
KIngs R at Peoples Weir nr Kingsburg, CA	36 29 06	119 32 22
Practice Station for QW Class, CA	40 50 30	120 30 20
Los Gatos Creek AB Nunez Canyon nr Coalinga	36 12 53	120 28 11
Los Gatos C nr Coalinga, CA	36 13 00	120 27 00
Warthan Creek Tributary No. 1 nr Coalinga	36 05 55	120 32 00
Warthan Creek Tributary No. 2 nr Coalinga	36 05 30	120 28 50
Los Gatos Cr BL Jacalitos Creek, nr Coalinga	36 10 00	120 12 35
Zapato Chino Creek near Avenal, CA	36 04 07	120 13 48
NF San Joaquin R BL Iron Creek, CA	37 36 50	119 14 00
San Joaquin R at Miller Crossing, CA	37 30 38	119 11 47
WF Granite C nr Trimber Knob, CA	37 32 40	119 17 00
MF Granite C nr Cattle Mountain, CA	37 33 00	119 16 20
EF Granite C nr Cattle Mountain, CA	37 33 00	119 15 40
Granite C nr Cattle Mountain, CA	37 31 36	119 15 28
Ward Tunnel Intake at Florence Lake, CA	37 16 27	118 58 23
Florence Lake nr Big Creek, CA	37 16 26	118 58 23
SF San Joaquin R nr Florence Lake, CA	37 16 24	118 57 54
Hooper C A DD nr Florence LK (SP & REL)	37 18 19	118 56 57
San Joaquin R BL Hopper Creek nr Florence Lake	37 18 30	118 57 40
Bear Cr nr Lake T.A. Edison, CA	37 20 18	118 58 23
Bear Creek Conduit nr Mono Hot Springs	37 20 06	118 58 24
Bear Creek at Diversion Dam nr Lake T.A. Edison	37 20 05	118 58 26
South Fork San Joaquin River at Mono Hot Springs	37 19 34	119 00 45
Chinquapin C A DD nr Big C (spill & rel)	37 18 11	119 01 08
Camp 62 C A DD nr Big Creek	37 18 13	119 01 46
Boldsillo C AB Div DM nr Big Creek	37 18 36	119 02 18
Boldsillo C BL Div DM nr Big Creek	37 18 40	119 02 22
Lake Thomas A. Edison nr Big Creek, CA	37 22 13	118 59 13
Mono C Bl LK Thomas A. Edison, CA	37 21 40	118 59 26
Mono Creek Conduit nr Mono Hot Springs, CA	37 21 36	118 59 54
Mono Bear Cond nr Mono Hot Springs	37 18 48	119 01 24
Mono Creek at Divesion Dam, CA	37 21 37	118 59 50
Warm C A Div DM nr LK T.A. Edison (spl & rel)	37 23 03	119 01 33
SF San Joaquin R nr Hoffman Mdw, CA	37 25 00	119 08 40
Jackass C nr Bass Lake, CA	37 29 20	119 18 10

Jackass C nr Fullers Meadow, CA	37 22 50	119 18 10
WF Jackass C nr Fullers Meadow, CA	37 22 50	119 18 50
Chiquito C nr Mugler Meadow, CA	37 28 20	119 22 50
Chiquito Cr nr Bass Lake, CA	37 24 47	119 22 52
Dummy Station used for calculations of Chiquito	37 24 47	119 22 52
Mammoth Pool Reservoir nr Big Creek, CA	37 19 45	119 19 40
Mammoth Pool Fishwater Turbine nr Big Creek, CA	37 19 21	119 18 53
San Juoaquin R AB Shakeflat Cr nr Big Creek, CA	37 19 00	119 19 37
San Joaquin River AB Big Creek, CA	37 14 15	119 19 50
Mammoth Pool TU OL PH 8 nr Big Creek, CA	37 13 30	119 20 30
Rancheria Creek Tributary nr Lakeshore, CA	37 16 40	119 06 35
Portal Ph nr Huntington, Lk	37 15 25	119 09 30
Ward Tunnel Outlet at Huntington Lake, CA	37 15 25	119 09 38
Huntington Lake nr Big Creek, CA	37 14 03	119 12 41
Huntington-Shaver CD it at Huntington, LK	37 13 10	119 13 10
Big Creek BL Huntington Lake, CA	37 13 19	119 12 43
South Fork Tamarack Creek Trib nr Big Creek	37 10 40	119 12 10
Pitman C BL Tamarack Creek, CA	37 11 54	119 12 48
Pitman C Shaft BL Tamarack, C nr Big Creek, CA	37 11 48	119 12 42
Pitman Creek nr Tamarack Mountain, CA	37 12 00	119 12 55
Pitman C at Big Creek, CA	37 12 10	119 14 00
Big C Ph No. 1 A Big Creek	37 12 18	119 14 18
Big C Ph No. 2 nr Big Creek	37 11 57	119 18 16
Big C Ph No. 2A nr Big Creek	37 10 56	119 18 18
Big C nr Mouth nr Big Creek	37 12 28	119 19 13
Big C Ph No. 8 nr Big Creek	37 12 34	119 19 42
San Joaquin R AB Stevenson C nr Big Creek	37 11 20	119 20 35
Huntington-Shavaer Conduit OTLT nr Shaver Lake	37 09 18	119 13 53
Shaver Lake nr Big Creek, CA	37 08 40	119 18 08
Stevenson Creek at Shaver, CA	37 08 50	119 18 40
Big C Ph No. 3 nr Shaver Lk	37 08 54	119 23 08
Redinger Lake nr Auberry, CA	37 08 42	119 26 58
Dummy Station Q Conv From AC/FT 11-241950	37 08 42	119 26 58
Dummy Station 11-241951 + 11-2420	37 08 42	119 26 58
San Joaquin R AB Willow CR nr Auberry, CA	37 08 40	119 27 13
Soquel Diversion nr Sugar Pine, CA	37 25 32	119 32 53
NF Willow Creek nr Sugar Pine, CA	37 23 52	119 33 55
Browns Creek CAnal at Bass Lake, CA	37 17 19	119 31 09
Bass Lake nr Bass Lake, CA	37 17 36	119 31 40
PG & E No. 3 Conduit nr Bass Lake, CA	37 17 21	119 31 44
NF Willow C nr Bass Lake, CA	37 17 20	119 31 45
San Joaquin PH No. 3 nr North Fork, CA	37 15 18	119 31 06
SF Willow Creek nr North Fork, CA	37 12 50	119 29 30
Whiskey C nr North Fork, CA	37 13 30	119 27 20

Cascadel C nr North Fork, CA	37 13 30	119 27 10
Willow Creek at Mouth nr Auberry, CA	37 09 03	119 27 34
Big C Ph No. 4 nr Auberry	37 08 24	119 29 18
San Joaquin Ph No. 2 nr North Fork, CA	37 12 06	119 29 48
San Joaquin PH No. 1A nr Auberry, CA	37 09 30	119 25 35
DUMMY STATION 11-2420 + 11-2465	37 09 03	119 27 34
San Joaquin PH No. 1 nr Auberry (Wishon PH)	37 09 12	119 30 18
Kercknoff Res nr Auberry, CA	37 07 40	119 31 25
San Joaquin R nr Auberry, CA	37 07 56	119 31 50
Kerckhoff PH nr Auberry, CA	37 05 36	119 33 06
San Joaquin R BL Kerckhoff PH nr Prather	37 04 45	119 33 36
Kerckhoff PH No. 2A Millerton LK nr Auberry	37 04 20	119 33 25
Big Sandy Cr Trib nr Tollhouse, CA	37 01 53	119 26 50
Big Sandy C nr Auberry, CA	37 03 10	119 32 30
Fine Gold C nr Friant, CA	37 04 00	119 38 50
Madera Canal at Friant, CA	37 00 10	119 42 21
Friant-Kern Canal at Friant, CA	36 59 53	119 42 11
Millerton Lake at Friant, CA	37 00 00	119 42 13
Cottonwood C nr Friant, CA	37 00 05	119 43 10
San Joaquin River BL Friant, CA	36 59 04	119 43 24
L Dry C nr Friant, CA	36 56 23	119 40 55
L Dry C at Mouth nr Friant, CA	36 56 05	119 43 45
San Joaquin R at Herndon, CA	36 50 35	119 55 55
San Joaquin R nr Biola, CA	36 49 22	120 05 14
Cantua Creek nr Cantua Creek, CA	36 24 08	120 25 57
Dog Creek nr Academy, CA	36 52 50	119 33 15
Dry Creek nr Academy, CA	36 53 15	119 33 25
James Bypass (Fresno Slough) nr San Joaquin	36 39 09	120 10 49
San Joaquin River nr Mendota, CA	36 48 38	120 22 38
Panoche C BL Silver C nr Panoche, CA	36 37 08	120 40 22
L Panoche C Trib No. 1 nr Panoche, CA	36 43 05	120 51 50
Little Panoche cr Tributary No. 2 nr Panoche, CA	36 47 15	120 45 55
Little Panoche Creek nr Panoche, CA	36 47 30	120 45 35
San Joaquin R nr Dos Palos, CA	36 59 42	120 30 00
Lewis Fork Fresno River nr Oakhurst	37 20 42	119 38 18
Miami Creek nr Oakhurst, CA	37 23 37	119 39 12
Fresno River nr Knowles, CA	37 14 14	119 46 26
Picayune C nr Coarsegold, CA	37 13 15	119 42 25
Fresno River Tributary nr Raynmond, CA	37 09 00	119 51 05
Fresno River Below Hidden Dam nr Daultan	37 06 16	119 53 13
Hensley lk nr Daulton, CA	37 06 34	119 53 03
Fresno River BL Hidden Dam nr Daulton, CA	37 05 51	119 53 19
Deep Creek nr Oro Loma, CA	36 53 00	120 47 15
EF Chowchilla R nr Ahwahnee, CA	37 20 10	119 48 55

WF Chowchilla River nr Mariposa, CA	37 25 14	119 52 25
MF Chowchilla R nr Nipinnawasee, CA	37 23 00	119 50 12
Striped Rock Creek nr Raymond, CA	37 20 36	119 53 18
Chowchilla River AB Willow Creek nr Raymond	37 16 23	119 52 49
Chowchilla River nr Raymond, CA	37 15 36	119 56 43
H V Eastman Lake nr Raymond, CA	37 13 00	119 59 04
Chowchilla River BL Buchanan Dam nr Raymond	37 12 56	119 59 25
Chowchilla Rvr Below Raynor Creek nr Raymond	37 12 00	120 00 23
Chamberlain Slough nr El Nido, CA	37 06 48	120 35 18
San Joaquin R nr El Nido, CA	37 06 43	120 35 20
San Joaquin R + Chamberlain Slough nr El Nid	37 06 43	120 35 20
Bear C nr Catheys Valley, CA	37 28 40	120 06 45
Bear Creek Tributary nr Catheys Valley, CA	37 26 45	120 06 05
Burns C at Hornitos, CA	37 29 46	120 14 19
Bear Creek at Merced, CA	37 18 36	120 28 06
Mariposa Creek nr Catheys Valley, CA	37 23 56	120 00 10
Bear Creek nr Stevinson, CA	37 16 18	120 48 00
San Joaquin R nr Stevison, CA	37 17 42	120 51 01
Salt Slough nr Los Banos, CA	37 09 35	120 48 30
Salt SL A Hwy 165 nr Stevison, CA	37 14 52	120 51 04
San Joaquin Rvr at Fremont Ford Bridge nr Stev	37 18 36	120 55 48
Los Banos C nr Los Banos, CA	37 01 00	120 54 05
Mud SL nr Gustine, CA	37 15 45	120 54 20
Wolf Creek nr Volta, CA	37 04 05	121 09 40
San Luis C nr Los Banos, CA	37 03 55	121 04 15
Garzas Creek nr Gustine, CA	37 13 58	121 07 28
Illilouette Creek nr Yosemite Village	37 43 31	119 33 22
Merced R at Happy Isles Brdige nr Yosemite	37 43 54	119 33 28
Tenaya C BL Tenaya Lk Outlet nr Yosemite Village	37 49 34	119 28 01
Porcupine C at Porcupine Flat CG nr Yosemite V	37 48 19	119 33 36
Tenaya Creek nr Yosemite Village CA	37 44 32	119 33 25
Merced R at Yosemite, CA	37 44 38	119 35 21
Yosemite C at Yosemite C CG nr Yosemite Vlg	37 49 43	119 35 31
Yosemite C at Yosemite, CA	37 44 44	119 35 40
Merced River at El Capitan br nr Yosemite Vlg	37 43 27	119 37 50
Effluent from treatment plant nr Yosemite Vlg	37 43 15	119 39 04
Merced River at Pohono Bridge nr Yosemite	37 43 01	119 39 55
Cascade Creek nr El Potal CA	37 44 31	119 42 09
Tamarack C at Tamarack Flat CG nr El Portal, CA	37 45 03	119 44 03
Merced River at Big Oak Flat nr El Portal	37 43 18	119 42 42
Merced R at Big Oak Flat nr El Portal, CA	37 43 18	119 42 45
Wildcate Creek nr El Portal, CA	37 43 31	119 43 03
Crane C AB Diversion Dam nr El Portal, CA	37 42 36	119 45 13
Little Crane Creek nr El Portal, CA	37 43 15	119 46 58

Merced River at Rancheria Flat nr El Portal, CA	37 40 10	119 48 25
Moss Creek nr El Portal, CA	37 43 57	119 49 39
SF Merced R at Wawona, CA	37 32 20	119 39 40
Big Creek Diversion nr Fish Camp CA	37 28 10	119 36 51
SF Merced R nr Wawona, CA	37 32 30	119 40 20
Strawberry Creek nr Wawona, CA	37 38 10	119 40 55
South Fork Merced River nr El Portal, CA	37 39 05	119 53 04
Resultant of Combining 11-2665 and 11-2680	37 39 05	119 53 04
Merced R Below South Fork nr Briceburg, CA	37 39 25	119 53 29
Merced River nr Briceburg, CA	37 38 09	119 55 56
North Fork Merced River nr Coulterville	37 45 06	120 01 54
Merced R at Bagby CA	37 36 40	120 07 50
Maxwell Creek at Coulterville, CA	37 42 58	120 11 20
North Fork Blacks Creek at Coulterville, CA	37 44 10	120 13 30
Lake McClure at Exchequer, CA	37 35 02	120 16 09
Exchequer Powerplant at Exchequer, CA	37 35 01	120 16 29
Merced R at Exchequer, CA	37 34 55	120 16 45
McSwain Reservoir nr Snelling	37 31 17	120 18 31
McSwain Poiwerplant nr Snelling, CA	37 31 17	120 18 32
Northside Canal at Merced Falls, CA	37 31 22	120 20 00
Merced River Below Merced Falls Dam nr Snell	37 31 18	120 19 53
Main Canal nr Diversion Dam nr Merced Falls, CA	37 30 44	120 22 24
Merced R at Shaffer Bridge nr Cressey, CA	37 27 15	120 36 28
Hayward Creek nr La Grange, CA	37 38 30	120 22 40
Dry Creek nr Snelling, CA	37 33 18	120 27 44
Merced R nr Livingston, CA	37 23 29	120 47 10
Merced R at Milliken Bridge nr Stevinson, CA	37 21 44	120 50 58
Merced River nr Stevinson, CA	37 22 15	120 55 46
Merced River Slough nr Newman, CA	37 21 36	120 57 38
San Joaquin River nr Newman, CA	37 21 02	120 58 34
Orestimba Creek nr Newman, CA	37 19 01	121 07 39
San Joaquin River nr Crows Landing, CA	37 25 42	121 00 12
San Joaquin R at Patterson Br nr Patterson	37 29 54	121 04 54
Del Puerto C Trib 1 nr Patterson, CA	37 24 15	121 26 10
Del Puerto C Trib 2 nr Patterson, CA	37 25 25	121 20 30
Windmill Canyon Creek nr Patterson, CA	37 27 15	121 16 10
Del Puerto Creek nr Patterson, CA	37 29 12	121 12 29
San Joaquin River nr Grayson, CA	37 33 46	121 09 05
Maclure C BL Maclure Glacier nr Tuolumn Mdws	37 45 09	119 16 52
Tuolumn River at Tuolumne Meadows, CA	37 52 34	119 21 15
Budd Creek nr Tuolumne Meadows, CA	37 52 25	119 22 55
Tuolumne R at Hetch Hetchy nr Seq C	37 57 20	119 45 30
Falls Creek nr Hetch Hetchy, CA	37 58 15	119 45 48
Hetch Hetchy Reservoir at Hetch Hetchy,CA	37 56 52	119 47 13

Tuolumne R nr Hetch Hetchy, CA	37 56 15	119 47 50
Tuolumne R AB early intake nr Mather, CA	37 52 46	119 56 46
Tuolumne River BL early intake nr Mather, CA	37 52 54	119 58 09
Cherry C nr Hetch Hetchy CA	37 59 54	119 54 00
Cherry Lake nr Hetch Hetchy, CA	37 58 33	119 54 47
Cherry Creek BL Valley Dam nr Hetch Hetchy	37 58 04	119 54 59
Lake Eleanor nr Hetch Hetchy, CA	37 58 27	119 52 48
Eleanor Creek nr Hetch Hetchy, CA	37 58 09	119 52 52
Cherry Cr Canal nr Early Intake, CA	37 53 36	119 57 17
Cherry Creek nr Early Intake, CA	37 53 40	119 57 42
Cherry C Bl Dion R. Holm Ph, nr Mather, CA	37 53 25	119 58 08
Jawbone C nr Tuolumne, CA	37 53 30	119 59 40
Smoky Jack CR Tributary nr Yosemite Villlage	37 49 10	119 42 45
Smokey Jack C at Smokey Jack CG nr Yosemite Vl	37 49 00	119 42 41
SF Tuolumne R at Italian F nr Seq C	37 49 24	119 55 00
SF Tuolumne R nr Sequoia, CA	37 48 42	119 55 54
SF Tuolumne River nr Oakland Recreation Camp	37 49 18	120 00 43
M Tuloumne R nr Mather, CA	37 51 00	119 52 00
Middle Tuolumne R at Oakland Recreation Camp	37 49 42	120 00 38
SF Tuolumne R nr Buck Meadow, CA	37 50 15	120 02 40
Tuolumne R nr Buck Meadows, CA	37 50 14	120 03 09
Lily Cr nr Pinecrest, CA	38 08 41	119 53 59
Bell Creek nr Pinecest, CA	38 09 46	119 56 32
Clavey R nr Long Barn, CA	38 04 36	120 00 37
Hull C A Mouth nr Long Barn, CA	38 00 05	120 03 37
Reed C nr Long Barn, CA	38 00 17	120 01 16
Clavaey River nr Buck Meadows, CA	37 54 02	120 40 15
Big Creek above Whites Gulch nr Groveland	37 50 31	120 11 02
Big Creek nr Goveland, CA	37 51 30	120 12 19
North Fork Tuolumne River nr Long Barn	38 05 56	120 05 55
Sugarpine Creek at Long Barn, CA	38 05 45	120 07 22
NF Tuolumne R AB Dyer C nr Tuolum C	37 58 53	120 12 20
Hunter Creek nr Tuolumne, CA	37 55 43	120 08 42
Tuolumne River nr Jacksonville, CA	37 50 50	120 21 40
Curtis Creek Tributary nr Standard, CA	37 59 05	120 18 06
Woods C nr Jacksonville, CA	37 51 30	120 23 45
Don Pedro Reservoir nr LA Grange, CA	37 42 06	120 25 16
Tuolumne R AB La Grange DAm, nr LA Grange	37 42 33	120 24 44
Tuolumne R nr La Grange, CA	37 40 00	120 27 42
Modesto CAnal nr La Grange, CA	37 40 04	120 27 26
Turlock Canal nr La Grange, CA	37 39 57	120 26 24
Combined Flow Modesto Canal Plus Turlock Canal	37 39 59	120 26 28
Turlock lk nr La Grange, CA	37 36 42	120 35 36
Tuolumne River BL La Grange Dam nr La Grange	37 39 59	120 26 28

Combined Flow Tuolumne R + Modesto + Turlock	37 39 59	120 26 28
Tuolumne R at La Grange Bridge at La Grange	37 39 57	120 27 40
Tuolumne River at Hickman nr Waterford, CA	37 38 08	120 45 14
Dry Creed near Modesto, CA	37 38 45	120 50 47
Tuolumne River at Modesto, CA	37 37 38	120 59 11
Tuolumne River at Tuolumne City nr Grayson, CA	37 36 12	121 07 49
San Joaquin R at Maze RD Bdg nr Modesto, CA	37 38 24	121 13 42
Relief Res nr Baker Station, CA	38 16 52	119 44 00
Relief C nr Baker Station, CA	38 17 00	119 44 00
MF Stanislaus R at Kendy,MD nr Dardanelle	38 17 51	119 44 25
Middle Fork Stanislaus River AT Dardanelle	38 20 27	119 49 32
Clark Fork Stanislaus River nr Dardanelle	38 21 50	119 52 13
Donnell Lake nr Dardanelle, CA	38 19 46	119 57 37
Donnell Powerplant nr Strawberry, CA	38 14 47	120 02 01
Cascade C nr Pinecrest, CA	38 16 45	119 58 10
MF Stanislaus R at Hells Half Acre Bridge	38 14 49	120 01 51
Beardsley Lake nr Strawberry, CA	38 12 17	120 04 31
Beardsley Powerplant nr Strawberry, CA	38 12 10	120 04 33
JW Southern PP a Sand Bar Div Dam nr Long Barn	38 11 04	120 09 24
MF Stanislaus R Bl Beardsley Dam, CA	38 11 36	120 05 53
MF Stanislaus R BL Beardsley Dm Tot Flow	38 11 36	120 05 53
MF Stanislaus R at SBF nr Avery, CA	38 11 12	120 08 28
MF Stanislaus R BL Sand Bar Div Dam nr Avery	38 10 59	120 09 31
North Fork Stanislaus R Trib nr Lake Alpine	38 30 20	119 56 50
Union Res Nr Big Meadows, CA	38 25 48	119 59 50
Utica Res nr Big Meadows, CA	38 26 25	120 00 08
Lake Alpine nr Big Meadows, CA	38 28 18	120 10 00
NF Stanislaus R BL Silver Creek, CA	38 26 22	120 00 53
NF Stanislaus R Div Tunnel nr Big Meadow, CA	38 24 39	119 59 41
NF Stanislaus Div Dam AM nr Big Meadow, CA	38 26 18	120 01 00
Nr Stanislaus R Bl Div Dam nr Big Meadow, CA	38 26 04	120 01 04
Spicer Meadows Res nr Big Meadows, CA	38 23 35	119 59 47
Highland C Bl Spicer Meadows Res CA	38 23 34	119 59 50
NF Stan R BL Gan DMS nr Big Meadows, CA	38 24 05	120 06 41
NF Stanislaus R nr Avery, CA	38 14 45	120 17 20
Utica Canal nr Avery, CA	38 14 36	120 17 24
NF Stanislaus R BL Utica, CA nr Avery, CA	38 14 25	120 17 22
NF Stanislaus R BL Beaver C nr Hathaway Pines	38 12 02	120 19 20
Stanislaus River nr Hathaway Pines, CA	38 08 29	120 22 19
Stanislaus Rivear nr Hathaway Pines, CA	38 08 29	120 22 19
Stanislaus TU at Outlet, CA	38 08 41	120 20 56
Pinecrest Lk nr Strawberry, CA	38 12 00	119 59 20
SF Stanislaus R at Strawberry, CA	38 11 51	120 00 27
Philadelphia Canal nr Strawberry, CA	38 10 39	120 02 46

SF Stanislaus R nr Strawberry, CA	38 10 40	120 02 45
Tuolumne Canal nr Long Barn, CA	38 05 35	120 10 03
Lyons Res nr Long Barn, CA	38 05 30	120 10 00
SF Stanislaus R nr Long Barn, CA	38 05 33	120 10 02
Stanislaus River at Parrotts Ferry BR nr Col	38 02 47	120 26 51
Melones Reservoir at Melones Dam, CA	37 57 12	120 30 49
Melones Powerplant BLW Melones Dam nr Sonora	37 56 47	120 31 38
Stanislaus R BL M PH nr Sonora, CA	37 56 50	120 31 45
Stanislaus R BL Melones Ph nr Sonora, CA	37 56 50	120 31 45
Black Cr. nr Copperopolis	37 57 40	120 36 51
Tulloch Reservoir nr Knights Ferry, CA	37 52 34	120 36 12
Tulloch Powerplant nr Knights Ferry, CA	37 52 34	120 36 15
Stanislaus R. BL Tulloch PP nr Knights Ferry	37 52 34	120 36 15
Stanislaus R at Tulloch Damsite nr Knights Ferry	37 52 33	120 36 18
Stanislaus R nr Knights Ferry, CA	37 52 30	120 36 18
South San Joaquin Canal nr Knights Ferry	37 51 16	120 38 14
South San Joaquin Main Bl Div Pt nr Knights Ferry	37 49 24	120 40 24
South San Joaquin Main Canal BL Woodward Res	37 51 38	120 52 15
North Main Canal BL Div Pt nr Knights Ferry	37 50 01	120 40 21
Oakdale Canal nr Knights Ferry, CA	37 51 32	120 37 56
Stanislaus R BL Goodwin Dam nr Knights Ferry	37 51 06	120 38 13
Stabuskays R ata Oakdale CA	37 46 38	120 51 07
Stanislaus River at Ripon, CA	37 43 47	121 06 34
Stanislaus River at Koetitz Ranch nr Ripon, CA	37 41 58	121 10 07
San Joaquin River nr Vernalis, CA	37 40 34	121 15 51
San Joaquin River nr Varnalis, CA	37 40 34	121 15 55
Corral Hollow C nr Tracy, CA	37 39 24	121 28 40
San Joaquin R at Mossdale, CA	37 47 10	121 18 25
San Joaquin River at Mossdale, CA	37 47 10	121 18 25
San Joaquin R at Garwood Bdg nr Stockton, C	37 55 45	121 19 38
San Domingo C nr San Andreas, CA	38 06 55	120 37 00
San Antonio C nr San Andreas, CA	38 07 52	120 38 10
South Fork Calaveras River nr San Andreas	38 08 40	120 39 46
Calveritas C nr San Andreas, CA	38 09 50	120 39 30
Esperanza C nr Mokelumne Hill, CA	38 19 00	120 35 40
Jesus Maria C nr Mokelumne Hill, CA	38 17 00	120 39 00
North Fork Calaveras River nr San Andreas	38 13 17	120 41 54
El Dorado Creek at Mountain Ranch, CA	38 13 38	120 32 37
Murray C nr San Andreas, CA	38 12 45	120 40 55
Calaveras River above new Hogan Dam, CA	38 10 40	120 47 20
Calaveras R AB new Hogan Res nr San Andreas	38 11 48	120 43 18
New Hogan Lake nr Valley Springs, CA	38 09 01	120 48 45
Calaveras R BL New Hogan Dam nr Valley Springs	38 08 53	120 49 26
Cosgrove C nr Valley Springs, CA	38 08 10	120 50 05

Calaveras R at Jenny Lind, CA	38 05 20	120 51 53
Calaveras River nr Stockton, CA	38 03 55	121 09 00
Stockton Divert CAat Stockton, CA	37 59 35	121 15 30
Stockton Ship Channel at light 40 CA	37 58 40	121 23 00
Stockton Shp Chnl nr Rindge Pump on Bindge Tr	37 58 15	121 25 15
Bear Creek Tributary nr Valley Springs, CA	38 11 10	120 50 45
Bear C nr Clements, CA	38 10 30	121 05 00
Bear Creek nr Lockeford, CA	38 09 10	121 08 16
Bear C at Harmony Sch nr Lockef, CA	38 07 00	121 10 42
Middle R A Borden Hwy nr Tracy	37 53 30	121 29 20
Old R at SO Tip of Fabian Tract nr Tracy, CA	37 47 20	121 28 30
Moutnain Hosue Creek nr Midway, CA	37 44 45	121 35 00
Mountain House Cr Tributary nr Altamont, CA	37 44 42	121 37 50
Delta=Mendota Canal AB Tracy PP nr Tracy, CA	37 48 45	121 34 40
Delta-Mendota CA at Tracy Pump Plt nr Tracy	37 47 49	121 35 03
Delta-Mendota Canal BL Tracy Pump Plt nr Tracy	37 47 49	121 35 03
Delta-Mendota Canal nr Mendota, CA	37 46 25	121 34 50
Kellogg Creek Tributary neara Byron, CA	37 50 45	121 43 05
California Aqueduct at Delta PPnr Byron, CA	37 48 04	121 37 10
Grant Line Canal at Tracy Road Bridge, CA	37 49 15	121 27 01
Old River at Clifton Courty Ferry, CA	37 49 28	121 33 05
Italian Slough at Mouth nr Byron, CA	37 51 36	121 34 48
Italian Slough at Clifton Court BR nr Byron CA	37 50 18	121 35 54
Indian Slough nr Brentwood, CA	37 55 05	121 37 20
Old R at Orwood Bridge nr Middle River, CA	37 33 32	121 33 32
Rock Slough nr Knightsen, CA	37 58 35	121 38 25
Old R at Mandeville Island, CA	38 04 00	121 34 30
Upper Blue LK outlet nr Markleeville, CA	38 37 34	119 56 08
Lower Blue LK outlet nr Marklee ville, CA	38 36 26	119 55 31
Meadow LK outlet nr Markleeville, CA	38 35 51	119 58 42
Salt Springs Reservoir nr West Point, CA	38 29 55	120 12 52
Salt Springs PH nr West Point, CA	36 29 48	120 13 00
Tiger Creek PH cond BL Salt Springs Dam, CA	38 29 47	120 13 04
NF Mokelumne R BL Salt Springs Dam, CA	38 29 37	120 13 12
Cole C nr Salt Springs Dam, CA	38 31 09	120 12 41
Cole C BL Div Dam nr Salt Springs Dam, CA	38 30 55	120 12 50
Bear R at Pardoe Camp, CA	38 32 00	120 15 00
Bear River below Lower Bear River Dam, CA	38 32 10	120 15 25
Bear R nr Salt Springs Dam, CA	38 29 37	120 17 18
Bear R BLW Bear R Div Dam CA	38 29 33	120 17 21
Nf Mokelumne R NR West Point, CA	38 28 00	120 22 00
NF Mokelumne R AB Tiger C, CA	38 26 48	120 29 21
Tiger Cr PH nr West Point, CA	38 26 58	120 29 32
Antelope CR nr West Point, CA	38 29 29	120 30 09

West PT PH N West Pt	38 25 16	120 32 54
NF Mokelumne R BL Tiger C Res nr West Pt, CA	38 26 25	120 30 14
NF Mokelumne R BL Electra Div Dam nr West Pt	38 25 15	120 32 56
Forest Creek nr Wilseyville, CA	38 24 12	120 26 45
M.F. Mokelumne River at West Point, CA	38 23 23	120 31 32
SF Mokelumne R nr Railroad Flat, CA	38 19 55	120 25 20
Licking F Mokelumne R nr RR Flat, CA	38 01 00	120 25 00
South Fork Mokelumne River nr West Point	38 22 06	120 32 40
Mokelumne R nr Mokelumne Hill, CA	38 18 46	120 43 09
Pardee Reservoir nr Valley Springs, CA	38 15 25	120 50 59
Mokelumne R at Lancha Plana, CA	38 13 25	120 53 20
Camanche C nr Camanche, CA	38 13 00	120 58 00
Rabbit C nr Camanche, CA	38 13 33	120 59 27
Camanche Reservoir nr Chements, CA	38 13 31	121 01 17
Murphy Creek nr Clements, CA	38 13 15	121 01 15
Mokelumne River BL Camanche Dam, CA	38 13 14	120 02 19
Woodbridge Canal at Woodbridge, CA	38 09 07	121 18 00
Mokelumne River at Woodbridge, CA	38 09 31	121 18 09
Dry C AB Sutter C nr Ione, CA	38 24 54	120 54 18
Sutter CC nr Volcano, CA	38 27 24	120 38 18
Sutter Creek nr Sutter Creek, CA	38 23 45	120 46 49
Sutter C at Sutter Creek, CA	38 23 48	120 46 48
Clay Creek nr Ione, CA	38 19 05	120 56 20
Dry C nr Ione, CA	38 17 57	121 03 45
Goose C nr Elliott, CA	38 15 18	121 07 12
Dry Creek nr Galt, CA	38 14 53	121 13 33
NF Consumnes R at Cosumnes Mine, CA	38 40 11	120 31 57
Camp C nr Sly Park, CA	38 41 10	120 21 20
Camp C nr Camino, CA	38 41 35	120 32 35
Sly Park C nr Pollock Pines, CA	38 42 50	120 34 10
Camp Creek nr Somerset, CA	38 39 26	120 39 46
North Fork Cosumnes River nr El Dorado,	38 35 20	120 50 38
Middle Fork Cosumnes River nr Somerset	38 37 29	120 42 02
South Fork Cosumnes River nr River Pines	38 33 25	120 47 32
Cosumnes R nr Plymouth, CA	38 32 21	120 51 45
Cosumnes River at Michigan Bar, CA	38 30 01	121 02 39
Deer Creek nr Shingle Springs, CA	38 39 30	120 59 25
Deer Creek nr Sloughhouse, CA	38 33 06	121 06 30
Cosumnes River at McConnell, CA	38 21 29	121 20 34
Badger Creek at Riley Rd nr Galt, CA	38 20 21	121 17 48
NorthFork Badger Creek at Riley Rd. nr Galt	38 21 06	121 17 48
Willow Creek at McKenzie Road nr Galt, CA	38 19 08	121 18 01
Cosumnes River at Highway 104 nr Galt	38 17 27	121 22 45
Hadselville C at Clay, CA	38 20 18	121 09 35

Laguna Creek at McKenzie Rd nr Galt, CA	38 18 46	121 18 01
Skunk Creek at McKenzie Rd nr Galt, CA	38 17 57	121 18 01
Laguna Creek at Highway 104 nr Galt, CA	38 17 27	121 22 29
Deadman Gulch at Christenson Road nr Galt	38 16 44	121 20 11
Morrison Creek nr Sacramento, CA	38 29 55	121 27 06
Delta Cross-Channel nr Walnut Grove, CA	38 14 43	121 30 18
Little Potato Slough nr Terminous, CA	38 06 52	121 29 46
Contra Costa Canal nr Oakley, CA	37 59 44	121 42 03
San Joaquin River at Antioch, CA	38 01 04	121 48 06
Marsh Creek nr Byron, CA	37 52 24	121 43 34
Goose Lake at Willow Ranch, CA	41 54 14	120 21 55
Goose Lake nr Everyl Rch nr Willow Ranch	41 52 17	120 29 49
Goose Lake at West Shore Log nr Willows Ranch	41 57 51	120 29 37
Dry Creek nr Lakeview, Oregon	42 00 30	120 36 00
Dog Creek Lakeview, Oregon	42 05 05	120 42 00
Dog Creek nr Lakeview, Oregon	42 07 00	120 40 00
Drews Reservoir nr Lakeview, Oregon	42 07 15	120 36 55
North Drews Canal nr Lakeview, Oregon	42 07 15	120 35 10
Drews Creek nr Lakeview, Oregon	42 07 10	120 34 45
Antelope Creek nr Lakeview, Oregon	42 10 56	120 34 06
South Drews Canal nr Lakeview, Oregon	42 06 55	120 33 45
Cottonwood Dr Abv Cottonwood Res nr Lakeview, OR	42 16 20	120 31 55
Cottonwood Reservoir nr Lakeview, OR	42 14 35	120 30 30
Cottonwood Creek nr Lakeview, Oregon	42 14 05	120 30 05
Cottonwood Cr BL N Drews, CA nr Lakeview, Oregon	42 11 27	120 28 38
Cottonwood Cr BL Hwy Crossing nr Lakeview, Oregon	42 10 30	120 28 35
Muddy Creek nr Lakeview, Oregon	42 10 47	120 29 52
Thomas Cr BL Cox Glat nr Lakeview, Oregon	42 19 56	120 35 18
Thomas Creek aB Barnes Sprg nr Lakeview, Oregon	42 16 00	120 28 00
Thomas Creek nr Lakeview, Oregon	42 16 00	120 27 00
Cox CR BL Salt Cr nr Lakeview, Oregon	42 18 27	120 22 30
Salt Creek nr Lakeview, Oregon	42 17 35	120 20 45
Cox Creek nr Lakeview, Oregon	42 17 25	120 23 06
Bauers nr Lakeview, Oregon	42 17 00	120 24 00
Camp Creek nr Lakeview, Oregon	42 17 47	120 26 53
Auger Creek nr Lakeview, Oregon	42 17 59	120 27 27
Mulkey Slough nr Lakeview, Oregon	42 13 27	120 24 56
Leehmann-Bishop Ditch nr Lakeview, Oregon	42 10 43	120 23 59
Crane Creek at Lakeview, Oregon	42 07 19	120 18 26
Crane Creek nr Lakeview, Oregon	42 07 05	120 17 25
Kelly Creek nr Lakeview, Oregon	42 00 47	120 17 17
Sacramento R AB LK Siskiyou nr Mt. Shasta	41 17 13	122 22 31
Deer Creek nr Mt. Shasta, CA	41 18 01	122 22 53
Scott Camp C at Div Dam nr Mt. Shasta, CA	41 16 22	122 20 47

Castle Lake C at Road xing nr Mt. Shasta, CA	41 16 08	122 20 15
Wagon C nr Mt. Shasta, CA	41 17 31	122 19 24
Big Springs C AB Fish Hatchery, CA	41 18 32	122 19 44
Big Springs Cr BL Hatchery nr Mt. Shasta	41 18 22	122 19 29
Cold C AB LK Siskiyou nr Mt. Shasta, CA	41 17 22	122 19 11
LK Siskiyou at Midpt L-1 nr Mt. Shasta, CA	41 17 06	122 20 25
LK Siskiyou in Wag C-COLD C Arm nr Mt. Shasta	41 17 01	122 19 40
LK Siskiyou at Dam L-3 nr Mt. Shasta, CA	41 16 46	122 19 43
Sacramento R AB Sewage Effluent, CA	41 16 48	122 19 21
Mt. Shasta Pond at Inlet, CA	41 16 53	122 18 54
Mt. Shasta Sew Pnd Eff at Outlet nr Mt. Shasta	41 16 51	122 18 56
Mt. Shasta Sew Pnd Eff at River, CA	41 16 48	122 19 21
Sacramento R BL Sew Eff nr Mt. Shasta, CA	41 16 47	122 19 21
Sacramento River nr Mt. Shasta, CA	41 16 00	122 18 38
Napa River nr St. Helena, CA	38 29 52	122 25 37
Lake Hennessey Trib nr Rutherford, CA	38 29 00	122 21 15
Conn Creek nr Oakville, CA	38 26 50	122 22 47
Dry C nr Napa, CA	38 21 23	122 21 50
Dry C nr Yountville, CA	38 22 00	122 21 00
Napa River nr Napa, CA	38 22 06	122 18 08
Napa River at Napa, CA	38 19 30	122 17 29
Milliken Creek nr Napa, CA	38 20 19	122 16 06
Milliken C Tributary nr Napa, CA	38 20 06	122 16 46
Milliken C nr Napa, CA	38 19 31	122 16 24
Sarco C nr Napa, CA	38 19 56	122 15 06
Redwood Creek nr Napa, CA	38 19 04	122 20 35
Napa Creek at Napa, CA	38 18 07	122 18 10
Napa R at Third St. at Napa, CA	38 17 54	122 16 58
Tulucay Creek at Napa, CA	38 17 09	122 16 29
Sonoma Cr nr Kenwood, CA	38 26 32	122 32 15
Sonoma C at Agua Caliente, CA	38 19 24	122 29 36
Petaluma R at Petaluma, CA	38 15 40	122 39 35
San Antonio C nr Petaluma, CA	38 10 57	122 36 55
Novato Creek at Novato, CA	38 06 28	122 34 44
San Rafael C at Sirard Ln at San Rafael	37 59 04	122 32 58
San Rafael Creek at San Rafael, CA	37 58 22	122 32 07
San Rafael RG at San Rafael, CA	37 58 30	122 31 50
Irwin C TR at San Rafael, CA	37 59 28	122 30 29
Irwin C TR No 2 at San Rafael, CA	37 58 56	122 30 24
Irwin Creek at San Rafael, CA	37 58 56	122 30 50
San Rafael C at Yacht Harbor at San Rafael	37 58 12	122 31 30
Corte Madera Creek at Ross, CA	37 57 45	122 33 20
Corte Madera C A College Av A Kenfiled, CA	37 57 16	122 32 51
Arroyo Corte Madera D Pres at Mill Valley	37 53 50	122 32 06

DATA STORAGE AND REFERENCES

Location: Reston, Virginia

Hardware: Amdahl mainframe

Software: WATSTORE, STORET

Volume of Data:

Quality Assurance: Data are computerized and reviewed for accuracy in USGS field offices. The information is then electronically transferred to WATSTORE.

Contact for Data Retrieval:

Name: Pete Antilla

Address: U.S. Geological Survey
Water Resources Division
Room W-2235 Federal Building
2800 Cottage Way
Sacramento CA 95825

Phone: (916) 978-4633

References:

USGS. 1987. Water resources data for California, Water Year 1985. USGS Water-data reports CA-85-2 to CA-85-4. 290 pages. $35.95

~**Descriptors:** hydrology; water quality; upper drainage; delta; bay-Delta; san francisco bay; san pablo bay; central bay; south bay; water pollution; water chemistry; streams; creeks;

GENERAL INFORMATION AND ABSTRACT

Program:	Dredge Disposal Study
Funding Agency:	U.S. Army Corps of Engineers
Principal Investigator:	Tom Wakeman
Conducting Agency:	U.S. Army Corps of Engineers
Study Cost:	$3.0 million
Period of Record, Earliest Date:	April, 1972
Period of Record, Latest Date:	1976
Length of Record:	3.5 years
Geographic Boundaries Description:	San Francisco Bay, including Suisun Bay, San Pablo Bay, Central Bay, and South Bay.

ABSTRACT

A detailed study completed in the mid-1970's by the San Francisco District of the US Army Corps of Engineers (USACE) examined the interrelationships of the various physical, chemical, and biological parameters influenced by dredging activity, and the mechanisms of that influence (USACE 1977). The "Dredge Disposal Study" consisted of many distinct lines of inquiry which were pursued over a period of 3.5 years at an expense of over $3,000,000. The findings of this Study fill thousands of printed pages. The results of some of these investigations are summarized briefly below.

Pollutant Distribution

The Pollutant Distribution Study was intended to characterize the distribution of certain trace metals (mercury, lead, zinc, cadmium, copper), volatile solids, total Kjeldahl nitrogen, oil and grease, and chemical oxygen demand (COD) along horizontal and vertical gradients in Bay sediments (USACE 1979: Appendix B). Samples were collected from 48 locations in three areas: northeastern San Pablo Bay; upper Central Bay; and the Oakland Inner and Outer Harbors. Dredged channels in San Pablo Bay had higher levels of lead, zinc, cadmium, and volatile solids than channels in the Central Bay. Dredged channels of Central Bay had higher levels of mercury, oil and grease, COD, and TKN. On the whole, undredged areas of North and Central Bay had lower levels of these contaminants.

Contaminant levels were primarily influenced by sediment particle size, but were also a function of proximity to contaminant sources, rates of shoaling of contaminated sediments, and other factors. Highest contaminant levels were typically associated with the finest sediments. Areas with widely varying particle size distributions also had broad ranges of contaminant concentrations. In general, five types of environments with distinct sediment/contaminant characteristics were noted in the Bay (in order of decreasing contamination): enclosed water bodies; shallow protected open water bodies; shallow exposed open water bodies; natural channel margins; and natural channels.

Water Column

From 1972 to 1975 the USACE assessed the influence of local dredging and disposal operations on suspended solids and dissolved oxygen (DO) levels in Bay waters. Disposal was found to have a considerably more severe impact on DO levels than dredging. Disposal can cause significant oxygen depletion at the bottom of the water column, with reductions of up to 6 ppm. Ambient concentrations were regained near the bottom after an average of 3 to 4 minutes, with a maximum of 11 minutes. The intensity of these fluctuations in DO concentrations were dependent upon the chemical composition of the material, its surface area, and aeration occurring during the disposal operation.

Similarly, suspended solids (SS) concentrations during disposal were an order of magnitude higher than those observed during dredging. Disposal increased the SS concentration at the bottom by up to 22 grams. Disposal influenced SS levels over 1000 meters from the disposal site. Neither dredging or disposal had much effect on the upper water column.

Biological Community

A survey of seasonal fluctuations in abundance of benthic infaunal species was conducted in 1973 and 1974 (USACE 1975: Appendix D). Over 340 bottom species were identified in the Bay (west of the Carquinez Strait), with 41 species constituting the greatest number of individuals. Greater numbers of species were observed in Central Bay than in South Bay, San Pablo Bay, or Suisun Bay. Widely fluctuating temperature and salinity in lower South Bay and the low salinity in Suisun Bay were thought to be limiting species diversity in those regions.

Sampling was performed in dredged channels, dredged material disposal areas, and undisturbed areas, allowing evaluation of the effects of these activities on benthic populations. Most of the taxa found near the Alcatraz disposal site appeared to be transient types. About 85% of the total number of individuals were collected in September 1973, while in March 1973 and March 1974 the sediment was almost devoid of benthic animals.

Material Release

Dredged sediment was tagged with i7ridium and released from the disposal site at Carquinez Strait (USACE 1977: Appendix E). Samples were then collected from Suisun and San Pablo Bays to assess movements of the disposed material. Within a month, released sediments were found to be well distributed both horizontally and vertically over a 100 square mile area including Suisun Bay, Carquinez Strait, and San Pablo Bay. An estimated maximum of 15% of the sediment disposed at the Carquinez Strait site was thought to return to the Mare Island Strait channel, the location from where it was dredged from. After sediment is initially released, a portion of the released quantity is transported through deep water channels into Central Bay and dispersed. Another portion of the sediments were dispersed immediately in San Pablo Bay. These sediments were subject to further transport, however, when circulation patterns changed as a result of annual climatic variation.

Crystalline Matrix

This investigation was undertaken to determine physical and chemical characteristics that determine the amounts of cadmium, copper, lead, mercury, and zinc that may be released from sediments. Sediments were collected from ten stations in the Bay representative of the range of sediment types and trace metal concentrations encountered in maintenance dredging. The greatest proportions of trace metals were strongly bound in clay or crystalline lattice-like and organic or sulfide-like sites. In controlled experiments, oxygen-rich conditions significantly increased concentrations of cadmium, copper, lead, and zinc found in the water column. Higher salinity also caused larger releases of cadmium and zinc than lower salinity.

Pollutant Uptake

Dredging operations in Mare Island Strait in northern San Pablo Bay were examined in 1973 and 1974 to determine whether trace metals are released from dredged sediments, resulting in elevated concentrations of these substances in adjacent sediments and invertebrate populations. Concentrations of 9 trace metals were measured in sediments, native invertebrates, and transplanted Mytilus edulis in samples collected within and outside the dredge zone and before and after dredging.

Average metal concentrations in sediments and benthic invertebrates changed by less than a factor of two, and changes in levels in Mytilus edulis were by less than a factor of three. The dredging period coincided with heavy rainfall and freshwater runoff into the study area, which caused significant changes in salinity and particulate loadings. It was not possible to determine if changes in metal levels were attributable to rainfall or dredging, although it appeared that rainfall had a larger influence since trends at control stations mirrored those at stations in the dredge zone.

Pollutant Availability

In February 1975 an experimental disposal operation was conducted in an evaluation of the physical, chemical, and biological impact of disposal of contaminated sediments from the Oakland Inner Harbor. Twelve trace elements and chlorinated hydrocarbons of the PCB and DDT groups were monitored in selected benthic invertebrates, mussels transplanted to the disposal site, sediments, settled and suspended particulates, and water. The pathways by which contaminants may be accumulated by invertebrates were examined in laboratory and in situ studies.

Short term increases in dissolved cadmium, copper, lead, p,p'-DDD, p,p'-DDE, and PCB 1254 concentrations were observed in the disposal plume immediately after each of the experimental disposals. These increases were significantly greater than pre- or post-spoiling natural fluctuations of these contaminants. Higher metal concentrations persisted for less than 1.5 hours (the time between the first and second sampling), and chlorinated hydrocarbon values returned to ambient levels in less than 0.5 hours. Copper and iron concentrations in surface sediments were higher at stations within the disposal area than at control stations. Trace element concentrations in invertebrates were not significantly affected by the disposal. Chlorinated hydrocarbon levels in mussels fluctuated slightly during the period of study, and only p,p'-DDE concentrations in mussels appear to have been increased due to disposal (an effect which lasted for less than one month). Dredging and disposal activities in these experiments were considered to redistribute polluted sediments without resulting in increased contaminant bioavailability.

Marsh Development

This study was designed to establish procedures for artificial propagation of marsh plants on a substrate of dredged material. Test plots of cordgrass (Spartina foliosa) and pickleweed (Salicornia spp.) were established and monitored for two growing seasons. Plots planted with cordgrass were observed to obtain a rapid reproductive rate by the second growing season, and it was anticipated that densities would be comparable to natural marshes by the third growing season. Pickleweed rapidly established itself in both the planted plots and in unplanted controls. Although planting of pickleweed significantly accelerated its establishment, after two growing seasons the differences between planted and unplanted plots were minor. The report also discusses costs and other considerations associated with marsh development using dredged material.

Dredging Technology

Laboratory studies were conducted to determine the factors controlling dispersal patterns of dredged material observed in the field (USACE 1975: Appendix M). The controlling factors were found to be the type of sediment and its water content. Cohesive sediments tended to have lower water or silt content, and descended to the bottom of the water column with little dispersion.

PARAMETERS

Media Analyzed: Biota. Sediment. Water.

BIOLOGICAL PARAMETERS MEASURED
species abundance

PHYSICAL PARAMETERS MEASURED
horizontal and vertical gradients of contaminants in Bay sediments
sediment grain size
seismic subbottom reflection profiling

CHEMICAL PARAMETERS MEASURED
Chlorinated Hydrocarbons

Hydrocarbons
oil and grease

Nutrients
ammonia
organic nitrogen
total Kjeldahl nitrogen

Other Parameters
carbonate content of sediment
chemical oxygen demand
dissolved oxygen
organic carbon
pH
salinity
sulfide
suspended solids
turbidity
volatile solids
water temperature

PCBs

Pesticides
DDD
DDE
DDT

Trace Elements
arsenic
cadmium

copper
lead
manganese
mercury
selenium
silver
zinc

MISCELLANEOUS PARAMETERS MEASURED
iridium in sediments

TAXA
Adula diegensis
Aetea anguina
Alcyonidium parasiticum
Alcyonidium polyoum
Alvinia californica
Alvinia compacta
Amoroucium sp.
Ampelisca milleri
Anaitides williamsi
Armandia brevis
Asychis sp.
Autolytus sp.
Balanus cariosus
Balanus crenatus
Balanus improvisus
Barentsia sp.
Bimeria sp.
Boccardia truncata
Bowerbankia gracilis
Bugula californica
Bugula neritina
Busycon canaliculatum
Callianassa californiensis
Callopora armata
Campanularia sp.
Cancer antennarius
Cancer jordani
Capitella capitata
Capitita ambiseta
Caprella sp.
Caulleriella hamata
Cellaria mandibulata
Chapperia paluta
Chaetozone sp.
Cheilopora praelonga

Chone gracilis
Chone mellis
Chone minuta
Ciona intestinalis
Cirratulus cirratus
Cirriformia spirabrancha
Conopeum commensale
Conopeum reticulum
Corophium acherusicum
Corophium insidiosum
Cossura pygodactylata
Crangon sp.
Crepidula convexa
Crepidula plana
Crisia maxima
Crisia occidentalis
Cryptosula pallasiana
Cumella vulgaris
Decamastus sp.
Diadumne sp.
Diastylopsis sp.
Disoma multisetosum
Dulichia sp.
Electra arctica
Electra crustulenta
Eteone dilatae
Eteone lighti
Eteone longa californica
Euchone limnicola
Eudorella pacifica
Eulalia aviculiseta
Eumida sp.
Epitonium tinctum
Exogone lourei
Fartulum sp.
Filicrisia geniculata
Foraminifera
Gemma gemma
Gonothyraea sp.
Glycera americana
Glycera oxycephala
Glycera tenuis
Glycinde sp.
Grandidierella japonica
Gyptis brevipalpa
Halicaridae
Haliplanella sp.

Haploscoloplos pugettensis
Harmothoe imbricata
Hemigrapsus oregonensis
Hesionella mccullochae
Hesionura sp.
Heteromastus filiformis
Hexactinellida
Hiatella arctica
Hippothoa cornuta
Hippothoa hyalina
Hydracarina
Insecta
Ischadium demissum
Ischyrocerus anguipes
Iselica ovoedea
Lagenipora punctulata
Lamprops sp.
Langerhansia sp.
Lecythorhynchus marginatus
Leptochelia dubia
Leptosynapta sp.
Limnoria quadripunctata
Lumbrineris tetraura
Lyonsia californica
Lysidice ninetta
Macoma acolasta
Macoma balthica
Macoma inquinata
Macoma nasuta
Marphysa sanguinea
Mediomastus californiensis
Melinnampharete gracilis
Melita dentata
Membranipora membranacea
Membranipora perfragilis
Membranipora villosa
Membraniporella sp.
Microphthalmus sp.
Microporella californica
Modiolus sp.
Musculus senhousia
Mya arenaria
Myriochele sp.
Mysella ferruginosa
Mytilus edulis
Nassarius obsoletus
Neanthes succinea

Nematoda
Nemertea
Nephtys caecoides
Nephthys cornuta franciscana
Nephthys parva
Nereis latenscens
Nudibranchia
Notomastus (Clistomastus) tennuis
Odontosyllis parva
Odostomia fetella
Odostomia franciscana
Odostomia tenuisculpta
Odostomia valdezi
Ophiodromus pugettensis
Ophionereis sp.
Osteichthyes
Ostrea lurida
Paleanotus bellis
Paraphoxus milleri
Parapleustes pugettensis
Parasmittina trispinosa
Pectinaria californiensis
Petricola sp.
Pholoe minuta
Phoronopsis viridens
Phoronis sp.
Photis brevipes
Photis californica
Pilargis sp.
Pinnixa franciscana
Platydon cancellatus
Plumaria sp.
Podocerus sp.
Pododesmus sp.
Polycirrus californicus
Polydora brachycephala
Polydora caeca
Polydora ligni
Polydora socialis
Prionospio sp.
Promystides sp.
Protomedeia zotea
Protothaca staminea
Psuedopolydora kempi californica
Pseudoplydora paucibranchiata
Pygospio sp.
Pyromaia tuberculate

Rithropanopeus harrisii
Salicornia sp. pickleweed
Sarsiella zostericola
Schistomeringos longicornis
Schizoporella sp.
Scolelepis squamata
Scrupocellaria californica
Sertularia sp.
Siliqua patula
Siliqua sloati
Sipunculus
Smittoidea prolifica
Spartina foliiosa California cordgrass
Sphaerosyllis sp.
Spiophanes bombyx
Spiophanes fimbriata
Spiophanes missionensis
Stenothoides sp.
Streblospio benedicti
Streptosyllis sp.
Sthenelanella uniformis
Styela sp.
Stylatula elongata
Syllides sp.
Syncoryne sp.
Synidotea bicuspida
Synidotea harfordi
Synidotea laticauda
Tapes japonica
Tegella armifera
Tellina modesta
Tharyx parvus
Tiron biocellata
Transenella tantilla
Tricellaria occidentalis
Tricellaria ternata
Trochochaeta multisetosum
Turbellaria
Upogebia pugettensis
Urosalpinx cinerea
Vorticella sp.
Zirfaea pilsbryi

METHODS

The Dredge Disposal Study actually consisted of several distinct investigations which cost several million dollars and whose findings fill thousands of pages of printed material. The descriptions of methods employed in these studies are therefore necessarily brief and generic. Methods are described separately for each individual study.

SAMPLING METHODS

Pollutant Distribution

Approximately 156 miles of continuous seismic subbottom reflection sampling was performed, covering an area of approximately 275 square miles. This technique was used to locate areas suitable for core sampling based on patterns in sediment characteristics. Core samples were collected by a push- tube vertical core method. Visual features of the 30 inch cores were noted and photographed prior to further analysis in the laboratory. The first six inches of each core was analyzed, followed by four other samples taken from distinct horizons where they were visible, or otherwise at regular intervals along the core. Chemical concentrations were determined according to EPA methods (EPA 1969: Chemistry Laboratory Manual, Bottom Sediments). Half of each core was preserved for future reference.

Water Column

This research included sampling for conductivity, temperature, pH, dissolved oxygen, and turbidity. Monitoring was conducted from 1972-1974 in concert with maintenance dredging activities by a trailing suction hopper dredge. Measurements were made in the principal channels that are dredged and at the Carquinez Strait, San Pablo Bay, and Alcatraz disposal areas. Sampling was also performed to evaluate hopper dredge overflow characteristics and to quantitatively describe plumes created by dredging. Suspended solids samples were collected by a surface pumping system or a Van Dorn sampler. All other measurements were made using meters.

Biological Community

Benthic macrofauna were collected from three dredged channels and four dredged material disposal areas in 1973 and 1974. A modified Petersen grab sampler was used in collections, and organisms were identified to species. Temperature, pH, and color of each sediment sample were recorded in the field. In the laboratory, measurements were made of total sulfides, grain-size distribution, and concentrations of cadmium, copper, zinc, lead, and total mercury. Water samples collected within 3ft of the bottom were analyzed in the field for temperature, salinity, dissolved oxygen, pH, total sulfide, and turbidity. Trace metals levels in sediment were determined by atomic absorption spectrophotometry.

Material Release

The movement of sediments dredged from Mare Island Strait and released at the Carquinez Strait disposal site was assessed by tagging the sediment with radioactive iridium. The technique employed in this experiment was new, and a large effort was required to develop the technique. Tagged sediments were released in February and March 1974. Sediments collected from 111 stations in Mare Island Strait, Carquinez Strait, western Suisun Bay, and most of San Pablo Bay were then analyzed over a 10 month period. Sampling stations were laid out on a grid, which allowed analysis of trends in sediment movement through time.

Samples were collected by the San Francisco District of the USACE, analytical work was handled by the Explosive Effects Division of the USACE Waterways Experiment Station and the Stanford Research Institute. The top two inches of each sediment core was analyzed separately, followed by four inch increments of the rest of the 20 inch core. Five cores were taken at each station; unused cores from each station were stored for further use. Iridium determinations were made with a neutron activation technique.

Crystalline Matrix

Ten sediment sampling stations in the Bay were selected to represent the range of sediment types and heavy metal concentrations which are involved in routine maintenance dredging and disposal. Particle size, mineral content, total sulfide, organic carbon, cation exchange capacity, PCBs, and trace metals were evaluated in the samples. For three regions a semi-selective chemical extraction procedure was employed to determine the relative distribution of trace metals among the various geochemical phases. A batch sorption-desorption experiment was performed to determine the fate of sediment bound trace metals during simulated dredging activities.

Pollutant Uptake

Tissues of Macoma balthica, the worm Neanthes succinea, and the amphipod Ampelisca milleri were analyzed for trace metal concentrations. A specially-designed suction dredge was used to collect benthic invertebrates for metals analysis. Benthic population samples were collected using plastic cores of two sizes, 10.2cm diameter and 7.6cm diameter, to capture larger and smaller invertebrates, respectively. Specimens were preserved in alcohol for future reference. Mytilus edulis collected from Tomales Bay were used in a transplant experiment. Sediment samples were collected from the upper 2cm of sediment for metals analysis. Water samples were collected for the determination of dissolved and particle-associated lead. Trace metal determinations were made using X-ray fluorescence spectrometry and isotope-shift Zeeman atomic absorption.

Pollutant Availability

Ten thousand cubic meters of polluted sediments dredged from Oakland Inner Harbor were dumped at an experimental disposal site east of Angel Island, and the pathways by which invertebrates may accumulate contaminants were investigated. Twelve trace elements and chlorinated hydrocarbons of the PCB and DDT groups were monitored in selected benthic invertebrates, mussels transplanted to the disposal site, sediments, settled and suspended particulates, and water before, during, and after a 42 hour disposal operation. Water quality parameters, including salinity, temperature, pH, nitrate-nitrogen, ammonia-nitrogen, and dissolved oxygen, were also monitored before, during, and after the experimental spoiling. Sampling and analytical methods were similar to those described in the preceding paragraph under "Pollutant Uptake". All of parameters listed above were also monitored for comparative purposes near the East Bay Municipal Utility District outfall in Central Bay.

The pathways by which cadmium, mercury, and lead are accumulated directly from seawater by invertebrates was further examined in laboratory studies. A controlled in situ experiment was also conducted where invertebrates were exposed to altered concentrations of suspended particulates in order to assess the importance of sediments and suspended particulates in pollutant uptake.

Marsh Development

In 1973 laboratory experiments were conducted to examine the germination, storage, and rooting of cordgrass and pickleweed. Also, propagules were collected, treated, and stored at that time. In 1974 48 cordgrass and 18 pickleweed test plots were established on dredged material placed at the Alameda Creek Flood Control Project, and monitored for two growing seasons. Growth and survival of test plantings were monitored, as well as soil characteristics (particle size, chemical concentrations, shear strength, and redox potential), and invertebrate abundance.

SAMPLING FREQUENCY AND LOCATION

Samples for the Pollutant Distribution Study (USACE 1979: Appendix B) were collected from the following stations in these three areas; San Pablo Bay-Carquinez Strait, San Pablo Strait- Berkeley Flats, and Oakland Inner and Outer Harbors.
NORTH SAN FRANCISCO BAY
Pinole Shoal
Napa River
Sonoma Creek
Petaluma River
Point Davis
Mare Island Strait
Carquinez Strait and Suisun Bay

CENTRAL BAY
West Richmond Bay

Southampton Shoal
Richmond Outer Harbor
Richmond Long Wharf
Richmond Inner Harbor
Sausalito

SOUTH SAN FRANCISCO BAY
Oakland Outer Harbor
Oakland Inner Harbor
Alameda N.A.S.
Islais Creek
San Leandro
San Bruno Shoal
Redwood City

Samples for the water column study were collected from 1972- 1975 (USACE 1976: Appendix C). Samples were collected from Mare Island Strait, Richmond Harbor, the Alameda Naval Air Station, the Pinole Shoal ship channel, Alcatraz, and the Carquinez disposal sites.

In the Biological Community study (USACE 1975: Appendix D), a census of the benthic macrofauna was conducted in three dredged channels, and four dredged-material disposal sites in March, September, and December of 1973, and in March and June 1974. These sampling sites were:

		Latitude	Longitude
1.	Mare Island Strait, dredged channel	38-05-38	122-15-33
2.	Mare Island Strait, undredged channel	38-05-42	122-15-28
3.	Center of Carquinez Strait disposal site	38-03-49	122-15-50
4.	N edge of Carquinez Strait disposal site	38-03-57	122-15-50
5.	South Bay disposal site,	37-34-05	122-12-33
	two stations established	37-34-47	122-13-45
6.	Redwood City Harbor entrance,	37-33-03	122-11-40
	two stations established	37-32-27	122-11-32
7.	Hunters Point disposal site	37-44-15	122-20-30
8.	Oakland Inner Harbor ship channel	37-20-46	122-19-04

In the Material Release study (USACE 1977: Appendix E) dredged sediments were taqged with iridium and released from the disposal site at Carquinez Strait in February 1974. Following the tagged sediment release, sediment samples were collected from South, Central, and San Pablo Bays, Carquinez Strait, Mare Island Strait, and Suisun Bay.

The Crystalline Matrix study (USACE 1975: Appendix F), was conducted over a 12 month period from August 1973 - June 1974; samples were collected at the following locations:

1. Southhampton Shoal Channel
2. Pinole Shoal Channel
3. Richmond outer harbor
4. Islais Creek Shoal
5. Oakland outer harbor (Seventh Street)
6.)akland outer harbor (Turning Basin)
7. Oakland inner harbor
8. Redwood Creek channel mouth
9. Redwood Creek channel by Corkscrew Slough
10. Mare Island Strait Channel
11. Alcatraz

The Pollutant Uptake study (USACE 1975: Appendix H) consisted of a field study of dredging operations at Mare Island, and accompanying laboratory tests. The field studies were carried out between July 1973 and May 1974; samples were collected at 13 benthic stations in the Mare Island Strait.

The Marsh Development study, (USACE 1976: Appendix K) was initiated in August 1973 on a total of 66 cordgrass and pickleweed test plots, which were monitored for 2 growing seasons in the intertidal zone along the north bank of the Alameda County Flood Control Channel in the South Bay.

REFERENCES

USACE. 1977. Dredge disposal study of San Francisco Bay and Estuary: Main report. US Army Corps of Engineers. San Francisco, CA.

USACE. 1974. Dredge disposal study of San Francisco Bay and Estuary: Appendix A, Main ship channel. US Army Corps of Engineers. San Francisco, CA.

