STATE WATER RESOURCES CONTROL BOARD

SPECIAL PROJECTS

Toxic Substances Control Program

Second Progress Report

COOPERATIVE STRIPED BASS STUDY (COSBS)

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SECOND PROGRESS REPORT

Contributing Authors

Marvin Jung	Co-Project Director, COSBS Toxic Substances Control Program State Water Resources Control Board
Jeannette A. Whipple	Co-Project Director, COSBS Southwest Fisheries Center Tiburon Laboratory National Marine Fisheries Service
Gerald W. Bowes	Environmental Toxicologist Toxic Substances Control Program State Water Resources Control Board
L. Michael Moser	Parasitologist Center for Coastal Marine Studies University of California, Santa Cruz
Kris P. Lindstrom	Sanitarian-Pathologist School of Medicine University of California, Davis
Carol A. Reilly	Research Biologist Center for Coastal Marine Studies University of California, Santa Cruz
Judy A. Sakanari	Research Biologist Center for Coastal Marine Studies University of California, Santa Cruz
Sefton R. Wellings	Pathologist School of Medicine University of California, Davis

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

I. SUMMARY

On August 16, 1979, the State Water Resources Control 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 (Morone saxatilis) fishery (Resolution No. 79-70). Water quality is one of many possible factors that may be affecting fishery. Studies on other factors such as Delta outflow and food abundance effects are being conducted by the Department of Fish and Game. This cooperative study has 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 Second Progress Report. It summarizes information on annual pesticide use trends since 1971 in the Bay-Delta; results of comparative fish population surveys; results from the investigation of the cause of lesioned Bay-Delta striped bass; and discusses additional information needed to determine the causes of the declining striped bass fishery.

Since April 1980, the study team has focused work on the following questions:

1. Which pesticides might be potentially harmful to the striped bass fishery and what is the pattern of use of these pesticides?

2. How do striped bass from other areas compare to those of the Bay-Delta?

3. What may be causing the open lesions found in Bay-Delta striped bass?

4. What information or work must be obtained to determine the cause of the declining striped bass fishery?

5. What actions should be taken?

Preliminary Results

Pesticide use data was tabulated for five counties (Yolo, Solano, Contra Costa, Sacramento and San Joaquin) where striped bass spawn and young bass reside. During 1971-1979, a major increase in the use of seven pesticides occurred. The seven included two insecticide-acaricides (carbaryl and omite), two fumigants (ethylene dibromide, D-D mixture), two fungicides (captan, chlorothalonil) and multipurpose petroleum distillates. A significant increase was seen in the use of D-D (dichloropropene-dichloropropane mixture). In 1979, over 2,500,000 lbs. of D-D compounds were applied in the five counties. Applications of 13 pesticides occurred during striped bass spawning (April-June) in the Delta.

The 13 pesticides were omite, carbaryl, toxaphene, endosulfan, dicofol, methomyl, azinophosmethyl (insecticides-acaricides); D-D and related three carbon compounds (fumigant); captafol (fungicide); molinate, xylene, and xylene range aromatic solvents (herbicides); and petroleum distillates (multi-use). Most of these compounds were applied in April through October.

Complex mixtures of petroleum hydrocarbons are active ingredients of pesticides as well as carriers used in their application. Over 60 million lbs. of petroleum solvents have been used as pesticides since 1971. The average amount used as a pesticide for the past 5 years has been about 3 million lbs. annually in the five counties. Their use as carriers suggests a greater amount is being used and unaccounted for. Chemical analyses of fish taken from the Delta will measure pesticide level. How some of these pesticides might affect striped bass survival will be investigated in Part III Cause-and-Effects Lab Studies of the Cooperative Striped Bass Study.

2. How do striped bass from other areas compare to those of the Bay Delta?

   Striped bass were collected from Coos River, Oregon, and Lake Mead, Nevada, for comparison to the Bay-Delta bass. General preliminary examinations show:

   a. A higher frequency of hermaphroditism (bisexuality) occurs in the Coos River, Oregon, striped bass population than in the Bay-Delta population. In a 1950 study (Morgan and Gerlach), a three percent incidence of hermaphroditism was reported for Coos Bay striped bass. During 1980, 41 Coos Bay striped bass were collected. Eleven were hermaphrodites. In contrast, only one hermaphroditic Bay-Delta striped bass has been observed by the National Marine Fisheries Service in a sample of over 400 fish collected since 1978 (Whipple, 1980). The significance of this difference is unknown.

   b. From gross observations, it appears that the nonhermaphroditic Coos River striped bass are in better condition than the San Francisco Bay fish.

   c. Fish collected from San Francisco Bay during the 1980 prespawning migration continue to show relatively high levels of parasitism and poor condition. Some fish showed extensive visceral adhesions associated with lesions and parasitism. Some of these parasites are harmful to man (e.g., anisakids).

   d. Preliminary data indicates that the Coos Bay male and female striped bass may represent a healthy striped bass population from a relatively clean West Coast estuary. Completion of all analyses will determine if they are a good baseline population for comparison.

   e. An effort to compare summer die-off striped bass from Lake Mead, Nevada, to those in the Carquinez Strait-Suisun Bay area was made. The Lake Mead bass were transplanted from the Delta in 1969.

