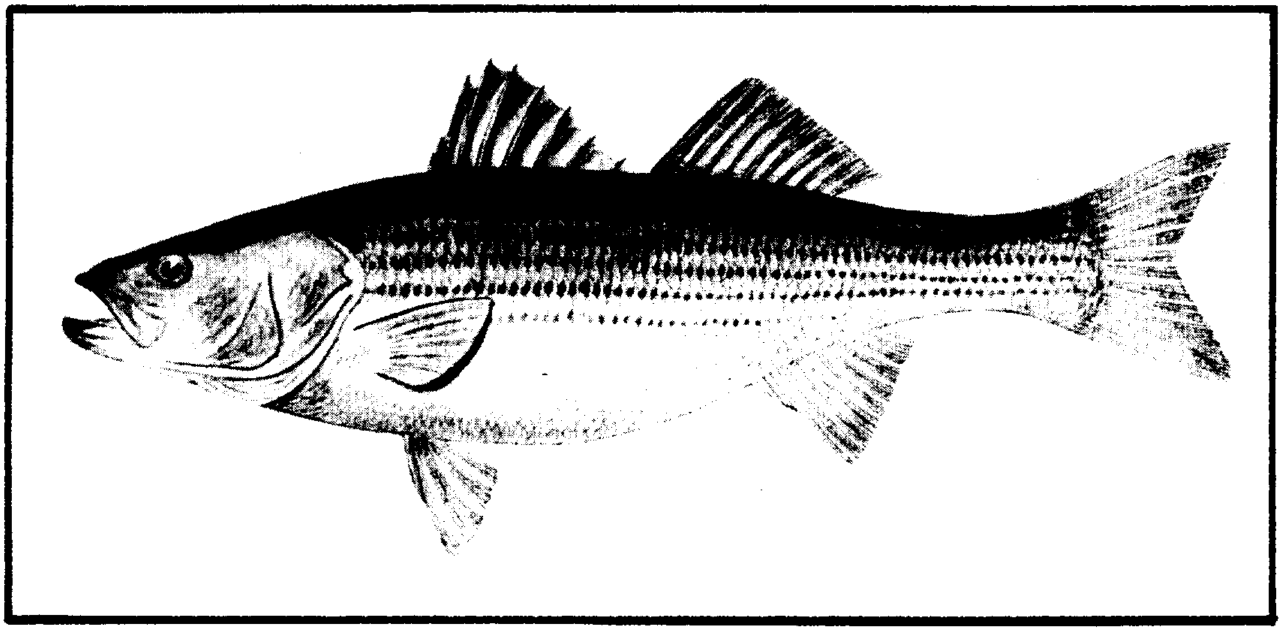
First Progress Report

COOPERATIVE STRIPED BASS STUDY



March 1980

California
State Water Resources Control Board

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SPECIAL PROJECTS

Toxic Substances Control Program

First Progress Report on the COOPERATIVE STRIPED BASS STUDY (COSBS)

Special Projects Report 8010–1

March 1980
(Printed October 1980)

PREFACE

The California State Water Resources Control Board, National Marine Fisheries Service, and the California Department of Fish and Game are jointly investigating the effects of pollution on the San Francisco Bay-Delta striped bass fishery. This interagency study is named the Cooperative Striped Bass Study (COSBS). This First Progress Report describes the findings from initial tasks performed under the COSBS study plan. These initial tasks were conducted by the State Water Resources Control Board. The purpose of this report is to inform the public about the activities and progress made since the establishment of this cooperative interagency study.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. SUMMARY

On August 16, 1979, the State Board approved funds to establish a cooperative study with the National Marine Fisheries Service and the California Department of Fish and Game. The study would investigate the effects of water pollution on the San Francisco Bay-Delta striped bass fishery (Resolution No. 79-70). The study was named the Cooperative Striped Bass Study (COSBS). The study is divided into four parts. Part I consists of literature searches on toxic materials discharged into Bay-Delta waters. Part II includes comparative surveys of striped bass populations. Part III involves cause-and-effect laboratory studies. Part IV will integrate all findings from the previous parts of the study to develop recommendations for Board action. As part of the study plan, three progress reports and a final report are scheduled.

This is the First Progress Report for the Cooperative Striped Bass Study. It summarizes information on known toxic wastes discharged into Bay-Delta waters, pesticide use in the Bay-Delta counties, results of preliminary screening for toxic compounds in striped bass and descriptions of literature searches.

The initial Part I tasks of the study address six key questions related to toxic substances in receiving waters.

1. Where are major Bay-Delta wastewater dischargers located?

2. What toxicants are being discharged?

3. What pesticides and in what amounts are being used in counties tributary to the Bay and Delta?

4. What information is available on the properties of these toxic substances?

5. What information is available on fish parasitism and fish diseases associated with poor water quality?

6. What toxic organic compounds are found in striped bass?

The majority of this information was compiled by comprehensive literature and computer information searches. The results are:

1. About fifty-five (55) major municipal outfalls and thirty-one (31) major industrial outfalls (e.g., petroleum refineries, chemical manufacturing plants) are located along the shoreline of San Francisco Bay to Chipps Island, located at the confluence of the Sacramento and San Joaquin Rivers. These wastewater discharges are the primary pollutant source in the Bay-western Delta. On the basis of limited 1979 effluent monitoring data,

the estimated daily sewage input is 500 million gallons of treated sewage containing over 53,700 lbs. of oil and grease and about 1,700 lbs. of various heavy metals. However, when comparing effluent data during 1975-1977 against 1979, we see significant reductions in oil and grease and heavy metals discharged into San Francisco Bay are being achieved as treatment facilities improve. Oil and grease loads into the Bay have reduced by 20,000 lbs. and heavy metal loadings by 1,000 lbs. since 1977.

2. Pesticide use data were developed for the top 100 pesticides used in ten counties providing most of the streamflow to the Bay and Delta. The pesticides were ranked according to amount applied for all ten counties. Four of the ten most heavily used pesticides are complex mixtures of petroleum hydrocarbons. The top ten pesticides are (1) sulfur, (2) D-D mixture, (3) petroleum hydrocarbons, (4) petroleum oil, unclassified, (5) sodium chlorate, (6) petroleum distillates, (7) xylene, (8) methyl bromide, (9) aromatic petroleum solvents, and (10) ethylene dibromide.

3. An EPA computer program named ISHOW (Information System for Hazardous Organics in a Water Environment) was used to obtain data on the chemical and physical properties of the top 100 pesticides. ISHOW contained information on 44 of the pesticides. On the basis of this data, these pesticides were ranked according to their potential to accumulate in organisms (partition coefficient). Based on this information, the top ten pesticides expected to accumulate to the greatest extent in fish are: (1) Toxaphene, (2) Kelthane, (3) PCNB, (4) Chlordane, (5) Methoxyclor, (6) Darthal, (7) Simazine, (8) Chlorothalonil, (9) DNBP, and (10) Carbophenthion. (Actual extent of accumulation would be dependent on the pesticides resistance to metabolism.)

4. During the spring spawning migration into the Delta, striped bass encounter areas of heavy pesticide use. Upon summer return to the Bay, they migrate into water containing treated domestic and industrial wastes.

5. Studies on parasites and diseases found in striped bass and other fish are well documented. Two bibliographies on these subjects were compiled.

6. Preliminary chemical analyses on some subadult and juvenile striped bass were performed at the EPA Environmental Research Laboratory, Duluth, Minnesota, in July of 1979. The samples of small fish showed amounts of PCB and total DDT to be under the U.S. Food and Drug Administration (FDA) standards (5 mg/kg PCB and 5 mg/kg total DDT fresh weight edible portion) for fish for human consumption. Because larger fish would accumulate toxics

over a longer period of time, analyses show the need for sampling larger fish. Screening for other toxic compounds should be included in further analyses.

There are no answers as to why the striped bass population is declining. The information obtained will help answer this question. Part II of the study will collect and compare striped bass from different Bay-Delta locations with those residing in less polluted areas (Coos River, Oregon, and Lake Mead, Nevada). These comparative studies will begin in May. An intensive effort to determine the cause of open lesions found in Bay-Delta striped bass will also be made in the summer.[1/] The Second Progress Report describing these aforementioned activities is planned for Fall 1980.

1/ At the time of printing this report, COSBS scientists discovered the possible cause of the open lesions. A report of this significant finding will be presented in the Second Progress Report.

II. INTRODUCTION

BACKGROUND AND STATEMENT OF THE PROBLEM

Striped bass is one of the most important sportfish in the State. Over the past several decades, California Department of Fish and Game (DF&G) population estimates and catch records of striped bass have shown considerable fluctuations with a downward trend. The adult striped bass population has declined from a peak estimate of 3 to 4.5 million in 1960 to a current population of 1.2 to 1.5 million. Annual total catches have declined from about 750,000 (1964) to 250,000 in recent years. This continued decline may result in an economic and recreational loss to California.

The Department of Fish and Game has been conducting studies since 1958 on the State's striped bass. They have studied the relationship between Delta outflows and survival of juvenile fish and spent two years attempting to identify the cause of recurring summer fish kills in the Delta. These mysterious die-offs have occurred annually for the past 30 years. Unfortunately, answers to this mystery were not found. The DF&G field data, however, did indicate that mortality during the first 60 days after hatching determines the size of the adult striped bass population. Aside from the direct export of eggs and larvae out of the estuary by water diversions, the primary cause(s) of mortality remain undetermined. In 1975, DF&G suggested to the National Marine Fisheries Service (NMFS) that they do intensive laboratory studies on factors affecting striped bass egg and larvae survival. NMFS and DF&G have been working together since 1976 on identifying the mortality factors.

Until 1977, the survival of young striped bass correlated highly with outflow and diversion factors. Since 1977, the data has shown that survival consistently has been poorer than expected from calculated relationships. These more recent observations suggest that some other factors are affecting survival of young striped bass. The National Marine Fisheries Service hypothesizes that pollution of the Bay-Delta waters may be a major contributing factor to this decline.

RECENT STUDY RESULTS

In 1978, large samples of adult striped bass were taken at the confluence of the Sacramento and San Joaquin Rivers during the upward spawning migration after passage through the heavily industrialized Carquinez Strait region. Fish from the vicinity of the NMFS facility at Tiburon were also taken for comparison. The purpose of the sampling was: (1) to determine the condition of parental fish just prior to spawning and to see if their condition might relate to the condition of gametes, and (2) to identify factors which might relate to the mysterious summer fish kills in the Delta. NMFS autopsied over 300 adult stripers. Their findings showed the Bay-Delta striped bass to be in poor health. Fifty-four percent (54%) of the fish were heavily parasitized, thirty-seven percent (37%) deformed, and thirty-five percent (35%) had healed wounds. Aromatic hydrocarbons were found in ovarian tissues. Abnormalities in skeletal structure were common and blood composition data indicated a weakened immunity system to combat infection and disease.

Preliminary findings in 1978 and present NMFS work led to the hypothesis that pollution may be contributing to the decline of the striped bass fishery.

The 1979 autopsy data showed an increasing number of unhealthy striped bass. NMFS researchers found the 1979 sampled population to be in poorer condition than those in the 1978 study. In addition over the years, DF&G has been capturing live juvenile and subadult stripers with open wounds exposing the internal organs.

While pollution remains a suspected cause of the observed abnormalities in striped bass and perhaps also of the decline in the fishery, it is by no means proven. The presence of pollutants in the environment is not in itself proof of effect.

PROGRAM OBJECTIVES

In response to the findings of NMFS and DF&G, the California State Water Resources Control Board (SWRCB) directed staff to examine what action would be necessary to address two key issues:

1. To what extent is water pollution responsible for the poor health of the striped bass?

2. What Board actions could be taken in response to this problem?

Upon discussions with NMFS, DF&G, and the SWRCB, a cooperative study approach was recommended. In effect, a multidisciplinary research team would be formed by pooling the resources, funding, and manpower from the three agencies. On August 16, 1979, the SWRCB approved funding for the recommended study plan (Resolution No. 79-70). The SWRCB and NMFS will manage the project with assistance from the DF&G. The project has been named the Cooperative Striped Bass Study (COSBS).

COSBS has eight specific objectives. Tasks associated with accomplishing these objectives will either be conducted by State Board investigators, NMFS Tiburon Laboratory researchers, or jointly by both agencies. The objectives are:

1. To identify major pollutants (wastewater constituents and pesticides) discharged into Bay-Delta waters and to identify their major sources. This information is needed to provide a list of toxic substances to be considered in the scope of chemical analyses of fish tissues and receiving waters.

2. To identify potentially accumulable toxics. This objective also is needed for considering the scope of chemical analyses needed.

3. To identify toxic effects, biological (parasitism) effects, and the effects of natural changes on fish health, growth, and development. This information is vital in the interpretation of data from the program tasks to answer the key issue: To what extent is water pollution responsible for the decline and poor health of the striped bass fishery?

4. To identify toxic substances in Bay-Delta waters. Although the first objective identifies known dischargers and discharged pollutants, the actual concentrations of toxic chemicals in the water are unknown. The sampling and analysis of Bay-Delta waters is needed to assure that: (a) toxic substances expected to accumulate in fish, and (b) compounds not expected to accumulate but which have potential for inducing a toxic effect, are identified.

5. To identify which pollutants are being accumulated by the striped bass in the Bay-Delta and other regions. This information is needed to develop a list of suspected compounds that may be adversely affecting the health of the fish and to determine if such levels may be harmful to fish consumers. (Compounds in the Bay and Delta waters that could be having a toxic influence on the fish may not be accumulated by them. Those that are accumulated may not be toxic in the concentrations measured.)

6. To compare the condition of striped bass from the Bay-Delta with those populating less polluted areas. This comparison is to determine the magnitude and extent of the unhealthy bass population and, most importantly, to see if the unhealthy condition can be correlated with pollution.

7. To examine the effects of pollutants on the life history stages of the striped bass. This is to determine cause-and-effect relationships for tissue damage by pollutants and to identify the most sensitive life period of the fish.

8. The last and overall objective of the program is to develop recommendations to the SWRCB on what action should be taken. Board actions to be considered include revising Bay-Delta water

quality objectives, NPDES permits and monitoring requirements, Delta outflow policies, and implementation of special monitoring and surveillance studies, and the development of nonpoint source control measures.

The results of COSBS will be useful to several agencies besides the State and Regional Water Quality Control Boards, NMFS, and DF&G. Other agencies include the California Department of Health Services (DOHS) and the U. S. Environmental Protection Agency (EPA). In view of this, joint participation has been encouraged in the design of this program.

STUDY PLAN

I. Toxic Substances in Effluents and Receiving Waters

Task I. 1: Identification of Sources of Pollutants

The State Board will be responsible for this task.

Information on major Bay-Delta dischargers and pesticide use will be compiled to identify major pollutants released into the Bay-Delta waters and to identify their sources.

This work will involve evaluating pesticide use data provided by the California Department of Food and Agriculture. The data is filed on computer tape at U. C. Davis. Pesticide data will be evaluated for the past 5 years of use.

Assistance will be sought from the San Francisco Bay and Central Valley Regional Boards to obtain information on municipal and industrial discharges.

The purpose is to provide a list of toxic substances to be considered in the scope of chemical analyses of fish tissues and receiving waters.

Task I. 2: Literature Information Searches

The State Board will be responsible for this task:

a. Information System for Hazardous Organics in a Water Environment (ISHOW). EPA has funded the development of a computer-based system which provides information on a large number of pesticides and industrial chemicals. The information includes an estimate of the extent to which each compound will accumulate in tissue. The ISHOW computer system will be used to provide information on major pesticides and chemicals identified in program Task 1 above.

This information will be used to guide the analysis of fish described below in Part B of the study plan (Field and Laboratory Investigations of Fish).

b. Chemical Effects. Summaries will be made of literature that relates concentrations of the selected toxic chemicals in aquatic organisms to observed nonlethal effects.

c. Parasite Effects. Summaries will be made of literature that relates parasite infestation in aquatic organisms to observed effects.

d. Environmental Effects. Summaries will be made of literature that relates abnormalities in fish to causes other than toxic chemicals and parasites.

The above information will be used for the evaluation of autopsy data, the design of the analytical chemistry work, the design of the cause-and-effect laboratory studies, and in the interpretation of results.