USACE. 1979. Dredge disposal study of San Francisco Bay and Estuary: Appendix B, Pollutant distribution. US Army Corps of Engineers. San Francisco, CA.

USACE. 1976. Dredge disposal study of San Francisco Bay and Estuary: Appendix C, Water column. US Army Corps of Engineers. San Francisco, CA.

USACE. 1975. Dredge disposal study of San Francisco Bay and Estuary: Appendix D, Biological community. US Army Corps of Engineers. San Francisco, CA.

USACE. 1977. Dredge disposal study of San Francisco Bay and Estuary: Appendix E, Material release. US Army Corps of Engineers. San Francisco, CA.

USACE. 1975. Dredge disposal study of San Francisco Bay and Estuary: Appendix F, Crystalline matrix. US Army Corps of Engineers. San Francisco, CA.

USACE. 1975. Dredge disposal study of San Francisco Bay and Estuary: Appendix G, Physical impact. US Army Corps of Engineers. San Francisco, CA.

USACE. 1975. Dredge disposal study of San Francisco Bay and Estuary: Appendix H, Pollutant uptake. US Army Corps of Engineers. San Francisco, CA.

USACE. 1975. Dredge disposal study of San Francisco Bay and Estuary: Appendix I, Pollutant availability. US Army Corps of Engineers. San Francisco, CA.

USACE. 1974. Dredge disposal study of San Francisco Bay and Estuary: Appendix J, Land disposal. US Army Corps of Engineers. San Francisco, CA.

USACE. 1976. Dredge disposal study of San Francisco Bay and Estuary: Appendix K, Marsh development. US Army Corps of Engineers. San Francisco, CA.

USACE. 1975. Dredge disposal study of San Francisco Bay and Estuary: Appendix L, Ocean disposal. US Army Corps of Engineers. San Francisco, CA.

USACE. 1975. Dredge disposal study of San Francisco Bay and Estuary: Appendix M, Dredging technology. US Army Corps of Engineers. San Francisco, CA.

USACE. 1978. Dredge disposal study of San Francisco Bay and Estuary: Appendix N, Addendum. US Army Corps of Engineers. San Francisco, CA.

Leahy, E.J., W.B. Lane, T.M. Tami, L.B. Inman, W.R. McLoud, and N.J. Adams. 1976. Dredged sediment movement tracing in San Francisco Bay utilizing neutron activation. Technical report N-76-1. Prepared for the U.S. Army Engineer District, San Francisco. San Francisco, CA, 94201.

~**Descriptors:** bay-delta; south bay; central bay; san pablo bay; suisun bay; dredgingd sediments; sediment chemistry; benthic infauna; benthos; abundance; heavy metals; grain size; pollutants and related parameters; water pollution; water chemistry; water quality; tracer studies; bioaccumulation; wetlands; wetland ecology; benthic ecology;

GENERAL INFORMATION AND ABSTRACT

Program:	Department of the Army Permit Program
Funding Agency:	U.S. Army Corps of Engineers, Sacramento
Conducting Agency:	U.S. Army Corps of Engineers, Sacramento
Period of Record, Earliest Date:	1900
Period of Record, Latest Date:	Present
Geographic Boundaries Description:	Areas north of Antioch, including Suisun Bay, and the Delta.

ABSTRACT

The U.S. Army Corps of Engineers (Corps) regulates dredging, disposal of dredged material, fill, and other modifications that take place in wetlands and waterways of the U.S. The Sacramento District of the Corps issues permits for projects that take place in the Delta. Data collected in the process of authorization of each permit includes quantities of dredge and fill, site descriptions, environmental impacts, proposed mitigation, and other information. Unauthorized activities are also documented on a site specific basis.

The Sacramento District has collected this information since 1900. Basic information, such as the name of the permittee, location of the activity, and the type of activity is computerized for the entire period of record. Materials relating to permits issued before the 1970's are available in hard copy. In the last 10 years, the Sacramento District has entered more detailed descriptive information for some projects on an inconsistent basis.

PARAMETERS

MISCELLANEOUS PARAMETERS ANALYZED

Basic information, such as name of the permittee, project location, and the type of activity has been entered for the entire database (1900 to the present). In the last 10 years, two computerized databases have been created to track in more detail the permitting and enforcement aspects of each project.

The Pending Permit Database, employing the software dBase, contains the following fields:

district code
application number
processor's initials
applicant's name
applicant's address
activity's state
activity's county
assessor's parcel number
land office survey section number
land office survey township number
land office survey identifier - range
waterway
waterway mileage
authority (section 10 or 404)
type of application
    permit application
    letter of permission
    grandfathered activities
    after-the-fact permit permission
type of work
wetlands involved (yes, no)
area of wetlands
date application received
date application complete
date of last inspection
listed historical site (yes, no)
date consultation requested on endangered species
date public notice issued
date public notice expires
date objections sent to applicant
violation number
compliance with 401(b)(1) guideline
    complies
    requires mitigation
    fails to comply
cubic yards of fill applied for and approved
cubic yards of dredging applied for and approved
area of wetlands applied for and approved
extension into waterway applied for and approved
any changes (yes, no)
wetlands created (number of acres)
wetlands improved and restored (number of acres)
fishery protection measures (yes, no)

wildlife protection measures (yes, no)
reason for processing delay
- public hearing
- EIS
- applicant delay
- referral 404 MOA
- 401 certification
- historic property
- CAM
- misc/admin

date of Finding of No Significant Impact
date of Environmental Statement
EIS prepared
public hearing requested
date of public hearing
draft copies sent to applicant
permit fee
draft copies received
action due date
type of action due
- date applicant needs to supply additional information
- date draft public notice due after application is complete
- date action due after Public Notice expires
- date draft copies of permit should be returned by applicant
- date applicant has to resolve objections from Public Notice

application status
final action date
type of final action
- issued
- denied
- withdrawn by applicant
- permit not required

elevated to higher authority (yes, no)
date forwarded

The Enforcement Database, which also employs dBase, contains the following fields:
district code
violation number
processor's initials
who reported the violation
date violation reported
violation type
cubic yards of fill involved in violation
acres of wetlands involved in violation
cubic yards of dredging involved in violation

authority (Section 10 or 404)
suspect's name and address
waterway
waterway mileage
bank code (left or right bank)
activity state
activity assessor's parcel number
land office survey section number
land office survey township number
land office survey identifier - range
permit number (if part of an existing permit)
cease and desist order date
date of violation
date of last inspection
date sent to office of Counsel
type of action due
- apply or remove
- remove
- supply additional information
- violation report suspense
- check status with counsel

date of final action resolving the violation
type of final action
- partial restoration or no restoration, after-the-fact permit accepted for that portion of the work not restored
- after-the-fact permit accepted
- violator voluntarily makes full restoration
- no permit required
- activity already under a valid individual permit
- activity already valid nationwide permit
- activity already under a valid general permit
- activity already under a grandfathered activity
- enforcement action transferred to another district
- administrative penalty
- no legal remedy

METHODS

SAMPLING FREQUENCY AND LOCATION

The boundaries of the Sacramento District of the Army Corps define the geographic limits of this database.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: U.S. Army Corps of Engineers, Sacramento

Hardware: IBM compatible

Software: dBase III+

Volume of Data: approximately 15 megabytes

Contact for Data Retrieval

Name: Art Champ

Address: U.S. Army Corps of Engineers, Sacramento District
650 Capitol Mall
Sacramento CA 95814

Phone: (916) 551-2275

REFERENCES

Civil works internal reports summarizing permitting and enforcement activities for the Regulatory Branch. Summarized quarterly. U.S. Army Corps of Engineers, Sacramento District. Sacramento, CA.

~**Descriptors:** dredging and spoil disposal; sediments and dredging; wetlands; north delta; central delta; east delta; south delta; bay-delta;

GENERAL INFORMATION AND ABSTRACT

Program:	Dredging and Permitting Activities: San Francisco District
Funding Agency:	US Army Corps of Engineers
Principal Investigators	Wade Eakle (415) 744-3318, ext. 222 Regulatory Branch
Conducting Agency:	US Army Corps of Engineers, San Francisco
Period of Record, Earliest Date:	1900
Period of Record, Latest Date:	Present

Geographic Boundaries Description: All of San Francisco Bay, including Suisun Bay, to Antioch.

ABSTRACT

The U.S. Army Corps of Engineers (Corps) regulates dredging, disposal of dredged material, fill, and other modifications that take place in wetlands and waterways of the U.S.. The San Francisco and Sacramento Districts of the Corps issue permits for each project that takes place in the Bay-Delta. The jurisdiction of the San Francisco District includes all of San Francisco Bay downstream of Antioch. Data collected in the process of authorization of each permit includes quantities of dredge and fill, site descriptions, environmental impacts, proposed mitigation, and other information. Unauthorized activities are also documented on a site specific basis.

Both the San Francisco and Sacramento Districts have collected this information since 1900. Materials relating to permits issued before the 1970's are available in either microfiche or hard copy. In the last 10 years, both Districts have entered basic information on computer.

Detailed information on dredging projects which release material at the three in-Bay disposal sites is handled separately from general permit information. This information includes quantities dredged, location, and dates. The San Francisco District is adopting a computer storage system to track these projects; the system should be in use in 1988.

The Corps has undertaken major studies assessing the environmental impacts of dredging and dredged material disposal. A detailed study completed in the mid-1970's examined the interrelationships of the various physical, chemical, and biological parameters influenced by dredging activity, and the mechanisms of that influence (USACE 1977) (see entry on this Estuarine Data Index entitled "Dredge Disposal Study"). Another study (an environmental impact study) was conducted in the mid- 1970's of maintenance dredging of 20 individual navigation projects in the Bay region (USACE 1975). This included an assessment of the impacts of Corps-authorized maintenance dredging and other maintenance dredging projects under permit from the Corps.

PARAMETERS

MISCELLANEOUS PARAMETERS RECORDED

Records from the turn of the century to the present are stored in various forms in 8 different databases. These are; the Main Body of Data; Projects From 1983 to the Present; the Original Computerized Dredging Database; the Detailed Dredging Database; Permit Database from 1980 - Present; the Environmental Impact Analysis Database; the Unauthorized Activities Database; and the various Environmental and Dredging-related Studies which have been conducted by the Corps. Below is a brief description of each database.

1. **MAIN BODY OF DATA: 1900-1983**

   Records from the early 1900s to 1983 are stored on microfilm. The microfilm record contains copies of all the documents which were found in each original file. In addition to the microfilmed records, a computerized database listing the applicant, waterway, microfilm carton, and frame start/stop for all of the microfilmed records exists on magnetic tape and in hard copy. The fields which are contained on the hard copy and magnetic tape are listed below.

   With regard to data on sediment testing and analyses, it should be noted that previous to the Federal Water Pollution Control Act of 1972, no sediment testing was required. Beginning in 1975, bulk sediment testing was performed on large dredging projects only; smaller projects required no testing. From 1978- 1987 elutriate tests were performed on all projects.

   Applicant name
   Application number
   Date the permit was issued
   Public notice number
   Microfilm container number
   Microfilm frame number start and end

2. PROJECTS FROM 1983-PRESENT

Dredging, projects requiring fill, and unauthorized activities which have taken place in navigable waters during the past 10 years have been monitored more closely recently than they were in the past. Specific information on permitting, environmental impacts, and dredging are now entered into a variety of databases. These activities have been divided up into 4 computerized and one hard copy database, which are discussed below.

Records on projects conducted from 1983 to the present are stored in hard copy files (although some of these files are now being microfilmed). Each file contains all of the documents relevant to the project.

2A. ORIGINAL COMPUTERIZED DREDGING DATABASE: 1986-present

General information on the amounts of dredge spoil disposed of at the three in-Bay disposal sites for 1986 to present is stored on a microcomputer in Lotus 1-2-3.

This database, contains general information on dredging activities, such as total amounts of dredge spoil (in cubic yards) disposed of at each of the three in-Bay disposal sites by month. The information listed below has been entered for projects conducted from 1986 to the present.

Project name
Project number
Workcode (clamshell, maintenance, hopper)
Cubic yards dredged per month at each site
Monthly totals dredged at each site
Design or permit quantity
Year total to date disposed of at each site
Year total to date dredged

2B. DETAILED DREDGING DATABASE: Beginning summer 1988

In an effort to track dredging projects more closely, the following database, using the the software package FOCUS, was designed. This database contains more specific information on each project than does the original LOTUS program (#3 above). This information includes specifics on permit conditions, project description, and information on dredging episodes.

(i) PERMIT IDENTIFICATION
Project name
Permit number

Waterway
Applicant

(ii) PERMIT CONDITION OR DESCRIPTION

Date permit issued
Date permit expires
workcode (clamshell, hopper, hydraulic)
Disposal method
Disposal site
Project type
Dredging method
Special conditions
Permit quantity
Episode, quantity
Episode, frequency
Window of operation
Reference, permits

(iii) DREDGING EPISODES

Other agency requirements
Episode number
Date of 60 Day Notice
Anticipated quantity
Date of anticipated commencement
Date of sediment analysis
Agency approval
Point of contact
Date of debris plan
Date of predredge survey
Predredge quantity
Date of dredge plan
Contractor
Equipment identification
Equipment capacity
Slurry plan
Date of authorization to proceed
Date of actual start
Date of actual finish
Date of postdredge survey
Postdredge quantity
Project remarks

2C. PERMITTING DATABASE: 1980-Present

Permit information for projects conducted between 1980 and the present is stored in FOCUS. This information includes specifics on the area the work has been conducted in, a description of the activity, and information on the processing information for each application.

Application number
Waterway
Cross reference this application to ADP number
County
Permit manager's initials
Applicant's name
Agent's name
Authority (10, 404, 103)
Work numbers
fills
dredged/land disposal
dredged/water disposal
discharge structures/outfall pipes
floating docks or piling
submarine pipeline/cable
crossing tunnel
overhead cable or power cross
riprap/walls/jetty/breakwater
dams
piers/wharfs/fixed over-water structure
buoys
other
time extension

Activity Information
cubic yards of fill in area of jurisdiction
area of fill in area of jurisdiction
amount of riprap in area of jurisdiction
lineal feet of riprap in area of jurisdiction
is fill in a wetland
if fill is in wetland, area of fill
is the work behind a dike
amount to be dredged per year
total amount to be dredged for permit
aquatic site (SF 9, SF 10. SF 11, other)
was a water quality test conducted?
ssing Information
date application received
date application complete

date suspended
date unsuspended
project number
revised project number
date of final environmental assessment
date of 404 Q letter
date of 1st transmittal letter
date of final transmittal letter
date of final transmittal
expiration date
was coastal zone certification provided from BCDC
was coastal zone certification provided from CCC
file numbers of BCDC or CCC
was a cultural resources survey requested
was an endangered species consultation required
environmental assessment initials
objectioning agencies or groups
404 Q letter sent to
EIS performed
public hearing
special conditions added
after-the-fact permit
final action code
permit/lop issued
application withdrawn
permit denied
permit not required
work is covered by regional or nationwide permit
ass project modified
was mitigation required
was mitigation offsite, onsite, dollars
did mitigation involve wetlands
acres of wetland involved
permit type (LOP, Regional)
was 60 days exceeded
reason for exceedance
project is controversial/noncontroversial
remarks
keywords

2D. ENVIRONMENTAL IMPACT ANALYSIS DATABASE: Summer 1988-present

This database, which is not being entered into any computer system, contains information on the environmental impacts each project presents. Data being compiled includes: impacts on the aquatic ecosystem - physical/chemical/biological characteristics and anticipated changes; historic-cultural characteristics and anticipated changes; summary of indirect and cumulative impacts; impacts on environmental resources outside of the aquatic ecosystem - physical/biological characteristics and anticipated changes; socioeconomic characteristics and anticipated changes; and conclusions and recommendations regarding the need for an EIS.

Applicant
Permit manager
Environmental assessment coordinator
ADP number
Date

Impacts on the Aquatic Ecosystem

(i) Physical/Chemical Characteristics and Anticipated Changes
substrate
currents/circulation
drainage patterns
streamflow
flood control function
water supply (natural)
aquifer recharge
baseflow
storm, wave, and erosion buffer
erosion/sedimentation
water quality (suspended particulates and turbidity)
water quality (temperature, salinity patterns, etc.)
mixing zone, in light of the depth of water at the disposal site; current velocity, direction and variability at the disposal site; degree of turbulence; water column stratification; discharge vessel speed and direction; rate of discharge; dredged material characteristics; number of discharges per unit of time; and any other relevant factors affecting rates and patterns of mixing.

(ii) Biological Characteristics and Anticipated Changes
wetlands
mudflats
vegetated shallows
pool and riffle areas
coral reefs
wildlife sanctuaries and refuges
endangered and threatened species
habitat for fish and other aquatic organisms
habitat for other wildlife

other biological factors
biological availability of possible contaminants in dredged or fill material, considering hydrography in relation to known or anticipated sources of contaminants; results of previous testing of material from the vicinity of the project; known significant sources of persistent pesticides from land runoff or percolation; spill records for petroleum products or designated (Section 311 of the CWA) hazardous substances; other public records of significant introduction of contaminants from industries, municipalities or other sources.
public facilities and services
public health and safety
recreational opportunities
recreational fishing
silviculture
traffic conditions
transportation
transportation - navigation
water supply (M&I)
wild and scenic rivers

(iii) Historic-Cultural Characteristics and Anticipated Changes
Archaeological resources
historic resources
national register properties
native American concerns

(iv) Summary of Indirect Impacts

(v) Summary of Cumulative Impacts

Impacts on Environmental Resources Outside of the Aquatic Ecosystem

(vi) Physical characteristics and Anticipated Changes
air quality
noise conditions
geologic hazards
other physical factors

(vii) Biological Characteristics and Anticipated Changes
terrestrial habitat
special wildlife habitat
other terrestrial biological factors

(viii) Socioeconomic Characteristics and Anticipated Changes
aesthetic quality

agricultural activity
business and industrial activity
commercial fishing
community cohesion
economics
employment
energy conservation/conservation/consumption/generation
land use - conformance with existing plans/zoning
mineral resources
population/growth inducement
prime and unique agricultural lands

(ix) Conclusions and Recommendations Regarding the Need for an EIS based on an analysis of the Environmental Assessment (EA).

2E. UNAUTHORIZED ACTIVITIES DATABASE

Data on unauthorized activities has been kept both manually and on computer. From 1977-1984 the information listed below was computerized. When the computerized database was abandoned in the early 1980s in favor of a manual log, a final hard copy was printed; the data now resides on a magnetic tape. Data currently collected includes drawings, maps, activity, impacts, and information on proposed mitigation.

Violator's name
File number
Waterway
Unauthorized activity
Narrative description (from 1980-1984 only)

METHODS

SAMPLING FREQUENCY AND LOCATION

In addition to data kept on permitting and regulatory activities, the Corps also has conducted hydrosurvey monitoring at Alcatraz monthly since 1982, and quarterly at the 2 North Bay disposal sites since 1984. Trawl studies are being conducted in 1988 at Napa and the San Rafael Creek, in a joint project with the California Department of Fish and Game. The Corps occasionally conducts project-specific fisheries studies.

At present, there are three sites in the Bay where dredged material is disposed. These are:

1. San Pablo Bay 38-00-28 122-24-55

2.6 miles NE of Pt. San Pedro at
black & white marker buoy

2. Carquinez Strait 0.8 nautical miles from Mare Island Strait entrance	38-03-50	122-15-55
3. Alcatraz about 0.3 nautical miles south of Alcatraz Island	37-49-17	122-25-23

Prior to 1972, dredged material was disposed of at a minimum of 12 sites, including the three listed above and 9 others listed below. Land disposal sites were on the margins of the Bay.

4. Suisun Bay 0.6 miles from shore, in 30 ft of water, parallel to Suisun Bay Channel	38-03-15	122-05-06
5. San Francisco Channel Bar 2.8 nautical miles from shore at depths of 35-46 ft; average depth of 40 ft.	37-45-06	122-35-45
6. 100 fathom line 29.6 miles from the Golden Gate at a depth of 600 feet.	37-31-45	122-59-00

7. New York Slough - land disposal site

8. Suisun Slough - land disposal site

9. Suisun slough - land disposal site (near Suisun Marsh)

10. San Rafael - land disposal site

11. San Leandro - land disposal site

12. Redwood City - land disposal site

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE INFORMATION FOR MAIN BODY OF DATA, 1900-1983

Location: U.S. Army Corps of Engineers, San Francisco

Description: Main body of data, 1900-1983. (Database #1 in M isc. Parameters Section above.)

Software: The bulk of the Corps data (1900-1983) is stored on microfilm. A magnetic tape contains limited information on each record.

DATA STORAGE INFORMATION FOR PROJECTS FROM 1983-PRESENT

Location: U.S. Army Corps of Engineers, San Francisco

Description: The Original Computerized Dredging Database. (Database #2A in Misc. Parameters Section above.)

Hardware: IBM compatibe

Software: LOTUS

Volume of Data:

Contact for Data Retrieval
Name: Wade Eakle
Regulatory Branch
U.S. Army Corps of Engineers

Address: 211 Main Street
San Francisco CA 94105-1905

Phone: (415) 744-3318, ext. 222

DATA STORAGE INFORMATION FOR DETAILED DREDGING DATABASE

Location: U.S. Army Corps of Engineers, San Francisco

Description: Detailed Dredging Database (Database #2B in Misc. Parameters Section above.)

Hardware: IBM compatible

Software: FOCUS

Volume of

Data: 1985-present

Contact for Data Retrieval
Name: Wade Eakle
Regulatory Branch
U.S. Army Corps of Engineers

Address: 211 Main Street
San Francisco CA 94105

Phone: (415) 744-3318 ext. 222

DATA STORAGE INFORMATION FOR PERMITTING DATABASE

Location: U.S. Army Corps of Engineers, San Francisco

Description: Permitting Database, 1983 to the Present. (Database #2C in Misc. Parameters section above.)

Hardware: IBM compatible

Software: FOCUS

Volume of Data: 1980 - present

Quality Assurance:

Contact for Data Retrieval

Name: Calvin Fong
Regulatory Branch, US Army Corps of Engineers

Address: 211 Main Street
San Francisco CA 94105

Phone: (415) 744-3036 ext. 233

DATA STORAGE INFORMATION FOR ENVIRONMENTAL IMPACT ANALYSIS DATABASE

Location: U.S. Army Corps of Engineers, San Francisco

Description: Environmental Impact Analysis Database. (Database #2D in Misc. Parameters section above.)

Hardware: hard copy only.

Volume of Data: 1983 to present

Contact for Data Retrieval
Name: Lars Forsman
Regulatory Branch, US Army Corps of Engineers

Address: 211 Main Street
San Francisco CA 94105

Phone: (415) 744-3322 ext. 226

DATA STORAGE INFORMATION FOR THE UNAUTHORIZED ACTIVITIES DATABASE

Location: U.S. Army Corps of Engineers, San Francisco

Description: Unauthorized Activities Database. (Database #2E in Misc. parameters section above.)

Software: FOCUS; Magnetic tape and hard copy

Volume of Data: 1977-present.

Contact for Data Retrieval
Name: Sharon Moreland

Address: Regulatory Branch, US Army Corps of Engineers
211 Main Street
San Francisco CA 94105

Phone: (415) 744-3318 ext. 232

REFERENCES

US Army Corps of Engineers. Quarterly report summarizing permit actions. For copies, contact Calvin Fong, Regulatory Branch at (415) 744-3036 ext. 233.

U.S. Army Corps of Engineers. Quarterly report summarizing data on unauthorized activities. For copies, contact Sharon Moreland, Regulatory Branch, at (415) 744-3318 ext. 232.

U.S. Army Corps of Engineers. 1975. Final composite environmental statement: Maintenance dredging; existing navigation projects, San Francisco Bay region, California, Volume I. U.S. Army Corps of Engineers, San Francisco, CA. 400 pages.

U.S. Army Corps of Engineers. 1975. Final composite environmental statement: Maintenance dredging; existing navigation projects, San Francisco Bay region, California, Volume II. U.S. Army Corps of Engineers, San Francisco, CA. 200 pages.

~**Descriptors:** bay-delta; san pablo bay; south bay; central bay; sediment testing; dredging and spoil disposal; sediments; sediment chemistry; bay fill; biological resources;

GENERAL INFORMATION AND ABSTRACT

Program: Sediment Quality Survey

Funding Agency: National Oceanic and Atmospheric Administration

Principal Investigator: Eugene Revelas (401) 847-4210

Conducting Agency: Science Applications International Corporation

Study Cost: $70,000

Period of Record, Earliest Date: February 3, 1987

Period of Record, Latest Date: February 9, 1987

Geographic Boundaries Description: Samples were collected from South, Central, and San Pablo Bays.

ABSTRACT

In 1987 Science Applications International Corporation (SAIC), under contract with the National Oceanic and Atmospheric Administration (NOAA), performed a survey of sediment quality in the Bay. This effort was intended to provide information supplemental to NOAA's National Status and Trends Program (described as a separate entry in this on-line database), particularly assessments that could rapidly be made of sediment texture, nutrient enrichment, bottom water hypoxia, and benthic infaunal community structure. In order to provide rapid assessment of these features SAIC performed a survey in February 1987 employing an apparatus that took photographs of sediment profiles on the Bay floor. The purpose of the survey was to map gradients in sediment and benthic habitat quality and relate them to natural and anthropogenic processes.

Most of the stations sampled in the study area (which included South Bay, Central Bay, and San Pablo Bay) showed evidence of recent sediment erosion, redistribution, or deposition (SAIC 1987). Sites of organic enrichment were identified based on an "organism-sediment index", low apparent redox potential discontinuity (RPD) depths, high counts of *Clostridium perfringens* (a bacterium found in sewage effluents), and high TOC values. The poorest habitats in terms of these parameters were found in Redwood Creek, Oakland Inner Harbor, in San Pablo Bay near the Petaluma River, and in the Richmond Inner Harbor. The highest quality habitats sampled were in San Pablo Bay near Wilson Point, in the Central Bay near Brooks Island, and in the South Bay near Candlestick Point. The authors recommend that long-term monitoring be considered at these seven locations.

|

PARAMETERS

Media Analyzed: Biota. Sediment. Water.

BIOLOGICAL PARAMETERS MEASURED
Clostridium perfringens spore density
density of polychaete and/or amphipod tubes at sediment interface
dominant faunal type (infauna or epifauna)
infaunal successional stage
microbial aggregations present
minimum and maximum depth of fecal pellet layers
minimum and maximum depth of feeding voids
presence of large head-down infauna
presence of feeding voids
species richness

PHYSICAL PARAMETERS MEASURED
diameter and number of mud clasts
dredged material thickness

CHEMICAL PARAMETERS MEASURED
Other Parameters
dissolved oxygen (near bottom)
redox potential discontinuity depth
salinity (near bottom)
sediment grain size
sediment surface boundary roughness
sediment type
sedimentary methane
total organic carbon
total organic nitrogen
water temperature (near bottom)

TAXA
Clostridium perfringens bacterium

|

METHODS

SAMPLING METHODS

Seventy sampling stations were selected by NOAA to provide reconnaissance data on the wide range of benthic environments which are present in San Francisco Bay. These environments included shallow fine-grained sediments, deep fine-grained and coarse-grained high energy channel habitats, active and inactive disposal sites, creeks and river mouths, and ports and inner harbors. REMOTS sediment profile images were taken using a specially developed camera mounted on an assembly that is lowered to the sediment surface from a boat. The assembly cuts a vertical profile into the sediment, which is photographed horizontally by the REMOTS camera. Five replicate photographs were collected at each sampling site.

The REMOTS camera was also fitted with a dissolved oxygen probe, which collected readings from 1cm above the bottom as each replicate image was obtained. Conductivity and temperature profiles were also collected through the water column at each site. At each site sediments were collected with a Ponar grab for sediment texture, *C. perfringens*, and TOC analyses.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: 69 of the 70 sites were sampled.

Stations 30 through 70 were located in the South Bay. Fourteen stations were located in Central Bay. Eighteen stations were sampled in San Pablo Bay.

		Latitude	Longitude
1.	behind Mare Island	38-06-38	122-16-25
2.	behind Mare Island	38-05-71	122-15-50
3.		38-04-19	122-14-29
4.	southwest San Pablo Bay	38-01-61	122-25-41
5.		38-03-50	122-23-58
6.		38-03-75	122-21-25
7.		38-03-37	122-18-28
8.	San Pablo	38-03-83	122-15-25
9.		37-57-00	122-25-83
10.		37-59-17	122-25-75
11.		38-00-47	122-24-92
12.		38-01-22	122-23-17
13.		38-02-00	122-21-67
14.		38-02-67	122-20-00
15.		38-03-22	122-18-08
16.	located just east of San Pablo Bay disposal area	38-03-57	122-15-67
17.		38-01-80	122-20-17
18.	San Pablo Bay	38-02-42	122-18-00
19.	offshore from the Berkeley Marina	37-53-50	122-22-75
20.	nearshore to the Berkeley Marina	37-53-50	122-20-50
21.	offshore from the Berkeley Marina	37-51-50	122-22-50
22.	nearshore to the Berkeley Marina	37-52-00	122-20-00
23.	offshore from the Berkeley Marina	37-49-71	122-21-25

24.	nearshore to the Berkeley Marina	37-49-72	122-20-31
25.		37-54-27	122-22-99
26.		37-54-33	122-21-67
27.	Richmond Harbor	37-55-00	122-21-67
28.	Outer Oakland Harbor	37-49-12	122-19-28
29.	Just outside Richmond Harbor	37-48-87	122-20-50
30.	Inner Oakland Harbor	37-48-17	122-20-00
31.	Inner Oakland Harbor	37-47-48	122-18-00
32.	inside part of Oakland Inner Harbor	37-47-12	122-25-25
33.	Oakland Harbor	37-47-12	122-14-80
34.	Port of San Francisco	37-44-87	122-22-83
35.		37-44-87	122-23-63
36.	Port of San Francisco	37-44-17	122-22-15
37.	South of Port San Francisco	37-44-15	122-21-72
38.	South of Port San Francisco	37-42-37	122-22-00
39.	South of Port San Francisco	37-41-67	122-22-25
40.	South of Port San Francisco	37-40-50	122-22-33
41.		37-39-25	122-21-42
42.	near South Bay main shipping ch	37-46-58	122-21-00
43.	off Coyote Point	37-37-50	122-20-00
44.	off Coyote Point	37-37-00	122-19-00
45.	off Coyote Point	37-36-28	122-18-63
46.	off Coyote Point	37-35-33	122-15-33
47.		37-36-32	122-14-79
48.	Alcatraz disposal site	37-49-38	122-25-25
49.	Alcatraz disposal site	37-49-38	122-25-67
50.	Alcatraz disposal site	37-49-38	122-25-47
51.		37-42-75	122-18-25
52.	South Bay	37-42-75	122-16-00
53.	near South Bay main shipping ch	37-41-20	122-19-28
54.		37-41-67	122-17-92
55.		37-41-67	122-16-50
56.	near South Bay main shipping ch	37-39-33	122-19-00
57.	near San Bruno shoal	37-39-33	122-16-50
58.	South Bay	37-39-63	122-14-17
59.	near San Bruno shoal	37-37-62	122-17-25
60.	E of South Bay main shipping ch	37-37-62	122-14-50
61.	E of South Bay main shipping ch	37-36-08	122-13-08
62.	near South Bay main shipping ch	37-34-17	122-13-00
63.	Redwood Creek	37-33-23	122-11-17
64.		37-31-85	122-09-58
65.		37-31-65	122-08-28
66.	mouth of Coyote Creek	37-30-17	122-07-00
67.	mouth of Coyote Creek	37-28-40	122-04-00
68.	Redwood Creek	37-32-00	122-11-50
69.	Redwood Creek	37-30-92	122-12-42

ANALYTICAL METHODS

REMOTS measurements of all physical parameters and some biological parameters were measured directly from the film negatives using a video digitizer and computer image analysis system. The system can discriminate up to 256 different shades of gray, so subtle features can be accurately measured. For each image 22 different variables were measured, including: sediment grain size; mud clast abundance; abundance of sedimentary methane; apparent redox potential discontinuity depth; infaunal successional stage; an organism-sediment index (combining several parameters into a measure of habitat quality), and other parameters.

Sediment samples were analyzed for percent fine-grained material by conventional wet sieve techniques using a 62 micron sieve. TOC measurements were obtained using a CHN analyzer. Clostridium perfringens spores in sediment samples were enumerated by SAIC's lab in La Jolla, CA. Clostridium spores were selectively germinated in a special medium, and densities were calculated per unit of dry weight of sediment.

QUALITY ASSURANCE TESTING AND REPORTING

Before REMOTS measurements were stored on computer an analyst verified that values were within expected ranges. Unlikely values were remeasured. All REMOTS data were reviewed by the principal investigator before being used in final data synthesis. Dr. Cabelli of the University of Rhode Island performed quality assurance checks of the *Clostridium* counts.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: Newport, Rhode Island

Contact for Data Retrieval

Name: Eugene Revelas

Address: Science Applications International Corp.
Admiral's Gate, 221 Third Street
Newport, Rhode Island

Phone: (401) 847-4210

Data Access: Open

Data Availability Date: Immediately
Report Cost: No charge

Hard copies of reports are located: In Seattle at NOAA's Ocean Assessment Division, contact Ed Long, (206) 526-6338.

REFERENCES

Revelas, E.C., D.C. Rhoads, and J.D. Geymano. 1987. San Francisco Bay sediment quality survey and analyses: Volume I. NOAA Technical Memo NOS OMA 35. National Oceanic and Atmospheric Administration. Rockville, MD. 122 pages.

Science Applications International Corporation. 1987. San Francisco Bay sediment quality survey and analyses: Volume II, Appendix I REMOTS image analysis methods and *Clostridium* analysis methods. Report No. SAIC-87/7509&139 submitted to the National Oceanic and Atmospheric Administration. Rockville, MD.

Science Applications International Corporation. 1987. San Francisco Bay sediment quality survey and analyses: Volume III, Appendix II REMOTS data sheets. Report No. SAIC-87/7509&139 submitted to the National Oceanic and Atmospheric Administration. Rockville, MD.

Science Applications International Corporation. 1987. San Francisco Bay sediment quality survey and analyses: Volume IV, Appendix III CTD/DO tabular data. Report No. SAIC-87/7509&139 submitted to the National Oceanic and Atmospheric Administration. Rockville, MD.

Science Applications International Corporation. 1987. San Francisco Bay sediment quality survey and analyses: Volume V, Appendix IV CTD/DO profiles. Report No. SAIC-87/7509&139 submitted to the National Oceanic and Atmospheric Administration. Rockville, MD.

~**Descriptors:** bay-delta; south bay; central bay; san pablo bay; san francisco bay; sediments; bacteria; benthic infauna; benthic ecology; community structure; benthos; dredging; sediment chemistry;

GENERAL INFORMATION AND ABSTRACT

Program: Biotoxicity in the San Joaquin and Sacramento River Watersheds

Funding Agency: Central Valley Regional Water Quality Control Board (CVRWQCB)

Principal Investigator: Jerry Bruns or Chris Foe
CVRWQCB (916) 361-5694

Conducting Agency: CVRWQCB
Dr. Allen Knight, U.C. Davis - lab analysis
Sierra Laboratory, Jackson, CA - metal analysis
California Laboratory, Sacramento, CA - metal analysis

Period of Record, Earliest Date: April, 1986

Period of Record, Latest Date: Present

Geographic Boundaries Description: These studies are conducted on the Sacramento River from Shasta Dam to Chipps Island, and the San Joaquin, American, and Feather Rivers.

ABSTRACT

The Water Quality Control Plan for the Central Valley Region states that all waters shall be maintained free of toxic substances in concentrations that are toxic or produce deleterious physiological responses. The Plan further states that compliance with this objective will be determined by the use of indicator organisms, bioassays, or other methods. The Central Valley Regional Water Quality Control Board (Central Valley Board) has initiated a toxicity testing program that includes ambient testing in the Delta and key tributaries to measure instream toxicity, and toxicity testing at point source discharge facilities. This program has employed bioassay procedures developed by the US Environmental Protection Agency (EPA) for the assessment of the aquatic toxicity of complex effluents. Both acute and chronic responses of organisms from three phyla (fish, zooplankton, and algae) are observed. This phylogenetic diversity is believed to increase the sensitivity of the tests, and insure the protection of a wide variety of aquatic organisms.
EPA has evaluated the ecological significance of these tests, concluding that instream toxicity, as measured in the bioassays, is positively correlated with decreases in the number and kind of aquatic organisms present.

The goal of the ambient toxicity testing program is to detect toxicity problems in surface waters and to define them sufficiently so that further study and development of control actions can be initiated by dischargers causing the problems. The testing program began in 1986 with a limited sampling network on the Sacramento River to characterize discharges from Colusa Basin Drain. Since then, the program has been expanded to include the entire reach of the Sacramento River from Shasta Dam to the Delta (about 300 miles), the San Joaquin River between Mendota Pool and Mossdale (about 150 miles), and all major tributaries to both Rivers.

Toxicity in the lower Sacramento River has been traced to discharges from Colusa Basin Drain. In each year (1986-89) Colusa basin Drain water discharging to the Sacramento River was acutely toxic. In 1988 and 1989, acute toxicity to the invertebrate test species was measured in Colusa Basin Drain for a 4 to 6 week period beginning in late April or early May. Carbofuran, methyl parathion,and malathion were identified at levels causing the toxicity. Drain water was also found to be toxic to striped bass larvae and to neomysis. Testing results in the Sacramento River watershed are described in several memos (Connor 1990, Foe and Connor 1990, Foe 1988a, Foe 1988b, Foe 1988c, Foe 1987a, Shaner 1986, and Wyels 1987.)

These same procedures were employed to assess the influence of urban runoff from the City of Sacramento on toxicity in the American River during a storm event in January 1987, and the toxicity of three urban runoff sumps. Acute toxicity to *Selenastrum* was observed in one of the sumps. Fathead minnows and *Ceriodaphnia* subjected to bioassays of samples collected from the American River during the storm experienced 100% mortality. American River testing results are described in two memos (Foe 1987b, and Foe 1986).

Toxicity testing runs have been completed on 15 occasions in the San Joaquin River between February 1988 and August 1990. The San Joaquin River and some tributaries have tested acutely toxic to the invertebrate test species on many occasions. At times, 20 to 30 mile reaches of the San Joaquin River test acutely toxic. Several pesticides, including diazinon, parathion, carbaryl, eptam and carbofuran, have been identified in the River at levels 10-70 times higher than levels recommended by EPA. Testing results in the San Joaquin River watershed are described in several memos (Foe 1990a, Foe 1990b, Foe 1989a, Foe 1989b, Foe 1989c, and Connor 1988.)

Toxicity testing at point source discharge facilities started in 1988. Central Valley Board staff are investigating the toxicity of all discharges (9 facilities) discharging between Nimbus Dam on the American River downstream to Rio Vista on the Sacramento River. Toxicity testing has also recently been included in about 30 NPDES permits that have come up for renewal. Among preliminary results in 1988 was the observation of acute invertebrate toxicity at the City of Stockton's treatment plant at dilutions as lows as 0.5% (99.5% San Joaquin River water and

0.5% effluent). Follow-up studies by the City identified pesticides used in the plant's pond midge spraying program as the primary toxic agent.

PARAMETERS

Media Analyzed: Water

BIOLOGICAL PARAMETERS MEASURED

algal nutrient limitation experiment
algal primary production

Ceriodaphnia, reproduction and survival in an increasing salt concentration

Pimephales tissue growth and survival at increasing salt concentrations.

Selenastrum primary production in an additional ration of each of the recommended EPA algal growth salts

Selenastrum primary production in an increasing salt concentration

CHEMICAL PARAMETERS MEASURED

Carbamates: EPA 632

aminocarb
barban
baygon
bromacil
carbaryl
carbofuran
chloprophan
diuron
fenuron
fenuron-TCA
fluormeturon
linuron
methiocarb
methomyl
mexacarbate
monuron
monuron-TCA
neburon
oxamyl
propham
propoxur
siduron
swepp

Chlorinated Herbicides: EPA 615

2,4-D
2,4-DB
2-4,5-T
2,4,5-TP
dalapon
dicamba
dichloroprop
dinoseb
MCPA
MCPP

Dithiocarbamates: EPA 630

ziram

EPA 631

benomyl

Halogenated Volatile Organics: EPA 601

bromodichloromethane
bromoform
bromomethane (methyl bromide)
carbon tetrachloride
chlorobenzene
chloroethane
chloroform
chloromethane
dibromochloromethane
dibromomethane
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
1,1-dichloroethane
1,2-dichloroethane
1,1-dichloroethylene
trans-1,2-dichloroethylene
dichloromethane
1,2-dichloropropane
1,3-dichloropropylene
1,1,2,2-tetrachlorethane
1,1,1,2-tetrachloroethane
tetrachloroethylene
1,1,1-trichloroethane
1,1,2-trichloroethane
trichloroethylene
vinyl chloride
dichlorodifluoromethane

trichlorofluoromethane
1,1-dichloroethene
2-chloroethylvinyl ether
trans-1,3-dichloropropene
cis-1,3-dichloropropene

Organochlorine Pesticides: EPA 608

aldrin
a-BHC
b-BHC
g-BHC
d-BHC (lindane)
chlordane
4,4'- DDD
4,4'- DDE
4,4'- DDT
dieldrin
endosulfan I
endosulfan II
endosulfan sulfate
endrin
endrin aldehyde
heptachlor
heptachlor epoxide
kepone
methoxychlor
toxaphene
PCB

Organophosphorus Pesticides: EPA 612

azinphos methyl
bolstar (sulprofos)
chlorpyrifos
chlorpyrifos methyl
coumaphos
demeton
diazinon
dichlorvos
demethoate
disulfoton
EPN
ethoprop
fensulfothion
fenthi on
malathion
merphos
mevinphos

monochrotophos
naled
parathion methyl
parathion ethyl
phorate
ronnel
stirophos (tetrachlorvinphos)
sulfotepp
TEPP
tokuthion
trichloronate

Other Parameters

alkalinity
dissolved oxygen
electrical conductivity
hardness
pH
suspended chlorophyll *a*

Pesticides

bentazon
captafol
captan
cyhexatin
dacthal
dicofol
paraquat
propanil
sodium chlorate

Thiocarbmates: EPA 630

tillam (pebulate)
sutan (butylate)
vernum (vernolate)
bolero (thiobencarb)
ordram (molinate)
eptam

Triazines: EPA 619

ametryn
atraton
atrazine
premeton
propazine
prometryn
terbutryn

simazine
simetryn
sumitol
terbruthylazine

Trace Elements

arsenic
cadmium
chromium
copper
lead
nickel
silver
zinc

TAXA

Ceriodaphnia dubia	cladoceran
Morone saxatilis	striped bass
Pimephales promelas	fathead minnow larvae
Selenastrum capricornutum	green alga

METHODS

SAMPLING METHODS

Sampling locations for toxicity testing in the first year (November 1986 - September 1987) of testing on the Sacramento River were selected to bracket all major river water sources south of the City of Colusa. Sampling sites were positioned above, in, and below each river joining the Sacramento. In April-June 1987 the number of stations was expanded to include the segment between the City of Sacramento and Chipps Island in the Delta. In March 1988 additional stations were added to cover the stretch of the River from Shasta Dam to the town of Colusa. Testing has continued into 1990. Sampling dates were selected to assess water quality in the drainage basin during all major seasonal hydrologic periods. Water samples were collected as single subsurface grabs. A limited number of pesticide and trace metal samples were collected concurrently with some of the toxicity samples (Wyels 1987).

Samples were also collected in tributaries from agricultural areas of the Sacramento River basin on 29 May and 24 June 1986. Analyses of pesticides and trace metals were also conducted on these samples. Bioassays of samples collected from the American River during a storm event (January 1987) producing urban runoff also used this three species approach.

The San Joaquin River and its major tributaries are also being surveyed for biotoxicity to the daphnid *Ceriodaphnia*, and the fathead minnow, *Pimephales*.

Toxicity screening began in February 1988, and 15 runs have been conducted through August 1990.

SAMPLING FREQUENCY AND LOCATION

Sacramento River Sampling

Water samples were collected on the 29th of May and the 24th of June 1986 from each of the following four tributaries to the Sacramento River. Samples were also collected above and below each tributary, as well as within the Sacramento River near the Natomas Drain outfall (Shaner 1986).

1. Butte Slough
2. Colusa Drain
3. Sacramento Slough
4. Feather River

During November and December 1986, chronic toxicity tests were conducted on the cladoceran, *Ceriodaphnia*, and the green alga, *Selenastrum*, with water collected from all the principal rivers and agricultural drains discharging into the Sacramento River between Colusa and the City of Sacramento at Freeport Bridge. Samples were collected at 12 stations (Foe 1987a).

1. Sacramento River at Colusa
2. Butte Slough
3. Sacramento River downstream from Butte Slough
4. Sacramento River upstream from Colusa Basin Drain
5. Colusa Basin Drain
6. Sacramento River downstream from Colusa Basin Drain
7. Sacramento River upstream from Sacramento Slough
8. Sacramento Slough
9. Sacramento River downstream from Sacramento Slough
10. Feather River
11. Sacramento River downstream from Feather River
12. Sacramento River at Natomas

On 8 occasions in 1986 and 1987 the water quality of the Sacramento River and also of major agricultural drains and rivers tributary to it between the cities of Colusa and Sacramento was sampled. The sampling range was extended downstream in April, May and June of 1987 to also include the Sacramento River and Delta between the city of Sacramento and Chipps Island. Water samples were also collected at the Feather River at Verona in May and June of 1987 (Foe 1988*a*).

1. Sacramento River, sample collected at the City of Colusa at the bridge off Highway 45.

2. Sacramento River sample collected 1 km upstream of the Colusa Basin Drain. This site is downstream of the Butte Slough outfall and Reclamation District 108 Drain.

3. Colusa Basin Drain at the Road 99E bridge.

4. Sacramento River 3.0 km downstream of Colusa Basin Drain at Portuguese Bend.

5. Sacramento River, 1.0 km upstream of Sacramento Slough.

6. Sacramento Slough, 0.5 to 1.0 km downstream of the Karnak Pumping Plant.

7. Sacramento River, collected 1.0 km downstream of Sacramento Slough and immediately above the Feather River.

8. Mouth of the Feather River, above Verona.

9. Sacramento River collected 2.0 to 7.0 km downstream of the Feather River.

10. Sacramento River, at Village Marina at the city of Sacramento. This site is above the entrance of the American and East Natomas Drains.

11. East Natomas Main Drainage Canal at Discovery Park in the City of Sacramento.

12. American River, upstream of the 15 bridge at Discovery Park.

13. Sacramento River, collected at the Freeport Bridge.

14. Sacramento River, collected at the City of Clarksburg.

15. Sacramento River sample, collected from the boat dock at the Walnut Grove bridge.

16. Sacramento River, collected at the City of Isleton.

17. Cache Slough, collected upstream of the Ryer Island Ferry.

18. Mouth of Steamboat Slough.

19. Sacramento River, sample collected at the Highway 12 bridge at the City of Rio Vista.

20. Sacramento River, sample collected 1 km downstream of the Army Depot at the City of Rio Vista.

21. Sacramento River, collected 1 km above the confluence of the Sacramento and San Joaquin Rivers.

22. Sacramento River sample, collected off the eastern tip of Chipps Island.

In March 1988 the sampling range was extended upstream to Lake Shasta. Fifteen sample runs were made between March 1988 and August 1990. Samples from the Sacramento River and agricultural drains analyzed for pesticide and trace metal concentrations were collected on all segments of the Sacramento River from Shasta Dam to Chipps Island from November, 1986 through the present (Wyels 1987).

1. Lake Shasta
2. below Shasta
3. below Keswick
4. Redding
5. Red Bluff
6. Hamilton
7. Colusa
8. Butte Slough
9. downstream from Butte Slough
10. USCBD
11. CBD
12. downstream from CBD
13. US Sacramento Slough
14. Sacramento Slough
15. downstream from Sacramento Slough
16. Feather River
17. downstream from Feather River
18. Village Marina
19. Natomas Drain
20. American River
21. Miller Park
22. Freeport
23. Clarksburg
24. Walnut Grove
25. Isleton
26. Steamboat Slough
27. Cache Slough
28. Rio Vista
29. Green Island
30. Chipps Island

SACRAMENTO RIVER
- Freeport
- Walnut Grove
- Rio Vista

Collinsville

NORTHERN DELTA
Toe Drain at I-80
Toe Drain, Prospect Slough
Shag Slough
Prospect Slough
Liberty Cut
Cache Slough at Hastings Cut
Cache Slough at Lindsey Slough
Cache Slough at Vallejo Pumping Plant
Lindsey Slough at Hastings Cut
Lindsey Slough at Barker Slough

CENTRAL DELTA
Delta Cross Channel
Mokelumne River at Little Potato Slough
Mokelumne River at Thornton Blvd
Mokelumne River at Highway 12
Little Connection Slough, 8 Mile Road
French Camp Slough, El Dorado Road
San Joaquin River at Mossdale
San Joaquin River at Vernalis
Delta Mendota Canal, Lindemar Road
Old River at Highway 4
Rock Slough, Old River
Middle River, Borden Highway

SUISUN BAY
Chipps Island

OTHER SAMPLING SITES
Colusa Basin Drain, Road 99e (CBD1)
Sycamore Slough, RD108 pumps
Reclamation Drain, Ensley road (RS1)
Butte Slough, outfall gates
Jack Slough, Jack Slough Road
Sacramento Slough, Lower Gage Station (SS1)
Sacramento River, Village Maine (SR1)
Bear Creek just upstream of Eastside Canal
Owens Creek at Dan McNamara Road
Duck_Slough at Dan McNamara Road
Firebaugh Drain just before discharge to Camp 13 Slough
Panoche Drain at O'Banion Gauging Station
Mercy Springs Drain Just before siphon to the Agatha Canal
Rice Drain just north of Mallard_Road
Reclamation District 108 main drain at Rough and Ready Pumping Plant

Reclamation District 1500 discharge to Sacramento Slough
Sacramento River, Village Marina
City of Sacramento, Sacramento River Water Treatment Plant

Urban Runoff Sampling

Samples were collected during a small rainstorm on December 5, 1986 from sump 104, believed to be representative of a Sacramento City urban watershed. Samples were collected 40 minutes before the storm, and after 40, 90, and 300 minutes of discharge (Foe 1986).

Samples were collected on January 27 and 28 1987 from three urban runoff sumps located in the City and County of Sacramento. These sump numbers were 99, which drains residential property, sump 104, which drains a mix of residential and commercial land, and sump 111, which collects runoff from a light industrial area (Foe 1987b).

San Joaquin River Sampling

The San Joaquin River is being surveyed for biotoxicity of the daphnid *Ceriodaphnia*, and the fathead minnow, *Pimephales*, in a year-long study which intends to characterize water quality in both the San Joaquin River and the major inputs to it, and to identify major sources of toxicity. Toxicity screening began in February 1988, and fifteen runs have been conducted at approximately 6 week intervals through August 1990.

1. Mendota Pool
2. Bear Creek
3. Salt Slough
4. San Joaquin River, Fremont Ford Park
5. Los Banos Creek
6. San Joaquin River, upstream of Merced
7. Merced River
8. Orestimba Creek
9. San Joaquin River, downstream of Orestimba Creek
10. Lateral #5
11. San Joaquin River, Laird Park
12. Tuolumne River
13. San Joaquin River
14. Stanislaus River
15. San Joaquin River, downstream from Stanislaus River
16. New Jerusalem
17. San Joaquin River, Mossdale

ANALYTICAL METHODS

Toxicity tests in the studies of the Sacramento River system were conducted in a laboratory at UC Davis employing a three species test methodology developed by EPA (1985). The three species were fathead minnow larva (*Pimephales promelas*), a cladoceran (*Ceriodaphnia dubia*) and the green alga *Selenastrum capricornutum*. Tests were commenced within 24 hours of sample collection. Laboratory controls were employed in the fish and algal portions of the bioassay. Water of moderate hardness was prepared and tested with the fish bioassay; this water was amended with algal growth salts for testing with *Selenastrum*. Temperature, dissolved oxygen, pH, and electrical conductivity were monitored in the laboratory. Pesticides were analyzed which were thought likely to be present, based on Pesticide Use Reports (see entry for this dataset compiled by the California Department of Food and Agriculture), at the time of sampling. Various EPA methods were employed in scans for classes of toxic organics (Wyels 1987).

Trace metal concentrations in these samples were determined by the inductively coupled plasma method, except for copper which was determined by graphite furnace atomic absorption. All pesticides were analyzed by gas chromatography. Toxicity in samples collected from the American River in January 1987 was tested with the three species approach.

DATA STORAGE INFORMATION AND REFERENCES

Data are available in hard copy reports.

Contact for Data Retrieval

Name: Jerry Bruns
CVRWQCB

Address: 3443 Routier Road
Sacramento CA 95827-3098

Phone: 916) 361-5694

Access: Public information

Report Location: At CVRWQCB, Sacramento

REFERENCES

Connor, V. 1990. Unpublished Central Valley Regional Water Quality Control Board memorandum of 13 March 1990. Subject: Bioptoxicity monitoring of pre-harvest drainage from rice fields. September 1987 to 1989. 5 pages.

Foe, C.G. 1990a. Unpublished Central Valley Regional Water Quality Control Board memorandum of 25 June 1990. Subject: Results of toxicity testing and pesticide analyses on San Joaquin River on 27 March and 24 April 1990. 7 pages.

Foe, C.G. 1990b. Unpublished Central Valley Regional Water Quality Control Board memorandum of 25 june 1990. Subject Results of toxicity testing and pesticide analyses on San Joaquin River during February 1990. 7 pages.

Foe, C.G. and Connor, V. 1990. Unpublished Central Valley Regional Water Quality Control Board memorandum of 19 October 1990. Subject: 1989 rice season toxicity monitoring results. 30 pages plus appendices.

Foe, C.G. 1989a. Unpublished Central Valley Regional Water Quality Control Board memorandum of 20 October 1989. Subject: Detection of pesticides in the San Joaquin River on 16 June 1989. 6 pages.

Foe, C.G. 1989b. Unbublished Central Valley Regional Water Quality control Board memorandum of 26 April 1989. Subject: Results of pesticide analyses of new Jerusalem title drain water collected on 6 March 1989. 6 pages.

Connor, V. 1988. Unpublished Central Valley Regional Water Quality Control Board memorandum of 10, March, 1988. Subject: Survey results of the San Joaquin River watershed survey. 8 pages.

Foe, C.G. 1988a. Unpublished Central Valley Regional Water Quality Control Board memorandum of January 19, 1988. Subject: Results of the 1986-87 lower Sacramento River toxicity survey. 35 pages.

Foe, C.G. 1988b. Unpublished Central Valley Regional Water Quality Control Board memorandum of August 29, 1988. Subject: Preliminary 1988 Colusa Basin Drain rice season biotoxicity results. 8 pages.

Foe, C. G. 1988c.Unpublished Central Valley Regional Water Quality Control Board memorandum of 26 August 1988. Subject: Preliminary analysis of results of 1988 Colusa Basin Drain rice season biotoxicity testing. 8 pages.

Foe, C.G. 1987a. Unpublished Central Valley Regional Water Quality Control Board memorandum of February 6, 1987. Subject: Results of the Sacramento River agricultural drain ambient toxicity test results for the months of November and December, 1986. 15 pages.

Foe, C.G. 1987b. Unpublished Central Valley Regional Water Quality Control Board memorandum of March 19, 1987. Subject: American River urban runoff toxicity test results for the January 27-28th, 1987 precipitation event. 20 pages.

Wyels, W. 1987. Unpublished Central Valley Regional Water Quality Control Board memorandum of June 17, 1987. Subject: Results of the 1986-1987 pesticide study of the Sacramento River and agricultural drains.

Foe, C.G. 1986. Unpublished Central Valley Regional WAter Quality Control board memorandum of December 15, 1986. Subject: Memorandum on the results of the December 5th, 1986 urban runoff toxicity tests.

Shaner, S.W. 1986. Unpublished Central Valley Regional Water Quality Control Board memorandum of August 25, 1986. Subject: Ambient water toxicity testing, May-June 1986. 32 pages.

~**Descriptors:** plankton/algae/seagrass; POTWs; bay-delta; agricultural drain water; herbicides; pesticides; urban runoff; water quality; agricultural drainage; heavy metals; toxicity testing; san joaquin; american; feather; ambient toxicity testing; effluent testing; water pollution; water chemistry; chlorinated solvents; chlorinated hydrocarbons; cyclodienes; west delta; pollutant sources; point sources; nonpoint sources; rivers; upper drainage; water quality;

GENERAL INFORMATION AND ABSTRACT

Program:	California State Mussel Watch (SMW) Program
Managing/Funding Agency:	State Water Resources Control Board (SWRCB)
Principal Investigator:	Timothy P. Stevens SWRCB, (916) 322-0216
Contributing Agencies:	Department of Fish and Game (field work, laboratory analyses) Regional Water Quality Control Boards (planning)
Total Budget:	$300,000/yr baseline $175,000/yr reimbursement contract with permitted dischargers
Earliest Data Records:	July, 1977
Latest Data Records:	Present
Geographic Boundaries:	Data have been collected at 381 sites over the full length of the California coast, including 45 sites in San Francisco Bay south of the Carquinez Strait. Ten to 15 sites are sampled annually in the Bay area.

ABSTRACT

Since 1976, the State Water Resources Control Board (State Board) has operated the State Mussel Watch (SMW) Program for monitoring marine and estuarine waters of California. Field collection and laboratory analysis are performed by the Department of Fish and Game (DFG) under inter-agency agreement. SMW provides the State Board and Regional Water Quality Control Boards (Regional Boards) with accurate means to locate and verify coastal areas with high levels of certain toxic pollutants in the marine environment. SMW also is used to assess baseline conditions and follow geographic and temporal trends in toxic contamination of coastal waters. Mussels and clams are used as subject species. These animals readily bioaccumulate various toxic pollutants (trace metals and synthetic organic compounds), and have been widely used throughout the world in similar monitoring programs.

1989-90 PROGRAM FINDINGS

Results from the 1989-90 sampling year will be available to the public following an official press release by the Office of Legislative and Public Affairs at the State Board. Staff is currently reviewing data in preparation for this release later in 1990.

SMW PARAMETERS

Media Analyzed: Biota (bivalve species tissues). Sediment and water at some sites on occasion.

Bio-Parameters Measured: shell length
% Water in tissues
% Lipid in tissues

Chem-Parameters Currently Measured For (other, undetected, substances measured for over the years not included):

CHLORINATED HYDROCARBONS

Aroclors

PCB-1242
PCB-1248
PCB-1254
PCB-1260
total PCBs (sum of above)

Congeners

PCB #s 5 - 207 (not all congeners included)
Polynuclear Aromatic Hydrocarbons (PAHs) (upon request)

PESTICIDES

aldrin
chlorbenside
total chlordane
alpha-chlordene
gamma-chlordene
cis-chlordane
trans-chlordane
oxychlordane

cis-nonachlor
trans-nonachlor
chlorpyrifos
dacthal
total DDT
o,p'-DDD
p,p'-DDD
o,p'-DDE
p,p'-DDE
p,p'-DDMS
p,p'-DDMU
o,p'-DDT
p,p'-DDT
diazinon
dichlorobenzide
dicofol (Kelthane)
dieldrin
endrin
total endosulfan
endosulfan I (Thiazan I)
endosulfan II
endosulfan sulfate
ethylparathion
ethion
HCH-alpha
HCH-beta
HCH-delta
HCH-gamma (Lindane)
heptachlor
heptachlor epoxide
hexachlorobenzene
methoxychlor
methylparathion
phenol
pentachlorophenol
tetrachlorophenol
tetradifon (Tedion)
toxaphene

ANTI-FOULING AGENT

tributyltin (TBT)

TRACE ELEMENTS

aluminum
arsenic (on occasion)
cadmium
chromium
copper
lead
mercury
manganese
nickel (on occasion)
selenium (on occasion)
silver
titanium (on occasion)
zinc

NON-ROUTINE CHEMICAL PARAMETERS MEASURED
(limited amount of data available - most not detected)

2,4-D acid
2,4-D isobutyl ester
2,4-D n-butyl ester
2,4-D isopropyl ester
atrazine
benefin
carbaryl
carbophenothion
2-chloroallyl diethyl
chloroneb
dichlofenthion
diphenamid
fenitrothion
fenthion
fonofos
guthion
malathion
methidathion
mirex
PCB-1242
perthane
phenkapton
phorate
pronamide
ronnel

simazine
strobane
S,S,S-tributylphosphorotrithioate

TAXA USED

Corbicula fluminea
Mytilus californianus
Mytilus edulis

|

METHODS

SAMPLING METHODS

For resident mussel collections, one hundred animals are taken at each station and divided equally between the trace metal and synthetic organic analytical groups. In order to minimize possible effects of variation in tidal height the mussels are collected from the highest tidal height where they occur in sufficient numbers. Mussels between 55 and 69 mm are used to reduce size-related effects on contaminant concentrations. For trace metals, three analytical replicates of 15 mussels are analyzed from each site. For synthetic substances, one replicate of 50 pooled individuals is analyzed from each site. Undissected replicates are archived so that further analyses at a later date are possible.

Transplanted mussels used in San Francisco Bay originate from the SMW Bodega Head reference station. Efforts are made to minimize handling-induced contamination. The transplanted mussels remain on-site in nylon mesh bait bags for 4 to 6 month intervals.

SAMPLING FREQUENCY AND LOCATION:

Number of sample sites

Numerous sites have been sampled in the San Francisco Bay and Delta. Complete sample site information is available in the annual SMW reports or, for 1977 through 1987, in the SMW 10-Year Report from SWRCB. The following table lists stations sampled from 1977-90.

Station Number	Station Name	latitude	longitude
298.00	Brannan Island	38-07-25	121-40-00

298.30	Concord Naval Pier 4		
298.40	Concord Naval Seal Island		
299.10	Selby Slag #4		
299.20	Selby Slag #5		
299.30	Selby Slag #6		
299.40	Selby Slag #7		
300.20	Mare Island	38-04-30	122-14-45
301.00	Davis Point	38-03-09	122-15-36
301.40	Union Oil Outfall		
302.00	Point Pinole	38-01-00	122-21-48
302.40	Castro Cove Bridge		
303.00	Richmond-San Rafael Bridge	37-54-55	122-24-30
303.10	Santa Fe Channel Mouth	37-54-30	122-21-40
303.20	Lauritzen Canal - Mouth	37-55-15	122-22-00
303.30	Lauritzen Canal - End	37-54-48	122-21-55
303.40	Santa Fe Channel - End	37-55-30	122-22-45
303.60	Richmond Inner Harbor Basin	37-54-45	122-21-00
304.00	Staufer's	37-54-30	122-21-45
304.60	Point Isabel		
305.00	San Francisco Bay - Angel Island	37-51-17	122-25-03
306.00	San Francisco Bay - Fort Baker	37-49-51	122-28-26
306.50	Alcatraz Island		
307.00	SF Bay - Treasure Island	37-48-53	122-20-20
307.20	Alameda Yacht Harbor	37-46-45	122-15-15
307.30	Oakland Inner Harbor - West	37-47-48	122-19-43
307.40	Oakland Inner Hrb-Embarcadero Cove	37-46-50	122-14-40
307.60	Oakland Back Harbor	37-45-30	122-13-25
307.80	San Francisco Outfall		
307.90	San Francisco - Islais Channel	37-44-51	122-23-05
308.00	San Francisco Bay - Hunter's Point	37-41-42	122-20-27
308.20	Hunter's Point - Shipyard		
309.00	San Mateo Bridge - 8B	37-36-21	122-17-20
310.00	San Mateo Bridge - 8A	37-25-22	122-16-06
311.00	San Mateo Old Bridge	37-35-52	122-15-08
312.00	Belmont Slough	37-33-00	122-14-47
313.00	SF Bay - near Redwood Creek	37-33-09	122-11-45
314.00	Redwood Creek - 10	37-31-49	122-11-38
315.00	Redwood Creek - Towers	37-30-55	122-12-22
316.00	Redwood Creek - Tradewinds	37-30-09	122-12-49
317.00	Redwood City - STP Outfall	37-29-44	122-13-03
318.00	Redwood Creek - Pete's Marina	37-30-00	122-13-24
318.40	Redwood Creek - Bair Island	37-30-02	122-13-23
319.00	Redwood Creek - Pulgas	37-30-30	122-14-37
320.00	San Francisco Airport	37-30-55	122-14-50

321.00	Dumbarton Bridge	37-30-50	122-07-58
323.30	Palo Alto Outfall		
324.00	Newark Slough	37-29-36	122-05-11
325.00	Channel Marker 17	37-28-41	122-04-32
326.00	Palo Alto - 8	37-27-38	122-03-06
327.00	Palo Alto - Yacht Club	37-27-09	122-02-10
328.00	Alviso Slough	37-28-00	122-55-46
330.00	Duxbury Reef	37-53-57	122-43-56
331.00	Muir Beach	37-51-28	122-34-50
332.00	Point Bonita	37-49-13	122-32-37
333.00	Farallon Islands	37-41-45	123-00-00
334.00	Cliff House	37-46-57	122-30-46
335.00	Pacifica	37-40-09	122-29-41
336.00	J. Fitzgerald	37-30-45	122-30-30

ANALYTICAL METHODS

Only substances that can be reliably identified by the laboratories are included in the SMW Program. Data are expressed in dry weight and wet (equivalent to fresh) weight formats. Data for synthetic organics are also reported on a lipid weight basis.