Summer die-off phenomenon similar to that seen in the western Delta for over 40 years occurred in Lake Mead each summer during 1976-1979. Unexpectedly, no die-off was seen in Lake Mead this year, although a summer die-off did occur in the western Delta. As a result, only 30 live Lake Mead bass were collected. These fish appeared thinner, weighed less, and had fewer parasites and skeletal abnormalities than Delta counterparts. The small sample size may not be indicative of the entire Lake Mead population. No earlier studies on bass health had ever been conducted on Lake Mead, so the data base is limited to drawing any conclusions.

3. What may be causing the open lesions found in Bay-Delta striped bass?

Progress was made in understanding the cause of lesions found in Bay-Delta striped bass. Observations indicate that the lesions are developed as an immunologic response to the Trypanorhyncha cestode larvae, Lacistorhynchus tenuis. This common tapeworm larvae is transmitted to fish through its food (e.g., shrimp, copepods). The adult tapeworms are found in elasmobranch fishes (sharks, rays, and skates). The cestode larvae burrows through the intestines and into the peritoneum (inside body wall). Clumps or rafts of these cestode larvae appear to create a severe immunologic response which we hypothesize to be the cause of the lesions.

Present information shows that only San Francisco Bay-Delta striped bass respond to the presence of these common parasites. These lesions are unique to the Bay-Delta bass. The study team recommends additional research to identify the cause of this severe immunologic response and its relation to changes in water quality as well as determine the synergistic relationship between parasitism and selected pollutants.

The significance of this problem as it relates to the overall decline of the fishery is unknown. A California Department of Fish and Game study recorded the incidence of striped bass caught with open lesions to be 11.8 percent (175 open lesioned bass/1,482 bass collected over a 35-day period) in 1979 and 8.4 percent (237 open lesioned bass/2,792 bass collected over a 54-day period) in 1980. The collections were made off Chipps Island.

The open lesions appear in late May. In 1979, the first open lesioned bass were collected by Fish and Game on May 21; in 1980, it was on May 22. The seasonal effect is unknown since the collections end in June.

More collections of lesioned bass are proposed. Answers to questions on whether the lesions heal or not have not been settled. Lesioned bass have been seen with pathogenic bacteria infections around the lesions. This suggests that the bass may succumb to infections that may lead to early mortality.

Recommendations for Action

Based on the recent preliminary findings of the Cooperative Striped Bass Study, the following recommendations are made:

1. On the basis of numerous known or suspected fish kills caused by pesticides and because of its prevalent use, an effort to measure selected pesticides (e.g., D-D mixture, toxaphene) in water should be initiated. Although the toxic pesticides may not be detected in adult striped bass, their presence in water and food may affect sensitive egg and larval stages. This information will supplement present tissue analyses of toxic materials.

2. Fish and Game should continue documenting incidence of lesioned striped bass. Continuous year-round sampling would provide information on seasonal variations of finding lesioned bass. Collections at other Bay-Delta sites would show geographic variations. The magnitude of this problem would also then be identified.

3. Determination of the synergistic effects of water quality changes on the ability of striped bass to combat fish disease and parasitism should be made. The lesioned bass problem associated with the Trypanorhynch tapeworm is unique to the San Francisco Bay-Delta striped bass. This tapeworm species, Lacistorhynchus tenuis, has a wide geographic range. It was reported in striped bass caught off Massachusetts in 1924 (Linton) and in a variety of other fishes (e.g., herring off Scotland, rockfish in San Francisco Bay, perch off San Diego). No other fish, including east coast striped bass which are infested with these tapeworm larvae, have been reported with similar lesions. Scientific evidence suggests that San Francisco Bay-Delta bass are hypersensitive to presence of these tapeworms and that the lesions result from an immunologic response.

   The immune response of the bass may have been altered by a combination of environmental stresses. The study team hypothesizes that a reduction in the ability of the striped bass to combat parasitic infestation has occurred. The health of other Bay fishes is unknown, however, open lesions have not been observed in these other fishes.