Task I. 3: Screening Bay-Delta Waters for Toxic Substances

The State Board will be responsible for this task.

Bay-Delta waters will be sampled and analyzed for toxic substances. The substances will include pesticides and compounds discharged in effluents. These will include (1) compounds expected to accumulate in fish, and (2) compounds not expected to accumulate but which have potential for inducing a toxic effect. The sampling program will be designed to assure that toxic substances in this latter category are not missed. The design will be based on information provided by Tasks 1 and 2 above.

II. Field and Laboratory Investigations of Fish

Task II. 1: Identification of Bioaccumulable Pollutants in Fish

This major task will be conducted jointly by the State Board, NMFS, and California Department of Fish and Game.

Fish collected from the Bay-Delta (primarily striped bass) will be autopsied and analyzed for as many of the EPA priority pollutants as possible. (Methods do not exist for many of the priority pollutants in tissue). Screening for a broad range of pollutants will be made initially to establish the scope of chemical analyses to be performed on fish tissues on a routine basis. This task is needed to develop a list of suspected causative agents that may be adversely affecting the health of the striped bass population. Tissue analyses for heavy metals will be provided by the California Department of Fish and Game at the Fish and Wildlife Pollution Control Laboratory.

Task II. 2: Comparative Fish Population Surveys

Fish (primarily striped bass) will be collected from less polluted areas for comparison of health and pollutants in tissues to the Bay-Delta population. Candidate sampling sites include the Umpqua River in Oregon and Lake Mead, Nevada. Sampling will focus on spawning adult fish.

Sampling efforts will also expand into the Bay-Delta region to supplement the NMFS program. The California Department of Fish and Game will provide some assistance in the fish collection.

III. Cause-and-Effects Laboratory Studies

The NMFS Tiburon Laboratory research team will take lead responsibility in this major task. The State Board will provide services in histopathological analyses and tissue chemistry as needed.

The effects of specific pollutants will be measured via chronic bioassay testing of striped bass at various life stages. Initiation of this task may begin as soon as a list of suspected causative agents is developed. This list would be based on preliminary analyses of fish tissues for the EPA priority pollutants. However, the majority of this task will be conducted after autopsy information has generated a list of observed abnormal fish conditions. The list of observed conditions will establish the scope of histopathological analyses.

IV. Data Evaluation and Recommendations for Board Action

Task IV. 1: Integration of Results

Results from the tasks of study elements I and II will be assembled for evaluation and interpretation. Statistical analyses of data will primarily be accomplished through the NMFS computer facility at Tiburon. Information compiled by the NMFS studies will also be assembled and integrated into the interpretation of results. A comprehensive report will be made.

Task IV. 2: Progress Review Meetings and Consultations

Periodic consultations with NMFS, the Department of Fish and Game, the Department of Health Services, the San Francisco Bay and Central Valley Region Water Quality Control Boards, the Environmental Protection Agency, and other interested agencies or organizations will be made to review progress of the project, interim results, and to identify needed changes in the project.

Task IV. 3: Recommendations for Board Actions

Staff will develop recommendations for Board action in conjunction with discussions with the San Francisco Bay and Central Valley Regional Boards, NMFS, EPA, Department of Health Services, and Department of Fish and Game. Board actions to be considered include but are not limited to the following:

a. Review of Bay-Delta water quality objectives.

b. Revision of NPDES discharges and monitoring requirements.

c. Review of Delta outflow policy.

d. Design of special effluent and receiving water monitoring programs.

e. Development of nonpoint source control measures for pesticides, urban runoff, etc.

Recommendations will be considered and made if possible at the end of the first half of the study depending on the amount of information analyzed and reviewed by the previously named agencies.

Final recommendations will be made at the conclusion of the striped bass program.

Task IV. 4: Reports to the Board

Four Progress Reports are scheduled for presentation to the Board prior to completion of the program. The results of each completed task and general status of ongoing tasks and program highlights will be presented in the Progress Reports.

ACTIVITY, EVENT, AND MILESTONE SCHEDULE

TASK DESCRIPTION	1979 O	N	D	1980 J	F	M	A	M	J	J	A	S	O	N	D	1981 J	F	M	A	M	J
I. TOXIC SUBSTANCES IN EFFLUENTS AND RECEIVING WATERS																					
1. Identification of Sources of Pollutants	X	X	X	X	E																
2. Literature-Information Searches																					
a. ISHOW		X	X	X	E																
b. Chemical Effects		X	X	X	X	X	X	X	X	X	X	X	X	X	E						
c. Parasite Effects				X	E																
d. Environmental Effects										X	X	X	E								
3. Screening Bay-Delta Waters for Toxic Substances																					
a. Analyses				X	X	X	X	X	E												
b. Data analyses								X	X	E											
c. Task Report											M										
II. FIELD AND LABORATORY INVESTIGATIONS OF FISH																					
1. Identification of Bioaccumulable Pollutants in Fish																					
a. Screening	X			X	X	E															
b. Analyses for key toxicants							X	X	X	X	X	X	X	X	E						
c. Data analysis, report prep											X	X	X	X	X	X	X	E			
d. Task report																				M	

"X" indicates period of task
"M" indicates events
"E" indicates end of task

ACTIVITY, EVENT, AND MILESTONE SCHEDULE

	1979			1980												1981					
TASK DESCRIPTION	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
2. Comparative Fish Population Surveys of:																					
a. Less polluted areas					X	X	X	X	E												
b. Bay-Delta				X	X	X	X	X	X	X	X	X	X	X	X	X	X	E			
c. Data analysis, report prep										X	X	X	X	X	X	X	X	X	E		
d. Task report																					M
III. Cause-and-Effects Laboratory Studies																					
a. Laboratory pollutant effects study										X	X	X	X	X	X	X	X	X	E		
b. Data analysis, report prep													X	X	X	X	X	X	X	E	
c. Task report																					M
IV. PROGRAM DATA EVALUATION AND RECOMMENDATIONS FOR BOARD ACTION																					
1. Integration of Results from Program Elements																					
a. Data assembly				X	X			X	X		X	X			X	E					
b. Data analysis, report prep										X	X	X	X	X	X	X	X	X	X	E	
c. Task report																					M
2. Progress Review Meetings and Consultations					X	X		X				X				X					
3. Recommendations for Board Action										X	X								X	X	
a. Final Report																					M
4. Progress Report to Board						E			E			E				E					

"X" indicates period of task
"M" indicates events
"E" indicates end of task

III. FIRST PROGRESS REPORT

The following tasks of the previously described Study Plan were accomplished by April 1980:

Task I.1. Identification of Sources of Pollutants.

Task I.2.a. Literature Information Search Using ISHOW (Information System for Hazardous Organics in a Water Environment) Computer Program.

Task I.2.c. Literature Information Search on Parasitism of California Coast Anadromous Fishes (including the striped bass).

Portions of Task I.2.b. (Literature Information Search on the Effects of Toxic Chemicals on Fish) and Task II.1.a. (Screening for Toxic Compounds in Striped Bass) are 25 percent completed. Reports on these tasks are presented herein.

Task I.1. Report: Identification of Sources of Pollutants

Task Description

This task is one of several aimed at developing a list of toxic substances for consideration in the scope of chemical analyses for the Cooperative Striped Bass Study (COSBS).

Information on dischargers and pesticide use in the Bay-Delta study area was compiled to identify major sources and types of pollutants entering Bay-Delta waters. The data on municipal and industrial dischargers was obtained with assistance from the San Francisco Bay and Central Valley Regional Water Quality Control Boards. The information on pesticide use was provided through State Department of Food and Agriculture statistics filed at the University of California Davis campus, Department of Environmental Toxicology library.

Geographical Areas Examined

The key areas of interest are the Bay-Delta waters where striped bass reside and spawn during their life cycle (Figure 1). These waters are under the jurisdiction of the San Francisco Bay and Central Valley Regional Water Quality Control Boards.

Demographic information on population and types of industries along the Bay-Delta system indicated point sources of pollution predominate west of Antioch and nonpoint sources dominate eastward into the Delta.

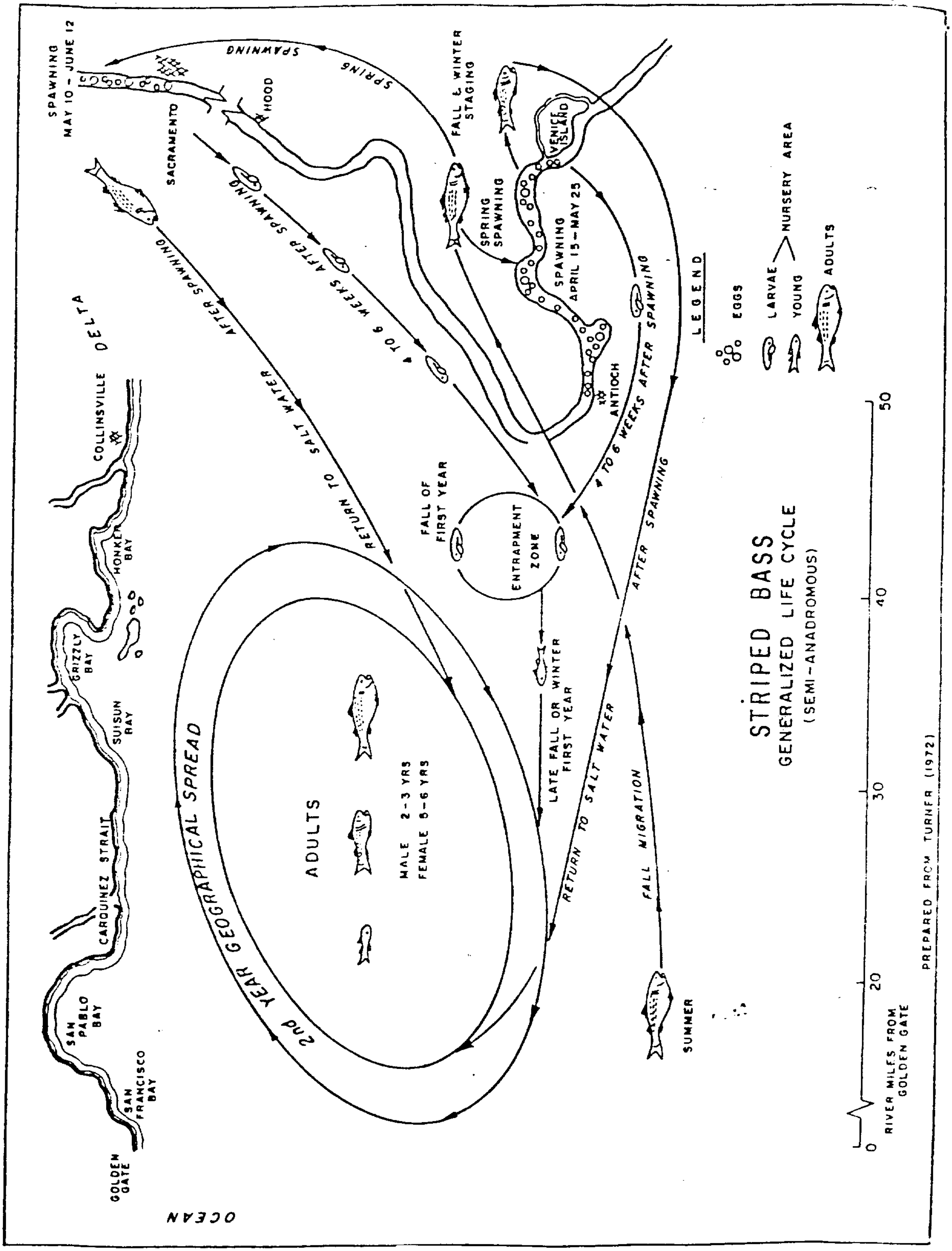
Effluent data on major point source discharges (outfalls) along the San Francisco Bay-western Delta were tabulated. Pesticide use information was compiled for ten counties which contribute the major streamflow to the Bay-Delta system. The ten counties included Colusa, Sutter, Yuba, Yolo, Sacramento, San Joaquin, Stanislaus, Madera, Merced, and Fresno (Figure 2). Pesticide use data on an additional fourteen (14) counties are presently being compiled. Tabulated results from all twenty-four (24) counties will be made available in the Second Progress Report. Tabulated results herein only consider ten counties.

Study Approach

The approach for developing the list of toxic substances for consideration in the scope of chemical analyses for COSBS addresses the following questions:

1. Where are the major wastewater dischargers located?

2. What known toxicants are being discharged by them?

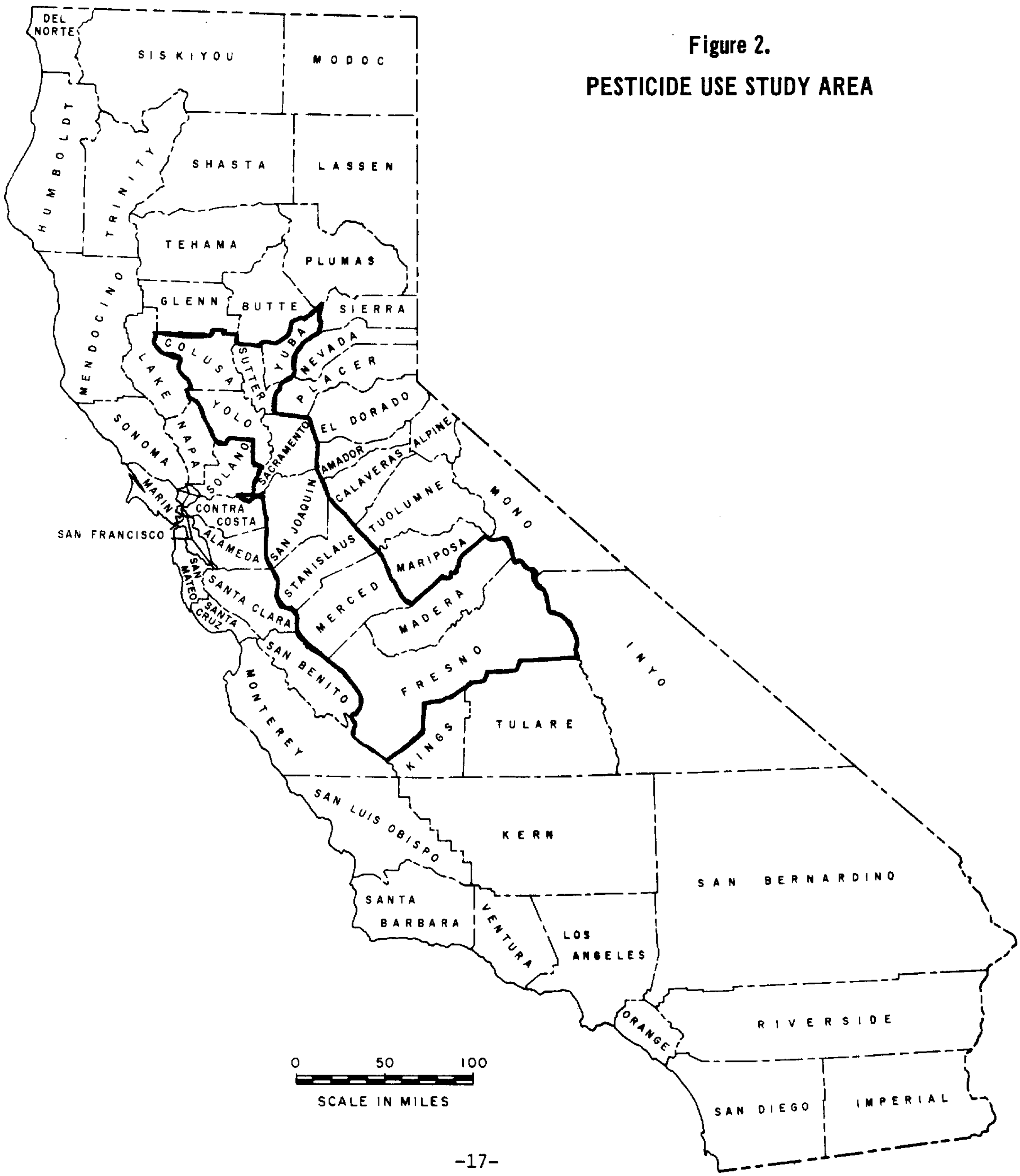


STRIPED BASS
GENERALIZED LIFE CYCLE
(SEMI-ANADROMOUS)
PREPARED FROM TURNER (1972)
RIVER MILES FROM GOLDEN GATE
0
20
30
40
50
LEGEND
EGGS
LARVAE
YOUNG
NURSERY AREA
ADULTS
ADULTS
MALE 2-3 YRS
FEMALE 5-6 YRS
2nd YEAR GEOGRAPHICAL SPREAD
OCEAN
GOLDEN GATE
SAN FRANCISCO BAY
SAN PABLO BAY
CARQUINEZ STRAIT
SUISUN BAY
GRIZZLY BAY
HONKER BAY
COLLINSVILLE
DELTA
SACRAMENTO
HOOD
SPAWNING MAY 10 - JUNE 12
SPRING SPAWNING
FALL & WINTER STAGING
VENICE ISLAND
SPRING SPAWNING
SPAWNING APRIL 15 - MAY 25
ANTIOCH
AFTER SPAWNING
TO 6 WEEKS AFTER SPAWNING
RETURN TO SALT WATER
TO 6 WEEKS AFTER SPAWNING
AFTER SPAWNING
FALL OF FIRST YEAR
ENTRAPMENT ZONE
LATE FALL OR WINTER FIRST YEAR
RETURN TO SALT WATER
FALL MIGRATION
SUMMER

FIGURE 1

Figure 2.