Trace element samples are processed under "clean room" conditions to minimize contamination. Atomic absorption (AA) spectrophotometry is employed in chemical determinations. Lead, silver, chromium, nickel, titanium, cobalt, and barium are measured using a graphite furnace; an air acetylene flame is used for cadmium, copper, manganese, and zinc; hydride generation for arsenic; a nitrous oxide/acetylene flame for aluminum; and flameless AA is used for mercury.

Synthetic organics are measured using high resolution glass capillary column gas chromatography with an electron capture detector.

QUALITY ASSURANCE TESTING AND REPORTING

Care is taken to prevent field and laboratory contamination of samples. "Clean Room" conditions are used to prevent metal contamination. National Bureau of Standards reference oyster material is analyzed to assure validity of trace metal analyses. In hydrocarbon analyses ten percent of the samples are tested in duplicate. To preclude errors due to contamination, vertical solvent blanks are passed through each set of glassware used. Replicate mussel samples from all stations are archived so that anomalous findings can be verified at a later date, and to allow measurement of new compounds as analytical capabilities improve.

A comprehensive Quality Assurance/Quality Control document that will cover all field and laboratory activities of the Mussel Watch Program is being prepared by Department of Fish and Game for the Environmental Protection Agency. This document will be available to the public upon finalization during 1990-91.

SMW DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location:	State Water Resources Control Board (SWRCB) Monitoring and Assessment Unit 901 P Street, Sacramento, CA 95814 P.O. Box 100, Sacramento CA 95801
Contact:	Timothy P. Stevens (916) 322-0216
Hardware:	IBM-compatible Personal Computer, Iomega Bernoulli Box
Software:	R:Base database software
Volume of Data:	Approximately 4 megabytes (MB)
Quality Assurance:	Data at SWRCB compared against DFG originals
Data Access Via:	Modem (2400 baud) at SWRCB, floppy disk, Bernoulli Cartridge (20 MB), hardcopy (for small amounts of data)
Hardcopy Access:	Copies of recent SMW annual reports, plus the 10 year data summary report, may be obtained by contacting: the SWRCB Office of Legislative and Public Affairs (OLPA) ([916] 322-3132) at the above addresses. These reports include maps of sampling sites, latitude/longitude, detailed methodology, all data, etc.
Information Brochure:	A layperson's guide to the program will be available in 1990-91 from the SWRCB Office of Legislative and Public Affairs (OLPA) ([916] 322-3132) at the above addresses. This brochure will answer common questions about the Program, its goals and objectives, and its activities.

ALSO

Location:	National Computer Center, North Carolina

Hardware: IBM mainframe

Software: SAS

Volume of Data: 1500 observations from 1984-1986 inclusive, have been entered into the NCC system.

Quality Assurance: Double entry software was used in keypunching, random samples of 10% of the raw data sheets were compared with computer entries, and statistical analysis was performed to detect outliers.

Contact: Jay Davis
180 Richmond Field Station
1301 South 46th Street
Richmond CA 94804

Phone Number: (415) 231-9539

Access: Public information Data Availability

Availability: Immediately

REFERENCES

Hayes, S.P., and P.T. Phillips. 1985. California State Mussel Watch: Marine Water Quality Program, 1983-1984. State Water Resources Control Board, Water Quality Monitoring Report No. 85-2WQ. Sacramento, CA.

Hayes, S.P., and P.T. Phillips. 1986. California State Mussel Watch: Marine Water Quality Program, 1984-1985. State Water Resources Control Board, Water Quality Monitoring Report No. 86-3WQ. Sacramento, CA.

Hayes, S.P., and P.T. Phillips. 1987. California State Mussel Watch: Marine Water Quality Program, 1985-1986. State Water Resources Control Board, Water Quality Monitoring Report No. 87-2WQ. Sacramento, CA.

Ladd, J.M., S.P. Hayes, M. Martin, M.D. Stephenson, S.L. Coale, J. Linfield, and M. Brown. 1984. California State Mussel Watch 1981-1983, biennial report: Trace metals and synthetic organic compounds in mussels from California's coast, bays and estuaries. State Water Resources Control Board, Water Quality Monitoring Report No. 83-6TS. Sacramento, CA.

Martin, M., D. Crane, T. Lew, and W. Seto. 1982. California Mussel Watch 1980-1981, Part III: synthetic organic compounds in mussels, *M. californianus* and *M.*

edulis, from California's coast, bays and estuaries. State Water Resources Control Board, Water Quality Monitoring Report No. 81-IITS. Sacramento, CA.

Risebrough, R.W., B.W. deLappe, E.F. Letterman, J.L. Lane, M. Firestone-Gillis, A.M. Springer, and W. Walker II. 1980. California State Mussel Watch 1977-1978, Volume III: Organic pollutants in mussels, *Mytilus californianus* and *Mytilus edulis*, along the California coast. State Water Resources Control Board, Water Quality Monitoring Report No. 79-22. Sacramento, CA.

Stephenson, M.D., S.L. Coale, M. Martin, D. Smith, E. Armbrust, E. Faurot, B. Allen, L. Cutter, G. Ichikawa, H. Goetzl, and J.H. Martin. 1982. California Mussel Watch 1980-81, Part II: Trace metal concentrations in the California mussel, *Mytilus californianus*, from California's coast, bays and estuaries. State Water Resources Control Board, Water Quality Monitoring Report No. 81-11TS. Sacramento, CA.

Stephenson, M.D., S.L. Coale, M. Martin, and J.H. Martin. 1980. California Mussel Watch 1979-1980. Trace metal concentrations in the California mussel, *Mytilus californianus*, and the Bay mussel *Mytilus edulis* along the California coast and selected harbors and bays. State Water Resources Control Board, Water Quality Monitoring Report No. 80-8. Sacramento, CA.

Stephenson, M.D., M. Martin, S.E. Lange, A.R. Felgal, and J.H. Martin. 1979. California Mussel Watch 1977-1978, Volume II. Trace metal concentrations in the California mussel, *Mytilus californianus*. State Water Resources Control Board, Water Quality Monitoring Report No. 79-22. Sacramento, CA.

Stevens, T. P. (1988). California State Mussel Watch: Marine Water Quality Program, 1986-87. State Water Resources Control Board, Water Quality Monitoring Report No. 88-3WQ.

~**Descriptors:** bay mussel; bioaccumulation; california mussel; central bay; freshwater clam; invertebrates; organotin; PAHs; pesticides; pollutants; san pablo bay; shellfish; south bay; toxics; trace metals; water pollution; water quality; carbamates; organophosphates; bay-delta; clams; mussels; cyclodienes;

GENERAL INFORMATION AND ABSTRACT

Program:	Chevron Deep Water Outfall Project
Funding Agency:	Chevron, USA, Inc. Richmond Refinery
Conducting Agency:	Jefferson Associates URS Corporation ANATEC Laboratory Wetlands Research Associates, Inc. California Archaeological Consultants
Period of Record, Earliest Date:	August, 1986
Period of Record, Latest Date:	1987
Geographic Boundaries Description:	Samples were collected from San Pablo Bay.

ABSTRACT

In 1985, the San Francisco Bay Regional Water Quality Control Board reissued the National Pollutant Discharge Elimination System (NPDES) permit for the Chevron USA, Inc. Refinery in Richmond, CA. The revised permit prohibited Chevron from discharging wastewater at its former outfall location, Castro Creek and Castro Cove, or at any point where it did not receive a minimum dilution of 10 to 1. To comply with the new permit, Chevron constructed a new outfall in deeper waters of San Pablo Bay. Prior to construction of the deep water outfall an environmental impact report (EIR) was prepared, analyzing the impacts of alternative pipeline/outfall locations. The EIR included extensive research into the impacts of the relocation of the outfall, both through the acquisition of new field and laboratory data and literature review.

This summary will focus on some of the original data obtained for the EIR that pertain to the estuary (interested readers should consult the EIR itself for comprehensive literature reviews of ecological data relating to environmental studies of Castro Cove and San Pablo Bay). These data included water and sediment quality, effluent toxicity, behavioral effects of the discharge on fish, fish abundance and diversity near the alternative outfall sites, and measurements of water circulation (Jefferson Associates 1987).

The refinery effluent contained relatively high concentrations of copper, chromium, cadmium, lead, nickel, zinc, and mercury. Accumulation of toxic organics such as polynuclear aromatics and pesticides in sediments near the former outfall suggested that these substances were also present in the effluent. Dissolved metal concentrations determined by ultraclean techniques were high in San Pablo Bay

relative to EPA receiving water standards and toxic levels for marine organisms. These elevated concentrations were attributed in part to Chevron (a crude estimate suggested that 11% of the nickel in Suisun, San Pablo, and Central Bays was contributed by Chevron), but mostly to other municipal and industrial point sources in the region. Cumulative inputs from point sources were considered to account for a substantial portion of the dissolved metal concentrations observed in San Pablo Bay.

Toxicity studies conducted for the EIR evaluated the sensitivity of species from several different taxonomic groups (including fish, crustaceans, molluscs, and algae) found in San Pablo Bay to dilutions of the refinery effluent. The most sensitive fish species (sanddabs, *Citharichthys stigmaeus*) subjected to chronic bioassays (25 day exposures) with Chevron effluent suffered 30% mortality at an effluent concentration of less than 10% (diluted with over 90% seawater). Striped bass (*Morone saxatilis*) and shiner perch (*Cymatogaster aggregata*) had similar sensitivities to the effluent. Fin erosion was noted during these tests on striped bass at all concentrations tested (down to 10% effluent), as well as fish caught in Castro Creek and Cove. Seventy percent of the striped bass exhibited severe fin erosion at an effluent concentration of 10%. Embryo-larval studies with the Korean prawn (*Palaemon macrodactylus*) yielded mortalities at an effluent concentration of less than 3.2%. The bioassay data suggested that the discharge must be diluted to less than 0.5 to 2% in order to protect organisms in the receiving waters.

Behavioral responses of striped bass and steelhead/rainbow trout (*Salmo gairdneri*) exposed to varied dilutions (10:1, 30:1, 100:1, and 500:1) of Chevron effluent were observed. At dilution levels of 100:1 and 500:1 the fish were clearly attracted to the effluent. Monthly field collections were made in 1986 of fish and crabs near Castro Cove and the proposed outfalls. Weekly transects were also made using acoustic imagery and chart recorders to determine the frequency and distribution of migratory fish in the study area. Fish use of the migratory corridor near Point San Pablo was heaviest in October and lowest in July and August. Fish were most abundant at depths of 10 to 30 feet.

Water circulation studies indicated that dispersion of the effluent from the deep water diffuser was likely to be more than adequate to dilute, within a short distance, contaminants entering San Pablo Bay. Typically, 100:1 dilution was expected within 55 feet of the diffuser, and 500:1 dilution within one mile. Because of these high dispersion rates, little direct ecological impact was expected by these researchers near the deep water outfall.

PARAMETERS

Media Analyzed: Biota. Sediments. Water.

BIOLOGICAL PARAMETERS MEASURED
benthic species abundance

fish species abundance; stomach contents
waterfowl species abundance

PHYSICAL PARAMETERS MEASURED
current speed and direction

CHEMICAL PARAMETERS MEASURED
MAHs
azobenzene
benzene
1,2-dichlorobenzene
1,3-dichlorobenzene
1,4-dichlorobenzene
2,6-dinitrotoluene

Nutrients
nitrogen as ammonia
phosphorus as phosphate

Other Hydrocarbons
BTX
4-chlorophenyl ether
n-nitrosodiphenylamine
EOX (extractable organic halogens)
2,4-dichlorophenol
2-methyl-4,6-dinitrophenol
2-methyl phenol
4-chloro-3-methylphenol
2,4,5-trichlorophenol
2,4,6-trichlorophenol
4-bromophenyl ether
4-chloroaniline
hexachloroethane + nitrobenzene
n-nitrosodimethylamine
pentachlorophenol
oil and grease
toluene
xylene

Phthalates
butylbenzylphthalate
di-n-butylphthalate
diethylphthalate
di-n-octylphthalate

Other Parameters
biochemical oxygen demand

dissolved oxygen
pH
phenols
salinity
sediment grain size
silicate as silica
sulfides
suspended particulate matter
total organic carbon
total suspended solids
water temperature

Polynuclear Aromatic Hydrocarbons
2-methylnaphthalene
acenaphthylene
benzo(b)fluoranthene
benzo(k)fluoranthene
chrysene
dibenzofuran
fluorene
phenanthrene
pyrene

MISCELLANEOUS PARAMETERS MEASURED
LC 50

Trace Elements
cadmium
chromium
copper
lead
mercury
nickel
selenium
zinc

TAXA
SPECIES USED IN BIOASSAYS

Acipenser transmontanus	white sturgeon
Citharichthys stigmaeus	sanddab
Crangon franciscorum	Bay shrimp
Cymatogaster aggregata	shiner perch
Cyprinodon variegatus	sheepshead minnow
Gasterosteus aculeatus	stickleback
Menidia beryllina	silversides
Morone saxatilis	striped bass
Neomysis mercedis	opossum shrimp

Palaemon macrodactylus	Palaemon shrimp
Rithropanopeus harrissii	mud crab
Salmo gairdneri	steelhead
Skeletonema costatum	diatom
Thallasiosira decipens	diatom

FISH COLLECTED IN MONTHLY TRAWLS

Amphistichus koelzi	calico surfperch
Citharichthys stigmaeus	speckled sanddab
Clupea herengus pallasi	Pacific herring
Cymatogaster aggregate	shiner perch
Engraulis mordax	northern anchovy
Gasterosteus aculeatus	threespine stickleback
Genyonemus lineatus	white croaker
Gillichthys mirabilis	longjaw mudsucker
Girella nigricans	opaleye
Hyperprosopon argenteum	walleye surfperch
Hyperprosopon ellipticum	silver surfperch
Lepomis macrochirus	bluegill
Leptocottus armatus	Pacific staghorn sculpin
Morone saxatilis	striped bass
Mustelus henlei	brown smoothhound
Myliobatis californica	bat ray
Parophrys vetulus	English sole
Platichthys stellatus	starry flounder
Porichthys notatus	plainfin midshipman
Sebastes sp.	rockfish
Spirinchus sp.	smelt
Syngnathus sp.	pipefish

PREY ITEMS IDENTIFIED IN FISH STOMACH CONTENTS

Annelida
Asychis elongata
Glycera sp.
Goniadidae
Oligochaeta
Phyllodocidae
Polychaeta

Arthropoda
Ampelisca
Choronomid
Copepoda
Corophium spp.
Crangon franciscorum
Crustacean frags.
Decapod frags.

Euphausid shrimp
Gammarid frags.
Hemigrapsus sp.
Isopoda
Mysidacea
Natantia frags.
Ostracods
Palaemon macrodactylus
Rithropanopeus harrissi
Synodotea sp.

Mollusca
bivalves, unident.
Gemma gemma
mollusc frags.
Musuculus senhousia
Mya arenaria

Nematoda

MACROINVERTEBRATES COLLECTED

Cancer gracilis	rock crab
Cancer magister	Dungeness crab
Cancer productus	rock crab
Ctenophora sp.	jellyfish
Crangon franciscorum	Bay shrimp
Hemigrapsus nudus	purple shore crab
Hemigrapsus oregonensis	yellow shore crab
Heptacarpus sp.	grass shrimp
Macoma sp.	clam
Palaemon macrodactylus	Oriental shrimp
Protothaca sp.	clam

COMMON PLANT SPECIES IN VICINITY OF THE PROJECT

Atriplex patula	saltbush
Cuscuta salina	dodder
Distichlis spicata	salt grass
Enteromorpha clathrata	algae
Enteromorpha spp.	algae
Frankenia grandifolia	alkali heath
Fucus gardneri	algae
Gracilaria sp.	algae
Gracilaria verrucosa	algae
Grindelia humilia	gumplant
Polysiphonia paniculata	algae
Polysiphonia sp.	algae
Salicornia virginica	pickleweed

Spartina foliosa	cordgrass
Ulva spp.	algae
Zostera marina	eelgrass

COMMON ANIMAL SPECIES IN VICINITY OF THE PROJECT

Armandia brevis	
Atherinops affinis	topsmelt
Balanus sp.	barnacles
Capitella capitata	
Clupea harengus	Pacific herring
Corophium spinicorne	
Cymatogaster aggregata	shine surfperch
Dirona albolineata	
Eteone californica	
Hemigrapsus oregonensis	shore crab
Idothea wasnesenski	
Ischadium demissum	rib mussel
Macoma balthica	Baltic clam
Morone saxatilis	striped bass
Mytilus edulis	Bay mussel
Nassarius obsoletus	mud snail
Nassarius oregonensis	mud snail
Orkestia traskiana	beach hopper
Photis californica	
Sphaeroma quoyana	burrowing isopod
Streblospio benedicti	
Tapes japonica	

WATERFOWL OBSERVED IN VICINITY OF THE PROJECT

Aechmophorus occidentalis	western grebe
Anas americana	American wigeon
Anas acuta	pintail
Anas platyrhyonchos	mallard
Anas strepera	gadwall
Ardea herodias	great blue heron
Arenaria melanocephala	black turnstone
Brant canadensis	Canadian goose
Casmerodius albus	great egret
Catoptrophorus semipalmatus	willet
Charadrius vociferus	killdeer
Egretta	snowy egret
Ereunettes mauri	western sandpiper
Erolia alpina	dunlin
Erolia minutilla	least sandpiper
Fulis americana	American coot
Himantopus mexicanus	black-necked stilt
Larus argentatus	herring gull

Larus californicus	California gull
Larus delawarensis	ring-billed gull
Larus heermanni	Herrmann's gull
Larus occidentalis	western gull
Limnodromus scolopaceus	long-billed dowitcher
Limosa fedoa	marbled godwit
Melanitta perspicillata	surf scoter
Numenius americanus	long-billed curlew
Numenius phaeopus	whimbrel
Pelecanus occidentalis	brown pelican
Phaelacrocorax auritus	double-crested cormorant
Pluvialis squatarola	black-billed plover
Podilymbus podiceps	pied-billed grebe
Rallus longirostris	clapper rail
Recurvirostra americana	American avocet
Sterna caspia	caspian tern
Sterna forsteri	Forster's tern
Tringa flavipes	lesser yellowlegs
Tringa melanoleucas	greater yellowlegs

METHODS

SAMPLING METHODS

As discussed in the Abstract, the Environmental Impact Report (EIR) for the Chevron deep water outfall included a multi- faceted investigation into the environmental characteristics of Castro Cove and San Pablo Bay, including many different types of original research. Only some of the methods employed in that effort are presented very briefly here. For further information, the reader should consult the EIR itself.

Circulation studies were conducted in the spring and summer of 1986 at the alternative outfall sites. Both drogue and current meter studies were performed. A sophisticated, recently developed vacuum-intercept pumping system was used to obtain sea water samples for trace element analysis from four stations near Point San Pablo and from one station 2 miles west of Pinole Point. Samples were collected from the approximate depth of the proposed outfall. Sediments were collected along the alternative outfall alignments, using a 0.1 square meter stainless steel Van Veen grab sampler from which the upper 2cm of the sample were taken for analysis. Fish collections were made at nine stations using a semi-balloon otter trawl with 0.25in mesh. Sonar transects, using a depth recorder/fish finder, were conducted at four locations in the study area. Creel census data were also obtained from local fishermen to assist in determination of migration routes for important species. In addition, crabpots covered with 0.25in mesh were placed at eight stations from Point Molate to Point Orient.

SAMPLING FREQUENCY AND LOCATION

Salinity, temperature, and other water quality baseline data were collected from 6 stations located near the refinery during the month of August in 1986.

Drogue studies were conducted at the proposed Pt. San Pablo, Pt. Orient, and Shallow Water Alternative outfall diffuser sites in August and September of 1986.

Sediments were collected during August 1986 from the 26 sampling sites located near the alternative outfall alignments. Sediments were sampled for metals, grain size, total organic carbon, oil and grease, BOD, sulfides, phenols, halogens, pesticides, and priority pollutants.

From April through March of 1987 a fisheries survey program was conducted which employed trawl, sonar transect, crab-pot, hook-and-line surveys and a creel study. Monthly otter trawl collections were made at 3 deep and 5 shallow water trawl stations. Crabpots were set out at 8 stations along Point Richmond from Point Molate to point Orient. Four collections were made from the end of July to the end of September in 1986.

Creel census data were obtained on eight sampling dates in August, seven dates in September, and six dates in October of 1986. Interviews were conducted with fisherman from 12 marinas, ranging from Sausalito to Vallejo, at several fishing piers, (Berkeley, Martinez, Blackpoint), and at shore fishing points.

Sonar transects were conducted once a week from April through March, 1987, during the daylight hours at four locations within San Pablo Bay. Night-time transects were initiated during the fall\winter migration periods at the alternative outfall sites. Night transects were usually followed by day transects, and follow-up mid-water tows and hook-and-line fishing periodically took place along the path of the transects to verify the type of bait fish observed on the chart recording. Migrating sportfish proved too fast to be recorded by the sonar equipment.

Epibenthic invertebrates were collected from stations located at the alternative outfalls and control stations at Corte Madera and Gallinas Creek in Marin County from April through October of 1986.

Waterbird and endangered species field studies were conducted weekly from mid-August through mid-October of 1986 near the proposed project sites, and at the two control areas, Gallinas Creek and Corte Madera Creek.

Trace metals in seawater were profiled from samples collected on August 29-30, 1986, at 4 stations near Point San Pablo and from 1 station located two miles west of Pinole Point.

ANALYTICAL METHODS

Analyses of trace element concentrations in Bay waters were conducted using an ultraclean technique which allows for the determination of concentrations in the nanogram per liter range.
EPA methods were employed in sediment analyses (further discussion was not provided).

Behavioral response tests were performed on striped bass and steelhead/rainbow trout. Dilutions of 10:1, 30:1, 100:1, and 500:1 were tested. A television/computer-based system was used that can follow the movements of 20-30 organisms in real time, recording linear velocity, angular velocity, acceleration, and location. Toxicity bioassays were conducted with locally important species, including fish, invertebrates, and algae. Screening studies were carried out initially to determine the concentration of effluent that organisms could tolerate indefinitely. These were run with continuous flows and were continued until mortality reached a plateau. Selected species were then tested in situ to determine their sensitivity to the discharge in real time and determine if the laboratory exposures were a good model of the actual toxicity of the discharge. Embryo-larval studies were also conducted on several organisms that were amenable to laboratory studies of this type.

QUALITY ASSURANCE TESTING AND REPORTING

Data for trace elements in Bay waters were supported by rigorous quality assurance procedures. Samples were collected and analyzed using state-of-the-art ultraclean techniques, allowing determinations on the order of 1 nanogram per liter. Reference samples of seawater were analyzed to estimate the accuracy of the analyses, which was within the tolerance limits of certified values.

Quality assurance data were also provided for analyses of sediment chemistry. Duplicate subsamples of various samples were analyzed to estimate precision. Spiked samples were analyzed to detect interferences. Also, reference standards were carried through the preparation and analysis procedures to detect analyte loss.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Information on data storage was not available.

REFERENCES

Jefferson Associates. 1987. Chevron, USA Richmond Refinery deep water outfall project. Prepared for the City of Richmond. Richmond, CA. 220 pages.

Jefferson Associates. 1987. Chevron, USA Richmond Refinery deep water outfall project: draft environmental impact report - appendices. Prepared for the City of Richmond. Richmond, CA. 500 pages.

Jefferson Associates. 1987. Chevron, USA Richmond Refinery deep water outfall project: addendum - environmental impact report. Prepared for the City of Richmond. Richmond, CA.

~**Descriptors:** sediment chemistry; sediments; toxicity testing; effluent testing; pollutants and related parameters; food chains; phthalates; phenols; plankton/algae/seagrass; hydrology and flow; hydrodynamics and modelling; biological resources; fisheries; pollutant sources; point sources; water pollution; water chemistry; water quality; birds; invertebrates; benthic ecology; clams; crabs; mussels; refineries; shellfish; shrimp; waterfowl; shorebirds; herons; dabbling ducks; diving ducks; water birds; bay-delta;

GENERAL INFORMATION AND ABSTRACT

Program: Contaminants of Concern: San Francisco Bay and San Pablo Bay National Wildlife Refuges

Funding Agency: U.S. Fish and Wildlife Service

Principal Investigator: Jean Takekawa
Doug Roster
(415) 792-0222

Conducting Agency: U.S. Fish and Wildlife Service

Period of Record, Earliest Date: July 1986

Period of Record, Latest Date: Present

Geographic Boundaries Description: Benthic invertebrates, fish, and waterfowl were collected from North Bay, Central Bay, and South Bay locations. Waterfowl, California clapper rail, wading bird and tern eggs were collected from wetland habitats adjacent to the Bay.

ABSTRACT

In 1986 the U.S. Fish and Wildlife Service issued a report describing a preliminary survey of contaminant issues of concern on National Wildlife Refuges. This was the first systematic attempt to develop a consolidated national listing of potential contaminant issues pertaining to National Wildlife Refuges which required management attention. Based on circumstantial evidence that point and non-point pollution sources had the potential to impact fish and wildlife resources associated with the San Francisco and San Pablo National Wildlife Refuges, a reconnaissance contaminant biomonitoring study plan was developed.

San Francisco Bay National Wildlife Refuge encompasses over 18,000 acres of salt ponds, tidal sloughs, and salt marshes at the southern end of the Bay. San Pablo Bay National Wildlife Refuge consists of 11,634 acres in north San Francisco Bay. Approximately 96% of this refuge is made up of open bay and mudflats that are below maximum high tide level and directly affected by bay waters. Fish, bay shrimp, and surficial sediments were collected in 1986 from eight South Bay creeks which are closely associated with lands comprising the San Francisco Bay National Wildlife Refuge. In 1987, waterbird egg, liver, and kidney tissue and carcasses from specimens collected from various North Bay and South Bay habitats were submitted for chemical analysis. In addition, ribbed horse mussels (*Ischadium demissum*), an

important food item for diving ducks and California clapper rails, were collected from known waterfowl habitats. Ongoing sampling in 1988 is emphasizing the collection and chemical analysis of benthic invertebrates, fish, and waterfowl eggs from both North Bay and South Bay locations. Sampling in 1989 included Caspian terns eggs from the South Bay; black-crowned night-heron and snowy egret eggs from the South Bay and *Macoma balthica* from North and South Bays. Data analysis and interpretation are pending completion of the chemical analyses of the biological samples.

PARAMETERS

Media Analyzed: Biota. Sediments.

CHEMICAL PARAMETERS MEASURED
Pesticides
BHC
dieldrin
DDD
DDE
DDT
dicofol
endrin
heptachlor epoxide
hexachlorobenzene
lindane
cis-chlordane
trans-chlordane
oxychlordane
mirex
cis-nonachlor
trans-nonachlor
PCB - 1254
PCB - 1260
toxaphene

Polycyclic Aromatic Hydrocarbons
anthracene
benz(a)anthracene
dibenz(a,h)anthracene
9,10-diphenylanthracene
chrysene
fluoranthene
benzo(b)fluoranthene
fluorene
naphthalene
perylene
benzo(g,h,i)perylene

phenanthrene
pyrene
benzo(a)pyrene
benzo(e)pyrene

Aliphatic Hydrocarbons
n-dodecane
n-tridecane
n-tetradecane octylcyclohexane
n-pentadecane nonylcyclohexane
n-hexadecane
n-heptadecane pristane
n-octadecane phytane
n-nonadecane
n-eicosane

Trace Elements
aluminum
arsenic
boron
cadmium
copper
iron
lead
magnesium
manganese
mercury
molybdenum
nickel
selenium
vanadium
zinc

TAXA

Anas platyrhynchos	mallard (eggs)
Anas strepera	gadwall (eggs)
Aythya affinis	lesser scaup
Aythya marila	greater scaup
Aythya valisneria	canvasback
Crangon franciscoru	bay shrimp
Cymatogaster aggregata	shiner surfperch
Egretta thula	*snowy egret*
Ischadium demissum	ribbed horse mussel
Leptocottus armatus	staghorn sculpin
Macoma balthica	baltic clam
Nycticorox nycticorox	*black-crowned night-heron*
Platichthys stellatus	starry flounder

Rallus longirostris obsoletus	California clapper rail
Sterna antillarum browni	least tern (eggs)
Sterna caspia	Caspian tern

|

METHODS

SAMPLING METHODS

All fish were collected with an otter trawl. Benthic invertebrates were collected by hand at low tide. Individuals from each location were composited to provide sufficient biomass for chemical analysis.

Waterfowl were collected using shotguns and steel shot. Dissection of liver and kidney tissue for inorganic element analysis was performed immediately after collection. Carcasses were frozen and later prepared for organic compound analyses. Nests were found by thorough searches, usually when incubating adults were flushed from their nests. One egg was collected from each rail nest for chemical analysis; a second egg was collected from waterfowl nests in case of breakage.

SAMPLING FREQUENCY AND LOCATION

Number of Stations: Approximately 40 stations are sampled.

During July and August 1986 fish were collected from Alviso Slough, Corkscrew Slough, Coyote Creek, Guadalupe Slough, Newark Slough, Plummer Creek, Redwood Creek, and West Point Slough. In 1988, fish were collected from Richmond Inner Harbor, Castro Cove, Petaluma River and the Napa River in the North Bay; and Mowry Slough, Palo Alto Area, Alameda Flood Control Channel, Steinberger Slough and San Leandro in the South Bay.

Waterfowl were collected by the California Department of Fish and Game during the winter of 1986-87 from the following locations: Alviso Salt Ponds, Midshipman Point (San Pablo Bay), Grizzly Bay, Coyote Hills (South Bay) Suisun Bay, and Central Bay. In 1986, California clapper rail eggs were collected from tidal marshes in the North and South Bay. Waterfowl and California clapper rail eggs were collected from nesting habitats along the perimeter of the bay in Marin and Contra Costa Counties in 1987. In addition, waterfowl eggs were collected in 1988 from nest sites on Bair Island, Castro Cove, and Grizzly Island. In 1989, wading bird and Caspian tern eggs were collected in the South Bay.

Benthic invertebrate sampling to date has included the collection of ribbed horse mussels (*Ischadium demissum*) from intertidal areas within the San Pablo Bay National Wildlife Refuge, and the collection of clams, (*Macoma balthica*) from 22 locations throughout the Bay in 1988. Ten of these sites were sampled again in 1989 and 1990. The clams were collected from mudflats associated with the following locations: Palo Alto, Mowry Slough, Southhampton Bay, Rodeo, Martinez, Steinberger Slough, Plummer Creek, China Camp, San Pablo Bay National Wildlife Refuge (lower Tubbs Island), Tolay Creek, Coyote Creek, San Leandro, Alameda Flood Control Channel, Burlingame, Castro Cove, Redwood Creek, Petaluma River, Pacheco Creek, Peyton Slough, Berkeley, Napa River, and Stevens Creek.

ANALYTICAL METHODS

All biological samples will be analyzed by the U.S. Fish and Wildlife Service Patuxent Analytical Control Facility in Laurel, Maryland, or a contract laboratory that has been subjected to a rigorous evaluation process prior to the awarding of its contract. Most elements are analyzed by inductively coupled argon-plasma atomic emission spectrometry following complete digestion with strong acids.

Arsenic and selenium are analyzed by hydride-generation atomic absorption and mercury is analyzed by flameless cold-vapor absorption. Gas-liquid chromatography is used to detect and quantify organic compounds.

QUALITY ASSURANCE TESTING AND REPORTING

A panel of U.S. Fish and Wildlife Service scientists certify Service contract laboratories to be technically qualified to perform chemical analysis of biological tissues. In addition, the Service continually monitors Service and contract laboratory performance using recognized quality assurance methods. These methods include analysis of procedural blanks, duplicate analysis of 10% of the samples, analysis of spiked samples to determine recoveries, and analysis of National Bureau of Standards reference samples in order to determine the precision and accuracy of the results of each lot of samples analyzed.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Data Access: Chemical results have been received on a majority of samples. Data are being analyzed.

REFERENCES

Lonzarich, D.G., T.E. Harvey, and J.E. Takekawa. Trace element and organochlorine levels in California clapper rail eggs (being revised to fit journal format).

~**Descriptors:** bay-delta; central bay; other hydrocarbons; bioaccumulation; endangered species; biological resources; pollutants and related parameters; birds; fisheries; sediment chemistry; sediments and dredging; wetlands; food chains; water birds; reproduction; cyclodienes; clams; dabbling ducks; pesticides; herons; mussels;

GENERAL INFORMATION AND ABSTRACT

Program: National Status and Trends Program

Funding Agency: National Oceanic and Atmospheric Administration

Principal Investigator: Ed Long
National Oceanic and Atmospheric Administration
(206) 526-6338

Conducting Agency: National Oceanic and Atmospheric Administration

Period of Record, Earliest Date: 1984

Period of Record, Latest Date: Present

Geographic Boundaries Description: Samples are collected in San Pablo Bay, Central Bay, and South Bay. Comparative data from other locations in the U.S. are available.

ABSTRACT

The National Oceanic and Atmospheric Administration (NOAA) has performed sampling in San Francisco Bay as part of the National Status and Trends (NS&T) Program. The NS&T Program is a nationwide monitoring and assessment effort that utilizes a uniform approach to quantify toxic contamination in sediment, bivalves and bottom fish from nearly 300 sites along the US coastline. The major objectives of the Program are to determine the status of and trends in marine environmental quality, primarily in relation to toxic chemical contaminants. The NS&T Program is NOAA's principal marine environmental quality monitoring and assessment program. The Program consists of two major data collection efforts. In the Benthic Surveillance Project, bottom-feeding fish and sediments are collected from over 75 sites nationally. In the Mussel Watch Project, bivalve mollusks and sediments are taken at 220 sites. Chlorinated organics, polycyclic aromatic hydrocarbons, and inorganic elements are measured in both projects. The incidence of histopathological disorders in the bottomfish is assessed. Additional measures of effects of contaminants in sediments and fish will be added to the Program in the future.

Sampling in San Francisco Bay and elsewhere began in 1984 and has continued to the present (NOAA 1987a, 1987b). Each year from 4 to 9 sites in San Francisco Bay have been sampled for sediments, 4 or 5 sites for bottomfish, and 2

or 3 sites for resident mussels (*Mytilus edulis*). Relative contamination at sampling sites across the nation is assessed based on concentrations of individual and total PAHs, PCBs, DDT, (non-DDT) chlorinated pesticides, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, tin, and zinc.

In 1984 (NOAA 1987a), several sites in San Francisco Bay were among the most contaminated sites measured in the nation. Bottom fish collected from Southhampton Shoal had the highest levels of cadmium in liver tissue observed at any location (43 sites total), the second highest levels of mercury, and the fourth highest levels of nickel. Fish from Hunters Point had the second highest total (non-DDT) chlorinated pesticide and third highest cadmium concentrations. Fish from Oakland Harbor had the fifth highest concentrations of both total (non-DDT) chlorinated pesticides and mercury. *Mytilus edulis* collected from the Bay at Dumbarton Bridge ranked third in total (non-DDT) chlorinated pesticides, fifth in total DDT, and twelfth in both cadmium and mercury levels observed at 145 locations nationwide. Mussels collected at the San Mateo Bridge ranked thirteenth in concentrations of both total (non-DDT) chlorinated pesticides and mercury. The Mussel Watch and Benthic Surveillance data uniformly suggest enrichment of chlorinated pesticides, cadmium, and mercury in the Bay.

In a study supplementary to the NS&T Program, in 1985 NOAA completed a field trial of its Sediment Quality Triad in San Francisco Bay (Chapman *et al.* 1986). The Triad assesses the degree of degradation of sediment quality in polluted areas by measuring bulk sediment chemistry, running sediment bioassays, and determining benthic community structure. Chemicals analyzed were the same as those in the NS&T Program. Sites were sampled once in Islais Creek waterway, off Oakland, and in San Pablo Bay.

In another study supplementary to the NS&T Program, entitled "An Evaluation of Candidate Measures of Bioeffects", NOAA evaluated the performance and relative sensitivity of various measures of biological effects of chemical contaminants. Five types of sediment toxicity bioassays, sediment chemical analyses, and benthic community analyses were performed with samples collected from the Oakland Inner Harbor, off Yerba Buena Island, in San Pablo Bay, off Vallejo, and in Tomales Bay. Many types of biochemical tests were conducted with starry flounder (*Platichthys stellatus*) collected at sites off Oakland, off Berkeley, in San Pablo Bay, off Vallejo, off the Russian River, and off Santa Cruz. Results of these tests are being evaluated and are expected to be published in several reports in 1990 and 1991.

NOAA has also published a review of data from many sources, including the NS&T Program, pertaining to the temporal and spatial patterns in concentrations of selected chemicals and measures of biological effects in the Bay (Long *et al.* 1988). Patterns among the various basins and peripheral areas of the Bay were discerned, and conditions in the Bay were compared to those in other regions of the Pacific coast. Data were evaluated for mercury, cadmium, copper, lead, chromium, silver, PAHs, DDT, PCBs, sediment toxicity, fish histopathological disorders, and incidence of effects on fish reproduction.

PARAMETERS

Media Analyzed: Water. Sediment. Biota.

BIOLOGICAL PARAMETERS MEASURED

bivalve gonadal state
bivalve length
bivalve weight
bivalve sex
fish external lesions
fish histopathological lesions
fish length
fish weight
fish sex
PAH metabolites in fish bile

PHYSICAL PARAMETERS MEASURED

sediment grain size

CHEMICAL PARAMETERS MEASURED

Chlorinated hydrocarbons
aldrin
alpha-chlordane
o,p' - DDD
o,p' - DDE
p,p' - DDE
o,p' - DDT
p,p' - DDT
dieldrin
endrin
heptachlor
heptachlor epoxide
hexachlorobenzene
lindane (gamma-BHC)
mirex
trans-nonachlor
PCBs
dichlorobiphenyls
trichlorobiphenyls
tetrachlorobiphenyls
pentachlorobiphenyls
hexachlorobiphenyls
heptachlorobiphenyls

octachlorobiphenyls
nonachlorobiphenyls

Polycyclic Aromatic Hydrocarbons

acenaphthene
anthracene
benz(a)anthracene
benzo(a)pyrene
benzo(e)pyrene
biphenyl
chrysene
dibenz(a,h)anthracene
2,6-dimethylnaphthalene
fluoranthene
fluorene
1-methylnaphthalene
naphthalene
perylene
phenanthrene
pyrene

Trace Elements

aluminum
antimony
arsenic
cadmium
chromium
copper
iron
lead
manganese
mercury
nickel
selenium
silicon
silver
thallium
tin
zinc

Other Parameters

Sediment TOC
Coprostanol in sediments

TAXA

Mytilus edulis
Platichthys stellatus

Genyonemus lineatus
Clostridium perfringens

METHODS

SAMPLING METHODS

For the national Mussel Watch Project, resident mussels are taken along the West Coast and the East Coast (north of Delaware Bay) and oysters are collected along the Gulf Coast, Hawaii, and the remainder of the East Coast. Two species of mussels and two species of oysters are collected. Cleaned specimens are shipped to laboratories for analysis. Six separate composites of whole tissue samples from each site are subsequently analyzed for contaminant concentrations, three for organic analysis and three for elemental analysis. Each mussel composite consists of 30 individuals.

At Benthic Surveillance sites trawls for target species of bottom fish are conducted. Starry flounder and white croaker are collected from San Francisco Bay. Livers are excised aboard ship and shipped to the laboratories. Liver samples from the Bay are split into three composites of ten livers each for organic analyses. Livers from three individuals were analyzed for trace elements.

SAMPLING FREQUENCY AND LOCATION

Number of Stations: Up to nine sites have been sampled annually.

For the NS&T program annual samples have been collected from nine sampling sites. For the Sediment Quality Triad 3 sites were sampled in 1985 only. For the Biological Effects Evaluation, 4 sites in the Bay were sampled in 1987 for sediment chemistry, sediment toxicity, and benthic community structure, and 4 other sites were sampled for measures of effects in fish.

Station	Latitude	Longitude
Semple Point	38-05	122-14
Point San Pedro	38-02	122-26
Eastern San Pablo Bay (off Rodeo)	38-03	122-17
Southhampton Shoal	37-54	122-25
Yerba Buena Island	37-50	122-20
Oakland	37-47	122-21
Hunters Point	37-43	122-20
San Mateo Bridge	37-36	122-14
Dumbarton Bridge	37-31	122-07

ANALYTICAL METHODS

The analytical methods currently being employed in the National Status and Trends Program are documented in a report published by NOAA's National Analytical Facility (NOAA 1985). Some of the methods have been changed to increase accuracy and efficiency in the analyses. Since its inception in 1976, the NAF has been at the forefront in developing advanced methods for analysis of trace amounts of toxic chemicals, especially toxic organics, in aquatic samples.

Tissue and sediment samples were first extracted with dichloromethane, and then concentrated in hexane. The samples were then separated into various fractions by chromatography on silica gel and alumina. Aromatic hydrocarbons were analyzed by capillary gas chromatography (GC) with a flame-ionization detector (FID). Chlorinated hydrocarbon concentrations were measured using GC with an electron-capture detector. Sediments were also analyzed for coprostanol, measured by GC/FID or GC/mass spectrophotometry.

QUALITY ASSURANCE TESTING AND REPORTING

In the National Status and Trends Program great emphasis is being placed on producing nationally uniform analytical results of known and accepted quality. The objective of the NS&T quality assurance program is to reduce measurement errors to less than 10% within laboratories and less than 10-20% between laboratories. In many respects this is an exemplary quality assurance program.

Standardized field sampling techniques and analytical protocols are employed. Frequent intralaboratory quality control checks are performed and documented. These include analyses of blanks, spiked samples, and replicates. One of the major deficiencies in marine pollution monitoring in the US has been a lack of standards for interlaboratory comparison. The NS&T Program has developed a set of Standard Reference Materials for marine sediments and tissues, and incorporated analysis of these materials into their analytical protocols.

Problems identified in intra- and interlaboratory testing are resolved at regular meetings of the technical specialists involved in each type of measurement. An annual quality assurance workshop for participating laboratories is held, and a biannual quality assurance newsletter is published.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: Seattle, WA and Rockville, MD

Hardware: A PRIME is used for storage of the national database. Analyses of the West Coast data have been performed in Seattle on Macintosh

	PCs and IBM computers linked to the PRIME.
Software:	Microsoft Excel and Statview for the West Coast data.
Volume of Data:	National data for the NS&T Program require approximately 5 megabytes.
Quality Assurance:	Contractors review the data for accuracy, and then transfer them electronically to NOAA.
Contact for Data Retrieval	
Name:	Jim Price
Address:	NOAA Ocean Assessments Division 11400 Rockville Pike Rockville, MD 20852
Phone:	(301) 443-8698

REFERENCES

Chapman, P.M., R.N. Dexter, S.F. Cross, and D.G. Mitchell. 1986. A field trial of the Sediment Quality Triad in San Francisco Bay. NOAA Technical Memorandum NOS OMA 25. Rockville, MD.

Long, E., D. MacDonald, M. Baker-Matta, K. Van Ness, M. Buchman, and H. Harris. 1988. Status and trends in concentrations of toxicants and measures of biological stress in San Francisco Bay. NOAA Tech. Memo. NOS OMA 41. NOAA, Office of Oceanography and Marine Assessment. Rockville, MD.

NOAA. 1985. Standard analytical procedures of the NOAA National Analytical Facility, 1985-1986: extractable toxic organic compounds (second edition). NOAA Tech. Memo. NMFS/NWAFC-92. National Oceanic and Atmospheric Administration.

NOAA. 1987*a*. National Status and Trends Program for Marine Environmental Quality: Progress report and preliminary assessment of findings of the Benthic Surveillance Project, 1984. NOAA, Office of Oceanography and Marine Assessment. Rockville, MD.

NOAA. 1987*b*. National Status and Trends Program for Marine Environmental Quality progress report: A summary of selected data on chemical contaminants in tissues collected during 1984, 1985, and 1986. NOAA Tech. Memo. NOS OMA 38. NOAA, Office of Oceanography and Marine Assessment. Rockville, MD.

~**Descriptors:** pollutants and related parameters; bay-delta; biological resources; sediments; cyclodienes; bhc; ddt; toxicity testing; sediment testing; fisheries; invertebrates; benthic infauna; physiology; abundance; benthic ecology; benthos; bioaccumulation; mussels; shellfish; water quality; water pollution; biological effects; community structure; species diversity;

GENERAL INFORMATION AND ABSTRACT

Program:	Organic Contamination in San Francisco Bay and Effects on Starry Flounder
Funding Agency:	Lawrence Livermore National Laboratory.
Principal Investigator:	Dr. Robert Spies (415) 422-5792 Lawrence Livermore National Laboratory
Conducting Agency:	Lawrence Livermore National Laboratory.
Period of Record, Earliest Date:	October, 1982
Period of Record, Latest Date:	June, 1986
Geographic Boundaries:	Samples were collected throughout San Francisco Bay, Suisun Bay and the Delta.

ABSTRACT

Researchers at Lawrence Livermore National Laboratory have conducted research for several years on toxic organic contamination in the estuary under contracts with the National Oceanic and Atmospheric Administration (NOAA). These efforts have focused in particular on the effects of polychlorinated biphenyls (PCBs) and polynuclear aromatic hydrocarbons (PAHs) on liver mixed function oxidase (MFO) activity in starry flounder, (*Platichthys stellatus*), and on the relationship between these parameters and reproductive success.

Most recently, Spies *et al.* (1988) reported the results of field studies in late 1986 and early 1987, investigating measures of contaminant exposure that might provide insight into the mode of action of contaminants on starry flounder reproduction and that might be useful in a program for monitoring estuarine fish health. Fish collected from four sites in the Bay and one site at the mouth of the Russian River were examined for: 1) trace organic levels in liver; 2) hepatic microsomal enzyme activities; 3) oocyte development in maturing females; 4) plasma concentrations of steroid hormones; and 5) incidence of nuclear abnormalities in circulating erythrocytes.

In general, hepatic concentrations of chlorinated pesticides and PCBs did not differ significantly between sites. A site near Oakland, however, had the highest observed concentrations of chlorinated hydrocarbons (including p,p-DDT, o,p-DDT, trans nonachlor, and mirex) and many PCB congeners. The most obvious overall pattern evident from measurements of hepatic P-450 proteins and their catalytic activities was that Oakland fish showed the greatest indications of contaminant induction, and those from the Russian River showed the least. Site differences

were generally not observed in plasma steroids. Nuclear abnormalities in circulating erythrocytes were significantly elevated in fish from all Bay sites relative to those from the Russian River site. Two of the eight large females collected did not have vitellogenic oocytes, indicating complete inhibition of vitellogenesis in these fish during the 1986-1987 reproductive season. Total PCB concentrations were correlated with EROD activity (an enzymatic activity catalyzed by P-450E), and EROD activity, in turn, was correlated with hepatic microsomal P-450E concentrations. The researchers recommend that immunoassays for P-450E be employed as a sensitive and potentially inexpensive measure of biochemical response of fishes to contaminants.

Earlier research involved the capture of gonadally mature starry flounder from the Bay and induction of spawning in the laboratory (Spies and Rice 1988). Observations were then made of survival of offspring through successive early life history stages, chlorinated hydrocarbon concentrations in maternal liver and spawned eggs, and maternal hepatic MFO activity (MFO activity is induced by some PAHs and PCBs). Significant negative correlations were found between MFO activity at the time of spawning and percent viable eggs, fertilization success, and embryological success. Embryological success was also negatively correlated with PCB concentrations in eggs. Starry flounder collected from a more urbanized site near Berkeley (in the Central Bay) had a lower proportion of floating eggs and poorer fertilization success than those captured at a site in northern San Pablo Bay.

Another line of inquiry examined contamination and MFO activity in fish collected from the Bay (Spies *et al.* 1988). Starry flounder were collected from the two sites mentioned above, and higher liver concentrations of PCBs and PAHs were observed in fish from the Berkeley site. MFO activity in males and immature females was significantly greater in the Berkeley population, with a particularly notable difference between sites during the time of spawning. Female starry flounder bearing yolky eggs were also collected during several successive reproductive seasons, with significantly higher MFO activity observed in the Berkeley population.

Results from these studies indicate the potential for detrimental effects of lipophilic neutral organic contaminants on reproduction of this important estuarine flatfish species. Induction of the MFO enzyme in starry flounder by PAH-type compounds appears to be widespread in San Francisco Bay.

Other recent research (Rice *et al.* unpublished) has characterized the distribution of certain PAHs, pesticides, PCBs, and benzthiazole in surficial sediments in the Bay and Delta. Sediments from enclosed waterways along the western edge of the Central Bay (Islais Creek and India Basin) and in the vicinity of the Port of Stockton in the Delta (Mormon Channel and the Port of Stockton), have total PAH concentrations that are among the highest reported on the Pacific Coast of the US. PCB concentrations found at sites around the Port of Stockton (Mormon Channel, Mormon Slough, and the Port of Stockton) also are among the highest reported on the Pacific Coast. Benzthiazole has been shown to be a component of weathered rubber, and is considered a potential chemical marker indicative of urban runoff. Relatively high concentrations of benzthiazole were found near major bridges and roadways.

|

PARAMETERS

Media Analyzed: Biota. Sediments.

BIOLOGICAL PARAMETERS MEASURED

contaminants in eggs and liver
erythrocyte micronucleus occurrence
fin erosion
fish length
gall bladder wet weight
gonad wet weight
liver wet weight
liver color melanin deposition in liver macrophages
mixed function oxidase activity number of eggs spawned
number of viable eggs
otolith age
parasites
percentage of normal larvae and viable eggs
percentage of eggs hatched and fertilized eggs
sex steroids
wet weight
white plaques on alimentary tract

PHYSICAL PARAMETERS MEASURED

sediment grain size

CHEMICAL PARAMETERS MEASURED

Chlorinated Hydrocarbons: aroclor 1242
aroclor 1254
aroclor 1260
2,2',3,4,4',5,5' heptachlorobiphenyl
2,2',3,4',5,5',6 heptachlorobiphenyl
2,2',3,3',5,5' hexachlorobiphenyl 2,2',3,3',5,5' hexachlorobiphenyl
2,2',3,3',4,4',5,5',6 nonachlorobiphenyl
2,2',3,3',4,4',5,6 octachlorobiphenyl 2,2'3,4,5' pentachlorobiphenyl
2,2',4,5,5' pentachlorobiphenyl
2,3',4,4',5 pentachlorobiphenyl
2,3',4,4' tetrachlorobiphenyl
2,2',5 trichlorobiphenyl

Other Hydrocarbons

benzthiazole 2-(4-morpholinyl)

Other Parameters

total organic carbon

Organochlorine Pesticides

aldrin
chlordane
p,p-DDD
p,p-DDE
o,p-DDT
p,p-DDT
dieldrin
lindane heptachlor
heptachlor epoxide
hexachlorobenzene
mirex
trans-nonachlor

Phthalates

butylbenzyl phthalate
dibutyl phthalate
diethyl phthalate
dioctyl phthalate

Polynuclear Aromatic Hydrocarbons

anthracene
benzanthracene
benzo(a)anthracene benzo(b)fluoranthene
benzo(k)fluoranthene benzo(g,h,i)perylene
benzo(a)pyrene
benzo(e)pyrene chrysene / triphenylene
9,10 dihydroanthracene
fluoranthene perylene
l-methyl phenanthrene
phenanthrene
pyrene

Trace Elements

cadmium
chromium
copper
lead
nickel
zinc

TAXA

Platichthys stellatus starry flounder

|

METHODS

SAMPLING METHODS

Starry flounder were collected by otter trawls. Sediments were collected using a variety of methods to take the top 2 to 5 cm. Sediments collected in conjunction with fish trawls were taken in the same general location as the trawls.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: 32

Over 400 starry flounder were collected in approximately 10- 20 feet of water, mainly during the winter months. Fish and sediments were sampled from October to February in 1982 to 1984, inclusive, and also from August 1984 to February of 1985. Sediments were sampled from February to June in 1986. These stations are listed below.

In a recent study on the effects of organic contaminants of the reproductive system of starry flounder two large collecting efforts were made; one during the middle part of the reproductive cycle, from November - early December, 1986, and one at the time of spawning, February - March, 1987. For the former period starry flounder were collected from Oakland Outer Harbor, Berkeley, San Pablo Bay, Vallejo, and near the mouth of the Russian River. Sediments were collected from Oakland Inner Harbor, Yerba Buena Island, San Pablo Bay, Vallejo, and Tomales Bay. In the latter collection (February - March, 1987), 11 females were captured near Berkeley, Oakland, or Santa Cruz.

Sampling Stations for the 1982 - June 1986 Studies

	Latitude	Longitude
1. Alameda Naval Air Station		
2. Berkeley	37-51-14	122-18-51
3.	37-51-19	122-18-51
4.	37-51-23	122-18-51
5. China Basin	37-46-38	122-23-17
6.	37-46-39	122-23-12
7. Coyote Creek		
8. Georgiana Slough	38-14-13	121-30-58
9. Guadalupe Slough		
10. Harris Harbor, Suisun Bay	38-02-57	121-57-35
11. Hunters Point	37-43-48	122-22-45
12.	37-42-47	122-21-43
13. India Basin	37-44-20	122-22-23
14.	37-44-20	122-22-17
15. Islais Creek	37-44-51	122-23-04
16. Mormon Channel, Stockton	37-56-58	121-18-12

17. Mormon Slough, Stockton	37-57-05	121-18-22
18. New York Slough, Suisun Bay	38-02-30	121-50-00
19. Oakland Outer Harbor	37-49-09	122-18-53
20.	37-49-15	122-18-48
21.	37-49-15	122-18-34
22. Oakland Middle Harbor	37-48-07	122-18-27
23. Oakland Inner Harbor	37-46-20	122-14-08
24.	37-46-25	122-14-17
25.	37-47-34	122-18-25
26. Oakland 7th Street Pier		
27. Port of Stockton turn. basin	37-57-04	121-18-22
28. Richmond	37-55-15	122-24-15
29.	37-55-06	122-24-06
30. Rio Vista	38-09-17	121-41-19
31. San Pablo Bay	38-05-27	122-26-05
32. Treasure Island	37-48-59	122-21-23

ANALYTICAL METHODS

These studies have evaluated contaminant concentrations in sediments and fish, enzyme activity, and reproductive success. Chlorinated hydrocarbons in fish tissue were analyzed by gas chromatography and electron capture detection. PAHs were analyzed using EPA Method 610, which employs HPLC (high performance liquid chromatography) and a fluorescence detector. PAHs in sediments were confirmed using GCMS (gas chromatography/mass spectrophotometry). Limited analyses for metals in sediments employed inductively-coupled plasma (ICP) emission spectroscopy.

MFO (mixed-function oxidase) activity was evaluated using an aryl hydrocarbon hydroxylase assay, in which the production of a fluorescent metabolite of benzo(a)pyrene is measured.

Detailed pathological examinations were performed, both of the whole organism and specific tissues. Sixteen features were noted in investigations of histopathological abnormalities in liver tissue, and combined to derive a liver grade score.

Fertilization success was measured in the laboratory after induction of spawning by the injection of carp pituitary hormone. Sources of variability in fertilization success attributable to laboratory manipulations were thoroughly investigated. These included effects of: partial hepatectomy, daily hormone injections, holding time, gamete handling techniques, and variability between sexes.

QUALITY ASSURANCE TESTING AND REPORTING

More recent studies by LLNL have included extensive QA testing. Rice *et al.* (unpublished), for example, analyzed external standards obtained from the National

Bureau of Standards, and a reference sediment obtained from NOAA for an interlaboratory comparison of their results. In earlier work, the researchers report that results were adjusted based on analyses of blanks and recovery percentages. Recovery data generated in the studies are summarized in the earlier reports.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location:	Lawrence Livermore National Laboratory
Hardware:	Macintosh PC, Microvax
Software:	Statview 512, SAS
Quality Assurance:	Computer entries are checked against original datasheets.
Contact for Data Retrieval	
Name:	Dr. Robert Spies
Address:	Lawrence Livermore National Laboratory P.O. Box 507 - L453, Livermore CA 94550
Phone Number:	(415) 422-5792

REFERENCES

Rice, D.W., R.B. Spies, C. Zoffman, M. Prieto, R. Severeid. Unpublished manuscript. Organic contaminants in surficial sediments of the San Francisco Bay-Delta.

Spies, R.B., B.D. Anderson, and D.W. Rice. 1987. Benzthiazoles in estuarine sediments as indicators of street runoff. Nature 327: 697-699.

Spies, R.B., K.P. Lindstrom, S.R. Wellings, J. Felton, and W. Doyle. 1985. Toxic chemicals in San Francisco Bay sediments and fish: relationships with mixed function oxidase activity and histopathological abnormalities in starry flounder (*Platichthys stellatus*). Report to the San Francisco Bay Regional Water Quality Control Board. July 1985.

Spies, R.B., and D.W. Rice. 1988. Effects of organic contaminants on reproduction of the starry flounder *Platichthys stellatus* in San Francisco Bay: Part II. Reproductive success of fish captured in San Francisco Bay and spawned in the laboratory. Marine Biology 98: 191-200.

Spies, R.B., D.W. Rice, and J. Felton. 1988. Effects of organic contaminants on reproduction of the starry flounder *Platichthys stellatus* in San Francisco Bay: Part I.

Hepatic contamination and mixed-function oxidase (MFO) activity during the reproductive season. Marine Biology 98: 181-189.

Spies, R.B., D.W. Rice, and R.R. Ireland. 1984. Preliminary studies of growth, reproduction and activity of hepatic mixed- function oxidase in *Platichthys stellatus.* Marine Environmental Research 14: 426-428.

Spies. R.B., D.W. Rice, P.A. Montagna, R.R. Ireland, J.S. Felton, S.K. Healy, and P.R. Lewis. 1985. Pollutant body burdens and reproduction in *Platichthys stellatus* from San Francisco Bay. National Oceanic and Atmospheric Administration, March 1985. UCID 19993-84.

Spies, R.B., D.W. Rice, Jr. and M. Prieto. 1988. The response of the reproductive system of *Platichthys stellatus* to organic contamination in San Francisco Bay. Final report to the National Oceanic and Atmospheric Administration. Rockville, MD.

~ **Descriptors** bay-delta; other hydrocarbons; sediment chemistry; san francisco bay; fisheries; urban runoff; pollutants and related parameters; sediments; biological resources; PCBs; PAHs; pollutant sources; reproduction; south bay; central bay; san pablo bay; parasitism; physiology; central bay; bioaccumulation; biological effects; cyclodienes; ddt;

GENERAL INFORMATION AND ABSTRACT

Program:	San Francisco Bay Effluent Toxicity Study
Funding Agency:	U.S. Environmental Protection Agency
Principal Investigator:	Donald Mount (218) 720-5528
Conducting Agency:	U.S. Environmental Protection Agency
Period of Record, Earliest Date:	1987
Period of Record, Latest Date:	1987
Geographic Boundaries Description:	Samples were collected from discharges and adjacent waters located throughout San Francisco Bay, and from urban creeks in the South Bay.

ABSTRACT

The US Environmental Protection Agency (EPA) established a program in 1986 to develop a suite of effluent toxicity test protocols for use on the Pacific coast. The first field trial of these procedures was performed in San Francisco Bay in 1987 as a result of the interest of the San Francisco Bay Regional Water Quality Control Board (Regional Board) in these techniques. The study was conducted by EPA scientists and coordinated by the Regional Board, and included toxicity bioassays using both marine and freshwater test species. This study marked the first field attempts to use EPA toxicity tests with sand-dollars, mussels, and kelp.

After preliminary screening of candidate effluents, bioassays with marine species were conducted using effluents from the Shell refinery, the City of San Francisco Southeast Water Pollution Control Plant (SFSE), and the East Bay Dischargers Authority combined discharge. Shell refinery effluent did not cause observable effects at concentrations of 10% or lower. At 32%, considerable mortality of mysids was the most significant effect, although a smaller but statistically significant reduction in sand-dollar fertilization was also found. No ambient samples were toxic to the test organisms. Effluents from the two municipal wastewater treatment plants were similar to each other. Both caused significant reduction in sand-dollar fertilization at 10% effluent, but no significant effect was observed at 3.2%. Mussel larvae exposed to the SFSE effluent experienced developmental problems at 32% effluent, but not at 10%. These results suggest that the municipal effluents were about three times as toxic as the Shell effluent, and the mysid and echinoderm sperm tests were about three times as sensitive as silverside and

mussel larvae tests. Tests conducted with kelp (*Laminaria saccharina*) were unsuccessful.

Toxicity tests using *Ceriodaphnia* were conducted from January to June 1987 with thirteen effluents from petroleum refineries, chemical manufacturing plants, and municipal wastewater treatment plants to obtain information that would be useful in formulating plans for testing in the summer of 1987. Two urban creeks were also subjected to this screening. In the summer study tests were performed on 10 effluents and 11 creeks that empty into the Bay. In total, 35 tests with 17 effluents were completed. Toxicity Identification Evaluations (TIEs), where the chemical characteristics of samples causing toxicity are investigated, were conducted on nine effluents as part of the summer study.

The most toxic effluent tested was from the City of South San Francisco, with toxicity observed at a concentration (10% in fathead minnow subchronic assays) lower than that typically observed for municipal effluents. Effluent from Shell refinery caused toxicity at concentrations of 30% in fathead minnows, *Ceriodaphnia*, and duckweed. Five effluents (from USS POSCO, Sunnyvale, Palo Alto, San Jose/Santa Clara, and Dow Chemical) were not toxic to *Ceriodaphnia* even in undiluted samples. Several urban creeks, including Calabazas Creek, Guadalupe River, San Leandro Creek, Codornices Creek, and Elmhurst Creek caused significant mortality in *Ceriodaphnia* assays. Calabazas Creek was also toxic to fathead minnows. Results of an in-depth TIE of effluent from the Central Contra Costa Sanitary District suggested that malathion and diazinon may be the cause of the toxicity observed for that effluent.

PARAMETERS

Media Analyzed: Water

BIOLOGICAL PARAMETERS MEASURED

chlorophyll in pigment of duckweed
fish weight
fertilization in *Dendraster*
larval development in *Mytilus edulis*
number of fronds in *Lemna minor*
reproduction of *Ceriodaphnia*

PHYSICAL PARAMETERS MEASURED

flows and dilutions through dye studies

CHEMICAL PARAMETERS MEASURED

benzene sulfonamide (4-methyl-N-propyl)
benzene sulfonamide N-butyl
benzene sulfonylchloride 2-methyl
benzene triethoxy methoxy

benzene carbothioc acid
benzoic acid acid phenylmethyl ester
benzoic acid phenylmethyl ester
benzoic acid 2-methylpropyl ester
benzothiazole 2-(methylthio)
bicyclo [2,2,1] heptane-1-methonesulfonic acid-7,7-dimethyl
cypropane carbonitrile 1-(4-chlorophenyl)
dichlorobenzene
dichlorophenol
diazinon
ethanol-2-butoxy phosphate
ethanol 2-chlorophosphate
ethanol 2,2-dimethoxy-1,2-diphenyl
ethanol 2-[2-[4-(1,1,3,3-tetramethylbutyl)phenoxy]ethoxy]
ethanone (1,2,5-dimethylphenyl)
malathion
methane diphenyl
methanone, diphenyl
delta 2-(1,3,4-oxadiazolin-5-one, 2-ethyl-4-phenyl)
phenol 3-(1,1-dimethylethyl)
phenol 2,6-bis(1,1-dimethylethyl)-4-methyl
phenol 4-(1,1,3,3,-tetramethylbutyl)
phenol 4-(2,2,3,3,-tetramethylethylbutyl)
propoxur
quinoxaline

PAHs

1,4-methanonaphthalene 1,4-dihydro
methanonaphthalene 1,4-dihydro
naphthalene

TAXA

Arbacia punctulata	sea urchin
Ceriodaphnia dubia	cladoceran
Dendraster excentricus	sand dollar
Laminaria saccharina	kelp
Lemna minor	duckweed
Menidia beryllina	inland silverside
Mysidopsis bahia	mysid shrimp
Mytilus edulis	mussel
Pimephales promelas	fathead minnow

METHODS

SAMPLING METHODS

Effluent samples were collected daily. Ambient samples collected near Shell's discharge and from a reference site in the Central Bay (at the end of the Berkeley Pier) were also collected daily. Samples collected near the zone of initial dilution of the San Francisco Southeast (SFSE) discharge were also gathered on days when SFSE effluent samples were collected.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: A total of approximately 30 sites were sampled.

Field testing of a suite of toxicity test protocols with west coast marine organisms began in 1987. Early that year, two separate rounds of preliminary toxicity screening tests were performed to evaluate the toxicity of candidate effluents for the field study. These tests were conducted at Duluth, Minnesota, and in Narragansett, Rhode Island.