4. The cause of the mysterious summer die-offs of striped bass and other fish along Suisun Bay remains unknown. To the best of our knowledge, this repeated die-off phenomenon is also unique to the San Francisco Bay striped bass. Should the Fish and Game annual young striped bass indices remain low, the significance of the die-offs in reducing the reproductively valuable adult population may increase. A coordinated intensive effort to determine the cause(s) of the die-offs should be planned. Knowledge gained from the present study will greatly contribute towards developing a more thorough study of the die-off.

5. The State Board's Inland Toxic Substances Monitoring Program should consider broadening its scope of analyses to include such pesticides as D-D mixture, captan and other toxic compounds.

II. INTRODUCTION

In August of this year, the California Department of Fish and Game announced its 1980 striped bass index. The index is an indicator of the relative abundance of young striped bass through the first summer of life. This year's measured index was 14, or about 18 percent of the predicted index value of 77. It was the fifth consecutive year in which survival had been 50 percent or less of the 1959-1975 average. The measured index was expected to be higher since relatively high Delta outflow and the return of *Neomysis* abundance to predrought levels occurred. In view of the low indices, the State Water Resources Control Board, the California Department of Fish and Game, and the National Marine Fisheries Service are concerned about factors such as Delta outflow, *Neomysis* abundance, and toxic substances that may be impacting the striped bass population. While the Department of Fish and Game is continuing studies on the former two factors, the State Board and National Marine Fisheries Service are co-directing a cooperative study on a third factor. The study, named the Cooperative Striped Bass Study (COSBS), investigates three observed problems that may contribute to the decline of the bass population. It is hypothesized that these problems are related to toxic materials in Bay-Delta waters. The association among these problems is presently unknown.

The first observed problem is the general poor health of the striped bass. Prior to establishing this study, the National Marine Fisheries Service examined over 300 striped bass in 1978 and found fifty-four percent (54%) of the samples to be heavily parasitized to the extent that physiological damage to some vital and reproductive organs had resulted, thirty-seven percent (37%) had some type of skeletal abnormality, and thirty-five percent (35%) had damaged tissues resulting from lesions (J. Whipple, 1979).

The second observed problem is the die-off of bass each summer in the Carquinez Strait-Suisun Bay areas. These mysterious die-offs have been observed for over 40 years. Although Fish and Game studied the characteristics of the die-offs in 1971-1973, no answers to the cause were found (Kolhorst, 1973, 1975).

The third problem is the effect of open lesions found in Bay-Delta striped bass. For years it was thought that lampreys were attaching themselves to the bass and leaving these open wounds. The open wounds may make the fish more susceptible to disease and bacterial infections which may lead to early death.

Since March 1980, the cooperative study team has been collecting striped bass for comparison under Part II of the study plan. Part II work involves comparisons of striped bass populations from different West Coast environments. Part I tasks had involved literature information searches on toxic substances in the Bay-Delta and the results of this work were reported in the First Progress Report (SWRCB, 1980).

COOPERATIVE STRIPED BASS STUDY (COSBS)
ORGANIZATIONAL CHART

PROJECT DIRECTORS

Mary Jung, M.S.
SWRCB
(916) 322-8341

Jeannette Whipple
National Marine
Fisheries Service
(415) 435-3183

TECHNICAL ADVISORS

STRIPED BASS COLLECTIONS

Pete Chadwick, Director
Cal Fish & Game-Bay-Delta Project
(916) 466-4421

HEALTH ADVISORIES

Jack Sheneman, Ph.D.
Cal Dept. of Health Serv.
(916) 445-2263

FISH COLLECTIONS (BAY DELTA SURVEY)

Perry Hergesell, Ph.D.
Cal Fish & Game
(916) 455-4421

ENDOCRINOLOGY

Howard Bern, Ph.D.
U.C., Berkeley
(415) 642-4711

SCIENTIFIC LIAISON Public/Management

Bruce MacFarlane, Ph.D., Coordinator NMFS
Marvin Jung Coordinator SWRCB

Jeannette Whipple NMFS
Maxwell Eldridge NMFS
Nina Hirsch SFSU

PRIORITY POLLUTANTS CHEMISTRY

Gerald Bowes, Ph.D.
SWRCB
(916) 322-6826

PARASITOLOGY

Michael Moser, Ph.D.
U.C. Santa Cruz
(408) 429-4675
(408) 429-2464

HISTOPATHOLOGY

Sefton Wellings, Ph.D., M.D.
U.C. Davis School of Medicine
(916) 752-2710
(916) 453-3152