PESTICIDE USE STUDY AREA



3. What pesticides and in what amounts are being used in counties providing most of the streamflow to the Bay and Delta?

1. Where are the Major Wastewater Dischargers Located?

The majority of municipal and industrial dischargers are located along San Francisco Bay and the western Delta. Comprehensive maps showing the locations of these dischargers have been published in the State Water Resources Control Board Basin Plan reports and by others (Breslaw, 1972). These reports were written in the early 1970's. No updated versions have been published. However, discussions with the San Francisco Bay and Central Valley Regional Water Quality Control Boards have indicated that the number of dischargers in these areas have not significantly changed (T. Wu, personal communication).

The Bay-Delta area is divided in this report into six receiving water zones for discussion and comparison. These are identified in Figure 5. The zones are:

ZONE 1	South San Francisco Bay
ZONE 2	Lower San Francisco Bay
ZONE 3	Central San Francisco Bay
ZONE 4	San Pablo Bay
ZONE 5	Suisun Bay
ZONE 6	Central Delta Basin Rivers

Zones 1 to 5 are under the jurisdiction of the San Francisco Bay Regional Water Quality Control Board (Region 2) and zone 6 is under the Central Valley Regional Water Quality Control Board (Region 5, Basin 5B).

The locations of all dischargers in the entire San Francisco Bay Basin are shown in Figure 3. Major industrial dischargers in the Bay Basin are shown in Figure 4. Figure 5 shows the distribution of municipal treatment plants in receiving water zones 1 to 5. Locations of major discharger groups (zone 6) In Central Valley Basin 5B are shown in Figure 6.

A list of major Bay-Delta dischargers in zones 1 to 6 are presented in Tables 1 and 2. This list may be incomplete and will be corrected and revised as new information is received.

The numbers and types of outfalls discharging into each zone are as follows:

Zone 1 (South San Francisco Bay)	8 municipal,	1 industrial;
Zone 2 (Lower San Francisco Bay)	5 municipal,	3 industrial;
Zone 3 (Central San Francisco Bay)	11 municipal,	1 industrial;

Zone 4 (San Pablo Bay)	9 municipal, 2 industrial;
Zone 5 (Suisun Bay)	10 municipal, 12 industrial; and
Zone 6 (Western Delta)	12 municipal, 12 industrial.

The total number of major outfalls discharging into these zones is 55 municipal and 31 industrial outfalls. The majority of the Bay municipal treatment facilities operate under secondary treatment with chlorination and dechlorination.

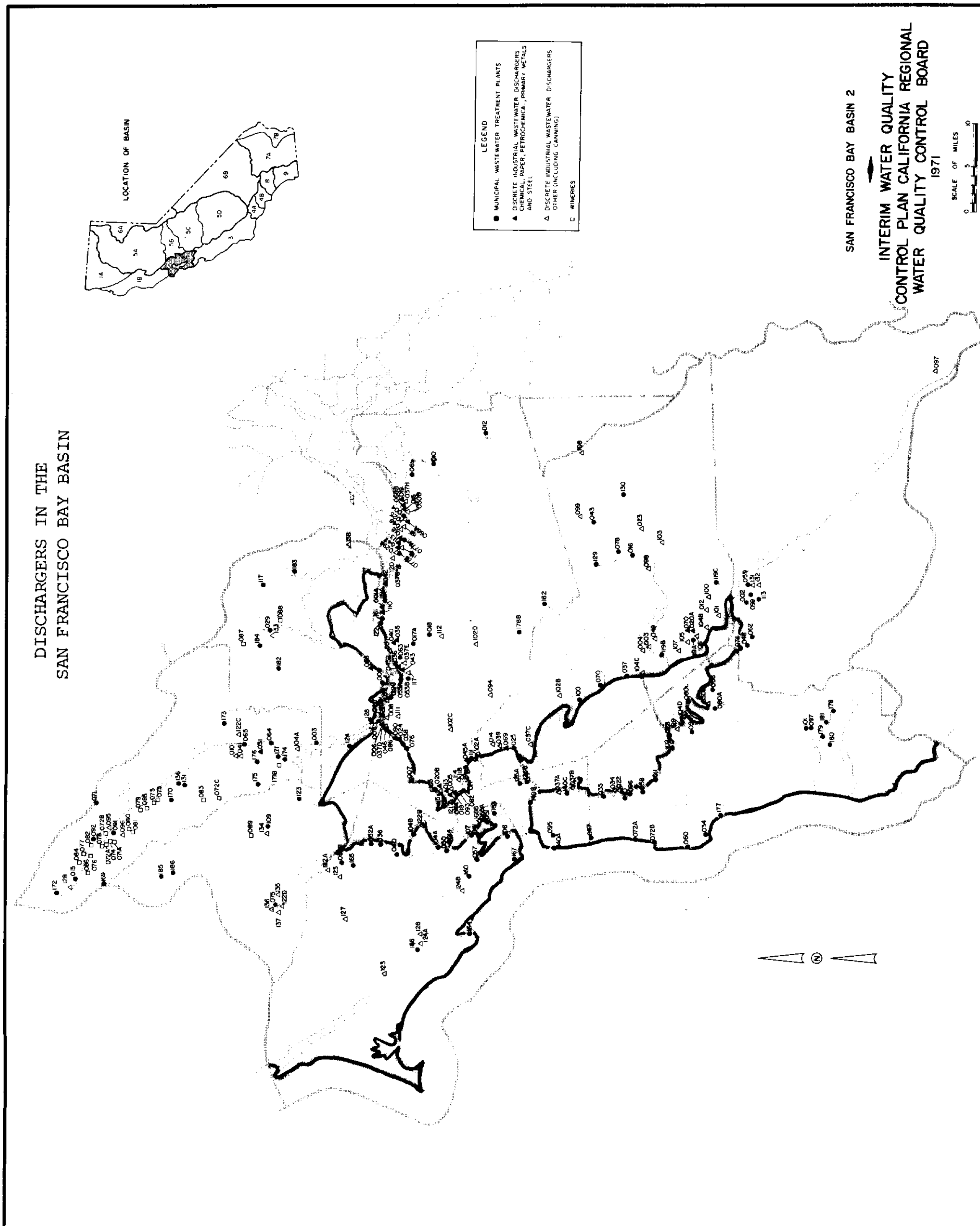

DISCHARGERS IN THE
SAN FRANCISCO BAY BASIN
LOCATION OF BASIN
LEGEND
MUNICIPAL WASTEWATER TREATMENT PLANTS
DISCRETE INDUSTRIAL WASTEWATER DISCHARGERS CHEMICAL, PAPER, PETROCHEMICAL, PRIMARY METALS AND STEEL
DISCRETE INDUSTRIAL WASTEWATER DISCHARGERS OTHER (INCLUDING CANNING)
WINERIES
SAN FRANCISCO BAY BASIN 2
INTERIM WATER QUALITY
CONTROL PLAN CALIFORNIA REGIONAL
WATER QUALITY CONTROL BOARD
1971
SCALE OF MILES

FIGURE 3

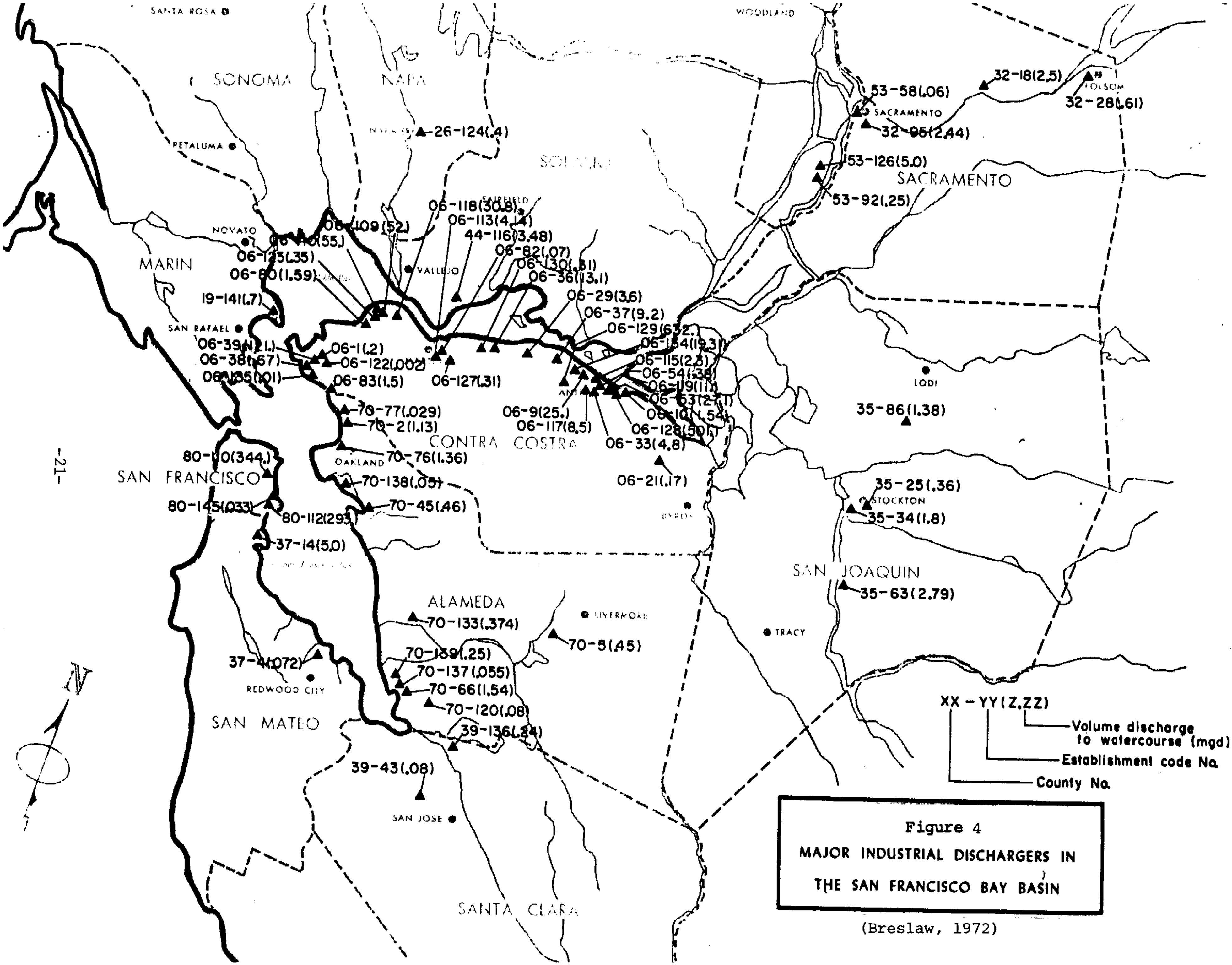


Figure 4

MAJOR INDUSTRIAL DISCHARGERS IN THE SAN FRANCISCO BAY BASIN

(Breslaw, 1972)