It was decided, from these results, to conduct effluent and receiving water tests at the Shell refinery outfall into Suisun Bay. In addition, the effluent from San Francisco Southeast (SFSE) was selected for more limited effluent toxicity testing. Samples from Shell and SFSE outfalls, and reference sites, were collected from July 21-27, 1988 (Chapman 1988).

1. Shell Refinery
2. near Chipps Island (reference site)
3. East Bay Municipal Utilities District
4. San Francisco South East Water Pollution Control Plant
5. Islais Creek
6. reference site located near the end of the Berkeley pier

Screening tests were conducted with effluents from the facilities listed below between January and June of 1987 at both the Duluth and Narragansett laboratories (Chapman 1988).

1. San Jose-Santa Clara POTW
2. Sunnyvale POTW
3. Palo Alto POTW
4. East Bay Municipal Utilities District
5. Central Contra Costa Sanitary District
6. City of San Francisco
7. City of South San Francisco
8. City of South San Francisco/San Bruno
9. East Bay Dischargers Authority

10. USS Posco (formerly US Steel)
11. UNOCAL refinery
12. Chevron refinery
13. TOSCO refinery
14. Exxon refinery
15. Shell Oil refinery
16. Dow Chemical Company
17. Stauffer Chemical (Martinez)

Samples were collected from the following urban creeks in March of 1987 (Norberg-King *et al.* 1988).

South Bay Sites

1. Oregon Expressway - At the Expressway and the Southern Pacific tracks in Palo Alto (no creek specified)

2. Calabazas Creek - at Highway 101

3. Guadalupe River downstream - near Trimble Road

4. Guadalupe River upstream - sample collected at Willow Road, south of Highway 280

5. Coyote Creek downstream - sample collected at Montague

6. Coyote Creek upstream - sample collected at Williams Street at the Williams Street Park, just N of Highway 280

East Bay Sites

7. San Leandro - end of Empire Road, off the Davis St. exit of Highway 880

8. Strawberry Creek - downstream of the south fork of the creek, in the eucalyptus grove at the west central portion of the UC Berkeley campus

9. Codornices Creek - near Gilman and Santa Fe streets in Berkeley

10. Cerritos Creek - near the El Cerrito Plaza

North Bay

11. Walnut Creek - near the bridge on Willow Pass Road

In addition to the above, samples were collected from these sites for screening tests.

12. Arroyo at the Park

13. Elmhurst Creek downstream

14. Elmhurst Creek upstream

ANALYTICAL METHODS

Some marine and freshwater bioassays were conducted in a mobile laboratories. In addition to the control waters collected from sites in the Bay, laboratory control waters used in tests.

Marine Bioassays

The following marine toxicity tests were performed: inland silverside (*Menidia beryllina*) were exposed to varying dilutions of test waters for 7 days with survival and growth as endpoints; mysid shrimp (*Mysidopsis bahia*) juveniles were exposed for 7 days with survival, growth, and number of eggs as endpoints; sand- dollar (*Dendraster excentricus*) sperm were exposed to test solutions for 60 minutes, and after addition of eggs fertilization success rates were measured; blue mussel (*Mytilus edulis*) embryos were exposed to test solutions for 48 hours, with an endpoint of development to the larval stage; and kelp (*Laminaria saccharina*) gametophytes were exposed for 48 hours, followed by 48 hours of growth in control water, with an endpoint of the number of sporophytes produced. This field study marked the first attempts to use sand-dollars, mussels, and kelp in EPA effluent toxicity field tests.

Freshwater Bioassays

The freshwater species *Ceriodaphnia dubia* was used in screening effluents and urban creeks in early 1987. Tests were run at the EPA Environmental Research Laboratory in Duluth, MN, with seven day exposures to dilution series of the effluent. In the summer testing the following freshwater bioassays were used: *Ceriodaphnia dubia* tests were performed as described above, with mortality and reproductive success as endpoints; fathead minnow (*Pimephales promelas*) larvae were exposed to dilutions of effluent for seven days with mortality and growth as endpoints; duckweed (*Lemna* spp.) fronds were exposed for 96 hours, and then measured for frond production and pigment concentrations.

Toxicity identification evaluations (TIEs) were also performed on two of the effluents which were tested for toxicity. TIEs were carried out by serial manipulations of the sample to separate different classes of chemicals from it. In these TIEs the following steps were performed on separate aliquots of effluent and then toxicity tests were conducted on each sample with *Ceriodaphnia*: addition of sodium thiosulfate (to remove oxidants) and ethyldiaminetetraacetate (EDTA, to remove chelatable metal cations); aeration (to remove volatile chemicals); passing the sample through a Solid Phase Extraction column (to remove non-polar compounds). Effluents were subsequently analyzed for presence of organics by mass spectrometry/gas chromatography.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: Environmental Research Laboratory, Duluth MN

Hardware: VAX

Software: VAX DOS

Quality Assurance:
Computer entries checked against original data sheets.

Contact for Data Retrieval

Name: Teresa Norberg-King (freshwater data only)

Address: Environmental Research Laboratory
6201 Congdon Blvd.
Duluth MN 55804

Phone: (218) 720-5529
OR
Gary Chapman (marine data only)
Pacific Division
Environmental Research Laboratory, Narragansett
Hatfield Marine Science Center
Newport OR 97365
(503) 867-4027 or
(503) 867-0100 (main desk)

Data Access: Available to the public

Data Availability Date: Immediately

REFERENCES

Report Location: San Francisco Regional Water Quality Control Board, contact Susan Anderson (415) 464-1346.

Chapman, G.A. 1988. Draft Report: 1987 San Francisco Bay effluent toxicity study: Toxicity of effluents discharged into San Francisco Bay from East Bay Dischargers Association and City of San Francisco Southeast Municipal Treatment Plants and from a Shell Refinery discharge into Suisun Bay July 20-28, 1987. U.S. Environmental Protection Agency, ERL-Narragansett, Pacific Division. Newport, Oregon. 25 pages.

Norberg-King, T.J., D.I. Mount, J.R. Amato, and J.E. Taraldsen. 1988. Draft Report: Application of the water quality based approach on a regional scale: Toxicity testing and identification of toxicants from the San Francisco Bay region. National Effluent Toxicity Assessment Center Technical Report 01-88. U.S. EPA, Duluth, MN. 63 pages.

~**Descriptors:** POTWs; refineries; suisun bay; carquinez strait; bay-delta; san pablo bay; central bay; south bay; west delta; pesticides; chlorinated solvents; MAHs; pollutants and related parameters; PAHs; phenol; effluent testing; toxicity testing; pollutant sources; point sources; ambient testing; water quality; nonpoint sources; water pollution; organophosphates;

GENERAL INFORMATION AND ABSTRACT

Program:	Selenium Verification Study
Funding Agency:	State Water Resources Control Board
Principal Investigator:	James White (209) 466-4421 Department of Fish and Game
Conducting Agency:	California Department of Fish and Game
Period of Record, Earliest Date:	January, 1986
Period of Record, Latest Date:	Present
Geographic Boundaries Description:	Samples are collected from 25 locations statewide; approximately 19 of these stations are located in the San Francisco Bay and Delta. These sampling sites range from the South Bay upstream to Antioch on the San Joaquin River and Clarksburg on the Sacramento River.

ABSTRACT

The Selenium Verification Study was initiated in December 1985 as one element of the State Water Resources Control Board (State Board) study entitled "Selenium and Other Trace Elements in California". The purpose of the Verification Study is to provide a detailed assessment of selenium and trace elements in birds, fish, and aquatic invertebrates from previously identified areas of potential concern. The Study is conducted by the Department of Fish and Game under an agreement with the State Board.

The areas investigated include: the San-Francisco Estuary, including Suisun Marsh; agricultural drainage evaporation ponds in Kern County; Salton Sea; the Stony Creek Drainage; and the San Joaquin River system in western Merced County. Also sampled were areas thought to be representative of background levels of selenium, including: Humboldt Bay; Gray Lodge State Wildlife Area; and the Sacramento National Wildlife Refuge. Since tissue selenium burdens in species at higher trophic levels apparently become elevated through ingestion of contaminated food sources, species at several trophic levels and with diverse food habits were chosen for examination. Birds included several species of diving ducks, dabbling ducks, shorebirds, the American coot (*Fulica americana*), and the double-crested cormorant (*Phalacrocorax auritus*). From coastal estuaries both pelagic and benthic fish species, in addition to several commonly occurring molluscs and crustaceans.

The most recent published findings from this program cover sampling from September 1987 through May 1988 (DFG 1989). This sampling effort focused on Suisun and San Pablo bays, the Sacramento-San Joaquin Delta, the lower San Joaquin River, and four agricultural drainwater evaporation ponds in the southern San Joaquin Valley. The species with elevated tissue selenium levels were either bottom-dwellers or species with diets comprised largely of benthic organisms. Based on preliminary data from this study, the Department of Health Services in September 1986 issued an advisory recommending limited consumption of scaup and surf scoters from Suisun Bay. Consistent with previous findings (DFG 1988), diving ducks wintering on Suisun and San Pablo bays had higher selenium concentrations than were measured in their counterparts from Humboldt Bay. Selenium levels in surf scoter tissues increased up to two fold during the winter months when these migratory birds were using Suisun and San Pablo bays. This increase was most pronounced for Suisun Bay scoters which had selenium levels higher, on average, in both muscle and liver tissue than scoters from San Pablo Bay. Selenium levels in the tissues of scaup and scoters from both bays were significantly higher in late winter 1988 than in the same period in 1986, with 1987 levels being intermediate although not always significantly different from 1986 or 1988. This limited data suggests that diving ducks wintering on Suisun and San Pablo bays may have accumulated selenium to progressively higher levels each year since 1986.

To date no biological effects of selenium have been observed on diving ducks wintering in California, and because they breed in Canada and Alaska, potential reproductive impacts have not been studied. Histopathological examination of tissues of diving ducks from Suisun and San Pablo bays with the highest levels of selenium in their tissues revealed no abnormal conditions attributable to selenium.

Bioaccumulation factors measured in 1987-88 were greater than those in 1986-87; however it is not known whether this difference is significant due to the small sample size. In 1986-87 diving ducks in Suisun Bay accumulated selenium up to 30,000 times the concentration dissolved in Bay water; in 1987-88 the accumulated selenium was up to 1,200,000 the concentration dissolved in Bay water. Accumulation of selenium from water by phytoplankton may account for much of this biomagnification. Bioaccumulation of selenium in mussels and oysters transplanted to sites in San Francisco Bay indicated selenium enrichment in areas near oil refineries in Suisun Bay and San Pablo Bay and near municipal and industrial discharges in South Bay. Striped bass (*Morone saxatilis*) and white sturgeon (*Acipensar transmontanus*) from the estuary had higher levels in spring 1987 than in early 1986, but the effect of this contamination is unknown. The 1988 levels for striped bass were lower than in 1987 but higher than in 1986. The 1988 levels for white sturgeon were lower than in either preceeding year.

Two-hundred eighty-one selected samples of bird and fish livers, invertabrates and water from 1986-88 sampling were sent to the California Veterinary Diagnostic Laboratory System's Toxicology Laboratory at U.C. Davis for analysis of twenty trace and toxic elements. Some of the samples collected had elevated levels of arsenic, chromium, copper, mercury, nickel, and zinc which could be considered above background levels. Water samples from some of the evaporation ponds had arsenic levels approaching a level which may be of concern for sensitive aquatic species, and copper levels which may exceed the EPA criterion for the protection of freshwater aquatic life. All other samples with trace element concentrations above background levels did not represent conclusive evidence of detrimental impacts to aquatic life.

PARAMETERS

Media Analyzed Biota. Sediment. Water.

BIOLOGICAL PARAMETERS MEASURED
species age, sex and weight

PHYSICAL PARAMETERS MEASURED
specific conductance

CHEMICAL PARAMETERS MEASURED
Trace Elements
arsenic
cadmium
chromium
copper lead
manganese
molybdenum
mercury
selenate
selenide
selenite
selenium
silver
zinc

TAXA
Species for which chemical analyses were performed:

Acanthogobius flavimanus	yellowfin goby *
Acipenser transmontanus	white sturgeon
Anas acuta	pintail
Anas americana	American wigeon *
Anas clypeata	northern shoveler
Anas cyanoptera	cinnamon teal *
Anas platyrhynchos	mallard
Artemia salina	*brine shrimp*
Aythya affinis	lesser scaup
Aythya marila	greater scaup
Aythya valisneria	canvasback

Bairdiella icistia	croaker *
Botaurus lentiginosuss	American bittern
Cancer magister	dungeness crab *
Catoptrophorus semipalmatus	willet *
Catostomus occidentalis	Sacramento sucker *
Citharichthys stigmaeus	speckled sanddab *
Clupea harengus pallasi	Pacific herring *
Corbicula fluminea	Asiatic freshwater clam
Crangon spp.	bay shrimp *
Cynoscioin xanthulus	orangemouth corvina *
Cyprinus carpio	common carp *
Engraulis mordax	northern anchovy *
Fulica americana	American coot
Gambusia affinis	mosquitofish *
Himantopus mexicanus	black-necked stilt *
Ictalurus catus	white catfish
Ictalurus nebulosus	*brown bullhead*
Ictalurus punctatus	channel catfish
Lepomis cyanellus	*green sunfish*
Leptocottus armatus	Pacific staghorn sculpin •
Lutra canadensis	river otter *
Macoma balthica	baltic clam
Macoma nasuta	bent-nosed clam
Melanitta perspicillata	surf scoter
Micropterus salmoides	largemouth bass *
Morone saxatilis	striped bass
Musculus senhousia	fingernail mussel
Mya arenaria	softshell clam *
Oxyura jamaicensis	*ruddy duck*
Parophrys vetulus	English sole •
Phalacrocorax auritus	double-crested cormorant *
Platichthys stellatus	starry flounder *
Potamocorbula spp	*potamocorbula spp*
Protothaca staminga	*littleneck clam*
Recurvirostra americana	American avocet *
Spirinchus thaleichthys	longfin smelt *
Tapes japonica	Japanese littleneck
Tilapia sp.	tilapia *
Corixidae	waterboatman *

* only used in first study

Species noted in waterfowl food habits survey

Annelida	polychaete tube worms
Balanus spp.	
Barleeia haliotiphila	gastropod
Cancer antennarius	
Clupea harengus	

Corbicula fluminea	
Crustacea	
Malacostracans	
Fusinus luteopictus	gastropod
Macoma balthica	
Macoma nasuta	
Mitrella spp.	
Musculus senhousia	
Mya arenaria	
Nassarius obsoletus	
Potamogeton pectinatus	
Rhithropanopeus harrisii	
Ruppia maritima	
Scirpus	
Tapes Protothaca	
Transenella spp.	bivalve
Urosalpinx cinerea	

METHODS

SAMPLING METHODS

Many species of birds, fish, and invertebrates were collected. Birds were collected using 12 gauge shotguns and steel shot. In order to reduce intraspecific variation, adult males were collected when identification and availability permitted. Females and immature birds collected inadvertently were analyzed and included in the results. Livers were removed from all birds, and breast muscle for some; tissues were subsequently analyzed at the DFG Fish and Wildlife Water Pollution Control Laboratory (FWWPCL).

Fish were collected by a variety of methods, including otter and mid-water trawls, an electrofisher, gill nets, and beach seines. Waterboatmen were collected with a kicknet. Clams and mussels were obtained with shovels and by hand. All species were delivered to the FWWPCL for dissection.

SAMPLING FREQUENCY AND LOCATION

Number of sampling stations: Nineteen in the Bay-Delta.

A total of 25 stations are sampled statewide; approximately 19 of these are located in the Bay and Delta. Sample collection is varied, although several samples of invertebrate, birds, and fish are collected each year.

Water samples were collected at nine sites; these site numbers, (which are described below) are: 1, 5, 9, 10, 11, 12, 13, 14, and 20. Benthic sediment samples were collected at nine of the sites listed below.

To assess bioconcentration processes in Suisun Bay, birds, *Corbicula*, and sediments samples were collected in late January and early April 1987 at two sites in Suisun Bay on each of four consecutive slack tides.

California mussels (*Mytilus californianus*), and the oyster (*Crassostrea gigas*) were deployed for 2 months at a total of 26 locations near municipal and industrial discharges, and at several other sites throughout the Bay. These sites are described below under the heading "Mussel and Oyster Sampling Sites".

Collection Sites of Fish, Invertebrate and Birds

	Latitude	Longitude
1. Antioch The San Joaquin River near Schad Landing, approx. 7 km upstream of Antioch Bridge.	38-03	121-42
2. Central San Francisco Bay Between the Richmond-San Rafael Bridge, the Golden Gate, and the Oakland-Bay Bridge.	37-54	122-25
3. Sacramento River at Clarksburg	38-26	121-31
4. Clifton Court Forebay Approximately 7 km southeast of Byron.	37-51	121-35
5. Goodyear Slough East of Highway 680, approximately 10 km northeast of Benicia.	38-07	122-06
6. Gray Lodge State Wildlife Area Off Pennington Rd approx 16km SW of Gridley.	39-29	121-48
7. Sacramento River near Gridley		
8. Mayberry Slough Approximately 4 km north of Antioch.	38-02	121-49
9. Mossdale San Joaquin River near Interstate 5 Bridge, 8 km west of Manteca.	37-48	121-18
10. Mud Slough 200 meters N of the end of the San Luis drain at Kesterson National Wildlife Refuge.	37-48	122-18

11. Rio Vista Sacramento R at the mouth of Steamboat Slough, upstream from Rio Vista.	38-10	120-51
12. Salt Slough Upstream from the Lander Avenue (Highway 165) crossing.	37-15	120-51
13. Lander Road San Joaquin River downstream from the Lander Avenue (Highway 165) crossing.	37-18	120-50
14. Merced River San Joaquin River just downstream from its confluence with the Merced River.	37-21	120-58
15. San Jose Water Treatment Plant The slough channel extending S from Coyote Creek to the San Jose Sewage Disposal Plant, 3 km north of Alviso.	37-27	121-58
16. San Pablo Bay N of the Richmond-San Rafael Bridge and west of the Carquinez Bridge.	38-03	122-23
17. South San Francisco Bay South of the Oakland-Bay Bridge.	37-38	122-15
18. Suisun Bay Between the Carquinez Bridge and Antioch, including Grizzly Bay.	38-04	122-03
19. Suisun Marsh On Grizzly Island Wildlife Area, South of Fairfield.	38-08	121-57
20. Vernalis San Joaquin River south of the Highway 132 crossing, 10 km east of Vernalis.	37-36	121-10

Mussel and Oyster Sampling Sites

Suisun Bay / Carquinez Strait
1. Suisun Bay Channel Marker 11
2. Inner E Avon Pier
3. W. End of Avon Pier (Tosco)
4. High voltage platform - Suisun

5. Exxon Outfall East
6. Exxon Railroad Bridge
7. East end of west Shell Pier
8. SE Benicia / Martinez Bridge

San Pablo Bay
9. Unocal Pier base
10. Unocal Outfall
11. North Unocal Outfall
12. Bennett's Marina
13. Point Pinole
14. Castro Cove entrance
15. Castro Cove mid-channel
16. Castro Cove upper channel
17. Castro Cove Bridge (Chevron)
18. Point San Pablo Yacht Harbor
19. Point San Pablo

South Bay
20. Hayward Outfall 1
21. Hayward Outfall 4
22. Palo Alto
23. San Francisquito Creek
24. Coyote Creek Bridge
25. Alviso Slough Tower
26. Channel 18

ANALYTICAL METHODS

Preparation of samples was begun less than 6 months after collection. All samples were prepared in a "clean room" to minimize contamination.

Levels of selenium in tissue were determined by hydride generation atomic absorption (HGAA). Fifty percent of the samples analyzed for selenium were also measured using Zeeman- corrected graphite furnace atomic absorption (GFAA). Twenty percent of the samples were tested in duplicate by Neutron Activation Analysis (NAA) at the University of Missouri Research Reactor. Trace element levels in tissue are analyzed at the Veterinary Diagnostic Toxicology Laboratory (VDTL) at UC Davis. Selenium, silver, arsenic, cadmium, chromium, copper, mercury, and zinc will be analyzed. A report describing these results is being prepared. Two US Fish and Wildlife Service laboratories also performed analyses for comparison with trace element results from the FWWPCL and VDTL. The Patuxent Wildlife Research Center tested 11 bird samples, and the National Fisheries Contaminant Research Center tested 10 fish samples.

Selenium concentrations in water were determined by NAA at the University of Missouri. Both field replicates and subsampled duplicates were analyzed. Ten samples and a field blank were also analyzed by the Department of Water

Resources Bryte Laboratory using HGAA. Also, the FWWPCL measured selenium in 21 samples using a new technique of dry-ashing the sample prior to HGAA. Other trace element (arsenic, silver, cadmium, chromium, copper, mercury, manganese, molybdenum, and zinc) levels in water are to be measured by the VDTL. Eighteen samples were analyzed at the Bryte Laboratory for interlaboratory comparison.

QUALITY ASSURANCE TESTING AND REPORTING

After analysis was completed, a portion of each sample was sent to UC Davis to be archived at -80 degrees centigrade. Analytical blanks were carried through with each group of samples measured for selenium to detect contamination by reagents.

In analyses of selenium in tissue, 10% of HGAA and GFAA samples were done in duplicate. The relative standard deviation (RSD) for HGAA averaged 1.7%, while the RSD for GFAA averaged 4.2%. National Bureau of Standards reference materials were analyzed with every batch of samples to verify accuracy. Accuracy was within 5% of reference materials for HGAA and GFAA measurements of oyster, and within 1.4% for bovine liver. In analyses of tuna reference tissue, HGAA was 6% above the known concentration, while GFAA was 25% too high.

As described under "Analytical Methods", analyses were repeated by several labs to allow interlaboratory comparisons. Regression analysis of selenium results using three different methods found acceptable agreement between paired results and consistent performance by the respective analytical instruments across the range of concentrations measured.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: Bay-Delta Project, Stockton

Hardware: IBM

Software: dBase III+

Quality Assurance: Keyed data are compared to original data sheets.

Contact for Data Retrieval

Name: James White
Department of Fish and Game
4001 North Wilson Way
Stockton CA 95205

Phone: (209) 466-4421

Access: Public information

Data Availability Date:
Available when finalized and keyed data entry has been proofed.

REFERENCES

White, J.R., D.H. Hammond, and S. Baumgartner. 1988. Selenium verification study, 1986-1987. Report to the State Water Resources Control Board. California Department of Fish and Game, Bay-Delta Project. Stockton, Ca.

White, J.R., P.S. Hofmann, D. Hammond, and S. Baumgartner. 1987. Selenium verification study 1986: A report to the State Water Resources Control Board. Department of Fish and Game, Bay-Delta Project. Stockton, CA.

White, J.R., P.S. Hoffman, K.A.F. Urquhart, D.H. Hammond, and S. Baumgartner. 1989. Selenium verification study, 1987-88. Report to the State Water Resources Control Board. California Department of Fish and Game, Bay-Delta Project. Stockton, Ca.

~**Descriptors:** bay-delta; san francisco bay; san pablo bay; central bay; suisun bay; suisun marsh; biological resources; fisheries; birds; invertebrates; point sources; pollutant sources; histopathology; mammal; sediment chemistry; sediments and dredging; water chemistry; water pollution; water quality; bioaccumulation; POTWs; refineries; food chains; clams; shellfish; crabs; mussels; oysters; waterfowl; water birds; herons; shorebirds;

GENERAL INFORMATION AND ABSTRACT

Program: South San Francisco Bay Avian Botulism Study

Funding Agency: South Bay Dischargers Authority

Principal Investigator: Peg Woodin
San Francisco Bay Bird Observatory

Conducting Agency: San Francisco Bay Bird Observatory
California Department of Fish and Game

Study Cost: $60,000

Period of Record, Earliest Date: July, 1982

Period of Record, Latest Date: October, 1986
From 1986 to present for dead and dying bird counts only

Length of Record: 5 years, 3 months for main study

Geographic Boundaries Description: This study took place in South San Francisco Bay, and encompassed the entire length of Artesian (or Mallard) Slough; part of Coyote Creek, upstream of the mouth of Artesian Slough; and for part of the study, Alviso and Guadalupe Sloughs.

ABSTRACT

The California Department of Fish and Game (CDFG) and the San Francisco Bay Bird Observatory (SFBBO) were subcontracted by Larry Walker Associates, Inc. and Kinnetics Laboratories, Inc. to take part in the five year biological and water quality monitoring program sponsored by the South Bay Dischargers Association. The role of CDFG and SFBBO was to assess the effects of wastewater discharge from the San Jose/Santa Clara Water Pollution Control Plant on the occurrence of avian botulism in the Artesian Slough and Coyote Creek area. The study included collection of sick and dead vertebrates to document and control outbreaks of the disease, identification and testing of benthic invertebrates for botulism toxin, and monitoring water quality parameters throughout Artesian Slough and Coyote Creek.

During each of the five years of the study avian botulism attributable to *Clostridium botulinum* type C was observed in the sick and dead invertebrates collected. The largest numbers of sick and dead birds were collected in 1982, when

409 birds, mostly from Artesian Slough, were found. The stagnant, anoxic, warm waters found in parts of the upper marsh in the study area are thought to favor growth and reproduction of *C. botulinum*. None of the benthic invertebrate samples tested positive for the bacterium.

Since the end of this study, dead and dying bird counts have been taken by the Sunnyvale and San Jose/Santa Clara Water Districts as part of their water pollution control plant discharge permit conditions. Yearly reports are produced. No other data are gathered.

PARAMETERS

Media Analyzed: Biota. Water.

BIOLOGICAL PARAMETERS MEASURED
age, sex, and species abundance of birds
Clostridium presence

PHYSICAL PARAMETERS MEASURED
air temperature
sediment temperature

CHEMICAL PARAMETERS MEASURED
dissolved oxygen
electrical conductivity
salinity
turbidity
water temperature

TAXA
Invertebrates

	acorn worms
Chaoboridae	phantom midge
Chironomidae	midges
Cladocera spp.	water fleas
Clostridium botulinum	anaerobic bacterium
Corixidae	water boatman
Cyclopoida spp.	cyclops
	clams
	clamshrimp
	foraminifera
Harpacticoida spp.	harpacticoids
	leeches
	roundworms
	springtails
Homoptera spp.	aphids

Isopoda spp.	sow bug, aquatic
Lepidoptera spp.	butterflies/moths
Natantia	grass shrimp
Notonecta	backswimmer
Odonata spp.	dragonflies
Podocopa spp.	seed shrimp
Prosobranchia spp.	snails, aquatic
Psychodidae	moth flies
Repantia	crabs
Thoracica spp.	barnacle (larva)
Tipulidae	crane flies
Tubificidae spp	tubifex worms
Turbellaria spp.	flatworms

Fish

Acipenser transmontanus	white sturgeon
Cyprinus carpio	carp
Morone saxatilis	striped bass
Oncorhynchus mykiss	steelhead trout

Birds

Agelaius phoeniceus	red-winged blackbird
Anas acuta	northern pintail
Anas clypeata	northern shoveler
Anas crecca	green-winged teal
Anas cyanoptera	cinnamon teal
Anas discors	blue-winged teal
Anas platyrhynchos	mallard
Anas strepera	gadwall
Ardea horodias	great blue heron
Bubulcus ibis	cattle egret
Calidris mauri	western sandpiper
Casmerodius albus	great egret
Cathartes aura	turkey vulture
Catoptrophorus semipalmatus	willet
Cirus cyaneus	northern harrier
Cistothorus palustris	marsh wren
Egretta caerules	little blue heron
Egretta thula	snowy egret
Elanus caeruleus	black-shouldered kite
Falco sparverius	American kestral
Fulica americana	American coot
Gallinula chloropus	common moorhen
Geothlypis trichas sinuosa	salt marsh yellowthroat
Himantopus mexicanus	black-necked stilt
Hirundo pyrrhonota	cliff swallow
Hirundo rustica	barn swallow

Larus argentatus	herring gull
Larus californicus	california gull
Larus delawarensis	ring-billed gull
Larus occidentalis	western gull
Limnedromus scolopaceus	long-billed dowitcher
Limosa fedoa	marbled godwit
Limnedromus grisene	short-billed dowitcher
Melospiza melodia	song sparrow
Numenius americans	long-billed curlew
Nycticorax nycticorax	black-crowned night heron
Oxyura jamaicensis	ruddy duck
Pelecanus erythrorhynchas	American white pelican
Phalacrocorax auritus	double-crested cormorant
Phalaropus lobatus	red-necked phalarope
Phasiansus colchicu	ring-necked pheasant
Podiceps	grebe
Porzana carolina	sora
Recurvirostra americana	American avocet
Sterna forsteri	Forster's tern
Tyto alba	common barn-owl
Zenaida macroura	mourning dove
Mammals	
Bos taurus	domestic cattle
Phoca vitulina	harbor seal
Ondatra zibethicus	muskrat
Rattus norvegicus	norway rat

METHODS

SAMPLING METHODS

Occurrence and abundance of wildlife species were recorded on a weekly basis in the study areas. Sick and dead birds and other vertebrates were collected. Blood serum from sick birds was used in assays (the Mouse Protection Test [MPT]) to determine the presence of *Clostridium botulinum* type C. Treatment of sick birds exhibiting symptoms of avian botulism was attempted. Birds that eventually recovered were banded and released.

When the study began in 1982 benthic samples were collected using a modified epibenthic sampling sled. The sled was pulled for 100 m at each site, collecting mud primarily from the subtidal zone. Material collected in this manner was stored in bottles and transported to the laboratory. In 1984 the sled sampler was replaced by a modified benthic grab apparatus. This grab sampler collected material in the upper 10 cm of the sediments.

Each year water quality measurements were made at 5 sites once or twice weekly during the study period. Sampling was performed at high tide as some sites were inaccessible at low tide. All water quality parameters were measured in the field; these included dissolved oxygen, salinity, temperature, and turbidity. At each station measurements were taken both near the surface and near the bottom of the water column.

The MPT was also performed with chicken meat placed in the study areas to determine the potential for on-site incubation of *C. botulinum.* Fly maggots from bird and fish carcasses were also tested.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: Eight

Eight stations were sampled for 4 months each year, during the time of year when avian botulism outbreaks were most likely to occur. In 1982, samples were collected from July through November; from 1983 through 1986, inclusive, samples were collected from June through October.

Five of these stations were located in Artesian Slough; 1 station was in Coyote Creek, and 2 were on the west side of Artesian Slough in channels running parallel to the main channel. In 1986 the study area was enlarged to include Guadalupe Slough, an area which included approximately 6 kilometers of the slough from the Highway 237 bridge, where San Tomas Aquinas Creek enters the slough, to Coyote Creek.

ANALYTICAL METHODS

At the laboratory, samples were washed through four nested sieves ranging in mesh size from 2.0 mm to 0.0104 mm. Live and dead invertebrates were examined and classified. To test for the presence of *C. botulinum* type C in these invertebrates a portion of each sample was pulverized, passed through a 0.45 um filter, and subjected to the MPT.

Over the five years of this study MPTs were performed on benthic samples, on blood serum from sick birds, on chicken meat placed in the study area, and on fly maggots from bird and fish carcasses. In this test, two sets of mice were injected with sample material suspected of containing type C toxin. One set also received antitoxin to type C toxin (the "protected" set). The test is positive when the unprotected mice die, while the protected mice survive.

The ELISA was also used on some samples to test for the type C toxin. This assay was performed by the California Department of Fish and Game (CDFG) Wildlife Investigations Laboratory. The assay is considered an improvement over the cumbersome MPT, but a protocol for it has not yet been established. Initial efforts by the CDFG lab to develop such a protocol could not be pursued to completion.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Contact for Data Retrieval:

Name: Peg Woodin
San Francisco Bay Bird Observatory

Address: P.O. Box 247
Alviso CA 95002

REFERENCES

Kinnetic Laboratories, Inc. and Larry Walker Associates. 1987. South Bay Dischargers Authority Water Quality Monitoring Program - final monitoring report. Prepared for the South Bay Dischargers Authority, San Jose, CA.

Larry Walker Associates and Kinnetic Laboratories, Inc. 1987. South Bay Dischargers Authority Water Quality Monitoring Program - final technical report. Prepared for the South Bay Dischargers Authority, San Jose, CA.

San Francisco Bird Observatory. 1987. South Bay Dischargers Authority Water Quality Monitoring Program: South San Francisco Bay avian botulism study. Prepared for the South Bay Dischargers Authority, San Jose, CA.

~**Descriptors:** bay-delta; waterfowl; bacteria; NPDES; invertebrates; water quality; biological resources; clams; shrimp; crabs; south bay; benthos; fisheries; birds; shorebirds; cdfg; shellfish; POTWs; biological effects; point source; pollutant sources; dabbling ducks; diving ducks; water birds; herons;

GENERAL INFORMATION AND ABSTRACT

Program:	South Bay Dischargers Authority Biological Studies
Funding Agency:	Funds were administered by the SWRCB: Federal Clean Water Grant Funds 75% State Clean Water Grant Funds 12.5% South Bay Dischargers Authority 12.5%
Principal Investigator:	Marty Stevenson Kinnetic Laboratories, (808) 874-7530 Thomas Grouhoug Larry Walker Associates, Inc.
Conducting Agency:	Larry Walker Associates, Inc. Kinnetic Laboratories, Inc. Harvey and Stanley Associates, Inc. ToxScan, Inc./ Marine Bioassay Laboratories
Period of Record, Earliest Date:	December, 1981
Period of Record, Latest Date:	November, 1986
Length of Record:	5 years
Geographic Boundaries Description:	Samples were collected in the South Bay, from the Dumbarton Bridge south to Coyote Creek and Guadalupe Slough.

ABSTRACT

A long-term study of the effects of municipal effluents from the members of the South Bay Dischargers Authority ([SBDA] the cities of San Jose, Santa Clara, Palo Alto, and Sunnyvale) was an eventual consequence of the prohibition in the San Francisco Bay Regional Water Quality Control Board's 1975 Basin Plan of effluent discharges into the Bay south of the Dumbarton Bridge. The Regional Board granted SBDA a deferral from those requirements under the condition that SBDA undertake a multi- faceted study, including investigations of: effluent quality; receiving water quality; accumulation of toxicants in indicator organisms and sediments; biological indicator species life history; predation habits of important fish species; and avian botulism. The study began in December of 1981 and was

completed in December 1986. Larry Walker Associates, Inc. and Kinnetic Laboratories, Inc. and various subcontractors implemented the study.

The primary objective of the biological studies was to provide quantitative information on the utilization of South Bay habitats by key species and to determine the relationship of their utilization to receiving water quality (Larry Walker Associates and Kinnetic Laboratories 1987). Among the findings of the study was that the major concentration of shrimp in the southern reach of the estuary consistently occur in the South Bay, especially in Guadalupe Slough and Coyote Creek. Significant variation was observed in age, sex, and reproductive stage both over time and between sites. Shrimp abundances in the Bay declined to low levels in the summer and fall of 1984, and remained low for the remainder of the study. Several other phenomena were also observed concurrently with this decline. Reductions in the mean size of individuals were observed in South Bay, and were most severe in early 1984. In late 1984 increases in the incidence and severity of a necrotic shell condition were observed. During this period of general decline in shrimp abundance, the population of one species (*Palaemon macrodactylus*) increased in number. Data collected for this study provided many clues to the general life history of *Crangon franciscorum* in South Bay.

Fish assemblages were also found to vary between seasons and years. A total of 55 species, representing 26 different families, were captured from 1980 to 1986. Large numbers of staghorn sculpin (*Leptocottus armatus*), northern anchovy (*Engraulis mordax*), starry flounder (*Platichthys stellatus*), and shiner perch (*Cymatogaster aggregata*) were seasonally abundant in South Bay during each monitoring year. In several years longfin smelt (*Spirinchus thaleichthys*), striped bass (*Morone saxatilis*), threadfin shad (*Dorosoma petenense*), California tonguefish (*Symphurus atricauda*), English sole (*Parophrys vetulus*), yellowfin gobies (*Acanthogobius flavimanus*), and white croaker (*Genyonemus lineatus*) were also found in abundance. Anadromous species of primary importance in South Bay were striped bass, American shad (*Alosa sapidissima*), and white sturgeon (*Acipenser transmontanus*).

Periods of increased abundance of these and some other species in the study area appeared to reflect their introduction from the northern reach of the estuary during high-flow periods in winter and spring. Some species, particularly staghorn sculpin and starry flounder, were observed to heavily use less saline areas of South Bay as juveniles. One category of species which is abundant in the South Bay, including northern anchovy and shiner perch, has juvenile stages that are found well into less saline waters, but most often occur in regions with water greater than 10 ppt salinity. Northern anchovy was common in the South Bay in summer months, and was frequently among the most abundant species in trawl collections.

Controlled experiments were conducted to evaluate the potential influence of SBDA discharges on the frequently occurring nuisance blooms in South Bay of the filamentous red alga *Polysiphonia denudata*. One experiment found that growth rates of algae did not vary in salinities varying from 22-30 ppt, or between nutrient enriched water from the ocean and ambient Bay water. A second experiment designed to examine growth response of the algae to varying dilutions of SBDA effluents was discontinued when growth failed to occur in either the treatments or controls. Available information suggest that *Polysiphonia* blooms are a regional phenomenon that may be controlled by large- scale variation in water quality or other environmental conditions in the South Bay.

PARAMETERS

Media Analyzed: Biota.

BIOLOGICAL PARAMETERS MEASURED

egg development
fecundity
fish stomach contents
parasitism
physiological condition
reproductive stage
sex
size
species abundance
species distribution
total length

TAXA

Acanthogobius flavimanus	yellowfin goby
Acipenser medirostris	green sturgeon
Acipenser transmontanus	white sturgeon
Alosa sapidissima	American shad
Amphistichus argenteus	barred surfperch
Argeia pugettensis	isopod
Artedius notospilotus	bonehead sculpin
Atherinops affinis	topsmelt
Atherinops californiensis	jacksmelt
Carassius auratus	goldfish
Catostomus occidentalis	Sacramento sucker
Clupea harengus pallasi	Pacific herring
Citharichthys sordidus	Pacific sanddab
Citharichthys stigmaeus	speckled sanddabs
Cottus asper	prickly sculpin
Crangon franciscorum	Bay shrimp
Crangon nigricauda	shrimp
Crangon nigromaculata	shrimp
Cymatogaster aggregata	shiner perch
Cyprinus carpio	common carp
Dorosoma petenense	threadfin shad

Embiotoca jacksoni	black perch
Engraulis mordax	northern anchovy
Gasterosteus aculeatus	threespine stickleback
Genyonemus lineatus	white croaker
Gillichthys mirabilis	longjaw mudsucker
Hippoglossina stomata	big mouth sole
Hyperprosopon argenteum	walleye surfperch
Hypomesus pretiosus	surf smelt
Hypsopsetta guttulata	diamond turbot
Ilypnus gilberti	cheekspot goby
Lampetra ayresi	river lamprey
Lampetra tridentata	Pacific lamprey
Lavinia exilcauda	hitch
Lepidogobius lipidus	Bay goby
Leptocottus armatus	Pacific staghorn sculpin
Liparis pulchellus	showy snailfish
Microgadus proximus	Pacific tomcod
Micrometrus minimus	dwarf perch
Morone saxatilis	striped bass
Mustelus henlei	brown smoothhound
Myliobatis californica	bat ray
Orthodon microlepidotus	Sacramento blackfish
Palaemon macrodactylus	oriental, or Korean shrimp
Paralichthys californicus	California halibut
Parophrys vetulus	English sole
Pimephales promelas	fathead minnow
Platichthys stellatus	starry flounder
Pogonichthys macrolepidotus	Sacramento splittail
Polysiphonia sp.	red algae
Porichthys notatus	plainfin midshipman
Psettichthys melanostictus	sand sole
Raja binoculata	big skate
Rhacochilus vacca	pile perch
Sebastes auriculatus	brown rickfish
Spirinchus thaleichthys	longfin smelt
Sygnathus leptorhynchus	Bay pipefish
Symphurus atricauda	California tonguefish
Synodus lucioceps	California lizardfish
Triakis semifasciata	leopard shark
Tridentiger trigonocehpalus	chameleon goby

Prey Species from Fish Gut Contents

Allorchestes augusta
Ampelisca abdita
Ampithoe valida
Asychis elongata
Cancer magister

Corophium sp.
Crangon franciscorum
Cumella vulgaris
Edgammarus confervicolus
Eteone lighti
Foraminifera
Gemma gemma
Grandidierella japonica
Hemigrapsus oregonsis
Lironeca vulgaris
Lyonsia californica
Macoma spp.
Mediomastus sp.
Musculus senhousia
Neanthes spp.
Neomysis mercedis
Odostomia spp.
Palaemon macrodactylus
Polydora ligni
Pseudopolydora spp.
Rhithropanopeous harrissii
Sphaeroma quoyanum
Streblospio benedicti
Sarsiella zostericola
Synidotea laticauda

Amphipoda
Arthropoda
Astacura
Brachyuran, unident.
Calanoid, unident.
Caridea
Cirripedia
Cladocera
Copepoda
Gastropoda
Harpactacoid, unident.
Hydroid, unident.
Insecta
Isopoda
Mysid, unident.
Mysidacea
Nematoda
Nereid, unident.
Oligochaeta
Ostracoda
Pelecypoda

Polychaeta
Pleustidae
Sphaeromatid, unident.
Spionidae
Vertebrata

METHODS

SAMPLING METHODS

Data obtained in this portion of the SBDA study was intended to complement the data obtained from 35 stations in the Bay for the California Department of Fish and Game Delta Outflow Study. Similar sampling methods and laboratory protocols were employed to allow direct comparison between the two studies. At each station otter trawls were made on a monthly basis. In the first three years, three 10 min. tows were made at each site. Beginning in December 1984 only two tows were made. Collections were made as close as possible to high tide. Standard shallow water trawling procedures were employed to allow comparison of catch per unit effort data. All fish collected were immediately sorted and preserved. Temperature and salinity measurements were recorded at each station.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Stations: 8

Monthly surveys were conducted for 5 years at 5 stations in the South Bay. The stations at Guadalupe and Artesian Sloughs, and at the mouth of Coyote Creek were utilized in the previous two-year Recovery Monitoring Program, (conducted by Kinnetic Laboratories, Inc., 1980 - 1981), thus extending the data base in the most southerly portions of the study area to a period of seven years. An additional 2 stations were located within the main channel in the open water region of the South Bay; these stations were located off the Dumbarton Bridge, and in the center of the South Bay, off Palo Alto. In the last year of the study, a sixth station at Newark Slough was monitored in order to provide information on utilization of a shallow water slough not presently subject to direct discharge of processed wastewater.

1. SJ2 Artesian Slough (7 years of data from this site)
2. SJ4 (Coyote Creek just west of the railroad bridge (7 years of data from this site)
3. SJ6 Guadalupe Slough (7 years of data from this site)
4. SB4 South Bay, between the Dumbarton Bridge and Channel marker #14, just north of the bridge
5. SB5 Located between channel markers #16 and 17 in the main channel of the open water region of the South Bay
6. SB6 Newark Slough (1 year of data from this site)

In addition to these stations, data from five of the California Department of Fish and Game Delta Outflow sampling stations in Suisun, Lower and San Pablo Bays were used for comparative analyses of trends in the abundance of shrimp.

ANALYTICAL METHODS

Subsamples of caridean shrimp from each collection were examined to determine species composition, community structure, and incidence of parasitism. A minimum of 200 individuals from each subsample were sorted by species and weighed to estimate the species compositions of the total catch by weight. After trawl replication was reduced to two tows, 300 individuals were examined from each subsample. Crangonid shrimp were sorted by sex, total length was recorded, parasite incidence was noted, and the stage of development of eggs from ovigerous females were obtained. An emphasis was placed on monitoring the occurrence of the parasitic isopod *Argeia pugettensis*, which commonly occurs in the gill chambers of many crangonids.

Fish from each tow were identified and sorted by species. Standard lengths were recorded for most species; total lengths were measured for elasmobranchs, gadids, and sturgeon. External signs of disease, parasitism, or other abnormalities were noted. Stomach contents from at least six individuals of two species were analyzed during each survey to document feeding habits. One species chosen was of sport or commercial importance and the other of ecological importance. Species, length, sex, and reproductive condition were observed for each of these fish. Stomachs were removed and the total volume of the contents measured. All prey items were identified as completely as possible and counted.

Controlled experiments also was conducted to examine factors affecting growth of *Polysiphonia* sp.. Algal thalli of similar size and morphology were placed in glass containers and allowed to grow under controlled temperature and light. In the first of these experiments, the feasibility of growing *Polysiphonia* in the lab and the effect of varying salinities on algal growth were investigated. Growth observed under three salinity treatments of 22, 26, and 30 ppt was compared to that of reference plants. In the second experiment, the influence of 3 dilutions of SBDA effluents on algal growth rates was evaluated.

QUALITY ASSURANCE TESTING AND REPORTING

All rare or unusual specimens were verified by experienced biologists. These specimens were preserved and brought back to the laboratory. Personnel were trained by checking 100% of their identifications.

I

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: Kinnetic Laboratories, Inc.

Hardware: IBM PC, and Cromenco

Software: PRODOS or ASCII files

Volume of Data: approximately 5 megabytes

Quality Assurance: 100% hard copy verification

Contact for Data Retrieval

Name: Marty Stevenson

Address: Kinnetic Laboratories, Inc.
P.O. Box 1040
Santa Cruz CA 95061

Phone: (408) 462-6200

Access: No restrictions to access.

Data Availability Date: Immediately.

REFERENCES

Kinnetic Laboratories, Inc. and Larry Walker Associates. 1987. South Bay Dischargers Authority Water Quality Monitoring Program- final monitoring report. Prepared for the South Bay Dischargers Authority, San Jose, CA.

Larry Walker Associates and Kinnetic Laboratories, Inc. 1987. South Bay Dischargers Authority Water Quality Monitoring Program- final technical report. Prepared for the South Bay Dischargers Authority, San Jose, CA.

San Francisco Bird Observatory. 1987. South Bay Dischargers Authority Water Quality Monitoring Program: South San Francisco Bay avian botulism study. Prepared for the South Bay Dischargers Authority, San Jose, CA.

~**Descriptors:** bay-delta; point source; biological resources; fisheries; invertebrates; pollutant sources; plankton/algae/seagrasses; reproduction; abundance; shrimp; delta outflow; hydrology and flow; clams; crabs; community structure; food chains; parasitism; algal blooms; species diversity; shellfish; physiology;

GENERAL INFORMATION AND ABSTRACT

Program:	Striped Bass Health Monitoring
Funding Agency:	State Water Resources Control Board
Principal Investigators:	Dr. Jeannette Whipple (from 1978-1983) National Marine Fisheries Service (415) 435-3149 Don Stevens (1984-present) California Department of Fish and Game (209) 466-4421
Conducting Agency:	Department of Fish and Game
Period of Record, Earliest Date:	April, 1978
Period of Record, Latest Date:	Present
Geographic Boundaries Description:	Striped bass are collected from the Sacramento River near Clarksburg, and the San Joaquin River in the western Delta. For comparative analyses, striped bass were also collected on a one-time basis from Coos Bay (Oregon), Lake Mead (Nevada), and the Hudson River (New York).

ABSTRACT

The Cooperative Striped Bass Study (COSBS) was initiated by the State Water Resources Control Board (SWRCB) in response to the declining condition of the striped bass fishery. Findings of Whipple and co-workers from the National Marine Fisheries Service (NMFS) in 1978 and 1979 served to focus concern for the fishery, finding organ damage and parasite infestation in many prespawning individuals, and elevated levels of contaminants in tissues. COSBS began in 1979, with the NMFS, SWRCB, and Department of Fish and Game (DFG) cooperating, focusing on the effects of water pollution on striped bass in the Bay-Delta. A massive amount of information was compiled for COSBS. In addition to analyzing more than 500 fish from 1978-1982 for condition and tissue concentrations of contaminants, data on toxic waste discharges, pesticide use, spills, and pertinent literature were compiled. The study included collection of striped bass from other estuaries (Coos River, Lake Mead, and the Hudson River) for comparative analyses.

In 1984, under contract to the State Water Resources Control Board, the DFG began to implement the Striped Bass Health Index (SBHI) Monitoring Program,

building on the database established by COSBS. Their program is similar to the core sampling performed during COSBS, and examines striped bass physical features and levels of trace metals and organic contaminants, primarily in liver.

The most recent SBHI report states that there are mixed indications that striped bass health has improved over the 10 year period of record (Urquhart and Knudsen 1987). Fish collected in 1987 were characterized by parasite burdens lower than the all-time high in 1986, with the exception of tapeworm rafts. Tapeworm lesions appear to be at an all-time low. Various measures of gonad maturity were at relatively high levels, but this did not appear to translate into increased fecundity. These measures may simply reflect the older average age of the fish collected in 1987. Between year comparisons of fish from the San Joaquin River indicate overall improvements in reproductive measures and tissue contamination, but loads of parasites and mercury that still justify concern over the health of the striped bass population.

Few strong, consistent correlations among the variables measured could be demonstrated for the 10 year period. Correlation of toxicant levels and fish health were constrained by the fact that only two groups of toxicants (monocyclic aromatic hydrocarbons [MAHs] and alicyclic hexanes) were monitored consistently throughout the 10 years. These substances were of particular concern because in the early stages of COSBS the strongest correlations observed among the many variables measured were between volatile petrochemicals (MAHs and alicyclic hexanes) and measured deleterious effects (such as egg resorption and abnormalities). Most fish collected after 1978 did not show MAH or alicyclic hexane levels above analytical limits of detection, so there has been little potential for measuring effects even of these compounds in field-sampled fish. The low frequency of detection does not, however, rule out the possibility of adverse effects on the population due to sporadic elevated levels of these compounds. The high volatility and rapid depuration rates of MAHs by striped bass may explain their low frequency of detection. Controlled laboratory studies are needed to supplement work performed to date by clearly identifying cause and effect relationships, which can only be suggested in field studies.

PARAMETERS

Media Analyzed: Biota.

BIOLOGICAL PARAMETERS MEASURED

age
body depth
body length
body wet weight
egg color
egg maturation stage
liver color
liver fat content

liver percent fat
liver somatic index
liver weight
mesenteric fat abundance rank
physiological condition
proportional body size
sex
skeletal abnormalities
striping pattern
viscera wet weight
fecundity
gonadosomatic index
ovary maturity stage
ovary size
ovary weight
predominant egg stage
proportion of eggs resorbing
parasite host reaction
parasite location
parasite severity
parasite type

CHEMICAL PARAMETERS MEASURED
Alicyclic Hexanes
cyclohexane
methylcyclohexane
1,1-dimethylcyclohexane
1,2-dimethylcyclohexane
1,3-dimethylcyclohexane
1,4-dimethylcyclohexane
ethylcyclohexane

Monocyclic Aromatic Hydrocarbons
benzene
ethylbenzene
toluene
para-xylene
meta-xylene
ortho-xylene

PCBs
PCB - 1242
PCB - 1248
PCB - 1254
PCB - 1260

Pesticides

aldrin
alpha-BHC
beta-BHC
gamma-BHC
delta-BHC
benefin
carbophenothion
CDEC
chlorbenside
cis-chlordane
trans-chlordane
alpha-chlordene
gamma-chlordene
chloroneb
o,p'- DDD
p,p'- DDD
o,p'- DDE
p,p'- DDE
p,p'- DDMS
p,p'- DDMU
o,p'- DDT
p,p'- DDT
dichlofenthion
dicofol
endosulfan I
ethion
fonofos
HCB (hexachlorobenzene)
heptachlor
heptachlor epoxide
methoxychlor
mirex
cis-nonachlor
trans-nonachlor
oxychlordane
PCNB
perthane
phenkapton
phorate
chlorpyrifos
ronnel
strobane
toxaphene

Other Parameters
salinity
water temperature

Trace Elements
cadmium
chromium
copper
mercury
selenium
zinc

TAXA

Anisakis sp.	roundworm
Lacistorhynchus tenuis	tapeworm
Morone saxatilis	striped bass

|

METHODS

SAMPLING METHODS

Adult striped bass are collected in conjunction with the Department of Fish and Game (DFG) tagging program using gill nets on the San Joaquin River near Antioch and fyke traps on the Sacramento River near Clarksburg. Mature prespawning females are selected because their reproductive condition is more easily evaluated. Twenty females are collected at each site, but no more than 4 each week. This assures that the majority of the spawning season is covered and renders collections less sensitive to episodic incidences of pollution. Surface water salinity and temperature are recorded during collections.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: 2

The same sites on the Sacramento and San Joaquin Rivers have been sampled annually since the inception of the study in 1978. During the COSBS study, from 1978 to 1983, over 500 striped bass were collected. Since that time, the Department of Fish and Game has sampled approximately 220 fish. In the current sampling regime, from April to May, at least 20 adult striped bass are collected on the San Joaquin River near Antioch, and 20 more adult striped bass are collected on the Sacramento River near Clarksburg. Prior to 1983 occasional collections were made from other locations in the San Francisco Bay.

ANALYTICAL METHODS

Each fish is systematically examined, dissected, and subsampled for analysis of biological features associated with pollutant exposure. Examination of external morphology includes observations of length, weight, striping pattern, and skeletal abnormalities. Examination of internal morphology includes observations of liver condition, ovary condition, mesenteric fat abundance, and parasite type and severity of host reaction.

Monocyclic aromatic hydrocarbons (MAHs) and alicyclic hexanes are analyzed by gas chromatography at the National Marine Fisheries Service laboratory in Tiburon. Synthetic organics (pesticides and PCBs) are analyzed by gas chromatography at the Department of Fish and Game Fish and Wildlife Water Pollution Control Laboratory (FWWPCL). Trace elements are also measured at the FWWPCL by atomic absorption, with various methods of inducing the emission spectra.

QUALITY ASSURANCE TESTING AND REPORTING

At the FWWPCL similar quality assurance measures are taken for both trace elements and synthetic organics. For both of these classes of substances, procedural blanks are analyzed to detect contamination, 10% of the samples are analyzed in duplicate, and all materials contacting the samples are analyzed. For synthetic organics, standards are used to determine recovery rates. Also, an EPA reference sample of freeze-dried fish is analyzed for PCBs. For trace elements, a National Bureau of Standards reference sample of oyster tissue is analyzed twice during analyses.

In determinations of MAHs and alicyclic hexanes the gas chromatograph is calibrated to a mixture of standards of the analyzed compounds. Additionally, a solvent blank is eluted between samples to detect residual contamination from previous samples.

|

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

SBHI MONITORING DATA

Location: DFG data are on computer in Stockton, and in hard copy appendices to the annual reports submitted to the San Francisco Bay Regional Water Quality Control Board and the State Water Resources Control Board. DFG computer files also contain some of the 1978-1983 COSBS data. These data consist only of those variables used in DFG's analyses.

Hardware: DFG hardware is a DEC Microvax

Software: DFG data are stored in ASCII, and analyzed with BMDP, Minitab, and SAS.

Volume of Data: From 1984-1987 DFG sampled 174 fish for roughly 150 variables. Thirty-seven of those variables are currently contained in DFG computer files, for a total of about 6,400 observations (100 kilobytes).

Quality Assurance: Prior to keypunching at DFG, lab sheets are reviewed thoroughly for inaccurate entries. The data are then key-punched and key-verified. Analyses of age, ovary condition and fecundity are performed twice by different analysts. Statistical analyses uncover remaining errors.

Contact for Data Retrieval
(for the 1978-1986 data used in DFG analyses)

Name: Richard Whitsel
San Francisco Regional Water Quality Control Board
1111 Jackson Street, Room 6040
Oakland CA 94607
Phone: (415) 464-1329

Contact for Data Retrieval
(for the 1987 data used in the DFG analyses)

Name: James Sutton
State Water Resources Control Board
P.O. Box 2000, Bay-Delta Unit
Sacramento CA 95810
Phone: (916) 322-9874

OR

Name: Diane Knudsen
Department of Fish and Game
4001 N. Wilson Way
Stockton CA 95205
Phone: (209) 466-4421

Data Availability Date: 1984-1986 data are available in the 1985 and 1986 reports, and from the San Francisco Bay Regional Water Quality Control Board. Data from 1987 are available in the 1987 report which will be released from the State Water Resources Control Board after September 1988.

COSBS DATA

Location: COSBS data, (1978-1983), are at the National Marine Fisheries Service, Tiburon. Some of the COSBS data are also computerized at the DFG in Stockton.

Hardware: IBM AT microcomputers

Software: NCSS (Number Cruncher Statistical System) and ASCII files.

Volume of Data: COSBS data require approximately 4 megabytes of storage.

Quality Assurance: All COSBS data were reviewed for outliers (which were discarded) before entry onto computer. After computer entry the data were checked by two people. Statistical analyses detected remaining errors.

Contact for Data Retrieval

Name: Dr. Jeannette Whipple
NMFS
Southwest Fisheries Center
3150 Paradise Drive
Tiburon CA 94920

Phone: (415) 435-3140

Access: Requests for NMFS data should be made to Dr. Whipple.

Data Availability Date: 1978-1984 data is available now.

REFERENCES

Knudsen, D.L. and D.W. Kohlhorst. 1987. Striped bass health monitoring 1985 final report. Interagency Agreement Report 4- 090-120-0 for the California State Water Resources Control Board.

Jung, M., J.A. Whipple, and L.M. Moser. 1984. Summary report of the Cooperative Striped Bass (COSBS) Study. Report to the California State Water Resources Control Board. December 1984.

SWRCB. 1986. Cooperative Striped Bass Study: First, Second, and Third Progress Reports and Appendix 1. Reprinted in October 1986. California State Water Resources Control Board, Sacramento, CA.

SWRCB. 1986. Cooperative Striped Bass Study: Technical supplements I and II. Reprinted in January 1986. California State Water Resources Control Board, Sacramento, CA.

Urquhart, K.A. and D.L. Knudsen. Striped bass health monitoring 1986 final report. Interagency Agreement Report 5-183-120-0 for the California State Water Resources Control Board.

Urquhart, K.A. and D.L. Knudsen. Striped Bass Health Index Monitoring 1987 Final Report, Draft. Interagency Agreement Report 6-170-300-0 for the California State Water Resources Control Board.

~**Descriptors:** fisheries; bay-delta; MAHs; biological resources; pollutants and related parameters; histopathology; other hydrocarbons; chlorinated hydrocarbons; bioaccumulation; spills; pollutant sources; physiology; parasitism; reproduction; biological effects; water pollution; water quality; petroleum hydrocarbons; ddt; cyclodienes; organophosphates; carbamates;

GENERAL INFORMATION AND ABSTRACT

Program: Toxicant Occurrence and Effects in Water Birds

Funding Agency: U.S. Fish & Wildlife Service

Principal Investigator: Dr. Harry Ohlendorf (916) 752-6420
U.S. Fish and Wildlife Service

Conducting Agency: U.S. Fish & Wildlife Service

Period of Record, Earliest Date: 1982

Period of Record, Latest Date: 1990

Geographic Boundaries Description: Waterbird tissue samples have been collected from South Bay, Central Bay, and San Pablo Bay.

Comparative samples have been collected from other coastal locations in California (San Diego Bay, Monterey Bay and Tomales Bay).

ABSTRACT

Researchers at the USFWS have conducted a series of investigations of toxic contaminant concentrations in tissues of various species of waterbirds of the Bay. This work began in 1982, when trace element levels in surf scoters (*Melanitta perspicillata*) and greater scaups (*Aythya marila*) were measured (Ohlendorf et al. 1986). Concentrations of mercury, cadmium, and some other metals were elevated in comparison to levels for these species in other published reports. No data on scaup and scoter selenium levels were available for comparison, but levels found in these diving ducks from the Bay were similar to those in dabbling ducks (*Anas* spp.) collected at Kesterson Reservoir. Severe reproductive impairment and other toxic effects were observed at Kesterson, and selenium is considered the primary cause.

Results of sampling for trace elements in Surf Scoters (*Melanitta perspicillata*) in January and March 1985 indicate spatial patterns in waterfowl contamination in the Bay (Ohlendorf et al. 1990). Overall, mean concentrations of copper and zinc were higher in Scoter liver tissue from the Southern Bay region, whereas mean iron and lead were higher from those in the Northern Bay region. Mean concentrations of copper and zinc increased, arsenic decreased, and cadmium remained the same between January and March. Selenium and mercury concentrations in scoter livers during 1985 were not correlated but cadmium concentrations in liver and kidneys

were positively correlated and body weight was negatively correlated with mercury concentration in the liver. Concentrations of selenium, mercury and cadmium in Scoter livers were significantly higher in March 1985 than in March 1982, but copper and zinc concentrations were not different between years.

In 1982, organochlorine and mercury concentrations were measured in eggs of 4 species of terns and wading birds on Bair Island in the South Bay (Hoffman et al. 1986). Caspian tern (*Sterna caspia*) eggs had significantly higher mean levels of DDE than those of the other species tested. Caspian tern eggs also had higher PCB concentrations than eggs of the same species from San Diego Bay, CA or Elkhorn Slough (Monterey Bay), CA. Caspian terns also had the highest mean concentrations of mercury of the 4 species tested. DDE concentrations in 10.6% of black-crowned night-heron (*Nycticorax nycticorax*) eggs exceeded 8 ppm, a level associated with impaired reproduction in this species.

Further research on organochlorine effects on reproduction in black-crowned night-herons on Bair Island was conducted in 1983. Embryonic weights were 15% lower in birds from Bair Island than control embryos from the Patuxent Wildlife Research Center. A significant negative correlation was found between embryonic weight and PCB residues (which had a geometric mean of 4.1 ppm wet weight), suggesting a possible impact of PCBs on embryonic growth.

A study on brain cholinesterase (ChE) activity of nestling great egrets, snowy egrets and black crowned night herons was conducted in 1987 (Custer and Ohlendorf 1989). Inhibition of ChE activity in birds is often used to diagnose exposure or death from organophosphorus or carbamate pesticides. ChE activity increases with age in the European starling, but this phenomenon has not been investigated in other altricial species. Brain ChE activity in all three altricial heron and egret species increased significantly with age and did not differ among individuals from different nests or colonies. This study demonstrates that age must be considered when evaluating exposure of nestling altricial birds to ChE inhibitors.

In a 1988 summary of environmental contaminants in birds of San Francisco and Chesapeake Bays, the major contaminants of concern in San Francisco Bay are selenium, cadmium and mercury in waterfowl and PCB's and DDE in shorebirds and night-herons (Ohlendorf and Fleming 1988).

Eggshell thinning was negatively correlated with DDE concentration in eggs in San Francisco Bay in a 1982-83 study of organochlorines and selenium in California night-heron and egret eggs (Ohlendorf and Marois 1990). In a 1987 study of contaminant acquisition by heron and egret eggs and nestlings, DDE and PCB's were detected in all eggs and chicks, and they accumulated as the chicks grew (Custer et al. 1987; Custer and Ohlendorf 1990).

PARAMETERS

Media Analyzed: Biota

BIOLOGICAL PARAMETERS MEASURED
brain acetylcholinesterase
brain DNA
brain protein
brain RNA
brain weight
eggshell thickness
eggshell weight
embryo length
embryo weight
femur length
humerus length
liver DNA
liver glutathione
S-transferase
liver microsomal AHH activity
liver microsomal protein
liver protein
liver RNA
liver weight
radius ulna weight
tibiotarsus length
whole egg weight
yolk-sac weight

CHEMICAL PARAMETERS MEASURED
Chlorinated Hydrocarbons
PCBs
p,p'- DDD
p,p'- DDE
p,p'- DDT
dieldrin
endrin
heptachlor epoxide
oxychlordane
cis-chlordane
trans-nonachlor
cis-nonachlor
toxaphene

Trace Elements
aluminum
arsenic
cadmium
chromium

cobalt
copper
iron
lead
manganese
mercury
nickel
selenium
silver
tin
zinc

TAXA

Aythya marila	greater scaup
Egretta thula	snowy egrets
Melanitta perspicillata	surf scoters
Nycticorax nycticorax	black-crowned night-herons
Sterna caspia	Caspian terns
Sterna forsteri	Forster's terns

METHODS

SAMPLING METHODS

Trace Element Studies

In 1982 scaups and scoters were collected with steel shot. An attempt was made to collect only adult males, but the sample included 2 female scaups and 1 immature male scoter. In 1985 adult male scoters were collected, again using steel shot.

Organochlorine Studies

In 1982, one egg was collected at random from each of 14 Caspian tern and 12 black-crowned night-heron nests early in the nesting season (April), and 8 Caspian tern and 12 black-crowned night-heron nests initiated late in the season (May/June). Also collected were eggs found broken in nests, that failed to hatch, were abandoned, or found outside nests.

In June 1983, one egg containing a late-stage embryo was collected from each of 12 black-crowned night-heron nests for morphological and biochemical evaluation. One other egg was randomly selected from each nest for organochlorine analysis. Eggs from a colony of captive black-crowned night-herons at the Patuxent Wildlife Research Center served as controls.