Kris Lindstrom, M.P.H.
U.C. Davis
(916) 447-5093

FIELD COLLECTIONS, SAMPLE PREPARATION, GENERAL BIOPSIES & HISTOLOGY

Mary Jung, M.S.
SWRCB
(916) 322-8341

Judy Sakanari, M.A.
Carol Reilly, B.S.
U.C. Santa Cruz
(415) 435-3697

TRACE METAL CHEMISTRY

Richard Hansen, Director
Norm Morgan, Chief Chemist
Cal Fish & Game Water Pollution Control Lab
(916) 355-0856

FISH PHYSIOLOGY, GILL TISSUES

Joseph Cech, Ph.D.
Steve Mitchell, M.S.
U.C. Davis, Dept. Fish Wildlife
(916) 752-0205

PETROLEUM HYDROCARBON CHEMISTRY

Pete Benville, M.S.
NMFS
(415) 435-3183

LARVAL STAGE STUDIES

Mick Eldridge, M.S. NMFS
Mark Kobe, A.S. NMFS
Karen Taberski, B.A. NMFS

BLOOD CHEMISTRY, CELLS, ELECTROPHORESIS, HISTOLOGY

Jeannette Whipple, Ph.D.
Michael Bowers, B.A.
Brian Jarvis, B.A.
NMFS
(415) 435-3183

EXPOSURE-TOXICITY BIOASSAYS

Nina Hirsch, M.S.

SFSU
Tiburon Center for Environmental Studies
(415) 435-1717

FIELD COLLECTIONS, SAMPLE PREPARATION & GENERAL BIOPSIES

Jeannette Whipple, Ph.D.
Brian Jarvis, B.A.
NMFS
(415) 435-3183

TRACE METAL CHEMISTRY-REFERENCE

George Collins, Chemist
Water & Power Resources Serv.
FTS 468-4507

BIOCHEMISTRY, HORMONES, ENZYMES

Bruce MacFarlane, Ph.D.
NMFS
(415) 435-3183

DATA MANAGEMENT

Jeannette Whipple, Ph.D.
Nancy Wiley, B.A. (ADP)
Rahel Fischer, Data Clerk
NMFS
(415) 435-3183
(415) 435-1007

PCB ANALYSES

NMFS- Microconstituents Task
Gloucester Lab
Don Gadbois, Ph.D.
(617) 281-3600

PROJECT TIMETABLE

(Revised 1/81)

PROJECT TITLE: COOPERATIVE STRIPED BASS STUDY (COSBS)

TASK NO.	TASK / ACTIVITY DESCRIPTION	1979			1980												1981								
		Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Sept
I.1	Identif. of major pollution sources	X	X	X	X	X																			
I.2.a.	ISHOW computer data search	X	X																						
I.2.b.	Chemical effects literature search	X												X	X				X	X	X	X			
I.2.c.	Parasite-diseases bibliographies	X	X	X	X	X																			
I.2.d.	Environmental effects literature search	postponed																							
I.3.	Screening Bay-Delta waters for toxics	proposed																							
II.1.	Identification of toxics in fish	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
II.2.	Comparative fish population surveys																								
	Routine Bay-Delta	X	X	X	X	X	X	X	X	X	X	X	X	X											
	Coos River, Oregon								X																
	Lake Mead, Nevada										X														
	Carquinez Strait die-off									X	X	X													
	Lesioned striped bass									X															
III.	Cause and effects laboratory studies																	X	X	X	X	X	X		
IV.	Data evaluation and reports																								
	Data analysis												X	X	X	X	X	X	X	X	X	X	X	X	
	Progress reports						X							X					X						
	Final report																								X

III. SECOND PROGRESS REPORT

Task I.1. - Annual Pesticide Use Trends in Five Bay-Delta Counties, 1971-1979
Gerald W. Bowes, Ph.D. 1/ and Marv Jung 1/

Work has continued in obtaining and reviewing pesticide use information. Previous tabulations of pesticide use data and pesticide partition coefficients, which represent their potential to concentrate in animal fat, were reported in the First Progress Report of the Cooperative Striped Bass Study. In view of the lethal and sublethal effects of pesticides and their heavy use in the Delta, pesticides are being considered as possibly contributing to the decline of the striped bass fishery. We define "pesticides" as toxic chemicals used to control pests such as rodents, insects, and unwanted vegetation. Pesticides include herbicides, insecticides, acaricides (miticides), fungicides, fumigants, bactericides, algicides, and nematocides.

Our second phase work to assess the effects of pesticides included:

1. Tabulating the top 100 pesticides used during 1971-79 for five counties (Solano, Yolo, Contra Costa, Sacramento and San Joaquin). Striped bass spawn and spend much of their younger lives in the waters of these five counties (Table 1). The integrated top 100 list for this grouping may be more meaningful than the comparable integrated list for the ten counties reported in the First Progress Report which included a larger watershed area.