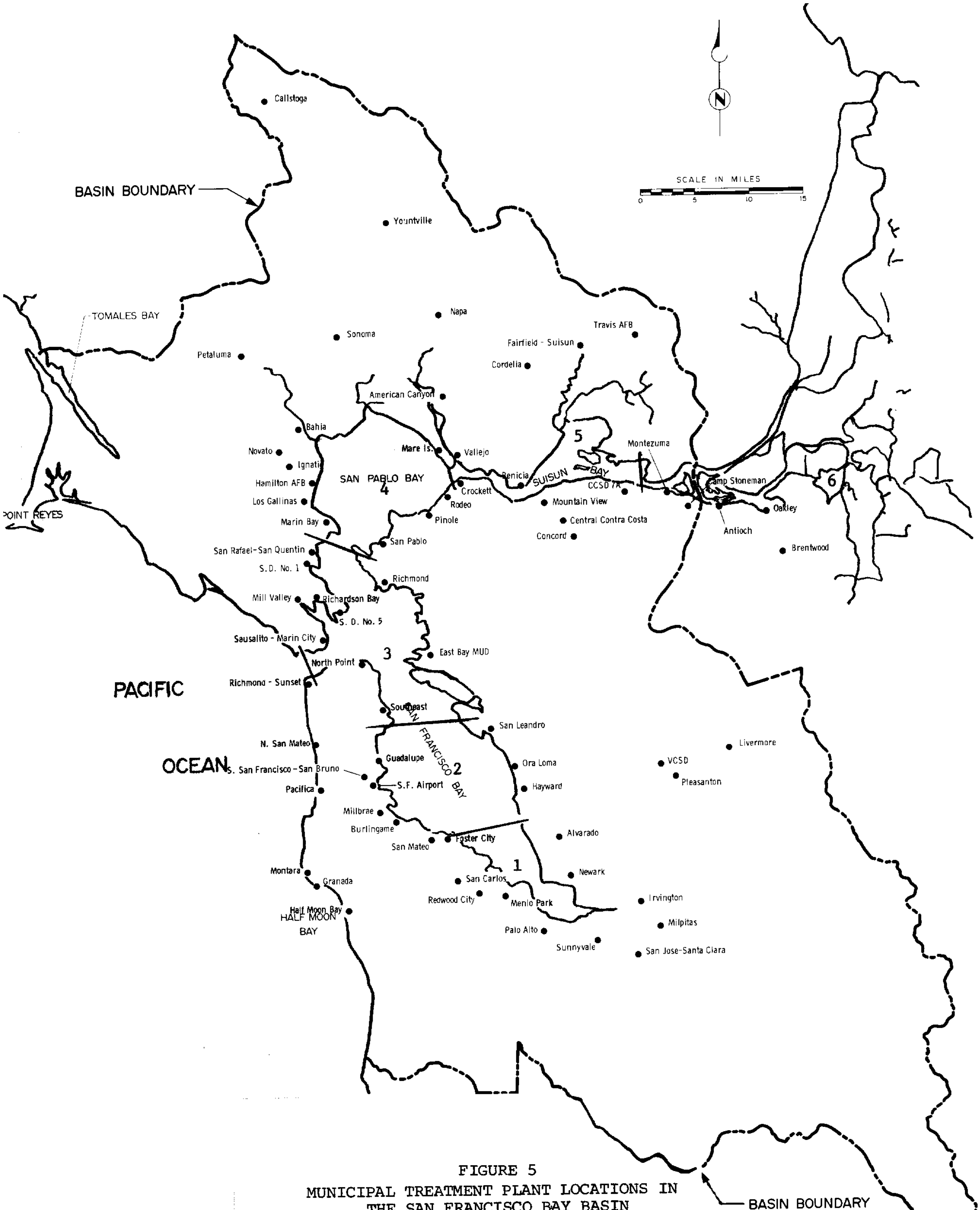


FIGURE 5

MUNICIPAL TREATMENT PLANT LOCATIONS IN THE SAN FRANCISCO BAY BASIN

SWRCB (Region 2) Water Quality Control Plan, 1975

FIGURE 6

GENERAL LOCATION OF
MAJOR DISCHARGERS IN
THE CENTRAL VALLEY BASIN

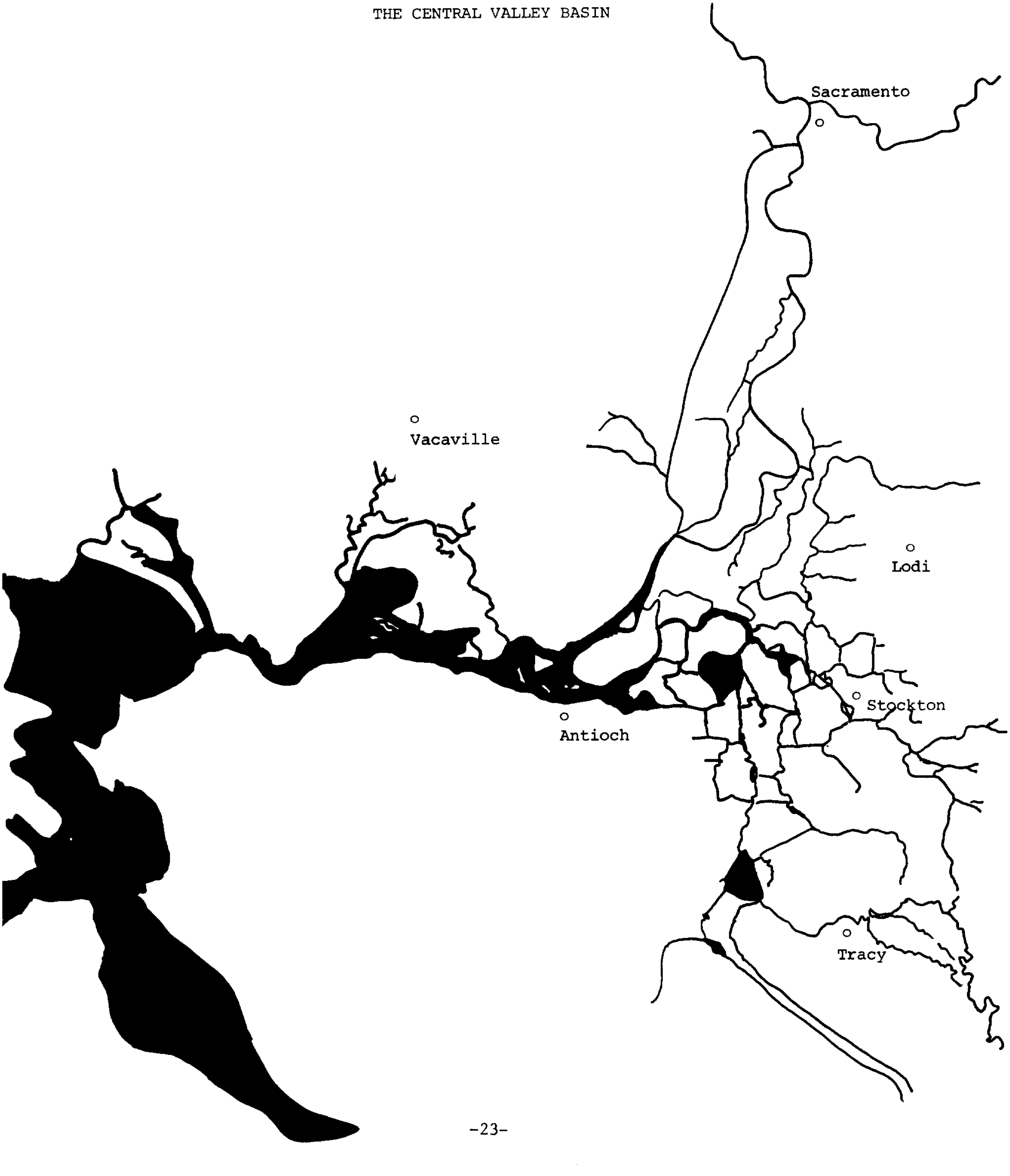


TABLE 1

DISCHARGERS IN RECEIVING WATER ZONES 1 TO 5

ZONE 1

San Jose-Santa Clara	South Bayside Systems Authority[1]
Sunnyvale	Union SD Irvington
Menlo Park SD FMC	Union SD Newark
	Union SD Alvarado
Palo Alto	

ZONE 2

Hayward-San Ramon-Livermore	San Leandro
Ora Loma SD	San Mateo
PGE Hunters Pt.	North Bayside Systems Authority[2]
Marine World	

ZONE 3

SF North Pt.	Richardson Bay SD	Mill Valley
SF Southeast	San Quentin prison	EBMUD
Sausalito	Marin Co. #1	Stauffer, Richmond
Marin Co. #5	San Rafael SD	Richmond

ZONE 4

Marin Co. #6 (Novato & Ignacio)	Pinole
Bahia	San Pablo SD
Hamilton AFB	Rodeo
Los Gallinas	Standard Oil of Calif., Richmond
Petaluma	Union Oil, Oleum
Sonoma Valley	

ZONE 5	Napa-American Canyon	US Steel, Pittsburg
	Vallejo	Pacific Refinery
	Pittsburg-Camp Stoneman	Exxon, Benicia
	Pittsburg-Montezuma	Tosco, Avon
	Contra Costa SD 7A	Allied Chemical
	Benicia	Dow Chemical
	Cordelia	C&H Sugar-Crockett
	Central CCSD	Stauffer, Martinez
	Mt. View	PGE Avon
	Fairfield-Suisun	PGE Martinez
	Shell Oil, Martinez	PGE Pittsburg

1/ Redwood City and Cities of Belmont and San Carlos have discontinued the use of their individual outfalls by consolidating into the South Bayside Systems Authority (SBSA) outfall. Sewage from these cities and from Menlo Park Sanitation District will be treated at a tertiary treatment plant now under construction and will be discharged through the SBSA outfall.

2/ The Cities of Burlingame, Millbrae, and South San Francisco, the San Francisco International Airport, and the Merck Company discontinued the use of their outfalls by consolidating into the North Bayside Systems outfall.

TABLE 2

DISCHARGERS IN ZONE 6

Sacramento Area

- Central SD
- McClellan AFB
- City of Sacramento (2 outfalls)
- Rancho Cordova
- Linwood SD
- Arden Plant Sacramento County
- Northeastern Sacramento County

West Sacramento Area

- Dixon Dryer
- American Crystal Sugar Co.
- West Sacramento

Lodi Area

- Calif. Canners & Growers
- East Side Winery
- City of Lodi
- Woodbridge SD

Stockton Area

- City of Stockton (2 outfalls)
- Tri-Valley Growers
- Fibreboard
- Mohawk River
- Westcoaster

Tracy Area

- City of Tracy
- Tracy Industrial
- Holly Sugar
- Libby-Owens-Ford

Antioch Area

- Du Pont
- Fibreboard
- P.G.& E
- Crown-Zellerbach
- City of Antioch

Vacaville Area

- City of Vacaville (municipal)
- City of Vacaville (industrial)
- Davis
- Woodland

SWRCB (Region 5) Basin Plan Report, 1975

2. <u>What Known Toxicants are Being Discharged and in What Amounts?</u>

Compared to the other zones, Central San Francisco Bay (zone 3 received the highest input of zinc, copper, chromium, lead, nickel, cadmium, and arsenic (in order of decreasing amounts) during 1975-77 from outfall discharges (Table 3). The southern Bay zones 1 and 2 received more heavy metals than the northern Bay zones 4, 5, and 6. This distribution reflects the metal plating industries and electronics manufacturing facilities located along the central and south Bay counties. Central Bay also received the highest amounts of oil and grease while the northern zones (zones 4 and 5) received more oil and grease than the southern Bay zones. The oil and grease in the northern zones are most likely originating from the petroleum refineries and chemical plants located along San Pablo and Suisun Bays.

In spite of the magnitude of refinery operations, municipal outfalls are much more significant contributors of oil and grease. We can, however, assume that much of the oil and grease in municipal wastewaters are non-petroleum products. Unfortunately, no estimates can be made as to the petroleum and non-petroleum fractions in wastewaters.

Zinc was discharged in the greatest amount of the heavy metals monitored and discharged into the Bay and western Delta from major outfalls during 1975-77. Copper, chromium, lead, nickel, cadmium, mercury, and arsenic, respectively, followed zinc. Significant reductions in the discharge of these heavy metals occurred after 1977 as treatment plant improvements at the East Bay Municipal Utility District plant and at the San Jose plant were made (Tables 4 and 5, respectively). Zinc discharges were reduced by 40 percent of 1975-77 levels but remained the highest metal discharged. Reductions in copper levels also changed the order of metals discharged to (in order of decreasing amounts) zinc, nickel, chromium, lead, copper, mercury, cadmium, and arsenic (Table 6) for zones 1 through 6.

Not all dischargers are required to monitor for all effluent constituents. Consequently, these tabulations are estimates from monthly averages of reported effluent constituents. Malfunctions at some treatment facilities have occurred, thereby allowing discharges of untreated sewage into the Bay-Delta on rare occasions. The input of these raw discharges were not included in the tabulated data reported by the discharger. Also, it is best to interpret the values as low estimates of discharges into the Bay-Delta system since we have not included data on surface runoff and spills of toxic substances.

TABLE 3

EFFLUENT DISCHARGES INTO

S.F. BAY-WESTERN DELTA (1975-77)

RECEIVING WATER ZONES

Constituent	1	2	3	4	5	Estimated TOTAL
Flow (MGD)	170.4	70.1	188.2	19.4	51.5	499.6
Oil & Grease (lbs/day)	7,370	6,162	42,598	2,045	14,672	72,847
Zinc (lbs/day)	182.9	60.1	669.4	22	40.2	974.6
Copper (lbs/day)	138.3	24.6	465.7	3.8	38.2	670.6
Chromium (lbs/day)	128.3	31.5	220.3	2	19.8	401.9
Lead (lbs/day)	68.7	16.5	155.3	4.8	36.8	282.1
Nickel (lbs/day)	89.2	29.8	85.8	16.9	7.1	228.8
Cadmium (lbs/day)	15.7	4.3	21.8	1.3	9.4	52.5
Mercury (lbs/day)	40.5	2.3	2.2	.04	<.3	45.3
Arsenic (lbs/day)	2.5	3.2	17.9	2.2	2.3	28.1

Tabulations based on Risebrough et al, 1977

TABLE 4

EAST BAY MUNICIPAL UTILITY DISTRICT EFFLUENT QUALITY

Constituent	Estimated Average Daily Discharges 1975-77[a]	Jan-Oct 1979[b]
Flow (MGD)	76.6	75.9
Oil & Grease (lb/day)	22,000	3,400
Arsenic (lb/day)	L.T. 7.0	1.8
Cadmium (lb/day)	9.0	1.3
Chromium (lb/day)	90	17
Copper (lb/day)	420	79
Lead (lb/day)	70	11
Mercury (lb/day)	0.7	0.13
Nickel (lb/day)	41.3	160.0
Zinc (lb/day)	520	100-130

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a/ Risebrough et al, 1977 (Primary treatment)

b/ Damas, personal communication (Secondary treatment)

TABLE 5

SAN JOSE MUNICIPAL TREATMENT PLANT EFFLUENT QUALITY

Constituent	1975-77[a/]	1979[b/]
Flow (MGD)	92.4	101.9
Oil & Grease (lb/day)	2,400	2,300
As (lb/day)	0.3	2.5
Cd (lb/day)	10.7	3.4
Cr (lb/day)	21	11.8
Cu (lb/day)	100	13.5
Pb (lb/day)	30	27
Hg (lb/day)	0.3	0.2
Ni (lb/day)	31	39.8
Zn (lb/day)	92	73.6

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a/ Risebrough et al, 1978

b/ W. Tom, personal communication based on Jan-Sept 1979 data.

TABLE 6

ESTIMATED 1975-77 AND 1979 TOTAL DAILY INPUT OF SELECTED WASTEWATER CONSTITUENTS INTO SAN FRANCISCO BAY-WESTERN DELTA FROM MAJOR WASTE DISCHARGERS

Constituent	1975-77 Estimated Total Daily Discharge	1979 Estimated Total Daily Discharge
Flow (MGD)	500	>500
Oil & Grease (lbs/day)	72,850	53,700
Zinc (lbs/day)	975 (1)*	580 (1)
Copper (lbs/day)	670 (2)	156 (5)
Chromium (lbs/day)	402 (3)	317 (3)
Lead (lbs/day)	282 (4)	225 (4)
Nickel (lbs/day)	229 (5)	362 (2)
Cadmium (lbs/day)	53 (6)	30 (7)
Mercury (lbs/day)	45 (7)	45 (6)
Arsenic (lbs/day)	28 (8)	26 (8)

* The estimates were based on Risebrough et. al, 1977 data and data provided by the San Francisco Bay Regional Water Quality Control Board. Parenthesized values are ranking order.

3. What Pesticides are Being Used in Counties Providing Most of the Streamflow to the Bay and Delta?

The following information was developed with the assistance of Department of Environmental Toxicology staff, U.C. Davis:

a. Application data for the top 100 pesticides for each of 10 selected counties for 1978 (1979 data will be available in May);

b. Listing of the pesticides according to amount applied (i.e., highest use pesticide would be ranked first) for each county; and

c. Listing of the pesticides used, as in b, but for all 10 counties taken together.

The printout for the ranked, integrated use data for the 10 counties is shown in Table 7.

This information will be used to design the analytical program.

The pesticide data lists will be developed for as far back as 1974 at least. (Information is now available through 1971.) The purpose is to determine which persistent chemicals were used in earlier years but not recently (i.e., they would not show up on the recent lists).

A striking feature of the 1978 list is the significance of petroleum hydrocarbons. The Second Progress Report will provide specific information on the nature of these compounds and their use.

TABLE 7

TOP 100 PESTICIDES BY TOTAL LBS APPLIED
IN 1978 IN INTEGRATED LIST FOR 10 COUNTIES: Colusa, Sutter, Yuba, Yolo, Sacramento, San Joaquin, Stanislaus, Merced, Madera and Fresno

RANK	CHEM	TOTAL LBS	ACRES	
1	00560	10723753.84	537817.10	SULFUR
2	00185	3069168.84	33992.94	D-D MIXTURE
3	00473	1738303.19	129250.84	PETROLEUM HYDROCARBONS
4	00765	1656375.58	64073.10	PETROLEUM OIL, UNCLASSIFIED
5	00536	1143602.82	301474.43	SODIUM CHLORATE
6	00763	898619.79	80714.45	PETROLEUM DISTILLATES
7	00622	826187.65	399030.31	XYLENE
8	00385	666617.17	15940429.22	METHYL BROMIDE ●
9	00752	647949.60	434903.49	AROMATIC PETROLEUM SOLVENTS
10	00271	581655.05	21439.01	ETHYLENE DIBROMIDE ●
11	00449	529047.40	146314.80	ORDRAM-R
12	00445	522421.98	298747.73	OMITE-R
13	00594	519756.00	127340.19	TOXAPHENE ●
14	00190	482454.46	245383.50	DEF
15	00105	459428.93	247047.26	CARBARYL ●
16	00573	416858.26	3740.76	TELONE-R
17	00346	379012.72	264001.88	KELTHANE-R ●
18	00104	338456.24	151294.44	CAPTAN ●
19	00173	322943.94	43601.00	CRYOLITE
20	01601	284109.31	689083.77	PARAQUAT DICHLORIDE ●
21	00383	234296.08	457170.99	METHOMYL
22	00162	230094.48	22700.06	COPPER SULFATE (BASIC)
23	01685	198756.78	305506.96	ACEPHATE (ORTHENE-R)
24	00459	189826.63	231342.56	PARATHION ●
25	00292	185311.84	85613.25	DIFOLATAN-R ●
26	00136	160768.19	5622094.13	CHLOROPICRIN ●
27	00216	154795.22	163978.20	DIMETHOATE ●
28	00238	151086.31	75554.30	DNBP ●
29	00786	133042.17	122765.70	MCPA, DIMETHYLAMINE SALT ●
30	00629	131780.29	23629.19	ZIRAM
31	00677	128085.20	57250.00	CHLOROTHALONIL ●
32	00367	115867.39	37172.21	MALATHION ●
33	00401	112951.87	5056.50	MINERAL OIL
34	00231	112769.63	29343.95	DIURON
35	00253	109447.49	151341.00	DURSBAN-R ●
36	00314	108915.35	90210.90	GUTHION-R
37	00198	108161.80	107894.15	DIAZINON ●
38	01697	108112.34	141431.50	MONITOR-R
39	00151	96865.49	24205.67	COPPER HYDROXIDE
40	00806	95119.49	87525.01	2,4-D, DIMETHYLAMINE SALT ●
41	00045	94531.35	10747.20	ATRAZINE ●
42	00230	92198.71	97373.26	DI-SYSTON-R ●
43	00478	91103.51	106344.40	PHORATE ●
44	00394	86140.47	141108.55	METHYL PARATHION ●
45	01689	85309.54	132613.06	SUPRACIDE-R
46	00418	82360.55	83788.60	NALED ●
47	00259	80717.58	92421.45	ENDOSULFAN
48	00862	80169.65	51805.25	XYLENE RANGE AROMATIC SOLVENT
49	01814	79459.21	158293.17	PETROLEUM DISTILLATE, AROMATIC
50	00181	72022.41	10434.25	DANASIT-R

o Indicates that partition coefficient information is available for this compound through ISHOW computer program (referred to in Task A.2.a. Report, p. 41).