Night-heron and egret eggs and chicks were collected in 1987 from one colony each along Rhode Island, Texas and California coasts. Within each clutch sampled, an egg was collected late in the incubation period, the chick from the first egg to hatch was collected when about 15 days old, the second when about 10 days old, and the third when about 5 days old. Eggs and carcasses were analyzed for organochlorines.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: Approximately 12

In March and April of 1982 18 greater scaups and 22 surf scoters were taken from Westpoint Slough and First Slough at Redwood City, at Ravenswood Slough and tidal flats in the Dumbarton Bridge vicinity, and from the Newark Slough and tidal flats (Ohlendorf *et al.* 1986).

Between April and June of 1982, one egg was collected from each of 22 Caspian tern, 10 Forster's tern, 10 snowy egret, and from 24 black-crowned night-heron nests on Bair Island. Ten Caspian tern eggs were also collected from Elkhorn Slough (Ohlendorf *et al.* 1988).

In June of 1983, 24 black-crowned night-heron eggs were collected from Bair Island at the San Francisco Bay National Wildlife Refuge (Hoffman *et al.* 1986) .

Thirty nine adult male surf scoters were taken in January 1985, and 40 more were collected in March from three sites in the South Bay and three in Central and San Pablo Bays. The South Bay sites were near Redwood Creek, Dumbarton Bridge, and Coyote Creek-Guadalupe Slough. The Central Bay and San Pablo Bay sites were located at Richmond Harbor, Point San Pablo-Pinole Point, and Hercules-Rodeo (Ohlendorf *et al.* 1987).

ANALYTICAL METHODS

Trace Elements

In 1982, bird weights and digestive tract contents were determined. Chemical analyses were conducted by Analytical Bio-Chemistry Laboratories, Inc. in Columbia, Missouri. Livers were analyzed for silver, chromium, copper, mercury, nickel, lead, selenium, and zinc. Kidneys were measured for cadmium, and wing bones for silver. Mercury was determined by cold vapor atomic absorption (CVAA); chromium, lead, and nickel by graphite furnace (GFAA); selenium by hydride generation (HGAA); and cadmium, copper, silver, and zinc by Inductively Coupled Argon Plasma spectrophotometry. Results were expressed in dry weight to avoid errors associated with varying levels of moisture content in tissues.

In 1985, as described in Ohlendorf *et al.* 1989 and 1990, selenium, mercury, cadmium, arsenic, iron, lead, copper, zinc, aluminum and organochlorines were measured in surf scoters. Tissue samples were analyzed by atomic absorption spectroscopy at the Environmental Trace Substances Research Center (ETSRC), Columbia, Missouri. Samples were freeze-dried and then weighed and homogenized using a blender. Subsamples of freeze-dried livers were digested using nitric-perchloric acids for analysis of selenium by hydride generation and aluminum, arsenic, cadmium, cobalt, copper, iron, lead, manganese, nickel, tin and zinc by inductively coupled plasma analysis. Seperate subsamples of the dried livers were digested by nitric acid reflux for mercury analysis using cold vapor atomic absorption. All results for trace elements were reported on a dry weight basis.

Organochlorines

In the 1982 study, eggshell thickness was measured after the shells had dried at room temperature for one month. The shells were weighed and thickness indices were computed. The entire contents of each egg were homogenized before chemical analysis. DDT and PCBs were determined by gas-liquid chromatography. Mercury was measured by cold vapor atomic absorption.

In the 1983 study, morphological features of the eggs and embryos were observed. Activities of glutathione S-transferase and aryl hydrocarbon hydroxylase in liver tissue, and acetylcholinesterase activity in brain tissue were measured. DNA and RNA concentrations in liver and brain were determined fluorimetrically with ethidium dibromide. Protein concentrations in liver and brain were determined using a folin phenol reagent. Organochlorine concentrations were determined using methods similar to those used the previous year.

In 1987, one egg was collected from each of 15 snowy egret and night-heron nests on West Marin Island. Later the chicks from these nests were collected at 5, 10, or 15 days of age. Brain ChE and organochlorines were measured. Acquisition rates (ug/day) for chicks were determined to compare uptake of organochlorines in these chicks with similar ones from colonies in Texas and Rhode Island. Trace element and PAH analyses are pending.

Heron and egret eggs were analyzed for organochlorine pesticides and their metabolites and PCBs by gas-liquid chromatography (Ohlendorf and Marois 1990).The entire contents of each egg were homogenized with a vitris homogenizer. A 5 g portion of this was used for analysis.

In the 1985 study on surf scoters (Ohlendorf et.al. 1990) carcasses and breast muscle samples were homogenized to uniform consistency and analyzed for organochlorines at the Patuxent Wildlife Research Center, Laurel, MD. A portion of the sample was analyzed for organochlorine pesticides and metabolites and for polychlorinated biphenyl compounds by gas-liquid chromatography. Results for all organochlorines were reported on a wet-weight basis. Carcass and breast muscle samples were also analyzed for lipid content.

QUALITY ASSURANCE TESTING AND REPORTING

Trace Elements

Recovery percentages for the 1982 data are presented (Ohlendorf *et al.* 1986). Detailed QA procedures are described for the 1985 analyses. Within-lab accuracy and precision were determined through analysis of standard reference materials, spiked samples, and replicated sample aliquots. Interlaboratory comparisons were also made.

Organochlorines

Approximately 10% of samples analyzed by gas-liquid chromatography were confirmed by gas chromatography-mass spectroscopy. The laboratory's quality assurance program includes analysis of sample blanks, duplicates, and standard reference materials, as well as recoveries from spiked bird tissue samples. Recoveries for all organochlorines and selenium averaged between 90 and 110 per cent (Ohlendorf and Marois 1990).

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Hardware: IBM compatible

Software: SAS, Statpro

Contact for Data Retrieval

from 1982 to 1990

Name: Dr. Harry Ohlendorf
CH2M Hill
3840 Rosin Court, Suite 110
Sacramento CA 95834

Phone: (916) 920-0300

after 1990

Name: Research Group Leader
Pacific Coast Research Station
U.S. Fish and Wildlife Service
c/o Dept. of Wildlife and Fisheries Biology
University of California
Davis CA 95616

Phone: (916) 752-4605

REFERENCES

Custer, T.W., and H.M. Ohlendorf. 1989. Brain cholinesterase activity of nestling great egrets, snowy egrets and black-crowned night-herons. Journal of Wildlife Diseases 25(3): 359-363.

Custer, T.W., and H.M. Ohlendorf. 1990. Heron and egret chicks as indicators of estuarine contamination. U.S. Fish and Wildlife Service Information Bulletin #90-52.

Custer, T.W., B.A. Rattner, H.M. Ohlendorf, and M.J. Melancon. Herons and egrets as indicators of estuarine contamination in the United States. Proceedings of the 20th International Ornithological Congress; Christchurch, New Zealand, Dec. 2-9, 1990. Authors Proof.

Hoffman, D.J., B.A. Rattner, C.M. Bunck, H.M. Ohlendorf, and R. W. Lowe. 1986. Association between PCBs and lower embryonic weight in black-crowned night-herons in San Francisco Bay. Journal of Toxicology and Environmental Health 19:383-391.

Ohlendorf, H.M., T.W. Custer, R.W. Lowe, M. Rigney, and E. Cromartie. 1988. Organochlorines and mercury in eggs of coastal terns and herons in California, USA. Colonial Waterbirds 11(1): 85-94.

Ohlendorf, H.M., and W.J. Fleming. 1988. Birds and environmental contaminants in San Francisco and Chesapeake Bays. Marine Pollution Bulletin 19(9): 487-495.

Ohlendorf, H.M., R.W. Lowe, P.R. Kelly, and T.E. Harvey. 1986. Selenium and heavy metals in San Francisco Bay diving ducks. Journal of Wildlife Management 50(1): 64-71.

Ohlendorf, H.M.and K.C. Marois. 1990. Organochlorines and selenium in California night-heron and egret eggs. Environmental Monitoring and Assessment 15: 91-104.

Ohlendorf, H.M., K.C. Marois, R.W. Lowe, T.E. Harvey, and P.R. Kelly. 1990. Trace elements and organochlorines in surf scoters from San Francisco Bay, 1985. Environmental Monitorning and Assessment. Authors Proof.

Ohlendorf, H.M., K.C. Marois, R.W. Lowe, T.E. Harvey, and P.R. Kelly. 1989. Environmental Contaminants and Diving Ducks in the San Francisco Bay, in Selenium and Agricultural Drainage: Implications for San Francisco Bay and the California Environment. Proceedings of the Fourth Selenium Symposium, Alice Q. Howard, editor. Bay institute of San Francisco, Ca. 215pp.

~**Descriptors:** bay-delta; embryotoxicity; teratogenicity; biological resources; birds; pollutants and related parameters; trace elements; biological effects; bioaccumulation; waterfowl; reproduction; physiology; cyclodienes; ddt; herons; USFWS;

GENERAL INFORMATION AND ABSTRACT

Program:	Toxic Substances Monitoring Program (TSMP)
Funding Agency:	State Water Resources Control Board
Principal Investigator:	Del Rasmussen State Water Resources Control Board (916) 324-1261
Conducting Agency:	Department of Fish and Game
Period of Record, Earliest Date:	1978
Period of Record, Latest Date:	Present
Geographic Boundaries Description:	Since 1978 over 300 stations statewide have been sampled, with approximately 65 of those stations located in the San Francisco Bay-Delta. New stations are added on an annual basis.

ABSTRACT

The State Water Resources Control Board (SWRCB) began the Toxic Substances Monitoring Program in 1976. The State board along with the nine Regional Water Quality Control Boards (Regional Boards) are responsible for the protection of water quality in California. In this regard, the TSMP was organized to provide a uniform statewide approach to the detection and evaluation of the occurrence of toxic substances in fresh and estuarine waters of the state. The Department of Fish and Game, through an Interagency Agreement, collects and analyzes fish and other aquatic organisms from fresh and estuarine waters. The fish collected accumulate measurable concentrations of certain contaminants, particularly lipophilic organics, that are difficult to detect in ambient water samples. Data generated are indicative of sources of pollution, and of potential hazards to human health.

Samples are analyzed for trace metals and synthetic organic compounds. Data for each year are summarized in a report issued by the SWRCB, which compares measured values to either existing standards for predator protection (established by the National Academy of Sciences) and human health (guidelines established by the US Food and Drug Administration) or internally developed criteria. Results exceeding criteria are emphasized in each annual report.

Sampling in the San Francisco Estuary and its direct tributaries included the San Joaquin River at Vernalis, Sacramento River at Hood and Rio Vista, and San Pablo Creek. Catfish from the San Joaquin River at Vernalis station have routinely over the years exceeded the NAS guidelines for chlordane, DDT, and toxaphene. PCBs were detected at Vernalis at concentrations below the selected criteria used in this analysis. Carp have exceeded the NAS guidelines for DDT since 1985 at the Sacramento Hood station. DDT concentrations since then have remained stable. Chlordane and toxaphene also have been found at elevated levels in carp in 1986 and 1987. Suckers and Sacramento squawfish from the Rio Vista station in 1987 had relatively low levels of organic compounds. Concentrations of trace elements and organics in San Pablo Creek were well below selected criteria in 1985.

Findings in 1984 included several extraordinary readings in the Estuary. Channel catfish from the San Joaquin River at Vernalis contained elevated levels of several contaminants, including: 14,000 ppb of toxaphene, by far the highest measurement of this pesticide found in the Program, 4,000 ppb total DDT, and chlordane in excess of the FDA action level of 300 ppb. A Sacramento squawfish from the San Joaquin River at Twitchell Island contained 980 ppb of total PCB's, exceeding the NAS guidelines of 500 ppb. The NAS guideline of 0.5 ppm mercury was exceeded in a white catfish from the Sacramento River at Hood.

PARAMETERS

Media Analyzed: Biota

BIOLOGICAL PARAMETERS MEASURED
age
mean length (mm)
mean weight (grams)
percent lipid
percent moisture
tissue type analyzed

CHEMICAL PARAMETERS MEASURED
Chlorinated Hydrocarbons
PCB - 1248
PCB - 1254
PCB - 1260
total PCBs

Pesticides
aldrin
chlorbenside
cis-chlordane
trans-chlordane
alpha-chlordene
gamma-chlordene

chlorpyrifos
dacthal
o,p'- DDD
p,p'- DDD
o,p'- DDE
p,p'- DDE
p,p'- DDMS
p,p'- DDMU
o,p'- DDT
p,p'- DDT
diazinon
p,p'-dichlorobenzophenone
dicofol (Kelthane)
dieldrin
endosulfan I
endosulfan II
endosulfan sulfate
endrin
ethion
ethyl parathion
alpha-HCH (hexachlorocyclohexane)
beta-HCH
delta-HCH
gamma-HCH (lindane)
heptachlor
heptachlor epoxide
hexachlorobenzene
methoxychlor
methyl parathion
nitrofen
cis-nonachlor
trans-nonachlor
oxychlordane
ethyl parathion
PCNB (pentachloronitrobezene)
pentachlorophenol
2,3,5,6-tetrachlorophenol
tetradifon
total chlordane
total DDT
total endosulfan
total HCH
toxaphene

Trace Elements
arsenic
cadmium

chromium
copper
lead
mercury nickel
selenium
silver
zinc

NON-ROUTINE CHEMICAL PARAMETERS MEASURED
(limited amount of data available - most not detected)

2,4-D acid
2,4-D isobutyl ester
2,4-D n-butyl ester
2,4-D isopropyl ester
atrazine
benefin
carbaryl
carbophenothion
2-chloroallyl diethyl
chloroneb
dichlofenthion
diphenamid
fenitrothion
fenthion
fonofos
guthion
malathion
methidathion
mirex
PCB-1242
perthane
phenkapton
phorate
pronamide
ronnel
simazine
strobane
S,S,S-tributylphosphorotrithioate

TAXA

Acipensar transmontanus	*white sturgeon*
Anistremus davidsoni	sargo
Bairdiella icistius	croaker
Carassius auratus	*goldfish*
Catostomus sp.	sucker
Corbicula manilensis	asiatic clam

Cottus sp.	sculpin
Cynoscion xanthulus	orangemouth corvina
Cyprinus auratus	goldfish
Cyprinus carpio	carp
Fundulus parvipinnis	California killfish
Gambusia affinis	mosquitofish
Gasterosteus aculeatus	threespine stickleback
Gila bicolor	*tui chub*
Gillichthys mirabilis	longjaw mudsucker
Girella nigracans	opaleye
Ictalurus catus	white catfish
Ictalurus natalis	yellow bullhead
Ictalaurs punctatus	channel catfish
Ictalurus sp.	bullhead
Lavinia exilicauda	hitch
Lepomis cyanellus	greensunfish
Lepomis machochirus	bluegill
Leptocottus armatus	*pacific staghorn sculpin*
Micropterus dolomie	smallmouth bass
Micropterus punctulatus	*spotted bass*
Micropterus salmoides	largemouth bass
Morone chrysops	white bass
Morone saxatalis	striped bass
Notamigonus crysoleucas	golden shiner
Notropis lutrensis	red shiner
Orthodon microlepidotus	Sacramento blackfish
Poecilia latipinna	sailfin molly
Pomoxis annularis	white crappie
Pomoxis nigromaculatus	black crappie
Prosopium williamsoni	mountain whitefish
Ptychocheilus grandis	Sacramento squawfish
Salmo clarki clarki	cutthroat trout
Salmo gairdneri	rainbow trout
Salmo gairdneri gairdneri	steelhead rainbow trout
Salmo trutta	brown trout
Syprinus carpio	
Tilapia mossambica	tilapia
Tilapia zillii	Zill's cichlid

METHODS

SAMPLING METHODS

Efforts are made to maintain uniformity in species collected among stations and throughout the years. Predator fish are collected whenever possible. Forage fish are collected where pollution problems are known to exist or where predators are unavailable. Collections are made using a variety of techniques, including electrofishing, netting, and trapping. Samples for analysis are composited, usually from six medium-sized fish. Replicate samples are also collected and analyzed.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: Approximately 65 sites total have been sampled in the Bay and Delta.

In 1985 73 stations were sampled once a year throughout the state, with 24 of those stations located in the Bay and Delta. In 1986 the number of Bay-Delta sampling stations was increased to 32.

		Latitude	Longitude
1.	Alameda Creek/Shinn Pit A percolation pond for Alameda County Water District in Niles.	37-34-20	121-59-20
2.	Alamitos Creek D/S Almaden Reservoir Samples are collected from 100 yards downstream of the Alamitos Road bridge at Almaden to 50 yds upstream of the bridge.	37-10-05	121-49-35
3.	Arcade Creek U/S Marysville Blvd From Marysville Blvd. Bridge upstream 50 yds.	38-37-40	121-25-50
4.	Beach Lake Located adjacent to Interstate 5; receives flow from Morrison and Union House Creeks.	38-26-25	121-28-55
5.	Black Butte Reservoir Northeastern portion of this impoundment on Stony Creek.	39-48-30	122-21-05
6.	Calero Reservoir Samples were taken from Berry cove and the cove south of the west dam.	37-10-50	121-47-10
7.	Colusa Drain/Abel Road Colusa National Wildlife Refuge.	39-09-20	122-02-00
8.	Colusa Drain/Knights Landing 3 miles upstream of the Sacramento River near Knights Landing outfall gates.	38-48-55	121-46-50

9.	Coyote Creek/Brokaw Road From Brokaw Road downstream to Hwy 17.	37-23-00	121-54-15
10.	Coyote Reservoir Below the dam on Coyote Creek.	37-07-15	121-33-05
11.	Davis Creek Reservoir Collected by UC Davis in relation to Homestake Mining Company Project.	38-51-35	122-21-35
12.	Don Pedro Reservoir Off State Highway 132 in Woods Creek arm.	37-51-25	120-23-45
13.	Don Pedro Reservoir/Tuolumne River This station is in the Middle Fork Tuolumne River arm above Moccasin Creek.	37-50-55	120-20-10
14.	Don Pedro Reservoir/Moccasin Creek	37-49-30	120-19-30
15.	East Park Reservoir From the dam to the tip of the south-eastern arm of the lake.	39-19-45	122-25-50
16.	French Camp Slough	37-55-00	121-18-20
17.	Guadalupe Creek D/S Guadalupe Reservoir Collected 50 to 150 yards below the dam.	37-12-00	121-52-50
18.	Guadalupe Reservoir	37-11-50	121-52-35
19.	Guadalupe River/Percolation Pond Collected from the percolation pond adjacent to Santa Clara Valley Water District Office.	37-16-00	121-57-00
20.	Kesterson Reservoir/Pond 2	37-13-50	120-53-00
21.	Lake Almanor/Hamilton Branch Within 100 yards north and south of cove where Hamilton Branch Powerhouse discharges.	40-16-05	121-05-20
22.	Lake Berryessa/Capell Creek Arm	38-30-35	122-13-20

23.	Lake Berryessa/Pope Creek Arm Located upstream of the bridge.	38-36-40	122-19-20
24.	Lake Berryessa/Putah Creek Arm Located upstream of the bridge.	38-37-55	122-17-25
25.	Lake Herman Samples were collected from the entire lake.	38-05-45	122-09-20
26.	Lake Kaweah Samples from the center of the lake.	36-24-20	118-58-35
27.	Lake McClure/Main Body Lake McClure on the Merced River	37-36-05	120-15-50
28.	Lake McClure/Merced River Arm Between Bagby and Hunters Pt. rec. areas.	37-39-05	120-10-55
29.	Lake Merced Collected in northeast arm of lake.	37-43-40	122-29-15
30.	Indian Valley Reservoir In the main reservoir and the enburg and Cache Creek arms.	39-07-25	122-32-20
31.	McCloud River/Shasta Lake 1/4-1/2 mile above McCloud River bridge.	40-57-10	122-14-00
32.	Mendota Pool Collected from launch ramp south 1/4 mile.	36-47-10	120-22-15
33.	Merced River/Hatfield SRA Collected near Hatfield St Rec Area	37-21-30	120-57-10
34.	Napa River	38-22-05	122-18-10
35.	Natomas East Main Drain/Arcade Ck From Silver Rd Bridge upstream 50 yds	38-37-50	121-28-10
36.	Old River From the Bascule bridge downstream about two miles to mouth of Rock	37-59-55	121-34-45

	Slough along Contra Costa/San Joaquin County Line.		
37.	Paradise Cut/Tracy Collected 300 yards upstream of high voltage powerline to 1/2 mile upstream.	37-48-10	121-24-35
38.	Pardee Reservoir Located on Channel Arm of Pardee Res, along Amador/Calaveras County line.	38-17-05	120-48-30
39.	Rollins Reservoir Located on Bear River arm of reservoir.	39-09-20	120-55-30
40.	Sacramento River/D/S Shasta Dam 1-4 miles downstream from Shasta Dam.	40-41-35	122-26-50
41.	Sacramento River/Hood Located in river stretch from Clarksburg to Courtland along Yolo/Sacramento County line.	38-22-10	121-31-10
42.	Sacramento River/Keswick 0.5 mi above railroad bridge over Lake Redding.	40-35-35	122-24-30
43.	Sacramento River/Keswick Dam Located immediately below Keswick Dam.	40-36-40	122-26-40
44.	Sacramento Slough Collected at irrigation pump 1/2 mile upstream of the mouth of the Slough.	38-47-10	121-39-30
45.	Salt Slough Collected by USGS near Lander Ave crossing.	37-14-50	120-51-00
46.	San Joaquin River/Fremont Ford Collected by USGS near Fremont Ford State Recreation Area.	37-18-15	120-55-25
47.	San Joaquin River/French Camp Slough Located about 0.5 mi above the San Joaquin River along South side of an island.	37-55-00	121-18-20

48.	Mud Slough Located on Highway 140, 0.5 mi north of Kesterson Wildlife Refuge.	37-17-30	120-56-35
49.	San Joaquin River/Newman Collected by USGS near Hills Ferry Crossing.	37-21-00	120-58-30
50.	San Joaquin River/Orestimba Creek Located at the river road crossing.	37-24-50	121-00-50
51.	San Joaquin Riv/Orestimba Ck/Bell Rd Located downstream of Bell Road bridge.	37-20-00	121-06-05
52.	San Joaquin River/Twitchell Island Located across channel from Twitchell Is. along shores of Bradford Is. and Webb Tract.	38-05-40	121-39-20
53.	San Joaquin River/Vernalis Extends about 4 mi upstream from Durham Ferry Park near San Joaquin city.	37-40-20	121-15-25
54.	San Leandro Creek Collected from under Highway 17 bridge.	37-43-30	122-10-55
55.	San Pablo Creek Located in San Pablo Ck from Third Ave to 1/2 mi upstream in city of San Pablo.	37-57-40	122-21-45
56.	Stockton Deep Water Channel From 50 yds east of San Joaquin River to 1/2 mile east of the river.	37-57-15	121-19-40
57.	Stony Gorge Reservoir	39-33-20	122-31-25
58.	Suisun Bay Several locations in Suisun Bay.	38-04-05	122-02-40
69.	Tuolumne River/Modesto Collected by the USGS near Modesto.	37-36-25	121-01-20

60.	Tuolumne River/San Joaquin River	37-36-25	121-08-40
61.	White Slough/Lodi Collected from 100 yards to 0.5 mi east of Honker Cut.	38-04-20	121-17-15

ANALYTICAL METHODS

Samples are processed in a "clean room" receiving filtered air. Liver composites are measured for eight trace metals. Flesh composites are measured for mercury, selenium, synthetic organics, and/or other trace metals. Occasionally, samples are analyzed for volatile organics, polynuclear aromatics, chlorinated phenols and organotins. These analyses are performed by the DFG Mussel Watch Laboratory or other labs

Synthetic organics (pesticides and PCBs) are analyzed by gas chromatography with an electron capture detector at the Department of Fish and Game Fish and Wildlife Water Pollution Control Laboratory (FWWPCL). Trace elements are measured at the FWWPCL by atomic absorption, with various methods of inducing the emission spectra.

QUALITY ASSURANCE TESTING AND REPORTING

At the FWWPCL similar quality assurance measures are taken for both trace elements and synthetic organics. For both of these classes of substances procedural blanks are analyzed to detect contamination, 10% of the samples are analyzed in duplicate, and all materials contacting the samples are analyzed. A mixture of synthetic standards was eluted to determine recovery rates. For trace elements, a National Bureau of Standards reference sample of oyster tissue is analyzed. Detailed results of quality control tests for the 1986 data are presented in Linn *et al.* (1987). Periodically, extra fish composites are processed and archived.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: State Water Resources Control Board, Division of Water Quality, Sacramento

Hardware: IBM PC

Software: RBase System V

Volume of Data: Approximately 2.0 megabytes

Quality Assurance: The data are entered by the Department of Fish and Game, who compare the computer entries against the original lab sheets.

Contact for Data Retrieval

Name: Del Rasmussen

Address: Monitoring and Assessment Unit
State Water Resources Control Board
Division of Water Quality
901 P Street
Mail: P.O. Box 100
Sacramento CA 95801

Phone: (916) 324-1261

Who Can Access This Information: Public information

Data Availability Date: The previous year's data are usually available in May or June of the following year.

REFERENCES

Agee, B.A. 1986. Toxic Substances Monitoring Program, 1984. Water Quality Monitoring Report 86-4WQ. State Water Resources Control Board. Sacramento, CA.

Linn, J.D., C. Reiner, D. Crane, L. Smith, and W. Seto. 1987. Toxic Substances Monitoring Program 1986 data report: Laboratory report No. 87-1. State Water Resources Control Board. Sacramento, CA.

Linn, J.D., C. Reiner, D. Crane, L. Smith, and W. Seto. 1986. Toxic Substances Monitoring Program 1985 data report: Laboratory report No. 86-1. State Water Resources Control Board. Sacramento, CA.

Phillips, P.T. 1987. Toxic Substances Monitoring Program: Data base description. State Water Resources Control Board. Sacramento, CA. 27 pages.

Rasmussen, D. and B.A. Agee. 1987. Toxic Substances Monitoring Program, 1985. Water Quality Monitoring Report No. 87-1WQ. State Water Resources Control Board. Sacramento, CA.

Rasmussen, D. 1988. Toxic Substances Monitoring Program, 1986. Water Quality Monitoring Report No. 88-2WQ. State Water Resources Control Board. Sacramento, CA.

~**Descriptors:** upper drainage; bay-delta; delta; biological resources; fisheries; invertebrates; pollutants and related parameters; bioaccumulation; histopathology; water pollution; water quality; clams; suisun bay; san francisco bay; drinking water; cyclodienes; organophosphates; carbamates;

GENERAL INFORMATION AND ABSTRACT

Program:	Trace Metal Accumulation in Benthos and Sediments
Funding Agency:	US Geological Survey U.S. Bureau of Reclamation (for the Suisun Bay studies)
Principal Investigator:	Dr. Sam Luoma (415) 329-4481 U.S. Geological Survey
Conducting Agency:	U.S. Geological Survey U.S. Bureau of Reclamation (sample collection for the Suisun Bay studies)
Period of Record, Earliest Date:	March, 1975
Period of Record, Latest Date:	Present
Length of Record:	13 years
Geographic Boundaries Description:	Samples have been collected throughout San Francisco Bay, from Suisun Bay to the South Bay.

ABSTRACT

Researchers at USGS have been collecting data on trace metal accumulation in bivalves and sediments throughout the Bay- Delta for over a decade.

Most recently, findings of an investigation of selenium accumulation in bivalves (*Corbicula* sp. and *Macoma balthica*) and sediments of the Bay, the Delta, and tributaries to the Delta have been reported (Johns *et al.*[In press]). Elevated concentrations of selenium in *Corbicula* were observed in Suisun Bay, and showed an increasing trend from the lower San Joaquin River into Suisun Bay. Concentrations of selenium in *Corbicula* from most stations in Suisun Bay were similar to those observed in an area of the San Joaquin River contaminated by agricultural runoff. The enrichment of selenium in Suisun Bay appears to be due to local inputs. Selenium levels in *Macoma balthica* also were elevated at one station in western Suisun Bay and one station in the South Bay. However, no enrichment was evident at two other stations, suggesting a lack of bay-wide contamination. Sediment concentrations of selenium did not consistently correlate with concentrations in tissues; tissue concentrations appeared to be more useful and

more sensitive indicators of selenium enrichment in the Bay. Selenium and mercury concentrations in tissues were not correlated.

Other recent research has characterized trace metal levels in the bivalve *Corbicula* sp. and sediments from Suisun Bay and the western Delta. This study indicates that the base level of metal enrichment in Suisun Bay is significantly greater than enrichment in the western Delta, apparently a consequence of greater urbanization surrounding Suisun Bay. Patches of substantial enrichment of cadmium, copper, and chromium were found to occur within Suisun Bay. Enrichment of chromium from a point source discharge into New York Slough, for example, appears to affect all of Suisun Bay. Enrichment of cadmium and copper in *Corbicula* was observed to be greater than the degree of enrichment observed in sediments, and relative to other estuarine systems. This suggests that parts of the Bay-Delta estuary may be more vulnerable to cadmium and copper accumulation in biota than many other aquatic environments exposed to similar inputs.

Long term monitoring of trace metals and associated variables has focused on the South Bay. The dynamics of biologically available metals in South Bay appear to be influenced by a complex interplay of processes whose individual roles are not fully understood. Seasonal patterns in fluctuations of copper and silver were evident in *Macoma balthica* at a metal-enriched station. These seasonal fluctuations are related to local discharges, seasonal changes in weight in bivalves, and seasonal hydrodynamics (driven by sporadic freshwater inputs to the estuary) that may affect both metal concentrations and bioavailability. Hydrodynamic influences could be manifested either by changes in sediment/water chemistry that affect metal bioavailability, or simply by affecting the accumulation of pollutants in South Bay through altering the residence time of water masses.

PARAMETERS

Media Analyzed: Biota. Sediment. Water.

BIOLOGICAL PARAMETERS MEASURED
bacterial numbers
condition factor
intra-cellular protein-associated metals
relative metal tolerance of populations
shell length

PHYSICAL PARAMETERS MEASURED
streamflow
sediment grain size
sediment surface Eh
surface area of sediments

CHEMICAL PARAMETERS MEASURED

Other Parameters

humic acid concentrations organic carbon
salinity
total carbon
water temperature

Trace Elements

cadmium
chromium
copper
iron
lead
manganese
mercury
selenium
silver
zinc

Other Hydrocarbons

extractable organics

TAXA

Acartia clausi	copepod
Corbicula sp.	clam
Ischadium demissus	mud mussel
Macoma balthica	clam
Musculista senhousia	mud mussel
Mya arenaria	bivalve
Nassarius obsoletus	snail
Tapes japonica	mussel

METHODS

SAMPLING METHODS

Clam and sediment samples collected from 1975 to the present throughout the Bay have been analyzed for trace metals and associated support variables. The principal focus of this research has been on trace metal concentrations in resident organisms and associated sediments (Luoma and Cain 1979, Thomson *et al.* 1984, Cain and Luoma 1985, Luoma *et al.* 1985, Johns *et al.* unpublished, Luoma *et al.* unpublished). The basic sampling procedures have changed little over the years. Sediments are collected in shallow water employing either a core or a hand grab. The oxidized surficial layer is scraped from the top of the sediment for analysis. Fifteen to thirty clams of a variety of sizes (*Macoma balthica* and *Corbicula* spp. have been used) are collected from each sampling site.

Manipulative experiments have also been conducted. Cain and Luoma (1985) examined silver and copper accumulation in transplanted *Macoma balthica* in the South Bay. In these experiments 120 animals were collected from a less enriched site and transplanted to a more enriched site. The clams were housed at the enriched site in 12 cages of plastic mesh for periods of 6 weeks and 6 months. On sampling dates two cages and twenty uncaged resident organisms were collected. In another controlled experiment, Luoma *et al.* (1983) assessed variation in tolerance to exposure of *Macoma balthica* and *Acartia clausi* to concentrations of copper. In these static toxicity assays individuals of both species were immersed in 2 liters of water with copper present from 10 to 1900 ppb, and LC50's were computed. Mortality rates were corrected for mortality observed in animals collected but not exposed to copper.

SAMPLING FREQUENCY AND LOCATION

Clams and sediments were collected at near monthly intervals at 8 intertidal stations in San Francisco Bay from March, 1977 to February, 1980 (Luoma and Cain 1977; Luoma and Cloern 1982; Nichols *et al.* 1986; Luoma *et al.* 1985). Station #1 has had on- going monthly collections from June 1975 to the present.

		Latitude	**Longitude**
1.	mouth of Palo Alto Yacht Harbor	37-27-35	122-05-58
2.	Candlestick Point	37-42-13	122-23-30
3.	east side of Dumbarton Bridge	37-30-31	122-06-33
4.	San Mateo Bridge - east side	37-38-14	122-09-02
5.	San Mateo Bridge - west side	37-34-13	122-15-22
6.	Pinole Point - east	38-00-11	122-20-20
7.	Pinole Point - west	37-59-03	122-21-45
8.	Martinez Yacht Harbor - proximity	38-01-24	122-06-30

Concentrations of copper, silver, and zinc were measured in the clam *Macoma balthica* in the South Bay at near monthly intervals for 8 years, from June 1975 to June 1983, off the mouth of the Palo Alto Yacht Harbor. Data resides in unpublished collections through the present (Luoma *et al.* 1985). Seasonal changes in intracellular metal distributions were determined in 1980-1982 employing gel filtration (Johansson *et al.* 1982). Effects of seasonally changing body weight and seasonally fluctuating metal concentrations also were determined (Cain and Luoma 1986), as were effects of varying metal correlations with body weight (Strong and Luoma 1981).

Macoma balthica (clams) were transplanted to Palo Alto from East Dumbarton Bridge in July and November of 1978 in order to assess the accumulation of copper and silver over time. The animals collected in July were used in a 6 week experiment during the summer, and the clams collected in November were used in an experiment which lasted throughout the 1978-1979 winter-summer period (Cain and Luoma 1985).

		Latitude	Longitude
1.	Palo Alto	37-27-35	122-05-58
2.	Redwood Creek	37-30-31	122-06-33

Eleven day static toxicity experiments were performed to evaluate the toxicity of soluble copper to different populations of two aquatic organisms, the bivalve *Macoma balthica*, and the plankter, *Acartia clausi. Macoma* samples were collected between February and October of 1979; *Acartia* were collected in October and December of 1980, and in February of 1981 (Luoma *et al.* 1983).

		Latitude	Longitude
1.	Central Bay	37-50-00	122-25-00
2.	San Pablo Bay	38-07-30	122-22-30
3.	Pinole Point	38-00-11	122-20-20
4.	east San Mateo Bridge	37-37-30	122-09-05
5.	Mouth of Palo Alto Yacht Harbor	37-27-35	122-05-58
6.	South Bay	37-40-00	122-12-30

Sediments and an indicator organism, *Macoma balthica*, were used to assess the relative importance of secondary sewage, urban runoff, a land-fill containing metal-enriched ash wastes, and a yacht harbor in contributing to silver, copper and zinc enrichment in the South Bay . Samples for this study were collected in July 1979, January 1980, and March of 1980, along 7 km of the shoreline near the Palo Alto sewage treatment plant and the mouth of San Francisquito Creek (Thomson *et al.* 1984).

		Latitude	Longitude
1.	Palo Alto Yacht Harbor	37-27-12	122-06-20
2.	Palo Alto Yacht Harbor	37-27-21	122-06-20
3.	Charleston Slough	37-27-12	122-05-05
4.	Palo Alto	37-27-35	122-05-58
5.	South Outfall 2	37-27-48	122-06-25
6.	South Outfall 1	37-27-50	122-06-40
7.	San Francisquito Creek	37-27-53	122-06-47
8.	University Avenue	37-28-26	122-07-18

The following 12 stations were sampled for trace metal concentrations in sediments and *Corbicula* (clams) from February to July in 1983 (Luoma *et al.* 1984).

		Latitude	Longitude
1.	Chain Island	38-04-00	121-51-20
2.	Delta-Mendota	37-49-00	121-33-15
3.	East Pinole	38-00-11	122-20-20
4.	Grizzly Bay	38-06-58	121-59-45
5.	Harris Harbor	38-02-57	121-57-35

6.	Honker Bay	38-04-07	121-54-53
7.	Mallard Slough	38-02-30	121-54-32
8.	Martinez	38-01-24	122-06-30
9.	Middle Ground	38-04-44	121-59-02
10.	New York Slough	38-01-53	121-50-00
11.	Roe Island	38-04-02	122-01-38
12.	Spoonbill Slough	38-03-12	121-53-23

At the following 9 stations in Suisun Bay and the San Joaquin Delta both sediments and clams were sampled and tested for metal concentrations over a three year period on 19 to 21 sampling dates. Samples were collected throughout the summer of 1983, then monthly from February 1984 through February of 1986. At the Grizzly Bay and Rio Vista stations sediments alone were sampled (Luoma *et al.* unpublished manuscript).

		Latitude	**Longitude**
1.	Chain Island	38-04-00	121-51-20
2.	Delta-Mendota Canal Intake	37-49-00	121-33-15
3.	Grizzly Bay	38-06-58	121-59-45
4.	Harris Harbor	38-02-57	121-57-35
5.	Mallard Slough	38-02-30	121-54-32
6.	Middle Ground	38-04-44	121-59-02
7.	New York Slough	38-01-53	121-50-00
8.	Rio Vista	38-10-12	121-40-00
9.	Roe Island	38-04-02	121-01-38

Selenium concentrations were measured in fine-grained, oxidized sediments, and in the benthic bivalves, *Corbicula*, and *Macoma balthica* (Johns *et al.* in press). Sampling took place from January, 1985 through September, 1986 at the first 7 stations listed. Mercury concentrations were determined in *Corbicula* from the initial 7 stations, and also from stations 10-12 in September of 1986, to test if interactions with mercury influenced concentrations of selenium.

In addition to the above, samples were collected once at one location each in North, Central and South Bays, and several times at another station in South Bay where selenium enrichment in birds had been reported. These results were compared to a collection from the estuary of Big River on the Northern California coast.

		Latitude	**Longitude**
1.	USGS Station C1	38-04-02	122-01-38
2.	USGS Station C2	38-04-44	121-59-02
3.	USGS Station C3	38-02-57	121-57-35
4.	USGS Station C4	38-02-30	121-54-32
5.	USGS Station C5	38-01-53	121-50-00
6.	USGS Station C6	38-04-00	121-51-20
7.	USGS Station C7 - lower San Joaquin River	37-49-00	121-33-15

9.	USGS Station C9 - Sacramento River (sampled once)	38-10-12	121-40-00
10.	USGS Station C10 - Tuolumne River (sampled once)	37-36-51	121-55-00
11.	USGS Station C11 - lower San Joaquin River (sampled once)	37-47-30	121-18-24
12.	USGS Station C12 - middle reach of the San Joaquin	37-18-25	120-55-40
13.	USGS Station M1 - Suisun Bay	38-01-24	122-06-30
14.	USGS Station M2 - Central Bay	37-50-39	122-17-55
15.	USGS Station M3 - San Mateo Bridge east	37-38-14	122-09-02
16.	USGS Station M4 - Palo Alto	37-27-35	122-05-58

ANALYTICAL METHODS

Sediment samples are analyzed for trace elements, total organic carbon (TOC), and other variables. Trace elements are analyzed by atomic absorption (AA) spectrophotometry. Background corrections are made where necessary. TOC and other carbon fractions are determined using a carbon analyzer.

Soft tissues from clams are analyzed for trace element concentrations using AA spectrophotometry. Animals from each sampling location are grouped into 4-8 pools of similar size for chemical determinations. Efforts have been made to obtain the full complement of sizes at each station to account for the influence of size upon tissue concentrations.

QUALITY ASSURANCE TESTING AND REPORTING

Reagent blanks and inorganic standard solutions have been carried through the analytical procedures to assure accuracy. National Bureau of Standards (NBS) reference sediments were analyzed to assure full recovery by the digestion techniques and analytical consistency with other methods. NBS reference oyster and albacore tissue, and other reference materials have also been analyzed. Reporting of quality control test results is more complete in recent reports.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Hardware: Prime computer and hard copy
Software: Minitab, Telegraph, 2020
Quality Assurance: Computer entries are double-checked against original data.
Contact for Data Retrieval
Name: Dr. Sam Luoma

Address: U.S. Geological Survey
Mail Stop 465, 345 Middlefield Road
Menlo Park CA 94025

Phone: (415) 329-4481

REFERENCES

Cain, D.J., and S.N. Luoma. 1985. Copper and silver accumulation in transplanted and resident clams (*Macoma balthica*) in South San Francisco Bay. Marine Environmental Research 15: 115-135.

Cain, D.J., and S.N. Luoma. 1986. The effect of seasonally changing tissue weight on trace metal concentrations in the bivalve *Macoma balthica* in San Francisco Bay. Marine Ecology Progressive Series 28: 209-217.

Cain, D.J. and S.N. Luoma. 1990. Influence of seasonal growth, age, and environmental exposure on Cu and Ag in a bivalve indicator, *Macoma balthica*, in San Francisco Bay. Mar. Ecol. Prog. Ser., 60:45-55.

Johansson, C., D.J. Cain, and S.N. Luoma. 1986. Variability in the fractionation of Cu, Ag, and Zn among cytosolic proteins in the bivalve *Macoma balthica*. Marine Ecology Progressive Series, 28: 87-97.

Johns, C.and S.N. Luoma. 1988. Selenium accumulation in benthic bivalves and fine sediments of San Francisco Bay, the Sacramento-San Joaquin Delta, and selected tributaries. Estuarine, Coastal and Shelf Science, 27:381-396.

Johns, C. and S.N. Luoma. In Press. Arsenic in benthic bivalves of San Francisco Bay and the Sacramento/San Joaquin River delta. Sci. Total Environ.

Kuwabara, J.S., C.C.Y. Chang, J.E. Cloern, T.L. Fries, J.A. Davis and S.N.Luoma. 1989. Trace metal associations in the water column of South San Francisco Bay, California. Estuarine, Coastal and Shelf Science, 28: 307-325.

Luoma, S.N., and D.J. Cain. 1977. Fluctuations of copper, zinc, and silver in tellenid clams as related to freshwater discharge-South San Francisco Bay. Presented at the Fifty-eighth annual meeting of the Pacific Division/American Association for the Advancement of Science, June 12-16, San Francisco, CA.

Luoma, S.N. 1989. Can we determine the biological availabiliaty of sediment-bound trace elements? Hydrobiologia, 176/177: 379-396.

Luoma, S.N., D.J. Cain, K. Ho, and A. Hutchinson. 1983. Variable tolerance to copper in two species from San Francisco Bay. Marine Environmental Research 10: 209-222.

Luoma, S.N., D.J. Cain, and C. Johansson. 1985. Temporal fluctuations of silver, copper, and zinc in the bivalve *Macoma balthica* at five stations in south San Francisco Bay. Hydrobiologia 129: 109-120.

Luoma, S.N., P.V. Cascos, and R.M. Dagovitz. 1984. Trace metals in Suisun Bay, California: A preliminary report. USGS Water Resources Investigations Report 84-4170.

Luoma, S.N. and J.E. Cloern. 1982. The impact of waste-water discharge on biological communities in San Francisco Bay. In "San Francisco Bay: Use and Protection". Kockelman, Levinton, Conomos (eds.) Pacific Division AAAS 137-160.

Luoma, S.N., R. Dagovitz, and E. Axtmann. Unpublished. Trace metals in sediments and the bivalve Corbicula sp. from the Suisun Bay/San Joaquin Delta of San Francisco Bay. USGS, Menlo Park.

Luoma, S.N., R. Dagovitz, and E. Axtmann. In Press. Temporally intensive study of trace metals in sediments and bivalves from a large river/estuarine system: Suisun Bay/Delta in San Francisco Bay. Sci. Total Environ.

Luoma, S.N. and D.J.H. Phillips. 1988. Distribution, variability and impacts of trace elements in San Francisco Bay. Marine Pollution Bulletin, 19(9): 413-425.

Nichols, F.H., J.E. Cloern, S.N. Luoma, and D.H. Peterson. 1986. The modification of an estuary. Science 231: 567-573.

Strong, C.R., and S.N. Luoma. 1981. Variations in correlation of body size with concentrations of Cu and Ag in the bivalve *Macoma balthica*. Can. Journal Fish. Aquatic Science. 38(9): 1059-1064.

Thomson, E.A., S.N. Luoma, C.E. Johansson, and D.J. Cain. 1984. Comparison of sediments and organisms in identifying sources of biologically available trace metal contamination. Water Research 18(6): 755-765.

~**Descriptors:** san francisco bay; bay-delta; san pablo bay; central bay; biological resources; invertebrates; plankton; trace elements; toxicity testing; sediment chemistry; delta inflow; hydrology and flow; pollutants and related parameters; agricultural drainage; benthos; POTWs; bioaccumulation; bivalve; clam; mollusc; urban runoff; pollutant sources; point sources; bacteria; sediments and dredging; plankton/algae/seagrass; mussel; ambient toxicity testing; nonpoint sources; water pollution; water chemistry; water quality; sacramento river; san joaquin river; benthic infauna; rivers; upper drainage; shellfish;

GENERAL INFORMATION AND ABSTRACT

Program:	Bioassays for Local Effects Monitoring of Wastewater Discharges
Principal Investigator:	Jim Roth (415) 231-9518 University of California at Berkeley, SEEHRL
Conducting Agency:	SEEHRL
Period of Record, Earliest Date:	July - October, 1982 July through September, 1983
Geographic Boundaries Description:	The 1982 aufwuchs study was conducted at the Chevron and East Bay Municipal Utilities District (EBMUD) outfalls in San Pablo and Central Bays, respectively. The 1983 mussel growth bioassays were conducted at the EBMUD outfall; mussels from Tomales Bay were also employed in this study.

ABSTRACT

A monitoring plan for the San Francisco Bay-Delta Aquatic Habitat Program was prepared in 1982 by researchers at the Sanitary Engineering and Environmental Health Research Laboratory (SEEHRL) of the University of California, Berkeley, and subsequently adopted by the California State Water Resources Control Board (California State Water Resources Control Board 1982). One component of the Aquatic Habitat Program was local effects monitoring using in situ tests (or "dilution field bioassays") to detect toxic or biostimulatory effects of discharges on animal and plant communities in receiving waters. The SEEHRL plan proposed that these bioassays use bagged bivalves for toxicity evaluation, and growth of aufwuchs (fouling organisms, mainly diatoms) to measure biostimulation. Results are described below from demonstrations of these two types of tests conducted in 1982 and 1983.

Biostimulation assays were conducted during 1982 near two wastewater discharges into San Francisco Bay, one a large municipal deepwater discharge in well-mixed water (East Bay Municipal Utility District) and the other a large industrial discharge flowing into a shallow cove (Chevron USA's Richmond Refinery). Aufwuch growth on artificial substrates was measured near discharges and at reference stations farther away. Aufwuchs growth consistently was significantly higher near the municipal outfall where initial dilution was at least 50:1. At both discharge sites, all measures of response (photosynthesis, respiration, chlorophyll a,

biomass accretion) showed a similar overall trend of enhanced production near the discharges.

Bivalve bioassays were performed on effluent from the City of San Francisco Southeast Water Pollution Control Plant (Roth et al. 1984). Tests were run on three separate occasions during 1982 and 1983. Toxic effects were found in only one test, with a significant reduction in growth rate as measured by shell length, fresh flesh weight, water content, and dry weight occurring near the discharge relative to mussels held further away. This toxic effect was thought to be probably ecologically insignificant because it was observed only once, and in a small area. The observed variation in toxicity was attributed to variation in the composition of the effluent. Concentrations of cyanide, chlorinated hydrocarbons, and fish toxicity of the effluent were higher when mussel growth rates were reduced.

PARAMETERS

Media Analyzed: Biota. Water.

BIOLOGICAL PARAMETERS MEASURED

chlorophyll *a*
mussel shell length, fresh and dry meat weight
photosysthesis
respiration

CHEMICAL PARAMETERS MEASURED

Chlorinated Hydrocarbons

Other Parameters

cyanide
dissolved oxygen
phenol
salinity
secchi depth
total volatile solids
water temperature

Pesticides

malathion

Trace Elements

zinc

TAXA

Licmorphora abbreviata	
Melosira	
Mytilus edulis	mussel

Navicula	diatom
Nitzschia	
Pleurosoma	
Synedra spp.	pennate diatom

I

METHODS

SAMPLING METHODS

Aufwuchs were collected on tygon tubing substrata suspended in the Bay. These tubes were harvested when growth covered the tubes; the duration of growth experiments was therefore not fixed but depended on the growth rate of colonizing aufwuchs. Surface temperature, salinity, and Secchi disk readings were recorded in the field, and BOD analysis was performed on the day of harvest.

Mussels collected from a site near the end of the Berkeley Pier were suspended in Bay waters held in plastic mesh cages. Each cage contained 40 mussels. Cages were held in the Bay for 2, 4, or 6 weeks. Surface temperature, salinity, and Secchi disk readings were recorded in the field. Water samples were collected at each station in one of the sampling periods.

Sampling Location and Frequency:

Two sampling sites were chosen for the 1982 aufwuchs studies; these were the outfalls from Chevron and the East Bay Municipal Utilities District (EBMUD). The Chevron USA Refinery outfall was located in Castro Creek, in San Pablo Bay. Five stations were established in an array extending about 1.6 miles from the discharge. Two reference sites were established east of Castro Cove, near the mouth of San Pablo Creek.

Five stations were also established in a line from the EBMUD outfall in Central Bay, beginning about 650 feet south of the Oakland-Bay bridge, and east of Yerba Buena Island. Two reference stations were established about 1000 yards off the end of the Berkeley pier.

For the July through September 1983 mussel growth bioassays five stations were established which extended from near the EBMUD diffuser upcurrent to about 3/4 mile away; these were the same stations as those occupied in the 1982 study discussed above. A sixth station was located downcurrent from the diffuser, 400 feet to the east. Mussels from Tomales Bay were also employed in these experiments.

ANALYTICAL METHODS

In the laboratory, aufwuch photosynthesis, respiration, chlorophyll, dry weight, and ash-free dry weight were measured. Photosynthesis and respiration were measured by oxygen production or consumption after incubation in light and dark BOD bottles, respectively. Dissolved oxygen levels were determined by the Winkler method. Chlorophyll a concentrations were determined by fluorometry.

Mussel shell length, total wet weight, fresh flesh weight, dry flesh weight, and dry shell weight were measured in the laboratory. Shells were archived for possible restudy later.

|

DATA STORAGE INFORMATION:

Information on data storage was not available.

REFERENCES:

Roth, J.C., D.W. Smith, and A.J. Horne. 1983. Dilution-field bioassays for local effects monitoring of wastewater discharges into San Francisco Bay. Sanitary Engineering and Environmental Health Research Laboratory report to the California State Water Resources Control Board. UCB/SEEHRL Report No. 83-1, available from SEEHRL, at the University of California, Berkeley.

Roth, J.C., R.L. Williamson, A.J. Horne, D.W. Smith, and M.L. Commins. 1984. Dilution-field bioassays for local effects monitoring of wastewater discharges into San Francisco Bay. Sanitary Engineering and Environmental Health Research Laboratory report to the California State Water Resources Control Board. UCB/SEEHRL report No. 84-1, available from SEEHRL, at the University of California, Berkeley.

Descriptors: bay-delta; san pablo bay; central bay; toxicity testing; effluent testing; shellfish; primary production; plankton/algae/seagrass; refineries; point sources; pollutant sources; POTWs;

GENERAL INFORMATION AND ABSTRACT

Program:	Butyltin Study
Funding Agency:	State Water Resources Control Board University of California Toxic Substances Teaching and Research Program
Principal Investigator:	Edward D. Goldberg (619) 534-2407 Scripps Institution of Oceanography
Conducting Agency:	Scripps Institution of Oceanography
Period of Record, Earliest Date:	February, 1986
Period of Record, Latest Date:	June, 1986
Length of Record:	4 months
Geographic Boundaries Description:	Samples were taken at 28 stations in the Bay and Delta, and at more than 90 locations throughout the State.

ABSTRACT

In a program sponsored by the State Water Resources Control Board and the University of California Toxic Substances Teaching and Research Program, researchers at Scripps Institution of Oceanography monitored 3 chemical forms of butyltin in waters and sediments throughout coastal California in 1986. Concentrations of tributyltin (TBT, the extremely toxic form of butyltin) ranged from 20 to 600 ppt, with the highest levels found in marinas. In general, TBT concentrations in marina waters were greater than those of dibutyltin (DBT) or monobutyltin (MBT). In those marinas where the concentrations of TBT were above approximately 100 ppt there was usually a conspicuous absence of native organisms, especially molluscs (molluscs are especially susceptible to TBT because of high bioaccumulation and low depuration rates). High values of TBT in the water column were usually associated with high total butyltin in the underlying sediment. However, MBT and DBT levels were higher in most sediments than TBT levels.

PARAMETERS

Media Analyzed: Sediment. Water.

CHEMICAL PARAMETERS MEASURED

dibutyltin
monobutyltin
tributyltin

|

METHODS

SAMPLING METHODS

Sampling was primarily performed in large marinas with high densities of pleasure and fishing craft so that TBT was likely to be present in relatively high concentrations. Surface water samples were collected from dock or shore areas in polycarbonate bottles. At each marina or water body at least two water samples and one sediment sample were taken. Duplicate water samples were taken from two different locations in the water body. Collecting duplicates ensured at least one value in case one of the samples was lost in analyses, and if neither of the samples were lost they provided a sense of variation in concentrations at each site.

Sediment samples were obtained with a corer. At least five grams of dry weight of solids taken from the upper 10cm of sediment were assayed.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: 28

Each of the following sites was sampled once.

1. Antioch Yacht Club
2. Berkeley Marina
3. Bethel Island, Yacht Sales
4. Coyote Point Marina
5. Emeryville Cove Marina
6. Fort Mason East (North)
7. Fort Mason South (West)
8. Martinez Marina
9. Oakland Estuary Alameda Marina
10. Oakland Estuary London Marina
11. Oxbow Marina, Isleton
12. Peninsula Marina off Whipple Blvd.
13. Pete's Harbor, Redwood City
14. Pier 39, San Francisco
15. Pittsburgh Marina
16. Rio Vista Delta Marina
17. Richardson Bay Clipper Yacht Harbor
18. Richardson Bay Sausalito Yacht
19. Sacramento Turning Basin

20. San Rafael Yacht Harbor
21. St. Francis Yacht Club
22. Stockton, Ladds Marina
23. Stockton, Paradise Point
24. Stockton Water-Front Yacht Club
25. Stockton, Tower Park
26. Tiki Lagoon Resort
27. Vallejo Across from Mare Island
28. Village West, Stockton

ANALYTICAL METHODS

Butyltin measurements in seawater and sediments were analyzed by hydride derivatization and hydrogen flame atomic absorption spectroscopy. Concentrations of butyltin in water are reported on a ppt basis, while sediment results are reported on a ppb basis.

QUALITY ASSURANCE TESTING AND REPORTING

Butyltin standards were prepared from monobutyltin trichloride, dibutyltin dichloride and tributyltin chloride. An interlaboratory comparison of analytical results for dibutyltin and tributyltin obtained by Scripps with those of the Naval Oceans Systems Center in San Diego found close agreement. The two labs analyzed water collected from the Chesapeake Bay by the National Bureau of Standards.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Contact for Data Retrieval

Name: Ed Goldberg
Address: University of California At San Diego
Mail Code A-020
La Jolla CA 92093
Phone: (619) 534-2407

REFERENCES

Goldberg, E. 1986. Butyltin in California coastal and Delta waters and sediments. Draft data report to the State Water Resources Control Board.

Stallard, M., V. Hodge, and E. Goldberg. 1986. The California coastal waters; monitoring and assessment. Environmental Monitoring and Assessment 9: 195-220.

Stang, P., and E. Goldberg. 1989. Butyltins in California River and Lake Marina Waters. Applied Organometallic Chemistry: 183-187.

~**Descriptors:** tin; organotin; shellfish; bivalves; molluscs; biocides; invertebrates; biological resources; bay-delta; trace elements; pollutants and related parameters; community structure; species diversity; water chemistry; water pollution; water quality;

GENERAL INFORMATION AND ABSTRACT

Program: Chevron Equivalent Protection Study

Funding Agency: Chevron, USA, Inc.

Conducting Agency: CH2M Hill
California Analytical Laboratories
Sanitary Engineering and Environmental Health Research Laboratory, UC Berkeley

Period of Record, Earliest Date: December, 1980

Period of Record, Latest Date: January, 1982

Geographic Boundaries Description: Samples were collected at the Chevron outfall in Castro Cove, (San Pablo Bay), and at Corte Madera and Gallinas Creek in Marin County.

ABSTRACT

In 1980 the San Francisco Bay Regional Water Quality Control Board ruled that Chevron, USA must move the outfall into Castro Creek from its Richmond Refinery unless it could be shown that Castro Creek was receiving "equivalent protection". Equivalent protection exists if the impact of the present discharge is no greater than projected impacts at an alternative discharge site which meets the requirements of the Basin Plan. The Equivalent Protection Study included a detailed examination of the Castro Cove ecosystem over an annual cycle. Results were compared to results obtained from the same analyses conducted in other marshes with similar ecological features. Water and sediment quality, epibenthic and infaunal invertebrates, fish, vegetation, and wildlife were evaluated in the marshes. Bioassays were also conducted using resident species.

Ecological characteristics of Castro Cove Marsh were compared with those of marshes in Corte Madera and near Gallinas Creek. Higher productivity was observed in Castro Cove Marsh, probably due to nutrient loadings from the refinery effluent. Populations of small mammals and birds in Castro Cove Marsh were generally comparable to those at the other marshes. The endangered California clapper rail, however, was less abundant, an observation attributed to less of its preferred habitat being present. Differences between benthic communities in Castro Cove and the control areas appeared to be due to poor sediment quality in the

Cove. Spatial trends in species diversity were correlated with spatial trends in oil and grease concentrations in deeper sediments. Benthic invertebrates which burrow into Bay sediments (including bay shrimp, Dungeness crab, *Macoma balthica, Mya arenaria*, and *Ischadium demissum*) were rare or absent from Castro Creek.

Fish collections failed to find small flatfishes in any of the areas sampled in Castro Cove. Larger starry flounder were found in the area, however, suggesting that more sensitive early life stages of these fish may be affected by conditions in the Cove. In bioassays with horse mussels, no mortality or reduction in growth was observed over 107 day *in situ* exposures, although mussels did accumulate chromium, chlordane, DDD, and hydrocarbons relative to controls. Dungeness crab exposed to undiluted refinery effluent in tanks over a 60 day period showed no response.

Sediment and water samples from the Castro Creek area were also analyzed for various constituents. Ammonia, nitrite, orthophosphate, chlorophyll, and alkalinity were higher near Castro Creek than in control areas, apparently a direct result of the wastewater discharge. Sediments from the area exhibited elevated levels of oil and grease, hydrocarbons, BOD, ammonia, and sulfide. This contamination, however, was thought to be attributable to previous discharges in the area, as the contaminated sediments were covered by a thin layer of relatively clean sediments.

PARAMETERS

Media Analyzed: Biota. Sediment. Water.

BIOLOGICAL PARAMETERS MEASURED
benthic species abundance and biomass; Dungeness and yellow shore crab carapace width; Bay shrimp total length fish species abundance, physiological condition, parasitism, length, and weight. Starry flounder and striped bass stomach contents. mammal sex, age, and general condition waterfowl species abundance and foraging strategy vegetation cover, frequency, height, and biomass

PHYSICAL PARAMETERS MEASURED
soil conductivity
soil pH
soil salinity
soil total Kjeldahl nitrogen

CHEMICAL PARAMETERS MEASURED
Chlorinated Hydrocarbons
Aroclor 1248
Aroclor 1254

Other Hydrocarbons
alkanes
oil and grease
PAHs
phenolic compounds

Other Parameters
bicarbonate alkalinity
biochemical oxygen demand
calcium
carbonate alkalinity
chlorophyll *a*
dissolved oxygen
electrical conductivity
fecal coliforms
magnesium
pH
pheophytin pigments
potassium
secchi depth
sediment grain size
silica
sulfide
total coliform
total organic carbon
total suspended solids
total volatile solids
water temperature

Nutrients
ammonia nitrogen
nitrate nitrogen
nitrite nitrogen
orthophosphate
phosphate
total Kjeldahl nitrogen
unionized ammonia

Pesticides
chlordane
4,4- DDD
4,4- DDE

Trace Elements
antimony
arsenic
beryllium boron
cadmium
calcium
chromium
copper
iron
lead
magnesium
manganese
mercury
nickel
potassium
selenium
silver
thallium
zinc

TAXA
Benthic and Other Invertebrate Species
Ampelisca milleri
Amphithoe valida
Anaitides williamsi
Armandia brevis
Asychis elongata
Barleeia sp.
Brania sp.
Cancer magister
Capitella capitata
Cerebratulus californiensis
Chaetozone spp.
Cirriformia spirabrancha
Chone gracilis
Corophium ascherusicum
Corophium indisiosum
Corophium spinacorne
Corophium uenoi
Corophium spp.
Crangon franciscorum
Cumella vulgaris
Cylindrolebidae
Diadumne franciscana

Edotea sublittoralis
Eteone californica
Eteone lighti
Eteone sp.
Exogone lourei
Exogenella sp.
Gemma gemma
Glycera capitata
Glycinde polygnatha
Glycinde spp.
Gobidae
Grandidierella japonica
Harmathoe imbricata
Harpacticoida
Hemigrapsus oregonensis
Heteromastus filiformis
Ischadium demissum
Leitoscoloplos pugettensis
Macoma balthica
Mediomastus californiensis
Megalopae
Molgula manhattensis
Musculus senhousia
Mya arenaria
Mysidacea
Mytilus edulis
Namanereis quadraticeps
Nassarius obsoletus
Neanthes brandt-virens
Neanthes spp.
Neanthes succinea
Nematoda
Nephthys caecoides
Nephthys cornuta franciscana
Nereis spp.
Nereis vexillosa
Nothria elegans
Nudibranchia (unidentified spp.)
Odostomia spp.
Olivella spp.
Ophiuroidea
Parapleustes sp.
Paraprionospio pinnata
Podocipdae

Polydora brachycephala
Polydora ligni
Polydora socialis
Polydora sp.
Prionospio pygmaea
Pseudopolydora kempi
Pseudopolydora paucibranchiata
Pygospio elegans
Sarsiella zostericola
Scolelepis squamatus
Sphaeroma pentodon
Sphaerosyllis californiensis
Streblospio benedicti
Synidotea laticauda
Tanais (Synelobus) standordi
Tapes japonica
Tharyx spp.
Turbellaria
Turbinilla spp.
Zirfaea pilsbryi

Bioassay Species

Cancer magister	Dungeness crab
Ishadium demissum	ribbed horse mussel

Bird Species

Actitis macularia	spotted sandpiper
Aechmophorus occidentalis	western grebe
Agelaius phoeniceus	red-winged blackbird
Anas acuta	pintail
Anas americana	American widgeon
Anas platyrhynchos	mallard
Aquila chrysaetos	golden eagle
Ardea herodias	great blue heron
Aythya collaris	ring-necked duck
Buteo jamaicensis	red-tailed hawk
Caladris alpina	dunlin
Calidris canutus	knot
Carpodacus mexicanus	house finch
Casmerodius albus	great egret
Cathartes aura	turkey vulture
Catoptrosphorus semipalmatus	willet
Charadrius semipalmatus	semi-palmated plover
Charadrius vociferous	killdeer

Circus cyaneus	marsh hawk
Corvus brachyrhynchos	common crow
Corvus corax	common raven
Cypseloides niger	black swift
Egretta thula	snowy egret
Elanus leucurus	white-tailed kite
Ereunetes pusillus	least sandpiper
Falco sparverius	American kestrel
Fulica americana	American coot
Himantopus mexicanus	black-necked stilt
Hirundo rustica	barn swallow
Lanius ludovicianus	loggerhead shrike
Larus argentatus	herring gull
Larus californicus	California gull
Larus canus	new gull
Larus delawarensis	ring-billed gull
Larus occidentalis	western gull
Laterallus jamaicensis	black rail
Limnodromus scolopaceus	long-billed dowitcher
Limosa fedoa	marbled godiwit
Megaceryle alcyon	belted kingfisher
Melospiza melodia	song sparrow
Nycticorax nycticorax	black-crowned night heron
Oxyura jamaicensis	ruddy duck
Palacrocorax auritus	double-crested cormorant
Phasianus colchichus	ring-necked pheasant
Podilymbus podiceps	pied-billed grebe
Pluvialis squatarola	black-bellied plover
Rallus limicola	Virginia rail
Rallus longirostris	clapper rail
Recurvirostra americana	American avocet
Sayornis saya	Say's phoebe
Spinus tristis	American goldfinch
Stelgidopteryx ruficollis	rough-winged swallow
Sterna forsteri	Forster's tern
Sturnus valgaris	starling
Sturnella neglecta	western meadowlark
Telmatodytes palustris	long-billed marsh wren
Tringa melanoleuca	greater yellowlegs
Tyto alba	barn owl
Zenaida macroura	mourning dove
Zonotrichia leucophrys	white-crowned sparrow

Fish

Acanthogobius flavimanus	yellowfin goby
Allosmerus elongatus	whitebait smelt
Amphistichus argenteus	barred surfperch
Amphistichus koelzi	calico surfperch
Atherinops affinis	topsmelt
Citharichthys sordidus	Pacific sanddab
Citharichthys stigmaeus	speckled sanddab
Clevelandia ios	arrow goby
Clupea harengus pallasii	Pacific herring
Cymatogaster aggregata	shiner surfperch
Damalichthys vacca	pile surfperch
Dorosoma petenense	threadfin shad
Engraulis mordax	northern anchovy
Gallichthys mirabilis	longjaw mudsucker
Gasterosteus aculeatus	threespine stickleback
Genyonemus lineatus	white croaker
Hyperprosopon anale	spotfin surfperch
Hyperprosopon argenteum	walleye surfperch
Lepidogobius lepidus	Bay goby
Leptocottus armatus	staghorn sculpin
Micrometrus minimus	dwarf surfperch
Mustelus henlei	brown smoothhound
Parophrys vetulus	English sole
Platichthys stellatus	starry flounder
Porichthys notatus	plainfin midshipman
Psettichthys melanostictus	sand sole
Roccus saxatilis	striped bass
Sebastes auriculatus	brown rockfish
Spirinchus thaleichthys	longfin smelt
Symphurus atricauda	California tonguefish
Syngnathus leptorhynchus	Bay pipefish
Triakis semifasciata	leopard shark

Mammals

Microtus californicus	California meadow vole
Mus musculus	mouse
Rattus norvegicus	Norway rat
Reithrodontomys raviventris	salt marsh harvest mouse

Plant Species

Atriplex patula	saltbush
Cuccuta salina	dodder
Distichlis spicata	saltgrass
Frankenia grandifolia	frankenia

Grindelia stricta	gumplant
Jaumea carnosa	jaumea
Limonium californicum	sea-lavender/marsh-rosemary
Salicorna virginica	pickleweed
Spartina foliosa	cordgrass
Triglochin maritima	arrow-grass

METHODS

SAMPLING METHODS

As discussed in the Abstract, the Equivalent Protection Study was a multi-faceted investigation into the environmental characteristics of Castro Cove, including many different types of original research. Only some of the methods employed in that effort are presented very briefly here. For further information, the reader should consult the study itself.