2. Plotting 1979 monthly pesticide use and annual use data for 1971 through 1979 for 27 selected pesticides used in the five counties (Again, this use data represents integrated information for the five counties. Figures 1-a - 1-aa). The 27 pesticides were selected from the top 100 as being potentially most toxic to aquatic life. The selection was made by G. W. Bowes and D. G. Crosby. 2/

The above tabulations were made to compare monthly and annual trends in the use of pesticides. The data base for the tabulations was the computerized Data Bank of Pesticide Use in California, maintained by the Food Protection and Toxicology Center and Department of Environmental Toxicology at the University of California, Davis. Pesticide Use Reports for all 58 counties in California since 1971 are stored in the Data Bank through the cooperation of the California Department of Food and Agriculture. However, computer programs have to be written to display the data in the format that a user wants, such as a ranking of the top 100 as shown in this report.

The Use Reports are submitted by licensed structural and agricultural pest control operators, government agencies (e.g., highway and park

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1/ Toxic Substances Control Program, California State Water Resources Control Board.

2/ Department of Environmental Toxicology, University of California, Davis.

TOP 100 PESTICIDES BY TOTAL LBS APPLIED
IN 1979 IN THE SPECIAL GROUP OF 5 COUNTIES: SOL.,YOLO,SAC.,S.J.,C.C.

RANK	CHEM	TOTAL LBS	ACRES		
1	00560	3858108.35	207559.54	*	SULFUR
2	00185	2252926.64	33057.35	*	D-D MIXTURE
3	00473	2203735.78	40585.50	*	PETROLEUM HYDROCARBONS
4	00765	517958.66	27103.50	*	PETROLEUM OIL, UNCLASSIFIED
5	00763	507728.72	25285.00	*	PETROLEUM DISTILLATES
6	00385	286295.87	11352.40	*	METHYL BROMIDE
7	00271	255246.63	10490.00	*	ETHYLENE DIBROMIDE
8	00445	249820.25	116074.80		PROPARGITE
9	00105	238953.16	118871.69	*	CARBARYL
10	00622	226555.17	133026.52	*	XYLENE
11	00573	222354.27	2245.00		1,2-DICHLOROPROPANE,1,3 DICHLOROPROPENE AND RELATED C3 COMPOUNDS
12	00449	165795.20	41042.00		MOLINATE
13	00292	158625.49	80278.40		CAPTAFOL
14	00752	142508.32	59765.20	*	AROMATIC PETROLEUM SOLVENTS
15	00594	119515.13	30020.00	*	TOXAPHENE
16	00806	114464.38	119353.24	*	2,4-D, DIMETHYLAMINE SALT
17	00238	101651.01	28888.50		DNBP
18	00677	95639.48	47848.77		CHLOROTHALONIL
19	00045	89130.29	20727.75	*	ATRAZINE
20	00862	88574.49	76898.63		XYLENE RANGE AROMATIC SOLVENT
21	00314	87532.20	77314.67		AZINPHOSMETHYL
22	00231	79119.90	22384.15	*	DIURON
23	00786	71878.65	69231.80	*	MCPA, DIMETHYLAMINE SALT
24	00259	71254.01	87114.92	*	ENDOSULFAN
25	00383	68637.59	137091.83	*	METHOMYL
26	00104	61763.21	21764.36	*	CAPTAN
27	00151	60702.28	12991.00		COPPER HYDROXIDE
28	01601	57176.53	166409.37	*	PARAQUAT DICHLORIDE
29	00459	56951.44	67782.00		PARATHION
30	00198	56195.69	46446.44	*	DIAZINON
31	00136	50019.67	12249.31	*	CHLOROPICRIN
32	00162	49585.26	5236.50		COPPER SULFATE (BASIC)
33	00346	48911.14	37374.01	*	DICOFOL
34	00536	46987.20	6488.50		SODIUM CHLORATE
35	00801	44255.92	38411.80	*	2,4-D, ALKANOLAMINE SALTS (ETHANOL AND ISOPROPANOL AMINES)
36	00394	40488.22	63559.50		METHYL PARATHION
37	00629	40375.72	8140.00		ZIRAM
38	00230	40115.33	52326.49		DESULFOTON
39	00161	39317.38	1199.00		BLUE VITRIOL
40	00130	37469.02	622.00	*	CHLORDANE
41	00367	34315.39	10768.25	*	MALATHION
42	00020	34156.16	398.23	*	AMITROLE
43	00181	33683.12	6294.00		FENSULFOTHION
44	00678	32091.18	14727.50		ALACHLOR
45	00401	31866.06	5917.00	*	MINERAL OIL
46	00226	28989.36	5536.00		DIPHENAMID
47	00384	28820.80	26886.00	*	METHOXYCHLOR
48	00531	28327.24	3269.53	*	SIMAZINE
49	01697	26839.93	28294.00		METHAMIDOPHOS
50	01855	26603.10	1919.88	*	GLYPHOSATE, ISOPROPYLAMINE SALT