RANK	CHEM	TOTAL LBS	ACRES	
51	00091	71383.00	70859.00	BUX-R
52	00575	70300.03	153448.78	ALDICARB
53	00597	67830.74	84358.80	TRIFLURALIN
54	00161	62970.39	5238.00	BLUE VITRIOL
55	00384	60236.64	55547.80	METHOXYCHLOR ●
56	00130	58787.08	3991.00	CHLORDANE ●
57	00369	56984.43	21706.00	MANEB
58	00088	54565.91	46000.90	DYLOX-R ●
59	00158	52672.63	8662.50	COPPER OXYCHLORIDE SULFATE
60	00179	51188.62	5472.00	DACTHAL-R ●
61	01929	48254.20	54655.50	?????????????????????????????
62	00531	47191.29	20259.69	SIMAZINE ●
63	00164	43129.84	4997.00	COPPER-ZINC SULFATE COMPLEX
64	00689	41310.70	0.00	SODIUM METABORATE
65	01673	41137.43	59946.50	SODIUM CACODYLATE
66	00335	40443.75	29685.00	IMIDAN-R
67	01552	39114.09	1106394.37	BENOMYL ●
68	00211	39057.08	23883.60	MANEB
69	01354	38843.96	160819.00	ENDOTHALL, MONO(N,N-DIETHYLALK
70	00636	38048.43	25596.50	2,4-D ●
71	00106	35137.19	55182.00	CARBOFURAN ●
72	01855	32053.46	2443.24	GLYPHOSATE, ISOPROPYLAMINE SAL
73	00081	31496.10	17362.10	BOTRAN-R ●
74	00020	30599.41	2160.95	AMITROLE ●
75	00503	30274.11	7423.50	PROPANIL ●
76	01728	30059.30	12800.84	2-(ALPHA-NAPHTHOXY)-N,N-DIETHY
77	00714	28082.81	12740.00	COPPER
78	00590	25453.57	4693.15	TILLAM-R
79	00801	24845.17	20378.00	2,4-D, ALKANOLAMINE SALTS (ETH ●
80	01081	22928.08	2217.00	DALAPON, SODIUM SALT ●
81	01626	21745.05	25788.00	ETHEPHON
82	01638	21384.25	26737.25	PLICTRAN-R
83	00052	19605.65	25107.50	AZODRIN-R
84	00268	19039.30	17148.33	ETHION ●
85	00480	17990.16	57429.50	PHOSDRIN-R ●
86	00293	17456.71	10257.50	FOLEX-R
87	00183	17302.08	115.00	DBCP ●
88	01752	17131.47	4330.50	COCS
89	01800	16513.42	0.00	DISODIUM OCTABORATE TETRAHYDRA
90	00109	15524.27	1599999.00	CARBON TETRACHLORIDE ●
91	00226	15093.25	3036.00	DIPHENAMID ●
92	00141	14170.14	3270.40	CIPC
93	00667	13918.14	217053.20	ZINC SULFATE
94	00479	13466.51	6315.50	PHOSALONE
95	00382	13442.37	27502.00	META-SYSTOX
96	00464	13271.55	27406.80	PCNB ●
97	00834	13221.25	12926.00	BROMOXYNIL OCTANOATE
98	00110	12898.66	10889.00	CARBOPHENTHION ●
99	00111	12423.26	16721.00	FORMETANATE HYDROCHLORIDE
100	90480	11967.63	57429.50	PHOSDRIN-R, OTHER RELATED ●
	TOTAL	31548734.40	33114780.34	

REFERENCES

State Water Resources Control Board; Regional Water Quality Control Board, San Francisco Bay Region (2) - Water Quality Control Plan Report, Vols. I and II, 1975.

State Water Resources Control Board; Regional Water Quality Control Board, Central Valley Region (5) - Water Quality Control Plan Report, Vols. I and II, 1975.

Breslaw, J. A., "Industrial Waste Discharges in the San Francisco Bay Region", Lawrence Berkeley Laboratory, University of California, LBL-1001, 1972.1

Risebrough, R. W., Chapman, J. W., Okazaki, R. K., and T. T. Schmidt, "Toxicants in San Francisco Bay and Estuary - A Report to the Association of Bay Area Governments", Bodega Bay Institute of Pollution Ecology, Draft, August 1, 1977.

FIGURE 7

ISHOW Printout for Toxaphene

```
COMMAND? SEARCH
PROPERTY? NAME
 NAME? TOXAPHENE
TOXAPHENE   (8CI9CI)
LOCAL ID =  1973,  CAS REG =   8001352
SYNONYMS? ALL
TOXAKIL
STROBANE T
POLYCHLOROCAMPHENE
PHENATOX
PHENACIDE
PENPHENE
M 5055
MELIPAX
KAMFOCHLOR
HERCULES 3956
GENIPHENE
ESTONOX
CHLORINATED CAMPHENE
CAMPHOCHLOR
CAMPHECHLOR
ALLTOX
TOXYPHEN
TOXAPHEN
TOXAPHENE   (8CI9CI)

FILE  1 CONTAINS     1 COMPOUND(S) NAMED     TOXAPHENE

COMMAND? DISPLAY
 FILE? 1
FILE  1 CONTAINS     1 COMPOUND(S) NAMED     TOXAPHENE

 HOW MANY CPDS? ALL


ID= 1973  REG=  8001352  TOXAPHENE
---       ----

    MF= C10 H10 CL8                           MW= 413.85
    ---                                       ---

    WLN=
    ----

    FP= 65-90 R704                 BP= DECOMPOSES R766
    ---                            ---

    VP(25C)= 0.2-0.4 T25 R745      SOL= 0.0003G T20 R766
    --------                       ----

                         PK             PK                        MATC
    PK=        PK=       TEMP=          REF=      MATC=1.0 E-2    REF= 710
    ---        ---       -----          ----      -----           ----

     LOGP SOLV FN   REF    LC50  SP TIM TC REF     BCF   SP TIM TC REF
     -----------------   -------------------   ---------------------
     6.44  01 804   776  1.4 E1   1  96    710
                         1.8 E1   2  96    710
                         1.1 E1   4  96    710
                         2.6 E1   6  96    710

    GC RETENTION DATA
    TIME TEMP   TIME TEMP   TIME TEMP   SOLV STD  REF
    -------------------------------------------------
```

The top 100 pesticides have been ranked according to the log P for each, when the log P value was available. The ranking is shown in Table 8. The higher the log P, the greater its expected accumulation in striped bass and in other organisms.

The ISHOW data base was then searched for the EPA designated organic priority pollutants. ISHOW was found to have essentially complete coverage for these compounds. Log P data for 121 compounds was available. The priority pollutants were ranked according to the log P value for each, following the approach taken for pesticides. This ranking is shown in Table 9.

TABLE 8

LISTING OF SELECTED PESTICIDES
ACCORDING TO PARTITION COEFFICIENT

Pesticide	Log P[1,2]	Rank[3]	Total lbs.[4]
Toxaphene	6.44	13	519,756.00
Kelthane	5.56	17	379,012.72
PCNB	5.42	96	13,271.55
Chlordane	5.34	56	58,787.08
Methoxychlor	5.33,4.30	55	60,236.64
Dacthal	4.95	60	51,188.62
Simazine	4.07,0.21	62	47,191.29
Chlorothalonil	3.83	31	128,085.20
DNBP	3.66	28	151,086.31
Carbophenthion	3.51	98	12,898.66
Botran	3.29	73	31,496.10
Propanil	3.12	75	30,274.11
Dursban	3.06	35	109,447.49
Difolatan	3.02	25	185,311.84
Carbon tetrachloride	2.83,2.66	90	15,524.27
2,4-D	2.81,2.74	70	38,048.43
Atrazine	2.78,0.81	41	94,531.35
MCPA	2.69	29	133,042.17
Malathion	2.62,1.85	32	115,867.39
Benomyl	2.53	67	39,114.09
Carbaryl	2.38,2.36	15	459,428.93
Chloropicrin	2.42,2.32	26	160,768.19
Captan	2.35	18	338,456.24

(Continued)

Pesticide	Log P[1,2]	Rank[3]	Total lbs.[4]
DBCP	2.29	87	17,302.08
Diphenamid	2.29	91	15,093.25
Carbofuran	2.26	71	35,137.19
Parathion	2.15	24	189,826.63
Methyl Parathion	2.04	44	86,140.47
Di-Syston	1.93	42	92,198.71
Phorate	1.93	43	91,103.51
Diazinon	1.92	37	108,161.80
Ethylene dibromide	1.76	10	581,655.05
Naled	1.38,1.36	46	82,360.55
Methyl bromide	1.19	8	666,617.17
Dylox	1.13	58	54,565.91
Ethion	0.91	84	19,039.30
Amitrole	0.52	74	30,599.41
Dimethoate	0.5	27	154,795.22
Phosdrin	-0.17	85	17,990.16
Phosdrin (Other Related)	-0.17	100	11,967.63
Dalapon	-2.76	80	22,928.08
Paraquat dichloride	-8.29	20	284,109.31

1/ Logarithm of partition coefficient of compound between organic solvent and water. Octanol has been the most common solvent used to determine this value. The higher the log P, the greater is the potential for a compound to be accumulated.

2/ Log P data were obtained through use of the ISHOW computer data base at the University of Minnesota, Duluth. Where more than 1 value for log P was given, the ranking is according to the higher value, which is placed first. For purpose of comparison the log P values for DDT (which is also banned) are 6.11, 4.96, 3.98, 3.76.

3/ A compound's rank is determined from the total amount applied in 1978 in the following ten counties: Colusa, Sutter, Yuba, Yolo, Sacramento, San Joaquin, Stanislaus, Merced, Madera, and Fresno. The higher the rank, the greater the amount applied.

4/ Amount applied in 1978 in the ten counties identified above.

TABLE 9

RANKING OF EPA DESIGNATED PRIORITY POLLUTANTS
ACCORDING TO PARTITION COEFFICIENT

Chemical Abstracts Service Numbers	Compound	Log P[1,2/]
119062	Bis(Tridecyl) Phthalate 1,2-Benzenedicarboxylic Acid, Ditridecyl Ester	14.52
84775	Decyl Phthalate 1,2-Benzenedicarboxylic Acid, Didecyl Ester	11.28
26761400	Bis (Isodecyl) Phalate 1,2-Benzenedicarboxylic Acid, Diisodecyl Ester	11.26
84764	1,2-Benzenedicarboxylit Acid, Dinonyl Ester	10.20
119073	1,2-Benzenedicarboxylic Acid, Decyl Octyl Ester	10.20
117840	Octyl Phalate 1,2-Benzenedicarboxylic Acid, Dioctyl Ester	9.36
117817	Ethylhexlyl Phthalate, Dioctyl Phthalate 1,2-Benzenedicarboxylic Acid, Bis (2-Ethylhexyl) Ester	8.86
89190	Phthalic Acid, Butyl Decyl Ester	8.28
25429292	1,1'-Biphenyl, Pentachloro-	7.64
85698	Butyl 2-Ethylhexyl Phthalate 1,2-Benzenedicarboxylic Acid, Butyl 2-Ethylhexyl Ester	7.07
29590407	Phthalic Acid, Butyl Sec-Octyl Ester	7.07
84753	Dihexyl Phthalate 1,2-Benzenedicarboxylic Acid, Dihexyl Ester	6.96
26914330	1,1'-Biphenyl, Tetrachloro-	6.93
8001352	Toxaphene	6.44
118741	Benzene, Hexachloro-	6.39
25323686	1,1'-Biphenyl, Trichloro-	6.22
72548	p,p' DDD Benzene, 1,1'-(2,2-Dichloroethylidene)Bis(4-Chloro-	6.19
72559	p,p' DDE Benzene, 1,1'-(Dichloroethenylidene)Bis(4-Chloro-	6.19

84617	Dicyclohexyl Phthalate 1,2-Benzenedicarboxylic Acid, Dicyclohexyl Ester	6.14
50293	p,p' DDT Benzene, 1,1'-(2,2,2-Trichloroethylidene)Bis(4-Chloro-	6.11,4.96,3.98,3.76
50328	Benzo(A)Pyrene	6.06
101586	Benzene, 1,1'-Oxybis(4-(1,1,3,3-Tetramethylbutyl)-	5.50
1836755	Nitrochlor Benzene, 2,4-Dichloro-1-(4-Nitrophenoxy)-)	5.37
309002	Aldrin	5.17,5.00
72208	Endrin	5.15,4.56,4.08
87865	Phenol, Pentachloro-	5.12,2.15,1.05
76448	Heptachlor 4,7-Methanoindene, 1,4,5,6,7,8,8-Heptachloro-3A, 4,7,7A-Tetrahydro-	5.05,4.40
95943	Benzene, 1,2,4,5-Tetrachloro-	4.97
85687	Benzyl Butyl Phalate 1,2-Benzenedicarboxylic Acid, Butyl Phenylmethyl Ester	4.73
97234	Dichlorophen Phenol, 2,2'-Methylenebis(4-Chloro-)	4.72
60571	Dieldrin	4.56,4.41,4.08,3.91
84695	Diisobutyl Phthalate 1,2-Benzenedicarboxylic Acid, Bis(2-Methylproply) Ester	4.54
330938	Benzene, 1,1'-Oxybis(4-Fluoro-	4.49
85018	Phenanthrene	4.46,4.45
120127	Anthracene	4.45
77474	1,3-Cyclopentadiene, 1,2,3,4,5,5-Hexachloro-	4.28
108703	Benzene, 1,3,5-Trichloro-	4.26
87616	Benzene, 1,2,3-Trichloro-	4.26
120821	Benzene, 1,2,4-Trichloro	4.26

58899	Lindane Cyclohexane, 1,2,3,4,5,6-Hexachloro-, .Gamma.-	4.22,3.72
87683	1,3-Butadiene, 1,1,2,3,4,4-Hexachloro-	4.14
83329	Acenaphthene Acenaphthylene, 1,2-Dihydro-	3.98
86306	Benzenamine, N-Nitroso-N-Phenyl-	3.96
530507	Hydrazine, 1,1-Diphenyl-	3.85
108601	DCIP Propane, 2,2'-Oxybis(1-Chloro)	3.84
95954	Phenol, 2,4,5-Trichloro-	3.84,3.72
208968	Acenaphthylene	3.74
88062	Phenol, 2,4,6-Trichloro-	3.69,0.90
100414	Benzene, Ethyl-	3.68,3.15,2.76
131168	Dipropyl Phthalate 1,2-Benzenedicarboxylic Acid, Dipropyl Ester	3.65
1024573	Heptachlor Epoxide	3.65
108907	Benzene, Chloro-	3.46,2.91,2.46
106467	Benzene, 1,4-Dichloro-	3.43,3.39
108883	Toluene Benzene, Methyl-	3.41,2.85,2.73,2.56
95501	Benzene, 1,2-Dichloro-	3.38
541731	Benzene, 1,3-Dichloro-	3.38,3.24
91203	Naphthalene	3.36,3.32
78591	Isophorone 2-Cyclohexen-1-One, 3,5,5-Trimethyl-	3.34
591355	Phenol, 3,5-Dichloro-	3.13
95772	Phenol, 3,4-Dichloro	3.13
120832	Phenol, 2,4-Dichloro-	3.08,1.92,1.91,1.39
10061026	1-Propene, 1,3-Dichloro-, (E)-	3.02,1.63
10061015	1-Propene, 1,3-Dichloro-, (Z)-	3.02,1.63