Marsh ecology

Vegetation and soils data were collected at permanent sites in Castro Creek marsh, and two control marshes at Gallinas Creek and Corte Madera. Vegetation cover, frequency, height, and biomass were measured in quadrats randomly located along transects at each site. Soil samples were collected from selected vegetation quadrats using a coring tube. In sampling of small mammals, trapping grids were established in stands of middle marsh vegetation (e.g. *Salicornia virginica*) using Sherman live-traps. Captured animals were examined for sex, age class, and general condition, then released at the station where it was captured. Avian surveys at the three marshes were conducted during February, June, and September in 1981. Transect locations were selected by vegetation communities so that similar habitats could be compared among the marshes. Population densities were determined using a modified strip census method. Audio call counts were conducted in June to determine the presence of the clapper rail at each marsh.

Benthic Invertebrates

Benthic sampling stations were established in the Castro Cove area in marsh creeks, intertidal, and subtidal areas around the discharge point, and in each of the control marshes. Four replicate benthic samples were collected at each station using a 0.05 square meter Ponar grab. Samples were washed through a 0.5mm sieve. Important epibenthic species, Dungeness crab (*Cancer magister*), Bay shrimp (*Crangon franciscorum*), and yellow shore crab (*Hemigrapsus oregonensis*), were also collected, using crab traps, minnow traps, and fish trawls. Dimensions, weight, reproductive state, and general condition of these species were noted.

Fish

Fish were collected monthly in each study area using three methods. Otter trawls were conducted to collect benthic and midwater species. Gill nets were used in small tidal sloughs to capture benthic, epibenthic, and midwater species. Minnow traps were used in small sloughs to capture epibenthic fish. Fish were identified to species, measured for length and weight, and examined for signs of disease, parasitism, and other anomalies. Stomachs were excised form 32 striped bass and starry flounder for food habits analysis.

Water and Sediment Quality

Water quality samples were gathered monthly at each of the three study areas, from February 1981 to January 1982. Field measurements were made of pH, electrical conductivity, temperature, depth, dissolved oxygen, and Secchi depth. Grab samples collected with a Van Dorn sampler were analyzed for in the laboratory for nutrients, zinc, and other standard parameters. Sediment samples were collected as described above. Four replicate cores were taken at each site.

SAMPLING FREQUENCY AND LOCATION

Aerial photographs were taken in December of 1980 and September of 1981 for vegetation analysis. All field activity for this study occurred at Castro Cove, Corte Madera, and Gallinas Creek in three sampling periods, late February, late May, and September of 1981.

Sampling of vegetation occurred on transects established at 6 locations per marsh in February, May and September of 1981.

Small mammal studies were conducted at all three marshes. Trapping periods were from February 24-March 11, May 15-June 13, and August 30-September 10. Traps were set for three consecutive nights during low or medium_tides.

Avian studies were conducted at the three marshes on 3 consecutive mornings in February, May, and September of 1981.

Benthic data were collected in March, June, September, and December of 1981. Thirteen benthic stations were established in Castro Creek Cove and marsh, and eight benthic stations were established in both Gallinas and Corte Madera marshes.

Sediment samples were collected concurrently with the benthic sampling at a total of 20 stations during the months of March, June, September, and December of 1981.

Creeks, mudflats, and channels were sampled by otter trawl at Castro Cove, Gallinas and Corte Madera marshes. Gill nets and minnow traps were set for approximately 24 hours at two stations in each of two tidal sloughs at each of the 3 study sites. These fish collections were made monthly from February 1981 through January 1982, except from April to July when collections were made twice a month.

Thirty cages containing young ribbed horse mussels, *Ischadium demissum*, were placed at each of the three study areas from the end of August through mid-December, 1981 for *in situ* experiments. *I. demissum* were also collected and employed in a 75-day bioassay laboratory experiment.

Bioassay experiments employing Dungeness crabs, (*Cancer magister)* were conducted from November 1981 through January of 1982 at both Chevron and SEEHRL laboratories.

Water quality data was gathered during monthly cruises at a total of 20 stations from February 1981 thorough January 1982. Water quality stations were established at the same locations benthic invertebrate and sediment quality samples were obtained.

ANALYTICAL METHODS

Benthic samples were sorted into major taxonomic groups (Crustacea, Mollusca, Polychaeta, and others), and the biomass for each group determined. Organisms were then identified to species, where possible, and enumerated. Life history studies of *Gemma gemma* and *Macoma balthica* were performed. Estimates of age and growth for both species were made using size-frequency methods.

In situ bioassays with ribbed horse mussels (*Ischadium demissum*) were performed. Cages containing mussels were installed at each of the three study areas in late August, then retrieved in mid-December. The mussels were then weighed and measured. A subsample of mussels was analyzed for pesticides, hydrocarbons, and metals by California Analytical Laboratories, Inc. in Sacramento, CA, using procedures prescribed by the California State Mussel Watch. Analog tank bioassays were also conducted, using tanks supplied continuously with either process wastewater (the treatment) or cooling water (the control). Ribbed horse mussels, Dungeness crab, and Bay shrimp were placed in the tanks for 75 to 90 days, and changes in size and vigor were recorded.

Water quality measurements were made using standard methods. Replicate sediment cores were analyzed for oil and grease, hydrocarbons, phenolics, cadmium, chromium, copper, lead, zinc, nutrients, grain size, and other parameters using standard methods.

QUALITY ASSURANCE TESTING AND REPORTING

Benthic samples were archived for future reference.

|

DATA STORAGE AND REFERENCES

DATA STORAGE

Data storage information was not available for this study.

REFERENCES

CH2M Hill. 1981. Equivalent protection study preliminary investigation. Report to Chevron, USA. Richmond, CA.

CH2M Hill. 1982. Equivalent protection study intensive investigation. Final report to Chevron, USA. Richmond, CA.

CH2M Hill. 1982. Equivalent protection study intensive investigation. Appendix to final report to Chevron, USA. Richmond, CA.

~**Descriptors:** bay-delta; PCBs; pollutants and related parameters; endangered species; biological resources; toxicity testing; sediment chemistry; sediments and dredging; hydrology and flow; effluent testing; benthic invertebrates; marsh ecology; fisheries; water quality; water chemistry; water pollution; refineries; point sources; birds; community structure; wetlands; bioaccumulation; wetland ecology; pollutant sources; benthic infauna; crabs; shellfish; clams; mussels; shrimp; waterfowl; herons; shorebirds; water birds; dabbling ducks; diving ducks; DDT;

GENERAL INFORMATION AND ABSTRACT

Program: Chevron Toxicity Reduction Evaluation

Funding Agency: Chevron, U.S.A.. Inc.

Principal Investigator: Pete Williams (415) 620-5400
Chevron, USA, Inc.

Conducting Agency: Chevron, USA
CH2M Hill
Envirosphere Company
Northwestern Aquatic Sciences Division
Flow Science, Inc.

Period of Record, Earliest Date: July, 1987

Period of Record, Latest Date: March, 1988

Length of Record: 8 months

Geographic Boundaries Description: Samples were collected at the Chevron refinery in Richmond.

ABSTRACT

A National Pollutant Discharge Elimination System (NPDES) permit issued by the San Francisco Bay Regional Water Quality Control Board to the Richmond Refinery of Chevron USA, Inc. (Chevron) in 1987 required the refinery to maintain 50% survival of rainbow trout in toxicity tests with 100% effluent. Chevron was initially unable to meet this requirement, and therefore conducted a Toxicity Reduction Evaluation (TRE) to determine the cause of toxicity and to bring the effluent into compliance. At the same time Chevron conducted a hazard assessment on their effluent, which included further effluent characterization and studies of the dilution of their effluent in the waters of the Bay.

One aspect of the TRE consisted of efforts to reduce effluent toxicity through improvements in methods of operation of the refinery, including a better wastewater treatment system and more careful tracking of chemicals used in refining (Chevron 1988). In addition, extensive testing was performed to identify the causes of effluent toxicity. Samples of influent and effluent from the refinery treatment system were analyzed for dissolved toxic organics. Some compounds were found to pass through the system, and were suspected to be one of the sources of toxicity in the final effluent. These organics were primarily found in waters that contacted

California crude oil. A source control program for these compounds was implemented, including a $1,500,000 treatment unit designed to recover soluble organic hydrocarbons. The effect of salinity on the sensitivity of rainbow trout was also tested, as the saline nature of Chevron's effluent was thought to contribute to its toxicity. After the TRE, the refinery has consistently met the requirements of the rainbow trout bioassay, achieving better than 90% survival in 100% effluent.

As mentioned above, Chevron concurrently conducted a hazard assessment of their effluent (Chevron 1988). The hazard assessment combined data obtained from toxicity bioassays of Chevron's effluent with estimates of the dilution of the effluent at the discharge point to determine whether toxicity in the receiving waters would be expected. Eleven different acute and chronic toxicity tests were conducted to determine the highest concentrations at which the effluent did not produce toxic effects. The lowest 96 hour LC50 in acute tests (conducted on striped bass, sand dab, and Dungeness crab) was exhibited with sand dab. The LC 50 for sand dab was 89% effluent. Chronic toxicity was evaluated by conducting three 28-day larval tests with indigenous species (striped bass, Korean prawn, and Dungeness crab) and five short- term early life stage tests with surrogate species (oyster, mussel, sand dollar, *Champia* [a red alga], and *Menidia* [silverside]). The most sensitive test was the 28-day striped bass larval test with a no-effect (on growth and development) concentration of 3%. A 7-day test with *Menidia* larvae was also highly sensitive, with a no-effect level of 8%. These acute and chronic tests also indicated a significant improvement in effluent quality after the completion of the TRE.

A field dye study and mathematical modeling were performed to determine the dilution rates of Chevron's effluent in the Bay. The hazard assessment was based on predictions obtained using EPA's UDKHDEN model for dilution of a buoyant plume. The worst- case minimum dilution estimated for this discharge at the edge of the zone of initial dilution was 80:1. The predicted minimum average dilution over a tidal cycle was 212:1. Combining these dilution rates with the no-effect levels observed in toxicity tests, Chevron concluded that their effluent does not present either an acute toxicity hazard or a chronic toxicity hazard to aquatic life in the Bay.

A microbial study of the Richmond Refinery aerated lagoon was also performed to assess the biodegradation capabilities of the effluent treatment system. The study showed that removal efficiencies and effluent quality for parameters such as phenol, ammonia, COD, TSS, TOC, oil and grease and BOD were equal to or greater than published values for aerated lagoons treating petroleum wastes.

PARAMETERS

Media Analyzed: Water

BIOLOGICAL PARAMETERS MEASURED

ATP bioassay measurements
light absorbance test (to determine microbial growth in inhibition testing)

CHEMICAL PARAMETERS MEASURED

Hydrocarbons
oil and grease
polynuclear aromatic hydrocarbons

Other Hydrocarbons
dissolved organics
phenols

Other Parameters
biological oxygen demand
cyanide (total, weak, and dissociated)
electrical conductivity
pH
salinity
total suspended solids

Nutrients
ammonia
phosphate

Trace Elements
aluminum
arsenic
chromium (hexavalent and total)
cobalt
copper
lead
mercury
nickel
selenium
silver
zinc

TAXA

Photobacterium phosphoreum	bacterium
Gasterosteus aculeatus	stickleback
Salmo gairdneri	rainbow trout
Citharichthys stigmaeus	speckled sanddab
Morone saxatilis	striped bass
Cancer magister	Dungeness crab
Palaemon macrodactylus	Korean prawn
Menidia beryllina	silverside
Crassostrea gigas	oyster
Mytilus edulis	mussel
Dendraster exentricus	sand dollar sperm cell

Champia parvula red alga

MISCELLANEOUS PARAMETERS ANALYZED
dilution
EC 50
LC 50
No Observable Effect Concentration (NOEC)

|

METHODS

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: Nine sample locations were employed in the bioreactor study, and 29 sampling sites were used in the microbial study. One sampling site is utilized to sample the process water effluent.

The dye study performed on the bioreactor was a one-time study performed over a three-week period. The process wastewater from the refinery is discharged through a deepwater diffuser and is sampled on a weekly basis.

The Bioreactor Dye Study took place between August 19 and September 9, 1987. The dye was injected at a site located upstream of the bioreactor injection pumps. Grab samples were collected at six stations one, three and seven hours after the initial dye injection. Samples were subsequently collected at these locations, (with the exception of station 6) at six-hour intervals for the next 42 hours. Additional samples were also collected from three other stations. Station 6, the effluent stream from the bioreactor, was sampled at 2 hour intervals. Samples at sites 1-9 continued at regular intervals for up to 20 days.

ANALYTICAL METHODS

Soluble organics were extracted with freon, followed by several evaporation steps which concentrated the freon by a factor of 8000 to 1. The extracts were then analyzed with an infrared spectrometer and gas chromatograph equipped with a flame ionization detector (used for hydrocarbons) and an electron capture detector (used for carbonyl compounds and phthalates).

Acute toxicity tests were performed on striped bass, sand dab, and Dungeness crab. These tests were continued beyond the conventional 96 hours, lasting for 10 to 21 days. These were flow-through tests, with LC50s measured as the endpoint. Chronic toxicity tests ran for up to 28 days, using larval stages of resident Bay species (striped bass, Korean prawn, and Dungeness crab), and early life stages of other species from several phyla (oyster [*Crassostrea gigas*], mussel [*Mytilus edulis*], sand dollar, the red alga *Champia*, and *Menidia* [silverside]). Chronic tests on the native species examined survival and growth/development after 28 day exposures.

Various endpoints, including abnormal larvae, abnormal reproduction, and reduced survival and growth were used in the other tests. No-effect concentrations were noted in the test on native species, the *Champia* test, and the *Menidia* test. EC50s were recorded in the oyster, mussel, and sand dollar tests.

The following table summarizes the toxicity testing in this study.

Menidia beryllina	7 day larval fish growth/survival
Mytilus edulis	48 hour toxicity test on larval development
Champia parvula	10 day test of sexual reproduction
Dendraster exentricus	1 hour exposure of sperm
Crassostrea gigas	48 hour exposure of embryos
Cancer magister	28 day early life stage subchronic
Cancer magister	10-21 day incipient lethal
Morone saxatilis	28 day early life stage subchronic
Morone saxatilis	21 day incipient acute lethal
Palaemon macrodactylus	28 day early life stage subchronic
Citharichthys stigmaeus	10-21 day incipient lethal

The dilution of Chevron's effluent in the Bay was assessed using field data and mathematical modeling. Long-term dilutions throughout San Pablo Bay were calculated using Monte Carlo simulations and the US Army Corps of Engineers' Bay/Delta Model. The UDKHDEN (full name not given) model developed by the US Environmental Protection Agency was used to estimate the mixing of Chevron's buoyant plume near the outfall.

QUALITY ASSURANCE TESTING AND REPORTING

Good lab practices were followed during the effluent characterization program.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Information on data storage was not available.

REFERENCES

Chevron USA, Inc. 1988. Toxicity reduction evaluation/environmental hazard assessment on Chevron, USA, Richmond refinery effluent. Submitted to the Regional Water Quality Control Board. Oakland, CA.

CH2M Hill. 1987. Dye study of the Richmond bioreactor. Prepared for Chevron, USA. Richmond, CA.

McFarland, B.L., M.A. Gutfeldt, S.E. Hughes, J.M. Pudlak, and D.R. Smart. 1988. Microbial study of Richmond refinery aerated lagoon: Appendix 2-3. Chevron, USA. Richmond, CA. 64 pages.

Flow Science Incorporated. 1987. Richmond diffuser field study and performance analysis. Prepared for Chevron, USA, FSI reference No. 8704034. Chevron, USA. Richmond, CA. 56 pages.

Northwestern Aquatic Sciences Division. 1988. Fish growth/survival test of inland silversides, *Menidia beryllina*, using static renewal exposure to Chevron Richmond refinery effluent. Study No. NAS-342-3-MB2 submitted to Chevron Environmental Health Center. Richmond, CA.

Northwestern Aquatic Sciences Division. 1988. 48-hour toxicity test on the larval development of the Bay mussel, *Mytilus edulis*, using static exposure to Chevron Richmond Refinery effluent. Study No. NAS-342-3-ME, submitted to Chevron Environmental Health Center. Richmond, CA.

Northwestern Aquatic Sciences Division. 1987. Incipient lethal bioassay of Dungeness crab, *Cancer magister*, using flow-through exposure to Chevron Richmond refinery effluent. Study No. NAS- 342-1-CM submitted to Chevron Environmental Health Center, Inc. Richmond, CA.

Northwestern Aquatic Sciences Division. 1987. Incipient lethal bioassay of striped bass, *Morone saxatilis*, using flow-through exposure to Chevron Richmond refinery effluent. Study No. NAS- 342-1-MS submitted to Chevron Environmental Health Center, Inc. Richmond, CA.

Northwestern Aquatic Sciences Division. 1987. Incipient lethal bioassay of speckled sanddab, *Citharichthys stigmaeus*, using flow-through exposure to Chevron Richmond refinery effluent. Study No. NAS-342-1-CS submitted to Chevron Environmental Health Center, Inc. Richmond, CA.

Northwestern Aquatic Sciences Division. 1987. Early life stage of Korean prawn, *Palaemon macrodactylus*, using flow-through exposure to Chevron Richmond refinery effluent. Study No. NAS-342-2-PM submitted to Chevron Environmental Health Center, Inc. Richmond, CA.

Northwestern Aquatic Sciences Division. 1987. Early life stage subchronic bioassay of striped bass, *Morone saxatilis*, using flow-through exposure to Chevron Richmond refinery effluent. Study No. NAS-342-2-MS submitted to Chevron Environmental Health Center, Inc. Richmond, CA.

Northwestern Aquatic Sciences Division. 1987. Early life stage subchronic bioassay of Dungeness crab, *Cancer magister*, using flow-through exposure to Chevron Richmond refinery effluent. Study No. NAS-342-2-CM submitted to Chevron Environmental Health Center, Inc. Richmond, CA.

E.V.S. Consultants. 1987. Refinery effluent bioassays with sand dollar sperm and oyster larvae; summary of results of toxicity testing. Prepared for Chevron, USA. Richmond, CA. 8 pages.

E.V.S. Consultants. 1987. Refinery effluent bioassay with *Champia parvula*; summary of results of toxicity testing. Prepared for Chevron, USA. Richmond, CA. 4 pages.

~**Descriptors:** toxicity testing; effluent testing; refineries; point sources; pollutant sources; hydrology and flow; hydrodynamics and modelling; wastewater treatment; mussels; oysters; crabs; bay-delta;

GENERAL INFORMATION AND ABSTRACT

Program:	Delta-Suisun Bay Ecological Studies
Principal Investigator:	Jim Arthur (916) 978-4923 U.S. Bureau of Reclamation
Conducting Agency:	US Bureau of Reclamation California Department of Water Resources California Department of Fish and Game
Period of Record, Earliest Date:	1968
Period of Record, Latest Date:	1974
Length of Record:	7 years
Geographic Boundaries Description:	Samples were collected throughout the San Joaquin/Sacramento Delta, Suisun Bay, and San Pablo Bay.

ABSTRACT

The US Bureau of Reclamation (USBR), California Department of Water Resources (DWR), and California Department of Fish and Game (DFG) contributed to the Delta-Suisun Bay Ecological Studies, which were conducted from 1968-1974. This program preceded a similar program, the Sacramento-San Joaquin Delta Water Quality Surveillance Program, which is currently carried out by DWR and DFG (this current program is also included in the Estuarine Data Index). The Delta-Suisun Bay studies examined standard water quality parameters, phytoplankton growth rates and community structure, and zooplankton community structure to evaluate the ecological impacts of water diversion on the Delta, Suisun Bay, and San Pablo Bay.

The results of measurements of phytoplankton growth and chlorophyll levels were summarized by Ball (1977, 1987). The dominant phytoplankters observed throughout the study were diatoms with green algae seldom exceeding 20% of the total. The study region was found to have seven areas with distinct patterns in phytoplankton growth, the northern Delta, western Delta, Suisun Bay, San Pablo Bay, Suisun Marsh, eastern Delta, and southern Delta.

In the western Delta spring phytoplankton blooms occurred most years of the study, with maximum measured chlorophyll a concentrations of 80 ug/l. The timing each year of these blooms appeared to be related to increasing water transparency and increasing water residence time. In Suisun Bay, phytoplankton bloom periods

varied considerably from year to year, occurring as early as February to as late as October. Peak chlorophyll a concentrations during the year have ranged from about 5 to 100 ug/l. Ideal entrapment zone locations stimulate blooms while high abundance of benthic filter feeders are thought to suppress the blooms. Maximum chlorophyll levels in the Suisun Marsh were similar to those observed in Suisun Bay, with peaks generally occurring during late spring. Erratic blooms were observed in the dead-end sloughs of the eastern Delta, with chlorophyll a concentrations from spring through fall in the 30-150 ug/l range. Chlorophyll a levels entering the southern Delta in the San Joaquin River peaked during midsummer and were the highest for the entire study area. June and July measurements showed peaks from 100 to over 250 ug/l, and varied inversely with San Joaquin River flow.

PARAMETERS

Media Analyzed: Water

BIOLOGICAL PARAMETERS MEASURED

algal growth potential
primary productivity
phytoplankton abundance
zooplankton abundance

PHYSICAL PARAMETERS MEASURED

air temperature
tidal stage
water temperature
water transparency
wind velocity

CHEMICAL PARAMETERS MEASURED

Nutrients

nitrate
nitrite
organic nitrogen
inorganic nitrogen
total nitrogen
total phosphate
ortho-phosphate

Other Parameters Measured

alkalinity
biochemical oxygen demand
chloride
chlorophyll a
chlorophyll b
chlorophyll c
dissolved oxygen

electrical conductivity
magnesium
pH
pheophytin *a*
potassium
silica
sodium
sulfate
suspended solids
total hardness
turbidity
water temperature

Pesticides
aldrin
dacthal
DDD
DDE
dieldrin
heptachlor
lindane
PCB - 1242
PCB - 1254
PCB - 1260
toxaphene

Trace Elements
arsenic
boron
cadmium
chromium
copper
iron
lead
manganese
mercury
zinc

TAXA
Chaetoceros
Coscinodiscus
Cyclotella
Leptosylindrus
Melosira
Microsiphona potamos
Skeletonema potamos
Stephanodiscus

Phytoplankton	
green algae	Chlorophyceae
euglenoid flagellates	Euglenophyceae
yellow-green algae	Chrysophyceae
blue-green algae	Cyanophyceae
cryptomonads	Cryptophyceae
dinoflagellates	Dinophyceae
diatoms	Bacillariophyceae
Zooplankton	
Neomysis	

METHODS

SAMPLING METHODS

Over the 6 year period of study (1968-1974), water samples were obtained with several sampling devices, including: dissolved oxygen cans, Kemmerer samplers, Van Dorn samplers, and submersible pumps. Most of the samples were collected near midchannel or bay. Three types of equipment were used to sample zooplankton: a Clarke-Bumpus net (150um mesh) collected crustaceans; a net made of 930um (in 1974 this was changed to 505um) openings collected *Neomysis*; and a pump collected rotifers and small crustaceans. Volumes sampled were recorded for all of these zooplankton samples.

SAMPLING FREQUENCY AND LOCATION

From 1968-1974, 87 stations were sampled with varying frequencies. Nine of these sampling sites were in the northern Delta; 23 in the western Delta; 10 in the eastern Delta; 27 in the southern Delta; 10 in Suisun and San Pablo Bays; and 8 in Suisun Marsh. Sampling frequency was approximately monthly for half of the sites; the other half were sampled twice monthly during the spring and fall seasons from 1971-1973. In 1974 nearly all the sites were sampled twice monthly during the spring through fall.

In addition to the standard water quality parameters measured from 1968-1974 in the Delta-Suisun Bay Ecological Studies Program, various related short-term intensive sampling studies have been conducted since 1968. These include algal growth potential studies, characterization of the entrapment zone, dissolved oxygen sag studies in the Southern Delta, sewage treatment effluent studies for wastewater disposal in Suisun Marsh, and trace metals in the water column, sediments, and invertebrates in Suisun Bay. (This last study was conducted by Dr. Sam Luoma of the US Geological Survey - see entry on the Estuarine Data Index entitled "Trace Metal Accumulation in Benthos and Sediment".) Station locations from each of these studies follow.

Algal growth potential studies were conducted with samples collected from the following 18 sites in May-November 1969; February-November 1970; September-October 1971; August 1972; and from August-September 1973. (These sites were a subset of the main study sites; latitude and longitudes can be found with the rest of the site descriptions below.)

ALGAL GROWTH POTENTIAL STUDY SAMPLING SITES

1. Suisun Bay near Preston Point
2. New York Slough at Pittsburgh Landing
3. Carquinez Strait at Martinez
4. Grizzly Bay near Suisun Slough
5. Honker Bay near Wheeler Point
6. Sacramento River at Chipps Island
7. San Joaquin River at Antioch Bridge
8. Big Break
9. San Joaquin River at Jersey Point
10. San Joaquin River at Twitchell Island
11. False River at Webb Pump
12. mouth of Old River
13. Franks Tract
14. Sacramento River at Emmaton
15. Three Mile Slough at Highway 24
16. Sacramento River at Rio Vista
17. Sacramento River at Green's Landing
18. San Joaquin River near Vernalis

Listed below are the core sampling sites for the 1968-1974 Ecological Studies Program.

	Latitude	Longitude
NORTHERN DELTA		
1. Sacramento River at Greene's Landing	38-20-45	121-32-42
2. Sacramento River at Rio Vista	38-09-27	121-41-01
3. Steamboat Slough above Cache Slough	38-11-00	121-39-20
4. Sacramento River near Ryde	38-14-28	121-33-09
5. Georgiana Slough near Isleton	38-09-03	121-35-47
6. N Fork of Mokelumne R - Broad Slough	38-08-44	121-33-24
7. Snodgrass Slough at Twin Cities Road	38-16-36	121-29-50
8. Mokelumne River at Franklin Road	38-15-20	121-26-21
9. Stonelake Slough at San Pablo RR br 0.3 km south of Lambert Road	38-19-00	121-30-00
WESTERN DELTA		
10. New York Slough - Pittsburg Landing	38-01-50	121-51-27
11. Sacramento R above Point Sacramento	38-03-45	121-49-10
12. Sherman Lake near Antioch	38-02-34	121-47-34
13. San Joaquin River at Antioch	38-01-15	121-48-28
14. San Joaquin River at Antioch bridge	38-01-40	121-45-10

15. Big Break	38-00-50	121-43-50
16. San Joaquin River at Jersey Point	38-03-09	121-41-17
17. San Joaquin R at north tip of Bradford Island	38-05-50	121-40-05
18. False River 1.5 km W of Old River	38-03-40	121-36-00
19. Old River at mouth	38-04-30	121-34-10
20. Franks Tract	38-03-10	121-37-00
21. Dutch Slough at Farrar Park bridge	38-00-45	121-38-25
22. Old River at Holland Tract	38-00-30	121-34-45
23. Sacramento River at Emmaton	38-05-20	121-44-30
24. Sacramento River at NW end of Three-Mile Slough	38-06-45	121-42-35
25. San Joaquin River at Potato Point	38-04-40	121-34-00
26. Rock Slough at Contra Costa Canal intake	37-58-35	121-38-20
27. Old River at SW corner of Fay Isl	37-56-38	121-34-00
28. Old River opposite Rancho Del Rio	37-58-10	121-34-20
29. Suisun Bay off Point Wise	38-02-40	121-53-56
30. Suisun Bay north of Point Emmet	38-33-00	121-52-38
31. Suisun Bay off Point San Joaquin	38-03-41	121-51-38
32. Sacramento River at bottom of Sherman Island	38-03-48	121-47-26
33. Sacramento River at top of Horseshoe Bend	38-06-45	121-42-33
34. San Joaquin R. N of Point Beenar	38-02-07	121-50-10
35. San Joaquin R. mid Jersey Island	38-02-15	121-42-09
36. San Joaquin R. W of Bradford Island	38-04-24	121-40-36
37. San Joaquin River at Fishermans Cut	38-05-17	121-38-39
38. San Joaquin River by Webb Reach	38-06-06	121-35-54
39. San Joaquin River by Burns Reach	38-03-12	121-30-36
40. San Joaquin River at Acker Island	37-59-50	121-26-45
41. Middle River, S end of Bacon Island	37-56-40	121-31-54
42. Old River, Lower Holland Tract	37-59-11	121-34-53
43. False River at top of Jersey Island	38-03-24	121-40-06
44. Turner Cut at McDonald Island Ferry	37-58-47	121-28-27
45. Middle River at Bacon Island bridge	37-57-21	121-31-40
46. San Joaquin River near mouth of Middle River	38-02-54	121-32-01
47. San Joaquin River near San Andreas Landing	38-05-55	121-35-10
48. False River 1.5 km W of Old River	38-03-40	121-36-00

EASTERN DELTA

49. S Fork Mokelumne R at Staten Island	38-07-00	121-29-50
50. Sycamore Slough 2 km from mouth	38-08-28	121-28-00
51. South Fork Mokelumne River below Sycamore Slough	38-07-34	121-29-43

52. White Slough at Correia Ferry	38-05-01	121-28-07
53. Disappointment Slough at Bishop Cut	38-02-38	121-25-04
54. Beaver_Slough at Blossom Road	38-12-15	121-26-40
55. Hog Slough 4 km upstream of mouth	38-10-20	121-26-50
56. Sycamore Slough near Lodi	38-08-45	121-26-10
57. Disappointment Slough 3 km east of Bishop Cut	38-02-40	121-23-10
58. White Slough near Lodi	38-05-10	121-26-00
59. White Slough at Rio Blanco Tract	38-05-13	121-24-10
SOUTHERN DELTA		
60. San Joaquin River at Brandt bridge	37-51-51	121-12-19
61. San Joaquin River at Mossdale	37-47-07	121-18-20
62. West Canal at mouth of Intake	37-49-50	121-33-09
63. San Joaquin River at Vernalis	37-40-30	121-15-02
64. Light 18 Stockton ship channel	38-01-18	121-27-54
65. Light 36 Stockton ship channel	37-59-30	121-24-20
66. Light 41 Stockton ship channel	37-58-06	121-22-14
67. Light 43 Stockton ship channel	37-57-34	121-21-31
68. Light 48 Stockton ship channel	37-57-07	121-20-12
69. Turning Basin Stockton ship channel	37-57-15	121-19-02
70. Stockton Sanitary Treatment Plant	37-56-20	121-20-07
71. Garwood Bridge on the San Joaquin R	37-55-32	121-19-28
72. Tracy Road br at Grant Line Canal	37-49-12	121-26-56
73. Upstream from junction of Old River and Middle River	37-49-12	121-21-34
74. Old River junction w Middle River	37-49-28	121-22-25
75. San Joaquin River i.f km NW of Rough and Ready Island	37-58-42	121-22-55
76. Whiskey Slough near Holt	37-56-10	121-26-00
77. Middle River at Victoria Canal	37-53-25	121-29-15
78. Middle River at Williams bridge	37-52-33	121-22-55
79. Old River at Tracy bridge	37-48-17	121-26-55
80. Stockton Ship Channel E of I5 bridge at boat landing	37-57-12	121-18-23
81. San Joaquin River at SW corner of Empire Tract	38-02-35	121-29-52
82. Stockton Ship Channel at light 28	37-59-38	121-27-54
83. South of Channel Point at Rough and Ready Island Bridge	37-56-54	121-20-10
84. San Joaquin River at the Wolfinger Road stacks	37-53-47	121-19-38
85. San Joaquin River at the south junction with Old River	37-48-37	121-19-21
86. Old River 2 km downstream of the junction with Middle River	37-48-33	121-23-31
87. Old River at the Junction with	37-48-33	121-23-31

Middle River

SUISUN BAY AND SAN PABLO BAY

88. Sacramento River at Port Chicago	38-03-00	122-01-00
89. Suisun Bay east of Avon Pier	38-03-10	122-04-50
90. Suisun Bay near Preston Point	38-03-58	122-03-00
91. Sacramento River near Benicia Br	38-02-40	122-07-00
92. Grizzly Bay near Suisun Slough	38-06-56	122-02-17
93. Suisun Bay at Middle Point	38-03-36	121-59-20
94. Honker Bay near Wheeler Point	38-04-26	121-56-12
95. Sacramento River at Chipps Island	38-02-45	121-55-02
96. San Pablo Bay near mouth of Petaluma River	38-05-20	122-26-20
97. San Pablo Bay near Pinole Point	38-01-50	122-22-15
98. San Pablo Bay near Mare Island	38-03-30	122-17-20
99. Suisun Bay opposite Pacheco Creek	38-03-30	122-06-27
100. Suisun Bay opposite Point Edith	38-04-30	122-05-27
101. Suisun Bay opposite Garnet Point	38-05-53	122-04-06
102. Grizzly Bay at the NW corner	38-07-10	122-03-24
103. Suisun Bay north of Ryer Island	38-05-21	122-00-29
104. Suisun Bay south of Roe Island	38-03-47	122-01-38
105. Suisun Bay off Middle Point	38-03-33	121-59-17
106. Suisun Bay off Stake Point	38-03-20	121-57-38

SUISUN MARSH

107. Montezuma Slough near Joice Island	38-10-56	122-01-00
108. Montezuma Slough S of Meins Landing	38-08-07	121-54-43
109. Montezuma Slough at Van Sickle Island	38-04-50	121-53-00
110. Hill Slough at Grizzly Island Road	38-13-40	122-01-20
111. Green Valley Creek at Cordelia Road	38-12-40	122-07-40
112. Cordelia Slough at Upper End	38-11-30	122-07-10
113. Chadbourne Slough, Chadbourne Road	38-11-00	122-04-50
114. Cordelia Slough at Cygnus	38-09-10	122-05-20
115. Suisun Slough at Joice Island	38-10-50	122-02-40
116. Montezuma Slough at Grizzly Island Road	38-11-10	121-58-30
117. Cordelia Slough at Vallejo Pipeline Bridge	38-12-34	121-07-20

Entrapment zone studies were carried out between 1973 and 1980 at the following sites:

1. San Pablo Bay N of Pinole Point at light 7	38-01-50	122-22-15

2. San Pablo Bay N of Wilson at light 7	38-03-05	122-19-40
3. E San Pablo Bay near end of breakwater at light 15	38-03-30	122-17-20
4. Carquinez Strait at the I-80 bridge	38-03-42	122-13-26
5. Carquinez Strait across from tower near Dillon Point	38-03-30	122-12-00
6. Carquinez Strait at light 25	38-02-07	122-09-45
7. Sacramento River Ship Channel, Benicia Br	38-02-40	122-07-00
8. Suisun Bay near Avon Pier at light 9	38-03-10	122-04-50
9. Suisun Bay SW of Preston Pt near light 14	38-03-58	122-03-00
10. Suisun Bay N of Port Chicago at light 17	38-03-45	122-01-15
11. Suisun Bay SW of Middle Ground at lt 20	38-03-36	121-59-20
12. Suisun Bay N of Stake Pt in Sacramento River ship channel	38-03-15	121-57-00
13. SW tip of Chipps Island at light 27	38-02-58	121-56-00
14. Sacramento River at old RR bridge south of Chipps Island	38-02-45	121-55-02
15. Sacramento River at Pittsburg near lt 31	38-02-50	121-53-15
16. Sacto River W of Pt San Joaquin at lt 31	38-03-35	121-52-00
17. Sacto River at mouth of San Joaquin R.	38-03-50	121-51-00
18. Sacramento River 1.5 km E of Pt Sacto	38-03-45	121-49-10
19. Sacramento River at lt 11 near NW tip of Sherman Island	38-03-10	121-47-30
20. Sacto River at Sherman Isl between 13:14	38-04-40	121-45-55
21. Sacramento River NW of Emmaton at lt 15	38-05-20	121-44-30
22. Sacramento River at NW end of 3 Mile Slough at light 19	38-06-45	121-42-35
23. Sacramento River 3 km SSW of Rio Vista Bridge at light 25	38-08-00	121-41-40
24. Sacto River at Rio Vista Br at light 34	38-09-27	121-41-01
25. San Joaquin River 2 km above mouth	38-02-50	121-50-30
26. New York Slough at light 7	38-01-50	121-51-27
27. San Joaquin River NW of Antioch Point near light 40	38-01-42	121-49-40
28. San Joaquin River at Antioch between lights 7 and 8	38-01-15	121-48-28
29. San Joaquin River N of West Island under	38-01-33	121-46-50
30. San Joaquin River at Antioch Bridge at light 113	38-01-40	121-45-10
31. San Joaquin River ENE of Blind Pt, lt 19	38-02-10	121-42-36
32. San Joaquin River at Jersey Point, lt 24	38-03-09	121-41-17
33. San Joaquin River 1/2 km above Three Mile Slough at light 32	38-05-50	121-40-05
34. San Joaquin River 1 km NNE of Oulton Pt at light 38	38-05-50	121-37-45
35. San Joaquin River at Webb Pt at light 49	38-05-30	121-34-30
36. Suisun Bay East of reserve fleet at lt 4	38-03-50	122-05-50

37. Suisun Bay E of reserve fleet at lt 6	38-03-52	122-04-56
38. Suisun Bay NE of reserve fleet at lt 8	38-05-40	122-03-58
39. Grizzly Bay 1.5 km SE of mouth of Suisun Slough at light 9	38-06-27	122-03-13
40. Grizzly Bay at Dolphin 2.5 km N of Garnet Point	38-06-56	122-02-17
41. Suisun cutoff 3/4 km SE of Point Buckler in mid-channel	38-05-30	122-00-50
42. Suisun Bay between Ryer and Freeman Isl	38-04-32	121-59-35
43. Suisun Bay 1/4 km S of Snag Island	38-04-10	121-58-35
44. Honker Bay 2 km NNw of Simmons Point	38-04-27	121-56-20
45. Honker Bay 3/4 km NW of Spoonbill Creek	38-04-37	121-55-00
46. Sacramento River at mouth of Cache Slough at light 17	38-10-40	121-40-05
47. Sacramento River at Ida Island 1/3 km west of light 5	38-10-25	121-38-10
48. 4.5 km N of mouth of Steamboat Slough	38-11-50	121-36-45
49. Cache Slough 2.5 km S of Prospect Island at light 44	38-12-45	121-36-45

Dissolved oxygen sag studies were carried out in the Southern Delta between 1968 and 1979 at these sites:

1. San Joaquin River at SW corner of Empire Tract at light 12	38-02-35	121-29-52
2. San Joaquin River at Stockton Ship channel at light 18	38-01-18	121-27-54
3. San Joaquin River at Stockton Ship channel at light 28	37-59-38	121-27-54
4. San Joaquin River main ship channel at Vulcan Island	37-59-30	121-24-20
5. San Joaquin River 1.5 km NW of Rough and Ready Island at light 40	37-58-42	121-22-52
6. San Joaquin River 0.3 km NW of Rough and Ready Island at light 41	37-58-06	121-22-14
7. San Joaquin River at Smith Canal in Stockton Ship Channel	37-57-34	121-21-31
8. San Joaquin River at E tip of Rough and Ready Island at light 48	37-57-07	121-21-31
9. Stockton Ship Channel Turning Basin	37-57-15	121-19-02
10. Stockton Ship Channel E of I-5 bridge	37-57-12	121-18-23
11. S of Channel Pt, Rough and Ready Isl Br	37-56-54	121-20-10
12. San Joaquin River at Stockton Trt Plant	37-56-20	121-20-07
13. San Joaquin River at Garwood Br, Hwy 4	37-55-32	121-19-28
14. San Joaquin River, at Wolfinger Rd Stack	37-53-47	121-19-38
15. San Joaquin River at Old Brandt Br site	37-51-51	121-12-19
16. San Joaquin River at the S junction	37-48-37	121-19-21

with Old River		
17. San Joaquin River at Mossdale at I-5 Br	37-47-07	121-18-20
18. San Joaquin River at Airport Way Br Vernalis	37-40-30	121-15-02
19. Grant Line Canal at the Tracy Rd Bridge	37-49-12	121-26-56
20. Old River at junction with Sugar Cut Sl	37-48-02	121-25-12
21. Old River at Tracy Road Bridge	37-48-02	121-25-12
22. Old River 2 km downstream from junction with Middle River	37-48-33	121-23-31
23. San Joaquin River 1.2 km upstream of junction with Middle River	37-49-07	121-21-34
24. Old River at junction with Middle River	37-49-18	121-22-25

A Suisun Marsh study which examined the use of sewage treatment effluent for marsh management took place between 1977- 1981 at the following locations:

1. Hill Slough at Grizzly Island Road	38-13-40	122-01-20
2. Green Valley at Cordelia Road	38-12-40	122-07-40
3. Cordelia Slough at Upper End	38-11-30	122-07-10
4. Chadbourne Slough at Chadbourne	38-11-00	122-04-50
5. Cordelia Slough at Cygnus	38-09-10	122-05-20
6. Suisun Slough at Joicde Island	38-10-50	122-02-40
7. Montezuma Slough at Grizzly Island Road	38-11-10	121-58-30
8. Cordelia Slough at Gibsons Club	38-09-28	122-06-04
9. Suisun Slough at Middle Peytonia Slough	38-13-33	122-02-04
10. Middle Peytonia Slough E of SP RR Bridge	38-13-24	122-02-59
11. Suisun Slough at Boynton Slough	38-12-36	122-02-31
12. Boynton Slough at Kaiser Club	38-02-36	122-02-31
13. Boynton Slough at Fairfield_outfall	38-12-33	122-03-17
14. Boynton Slough at E side of SP RR Br	38-12-29	122-03-48
15. Suisun Slough at Sheldrake Slough	38-11-59	122-02-42
16. Cordelia Slough at Sweetwater footbridge	38-12-17	122-07-10
17. Cordelia Slough at Vallejo pipeline Br	38-12-34	122-07-20
18. Suisun Slough at Suisun City	38-14-30	122-02-13
19. Chadbourne Slough at Sunrise Club	38-10-58	122-04-55
20. Goodyear Slough at Morrow Island	38-07-10	122-06-49
21. Suisun Slough at Grizzly Bay	38-07-14	122-05-06
22. Little Honker Bay	38-10-57	121-54-07
23. Montezuma Slough at National Steel	38-07-27	121-53-15
24. Cordelia slough at Sun Slough	38-07-20	122-05-00
25. Chadbourne Slough at SP RR bridge	38-10-44	122-04-26

ANALYTICAL METHODS

Dissolved oxygen was measured using standard procedures in 5-day and longer term (up to 49 day) tests. Several methods for chlorophyll analyses were used. Initially chlorophyll *a* was measured using a fluorometer. This method did not correct for interference due to pheo-pigments (these data were later modified by the use of a correction factor). In September 1969, a trichromatic spectrophotometric method was adopted, allowing determination of chlorophylls *a*, *b*, and *c*. An acidification spectrophotometric method, the most accurate method used, was also employed concurrently to determine chlorophyll *a* and pheophytin *a*.

Phytoplankton species were analyzed by several different persons using inverted microscopes and various types of settling chambers. The organisms were identified and enumerated at the genus level. Zooplankton collected in the Clarke-Bumpus net were counted in Sedgewick-Rafter slides, with all organisms identified to the species level when possible. Organisms from pumped samples that were retained on a 43um mesh screen were counted and identified to species level when possible.

Primary productivity measurements were made to determine the rate of phytoplankton photosynthesis and the total respiration in a water sample under ambient light, temperature, and nutrient levels. Sample bottles, including "dark" bottles to serve as controls, were placed in the water column at each sampling location. Dissolved oxygen levels were recorded at the end of the incubation and used to estimate production and respiration. Algal growth potential studies were conducted in the laboratory to determine the maximum standing crop of algae that could grow in a given water sample under optimal light and temperature, and varying nutrient additions. Chlorophyll concentrations were determined as described above. In 1971 nutrient measurements of these incubations began, using a Technicon Auto Analyzer to measure nitrate plus nitrite, orthophosphate, and dissolved silica.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: Research Triangle Park, North Carolina

Hardware: IBM mainframe

Software: STORET

Volume of Data: 350,000 observations

Quality Assurance: Random subsample is drawn for error check; the error rate was 1.2%. A line-by-line check is in progress.

Contact for Data Retrieval

Name: Sheryl Baughman

Address: U.S. Bureau of Reclamation
2800 Cottage Way
Sacramento CA 95825

Phone: (916) 978-5260

Data Access: Available to anyone with STORET access codes.

Data Availability Date: Immediately

REFERENCES

Arthur, J. 1987. Draft report: River flows, water project exports, and water quality trends in the San Francisco Bay-Delta estuary. U.S. Exhibit No. 111, submitted in the Bay-Delta hearings. Available from the US Bureau of Reclamation. Sacramento, CA. 100 pages.

Ball, M.D. 1977. Phytoplankton growth and chlorophyll levels in the Sacramento-San Joaquin Delta through San Pablo Bay. Available from the US Bureau of Reclamation. Sacramento, CA. 96 pages.

Ball, M.D. 1987. Draft report: Phytoplankton dynamics and planktonic chlorophyll trends in the San Francisco Bay-Delta estuary. USBR Exhibit No. 103, submitted in the Bay-Delta hearings. Available from the US Bureau of Reclamation. Sacramento, CA. 95 pages.

USBR, DWR, and DFG. 1977. Delta-Suisun Bay Ecological Studies, a water quality data report of the Coordinated Monitoring Program: Biological methods and data, 1968-1974. U.S. Bureau of Reclamation. Sacramento, CA. 592 pages.

~**Descriptors:** bay-delta; algal blooms; plankton/algae/seagrass; biological resources; primary productivity; salinity; bioaccumulation; community structure; water quality; pollutants and related parameters; cyclodienes; chlorinated hydrocarbons; PCBs; water chemistry; water pollution; invertebrates;

GENERAL INFORMATION AND ABSTRACT

Program:	EBMUD Local Effects Monitoring Program
Funding Agency:	East Bay Municipal Utility District
Principal Investigator:	Tom Selfridge (415) 465-3700 East Bay Municipal Utility District
Conducting Agency:	CH2M Hill Walter Long Associates EAL Laboratories Eureka Laboratories Camp Dresser and McKee
Study Cost:	$575,000
Period of Record, Earliest Date:	1980
Period of Record, Latest Date:	March, 1987 (Not each year)
Length of Record:	7 years, not continuous
Geographic Boundaries Description:	Samples were collected from Point Isabel, near Albany; Emeryville Crescent; Oakland Inner Harbor; San Leandro Bay; and San Mateo.

ABSTRACT

The East Bay Municipal Utility District, Special District No. 1 (District) provides wastewater interception, treatment, and disposal for seven communities along the eastern shore of San Francisco Bay. Infiltration/inflow during winter rainfall periods causes collection system flows to increase dramatically, resulting in sewer overflows at 175 locations in the community systems and interceptor overflows at 7 locations. In 1982, the Local Effects Monitoring (LEM) Program was initiated by the District to monitor the offshore impacts of treated wastewater discharges and to determine the effects of wet weather overflows into nearshore receiving waters. The Program examined contaminant loadings in urban runoff and wastewater discharges, and contaminant levels in receiving waters, sediment, and shellfish.

The winter of 1982 was relatively dry, however, and no conclusions regarding the impacts of wet-weather overflows could be drawn. Data were gathered in 1985/1986 in an attempt to document a more typical wet winter (EBMUD 1986). Results of these tests were compared to water quality objectives in the 1982 San

Francisco Bay Regional Water Quality Control Board Basin Plan, and EPA Aquatic Life Hazardous Levels (ALHL). The data also allowed a comparison of the relative magnitude of inputs from District overflows and urban runoff. High coliform levels were the only receiving water problem observed in association with wet weather. Coliform concentrations exceeded water quality objectives by several orders of magnitude for extended periods after significant storms. Zinc concentrations rose above EPA ALHLs on two occasions as an apparent consequence of inputs from urban runoff. Sediment and shellfish levels of coliforms and metals generally increased in response to wet weather discharges. Urban runoff was found to contribute much larger loadings of trace metals than District overflows.

Monitoring was again performed in the winter of 1986/1987, including analyses of water from the stormwater interceptor system, the community collection system, urban runoff, sediments, and Elmhurst and San Leandro Creeks. Concentrations of trace metals in the interceptor system showed a "first-flush" effect, especially during the first storm of the season. Samples from Oakland were generally more contaminated than those from the Richmond area, probably owing to a larger number of industrial sources of waste. Basin Plan effluent limits for chromium, copper, lead, nickel, and zinc were exceeded in nearly all samples. In the collection system, metals were even higher than those in the interceptor system, and Basin Plan effluent limits for metals were grossly exceeded by all samples.

Trace metal concentrations in urban runoff in 1986/1987 were similar to those found in earlier LEM studies. Elmhurst Creek had the highest concentrations. Basin Plan objectives for copper, lead, and zinc were exceeded in most wet weather samples from downstream stations in the Oakland area. The copper objective was exceeded in several dry weather samples as well. The Basin Plan saltwater objective for polynuclear aromatic hydrocarbons (15 ug/l) was reached in one sample from Elmhurst Creek.

The highest sediment concentrations of contaminants in 1986/1987 were in San Antonio Creek. Sediment trace metal concentrations decreased between January and March. Organic priority pollutants were found in low concentrations. Benthic invertebrate faunal communities were dominated by species characteristic of disturbed environments. Between January and March species diversity decreased while species abundance increased.

PARAMETERS

Media Analyzed: Biota. Sediment. Water.

BIOLOGICAL PARAMETERS MEASURED

benthic species abundance and diversity
biological oxygen demand
enterococcus bacteria
fecal coliforms
total coliforms

PHYSICAL PARAMETERS MEASURED
precipitation

CHEMICAL PARAMETERS MEASURED
MAHs
benzoic acid
1,2-dichlorobenzene
1,4-dichlorobenzene

Nutrients
total Kjeldahl nitrogen

Other Hydrocarbons
cresols
oil and grease

PAHs
anthracene
benzo (a) anthracene
benzo (ghi) perylene
benzo (k) fluoranthene
benzo (a) pyrene
3,4-benzofluoranthene
chrysene
fluoranthene
fluorene
indeno(1,2,3-cd) pyrene
methyl naphthalene
naphthalene
phenanthrene
pyrene

Phenol
2,4-dimethylphenol

Phthalates
bis (2-ethylhexyl) phthalate
butylbenzylphthalate
di-n-butylphthalate
di(n)octylphthalate

Other Parameters
alkalinity
ammonia
chlorine demand
dissolved oxygen pH

salinity
organic priority pollutants
sediment grain size
total organic carbon
total suspended solids
total volatile solids
volatile suspended solids
water temperature
water transparency

Trace Elements
cadmium
chromium
copper
lead
mercury
nickel
silver
selenium
zinc

TAXA
Ascidacea
Acmaeidae
Actinaria
Ammothea hilgendorfi
Ampelisca abdita
Ampelisca milleri
Ampithoe sp.
Anaitides williamsi
Anaitides sp.
Anisogammarus pugettensis
Asychis elongata
Balanomorpha
Balanus crenatus
Balanus sp.
Bryzoa
Callianassa sp.
Cancer jordani
Cancer sp.
Capitella capitata
Caprella californica
Caprella equilibra
Caprella ferrea
Caprella natalensis
Caprella scaura
Caprella spp.

Chaetozone sp.
Chironomidae larvae
Cirratulidae
Cirratulus cirratus
Cirriformia spirabrancha
Cirripedia
Clevelandia ios
Collembola
Corophium acherusicum
Corophium insidiosum
Corophium spinicorne
Corophium spp.
Cossura pugettensis
Crangon nigricauda
Crepidula sp.
Ctenodrilus serratus
Cumella vulgaris
Cyclopoida
Decapoda
Dorvillea rudolphi
Eogammarus confervicolus
Eteone californica
Eteone diliatae
Eteone lighti
Eteone pacifica
Eteone sp.
Euchone limnocola
Eumida bifoliata
Exogene lourei
Foraminifera
Gemma gemma
Glycinde polygnatha
Gnoimosphaeroma sp.
Gobidae larvae
Grandidierella japonica
Halosoma viridintestinale
Harmothoe imbricata
Harmothoe sp.
Harpacticoida
Hemigrapsus oregonensis
Heteromastus filibranchus
Heteromastus filiformis
Hipponix tumens
Hydracarina
Hydrozoa
Ilypnus gilberti
Insecta

Janiralata occidentalis
Lacuna sp.
Leitoloscoloplos pugettensis
Leptochelia dubia
Lyonsia californica
Macoma balthica
Macoma nasuta
Macoma yoldiformis
Marphysa sanguinea
Mediomastus californiensis
Mercierella enigmatica
Modiolus rectus
Modiolus sp.
Molgula manhattensis
Musculista senhousia
Mya arenaria
Mytilus edulis
Mytilus sp.
Neanthes succinea
Neanthes virens
Nebalia pugettensis
Nematoda
Nemertea
Nephtys caecoides
Nephtys cornuta franciscana
Nephthys sp. (caecoides/parva)
Nereidae
Nereis latescens
Nereis succinea
Notomastus tenuis
Odontosyllis phosphorea
Oligochaeta
Pagurus hirsutiusculus
Pagurus sp.
Paranthura elegans
Pennatulacea
Phoronis sp.
Photis brevipes
Phylodocidae
Platyhelminthes
Platynereis sp.
Podocopa
Polydora brachycephala
Polydora ligni
Polydora socialis
Pseudopolydora kempi
Pseudopolydora paucibranchiata

Pseudopolydora spp.
Psychodid pupae
Pygodelphys sp.
Pygospio elegans
Sacoglossa
Sarsiella zostericola
Schistomeringos longicornis
Schistomeringos rudolphi
Scolepis squamata
Scyphistoma
Siliqua sp.
Sinelobus stanfordi
Sphaeroma quoyana
Sphaerosyllis brandhorsti
Sphaerosyllis californiensis
Spionidae larvae
Spiophanes spp.
Streblospio benedicti
Syllis sp.
Stylatula elongata
Synidotea laticauda
Tharyx parvus
Tharyx spp.
Transennella
Tapes japonica
Turbellaria
Typosyllis hyalina
Upogebia pugettensis

METHODS

SAMPLING METHODS

Urban runoff sampling sites were selected to reflect the quality of runoff from different land use areas. Sites were also sampled in storm drains unaffected by sewage overflows from city collection systems and from District overflow structures in order to determine the contributions of stormwater collection systems. Stormwater samples were analyzed for total and fecal coliforms, oil and grease, hydrocarbons, ammonia, BOD, trace metals, and priority pollutant organics. Flow measurements in channels and pipes were made using a variety of devices selected to best suit site-specific conditions. Flow quantities for entire drainage basins were estimated using an area times rainfall equation. Rainfall was measured with gauges at 12 locations throughout the East Bay.

Receiving water samples were collected from the surface by hand, and from deeper waters with a Van Dorn sampling bottle. Samples were taken from the Bay at or near high slack tide. *In situ* measurements were made of temperature, salinity, and dissolved oxygen. All samples were analyzed for total and fecal coliforms, ammonia, and oil and grease; some were analyzed for trace metals.

Sediments were most recently collected with a ponar sampler. Sediments were analyzed for biochemical oxygen demand, total volatile solids, particle size distribution, trace metals, priority pollutant organics, and taxonomy. Benthic fauna samples were screened in the field using a 0.5mm sieve. In 1985/1986 shellfish tissues were analyzed for total and fecal coliforms; some were analyzed for trace metals.

SAMPLING FREQUENCY AND LOCATION

The 1980-81 Local Effects monitoring program was composed of a series of studies. These included hydrodynamic dye, drogue and current studies; benthic infaunal and monthly epibenthic and trawl sampling; *in situ* studies using coliform bacteria; and an examination of bioaccumulation of contaminants by the mollusc *Tapes japonica.* Each of these studies is discussed below.

The hydrodynamic component of the 1981 LEM program was carried out in two areas; the first was offshore, around the outfall east of Yerba Buena Island and south of the Bay Bridge, the second area was inshore at San Leandro Bay, the Oakland Estuary, and the shallow waters along the Oakland/Berkeley shoreline.

Five hydrographic and eighteen meter stations were established in order to conduct the drogue, current meter, and dye studies. Current meters were deployed at 18 stations early in April and recovered in May and early June 1981. Two drogue experiments were also conducted during this period. The first drogue experiment began on an ebb current on April 14, and the second began on a flood current on April 15 1981. In both studies the drogues were released at the EBMUD discharge site near the Bay Bridge east of Yerba Buena Island.

Two dye studies were conducted during the 1980-81 wet- weather season. The first took place on 27 January in the inshore waters from El Cerrito south through Alameda and Oakland. The second study concentrated on the inshore area from the Bay Bridge to Richmond, and was conducted on 21 March.

The overflow / dye injection sites for the 1980-81 studies were as follows:

1. Stege Plant Overflow (Berkeley/Oakland area)
2. Cerrito Creek Overflow (Berkeley/Oakland area)
3. Virginia Street Storm Drain Discharge (Berkeley
4. Alice Street Overflow (Oakland Estuary)
5. Elmhurst Creek Overflow, Oakland Coliseum (San Leandro Bay)
6. San Leandro Creek Overflow, Hegenberger Road (San Leandro Bay)

Baseline data on sediment quality and infaunal species found in the areas of the present wet weather overflow discharge points were collected. The two proposed outfall sites were sampled once in July 1980; the present outfall station was sampled three times, in July 1980, and April and June of 1981.

1. present outfall
2. alternative wet weather outfall in North Bay
3. second alternative wet wather outfall off Bay Farm in the South Bay

The following three areas were selected as typical of shallow inshore zones adjacent to present wet weather overflow points. Benthic infauna and sediments were sampled from these stations three times, in June and September of 1980, and in May of 1981.

		Latitude	Longitude
1.	Stege Plant	37-53-48	122-19-39
		37-53-29	122-19-54
		37-53-38	122-19-22
		37-53-45	122-19-03
		37-53-07	122-18-55
2.	San Leandro Bay	37-44-59	122-13-56
		37-45-18	122-13-20
		37-45-27	122-12-58
		37-45-07	122-12-45
		37-44-45	122-13-05
3.	just S of the Berkeley Yacht Harbor	37-51-20	122-18-50
		37-51-27	122-18-20
		37-51-15	122-18-30
		37-50-49	122-18-32
		37-51-57	122-18-32

Epibenthic samples were collected monthly, beginning in 1980, for one year from the following three stations:

1. Point Isabel
2. Berkeley Aquatic Park
3. San Leandro Bay

A life history survey was performed on *Ampelisca milleri*. For this survey, length measurements, egg diameter, and embryo length were recorded from a subsample taken from each tow.

The following three stations were sampled monthly in a nekton study conducted between June 1980 and May 1981.

1. small embayment near Point Isabel
2. south of the Berkeley Marina
3. San Leandro Bay

Two studies examining coliform bacteria were also performed during the 1980-81 study. The first was an *in situ* experiment designed to test coliform bacteria survivability in East Bay waters. Plastic bags containing diluted wastewater were placed in the Ballena Bay Marina for a 23 hour period.

In the second study the distribution and density of coliform bacteria within the interstitial waters of intertidal sediments was examined. The three study sites at Point Isabel, Virginia Street, and San Leandro Creek were sampled from March 2-4, 1981.

Two surveys of the bioaccumulation of contaminants in the clam *Tapes japonica* were performed during between August 27-29 1980, and March 2-4 1981.

1. southern shore of Point Isabel
2. Virginia Street, west of the storm drain
3. San Leandro Creek, directly NW of the Hegenberger Road Bridge

For the 1985-86 and 1986-87 studies the following stations, located just north of the Golden Gate Field racetrack in Albany, were sampled.

1. Cerrito Creek upstream, Point Isabel
2. Cerrito Creek downstream, Point Isabel
3. Buchanan Street storm drain, Point Isabel

The following stations are located in the Emeryville Crescent, in the cove just north of the Bay Bridge entrance, south of the Emeryville Peninsula.

4. Temescal Creek, Emeryville
5. Vinmnared Creek, Emeryville
6. Open water between stations 4 and 5

The following stations are located in the Oakland Inner Harbor. No sediment or shellfish samples were collected here, and no estimates of contaminants in urban runoff were made for the Oakland Inner Harbor; receiving water quality only was monitored.

7. Webster Street
8. Alice Street
9. one mile north of Webster Street
10. one mile south of Webster Street
11. San Antonio Creek
12. Government Island - south end

The following stations are located in San Leandro Bay.

13. Elmhurst Creek upstream
14. Elmhurst Creek downstream
15. East Creek Slough
16. San Leandro Creek

All of the following stations are located in the 3rd Avenue shellfish bed, between the Coyote Point Yacht Harbor and the mouth of the San Mateo Creek in San Mateo.

17. mouth of the San Mateo Creek
18. nearshore station midway between San Mateo Creek and the Coyote Point Yacht Harbor
19. north of station 18
20. offshore from station 18
21. offshore from station 19

Sampling of the interceptor system, community collection system and urban runoff was conducted during 3 storms occurring in January and February 1987. Sediment sampling was done in early January and late March 1987, before and after most of the wet weather. Sampling in Elmhurst and San Leandro Creeks was conducted in association with 3 storm events and samples were also collected 6 times during dry weather. Descriptions of the station locations are given below.

The collection system was sampled from the following 3 stations:

1. San Joaquin and Modoc Streets, in Richmond
2. D Street and 84th Avenue, in the City of Oakland
3. 71st Avenue at Holly Street, in the City of Oakland

Urban runoff samples were collected from 3 storms at the following 3 stations:

1. Cerrito Creek at Pump Station A
2. East Creeks Slough at Oakport Blvd.
3. Elmhurst Creek at Hegenberger Road

Sediment and benthic samples were collected January 14, and March 25, at 6 stations from each of the following areas:

1. Point Isabel
2. San Antonio Creek
3. Coast Guard Island
4. East Creeks Slough (Oakport)

Bacteria and metals were measured at 8 stations on Elmhurst Creek, and 4 stations on San Leandro Creek during wet and dry weather conditions between January and April, 1987.

1. Elmhurst Creek at Edgewater Drive
2. Elmhurst Creek near District overflow site
3. Elmhurst Creek at San Leandro Street
4. Elmhurst Creek at 87th Avenue and E Street
5. Elmhurst Creek at 89th Avenue and E Street
6. Elmhurst Creek at 90th Avenue and Hillside
7. Elmhurst Creek at 94th Avenue and Plymouth
8. Elmhurst Creek and 94th Avenue and Holly
9. San Leandro Creek at 98th Avenue
10. San Leandro Creek at San Leandro Street
11. Storm drain at 105th Avenue and San Leandro Creek
12. Storm drain at Bergado Drive at San Leandro Creek

ANALYTICAL METHODS

Analytical determinations were performed by CH2M Hill in Emeryville, CA or contract commercial laboratories. Standard APHA (1985, "Standard Methods for the Examination of Water and Wastewater") and EPA (1979, "Methods for Chemical Analysis of Water and Wastes"; 1982, Method 200.7) were employed in water analyses. Method 200.7, an inductively coupled plasma/ atomic absorption (AA) method, was used for cadmium, copper, and zinc. Chromium and lead were measured by graphite furnace AA, mercury by cold vapor AA, and selenium by hydride generation AA. Base/neutral organics were measured by gas chromatography/mass spectroscopy (EPA 1985, "Code of Federal Regulations"; Method 625). Similar techniques were used in analyses of sediments and shellfish, as prescribed by EPA (1982, "Test Methods for Evaluating Solid Waste") and the previously cited references.