RANK	CHEM	TOTAL LBS	ACRES		
51	00392	26332.20	1077.00	*	METHYLISOTHIOCYANATE
52	00575	26102.47	6497.88	*	ALDICARB
53	00109	25750.57	98.00	*	CARBON TETRACHLORIDE
54	00211	25610.72	9897.00		MANEB WITH ZINC ION
55	00534	24045.17	5347.00		SODIUM ARSENITE
56	01800	23819.90	0.00		DISODIUM OCTABORATE TETRAHYDRATE
57	00088	23691.16	19474.18	*	TRICHLOROPHON
58	01814	22477.06	56568.29	*	PETROLEUM DISTILLATE, AROMATIC
59	01552	22389.40	29018.25	*	BENOMYL
60	00335	21799.50	14478.50		IMIDAN
61	01626	20896.04	26500.00		ETHEPHON
62	00369	20852.64	6948.11		MANEB
63	00216	20148.86	31680.73		DIMETHOATE
64	00418	17324.66	16684.50		NALED
65	00590	16080.08	2728.50		S-PROPYL BUTYLETHYLTHIOCARBAMATE
66	00479	14866.74	7099.50		PHOSALONE
67	00503	14208.96	2855.00		PROPANIL
68	01692	14172.26	21774.00		METRIBUZIN
69	00173	14120.64	2076.00		CRYOLITE
70	01685	13846.81	17749.80	*	ACEPHATE (ORTHENE-R)
71	00239	13744.59	6047.50		DNBP, AMINE SALTS
72	00689	12742.73	0.00		SODIUM METABORATE
73	01314	12114.49	31873.72		POLY-1-PARA-MENTHENE
74	00636	11131.55	12209.00		2,4-D
75	01930	10535.18	10721.00		DIFENZOQUAT
76	01728	10155.06	6371.50	*	NAPROMIDE
77	00714	9997.93	2944.00		COPPER
78	00478	9787.73	10273.00		PHORATE
79	00339	9137.55	2151.00		IPC
80	00083	9061.32	156.73		BROMACIL
81	00748	8791.58	19931.33		ALKYLARYLPOLY/OXYETHYLENE/GLYCOL
82	00021	8464.02	45.25		AMMONIUM SULFAMATE
83	00834	8313.40	10333.00		BROMOXYNIL OCTANOATE
84	00788	7990.45	7801.00		MCPA, SODIUM SALT
85	01096	7895.84	7956.50		2,4-D, N-OLEYL-1,3-PROPYLENEDIAMINE SALT
86	01868	7892.11	36.50		ORYZALIN
87	00849	7693.84	17895.53	*	DICAMBA, DIMETHYLAMINE SALT
88	00597	7534.57	10633.05		TRIFLURALIN
89	00264	7365.85	2208.50		EPTAM-R
90	01081	7062.26	1090.00		DALAPON, SODIUM SALT
91	00274	6955.34	98.00	*	ETHYLENE DICHLORIDE
92	00179	6612.79	406.33		DIMETHYL TETRACHLOROTEREPHTHALATE
93	00110	6560.59	5395.50		CARBOPHENTHION
94	00229	6554.39	12.50		DIQUAT DIBROMIDE
95	01689	6539.22	10281.00		METHIDATHION
96	00359	6504.39	313.00	*	LINDANE
97	01385	6254.33	4354.00		4(2,4-DB), ISOOCTYL ESTER
98	00268	6027.25	4126.50		ETHION
99	00240	5813.03	7275.00		DNBP, AMMONIUM SALT
100	00342	5337.01	26554.83		ISOPROPYL ALCOHOL