127184	Ethene, Tetrachloro-	2.94,2.60
122667	Hydrazine, 1,2-Diphenyl-	2.94
98953	Benzene, Nitro-	2.93,1.85,1.69,1.46
84742	Dibutyl Phthalate 1,2-Benzenedicarboxylic Acid, Dibutyl Ester	2.88
87650	Phenol, 2,6-Dichloro-	2.88
56235	Methane, Tetrachloro-	2.83,2.66
71432	Benzene	2.80,2.15,2.10
563586	1-Propene, 1,1-Dichloro-	2.67
79345	Ethane, 1,1,2,2-Tetrachloro-	2.66
630206	Ethane, 1,1,1,2-Tetrachloro-	2.66
84662	Diethyl Phthalate 1,2-Benzenedicarboxylic Acid, Diethyl Ester	2.64
75694	Methane, Trichlorofluoro-	2.55,2.53,2.52
75252	Methane, Tribromo-	2.52
71556	Ethane, 1,1,1-Trichloro	2.50,2.49
106489	Phenol, 4-Chloro-	2.42
108430	Phenol, 3-Chloro-	2.42
78999	Propane, 1,1-Dichloro	2.34
594207	Propane, 2,2-Dichloro-	2.34
88755	Phenol, 2-Nitro-	2.33,2.18,1.79,1.49
329715	Phenol, 2,5-Dinitro-	2.32
79016	Ethene, Trichloro-	2.29
124481	Methane, Dibromochloro-	2.26
75274	Methane, Bromodichloro-	2.24
554847	Phenol, 3-Nitro-	2.20,2.01,0.42,-1.57
95578	Phenol, 2-Chloro-	2.17
534521	Phenol, 2-Methyl-4,6-Dinitro-	2.17

75354	Ethene, 1,1-Dichloro-	2.13
131113	Dimethyl Phalate 1,2-Benzenedicarboxylic Acid, Dimethyl Ester	2.09,1.56
79005	Ethane, 1,1,2-Trichloro-	2.07
100027	Phenol, 4-Nitro-	2.04,1.91,0.15,-1.93
121142	Benzene, 1-Methyl-2,4-Dinitro-	2.03,1.98
606202	2,6-Dinitrotolliene Benzene, 2-Methyl-1,3-Dinitro-	2.03,1.98
88891	Picric Acid Phenol, 2,4,6-Trinitro-	2.03
619158	Benzene, 2-Methyl-1,4-Dinitro-	2.03
142289	Propane, 1,3-Dichloro-	2.00,1.74
67663	Chloroform Methane, Trichloro-	1.97,1.94,1.86
75343	Ethane, 1,1-Dichloro-	1.79
111444	2,2'Dichloroethyl Ether Ethane, 1,1'-Oxybis(2-Chloro-	1.73
108952	Phenol	1.64,1.49,0.36,-0.81
573568	Phenol, 2,6-Dinitro-	1.55,1.51,1.18
92875	Benzidine (1,1'-Biphenyl)-4,4'-Diamine	1.55,1.34
75434	Methane, Dichlorofluoro-	1.55,1.52
156592	Ethene, 1,2-Dichloro-, (Z)-	1.53
156605	Ethene, 1,2-Dichloro-, (E)-	1.53
51285	Phenol, 2,4-Dinitro-	1.51,1.51
107062	Ethane, 1,2-Dichloro-	1.48
75003	Ethane, Chloro-	1.43,1.38
75014	Ethene, Chloro-	1.38
75092	Methane, Dichloro-	1.25
78875	Propane, 1,2-Dichloro-	1.11

74873	Methane, Chloro-	0.91
2150029	Ethanethiol, 2,2'Oxybis-	0.83
143248	Bis(2-Methoxyethoxyethyl) Ether 2,5,8,11,14-Tehtaoxapentadecane	0.60
111966	Ethane, 1,1'-Oxybis(2-Methoxy-	0.43
107131	2-Propenenitrile	-0.08
107028	Acrolein 2-Propenal	-0.08
110985	2-Propanol, 1,1'-Oxybis-	-1.17,-1.38
111466	Diethylene Glycol Ethanol, 2,2'-Oxybis-	-1.26
4901513	Phenol, 2,3,4,5-Tetrachloro	
935955	Phenol, 2,3,5,6-Tetrachloro-	
608935	Benzene, Pentachloro-	
609938	Phenol, 4-Methyl-2,6-Dinitro-	
542881	Dichlorodimethyl Ether Methane, Oxybis (Chloro-	
115297	5-Norbornene-2,3-Dimethanol, 1,4,5,6,7,7-Hexachloro-, Chclic Sulfite	
111911	Ethane, 1,1-(Methylenebis(Oxy)Bis(2-Chloro-	
110758	Ethane, 1,1-(Methylenebis(Oxy))Bis(2-Chloro-	
56553	Benz(A)Anthracene	

1/ Logarithm of partition coefficient of compound between organic solvent and water. The higher the log P, the greater is the potential for a compound to be accumulated.

2/ Log P data were obtained through use of the ISHOW computer data base at the University of Minnesota, Duluth. Where more than 1 value for log P was given, the ranking is according to the higher value, which is placed first.

Task I.2.b. Progress Report: Sublethal Effects of Selected Toxic Compounds on Fish.

A current activity which will continue through the entire study period is the compilation of published information on the effects of selected toxic compounds on fish. This comprehensive literature search will categorize the information into the following matrix.

	Heavy Metals					Organic Compounds				
	Exposure (water) Concentrations	Tissue burdens	Lethal Concentrations LC50	Sublethal effects	Synergistic Studies	Exposure (water) Concentrations	Tissue burdens	Lethal Concentrations LC50	Sublethal effects	Synergistic Studies
Freshwater fishes	X	X	X	X	X	X	X	X	X	X
Estuarine & Anadromous fishes	X	X	X	X	X	X	X	X	X	X
Marine fishes	X	X	X	X	X	X	X	X	X	X

At present, nearly one hundred articles have been compiled on the effects of heavy metals on fish.

When completed, this compilation will serve as a basis for developing sublethal toxicity tests with the striped bass. Hypotheses on the cause of observed abnormalities in biopsied stripers can be drawn from this information.

Task I.2.c. Report: Literature Information Search on Parasitism of California Coast Anadromous Fishes

A one-hundred and ten (110) page bibliography on literature describing major classes of internal and external parasites found in anadromous fishes of the California coast was compiled. The work was done by Dr. L. Michael Moser, a fish parasitologist with the Center for Coastal Marine Studies, University of Californa, Santa Cruz. Over a thousand references were cited in this comprehensive report. It included literature on the parasites of the striped bass (Morone saxatilis), cutthroat trout (Salmo clarki), rainbow trout (Salmo gairdneri), pink salmon (Oncorhynchus gorbuscha), chum salmon (Oncorhynchus keta), silver salmon (Oncorhynchus kisutch), sockeye salmon (Oncorhynchus nerka), and king salmon (Onchorhynchus tschawytscha).

This bibliography will be used as an important reference source during the study to relate parasite infestation to the observed state of health of the striped bass. New references will be added to this bibliography as the study progresses.

In addition to the comprehensive bibliography on fish parasitism, a bibliography of fish diseases was compiled. Approximately 140 citations were compiled by Mr. Kris Lindstrom, M.P.H., a graduate researcher at the U.C. Davis School of Medicine Pathology Department. This information will be used in examining the relationship between pollution and fish diseases during the study.

Task II.1.a. Progress Report: Screening for Toxic Organic Compounds in Striped Bass

A. Introduction

The National Marine Fisheries Service biopsied over 300 adult striped bass in 1978 and 1979. These fish were collected from various locations in San Pablo Bay and eastward to the confluence of the Sacramento-San Joaquin Rivers and off Clarksburg in the Sacramento River. Their findings showed numerous Bay-Delta striped bass to be unhealthy. Fifty-four percent (54%) of the fish were heavily parasitized, thirty-seven percent (37%) had one or more types of skeletal deformities, and thirty-five percent (35%) had healed lesions (J. Whipple, 1979). In addition the State Department of Fish and Game has captured live juvenile and subadult striped bass with open lesions exposing the internal organs.

The causes of these conditions are unknown although pollution is a suspected contributor based on tissue analyses for some heavy metals, and aromatic petroleum hydrocarbons. The fact that a variety of pesticides and other toxic substances enter the Bay-Delta waters leads us to believe that water pollution should be considered as one major cause of the unhealthy state of the striped bass fishery and that investigation of other toxic compounds accumulated by fish should be made.

Three studies have reported toxic organic compounds to be in striped bass from the San Francisco Bay and the Delta:

(1) Stout (1975) reported on polychlorinated biphenyls (PCB) and DDT compounds in fillets of 10 striped bass caught near Clarksburg, CA, and in 10 from Oregon. Lingcod and albacore from northern and southern California were included in the study. Based on her data, she concluded that "Further study of albacore, lingcod, and striped bass is not warranted in the near future". The statement was made with respect to impact on human health.

(2) An EPA-NOAA estuarine monitoring report (Butler, 1977) described analytical results of 120 striped bass collected March 1977 in San Francisco Bay. The fish ranged in length from 33 to 47 cm (510-1814g). None of the 10 muscle (fillet) samples contained detectable amounts of PCB; 8 of 10 contained DDT compounds ranging in concentrations from 11 to 49 micrograms per kilogram (ug/kg) (= parts per billion) total DDT. Three of the liver samples showed detectable amounts of PCB; concentrations ranged from 305 to 823 ug/kg. DDT compounds were also detected in all samples (28-866 ug/kg). All values reported are on

a fresh weight basis. The absence of PCB in muscle samples suggests that the detection limits were high for this study.

(3) Whipple's group also has detected petroleum hydrocarbon pollutants in the fish. Several compounds of the "alkyl benzene" type have been tentatively identified by gas chromatography. The identities of benzene and toluene have been confirmed by mass spectrometry (J. Whipple, 1979).

Three trace elements were looked for in the latter study. Zinc, copper, and iron were found to be present at mean concentrations of 26.7, 3.2, and 11.7 parts per million, fresh weight basis, in ovaries.

Sheneman (1979) commented on the significance of these trace element concentrations at a recent hearing held by the California State Water Resources Control Board and the Department of Fish and Game. Representing the California Department of Health Services, he concluded "10 to 50 times as much may be in several kinds of food that are consumed by human beings normally". These concentrations are allowable in food.

Detection of mercury in tissue requires a technique slightly different from that used for zinc, copper and iron. Mercury detection was not part of the screening program for those trace elements. However, in the same hearing, Sheneman did comment on mercury in striped bass tissue:

> "This issue was considered previously by the Department of Health Services. As a result of a study done in 1971-72, the Department issued the following advisory which is still in effect for mercury:
>
> 1. Not more than one meal per week of striped bass from the Bay-Delta fishery exceeding four pounds in weight should be consumed by anyone.
>
> 2. Pregnant women and young children should not consume any striped bass from the Bay-Delta area."

Clearly, we need more information on toxic substances in striped bass. We need it to help the fishery--and for the people who eat the fish. These striped bass should be carefully examined for the presence of a larger number of potentially harmful substances representing a number of chemical classes. Other species of fish in the San Francisco Bay and Delta should be examined in the same way.

The present investigation began with a call for freshly caught, unhealthy, adult striped bass with lesions. Adults were a first choice because the detection of toxic substances often is easiest in larger fish, especially in a screening program (certain toxic substances accumulate through time in animals, within limits).

The basis for the mercury health advisory was analyses conducted for the California Department of Fish and Game by the California Department of Water Resources. The Department of Fish and Game is preparing a report on that work and on analyses of striped bass for mercury conducted in following years (N. Morgan, personal communication).

The screening program was designed to address the EPA list of organic priority pollutants, as well as other substances that may be present in the tissue. One value of the EPA list is that it represents many classes of toxic compounds. However, the list presents a major problem to the analytical chemist. The detection of many of the priority pollutants <u>in biological tissue</u>, perhaps a majority, is still a matter of state-of-the art analytical chemistry. Further, the scope of the combined methodologies required to detect those substances is beyond the experience of most laboratories. A strategy has been presented recently for the detection of the <u>halogenated</u> priority pollutants for a New York Bight program (Bowes, 1979). The present study in part follows that strategy.

B. <u>Experimental</u>

1. Fish specimens:

Four fish were caught for this study. All contained lesions or healed lesions on the side and below the midline. The bass were younger than desired: A fairly large one-month effort to find larger specimens failed to produce adults. After being caught, the bass were kept on ice until being frozen at -20C within 2 hours of collection. The fish, place of collection, and tissue analyzed are described in Table 10. The fish were sent frozen, air freight, to the EPA Environmental Research Laboratory, Duluth, Minnesota, where the analytical work was performed by Dr. G. W. Bowes, in collaboration with EPA scientists: Drs. G. Veith, D. W. Kuehl, and E. N. Leonard.

2. Sample selection:

Public concern about possible toxic chemicals in the edible tissue of fish with lesions resulted in selection of the fillet (muscle) for analysis in this first stage of screening.

TABLE 10

CHARACTERISTICS OF STRIPED BASS ANALYZED IN PRESENT STUDY

Specimen Code	Date Caught	Location	Fork Length (cm)	Weight (g)	Condition of Fish	Sample Analyzed
28.6.79.1	June 28, 1979	Martinez-Benicia Bridge	38.8	728	Juvenile with open sores.	Fillet
3.6.79.3	July 3, 1979	Navy Mothball Fleet, Suisun Bay	41.2	900	Juvenile with closed sores.	1. Fillet 2. Remainder of Fish
5.6.79.6	July 5, 1979	Navy Mothball Fleet, Suisun Bay	46.1	1,094	Young adult with healed wound.	Fillet
9.6.79.10	July 9, 1979	Chipps Island	30.7	242	Juvenile with open sores.	Fillet

The fillet samples were taken from the sides that had lesions. A total of six samples were taken from the four fish for analysis. Those samples consisted of:

(a) a significant portion of the fillet from one side of each fish (not included in the skin),

(b) a duplicate fillet sample from the other side of one fish,

(c) the whole fish less one fillet sample from one fish.

The whole fish analysis was a back-up that would provide some information on chemicals that could be accumulating in other parts of the fish.

3. Sample Extraction, Chromatography Clean-up of Extract, and Instrument Analysis:

The procedures are similar to those described by Kuehl and Leonard (1978) and Veith, et al., (1979).

Further details on the analytical technique and instrumentation are available on request.

Samples were extracted by use of the Soxhlet technique. Toxic compounds were separated from most of the lipid on a gel permeation chromatography (GPC) column eluted with methylene chloride. Toxics were separated by polarity on a second GPC column which was eluted with 1:1 methylene chloride and cyclohexane. The solvent eluting from the second column was scanned with an ultraviolet (UV) detector. The detector response serves as a rough guide to amount of material passing from the GPC system and the time of elution of the various components.

One sample (Specimen 9.6.79.10, Table 11) was handled differently. The steam distillation technique of Veith and Kiwas (1977) was used to recover volatile toxic compounds which may be present in the fish.

Fractions were taken after UV scanning, or after steam distillation, and analyzed in detail. The first step was analysis by two gas chromatographs, one containing a flame ionization detector, the other having an electron-capture detector. The extracts were then analyzed on a gas chromatograph-mass spectrometer-computer system.