QUALITY ASSURANCE TESTING AND REPORTING

Results of quality assurance testing are not available in the published reports. Voucher specimens for the 1980-81 studies are kept at the California Academy of Sciences.

DATA STORAGE AND REFERENCES

DATA STORAGE

Location: EBMUD Wet Weather Program Office

Contact for Data Retrieval
Name: Mike Wallis

Address: Wet Weather Program Manager
East Bay Municipal Utility District
P.O. Box 24055
Oakland CA 94803
Phone: (415) 465-3700 x 224

Who Can Access This Information:

Available to all interested parties.

Data Availability Date: Immediately

REFERENCES

East Bay Municipal Utility District. 1988. Wet weather facilities: local effects monitoring update. East Bay Municipal Utility District, Oakland, CA.

East Bay Municipal Utility District. 1986. Wet weather facilities: local effects monitoring. East Bay Municipal Utility District, Oakland, CA.

East Bay Municipal Utility District. 1986. Wet weather facilities: local effects monitoring update, field sampling data. East Bay Municipal Utility District, Oakland, CA.

ANATEC and Kinnetic Laboratories. 1982. East Bay Municipal Utilities District: Local effects monitoring program, Final Report, Volume I: Summary. East Bay Municipal Utility District. Oakland, CA.

ANATEC and Kinnetic Laboratories. 1982. East Bay Municipal Utilities District: Local effects monitoring program, Final Report, Volume II: Hydrodynamics. East Bay Municipal Utility District. Oakland, CA.

ANATEC and Kinnetic Laboratories. 1982. East Bay Municipal Utilities District: Local effects monitoring program, Final Report, Volume III: Biology, Part I, Benthic Studies. East Bay Municipal Utility District. Oakland, CA.

ANATEC and Kinnetic Laboratories. 1982. East Bay Municipal Utilities District: Local effects monitoring program, Final Report, Volume III: Biology, Part II, Epibenthics, Nekton, Bacterial Survival, Bioaccumulation, and Sediment Bacteria. East Bay Municipal Utility District. Oakland, CA.

ANATEC and Kinnetic Laboratories. 1982. East Bay Municipal Utilities District: Local effects monitoring program, Final Report, Volume IV: Water and sediment quality, beneficial use survey, and project responsibilities and personnel. East Bay Municipal Utility District. Oakland, CA.

Report Location: Copies of these reports are kept in the EBMUD Wet Weather Office.

~**Descriptors:** heavy metals; coliform; urban runoff; water quality; bay-delta; shellfish; worms; organic priority pollutants; biological resources; pollutants and related parameters; POTWs; point sources; pollutant sources; invertebrates; bioaccumulation; sediments; sediment chemistry; water chemistry; water pollution; bacteria; shrimp; clams; mussels; benthic infauna; benthos; nonpoint sources;

GENERAL INFORMATION AND ABSTRACT

Program:	Municipal Water Quality Investigations (formerly Interagency Delta Health Aspects Monitoring Program)
Funding Agency:	State of California Water Contractors of the State Water Project California Urban Water Agencies East Bay Municipal Utility District Contra Costa Water District
Principal Investigators:	Bruce Agee Department of Water Resources (916) 327-1677 Rick Woodard Department of Water Resources (916) 327-1636
Conducting Agency:	Department of Water Resources
Study Cost:	$849,000 (FY 1990-91)
Period of Record, Earliest Date:	July, 1983
Period of Record, Latest Date:	Present
Geographic Boundaries Description:	Sampling stations are located throughout the Delta.

ABSTRACT

The Municipal Water Quality Investigations Program was initiated by the Department of Water Resources as the Interagency Delta Health Aspects Monitoring Program in July 1983 in response to concerns expressed by a scientific advisory panel (appointed by DWR) about the quality of drinking water supplies taken from the Delta. When the program began, its focus was on monitoring raw water supplies in the Delta for contaminants that could affect human health. The scope has since expanded to include monitoring of specific factors that can affect the quality and quantity of exported water, such as river flows, agricultural drainage, and tidal movements. There are two major areas of investigation (as described in the

reference listed below).

Effects of Island Drainage of Channel Water Quality. Measurements of organic THM precursors in agricultural drain water are combined with drainage volumes to estimate the effect of drainage on Delta channel water quality.

Effects of Bay water Intrusion on Delta Channel Water Quality. Bromides in raw water have been identified as potentially causing problems in water treatment processes. Bromides have been measured since April 1990 in the Delta.

Other studies include: selenium monitoring in the San Joaquin River and southern Delta; pesticide monitoring at selected locations; development of a Delta transport model of organic THM precursors and bromides.

Among the recent findings of the program is that agricultural drainage may contribute as much as 40% of Delta organic THM precursors in a drought year. The major source of bromides may be from bay water intrusion and the San Joaquin River. Concentrations of selenium and pesticides have been below drinking water limits and action levels. A process has been developed to select times and locations with relatively high probabilities of detection of pesticides, which are present in Delta waters at levels approaching the limits of analytical detection.

PARAMETERS

Media Analyzed: Water

PHYSICAL PARAMETERS MEASURED

flow, temperature
water color

CHEMICAL PARAMETERS MEASURED

alkalinity
asbestos
bromide
chloride
dissolved oxygen
dissolved organic carbon
electrical conductivity
pH
sodium
sulfate
total dissolved solids
total hardness

trihalomethane formation potential
turbidity
UV absorbance

Nutrients
nitrate
potassium

Pesticides
2,4-D salt
atrazine
bentazon
benzene
bromide
bromodichloromethane
bromoform
captan
carbofuran
chloroform
chloropicrin
chloropropham
chlorpyrifos
copper
dacthal
D-BHC
dibromochloromethane
d-d mixture
diazinon
dimethoate
di-n-octyl adipate
endosulfan II
ethion
guthion
MCPA
metalaxyl
methamidophos
methyl bromide
methyl parathion
molinate
monocrotophos
paraquat dichloride
pentachlorophenol (pcp)
simazine
tetrachloroethylene
trichloroethane

thiobencarb
trichloroethylene
xylene
Phthalates
bis (2-ethyl hexyl) phthalate
di-n-butyl phthalate
di-n-octyl phthalate

Trace Elements
boron
magnesium
selenium

METHODS

SAMPLING METHODS

Prior to 1984, samples were collected in a 1.5 L steel bucket. Since then a special sampling device developed by DWR has been used. Temperature, pH, dissolved oxygen, and electrical conductivity measurements are made in the field.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: Approximately 130 are listed here.

ID	STATION #	STATION NAME
1	A0714010	American River at W.T.P
2	B9D82071327	Sacramento River at Greene's Ldg.
3	B9D81781448	Cache Slough @ Vallejo P.P
4	B9D81581462	Lindsey Slough @ Hastings Cut
5	B9V81171369	Ag Drain on Grand Island
6	B9V80801348	Ag Drain on Tyler Island
7	B9D80371300	Little Connection Sl. @ Empire Tr.
8	B9V80361299	Ag Drain on Empire Tract, W.end 8-Mi.Rd.
9	B9D75841348	Rock Slough @ Old River
10	KA000000	Clifton Court Intake
11	B9C74901336	DMC Intake @ Lindeman Rd.
12	KA000331	Delta P.P. Headworks
13	B9D75351293	Middle R. @ Borden Hwy.
14	B0702000	San Joaquin R. nr. Vernalis
15	DV004000	Lake Del Valle Stream Release
16	B8X80221556	Mallard Slough at CCWD PP
17	E0B80261551	Sacramento River @ Mallard Island
18	KE000000	North Bay Interim PP Intake

19 B9D81651476 Barker Slough at Pumping Plant
20 A0V83681312 Natomas Main Drain
21 B9V80541310 Ag Drain on Bouldin Tract, PP. No. 1
22 B9V80611335 Ag Drain on Bouldin Tract, PP. No. 2
23 B9V81181397 Ag Drain on Egbert Tract, PP. No. 1
24 B9V81461416 Ag Drain on Egbert Tract, PP. No. 2
25 B9V80461224 Ag Drain on King Island, PP. No. 1
26 B9V80271262 Ag Drain on King Island, PP. No. 2
27 B9V80331273 Ag Drain on King Island, PP. No. 3
28 B9V81421292 Ag Drain on McCormack/Williams Tr. No.1
29 B9V81551295 Ag Drain on McCormack/Williams Tr. No.2
30 B9V75391195 Ag Drain on Mossdale Tract, PP. No. 1
31 B9V75381196 Ag Drain on Mossdale Tract, PP. No. 2
32 B9V75251199 Ag Drain on Mossdale Tract, PP. No. 3
33 B9V75221196 Ag Drain on Mossdale Tract, PP. No. 4
34 B9V75131191 Ag Drain on Mossdale Tract, PP. No. 5
35 B9V75071192 Ag Drain on Mossdale Tract, PP. No. 6
36 B9V74911187 Ag Drain on Mossdale Tract, PP. No. 8
37 B9V74911188 Ag Drain on Mossdale Tract, PP. No. 9
38 B9V75501184 Ag Drain on Mossdale Tract, PP. No. 10
39 B9V75581196 Ag Drain on Moss Tract, PP. No. 1
40 B9V75561194 Ag Drain on Moss Tract, PP. No. 2
41 B9V75521183 Ag Drain on Moss Tract, PP. No. 3
42 B9V81761386 Ag Drain on Netherland Tr., PP. No. 1
43 B9V81791362 Ag Drain on Netherland Tr., PP. No. 2
44 B9V74811246 Ag Drain on Pescadero Tr., PP. No. 1
45 B9V74811241 Ag Drain on Pescadero Tr., PP. No. 2
46 B9V74821231 Ag Drain on Pescadero Tr., PP. No. 3
47 B9V81801307 Ag Drain on Pierson Tr., PP. No. 1
48 B9V81521393 Ag Drain on Prospect Island, PP. No. 1
49 B9V81461400 Ag Drain on Prospect Island, PP. No. 2
50 B9V80001255 Ag Drain on Rindge Tract, PP. No. 1
51 B9V80271282 Ag Drain on Rindge Tract, PP. NO. 2
52 B9V80481248 Ag Drain on Rio Blanco Tr., PP. No. 1
53 B9V80441249 Ag Drain on Rio Blanco Tr., PP. No. 2
54 B9V80131231 Ag Drain on Shima Tract
55 B9V80561290 Ag Drain on Terminous Tract, PP. No. 1
56 B9V80691297 Ag Drain on Terminous Tract, PP. No. 2
57 B9V81221312 Ag Drain on Tyler Island, PP. No. 1
58 B9V80791347 Ag Drain on Tyler Island, PP. No. 2
59 B9V75441298 Ag Drain on Upper Jones Tr., PP. No. 1
60 B9V75641318 Ag Drain on Upper Jones Tr., PP. No. 2
61 B9V80671368 Ag Drain on Brannan Island, PP. No. 1
62 B9V80711377 Ag Drain on Brannan Island, PP. No. 2
63 B9V80721385 Ag Drain on Brannan Island, PP. No. 3

64	B9V80741398	Ag Drain on Brannan Island, PP. No. 4
65	B9V74961340	Ag Drain on Clifton Court
66	B9V74831187	Drain on Mossdale Tract, PP. No. 7
67	B9V75451194	Ag Drain on Mossdale Tract, PP. No. 11
68	B9V74781220	Ag Drain on Pescadero Tract, PP. No. 4
69	B9V74661251	Ag Drain on Pescadero Tract, PP. No. 5
70	B9V81471419	Ag Drain on Upper Egbert Tr., PP. No. 1
71	B9V81501433	Ag Drain on Upper Egbert Tr., PP. No. 2
72	B9V81521435	Ag Drain on Upper Egbert Tr., PP. No. 3
73	A0294500	Ag Drain on Colusa Basin Main Drain
74	A0292600	Ag Drain on Karnack (RD 1500)
75	B0704000	San Joaquin R. @ Maze Rd. Bridge
76	B9V75651318	Ag Drain on Lower Jones Tr., PP. No. 1
77	B9V75831305	Ag Drain on Lower Jones Tr., PP. No. 2
78	B9V80661391	Ag Drain on Twitchell Isl., PP. No. 1
87	B9D81661478	Barker Sl @ North Bay PP
88	B9D80961411	Sacramento River @ Rio Vista Bridge
89	B0117501	Cosumnes River @ Dillard Road
90	DV001000	Lake Del Valle at Glory Hole
91	B9D80361275	Honker Cut at Atherton Road Bridge
92	B9178000	Sacramento River at Hood
93	B0210520	Mokelumne R. @ Lower Sacramento Rd
100	B9D75891348	Old R. N/O Rock Sl (St 4b)
101	B9D75811343	Old R. S/O Rock Sl (St 5A)
102	B9D75571335	Old R. S/O Orwood (St 6A)
103	B9D75351342	Old R. nr. Byron (St 9)
104	B9D75111331	West Canal @ Old R. (St 12)
105	B9D74971331	West Canal at Clifton Court FB Intake
106	B9D74901334	DMC Intake @ Old R. - Canal Side (St 16)
107	B9D81481305	Delta Cross Channel Gate nr Walnut Grove
108	B9D81441309	Georgiana Slough at Walnut Grove Bridge
110	B9D75741317	Middle River at Bacon Island Bridge
111	B9D75011229	Middle River at Mowry Bridge (Undine Rd)
112	B9D75881285	Turner Cut at McDonald Island Ferry
113	B9D80191348	Old River at Sand Mound Slough
114	B9D80011307	Middle River nr Latham Sl (Ferry Site)
115	B9D80031294	Connection Sl. at Mandeville Isl Bridge
117	B9D75651333	Santa Fe-Bacon Island Cut nr Old River
118	B9D75481334	Woodward/N. Victoria Canal nr Old River
119	B9D75171329	North Canal nr Old River
121	B9D74931328	Grant Line/Fabian/Bell Canals nr Old R.
122	B9D74891331	Old River U/S from DMC Intake
123	B9V80451387	Ag Drain on Webb Tract, PP. No. 1
124	B9V80381361	Ag Drain on Webb Tract, PP. No. 2
125	B9V75931350	Ag Drain on Holland Tract, PP. No. 1

126 B9V80011348 Ag Drain on Holland Tract, PP. No. 2
127 B9V80111361 Ag Drain on Holland Tract, PP. No. 3
128 B9V75881342 Ag Drain on Bacon Island, PP. No. 1
129 B9V80031328 Ag Drain on Bacon Island, PP. No. 2
130 B9D80311413 San Joaquin River at Jersey Point
131 B9D80301377 False River at Southerly Tip of Webb Tr.
132 B9D74951331 Old River 6/10 mile below DMC intake.

ANALYTICAL METHODS

Analyses have been conducted by various contract laboratories over the years. These laboratories include Clayton Environmental Consultants (previously McKesson Environmental Services), ENSECO Labs (formerly Cal Analytical), and PACE laboratory. In addition, DWR Bryte Laboratory has carried the majority of the analytical load. THM concentrations were measured using a purge and trap gas chromatographic method (EPA Methods 601 and 502.2). Selenium was analyzed using a hydride generation atomic absorption method developed by the USGS. EPA methods were used for analyses of priority pollutants, including Methods 601, 608, 614, 624, and 625. All other analyses were performed according to "Standard Methods" (published by the American Public Health Association).

QUALITY ASSURANCE TESTING AND REPORTING

Results of quality control tests are presented in all major reports. Quality assurance has become a major objective of our program. Both field procedures and laboratory performance are monitored.

DATA STORAGE AND REFERENCES

DATA STORAGE

Location: Department of Water Resources, Sacramento, CA.

Hardware: IBM-compatible

Software: RBase for DOS

Volume of Data: Approximately 45,000 records

Quality Assurance: Computer entries are verified against hard copies of the data sheets.

Contact for Data Retrieval

Name: Bruce Agee
Address: Department of Water Resources
1025 P Street
Sacramento CA 95816
Phone: (916) 327-1677

REFERENCES

DWR. 1986. Interagency Delta Health Aspects Monitoring Program: Project Report. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1987. Progress Report 6 of the Interagency Delta Health Aspects Monitoring Program, April 1987. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1987. Progress Report 7 of the Interagency Delta Health Aspects Monitoring Program, October 1987. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1988. Progress Report 8 of the Interagency Delta Health Aspects Monitoring Program, October 1988. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1989. The Delta As A Source of Drinking Water, Summary of Monitoring Results - 1983 to 1987, January 1989. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1989. Progress Report 9 of the Interagency Delta Health Aspects Monitoring Program, March 1989. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1989. The Delta As A Source of Drinking Water, Monitoring Results - 1983 to 1987, January 1989. Department of Water Resources, Central District. Sacramento, CA.

DWR 1990. Delta Islands Drainage Investigation. In Press. Department of Water Resources, Division of Local Assistance, Sacramento, CA

DWR. 1990. Progress Report 10 of the Interagency Delta Health Aspects Monitoring Program, In Press. Department of Water Resources, Division of Local Assistance, Sacramento, CA.

~**Descriptors:** drinking water; bay-delta; contaminant fates; upper drainage; pollutants & related parameters; salinity; chlorinated hydrocarbons; water diversion; hydrology and flow; hydrodynamics and modelling; non-urban runoff; pollutant sources; MAHs; water quality; agricultural drainage; THMs; salt water intrusion; water pollution; water chemistry; other hydrocarbons; point sources; halogenated aliphatics; bromides; THM precursors; THMFP; selenium; state water project; pesticides;

GENERAL INFORMATION AND ABSTRACT

Program:	Phytoplankton and Zooplankton Studies
Funding Agency:	USGS
Principal Investigator:	Jim Cloern US Geological Survey (415) 354-3357
Conducting Agency:	USGS
Period of Record, Earliest Date:	1976
Period of Record, Latest Date:	Present
Geographic Boundaries Description:	Various sites were employed during this series of studies. Sampling locations ranged from the lower reaches of the Sacramento and San Joaquin Rivers to the South Bay.

ABSTRACT

The US Geological Survey has examined phytoplankton ecology in the Bay since 1968. Currently, an ongoing program is measuring *in vivo* fluorescence, turbidity, temperature, salinity, and other parameters in the South Bay and North Bay to Rio Vista.

One recent publication resulting from these research activities assessed the relative contribution of phytoplankton to seston carbon over an annual cycle (Wienke and Cloern 1987). Phytoplankton biomass (as carbon) was estimated from chlorophyll *a* concentrations and a mean value for the ratio of phytoplankton carbon to chlorophyll *a* in San Francisco Bay. Samples were collected from fixed sites in the Bay in 1980, and at irregular intervals in the South Bay during 1984 and 1985. Phytoplankton biomass was found to constitute about one third of seston carbon under most circumstances, but this fraction ranges from about 95% during phytoplankton blooms to less than 20% during periods of low phytoplankton biomass and high suspended sediment concentrations.

Primary productivity and biomass of three size classes of phytoplankton were characterized in other samples collected in 1980 (Cole *et al.* 1986). Monthly measurements were collected in the Suisun Bay, San Pablo Bay, and South Bay, representing a range of environments, phytoplankton communities, and seasonal cycles in the estuary. Spatial and temporal variations in productivity of each size class was found to be primarily due to differences in biomass rather than size-dependent carbon assimilation rates.

Other research has examined factors controlling phytoplankton dynamics in the Bay (Cloern 1987, Cloern *et al.* 1983, Cole and Cloern 1984). Sampling in 1980, mentioned above, also served to document the significance of biomass and light availability to phytoplankton productivity. Annual net production in the photic zone was highest in regions of lowest turbidity. Linear regression showed that most of the spatial and temporal variability in daily photic zone net productivity was explained by variation in biomass and light availability.

Research conducted in the 1970's focused on the influence of river discharge on phytoplankton dynamics in the northern reach of the Bay (Cloern *et al.* 1983). Evidence was presented that characteristic blooms of neritic diatoms in summer in the northern reach were a consequence of the same physical mechanism that creates local maxima of suspended sediments in partially- mixed estuaries: density-selective retention of particles within an estuarine circulation cell. River discharge determines the location of the turbidity maximum, and population blooms occur when the turbidity maximum is positioned adjacent to shallow areas where light limitation is less severe.

PARAMETERS

BIOLOGICAL PARAMETERS MEASURED

chlorophyll *a* concentration
particulate organic carbon
planktonic biomass as carbon *
phytoplankton biomass and production *
production for various phytoplankton size classes *
species identification *
total phytoplankton community productivity *

PHYSICAL PARAMETERS MEASURED

photic depth
surface irradiance
temperature

*Currently not being measured. They have been in the past.

CHEMICAL PARAMETERS MEASURED

salinity

TAXA

Amphora spp.
Chaetoceros spp.
Chroomonas amphioxeia
Chroomonas minuta
Chrysochromulina kappa
Coscinodiscus jonesianus
Cryptomonas testacea
Cyclotella caspia

Cyclotella eccentrica
Cyclotella minuta
Cyclotella striata
Fragilaria crotenensis
Leptocylindricus danicus
Melosira distans
Melosira spp.
Mesodinium rubrum
Peridinium sp.
Pyramimonas spp.
Skeletonema costatum
Thalassiosira decipiens
Thalassiosira spp.

METHODS

SAMPLING METHODS

Water samples collected for analysis in the laboratory were taken near the surface, at a depth of 1-2 m. Measurements of certain parameters have been made in the field. *In situ* measurements of salinity were made with an inductive salinometer. Light attenuation and total ambient insolation have been measured *in situ* using a Licor quantum sensor. Since 1987, core measurements have been made at 1 m depth intervals with a Seabird CTD (conductivity-temperature-depth) package and a Sea Tech in situ fluorometer.

SAMPLING FREQUENCY AND LOCATION

Near monthly measurements were taken of salinity, temperature, turbidity, primary production, and *in vivo* fluorescence in surface water at 19 stations from Central Bay to Horseshoe Bend on the Sacramento River from 1976 through 1979 (Cloern *et al.* 1983). Samples were collected biweekly during the spring and summer.

The breakdown of a waste treatment plant in the South Bay in 1979 resulted in a 12 station, month-long study (October). Analyses were performed for: concentrations of particulate organic carbon; dissolved oxygen; methane; ethylene; total carbon dioxide; four species of dissolved inorganic nitrogen; phytoplankton biomass; abundances of streptococci and coliform bacteria; salinity; temperature; and Secchi depth. At selected sites, rates of photosynthetic oxygen production and community respiration were measured (Cloern and Oremland 1983).

Size fractionated chlorophyll *a* and the primary productivity of 3 size classes of plankton was measured monthly at 6 sites (2 sites each in South, San Pablo, and Suisun Bays, one in the channel, and the other in the shoals) between January, 1980 and February 1981 (Cole *et al.* 1986).

Primary productivity, light attenuation, and chlorophyll *a* were measured monthly at 6 sites, (2 each in South, San Pablo and Suisun Bays), between January 1980 and February 1981 (Cole and Cloern 1984).

In 1980 data were collected monthly from two sampling sites in the South Bay, and two more in northern San Francisco Bay. Data were also collected from 2 more sites in South San Francisco Bay monthly in 1982. Productivity, biomass, photic depth, and surface irradiance were measured (Cole and Cloern 1987).

Near surface water was sampled at 14 channel stations and 18 shoal stations (<2 meters) from the confluence of the Sacramento and San Joaquin Rivers throughout San Francisco Bay to the South Bay, once or twice a month from April to November, 1980, and irregularly in the South Bay in 1984 and 1985. In an effort to estimate plankton biomass, particulate organic carbon, and chlorophyll *a* samples were collected (Wienke and Cloern 1987).

Throughout 1980, measurements of chlorophyll *a* levels, light extinction, and suspended particulate matter were taken at about 30 stations twice a month from the lower reaches of the Sacramento and San Joaquin Rivers to the South Bay. During 1980 and 1982 primary productivity was measured at 6 stations; two stations each in South, San Pablo, and Suisun Bays. In addition, a surface transect for continuous measurement of chlorophyll *a* was run between the deep channel and subtidal shoals across mid South San Francisco Bay in March of 1985 (Cloern *et al.* 1985).

The response of the phytoplankton population to salinity stratification was measured approximately twice a month at 4 stations in the central channel of the South Bay throughout 1982, with samples being collected more frequently during the spring neap tide. Near bottom and surface salinity, primary productivity, nutrient, and chlorophyll *a* levels were measured (Cloern 1984).

In recent years, core measurements (salinity, temperature, transparency, chlorophyll) have been made at least monthly, along the deep channel from South Bay to Rio Vista on the Sacramento River.

ANALYTICAL METHODS

Water samples were prescreened through 60um screens to exclude macrozooplankton. In the study of productivity of different size classes of phytoplankton (Cole *et al.* 1986), chlorophyll samples were partitioned among netplankton (22-59 um), nanoplankton (5-22 um) and ultraplankton (<5 um) by filtration.

Carbon fractions, suspended particulate matter (SPM) and chlorophyll samples were filtered onto glass fiber filters prior to analysis.

Chlorophyll *a* determinations have been made by fluorometry or spectrophotometry. Particulate organic carbon was measured with an elemental analyzer. Suspended particulate matter concentrations were measured by collecting particulates on preweighed filters, then reweighing the filters.

Phytoplankton productivity was estimated by measuring the uptake of carbon-14 in *in situ* incubations. Following incubation, the phytoplankton samples were passed through glass fiber filters. Carbon-14 was then stripped from the sample, and the residual activity of the sample determined using a liquid scintillation spectrometer. Productivity at different depths was estimated by conducting incubations at eight light levels. The light levels were determined using LiCor quantum sensors.

QUALITY ASSURANCE TESTING AND REPORTING

Recent publications have included results of quality control testing (Wienke and Cloern 1987). Duplicate analyses of particulate organic carbon for 1980 samples had a mean precision of 8%, and the mean for 1984-1985 determinations was 5%. Duplicates of chlorophyll *a* samples showed a mean precision of 6% in 1980, and of 9% in 1984-1985. Duplicate samples analyzed for SPM concentrations had a mean deviation of 1.4 mg/l.

|

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: U.S. Geological Survey, Deer Creek
Hardware: IBM PC
Software: Data is stored as ASCII files.
Volume of Data: Approximately 180,000 observations.
Quality Assurance: Data reports are reviewed independently by several researchers.

Contact for Data Retrieval

Data reports listed here can be obtained by contacting:

U.S. Geological Survey
Books and Open-File Reports
P.O. Box 25425, MS512
Denver CO 80225

Who Can Access This Information: Public information

Data Availability Date: Data are published as USGS Open-File Reports, usually within 1-2 years after annual sampling cycle.

REFERENCES

Alpine, A.E., J.E. Cloern, and B.E. Cole. 1981. Plankton studies in San Francisco Bay 1. Chlorophyll distributions and hydrographic properties of the San Francisco Bay Estuary, July 1977-December 1979. USGS Open-File Report 81-213. 150 pages.

Alpine, A.E., S.M. Wienke, J.E. Cloern, B.E. Cole, and R.L.J. Wong. 1985. Plankton studies in San Francisco Bay, VIII: Chlorophyll distributions and hydrographic properties of South San Francisco Bay, 1983. USGS Open-File Report 85-196. 58 pages.

Alpine, A.E. S.M. Wienke, J.E. Cloern, and B.E. Cole. 1988. Plankton studies in San Francisco Bay IX. Chlorophyll distributions and hydrographic properties of South San Francisco Bay, 1984-1986. USGS Open-File Report 88-319. 86 pages.

Cloern, J.E., A.E. Alpine, B.E. Cole, R.L.J. Wong, J.F. Arthur, and M.D. Ball. River discharge controls phytoplankton dynamics in the Northern San Francisco Bay Estuary. 1983. Estuarine, Coastal and Shelf Science 16: 415-429.

Cloern, J.E. 1987. Turbidity as a control of phytoplankton biomass and productivity in estuaries. Continental Shelf Research Vol.7 Nos. 11/12:1367-1381.

Cloern, J.E. 1984. Temporal dynamics and ecological significance of salinity stratification in an estuary (South San Francisco Bay, USA). Oceanologica Acta Vol. 7 No. 1: 137-141.

Cloern, J.E., A.E. Alpine, B.E. Cole, R.L.J. Wong, J.F Arthur, and M.D. Ball. 1983. River discharge controls phytoplankton dynamics in the northern San Francisco Bay estuary. Estuarine, Coastal and Shelf Science 16: 415-429.

Cloern, J.E., B.E. Cole, R.L.J. Wong, and A.E. Alpine. 1985. Temporal dynamics of estuarine phytoplankton: A case study of San Francisco Bay. Hydrobiologia 129:153-176.

Cole, B.E., and J.E. Cloern. 1984. Significance of biomass and light availability to phytoplankton productivity in San Francisco Bay. Marine Ecology - Progress Series 17: 15-24.

Cole, B.E., and J.E. Cloern. 1987. An empirical model for estimating phytoplankton productivity in estuaries. Marine Ecology 36: 299-305.

Cole, B.E., J.E. Cloern, and A.E. Alpine. 1986. Biomass and productivity of three phytoplankton size classes in San Francisco Bay. Estuaries 9:117-126.

Smith, R.E., R.E. Herndon, and D.D. Harmon. 1979. Physical and chemical properties of San Francisco Bay waters, 1969-1976. USGS Open-File Report 79-511.

Wienke, S.M. and J.E. Cloern. 1987. The phytoplankton component of seston in San Francisco Bay. Netherlands Journal of Sea Research 21:25-33.

Wienke, S.M., A.E. Alpine, J.E. Cloern, and B.E. Cole. 1990. Plankton Studies in San Francisco Bay, California. X. Chlorophyll Distribution and Hydrographic Properties in South San Francisco Bay, California, 1987. USGS Open-File Report 90-145.

Open-File reports can be obtained from:
U.S. Geological Survey
Books and Open-File Reports
P.O. Box 25425 MS 512
Denver CO 80225

~**Descriptors:** primary production; phytoplankton biomass; algal blooms; biological resources; bay-delta; plankton/algae/seagrass; hydrology and flow; hydrodynamics and modelling; point sources; pollutant sources; pollutants and related parameters; abundance; delta outflow; bacteria; community structure; zooplankton;

GENERAL INFORMATION AND ABSTRACT

Program: Sacramento-San Joaquin Delta Water Quality Surveillance

Program: Continuous Monitoring

Funding Agency: Department of Water Resources

Principal Investigator: Harlan Proctor
Department of Water Resources (916) 445-7517

Conducting Agency: DWR

Period of Record, Earliest Date: 1984

Period of Record, Latest Date: Present

Geographic Boundaries Description: Stations are located near the Carquinez Strait at Martinez; on the Sacramento River at Rio Vista, and also at Mallard Island; and on the San Joaquin River at Mossdale, Stockton and Antioch. Telemetered stations are Rio Vista, Mallard Island and Antioch.

ABSTRACT

Since 1975 the California Department of Water Resources (DWR) has monitored water quality from the Delta through San Pablo Bay. This monitoring is a requirement of Water Right Decision 1485, in which the State Water Resources Control Board establishes conditions for the operation of the State Water Project. [Other aspects of the Decision 1485 monitoring program are described separately in the Estuarine Data Index]. As part of this monitoring program, a network of 6 automatic continuous recorders have been operated since 1984. Hourly readings of conductivity, dissolved oxygen, pH, temperature, solar radiation, and wind temperature, speed and direction are recorded at each site. Tidal stage and chlorophyll are also measured at some sites.

The data are used primarily for State Water Project operations and are available from the telemetered stations (Rio Vista, Mallard Island and Antioch) through the California Data Exchange Center (CDEC). The CDEC can provide hourly data for tidal stage and electrical conductivity (EC) from all three telemetered stations. In addition, available data includes chlorophyll levels and water temperature from Mallard Island, wind speed and direction from Antioch, and wind speed and solar radiation from Rio Vista.

PARAMETERS

Media Analyzed: Water.

BIOLOGICAL PARAMETERS MEASURED
chlorophyll

PHYSICAL PARAMETERS MEASURED
air temperature
solar radiation
wind direction
wind velocity

CHEMICAL PARAMETERS MEASURED
Other Parameters
dissolved oxygen
electrical conductivity
pH
water temperature

METHODS

SAMPLING FREQUENCY AND LOCATION

Number of Stations: 6

The following sites have been monitored since 1984 with the use of multiparameter continuous monitoring recorders. The sites at Rio Vista, Antioch, and Mallard Island are telemetered. Chlorophyll data is collected from April to October at the Mallard Island site only.

	Latitude	Longitude
1. San Joaquin River at Mossdale	37-41-11	121-18-22
2. San Joaquin River at Stockton	37-57-46	121-21-54
3. San Joaquin River at Antioch	38-01-04	121-48-06
4. Sacramento River at Rio Vista	38-08-42	121-41-30
5. Sacramento River at Mallard Island	38-02-37	121-55-07
6. Carquinez Strait at Martinez	38-01-41	122-08-17

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE
Location: Research Triangle Park, North Carolina
Hardware: IBM Mainframe
Software: STORET and SAS files

Volume of data: Approximately 400,000 observations have been recorded.

Contact for Data Retrieval

Name: Harlan Proctor
Department of Water Resources
California Data Exchange Center
1416 Ninth Street, Room 1609-5
P.O. Box 942836
Sacramento CA 94236-0001
Phone: (916) 445-2312
1-800-952-5530

REFERENCES

DWR. 1990. Water quality conditions in the Sacramento-San Joaquin Delta during 1988. Department of Water Resources, Central District. Sacramento, CA.

~**Descriptors:** bay-delta; water chemistry; water quality; tides; salt water intrusion; primary productivity; chlorophyll a; salinity;

GENERAL INFORMATION AND ABSTRACT

Program: Sacramento-San Joaquin Delta Water Quality Surveillance

Program: Phytoplankton

Funding Agency: Department of Water Resources

Principal Investigator: Harlan Proctor (916) 445-7517
Department of Water Resources

Conducting Agency: Department of Water Resources

Period of Record, Earliest Date: January, 1975

Period of Record, Latest Date: Present

Geographic Boundaries Description: The sample collection area is bounded by Courtland on the Sacramento River, to Mossdale on the San Joaquin River, and downstream to San Pablo Bay.

ABSTRACT

Since 1975 the California Department of Water Resources (DWR) has monitored water quality from the Delta through San Pablo Bay. This monitoring is a requirement of Water Right Decision 1485, in which the State Water Resources Control Board establishes conditions for the operation of the State Water Project. [Other aspects of the Decision 1485 monitoring program are described separately in the Estuarine Data Index]. As part of this monitoring program, phytoplankton distribution patterns are characterized through observation of trends in chlorophyll a concentrations, and by identification and enumeration of the planktonic algae contributing to the observed growth patterns. Samples are collected once or twice each month at 18 stations from the Delta downstream to San Pablo Bay.

Results of this monitoring are summarized on an annual basis (DWR 1988). During the summer of 1988, the Delta was monitored for phytoplankton productivity. Early detection of phytoplankton blooms was achieved through increasing sampling stations and sampling frequency over Decision 1485 requirements.

The phytoplankton productivity pattern in the Delta for 1988 was somewhat atypical. Usually, a series of phytoplankton blooms in the Delta begins in the spring and ends in the fall. However, in 1988 there was only a single, intense, late spring

bloom of the filamentous diatom *Melosira granulata* throughout much of the central Delta. The bloom lasted from May 20 through June 6 and produced 30-50 micrograms/liter of chlorophyll a. *M. granulata* blooms clog the filters of municipal water treatment plants. This late spring bloom was followed by a brief, mid-July bloom of the centric diatom *Skeltonema potamos* in the Mildred Island area. Chlorophyll a levels were over 30 micrograms/liter, with a maximum concentration of 36 micrograms/liter. Fluorometer readings confirmed that this bloom was localized but had spread into adjacent channels, producing moderate levels of chlorophyll a (10-15 micrograms/liter) in nearby Latham Slough and Empire Cut.

Lesser amounts of chlorophyll a from the bloom, measurable above background, were recorded in Middle River as far south as Santa Fe Cut and as far north as Columbia Cut. Although this *S. potamos* bloom did not reach the intensity or expand to the area of the late spring *M. granulata* Delta bloom, it did appear to support the hypothesis that flooded islands in the central Delta may serve as "seeding" areas for further Delta phytoplankton blooms. Subsequent Decision 1485 monitoring did not discover any additional late summer or fall phytoplankton blooms in the Delta, Suisun Bay, or San Pablo Bay. Chlorophyll a levels did not exceed background levels (5 micrograms/liter or less). Continuous monitoring at the Banks Pumping Plant revealed only the late spring phytoplankton bloom entering the SWP water supply.

The 1986-1987 and 1987-1988 water years were both classified as critical and were characterized by low Delta outflow and summer salinity intrusion. Phytoplankton productivity was lower for these years than for normal years, but was higher than the phytoplankton productivity measured during the 1976-77 drought.

PARAMETERS

Media Analyzed: Water

BIOLOGICAL PARAMETERS MEASURED
organisms per milliliter by genus
phytoplankton species abundance

TAXA
Bacillariophyceae
Amphiprora
Amphora
Achnanthes
Asterionella
Attheya
Caloneis
Cocconeis

Coscinodiscus
Cyclotella
Cymatopleura
Cymbella
Diatoma
Epithemia
Eunoita
Fragilaria
Gomphonema
Gyrosigma
Hantschia
Melosira
Navicula
Neidium
Nitzschia
Pinnularia
Rhoicosphenia
Rhizoselenia
Skeletonema
Stephanodiscus
Surirella
Synedra
Tabellaria
Thalassiosira

Chlorophyceae
Actinastrum
Ankistrodesmus
Carteria
Coelastrum
Chlamydomonas
Chodatella
Closterium
Crucigenia
Dictyosphaerium
Elakatothrix
Eudorina
Kirchneriella
Oocystis
Pandorina
Pyramimonas
Scenedesmus
Schroederia
Selenastrum
Spermatozopsis

Sphaerocystis
Tetraedron
Tetrastrum
Treubaria

Chrysophycea
Chrysocromulina
Dinobryon
Synura

Cryptophyceae
Cryptomonas

Cyanophyceae
Agmenellum
Anabaena
Anabaenopsis
Anacystis
Aphanizomenon
Oscillatoria

Dinophyceae
Glenodinium
Gyrodinium
Hemidinium
Massartia
Peridinium

Euglenophyceae
Euglena
Phacus
Trachelomonas

Additional organisms as identified.

METHODS

SAMPLING METHODS

Water samples are typically obtained with Van Dorn samplers. Submersible pumps are also used to pump sample water aboard the boat. Grab samples are collected at a depth of 3ft, during high slack tide.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: 18

One sample is taken each month from November through March if outflows are greater than 10,000 cfs, and two samples a month are collected throughout the rest of the year.

	Site	Latitude	Longitude
1.	Sacramento River at Greene's Landing Samples are collected approximately 1.8 miles upstream from Courtland.	38-20-45	121-32-42
2.	San Joaquin River at Mossdale Bridge This site is 2.8 miles upstream from the San Joaquin - Old River junction.	37-47-11	121-18-22
3.	West Canal at juncture of intake to Clifton Court Forebay Samples are collected from a boat dock on the West bank.	37-49-50	121-33-09
4.	Sacramento River above Point Sacramento This site is 1.7 miles above the confluence of the Sacramento and San Joaquin Rivers.	38-03-45	121-49-10
5.	Grizzly Bay at Dolphin near Suisun Slough Samples are collected in the center of a shallow embayment 1.4 mi E of the mouth of Suisun Slough.	38-07-02	122-02-19
6.	Suisun Bay off Middle Point near Nichols Suisun Bay within the W reach of the middle ground channel.	38-03-36	121-59-20
7.	Honker Bay near Wheeler Point This sampling station is located in a shallow embayment 1.9 miles NE from Point Palo Alto.	38-04-26	121-56-12
8.	San Joaquin River at Antioch Ship Channel This site is 0.3 mi north of Antioch.	38-01-15	121-48-28

9.	San Joaquin River at Jersey Point This sampling station is located 6.5 miles northeast of Antioch in the shipping channel.	38-03-09	121-41-17
10.	Frank's Tract near Russo's Landing This site is in a submerged tract located at the confluence of False and Old Rivers.	38-02-38	121-36-49
11.	Sacramento River below Rio Vista Bridge Samples are collected in the Sacramento ship channel, 450 feet south of the Rio Vista Bridge.	38-09-27	121-41-01
12.	San Joaquin River at Potato Point Samples are collected in the San Joaquin River near the mouth of Old River.	38-04-40	121-34-00
13.	Old River opposite Rancho Del Rio Samples are collected on Old River 0.5 mi upstream from the mouth of Rock Slough.	37-58-14	121-34-19
14.	San Pablo Bay near Pinole Point Samples are collected 1.2 mi NW from Pinole Point.	38-01-50	122-22-15
15.	Little Potato Slough at Terminus Samples are collected 50 yards south of the State Highway 12 bridge overcrossing.	38-06-53	121-29-47
16.	Disappointment Slough at Bishop Cut Samples are taken from a dock 0.17 mi W of the bridge between Rindge Tract and Bishop.	38-02-38	121-25-04
17.	San Joaquin River at Buckley Cove Approximately 4.2 miles west of the city of Stockton on the Stockton Deep Water Channel.	37-58-42	121-22-55
18.	Old river at Tracy Road Bridge Samples are collected in Old river 3.4	37-48-17	121-26-55

mi N of the city of Tracy.

ANALYTICAL METHODS

The Utermohl inverted microscope method is used for identification and enumeration of phytoplankton species. Organisms are identified at least to genus. Counts and densities of each genus are tabulated.

QUALITY ASSURANCE TESTING AND REPORTING

Analyses are conducted according to Standard Methods (APHA, 1989) using a photographic identification key developed over the years in consultation with experienced Delta phytoplankton taxonomists.

DATA STORAGE AND REFERENCES

DATA STORAGE

Location:	Research Triangle Park, North Carolina
Hardware:	IBM mainframe
Software:	STORET and SAS files
Volume of Data:	Approximately 37,000 lines

Contact for Data Retrieval:

Name:	Harlan Proctor Department of Water Resources 3251 S Street Sacramento CA 95816-7017
Phone:	(916) 445-7517

REFERENCES

DWR. 1990. Water quality conditions in the Sacramento-San Joaquin Delta during 1988. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1990. Sacramento-San Joaquin Delta Water Quality Surveillance Program, 1988: Volume II. Department of Water Resources, Central District. Sacramento, CA

DWR. 1989. Water quality conditions in the Sacramento-San Joaquin Delta during 1987. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1989. Sacramento-San Joaquin Delta Water Quality Surveillance Program, 1987: Volume II. Department of Water Resources, Central District. Sacramento, CA

DWR. 1988. Water quality conditions in the Sacramento-San Joaquin Delta during 1986. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1988. Sacramento-San Joaquin Delta Water Quality Surveillance Program, 1986: Volume II. Department of Water Resources, Central District. Sacramento, CA.

~**Descriptors:** primary production; plankton/algae/seagrass; biological resources; algal blooms; primary productivity; hydrology and flow; delta outflow; bay-delta; suisun bay; south delta; north delta; west delta; east delta; community structure; species diversity; abundance;

GENERAL INFORMATION AND ABSTRACT

Program:	Sacramento-San Joaquin Delta Water Quality Surveillance
Program:	Water Chemistry
Funding Agency:	Department of Water Resources
Principal Investigator:	Harlan Proctor (916) 445-7517 Department of Water Resources
Conducting Agency:	Department of Water Resources
Period of Record, Earliest Date:	January, 1975
Period of Record, Latest Date:	Present
Geographic Boundaries Description:	Twenty-six stations are sampled throughout the Delta from Hood to Vernalis, and downstream to San Pablo Bay.

ABSTRACT

Since 1975 the California Department of Water Resources (DWR) has monitored water quality from the Delta through San Pablo Bay. This monitoring is a requirement of Water Rights Decision 1485, in which the State Water Resources Control Board establishes conditions for the operation of the State Water Project. [Other aspects of the Decision 1485 monitoring program are described separately in the Estuarine Data Index]. DWR measures standard water quality parameters (including suspended solids, nutrients, and others) in grab samples taken biweekly from approximately 26 stations during most of the year. Trace elements and chlorinated organics are also analyzed twice per year at selected locations.

Results of this monitoring have been summarized since 1975 on an annual basis. Observed concentrations of trace metals and pesticides are compared to drinking water quality standards. During 1988, dissolved and total trace metal concentrations were determined during sampling runs in May and September at 11 sites throughout the Delta. All trace metal levels measured in 1988 were below the primary and secondary drinking water standards and there were no notable spatial trends. Due to improved analytical procedures resulting in lower reporting limits, metals such as arsenic that previously went undetected were found in low level concentrations at all stations in May and September. Copper, iron, manganese, lead and zinc were also detectable at increased frequencies throughout the Delta.

Installation of a new gas chromatography unit with automatic sampler and dual electrolytic conductivity detectors at the Department's chemical laboratory was completed prior to the 1988 pesticide analysis. This equipment has greater

residual and Co. The poor reproducibility was thought to be caused predominantly by sample heterogeneity.

In the study of soluble metals in the water column, total procedural blanks were <0.1 ug/kg for Cu, <0.05 ug/kg for Ni, <0.1 ug/kg for Zn, and <2 ug/kg for Fe. All samples were analyzed at least in duplicate using standard addition techniques to correct for incomplete yields. Precision of replicates was better than 10% at levels of 1 ppb for Cu, 2 ppb for Ni, 3 ppb for Zn, and 50 ppb for Fe. Estimated errors based on replicate samples are presented with the raw data. Several duplicate samples obtained in March 1976 were analyzed for Cu and Cd by an outside laboratory. Cu determinations were good to better than 5%, while Cd determinations were good to 15%. Samples collected using other techniques by another outside laboratory yielded results suggesting that the sampling was generally accurate to within 10%, with the exception of Fe. The lack of agreement between the two sampling procedures for Fe was probably due to the use of different filters (0.4um vs. 0.2um).

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Information on data storage was not available.

REFERENCES

Eaton, A. 1979a. Leachable trace elements in San Francisco Bay sediments: indicators of sources and estuarine processes. Environmental Geology 2(6): 333-339.

Eaton, A. 1979b. Observations on the geochemistry of soluble copper, iron, nickel, and zinc in the San Francisco Bay Estuary. Environmental Science and Technology 13: 425-431.

~**Descriptors:** bay-delta; pollutants and related parameters; sediment chemistry; san francisco bay; suisun bay; carquinez strait; san pablo bay; central bay; south bay; sediments; grain size; water chemistry; water quality; water pollution; primary production; heavy metals;

components. These pairs of samples could be compared to examine short-term changes in metal levels caused by bioturbation or other sediment-mixing processes. Samples were then stored at about 5 degrees C until analysis.

In the study of metals in solution in waters of the estuary, samples were collected in July and September 1975 and March 1976. Samples were taken from a depth of 1m. Immediately after collection, samples were filtered using 0.6um filters in July and 0.4um filters in September and March. Trace metal sampling was supplemented by USGS measurements of nutrients, salinity, temperature, dissolved oxygen, chlorophyll a, turbidity, and other parameters (see Parameters section above).

SAMPLING FREQUENCY AND LOCATION

Number of Stations: 43 stations were sampled in the 1973 study; 7 to 11 stations were sampled in the 1975-1976 study.

Forty-three stations were sampled from February to August in 1973. These stations were located throughout San Francisco Bay and up through Suisun Bay.

Samples were collected from Central, San Pablo and Suisun Bays in July and September of 1975, and March 1976 from 7 to 11 stations, depending on the sampling date.

ANALYTICAL METHODS

In the study of leachable trace elements three different leaches of each sample were analyzed by flame atomic absorption spectroscopy (FAS) for six metals: Fe, Mn, Cu, Zn, Co, and Ni. Samples were then leached with pyrophosphate (to remove organically bound metals) and ammonium oxalate-oxalic acid (to remove metals associated with amorphous iron oxides).

In the study of soluble metals in the water column, preserved samples were generally analyzed within a few months after collection, but in some cases up to 4 months elapsed. Thorough cleaning of bottles was performed to prevent significant leaching of metals from containers. All elements except for Fe were determined by atomic absorption spectroscopy. Fe was determined in most cases using a colorimetric method.

QUALITY ASSURANCE TESTING AND REPORTING

In the study of leachable trace elements, accuracy was tested by analyzing several samples by the method of standard additions. The comparison indicated that the method was accurate within 10%. Precision was estimated by analyzing one sample in triplicate for each batch of 10-15 samples. Precision for Cu, Zn, Fe, Ni, and Mn pyrophosphate and oxalate was better than 10%, and 20% for Mn that the behavior of all of these elements is probably dominated by physical processes (mixing) during most seasons, although there was some evidence for Cu removal in the northern reach in summer months when river flow is low. Cu, Ni, and Zn showed an excess of about 1 ppb relative to conservative mixing in the more saline portion of the Estuary. This excess was attributed to municipal and industrial discharges.

PARAMETERS

Media Analyzed: Water. Sediments.

PHYSICAL PARAMETERS MEASURED
light transmission
temperature
turbidity

CHEMICAL PARAMETERS MEASURED
Nutrients
ammonia
nitrate
nitrite
phosphate

Other Parameters
alkalinity
chlorophyll a
dissolved oxygen
pH
salinity
silicon dioxide

Trace elements
cadmium
copper
iron
manganese
nickel
zinc

METHODS

SAMPLING METHODS

Leachable trace elements in sediments were sampled in February and August 1973 from 43 stations in the Bay. Samples were collected with a Van Veen grab, and immediately split into surface (top 5cm) and subsurface (bottom 5cm)

GENERAL INFORMATION AND ABSTRACT

Program:	Trace Metal Geochemistry of San Francisco Estuary
Principal Investigator:	Andrew Eaton
Conducting Agency:	Chesapeake Bay Institute
Period of Record, Earliest Date:	February 1973
Period of Record, Latest Date:	March 1976
Geographic Boundaries Description:	Samples were collected from throughout San Francisco Bay to the lower reaches of the Sacramento River.

ABSTRACT

One of the earliest reliable accounts of trace metal geochemistry in the Estuary was provided by Andrew Eaton of the Chesapeake Bay Institute in the 1970's. This research intended to observe and attempt to explain some of the seasonal and geographic trends in the concentrations of trace metals in the water column and sediments of the Estuary. This work is documented in two peer-reviewed articles that are summarized below.

Eaton (1979a) examined the distribution of leachable trace metals in Bay sediments, based on samples collected in 1973. Results of this sampling indicated that geographic variations of leachable Fe, Mn, Cu, Zn, Co, and Ni in San Francisco Bay were all predominantly supplied to Bay sediments from the Sacramento-San Joaquin River system, with little evidence for direct contributions from municipal and industrial sources. North Bay sediments were found to be strongly enriched relative to the Central Bay, a result of smaller grain size and the trapping of river-derived metals in the region of the turbidity maximum. Both Cu and Zn had significant sources within the Bay system, probably municipal and industrial discharges. Evidence for this conclusion was the observation of relatively high levels of leachable Zn and Cu, particularly in the South Bay which receives no measurable river-derived sediment or river inflow.

Eaton (1979b) described the distribution of soluble trace metals (Cu, Fe, Ni, and Zn) in Bay waters based on samples collected in 1975 and 1976. Concentrations of dissolved Cu and Ni (1 to 4 ppb) were approximately an order of magnitude higher than those observed in ocean waters outside the Bay. Zn concentrations were 2-6 ppb within the Estuary and generally less than 1 ppb in the ocean. Cd levels were 0.08 to 0.2 ppb within the Estuary and 0.05 to 0.11 ppb outside. It was concluded

DATA STORAGE INFORMATION AND REFERENCES

Contact for Data Retrieval

Name: R. Michael Gordon
Address: Moss Landing Marine Laboratory
P.O. Box 450
Moss Landing CA 95039
Phone: (408) 633-3304 ext. 32

REFERENCES

Gordon, R.M. 1980. Trace element concentrations in seawater and suspended particulate matter from San Francisco Bay and adjacent coastal waters. M.A. Thesis, Department of Biological Sciences, San Jose State University. 84 pages.

~**Descriptors:** bay-delta; water quality; pollutants and related parameters; water pollution; water chemistry; trace elements;

(October 1978 data were excluded from further analyses because sampling did not occur at slack water). One surface sample was collected from each bay station. The lower salinity surface layer of water leaving San Francisco Bay was sampled at offshore stations. Sampling bottles and other equipment were either non- metallic or coated with teflon, and were vigorously cleaned under clean lab conditions prior to each cruise. Samples were collected during the first three cruises with GoFlo bottles, modified to provide the cleanest possible samples. On the final cruise a pumping system was employed to collect the samples.

SAMPLING FREQUENCY AND LOCATION

Number of Stations: 17 sites were sampled

Four cruises were undertaken in October, 1978, March 1979, August, 1979, and March 1980. The 17 sampling sites ranged from the Carquinez Strait through San Pablo and Central Bay, and out to the Gulf of the Farallones.

ANALYTICAL METHODS

A specially-constructed portable trace metal laboratory - complete with positive pressure filtered air, teflon-coated work surfaces, and other clean lab features - was used for sample filtration and collection on the boats used for sampling. Later handling of samples was also under clean lab conditions. Particulate trace metals were determined from the material retained by 0.4um filters. Dissolved trace metals were preconcentrated by liquid-liquid organic extraction and Chelex 100 ion exchange. Elemental determinations were made by atomic absorption spectrophotometry. Samples were analyzed by flame or flameless techniques depending upon the analyte concentration. Chelex eluates were analyzed for Cd, Mn, Ni, Pb, and Zn; organic extracts for Cd, Cu, Fe, Ni, and Zn; and particulate matter for Ag, Al, Cd, Cr, Fe, Mn, Ni, Pb, and Zn.

QUALITY ASSURANCE TESTING AND REPORTING

At one station during the two last cruises, consecutive replicate samples were collected from the same depth in order to assess overall reproducibility of the sampling and analytical process. Coefficients of variation were found to be much lower for samples collected with a pump system than those collected with GoFlo bottles. Results of the analysis of procedural blanks run with all samples are presented. Trace metal concentrations in procedural blank solutions were usually much lower than sample concentrations. Analytical accuracy was established for the particulate matter concentrations through the use of USGS reference material. The results were in good agreement with values reported by USGS. Reference materials were not available for dissolved trace metal concentrations in seawater, however, the laboratory conducting these analyses had previously demonstrated the ability to collect uncontaminated, consistent measurements of seawater.

zinc also had sources in the upper estuary, but almost complete removal occurred at slightly higher salinities.

Little variation in leachable trace element content was observed between the Bay and the Gulf. Bay particulate matter contained significantly higher concentrations of refractory aluminum, chromium, manganese, nickel, and zinc compared to particulate matter from coastal waters.

PARAMETERS

Media Analyzed: Water

PHYSICAL PARAMETERS MEASURED
sample depth

CHEMICAL PARAMETERS MEASURED
Nutrients
phosphate

Other Parameters
conductivity
light transmission
salinity
silicate
suspended loads
temperature
turbidity

Trace Elements
aluminum
cadmium
chromium
copper
iron
lead manganese
nickel
silver
zinc

METHODS

SAMPLING METHODS

Rigorous precautions were taken in all phases of sampling and analysis to prevent contamination of samples. Four cruises were undertaken in October 1978, March 1979, August 1979, and March 1980. Sampling on the three later cruises was conducted at or near slack water following either an ebb or a flood tide

GENERAL INFORMATION AND ABSTRACT

Program:	Trace Element Concentrations in Seawater and Suspended Particulate Matter
Funding Agency:	CH2M Hill Environmental Protection Agency National Science Foundation, Marine Chemistry
Principal Investigator:	R. Michael Gordon
Conducting Agency:	Moss Landing Marine Laboratories
Period of Record, Earliest Date:	October, 1978
Period of Record, Latest Date:	March, 1980
Length of Record:	2 years
Geographic Boundaries Description:	Samples were collected from the Carquinez Strait through San Pablo Bay, Central Bay, and out to the Gulf of the Farallones.

ABSTRACT

One of the few reliable studies of trace element concentrations in the water column of San Francisco Bay was conducted by R.M. Gordon for his Master's Thesis at San Jose State University. The purpose of this research was to address the almost complete lack of accurate and precise data for the Bay and the Gulf of the Farallones, and to investigate trace metal partitioning in these areas. A thorough effort was made in this work to produce sound data, including ultra-clean sampling and analytical techniques and thorough testing to assure the quality of the data.

Samples of Bay and ocean water were collected from 1978- 1980. The results of this study showed that Bay waters contained high concentrations of dissolved trace elements relative to ocean waters. Dissolved concentrations of copper, iron, manganese, nickel, and zinc were all much higher in Bay samples. Large variations in concentrations for the Bay samples, however, precluded statistically significant comparisons of Bay and coastal measurements. Copper, zinc, nickel, and manganese appeared to be transported out of the Bay, with elevated concentrations observed in the surface levels of water in the Gulf of the Farallones. Under high freshwater outflows, dissolved copper, nickel, and cadmium showed a source in the upper estuary followed by conservative mixing. Dissolved iron, manganese, and

ANALYTICAL METHODS

Dissolved trace elements in filtered and acidified samples were concentrated with liquid-liquid organic extraction, followed by acid or ammonium-cyanide back extraction. Final extracts were analyzed by flameless atomic absorption spectroscopy. Trace elements in dried samples of suspended particulates were analyzed by X-ray fluorescence (cadmium, copper, nickel, lead, and zinc) and Zeeman atomic absorption spectroscopy (silver). Extensive precautions were taken to minimize sample contamination.

QUALITY ASSURANCE TESTING AND REPORTING

These measurements are supported by thorough quality assurance testing. Results of analyses of reagent blanks were well below sample concentrations. Two or more replicate extractions were performed for each sample. Precisions for the combined extraction and analytical procedures were presented using data from samples extracted four or more times. Analyses of lead showed large variation among replicates; problems with contamination were suspected. Extraction efficiencies for the trace elements were determined by making spiked additions of known standards to Bay water samples.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Information on data storage was not available for this study.

REFERENCES

Girvin, D.C., A.T. Hodgson, M.E. Tatro, and R.N. Anaclerio. 1978. Spatial and seasonal variations of silver, cadmium, copper, nickel, lead, and zinc in South San Francisco Bay water during two consecutive drought years. Final report W5-039-12 to the San Francisco Bay Regional Water Quality Control Board. 117 pages.

~**Descriptors:** bay-delta; salinity; pollutants and related parameters; water chemistry; water pollution; water quality; trace elements; heavy metals;

SAMPLING FREQUENCY AND LOCATION

Number of Stations: 18

Water and suspended particulate samples were collected at 8 ship channel stations in South Bay and 2 ship channel stations in Central Bay. Additional samples were taken from 5 South Bay shoreline locations, and from three stations in the Gulf of the Farallones. Samples were collected in March, July, and September of 1976, and March and July of 1977. The Gulf of the Farallones samples were collected in March of 1976. In September of 1976 samples were taken over a period of 24 hours at one South Bay station in order to evaluate tidal cycle variations.

SHIP CHANNEL STATIONS

	Latitude	Longitude	Distance from Golden Gate
1.	37-28-30	122-03-80	56.5 km
2.	37-29-60	122-05-30	53.1 km
3.	37-31-10	122-08-10	48.0 km
4.	37-31-70	122-09-30	45.9 km
5.	37-33-30	122-11-50	41.5 km
6.	37-34-90	122-14-80	35.9 km
7.	37-36-00	122-16-20	33.3 km
8.	37-37-10	122-17-50	30.2 km
9.	37-42-00	122-20-30	21.1 km
10.	37-48-00	122-22-20	9.6 km
11.	37-49-10	122-28-30	0.4 km
12.	37-52-90	122-25-60	8.2 km

SHORELINE STATIONS

	Latitude	Longitude	Distance from Golden Gate
1.	37-31-10	122-06-90	49.1 km
2.	37-31-40	122-11-80	43.6 km
3.	37-34-30	122-15-30	35.9 km
4.	37-35-50	122-19-80	33.0 km
5.	37-42-40	122-23-20	20.2 km

GULF OF THE FARALLONES STATIONS

	Latitude	Longitude	Distance from Golden Gate
1.	37-43-00	122-51-40	35.3 km
2.	37-44-90	122-45-20	25.4 km
3.	37-47-20	122-37-20	13.1 km

plants relative to the volume of the receiving waters, low tidal diffusion rates, and minimal freshwater dilution.

Comparison of estimates of loading and diffusion of cadmium, copper, and zinc led the authors to conclude that the bottom sediment is a sink for these elements. In the 24 hour study of tidal influence on trace metal concentrations, fluctuations could only be resolved for nickel and zinc. Tidal variations for these elements were approximately sinusoidal and 180 degrees out of phase with tidal amplitude.

PARAMETERS

Media Analyzed: Water.

PHYSICAL PARAMETERS MEASURED

tidal cycle

CHEMICAL PARAMETERS MEASURED

Other Parameters

dissolved organic carbon
suspended particulate load
salinity
water temperature

Trace Elements

cadmium
copper
nickel
lead
silver
zinc

METHODS

SAMPLING METHODS

Water and suspended particulate samples were routinely collected from a depth of 2 m at eight ship channel stations in the South Bay and at two Central Bay stations. Additional samples were obtained from the Gulf of the Farallones and from several South Bay shoreline locations. Shoreline samples were collected within two hours of high tide in approximately 2 m of water. In September 1976 samples were taken over a period of 24 hours at one station to evaluate tidal cycle variations. All samples for trace element analyses were collected with a pumping system. Samples of dissolved metals were passed through a 0.2 um filter.

GENERAL INFORMATION AND ABSTRACT

Program:	Spatial and Seasonal Variations of Trace Elements in South San Francisco Bay
Funding Agency:	California State Water Resources Control Board
Principal Investigator:	Donald C. Girvin
Conducting Agency:	Lawrence Berkeley Laboratory,
Period of Record, Earliest Date:	March 1976
Period of Record, Latest Date:	July 1977
Geographic Boundaries Description:	Samples were collected in South Bay, Central Bay, and out to the Gulf of the Farallones.

ABSTRACT

In this study, funded by the California State Water Resources Control Board, researchers at Lawrence Berkeley Laboratory examined spatial and temporal variation in levels of silver, cadmium, copper, nickel, lead, and zinc in the South Bay. The study was performed over a 1.5 year period, in 1976 and 1977, coinciding with drought conditions and a lack of significant freshwater dilution of South Bay. The primary objective of the study was to document dissolved and particulate concentrations of these elements, particularly in ship channels. Secondary objectives of the study were to document concentrations associated with the tidal cycle, and compare shoreline levels with those in the ship channels.

Cadmium, copper, and nickel showed similar patterns. A well-defined gradient persisted throughout the study with concentrations increasing from the Central Bay to the southern South Bay. Lead and zinc were found at consistently high concentrations at the southernmost station in the Bay. The distribution of dissolved silver was distinct from the other elements, with no north to south gradient. Several elevated levels of silver were recorded in the South Bay, but no station had consistently high values throughout the study. Comparisons of South and Central Bay dissolved trace element concentrations with levels reported for oceanic waters demonstrated that average dissolved cadmium, copper, nickel, and zinc levels were consistently elevated in the Bay relative to offshore waters (20, 21, 29, and 20 times higher, respectively). On occasion, dissolved silver concentrations were highly elevated relative to offshore waters, although the average Bay concentrations were only 8 times higher. The major factors thought to contribute to elevated levels of these elements in the South Bay were large loadings from wastewater treatment

pollutant sources; shrimp; sediments and dredging; bioaccumulation; bacteria; food chains; water pollution; water chemistry; water quality; clams; shellfish; pollutants and related parameters; grain size;

Bridge and Coyote Creek samples were analyzed for heavy metals on a quarterly basis and chlorinated hydrocarbons on an annual basis.

ANALYTICAL METHODS

KLI analyzed their samples for dissolved oxygen; other analyses were performed by Marine Bioassay Laboratories of Watsonville, CA. Trace metal concentrations in water samples were determined by standard atomic absorption spectrophotometric (AAS) methods (EPA 1983: Manual of Methods for Chemical Analysis of Water and Wastes). Silver, chromium, cadmium, copper, nickel, and zinc were analyzed by air-acetylene AAS, lead by graphite furnace AAS, and mercury by cold vapor AAS. Trace metal levels in sediments were also analyzed by AAS, in accordance with ASTM Standards, Par 32 (1982) and Test Methods for Evaluating Solid Waste (EPA 1982). Phenolic compounds were quantified using a photometric method (EPA 1983). Chlorinated hydrocarbons were measured by gas chromatography with electron capture detection (EPA 1976: Analysis of Pesticide Residues in Human and Environmental Samples). TOC measurements of water and sediments were performed by the Kennedy/Jenks/Chilton Laboratory in San Francisco using an organic carbon analyzer.

Tissue samples of *Crangon franciscorum* were also analyzed for trace metals and TICH. Trace metals in tissue were determined using methods of the California State Mussel Watch Program. TICH procedures were the same as described for water and sediment samples. In the first year whole shrimp were analyzed. In subsequent years only abdominal tissue was analyzed to provide data more comparable to available data regarding human consumption of shrimp.