1,2-DICHLOROPROPANE, 1,3-DICHLOROPROPENE AND RELATED C3 COMPOUNDS

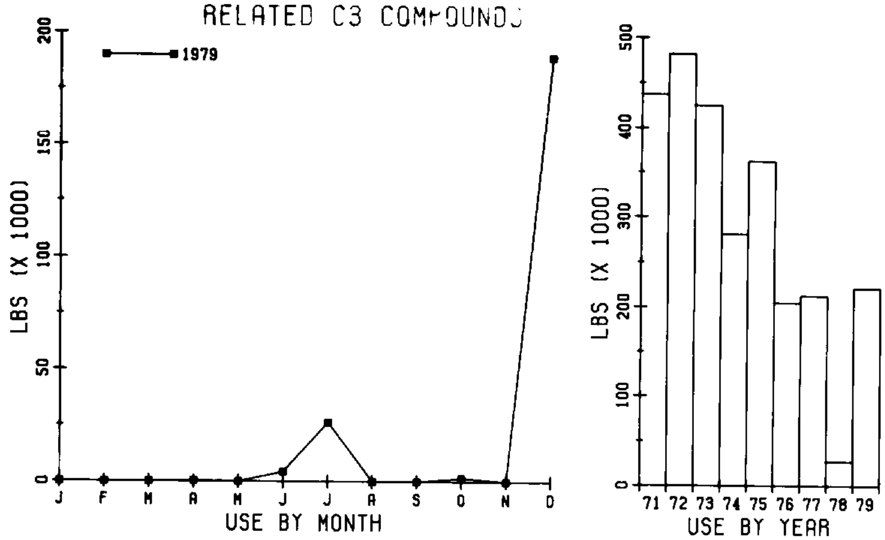

Figure 1-a

MOLINATE (ORDRAM-R) IN 5 SELECTED COUNTIES

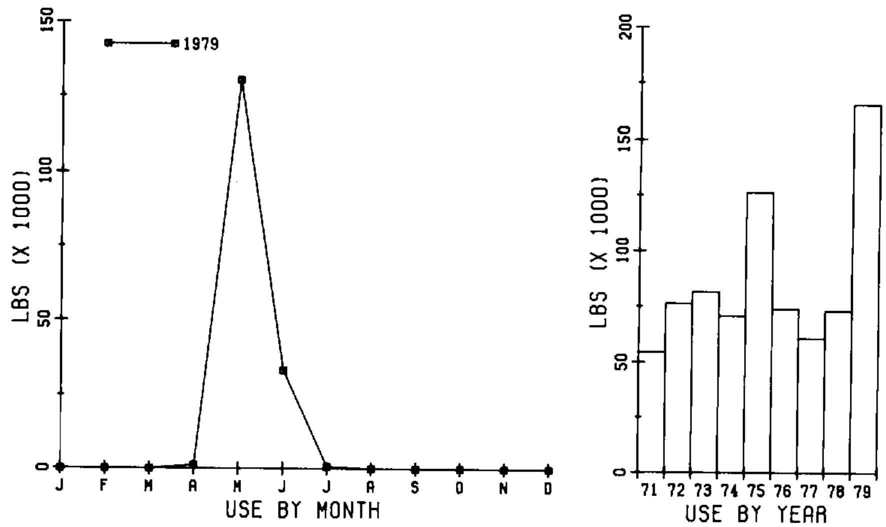

Figure 1-b

CAPTAFOL (DIFOLATAN) IN 5 SELECTED COUNTIES

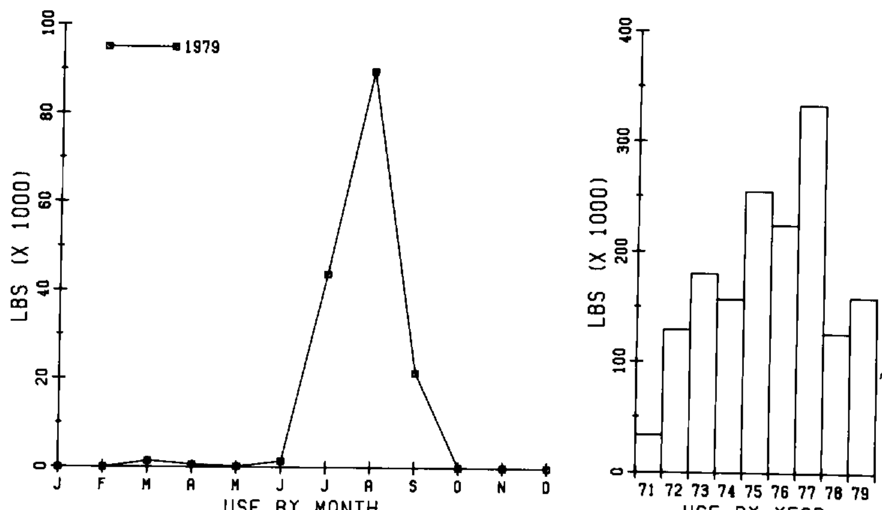

Figure 1-c