The mass spectra characteristics of the compounds resulting from gc/ms analysis were first compared with those of 125 specific toxic compounds. The comparison was done with the use of a computer program, acronym "GVMAP". The 125 compounds are listed in Table 11. The same characteristics were then compared with those of approximately 25,000 reference compounds in the National Bureau of Standards (NBS) mass spectra library. Manual identifications also were made.

C. Results and Discussion

The results of the first stage of separating compounds in extracted striped bass tissue are presented in Figure 8. The traces show the response of the UV detector to fractions coming from the second GPC column. Some lipid remaining from fractions in the first GPC column appears first. Toxic substances, if they are present, appear after the lipid. They would be in the two large UV-absorbing peaks marked Fraction 1 and Fraction 2. Certain chlorinated pesticides, such as toxaphene, would be in Fraction 1, if they are present. More polar compounds, such as chlorinated phenols, would be in Fraction 2. The detailed analyses of Fraction 1 and Fraction 2 by the gas chromatograph-mass spectrometer system are represented by the tracings in Figures 9 and 10 respectively.

Manual and computer-assisted identifications of compounds in Fraction 1 were made as follows (Figure 9, the order of compound elution is from left to right):

1. The first peaks appearing are alkylbenzenes. These compounds appear in the lighter fraction of petroleum; for example, in gasoline, diesel fuel, petroleum formulations used as pesticides, and in detergents.

2. Pentadecane and heptadecane, respectively, appear after the alkylbenzenes. They are dominant, natural hydrocarbons in marine algae; they have also been detected in freshwater fish and streams.

3. The majority of the synthetic chlorinated hydrocarbons elute after the natural hydrocarbons. Those identified include many PCB isomers, DDE (a breakdown product of DDT), chlordane, which consists of many compounds, and nonachlor, a component of chlordane.

4. The large amounts of material appearing after these substances appear to be natural compounds. Their characteristics could not be matched with those in the computer data files. They were judged to be "cholesterol-type" compounds and are labeled as such.

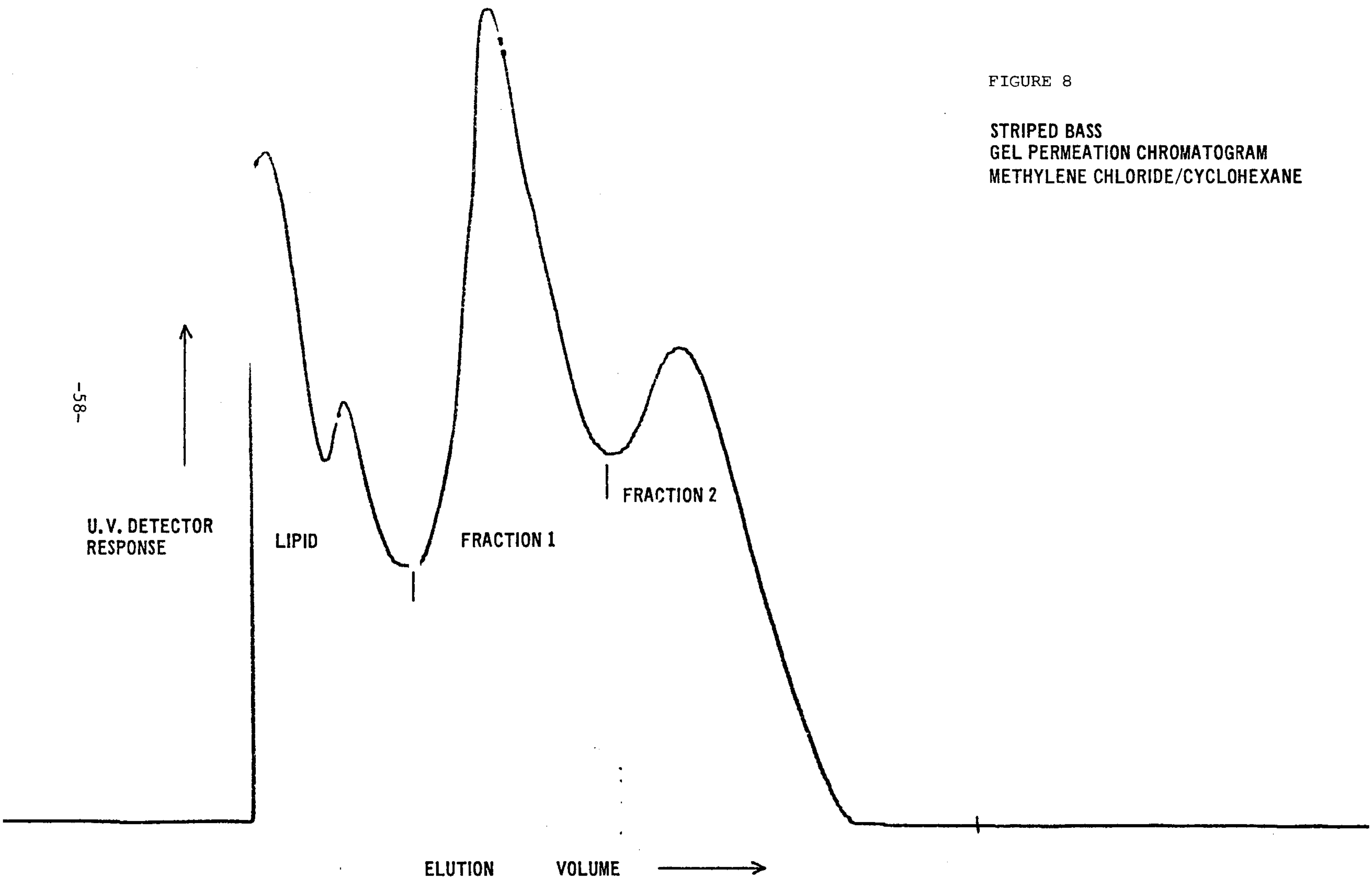
LIST OF TOXIC ORGANIC COMPOUNDS IN "GVMAP" COMPUTER PROGRAM TABLE 11

NAM	NUM:	WT	FORMULA	NAME
GV	1:	310	C12.H8.BR2	P,P'-DIBROMOBIPHENYL
GV	2:	112	C6.H5.CL	BENZENE,CHLORO-
GV	3:	146	C6.H4.CL2	BENZENE,1,4-DICHLORO-
GV	4:	180	C6.H3.CL3	BENZENE,1,3,5-TRICHLORO-
GV	5:	214	C6.H2.CL4	BENZENE,1,2,4,5-TETRACHLORO-
GV	6:	248	C6.H.CL5	BENZENE,PENTACHLORO-
GV	7:	282	C6.CL6	BENZENE,HEXACHLORO-
GV	8:	126	C7.H7.CL	BENZENE,1-CHLORO-3-METHYL-
GV	9:	160	C7.H6.CL2	BENZENE,2,4-DICHLORO-1-METHYL-
GV	10:	194	C7.H5.CL3	BENZENE,2,4-DICHLORO-1-(CHLOROMETHYL)-
GV	11:	228	C7.H4.CL4	BENZENE,TETRACHLORO-,METHYL-
GV	12:	262	C7.H3.CL5	BENZENE,PENTACHLORO-,METHYL-
GV	13:	162	C10.H7.CL	NAPHTHALENE,2-CHLORO-
GV	14:	196	C10.H6.CL2	NAPHTHALENE,1,2-DICHLORO-
GV	15:	230	C10.H5.CL3	NAPHTHALENE,TRICHLORO-
GV	16:	264	C10.H4.CL4	NAPHTHALENE,TETRACHLORO-
GV	17:	298	C10.H3.CL5	NAPHTHALENE,PENTACHLORO-
GV	18:	332	C10.H2.CL6	NAPHTHALENE,HEXACHLORO-
GV	19:	366	C10.H.CL7	NAPHTHALENE,HEPTACHLORO-
GV	20:	400	C10.CL8	NAPHTHALENE,OCTACHLORO-
GV	21:	138	C8.H7.CL	STYRENE,CHLORO-
GV	22:	172	C8.H6.CL2	STYRENE,DICHLORO-
GV	23:	206	C8.H5.CL3	STYRENE,TRICHLORO-
GV	24:	240	C8.H4.CL4	STYRENE,TETRACHLORO-
GV	25:	274	C8.H3.CL5	STYRENE,PENTACHLORO-
GV	26:	308	C8.H2.CL6	STYRENE,HEXACHLORO-
GV	27:	342	C8.H.CL7	STYRENE,HEPTACHLORO-
GV	28:	376	C8.CL8	STYRENE,OCTACHLORO-
GV	29:	188	C12.H9.CL	BIPHENYL,CHLORO-
GV	30:	222	C12.H8.CL2	BIPHENYL,DICHLORO-
GV	31:	256	C12.H7.CL3	BIPHENYL,TRICHLORO-
GV	32:	290	C12.H6.CL4	BIPHENYL,TETRACHLORO-
GV	33:	324	C12.H5.CL5	BIPHENYL,PENTACHLORO-
GV	34:	358	C12.H4.CL6	BIPHENYL,HEXACHLORO-
GV	35:	392	C12.H3.CL7	BIPHENYL,HEPTACHLORO-
GV	36:	426	C12.H2.CL8	BIPHENYL,OCTACHLORO-
GV	37:	460	C12.H.CL9	BIPHENYL,NONACHLORO-
GV	38:	264	C18.H13.CL	TERPHENYL,CHLORO-
GV	39:	298	C18.H12.CL2	TERPHENYL,DICHLORO-
GV	40:	332	C18.H11.CL3	TERPHENYL,TRICHLORO-
GV	41:	366	C18.H10.CL4	TERPHENYL,TETRACHLORO-
GV	42:	400	C18.H9.CL5	TERPHENYL,PENTACHLORO-
GV	43:	434	C18.H8.CL6	TERPHENYL,HEXACHLORO-
GV	44:	468	C18.H7.CL7	TERPHENYL,HEPTACHLORO-
GV	45:	502	C18.H6.CL8	TERPHENYL,OCTACHLORO-
GV	46:	150	C9.H7.CL	INDENE,CHLORO-
GV	47:	184	C9.H6.CL2	INDENE,DICHLORO
GV	48:	218	C9.H5.CL3	INDENE,TRICHLORO-
GV	49:	252	C9.H4.CL4	INDENE,TETRACHLORO-
GV	50:	286	C9.H3.CL5	INDENE,PENTACHLORO-
GV	51:	320	C9.H2.CL6	INDENE,HEXACHLORO-
GV	52:	354	C9.H.CL7	INDENE,HEPTACHLORO-
GV	53:	204	C12.H9.O.CL	BIPHENYL,OL-,CHLORO-
GV	54:	238	C12.H8.O.CL2	BIPHENYL,-OL,DICHLORO-
GV	55:	272	C12.H7.O.CL3	BIPHENYL,-OL,TRICHLORO-
GV	56:	306	C12.H6.O.CL4	BIPHENYL,-OL,TETRACHLORO-
GV	57:	340	C12.H5.O.CL5	BIPHENYL,-OL,PENTACHLORO-
GV	58:	374	C12.H4.O.CL6	BIPHENYL,-OL,HEXACHLORO-
GV	59:	408	C12.H3.O.CL7	BIPHENYL,-OL,HEPTACHLORO-
GV	60:	442	C12.H2.O.CL8	BIPHENYL,-OL,OCTACHLORO-
GV	61:	476	C12.H.O.CL9	BIPHENYL,-OL,NONACHLORO-
GV	62:	202	C12.H7.O.CL	DIBENZOFURAN,CHLORO-
GV	63:	236	C12.H6.O.CL2	DIBENZOFURAN,DICHLORO-
GV	64:	270	C12.H5.O.CL3	DIBENZOFURAN,TRICHLORO-
GV	65:	304	C12.H4.O.CL4	DIBENZOFURAN,TETRACHLORO-
GV	66:	338	C12.H3.CL5	DIBENZOFURAN,PENTACHLORO-
GV	67:	372	C12.H2.CL6	DIBENZOFURAN,HEXACHLORO-
GV	68:	406	C12.H.CL7	DIBENZOFURAN,HEPTACHLORO-

GV	69:	440	C12.CL8	DIBENZOFURAN,OCTACHLORO-
GV	70:	218	C12.H7.O2.CL	DIBENZODIOXIN,CHLORO-
GV	71:	252	C12.H6.O2.CL2	DIBENZODIOXIN,DICHLORO-
GV	72:	286	C12.H5.O2.CL3	DIBENZODIOXIN,TRICHLORO-
GV	73:	320	C12.H4.O2.CL4	DIBENZODIOXIN,TETRACHLORO-
GV	74:	354	C12.H4.O2.CL5	DIBENZODIOXIN,PENTACHLORO-
GV	75:	388	C12.H3.O2.CL6	DIBENZODIOXIN,HEXACHLORO-
GV	76:	422	C12.H.O2.CL7	DIBENZODIOXIN,HEPTACHLORO-
GV	77:	456	C12.O2.CL8	DIBENZODIOXIN,OCTACHLORO-
GV	78:	127	C6.H6.N.CL	BENZENAMINE,2-CHLORO-
GV	79:	161	C6.H5.N.CL2	BENZENAMINE,3,4-DICHLORO-
GV	80:	195	C6.H4.N.CL3	BENZENAMINE,2,4,5-TRICHLORO-
GV	81:	229	C6.H3.N.CL4	BENZENAMINE,2,3,4,5-TETRACHLORO-
GV	82:	263	C6.H2.N.CL5	BENZAMINE,PENTACHLORO-
GV	83:	142	C7.H7.O.CL	BENZENE,1-CHLORO-4-METHOXY-
GV	84:	176	C7.H6.O.CL2	BENZENE,DICHLOROMETHOXY-
GV	85:	210	C7.H5.O.CL3	BENZENE,1,2,4-TRICHLORO-5-METHOXY-
GV	86:	244	C7.H4.O.CL4	BENZENE,1,2,3,5-TETRACHLORO-4-METHOXY-
GV	87:	278	C7.H3.O.CL5	BENZENE,PENTACHLOROMETHOXY-
GV	88:	151	C8.H6.N.CL	INDOLE,CHLORO-
GV	89:	185	C8.H5.N.CL2	INDOLE,DICHLORO-
GV	90:	219	C8.H4.N.CL3	INDOLE,TRICHLORO-
GV	91:	253	C8.H3.N.CL4	INDOLE,TETRACHLORO-
GV	92:	287	C8.H2.N.CL5	INDOLE,PENTACHLORO-
GV	93:	165	C9.H8.N.CL	INDOLE,CHLORO-,METHYL-
GV	94:	199	C9.H7.N.CL2	INDOLE,DICHLORO-,METHYL-
GV	95:	233	C9.H6.N.CL3	INDOLE,TRICHLORO-,METHYL-
GV	96:	267	C9.H5.N.CL4	INDOLE,TETRACHLORO-,METHYL-
GV	97:	113	C5.H4.N.CL	PYRIDINE,3-CHLORO-
GV	98:	147	C5.H3.N.CL2	PYRIDINE,DICHLORO-
GV	99:	181	C5.H2.N.CL3	PYRIDINE,TRICHLORO-
GV	100:	215	C5.H.N.CL4	PYRIDINE,TETRACHLORO-
GV	101:	406	C10.H6.CL8	CHLORDANE-GAMMA
GV	102:	440	C10.H5.CL9	CIS-NONACHLOR
GV	103:	316	C14.H8.CL4	DDE
GV	104:	352	C14.H9.CL5	DDT
GV	105:	318	C14.H10.CL4	DDD
GV	106:	284	C14.H11.CL3	DDMS
GV	107:	282	C14.H9.CL3	DDMU
GV	108:	336	C10.H6.CL6	CHLORODENE
GV	109:	540	C10.CL12	MIREX
GV	110:	344	C16.H15.O2.CL3	METHOXYCHLOR
GV	111:	370	C10.H5.CL7	HEPTACHLOR
GV	112:	386	C10.H5.O.CL7	HEPTACHLOR EPOXIDE
GV	113:	296	C7.H2.CL6	HEXACHLORONORBORNADIENE
GV	114:	332	C7.H3.CL7	HEPTACHLORONORBORNENE
GV	115:	234	C2.CL6	ETHANE,HEXACHLORO-
GV	116:	204	C12.H9.O.CL	BENZENE,1-CHLORO-4-PHENOXY-
GV	117:	270	C5.CL6	1,3-CYCLOPENTADIENE,1,2,3,4,5,5-HEXACHLO
GV	118:	190	C4.H2.CL4	1,3-BUTADIENE,1,1,3,4-TETRACHLORO-
GV	119:	224	C4.H.CL5	BUTADIENE,PENTACHLORO-
GV	120:	258	C4.CL6	1,3-BUTADIENE,1,1,2,3,4,4-HEXACHLORO-
GV	121:	178	C3.H2.CL4	1-PROPENE,1,2,3,3-TETRACHLORO-
GV	122:	0		TOXAPHENES
GV	123:	202	C5.H2.CL4	CYCLOPENTADIENE,TETRACHLORO-
GV	124:	270	C5.CL6	CYCLOPENTADIENE,HEXACHLORO
GV	125:	288	C6.H6.CL6	BHC-ALPHA