QUALITY ASSURANCE TESTING AND REPORTING

Results of quality assurance tests are not discussed in published reports.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Information on data storage is not available.

REFERENCES

Kinnetic Laboratories, Inc. and Larry Walker Associates. 1987. South Bay Dischargers Authority Water Quality Monitoring Program - final monitoring report. Prepared for the South Bay Dischargers Authority, San Jose, CA.

Larry Walker Associates and Kinnetic Laboratories, Inc. 1987. South Bay Dischargers Authority Water Quality Monitoring Program - final technical report. Prepared for the South Bay Dischargers Authority, San Jose, CA.

Descriptors: NPDES permit monitoring; biological resources; invertebrates; wetlands; sediment chemistry; bay-delta; point sources; POTWs; nonpoint sources;

trace metals, TOC, and phenolic compounds. Total identifiable chlorinated hydrocarbons (TICH) were determined once a year in water and sediment. From 1982-1984 metal concentrations were "totals"; in 1985 efforts began to discriminate between particulate and dissolved states. The revised methods included adopting a pump and filtration systems for sample collection. Water samples were collected at high tide, and drawn from below the surface and near the bottom. Temperature, conductivity, salinity, pH, and percent light transmittance were measured in the field. Samples of the top 5 cm of sediment were collected using a PVC gravity coring device. Samples of *Crangon franciscorum* were also collected from two South Bay stations and two North Bay stations for contaminant analysis.

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: 27

Samples were collected from the following areas:

2 sites in the South Bay
3 sites in Artesian Slough
5 sites in Coyote Creek
1 site at the mouth of Coyote Creek
4 sites in upper Guadalupe Slough
7 sites in lower Guadalupe Slough
3 sites in Palo Alto Channel
1 site Palo Alto Reference site
1 site at the Mouth of Mowry Slough

Semimonthly effluent monitoring was performed at each of the 27 receiving water stations (listed above), as required by NPDES permits. Sediment and water column monitoring for trace metals, phenolic compounds, chlorinated hydrocarbons, and total organic carbon, was conducted quarterly at 4 stations total; 2 of these were open water stations, located midchannel at the Dumbarton Bridge, and midchannel off Palo Alto; and 2 stations at the San Jose/Santa Clara and Sunnyvale receiving water outfalls at Artesian and Guadalupe Sloughs.

Water quality monitoring was conducted twice a month from May through October in 1985 and 1986 at Newark Slough and Faber Tract Marsh, which were used as reference sites. In 1986, 3 diurnal samplings were made at each station to assess daily fluctuations of selected water quality parameters; particular emphasis was placed on dissolved oxygen levels.

Biological indicator species were monitored monthly at the following 5 stations: midchannel at Dumbarton Bridge; midchannel off Palo Alto; midchannel near the mouth of Coyote Creek; near the junction of Coyote Creek and Mud Slough; and Guadalupe Slough. In the last year of the study a sixth station at Newark Slough was also sampled. In addition to these stations, samples from two California Department of Fish and Game stations in San Pablo and Suisun Bays were collected for comparative data. The San Pablo and Suisun Bay, Dumbarton

pH
salinity
secchi depth
sediment particle size
sulfides
total organic carbon
turbidity
water temperature

Nutrients
ammonia
nitrates
nitrites
phosphate
total organic nitrogen
total phosphate

Trace Elements
cadmium
chromium
copper
lead
mercury
nickel
zinc

Taxa

Crangon franciscorum	bay shrimp

METHODS

SAMPLING METHODS

Receiving water measurements of standard water quality parameters (dissolved oxygen, salinity, etc.) and nutrients were collected at 27 South Bay locations. Grab samples of receiving water were collected, preserved, and analyzed according to standard EPA methods. Chemical and bacteriological analyses of receiving waters were performed by State-certified laboratories. Most samples were collected by members of the South Bay Dischargers Authority in proximity to their outfalls according to the requirements of their individual NPDES permits. Supplemental samples were collected by Kinnetic Laboratories, Inc. (KLI). Samples were taken during lower low or higher low water. *In situ* measurements made at the surface and bottom of the water column by KLI included temperature, salinity, light transmittance, and pH.

Intensive sampling of the water column and sediments occurred at 4 locations. Water samples were analyzed for standard parameters, trace metals, total organic carbon (TOC), and phenolic compounds. Sediments were analyzed for metals from SBDA treatment plants generally decreased over the five year period . In particular, declines were observed for copper (a 61% decline), nickel (34%) and lead (17%). Receiving water quality was documented under a broad range of hydrologic conditions, with very wet, normal, and very dry years all occurring during the five years. Although salinities in the South Bay vary in response to Delta outflow and local runoff in the wet season, salinity gradients are maintained in the sloughs where effluents are released. Typical conditions range from nearly freshwater in Artesian Slough and upper Guadalupe Slough (in the vicinity of the San Jose/Santa Clara outfall), to brackish at the mouth of Coyote Creek, to saline in the open waters of the South Bay. SBDA effluents are the principal source of nitrogen and phosphorus loadings to the South Bay. High counts of coliform bacteria were observed in the receiving waters downstream from each of the SBDA outfalls.

Trace metal concentrations in sediments in general showed no clear spatial or temporal trends. Trace metal concentrations observed in receiving waters exhibited a great deal of variability, but were largely comparable to values previously reported for the Bay. Receiving water concentrations of trace metals in the South Bay were generally below EPA ambient saltwater criteria, with the exceptions of copper and nickel. Mercury, cadmium, and lead levels in tissue of *Crangon franciscorum* from the South Bay were higher than samples from the North Bay. Although chlorinated hydrocarbons were not frequently detected, very high levels were measured in 1984, with an apparent gradient of increasing concentrations toward the North Bay.

PARAMETERS

Media Analyzed: Biota. Sediment. Water.

BIOLOGICAL PARAMETERS MEASURED
- fecal coliforms
- total coliforms

PHYSICAL PARAMETERS MEASURED
- water color
- sediment grain size

CHEMICAL PARAMETERS MEASURED

Chlorinated Hydrocarbons
- total identifiable chlorinated hydrocarbons

Other Hydrocarbons
- phenols

Other Parameters
- conductivity
- dissolved oxygen
- dissolved sulfides
- light transmittance

GENERAL PARAMETERS AND ABSTRACT

Program: South Bay Dischargers Authority Water Quality Monitoring Program

Funding Agency: Grants were administered by the SWRCB
Federal Clean Water Grant Funds 75%
State Clean Water Grant Funds 12.5%
South Bay Dischargers Authority 12.5%

Principal Investigator: Marty Stevenson
Kinnetic Laboratories (808) 874-7530

Conducting Agency: Larry Walker Associates, Inc.
Kinnetic Laboratories, Inc.
Harvey and Stanley Associates, Inc.
K.P. Lindstrom, Inc.
Marine Bioassay Laboratories - lab analyses
Kennedy/Jenks/Chilton Laboratory - lab analyses

Period of Record, Earliest Date: December, 1981

Period of Record, Latest Date: November, 1986

Length of Record: 5 years

Geographic Boundaries Description: Samples were collected in the South Bay, from the Dumbarton Bridge south to Coyote Creek and Guadalupe Slough.

ABSTRACT

A long-term study of the effects of municipal effluents from the members of the South Bay Dischargers Authority ([SBDA] the cities of San Jose, Santa Clara, Palo Alto, and Sunnyvale) was an eventual consequence of the prohibition in the San Francisco Bay Regional Water Quality Control Board's 1975 Basin Plan of effluent discharges into the Bay south of the Dumbarton Bridge. The Regional Board granted SBDA a deferral from those requirements under the condition that SBDA undertake a multi-faceted study, including investigations of: effluent quality; receiving water quality; accumulation of toxicants in indicator organisms and sediments; biological indicator species life history; predation habits of important fish species; and avian botulism. The study began in December of 1981 and was completed in December 1986. Larry Walker Associates, Inc. and Kinnetic Laboratories, Inc. and various subcontractors implemented the study.

Only a few of the findings of the water quality monitoring portion of the South Bay Dischargers research program can be summarized here. Loadings of trace

REFERENCES

EA Engineering, Science and Technology, Inc. 1986. Derivation of water quality-based toxicity effluent limits for the Shell Oil Martinez manufacturing complex: Volume I Text, Appendix I, Protocols and Appendix II, Result Summaries. Available from Shell Oil. Martinez, CA. Also available at the SFRWQCB, contact Michael Drennan.

~**Descriptors:** bay-delta; PAHs; TICH; pollutants and related parameters; point sources; toxicity testing; effluent testing; carquinez strait; pollutant sources; refineries; bacteria; other hydrocarbons; water quality;

In acute toxicity testing, five surrogate (non-resident) species (threespine stickleback, *Gasterosteus aculeatus*; sheepshead minnow, *Cyprinodon variegatus*; a mysid, *Mysidopsis bahia*; rainbow trout, *Salmo gairdneri*; and a diatom, *Thalassiosira decipiens*) were used. Exposure concentrations varied among the test species due to differences in sensitivity. Initial tests helped define appropriate exposure concentrations. Endpoints were mortality, except for the *Thalassiosira* assay in which growth rate was assessed. Toxicity of the effluent to *Photobacterium phosphoreum* was also measured using the Microtox bioassay. The endpoint for the Microtox assay was loss of luminescence at the end of 20 minutes. Water used in diluting the effluent was taken from the Carquinez Strait. The variable salinity of waters in the Strait necessitated the use of artificial sea salts to maintain salinities in test and control solutions.

In chronic toxicity testing, the responses of three surrogate species (fathead minnow, *Pimephales promelas*; a cladoceran water flea, *Ceriodaphnia dubia*; and the mysid, *Mysidopsis bahia*) to a range of effluent concentrations were measured. *Ceriodaphnia* and *Mysidopsis* assays were performed at the EA Engineering, Science, and Technology, Inc. laboratory in Baltimore, MD. Fathead minnow tests were conducted onsite. All of these tests exposed early life stages for seven days, and evaluated mortality and additional measures of chronic toxicity (reproduction for *Ceriodaphnia*, growth for fathead minnows, and growth and reproduction for *Mysidopsis*). All tests consisted of doubly replicated controls and five effluent concentrations. Exposure concentrations varied among the species due to significant differences in their sensitivity. Spring water was used for control and dilution purposes, as fathead minnows and *Ceriodaphnia* are intolerant of salinities above a few parts per thousand.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Contact for Data Retrieval

Name: Mike Drennan
Address: San Francisco Bay Regional Water Quality Control Board
1111 Jackson St.
Oakland, CA 94607
Phone: (415) 464-0699

Data Access: Available to public in hard copy at SFRWQCB

Data Availability Date: Immediately

METHODS

SAMPLING METHODS

Inputs to the DKHPLM model (see Analytical Methods) were obtained from a review of available information. In the dye studies, Rhodamine dye was injected at a constant rate into the effluent diffusion line. As the effluent was released, samples were taken from a three-dimensional grid both upstream and downstream of the diffuser. Dye studies were performed on two ebb tides and one flood tide. Receiving water and effluent characteristics (velocity, temperature, and salinity) were monitored during the dye studies.

Effluent samples used in acute toxicity tests were 24 hour composites. Dilution and control water for these tests was collected from the Carquinez Strait.

SAMPLING FREQUENCY AND LOCATION

The acute No-Observable-Effect-Level (NOEL) was estimated from the result of 84 tests conducted over a 6-month period (from November-May, 1986) in which 6 species were tested for their sensitivity to the refinery effluent. These species were the threespine stickleback, sheepshead minnow, a mysid, rainbow trout, a diatom, and a bacterium.

The chronic NOEL was based on the results of 24 tests conducted over a 5 month period during which a cladoceran water flea, fathead minnnow, and a mysid were tested for chronic sensitivity to Shell refinery effluent.

Dye studies were performed three times in 1985; on the November 8, ebb tide, the November 9 flood tide, and the November 9 ebb tide. In these studies dye was injected into the Shell effluent at a location upstream of the diffuser. Samples for the ebb tide studies were collected along 8 transect lines placed 25 feet apart, from 25 to 200 feet downstream of the diffuser. Samples for the flood tide study were collected at 2 transects located 25 and 50 feet downstream from the diffuser; at the diffuser itself; and at 5 more transects placed 25 feet apart, from 25 to 100 feet upstream from the diffuser.

A study was carried out on June 17, 1986 to measure the influence of wharf pilings and the presence of ships docked at the wharf on the nominal tidal velocity in the vicinity of the Shell diffuser.

ANALYTICAL METHODS

The US Environmental Protection Agency (EPA) model, DKHPLM, was selected as most appropriate for evaluating the Shell discharge. The DKHPLM model simulates a multiport, positively buoyant plume in a linearly stratified flowing receiving water. Inputs to the model include characteristics of the effluent, the diffuser, and the receiving water.

Other Parameters Measured
biochemical oxygen demand
chlorine, residual and dosage
cyanide
dissolved oxygen
pH
salinity
settleable matter
soluble biochemical oxygen demand
sulfides
total organic carbon
total suspended matter
water temperature

Trace Elements
aluminum
arsenic
cadmium
chromium
cobalt
copper
cyanide
lead
mercury
nickel
selenium
silver
vanadium
zinc

TAXA (for bioassays)

Ceriodaphnia dubia	cladoceran water flea
Cyprinodon variegatus	sheepshead minnow
Gasterosteus aculeatus	threespine stickleback
Mysidopsis bahia	mysid
Photobacterium phosphoreum	bacterium
Pimephales promelas	fathead minnow
Salmo gairdneri	rainbow trout
Thalassiosira decipens	diatom

MISCELLANEOUS PARAMETERS ANALYZED
dilution
EC50
LC50
No observable effect concentration (NOEC)
flow rate

NOEL, and used them to calculate a water quality- based effluent toxicity limit based on the acute response (96 hour LC50) of the threespine stickleback (*Gasterosteus aculeatus*) (EA 1986).

The maximum IWC was estimated by dilution modeling under assumed conservative hydrologic conditions. A modified version of EPA's DKHPLM model and dye studies were used, predicting minimum dilutions at the edge of the zone of initial dilution of 33:1 and 39:1, respectively. Both acute and chronic NOELs were computed. The acute NOEL was estimated from testing conducted over a period of six months on six species (threespine stickleback, *Gasterosteus aculeatus*; sheepshead minnow, *Cyprinodon variegatus*; a mysid, *Mysidopsis bahia*; rainbow trout, *Salmo gairdneri*; a diatom, *Thalassiosira decipiens*; and a bacterium, *Photobacterium phosphoreum*). Mean 48- and 96-hour LC50 values ranged from 28.9% effluent (for the mysid) to over 100% effluent. Chronic toxicity testing was conducted over a five month period on three species (fathead minnow, *Pimephales promelas*; a cladoceran water flea, *Ceriodaphnia dubia*; and *Mysidopsis bahia*). Mean NOELs ranged between 10.7% effluent (for the fathead minnow) and 19.8% effluent.

Acute and chronic effluent toxicity limits were calculated based on the acute response (96 hour LC50) of the threespine stickleback, the species designated by the Regional Board. The acute limit was 48.2% effluent, and the chronic limit was 53.6% effluent.

|

PARAMETERS

Media Analyzed: Water

BIOLOGICAL PARAMETERS MEASURED
fecal coliforms
total coliforms

PHYSICAL PARAMETERS MEASURED
precipitation

CHEMICAL PARAMETERS MEASURED
Hydrocarbons
oil and grease
phenolic compounds
polynuclear aromatic hydrocarbons
total identifiable chlorinated hydrocarbons
volatile organics

Nutrients
ammonia-nitrogen

GENERAL INFORMATION AND ABSTRACT

Program:	Shell Oil Company Effluent Toxicity Studies
Funding Agency:	Shell Oil Company
Principal Investigator:	Daniel Glaze (415) 228-6161 x 3348 Shell Oil
Conducting Agency:	EA Engineering, Science, and Technology, Inc.
Study Cost:	$250,000
Period of Record, Earliest Date:	October 1985
Period of Record, Latest Date:	August 1986
Length of Record:	10 months
Geographic Boundaries Description:	Samples were collected from the Shell Oil effluent outfall just west of the Benicia-Martinez bridge.

ABSTRACT

In 1975 the San Francisco Bay Regional Water Quality Control Board (Regional Board) adopted a Basin Plan that required all dischargers to keep five out of ten test fish alive in bioassays with undiluted effluent for 96 hours. Since that time, Shell Oil Company, which discharges effluent from their refinery into the Carquinez Strait, has pursued an exception to this requirement, which actually became more stringent in 1986. To receive an exception a discharger must demonstrate that its discharge will not cause any acute or chronic effects to aquatic life, and that the toxicants do not persist in the Bay. Shell formulated the scientific basis for its argument in a study conducted by the consultants EA Engineering, Science, and Technology, Inc. (EA) (EA 1986). This study was based on an approach recommended by the US Environmental Protection Agency (EPA) in a "Technical Support Document for Water Quality-based Toxics Control" (USEPA 1985).

The EPA approach is based on a concept of hazard assessment, in which adverse impacts of discharges on the biological communities of receiving waters are thought to be avoided if the resulting concentration of effluent in the receiving water following minimum initial dilution (called the instream waste concentration, or IWC) is less than the minimum concentration which will cause an adverse acute or chronic impact on the most sensitive species in the biological community (the no-observable-effect level, or NOEL). The study conducted by EA estimated the IWC and the

Department of Water Resources
3251 S Street
Sacramento CA 95816-7017
(916) 978-4923 or (916) 323-8978

Who Can Access This Information: Public information

Data Availability Date: October 1, 1988

Map information Availability: October, 1988

Subject Description: Sampling locations

Level of detail: Major cities and streams

Cost: No charge

Contact: Sheila Greene
Department of Water Resources
3251 S Street
Sacramento CA 95816-7017

Phone: (916) 978-4923

REFERENCES

USBR. 1987. "Report on selenium behavior in the Sacramento-San Joaquin Estuary." USDI Exhibit #105 submitted in the State Hearings, available from the U.S. Bureau of Reclamation, Mid- Pacific Region, 2800 Cottage Way, Rm. W-2127, Sacramento, CA, 95825.

USBR. 1987. "Report on selenium concentrations and loadings in the San Francisco Bay-Delta Estuary." USDI Exhibit #107 submitted in the State Hearings, available from the U.S. Bureau of Reclamation, Mid-Pacific Region, 2800 Cottage Way, Rm. W-2127, Sacramento, Ca, 95825.

~**Descriptors:** freshwater inflow; trace elements; sacramento river; san pablo bay; bay-delta; central bay; south bay; suspended solids; salinity; water quality; selenium; pollutants and other parameters; water pollution; water chemistry; point sources; pollutant sources; refineries; upper drainage; san joaquin river; rivers; POTWs; nutrients; riverine inputs;

WESTERN DELTA

24. New York Slough near buoy marker #27
25. Sacramento River at Rio Vista
26. San Joaquin River at Jersey Point

Tributaries to the estuary which are sampled include the San Joaquin, Sacramento, Merced, Tuolumne, and Stanislaus Rivers. The San Joaquin River near Vernalis and the Sacramento River at Freeport have been sampled a total of 42 times each since July of 1984. Samples were collected once a month, with the exception of September of 1986 through October of 1987, when samples were collected twice a month.

The Merced River near Stevinson, the Tuolumne River at Modesto, and the Stanislaus River at Ripon were sampled in March and April of 1988

ANALYTICAL METHODS

Samples are held less than 1 month before determinations are made. Dr. Cutter at ODU has developed an improved method of selenium analysis, with a detection limit of 5 nanograms per liter. The basic technique involves the generation of hydrogen selenide from "dissolved" selenium, liquid nitrogen-cooled trapping, and atomic absorption. Concentrations of several of the many species of selenium can be quantified using this method, including: selenite (+4 oxidation state), selenate (+6), organic selenide (-2), total dissolved selenium, total suspended particulate selenium, and total selenium.

QUALITY ASSURANCE TESTING AND REPORTING

All determinations are performed in triplicate. The standard additions method of calibration is used to ensure accuracy.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location:	DWR, Sacramento
Hardware:	Compaq
Software:	Rbase
Volume of Data:	500 kilobytes
Quality Assurance:	Hand-keyed data is checked, line by line, to data sheets.
Contact for Data Retrieval	Sheila Greene

4.	Coyote Creek below Anderson Lake (at Lee C. Jordan Boy's Ranch)	37-08-43	121-39-57
5.	Coyote Lake at Dam	37-07-09	121-32-52
6.	Coyote Creek above Coyote Lake	37-04-31	121-30-30

Samples were collected at 26 stations throughout the Bay and Delta in April and September of 1986.

SAN FRANCISCO BAY

1. Coyote Creek
2. Dumbarton Bridge in deep water Channel
3. San Mateo Bridge in deep water Channel
4. Midway between San Mateo and Bay Bridges

CENTRAL BAY

5. Bay Bridge
6. Point Bonito (outside the Golden Gate Bridge)
7. Golden Gate Bridge
8. Raccoon Strait near Angel Island
9. Raccoon Strait between Angel Island and Tiburon

SAN PABLO BAY

10. San Pablo Bay near buoy marker #16
11. San Pablo Bay near buoy marker #8
12. San Pablo bay between buoy markers #13 and #14
13. San Pablo Bay near buoy marker #14
14. San Pablo Bay west of Carquinez Bridge

CARQUINEZ STRAIT

15. Carquinez Strait
16. Carquinez Strait
17. Carquinez Strait
18. Carquinez Strait near Benicia

SUISUN BAY

19. Suisun Bay east of Benicia Bridge
20. Suisun bay near buoy marker #9
21. Suisun Bay near buoy marker #21
22. Suisun Bay near Port Chicago
23. Suisun bay near buoy marker #22

2.	1/8 mile sw of BX "E" Mo (A)	38-00-58	122-24-30
3.	between 4M "9" and "10"	38-02-40	122-21-03
4.	1/8 mile s of "15" (F1 2.5 sec)	38-03-45	122-16-35
5.	mid channel off Napa River Mouth	38-03-78	122-14-53
Carquinez Strait			
6.	1/2 m east of Carquinez Bridge, mid channel	38-03-67	122-12-87
7.	1/4 mile of Dillon Point, ("21) mid channel	38-03-40	122-11-58
8.	1/4 mile w of "23" mid channel	38-02-60	122-10-28
9.	1/4 mi n of Martinez Marina entrance	38-02-00	122-08-00
10.	east of Benicia Bridge	38-02-37	122-07-12
Suisun Bay			
11.	east end of Avon Pier	38-03-00	122-05-37
12.	between 3M "11" and 3M "12"	38-03-83	122-03-63
13.	south of 3M "17"	38-03-30	122-01-22
14.	south of 3M "21"	38-03-58	121-58-92
15.	between end of Chipps Island and West Pittsburg	38-02-97	121-56-00

In addition to the above, samples were collected from 6 stations on Coyote Creek in the South Bay in April of 1988.

		Latitude	Longitude
1.	Coyote Creek at Highway 237	37-25-22	121-55-32
2.	Coyote Creek at Mabury Road	37-21-50	121-52-50
3.	Coyote Creek at Bernal Road	37-14-16	121-14-16

Corporation in Avon; and Exxon in Benicia. These were sampled monthly from October, 1987 through June, 1988.

The seven municipal dischargers sampled are East Bay MUD; East Bay Dischargers Authority; City of San Jose Water Pollution Control Plant; City of Sunnyvale Water Pollution Control Plant; City of Palo Alto Water Quality Control Plant; City and County of San Francisco, Department of Public Works, San Francisco Southeast Plant; Central Contra Costa Sanitary District. These dischargers were sampled monthly from December 1987 through March 1988.

The following 5 stations were a special monitoring effort on the San Joaquin River which was undertaken on March 3, 1988, during the period when water from Kesterson was being pumped into the San Joaquin River.

		Latitude	Longitude
1.	Samples were collected 3.5 miles northeast of Vernalis, at the bridge where County Road J-3 crosses the San Joaquin River.	37-40-34	121-15-51
2.	Samples were collected 2.8 miles upstream from its junction with Old River, at the Mossdale Bridge.	37-47-11	121-18-22
3.	Samples were collected 4.2 miles west of the City of Stockton on the Stockton Deep Water Channel. Collections were made mid-channel opposite Buckley Cove.	37-58-42	121-22-55
4.	Samples were collected on the San Joaquin River near the mouth of Old River. Collections are made in the channel southeast of Potato Point.	38-04-40	121-34-00
5.	Samples were collected 0.3 mile north of Antioch between the entrance markers of the Antioch Reach channel in the San Joaquin River.	38-01-15	121-48-28

Samples were collected at a total of 15 sites in San Pablo Bay, Carquinez Strait and Suisun Bay in October and December of 1987, and March and May of 1988.

		Latitude	Longitude
San Pablo Bay			
1.	1/4 mile west of "16" (Qk F1 r)	37-57-33	122-26-55

PARAMETERS

Media Analyzed: Water

BIOLOGICAL PARAMETERS MEASURED

chlorophyll a

CHEMICAL PARAMETERS MEASURED

Nutrients

ammonium
nitrate
nitrate
nutrients
ortho-phosphate
salinity
total suspended matter

Other Parameters

conductivity
silicate
water temperature

Trace Elements

selenate
selenide
selenite
suspended particulate selenium
total selenium

|

METHODS

SAMPLING METHODS

Samples are taken 1 to 2 m below the surface at all stations. The water is filtered through a 0.45 um filter, preserved with hydrochloric acid, shipped to Old Dominion University (ODU) and refrigerated until analysis.

SAMPLING FREQUENCY AND LOCATION

In June of 1985 an 8 station transect covering most of the estuary was sampled. In April of 1986 a total of twenty stations were sampled; 3 were in the South Bay, 16 in the estuary, 1 at Rio Vista on the Sacramento River, and 1 at Antioch on the San Joaquin River. In September of 1986 26 stations were sampled; 5 in the South Bay, 19 in the estuary, and one each in the Sacramento and San Joaquin Rivers. Latitude and longitude are not available for either 1985 or 1986.

The six petroleum refineries sampled are Chevron in Richmond; Unocal in Rodeo; the Pacific Refining Company in Hercules; Shell Oil in Martinez; Tosco

GENERAL INFORMATION AND ABSTRACT

Program:	Selenium Biogeochemical Studies
Agency:	Department of Water Resources U.S. Bureau of Reclamation
Principal Investigator:	Dr. Greg Cutter Old Dominion University (804) 440-4929
Funding Agency:	Department of Water Resources
Conducting Agency:	Department of Water Resources - field sampling Old Dominion University - lab analyses
Study Cost:	$60,000
Period of Record, Earliest Date:	1984
Period of Record, Latest Date:	1988
Geographic Boundaries Description:	Samples are collected throughout the estuary from the Sacramento and San Joaquin Rivers in the Delta to Coyote Creek in the South Bay.

ABSTRACT

The U.S. Bureau of Reclamation and the California Department of Water Resources have contracted Dr. Gregory Cutter of Old Dominion University to examine selenium behavior in the estuary. Using rigorous analytical procedures, the presence of different forms of selenium has been measured in the estuary and in effluent discharges during sampling surveys which began in 1984. Results from this work have shed light on the possible origins of waterborne selenium, which has been shown to be present in various forms throughout the estuary.

Significant sources of dissolved selenium include: the Sacramento and San Joaquin Rivers; oil refinery effluents in the North Bay; an unidentified source in the South Bay; and internal production, presumably through the dissolution of particulate selenium. Some of these different sources appear to contribute different species of selenium. For example, in the major rivers selenate is the predominant form, while selenite predominates in refinery effluents. Thus, variability observed in speciation patterns in the estuary over time are suggestive of the relative significance of contributions from different selenium sources. Recent efforts have included analysis of effluents from municipal wastewater treatment plants.

REFERENCES

DWR. 1990. Water quality conditions in the Sacramento-San Joaquin Delta during 1988. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1990. Sacramento-San Joaquin Delta Water Quality Surveillance Program, 1988: Volume I. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1989. Water quality conditions in the Sacramento-San Joaquin Delta during 1987. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1989. Sacramento-San Joaquin Delta Water Quality Surveillance Program, 1987: Volume I. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1988. Water quality conditions in the Sacramento-San Joaquin Delta during 1986. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1988. Sacramento-San Joaquin Delta Water Quality Surveillance Program, 1986: Volume I. Department of Water Resources, Central District. Sacramento, CA.

~**Descriptors:** salinity; bay-delta; san pablo bay; suisun bay; pollutants and related parameters; water quality; water chemistry; pesticides; water pollution; chlorinated hydrocarbons; suisun bay; delta; salt water intrusion; triazines; west delta; north delta; east delta; south delta;

3.4 miles north of the city of Tracy.
The sampling point is located on the
right bank 50 yards downstream from the
Tracy Road Bridge.

ANALYTICAL METHODS

All laboratory analyses are performed at DWR's Bryte Laboratory. Chlorophyll a and pheophytin levels are measured with a scanning spectrophotometer. Silica is measured using a molybdate blue method developed by USGS. Other parameters are analyzed using standard methods prescribed by the American Public Health Association ("Standard Methods for the Examination of Water and Wastewater") or the US Environmental Protection Agency (EPA) ("Methods for Chemical Analysis of Water and Wastes"). Trace metal concentrations were determined using atomic absorption (Standard Methods 303B and 303F). Colorimetric EPA methods were employed for nutrients. Pesticide concentrations are ascertained using a gas chromatograph with a microcoulomic detector, as suggested in "Standard Methods".

QUALITY ASSURANCE TESTING AND REPORTING

Quality assurance procedures have been conducted before, during and after compliance monitoring runs since 1975. These procedures consist of pre and post monitoring calibration checks of monitoring instrumentation using standard solutions which are prepared at DWR's Bryte Laboratory or purchased from suppliers. Duplicate samples are also obtained or samples of known concentration are obtained and submitted to the laboratory for analysis and verification of their results for the nitrate series, phosphate series, silica, and chlorophyll samples.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: Research Triangle Park, North Carolina

Hardware: IBM mainframe

Software: STORET and SAS files

Volume of Data: 270,000 records

Contact for Data Retrieval

Name: Harlan Proctor
Department of Water Resources
3251 S Street
Sacramento CA 95816-7017

Phone: (916) 445-7517

15.	San Joaquin River at Twitchell Is This sampling site is located in the San Joaquin River 1.2 miles above its confluence with Three Mile Slough.	38-05-50	121-40-05
16.	Frank's Tract near Russo's Landing A submerged tract located at the confluence of the False and Old Rivers.	38-02-38	121-36-49
17.	Sacramento River at Emmaton Sacramento River near its downstream confluence with Horseshoe Bend.	38-05-04	121-44-17
18.	Sacramento River below Rio Vista Bridge Sacramento Ship Channel at Rio Vista.	38-09-27	121-41-01
19.	San Joaquin River at Potato Point San Joaquin River near the mouth of Old River.	38-04-40	121-34-00
20.	Old River opposite Rancho del Rio Old River 0.5 miles upstream from the mouth of Rock Slough. Samples are collected opposite Rancho del Rio headquarters on Bacon Island.	37-58-14	121-34-19
21.	San Pablo Bay near Pinole Point The station is 1.2 mi from Pinole Point.	38-01-50	122-22-15
22.	Little Potato Slough at Terminous Samples are collected near the State Highway 12 bridge overcrossing.	38-06-53	121-29-47
23.	Disappointment Slough at Bishop Cut Samples are taken west of the bridge between Rindge Tract and Bishop Tract.	38-02-38	121-25-04
24.	San Joaquin River at Buckley Cove Approximately 4.2 miles west of the city of Stockton on the Stockton deep water channel.	37-58-42	121-22-55
25.	Middle River at Union Point The sampling site is located on Middle River at Union Point Marina.	37-53-28	121-29-14
26.	Old River at Tracy Road Bridge	37-48-17	121-26-55

6.	Suisun Bay off Bull's Head Point near Martinez Samples are collected near the Southern Pacific Railroad bridge at Benicia.	38-02-40	122-07-00
7.	Grizzly Bay at Dolphin near Suisun Slough Samples are collected from a shallow embayment 1.4 miles east of the mouth of Suisun Slough.	38-07-02	122-02-19
8.	Suisun Bay off Middle Point near Nichols Samples are collected in Suisun Bay within the west reach of the Middle Ground Channel.	38-03-36	121-59-20
9.	Honker Bay near Wheeler point The sampling site is located in a shallow embayment 1.9 miles northeasterly from Point Palo Alto.	38-04-26	121-56-12
10.	Sacramento River at Chipps Island Samples are collected west of the confluence of the Sacramento and San Joaquin Rivers between Chipps and Mallard Islands.	38-02-47	121-55-02
11.	Sherman Lake near Antioch Samples are collected 2 miles north of Antioch near the center of a submerged tract between the Sacramento and San Joaquin Rivers.	38-02-34	121-47-34
12.	San Joaquin River at Antioch. Ship Channel Samples are collected 0.3 miles north of Antioch between the entrance markers of the Antioch Reach Channel in the San Joaquin River.	38-01-15	121-48-28
13.	Big Break near Oakley The sampling site is located 1.3 miles north of Oakley in a submerged tract.	38-01-05	121-42-38
14.	San Joaquin River at Jersey Point This sampling site is located on the San Joaquin River 6.5 miles northeast of Antioch in the shipping channel.	38-03-09	121-41-17

6.	Suisun Bay off Bull's Head Point near Martinez Samples are collected near the Southern Pacific Railroad bridge at Benicia.	38-02-40	122-07-00
7.	Grizzly Bay at Dolphin near Suisun Slough Samples are collected from a shallow embayment 1.4 miles east of the mouth of Suisun Slough.	38-07-02	122-02-19
8.	Suisun Bay off Middle Point near Nichols Samples are collected in Suisun Bay within the west reach of the Middle Ground Channel.	38-03-36	121-59-20
9.	Honker Bay near Wheeler point The sampling site is located in a shallow embayment 1.9 miles northeasterly from Point Palo Alto.	38-04-26	121-56-12
10.	Sacramento River at Chipps Island Samples are collected west of the confluence of the Sacramento and San Joaquin Rivers between Chipps and Mallard Islands.	38-02-47	121-55-02
11.	Sherman Lake near Antioch Samples are collected 2 miles north of Antioch near the center of a submerged tract between the Sacramento and San Joaquin Rivers.	38-02-34	121-47-34
12.	San Joaquin River at Antioch. Ship Channel Samples are collected 0.3 miles north of Antioch between the entrance markers of the Antioch Reach Channel in the San Joaquin River.	38-01-15	121-48-28
13.	Big Break near Oakley The sampling site is located 1.3 miles north of Oakley in a submerged tract.	38-01-05	121-42-38
14.	San Joaquin River at Jersey Point This sampling site is located on the San Joaquin River 6.5 miles northeast of Antioch in the shipping channel.	38-03-09	121-41-17

6.	Suisun Bay off Bull's Head Point near Martinez Samples are collected near the Southern Pacific Railroad bridge at Benicia.	38-02-40	122-07-00
7.	Grizzly Bay at Dolphin near Suisun Slough Samples are collected from a shallow embayment 1.4 miles east of the mouth of Suisun Slough.	38-07-02	122-02-19
8.	Suisun Bay off Middle Point near Nichols Samples are collected in Suisun Bay within the west reach of the Middle Ground Channel.	38-03-36	121-59-20
9.	Honker Bay near Wheeler point The sampling site is located in a shallow embayment 1.9 miles northeasterly from Point Palo Alto.	38-04-26	121-56-12
10.	Sacramento River at Chipps Island Samples are collected west of the confluence of the Sacramento and San Joaquin Rivers between Chipps and Mallard Islands.	38-02-47	121-55-02
11.	Sherman Lake near Antioch Samples are collected 2 miles north of Antioch near the center of a submerged tract between the Sacramento and San Joaquin Rivers.	38-02-34	121-47-34
12.	San Joaquin River at Antioch. Ship Channel Samples are collected 0.3 miles north of Antioch between the entrance markers of the Antioch Reach Channel in the San Joaquin River.	38-01-15	121-48-28
13.	Big Break near Oakley The sampling site is located 1.3 miles north of Oakley in a submerged tract.	38-01-05	121-42-38
14.	San Joaquin River at Jersey Point This sampling site is located on the San Joaquin River 6.5 miles northeast of Antioch in the shipping channel.	38-03-09	121-41-17

sensitivity than the unit used previously, resulting in lower reporting units of all pesticides analyzed. During May and September 1988, pesticide samples were collected at the same sites sampled for trace metals.Only the chlorinated hydrocarbon compound Diuron occurred above the minimum reporting limit. On September 2, Diuron was detected in the San Joaquin River at Buckley Cove (P8) at a concentration of 0.1 mg/L. Diuron is a general herbicide used at low application levels for controlling broadleaf weeds in germinating crops such as alfalfa, cotton, and grapes. At higher concentrations, it is used as a general weed killer and soil sterilant in vineyards and crops such as barley, wheat, and cotton (Farm Chemicals Handbook, 1989). No drinking water standards have been established for Diuron (personal communication with Joel Trumbo, California Department of Food and agriculture, and Lee Casaleggio, California Department of Health Services).

PARAMETERS

Media Analyzed: Water

BIOLOGICAL PARAMETERS MEASURED

chlorophyll
pheophytin

PHYSICAL PARAMETERS MEASURED

air temperature wind direction

CHEMICAL PARAMETERS MEASURED Nutrients

ammonia-nitrogen
nitrite plus nitrate-nitrogen
organic nitrogen
ortho-phosphate
total phosphorus

Other Parameters

chloride
dissolved oxygen
dissolved solids
pH
secchi disc depth
silica
specific conductance
suspended solids
turbidity
volatile suspended solids
water temperature

Chlorinated Hydrocarbons

alachlor
aldrin
atrazine

GENERAL INFORMATION AND ABSTRACT

Program:	Sacramento-San Joaquin Delta Water Quality Surveillance
Program:	Water Chemistry
Funding Agency:	Department of Water Resources
Principal Investigator:	Harlan Proctor (916) 445-7517 Department of Water Resources
Conducting Agency:	Department of Water Resources
Period of Record, Earliest Date:	January, 1975
Period of Record, Latest Date:	Present
Geographic Boundaries Description:	Twenty-six stations are sampled throughout the Delta from Hood to Vernalis, and downstream to San Pablo Bay.

ABSTRACT

Since 1975 the California Department of Water Resources (DWR) has monitored water quality from the Delta through San Pablo Bay. This monitoring is a requirement of Water Rights Decision 1485, in which the State Water Resources Control Board establishes conditions for the operation of the State Water Project. [Other aspects of the Decision 1485 monitoring program are described separately in the Estuarine Data Index]. DWR measures standard water quality parameters (including suspended solids, nutrients, and others) in grab samples taken biweekly from approximately 26 stations during most of the year. Trace elements and chlorinated organics are also analyzed twice per year at selected locations.

Results of this monitoring have been summarized since 1975 on an annual basis. Observed concentrations of trace metals and pesticides are compared to drinking water quality standards. During 1988, dissolved and total trace metal concentrations were determined during sampling runs in May and September at 11 sites throughout the Delta. All trace metal levels measured in 1988 were below the primary and secondary drinking water standards and there were no notable spatial trends. Due to improved analytical procedures resulting in lower reporting limits, metals such as arsenic that previously went undetected were found in low level concentrations at all stations in May and September. Copper, iron, manganese, lead and zinc were also detectable at increased frequencies throughout the Delta.

Installation of a new gas chromatography unit with automatic sampler and dual electrolytic conductivity detectors at the Department's chemical laboratory was completed prior to the 1988 pesticide analysis. This equipment has greater

DWR. 1988. Water quality conditions in the Sacramento-San Joaquin Delta during 1986. Department of Water Resources, Central District. Sacramento, CA.

DWR. 1988. Sacramento-San Joaquin Delta Water Quality Surveillance Program, 1986: Volume II. Department of Water Resources, Central District. Sacramento, CA.

~**Descriptors:** primary production; plankton/algae/seagrass; biological resources; algal blooms; primary productivity; hydrology and flow; delta outflow; bay-delta; suisun bay; south delta; north delta; west delta; east delta; community structure; species diversity; abundance;

GENERAL INFORMATION AND ABSTRACT

Program:	Urban Runoff Discharges from Sacramento, California
Funding Agency:	Central Valley Regional Water Quality Control Board (CVRWQCB)
Principal Investigator:	Barry Montoya (916) 361-5692 CVRWQCB
Conducting Agency:	CVRWQCB
Period of Record, Earliest Date:	July, 1984
Period of Record, Latest Date:	June, 1985
Geographic Boundaries Description:	This study examined urban runoff from greater Sacramento, (City and County jurisdiction), which is discharged to the Sacramento and American Rivers.

ABSTRACT

The Central Valley Regional Water Quality Control Board (CVRWQCB) is conducting an investigation of all point and non- point source discharges in the Central Valley Region following initial findings of the Sacramento River Toxics (205[j]) Study. The objective is to define the scope and relative contributions of priority pollutants from agricultural tailwater, acid mine drainage, point source discharges, and urban runoff. The first in what is intended to be a series of reports addressed urban runoff from the City of Sacramento during 1984 and 1985.

Mass loadings data were calculated from flow and concentration data gathered in other studies (Montoya 1987). Approximately half of the water discharged from flood control pumps during the study period was correlated with rainfall. Monthly average dilution ratios of urban runoff in the Sacramento River ranged between 1 and 3%, although a weekly ratio above 6% was observed. Mass loading of some trace elements exceeded emissions from the Sacramento Regional wastewater treatment plant (the largest volume point source discharger in the estuary). Concentrations of copper, lead, zinc, cadmium, and chromium in urban runoff typically exceed EPA criteria for the protection of freshwater aquatic biota. Polynuclear aromatic hydrocarbons present in urban runoff appear to be a major contributor to levels in downstream sediments.

PARAMETERS

Media Analyzed: Sediments. Water.

PHYSICAL PARAMETERS ANALYZED
flow

CHEMICAL PARAMETERS ANALYZED
Chlorinated Hydrocarbons
PCBs

Other Hydrocarbons
Monocyclic Aromatic Hydrocarbons benzene
1,2,4-trichlorobenzene
hexachlorobenzene
1,4-dichlorobenzene
chlorobenzene
ethylbenzene
toluene
xylenes (total)

Phenols and Cresols
phenol
pentachlorophenol
4-nitrophenol
2,4-dimethylphenol
4-methylphenol

Phthalates
bis (2-ethylhexyl) phthalate
diethylphthalate
dimethylphthalate
di-n-butylphthalate
di-n-octylphthalate
butylbenzylphthalate

Polynuclear Aromatic Hydrocarbons
acenaphthene
acenaphthylene
anthracene
benzo(a)anthracene
benzo(b)fluoranthene
benzo(k)fluoranthene
benzo(a)pyrene
benzo(g,h,i)perylene
dibenzo(a,h)anthracene
chrysene

fluoranthene
fluorene
indeno(1,2,3-cd)pyrene
2-methylnaphthalene
naphthalene
phenanthrene
pyrene

Volatile Organic Chemicals (Halogenated Aliphatics)
chloroform
methylene chloride
chloroethane
1,2-trans-dichloroethene
dichloromethane
1,1-dichloroethane
1,1-dichloroethene
1,3-dichloropropene
dichlorobromomethane
1,1,2-trichloroethane
trichloromethane
tetrachloroethene
trichlorofluoromethane
1,1,2,2-tetrachloroethane
tetrachloromethane

Pesticides
aldrin
BHC
DDE
dieldrin
endosulfan
endrin
heptachlor
heptachlor epoxide
methoxychlor
toxaphene

Trace Elements
copper
lead
zinc

METHODS

SAMPLING METHODS

Field sampling was not performed for this study. Stormwater drainage watersheds within and surrounding the City of Sacramento were divided into 4 domains. Flow data were compiled from records of operation of numerous flood control pumps in the Sacramento area. Monthly rainfall data obtained from the National Weather Service were used to estimate the proportion of urban runoff attributable to rainfall. Average concentration data were gathered from other reports.

SAMPLING FREQUENCY AND LOCATION

Mass loads of copper, zinc, and lead were estimated from the city of Sacramento's urban runoff using actual pumpage values and nationwide concentration statistics. Agricultural and open-type lands situated in the greater Sacramento area were excluded from discharge estimates, as were the following watersheds: Laguna Creek; Dry Creek; Natomas East; and Aerojet.

I

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE

Location: These data are in published format with the Central Valley Regional Board.

Contact for Data Retrieval

Name: Barry Montoya

Address: California Regional Water Quality Control Board
Central Valley Region
3433 Routier Road
Sacramento CA 95827-3098

Phone: (916) 361-5692

Who Can Access This Information: Public document

REFERENCES

Montoya, B.L. 1987. Urban runoff discharges from Sacramento, California. Central Valley Regional Water Quality Control Board Report Number 87-1SPSS. Available from the CVRWQCB, Sacramento, CA. 63 pages.

~**Descriptors:** chlorinated hydrocarbons; PAHs; urban runoff; non-point sources; sacramento river; american river; pollutant sources; delta; MAHs; pollutants and related parameters; rivers; cyclodienes; ddt; halogenated aliphatics; bay-delta;

GENERAL INFORMATION AND ABSTRACT

Program: Water Quality Monitoring Network

Funding Agency: US Bureau of Reclamation

Principal Investigator: Sandy Wagner
US Bureau of Reclamation (916) 978-5225

Conducting Agency: US Bureau of Reclamation

Period of Record, Earliest Date: 1950

Period of Record,

Latest Date: Present

Geographic Boundaries Description: Seventeen sites in the Delta are monitored, which range from Hood to Mossdale, and the Federal pumping plant at Tracy. Seven sites are monitored in Suisun Marsh.

ABSTRACT

The US Bureau of Reclamation collects daily data from continuous monitoring stations for use in maintaining salinity levels in the Delta. Data have been collected from 1950 at some stations to the present.

Data from some of the stations which are part of this monitoring network are discussed in Arthur (1987). On the Sacramento River specific conductance measurements have been in the range which is generally considered to be excellent for domestic or agricultural use. Specific conductance in the San Joaquin River has been considerably higher. Overall loads of total dissolved solids to the Delta have been much higher in the Sacramento as a result of its greater flows. As might be expected, peak specific conductance in the lower Sacramento River and Suisun Bay occur during periods of low flow in the late summer and fall, while lower values are observed during periods of high runoff in the winter and spring.

PARAMETERS

Media Analyzed: Water

CHEMICAL PARAMETERS MEASURED
Other Parameters
electrical conductivity total dissolved solids

METHODS

SAMPLING METHODS

Salinity is monitored at seventeen sites in the Delta and seven sites in Suisun Marsh. The data are recorded electronically using electrical conductivity meters. Specific conductance is obtained from these measurements by correcting the values to 25 degrees C. Hourly readings at these stations are continuously recorded (however, only high, low, and average values for each day are stored on STORET).

SAMPLING FREQUENCY AND LOCATION

Number of Sampling Sites: A total of 22 sites are sampled.

Electrical conductivity readings have been taken from the mid-1960s to the present in the Delta, and from 1976-1981 in Suisun Marsh. TDS readings were taken from 1950 to the mid-1960s in the Delta.

San Joaquin River at Antioch

Cache Slough at Vallejo Pumping Plant

Sacramento River At Collinsville

Contra Costa Canal at Plant 1

Delta Mendota Canal at Headworks

Delta Mendota Canal at Check 13

Delta Mendota Canal at Check 20

Sacramento River at Emmation

Dutch Slough at Farrar Park

Sacramento River at Greens Landing

Old River at Holland Tract

San Joaquin River at Jersey Point

Sacramento River at Pittsburg

Sacramento River at Rio Vista

San Joaquin River at San Andreas Landing

Stanislaus River at Ripon

Mokelumne, South Fork at Staten Island

Old River at Middle River (Union Island)

Middle River at Victoria Canal

San Joaquin River at Vernalis

Carquinez Strait at Martinez

Suisun Bay at Port Chicago

QUALITY ASSURANCE TESTING AND REPORTING
The continuous monitoring recorders are calibrated weekly.

DATA STORAGE INFORMATION AND REFERENCES

DATA STORAGE
Location: Research Triangle Park, North Carolina
Hardware: IBM mainframe
Software: STORET
STORET Agency Code: 113Burec
Volume of Data: 380,000 records
Quality Assurance: Yearly subsample drawn; error rate is 0.4%.
Contact for Data Retrieval
Name: Sheryl Baughman
Address: US Bureau of Reclamation
2800 Cottage Way, Rm W-2137
Sacramento CA 95825-1898
Phone: (916) 978-5260
Data Access: Available to anyone with STORET access codes.
Data Availability Date: All data up to the month previous to the current month is available.

REFERENCES

Arthur, J. 1987. River flows, water project exports, and water quality trends in the San Francisco Bay-Delta Estuary. USBR Exhibit No.111 submitted in the State Hearings, available from the U.S. Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA.

USBR. 1967. Delta surveillance and study program. United States Bureau of Reclamation, Region 2, Division of Project Development, Hydrology Branch. Sacramento, CA.

~**Descriptors:** salinity; bay-delta; pollutants and related parameters; salt water intrusion; water diversion; hydrology and flow; drinking water; central delta; north delta; west delta; south delta;

AQUATIC HABITAT INSTITUTE

announces

S I N B A D

the Scientific Information Network for the Bay And Delta

The Aquatic Habitat Institute announces an on-line information system for people interested in the San Francisco Estuary. The system, known as the Scientific Information Network for the Bay And Delta (SINBAD), includes the Estuarine Data Index, the Bay-Delta Hearing Testimony and Exhibits Database, the Bay-Delta Bibliography, and the AHI Bulletin Board. All the information services are menu-driven, keyword searchable, and are available to any interested party at no charge.

THE ESTUARINE DATA INDEX: The first database, known as the Estuarine Data Index, contains detailed summaries of 70 research and monitoring programs that have been, or are presently being, conducted in the San Francisco Estuary. Each summary contains an abstract, and information about methods, and quality assurance procedures. The summaries also list sampling site locations, parameters studied, references, and contains information on data storage, including contact names and telephone numbers. The EDI was recently updated and expanded, and each summary has been verified for accuracy by the principal investigator. This data base was designed to be useful in enhancing coordination and communication between the scientific community, environmental managers, and the public.

THE BAY-DELTA BIBLIOGRAPHY: The second database is the Bay-Delta bibliography. The more than three thousand entries in the database can be searched by author, title, or subject. This database was compiled from in-house publication lists of state and federal agencies, consulting firms, and environmental organizations. In addition, hundreds of recent reports and articles obtained by the Institute have been included, and new documents are added monthly. Many entries have abstracts, and those contained in AHI's noncirculating library include the library call number for easy access.

BAY-DELTA HEARING TESTIMONY: The third data base is the Bay-Delta Hearing Testimony and Exhibits database. The California State Water Resources Control Board is presently conducting evidentiary hearings to set water quality standards for the San Francisco Estuary, and to consider amending water rights to implement these standards. This complex task began in 1987 with the receipt of tremendous quantities of written and oral evidence regarding the beneficial uses of the Estuary, factors that affect those uses, and means of implementing water quality objectives. The Hearing Testimony and Exhibits Database contains verbatim transcripts of the oral testimony given during Phase 1 (and the beginnings of Phase II) of the Bay-Delta Hearings; and a list of the exhibits submitted during the hearings.

AHI ELECTRONIC BULLETIN BOARD: The most recent addition to the system is an electronic "bulletin board". This includes a complete electronic messaging service, allowing all users of the Bay-Delta community to send and receive messages. The Institute will also post lists of recently obtained reports and journal articles relevant to the ecology of the Estuary.

Individuals may access the system at publicly available terminals (locations are listed in Dial-up access instructions) or by using a personal computer and modem. The modem number is (415) 643-7485. Communications software with VT-100 emulation capability (an industry standard) is needed to log onto the system. Dial-up access instructions are attached. Public domain communications software is available from the Aquatic Habitat Institute at (415) 231-9539.

SINBAD

Dial-Up Access Instructions

for the

Scientific Information Network for the Bay And Delta

The following instructions are intended to serve as a general reference guide to the utilization of the Aquatic Habitat Institute's Scientific Information Network for the Bay And Delta (SINBAD). This system contains the State Bay-Delta Hearing Testimony and Exhibits Database, the Estuarine Data Index, the Bay-Delta Bibliography, and the AHI Bulletin Board. SINBAD runs on a MicroVax 3400 minicomputer that is located at the Aquatic Habitat Institute in Richmond, CA. It may be accessed using one of the Digital Equipment Corporation (DEC) VT- 320 video terminals and Packard Bell 1200/2400 baud modems which have been installed at the official Bay-Delta Hearing exhibit lodging locations listed in Table 1. Alternatively, the database may be accessed using any microcomputer with telecommunication capability (i.e., a microcomputer with a 300/1200/2400 baud modem and appropriate communications software such as XTALK or PROCOMM).

To link one of the DEC VT-320 video terminals up with SINBAD via a telephone line, follow the instructions below starting with Step 1.

NOTE - Within the following instructions the information to be entered through the terminal or microcomputer accessing the database is enclosed in quotation marks.

DO NOT TYPE THE QUOTATION MARKS!

If attempting to access the database with a microcomputer follow the procedure given in your telecommunication software user's manual to establish contact with SINBAD. The parameter settings which should be used to initialize telecommunication software systems are presented in Table 2. Once communication has been established between your microcomputer and SINBAD follow the instructions below starting with Step 4.

Step 1: Turn on the modem and video terminal using the on-and-off switches on the back of the modem and on the lower left-hand side of the terminal monitor.

Step 2: Once the terminal's automatic startup test sequence has been completed and the 'wait' light on the keyboard goes out, type "AT" (the modem's Attention code) and press the RETURN key to "awake" the modem.

Step 3: After the modem responds with 'OK', type "ATDT phone number" and again press the RETURN key. The basic phone number is 643-7485. When dialing out through a switchboard to a public long distance telephone line use "9,1,415, 643-7485". When using a State ATSS telephone line the "phone number" should be replaced with "8,583-7485". If you are using a State telephone line in the 415 area code use "3-7485". A successful connection is indicated on the screen as 'CONNECT 2400' or 'CONNECT 1200' or 'CONNECT 300'.

Step 4: Once your video terminal or microcomputer is successfully connected to SINBAD press the RETURN key once or twice and the SINBAD will request 'USERNAME:'. If you are a first time user of the system, type "GUEST". If you have previously accessed the system you will have been assigned a USERNAME at that time (see Step 7 explanation). Please use that USERNAME in response to the request.

Step 5: SINBAD will next prompt you with 'PASSWORD:'. If you are a first time user enter "GUEST" as your PASSWORD and then press the RETURN key. If you were given a USERNAME previously, you selected a unique PASSWORD at that time, please enter that PASSWORD in response to the 'PASSWORD' prompt and then press the RETURN key.

AT THIS POINT ALL BUT FIRST TIME USERS ADVANCE TO STEP 9.

Step 6: If you entered "GUEST" in response to the 'USERNAME:' prompt and "GUEST" in response to the 'PASSWORD:' prompt you will be asked for the following information:

FIRST NAME:
LAST NAME:
ORGANIZATION:
STREET ADDRESS:
CITY:
STATE:
ZIP:
PHONE NUMBER:

After each prompt enter the requested information and press the RETURN key. After entering all of the above information the SINBAD will repeat your entries and prompt you to make any necessary changes to them or to press RETURN to continue.

Step 7: Following your verification of the above information, enter what you want your USERNAME to be: it can be any character string from three to eight characters.

Step 8: You will next be prompted to enter a 6 to 12 character long PASSWORD of your choice. You may enter any combination of 6 to 12 letters and/or numbers for your PASSWORD and then press the RETURN key. Both your USERNAME and PASSWORD should be written down at this time so that you may use them in the future to access SINBAD.

Step 9: The system will take you directly to the main menu, from which you can select any of the on-line information services. Use the arrow keys to move the cursor to your selection and then press RETURN (you can also just select the highlighted letter in the title of your choice). Your selection will be loaded and further instructions will be available. Please read the information provided on each screen carefully. Following your queries of the database, select EXIT and LEAVE THE SYSTEM and SINBAD will automatically log you off and hangup the telephone line to which your modem is connected.

Step 10: Please turn off both the modem and video terminal before leaving.

Step 11: Please report problems or suggestions to one of the individuals listed below:

A. For assistance SINBAD and/or telecommunications problems;

Todd Featherston
Aquatic Habitat Institute
180 Richmond Field Station
1301 South 46th Street
Richmond, CA 94804

(415) 231-9539

B. For questions relative to the State Bay-Delta Hearing Testimony and Exhibits Database and/or hearing schedules, procedures, etc.;

Tom Tamblyn
State Water Resources Control Board
Division of Water Rights, Bay-Delta Program
901 P Street
P.O. Box 2000
Sacramento, CA 95810
(916) 445-8841 or ATSS 8-485-8841

C. For questions relative to the contents of the Estuarine Data Index or the Bay-Delta Bibliography:

Ted Daum
Aquatic Habitat Institute
180 Richmond Field Station
1301 S. 46th Street
Richmond, CA 94804

(415) 231-9539

TABLE 1

Official Bay-Delta Hearing Exhibit Lodging Locations with access to the State Hearing Testimony and Exhibits Database

Address	Contact Person/Phone No.
State Water Resources Control Board Bay-Delta Hearing Record, Room 311 B 901 P Street Sacramento, CA 95814	Tom Tamblyn (916) 445-8841 or ATSS 8-485-8841
U.S. Environmental Protection Agency 75 Hawthorne Street San Francisco, CA 94105	Linda Sunnen (415) 556-6597
Regional Water Quality Control Board Oakland - San Francisco Bay Region (2) 2101 Webster Street, Suite 500 Oakland, CA 94612	Michael Carlin (415) 561-1325
Regional Water Quality Control Board Los Angeles Region (4) 107 South Broadway, Room 4027 Los Angeles, CA 90012-4596	Dennis Dasker (213) 549-5522
Regional Water Quality Control Board Fresno - Central Valley Region (5) 3614 East Ashland Fresno, CA 93726	Betty Yee (209) 445-5116
Regional Water Quality Control Board Redding - Central Valley Region (5) 415 Knollcrest Drive Redding, CA 96002	Jim Pedri (916) 224-4845
Regional Water Quality Control Board Riverside - Santa Ana Region (8) 6809 Indiana Avenue, Suite 200 Riverside, CA 92200	Pat Wong (714) 632-4130
Regional Water Quality Control Board San Diego Region (9) 9771 Clairemont Mesa Boulevard San Diego, CA 92124	Mike McCann (619) 636-5114

Public Access is also available at the Aquatic Habitat Institute in Richmond, CA.

TABLE 2

Microcomputer Parameter Settings
for
Telecommunication Software Systems

Parameter	Setting
Speed	300/1200/2400 baud
Data	8 bits
Port	COMM1
Parity	None
Stop bits	1
Duplex	Full
Terminal Emulation	VT-100*

* If your telecommunications program does not support VT-100 emulation, obtain another that does support this emulation before using the system. Todd Featherston at the Aquatic Habitat Institute can supply you with a copy of PC-VT 100 at no charge. Please mail a diskette to:

Todd Featherston
Aquatic Habitat Institute
180 Richmond Field Station
1301 South 46th Street
Richmond, CA 94804

EDI PROGRAMS AND PRINCIPAL INVESTIGATORS LISTED BY CONDUCTING AGENCY

AQUATIC HABITAT INSTITUTE

NPDES Discharge Monitoring Database	Jay Davis
Segmentation Scheme for SF Bay	Andy Gunther

ASSOCIATION OF BAY AREA GOVERNMENTS

ABAG Urban Runoff Studies	Taras Bursztynsky

THE BAY INSTITUTE

San Francisco Bay Shoreline Information System (BAYSIS)	Bill Davoren

CALIFORNIA DEPARTMENT OF FISH AND GAME

Calif. State Mussel Watch Program	Mike Martin
Delta Outflow Study	Perry Herrgesell
Natural Diversity Database	John Ellison
Neomysis-Zooplankton Study	Jim Orsi
Selenium Verification Study	James White
Striped Bass Egg & Larva	Lee Miller
Striped Bass Health Index Monitoring	Don Stevens
Striped Bass Midwater Trawl	Lee Miller
Striped Bass Summer Tow Net	Lee Miller
Trace Element Concentrations in Seawater and Suspended Particulate Matter	R. Michael Gordon

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE

Pesticide Use Reporting System	Ria Spencer

CALIFORNIA DEPARTMENT OF WATER RESOURCES

DAYFLOW	Kamyar Guivetchi
Municipal Water Quality Interagency Delta Health Aspects Monitoring Program	Rick Woodward
Sacramento-San Joaquin Delta Water Quality Surveillance: Benthic Studies	Harlan Proctor
Sacramento-San Joaquin Delta Water Quality Surveillance: Continuous Monitoring	Harlan Proctor
Sacramento-San Joaquin Delta Water Quality Surveillance: Phytoplankton	Harlan Proctor
Sacramento-San Joaquin Delta Water Quality Surveillance: Water Chemistry	Harlan Proctor
Selenium Biogeochemical Studies	Sheila Greene
Spatial Distribution of *Potamocorbula amurensis* in the Northern Bays and Western Delta	Zach Hymanson

CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

Biotoxicity in the San Joaquin and Sacramento River Watersheds	Chris Foe
Sacramento Urban Runoff Monitoring Study	Barry Montoya

CHESAPEAKE BAY INSTITUTE

Trace Metal Geochemistry of San Francisco Estuary	Andrew Eaton

CHEVRON, USA

Chevron Deep Water Outfall Studies	Larry Goodheart
Chevron Equivalent Protection Study	Pete Williams
Chevron Toxicity Reduction Evaluation	Pete Williams

EAST BAY MUNICIPAL UTILITY DISTRICT

Local Effects Monitoring	Tom Selfridge

KINNETIC LABORATORIES/SOUTH BAY DISCHARGERS AUTHORITY

South Bay Dischargers Authority: Biological Studies	Marty Stevenson
South Bay Dischargers Authority: Water Quality	Marty Stevenson

LAWRENCE BERKELEY LABORATORIES

Spatial and Seasonal Variations of Trace Elements in South San Francisco Bay	Donald Girven

LAWRENCE LIVERMORE NATIONAL LABORATORY

Organic Contaminants in Sediments and Starry Flounder	Bob Spies

NATIONAL MARINE FISHERIES SERVICE (NMFS)

National Marine Recreational Fishery Statistics Survey	Marty Golden
South Bay Fish Survey	Don Pearson

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

National Coastal Pollutant Discharge Inventory	Dan Farrow

National Status and Trends Program	Ed Long
Sediment Quality Survey	Ed Long

SAN FRANCISCO BAY BIRD OBSERVATORY

South Bay Dischargers Authority Avian Botulism Study	Peg Woodin

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION

Project Tracking System	Alan Pendleton

SAN FRANCISCO STATE UNIVERSITY

Regional Effects Monitoring Program: Macroalgae	Mike Josselyn

SHELL OIL COMPANY

Shell Oil Company Effluent Toxicity Studies	Daniel Glaze

STATE WATER RESOURCES CONTROL BOARD

Bay-Delta Testimony	Tom Tamblyn
Toxic Substances Monitoring Program	Del Rasmussen

UNITED STATES ARMY CORPS OF ENGINEERS

Dredge Disposal Study	Tom Wakeman
Dredging and Permitting: Sacramento District	Art Champ
Dredging and Permitting: San Francisco District	Wade Eakle

UNITED STATES BUREAU OF RECLAMATION

Delta-Suisun Bay Ecological Studies	Jim Arthur
Water Quality Monitoring Network	Sandy Wagner

UNITED STATES COAST GUARD

U. S. Coast Guard Spills Data	Marine Response Officer

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

San Francisco Bay Effluent Toxicity Study	Donald Mount

UNITED STATES FISH AND WILDLIFE SERVICE

Diked Baylands Wildlife Study	Jini Tinling
Interagency Salmon Study Program	Patricia Brandes
Midwinter Waterfowl Survey	Jim Bartonek
National Wetlands Inventory	Larry Handley
Contaminants of Concern: San Francisco Bay and San Pablo Bay National Wildlife Refuges	Jean Takekawa
Toxicant Occurrance and Effects in Water Birds	Harry Ohlendorf
Wildlife Use of Salt Ponds	Jean Takekawa

UNITED STATES GEOLOGICAL SURVEY

Benthic Community Structure	Fred Nichols
Hydrodynamic Monitoring and Modeling	Jeff Gartner
Phytoplankton and Zooplankton Studies	Jim Cloern
Regional Effects Monitoring Program: Benthic Studies	Larry Schemel
Trace Metal Accumulation in Benthos and Sediments	Sam Luoma
Water Resources Data	John Bader
Western San Joaquin Valley Hydrogeologic Studies	Robert Gilliom

UNIVERSITY OF CALIFORNIA AT BERKELEY

Bioassays for Local Effects Monitoring of Wastewater Discharges	Alex Horne

UNIVERSITY OF CALIFORNIA AT SAN DIEGO

Butyltin Studies	Ed Goldberg

WOODWARD-CLYDE CONSULTANTS/SANTA CLARA VALLEY WATER DISTRICT

Santa Clara Nonpoint Source Study	Peter Mangarella