FIGURE 8

STRIPED BASS
GEL PERMEATION CHROMATOGRAM
METHYLENE CHLORIDE/CYCLOHEXANE



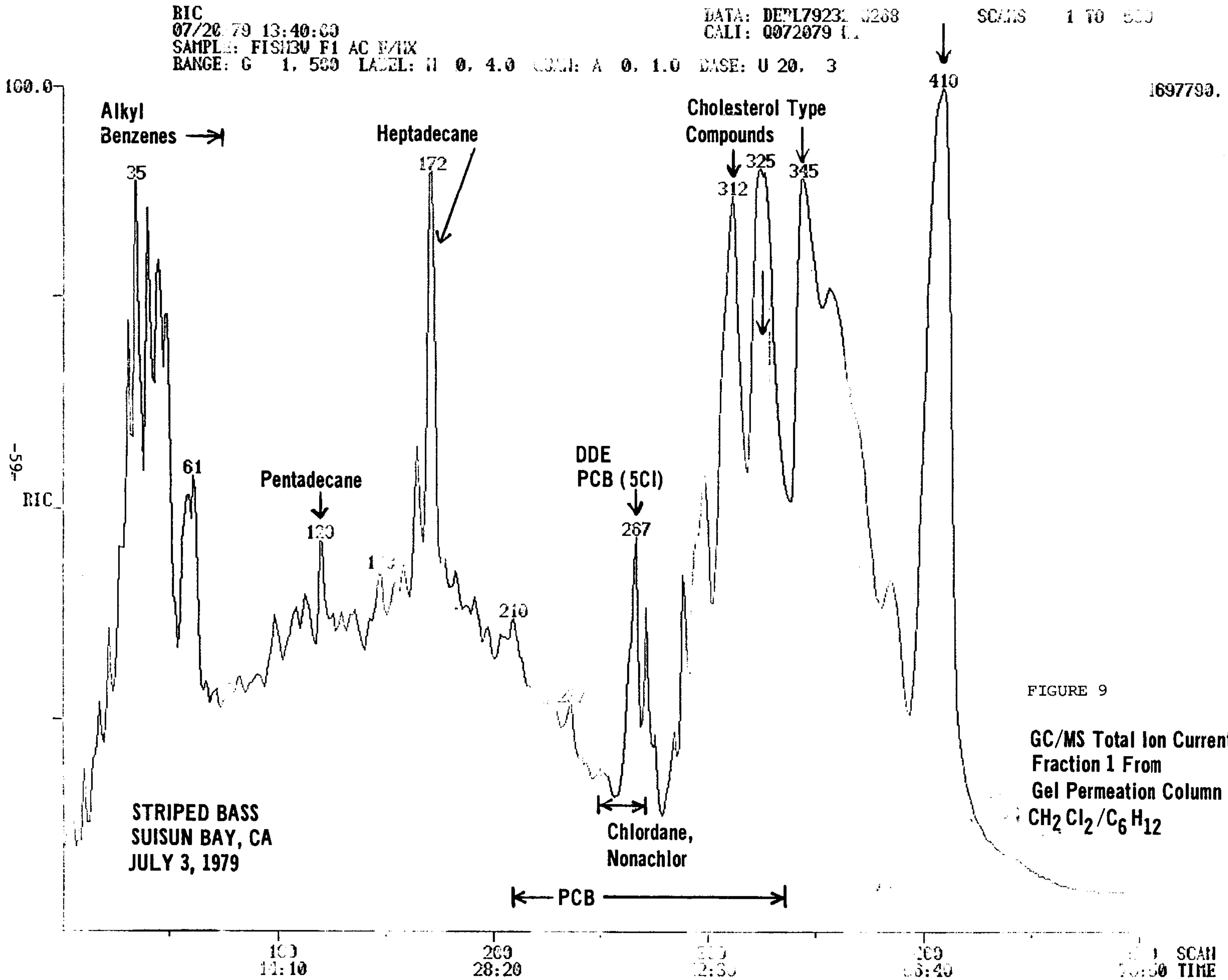


FIGURE 9

GC/MS Total Ion Current Fraction 1 From Gel Permeation Column CH_2Cl_2/C_6H_{12}

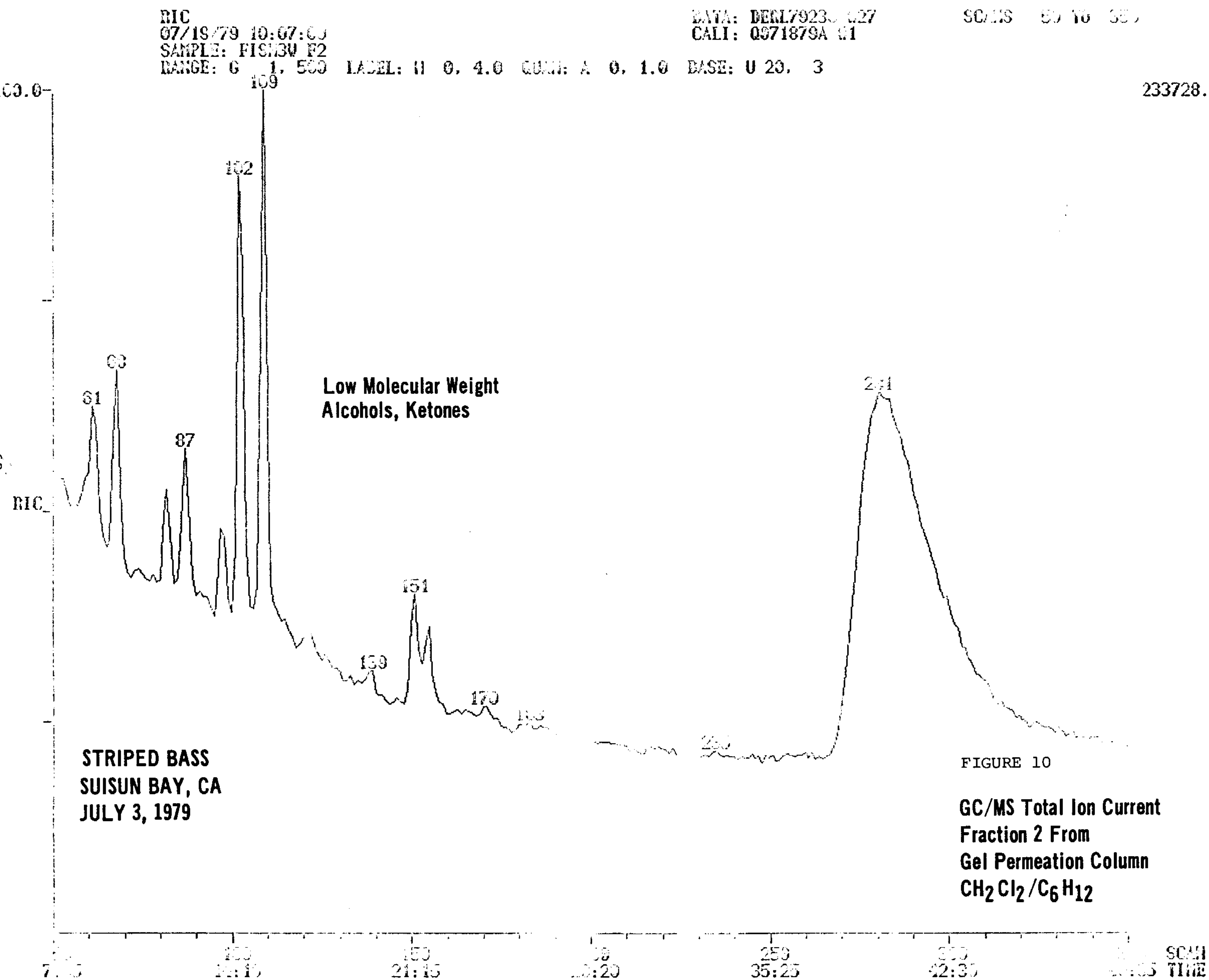


FIGURE 10

GC/MS Total Ion Current
Fraction 2 From
Gel Permeation Column
CH_2Cl_2/C_6H_{12}

Identification of compounds in Fraction 2 (Figure 10) by the same means showed them to be low molecular weight alcohols and ketones. Many of these are naturally occurring.

Fraction 2 (Figure 8) needs further attention. The number of compounds and/or the quantity of them that one would expect because of its size, do not appear in Figure 10. There is one possible explanation: the compounds did not pass through the analytical system. High molecular weight compounds, such as certain petroleum hydrocarbons, and compounds of high polarity, are examples of compounds that are not measured by the gc/ms technique used in the study. This analytical result is a reminder that what we know of toxic substances in the environment is very much dependent on limitations of current analytical capability.

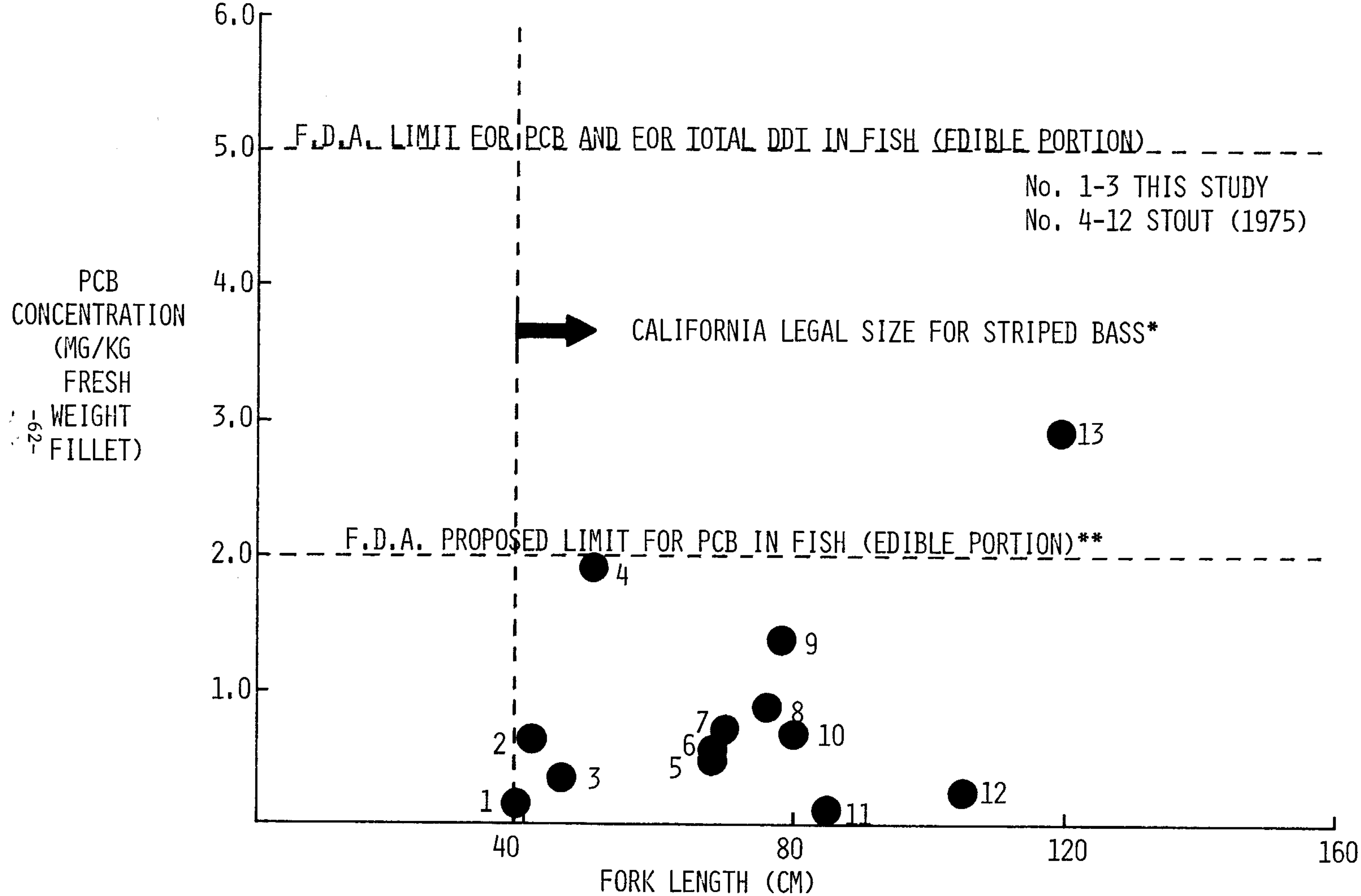
PCB concentrations were determined for 3 fillet samples. The amounts of these chlorinated hydrocarbons ranged from 0.16 to 0.63 mg/kg (= parts per million) fresh weight. These results were compared with those of Stout (1975) who had analyzed San Francisco Bay striped bass for PCB earlier. The comparison is represented in Figure 11. Together, the two studies show a general trend of increasing PCB with increasing size. However, two striped bass (#11 and 12) analyzed by Stout that were more than twice the size of those examined in this study (#1-3), had lower or similar PCB concentrations. This "scatter" is typical of PCB and DDT concentrations in fish Stout has analyzed (personal communication). Note also that the largest fish analyzed (#13) had the highest PCB concentration (2.9 mg/kg), while a fish almost as large (#12) had one of the lowest amounts of PCB.

The analysis of one fish for volatile toxic substances showed that traces of these compounds could be present. However, if present, the compounds were there in such minute quantities that they could not be distinguished from the normal "background" for positive identification. In future, this part of the analytical program will have to be pursued with great care because of the high volatility of the compounds sought.

FDA has set standards for two of the categories of compounds identified in the striped bass, PCB and total DDT. The limit for each is 5.0 mg/kg fresh weight edible tissue. Both the PCB and total DDT concentrations were below these limits in the fish analyzed. (FDA has proposed a regulatory limit of 2.0 mg/kg for PCB; this limit has been stayed pending resolution of an objection to the limit.) The levels of other toxic substances looked for in the samples

FIGURE 11

PCB CONCENTRATIONS IN SAN FRANCISCO
BAY AND DELTA STRIPED BASS



* LEGAL SIZE LIMIT IS 16 INCHES TOTAL LENGTH.

**PROPOSED LIMIT HAS BEEN STAYED PENDING COURT RESOLUTION OF OBJECTION TO THE NEW LIMIT.

were either low or not established because they were below detection limits in this screening study. The planned follow-on project will include a search for additional kinds of toxic compounds and will include a significant number of analyses of large, adult striped bass.

The basis of the conclusions just stated is identification of organic compounds. The health advisory referred to earlier is based on mercury concentrations measured in striped bass during the early 1970's.

Are the detected substances harmful to the fish? The petroleum and chlorinated hydrocarbons are fat soluble. They could be associated with fat wherever it is in the body. Generally, the higher the fat content in a tissue or organ, the higher will be the concentrations of the fat soluble compounds. The concentrations of the chlorinated hydrocarbons in the striped bass fillets were low. They can be expected to be higher in the eggs and liver, which contain more lipid. Exceptions to the rule have been recorded, however, for some fish (Stout, personal communication) and because of seasonal changes and variations in the size of fish.

The accurate evaluation of potential harm to the striped bass from toxic substances remains to be done. It awaits a detailed analysis of selected tissues and organs from different life stages of these fish. This work is part of the planned cooperative study.

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