CHLOROPICRIN IN 5 SELECTED COUNTIES

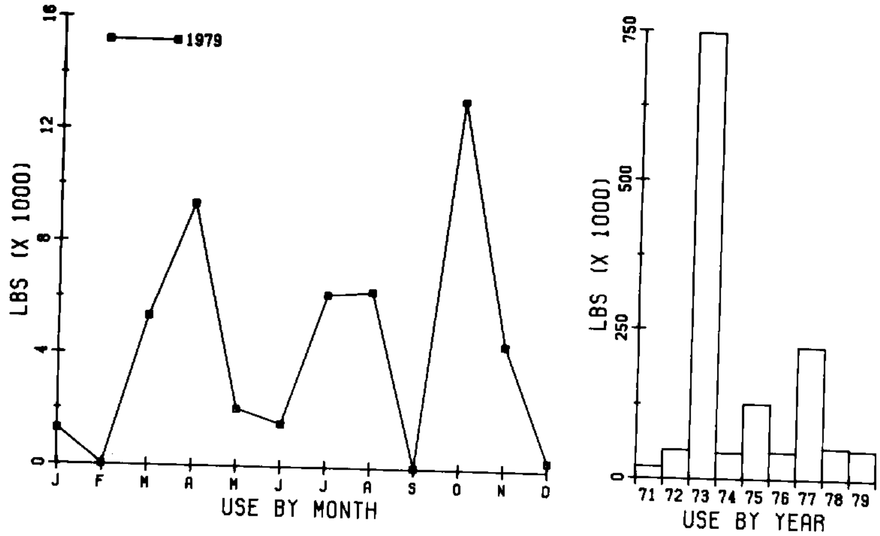

Figure 1-d

DICOFOL (KELTHANE) IN 5 SELECTED COUNTIES

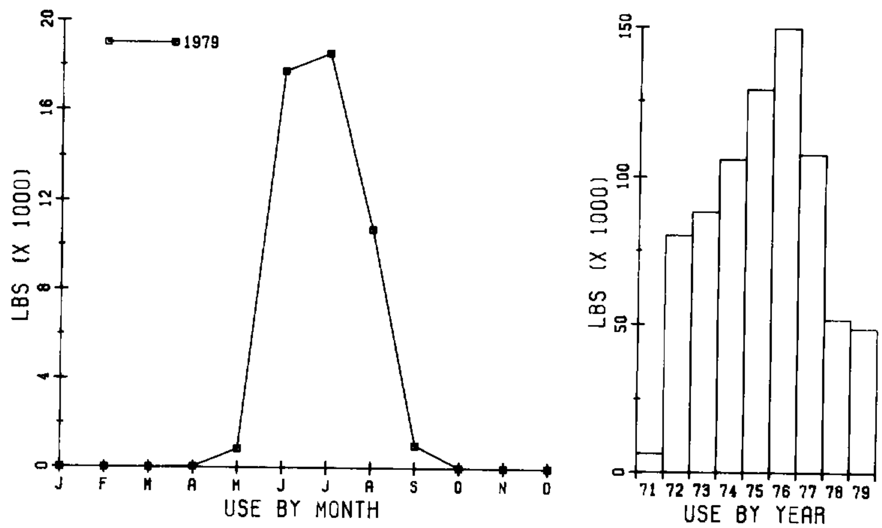

Figure 1-e

METHYL PARATHION IN 5 SELECTED COUNTIES

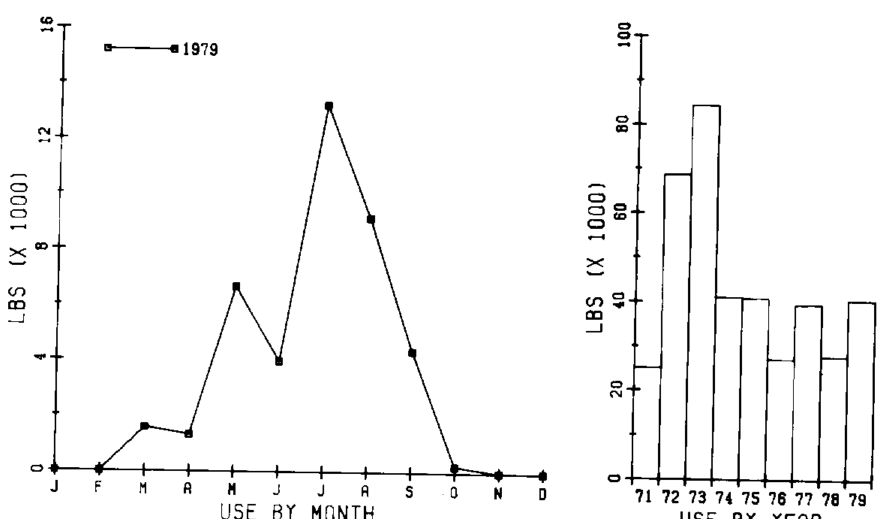

Figure 1-f

CAPTAN IN 5 SELECTED COUNTIES

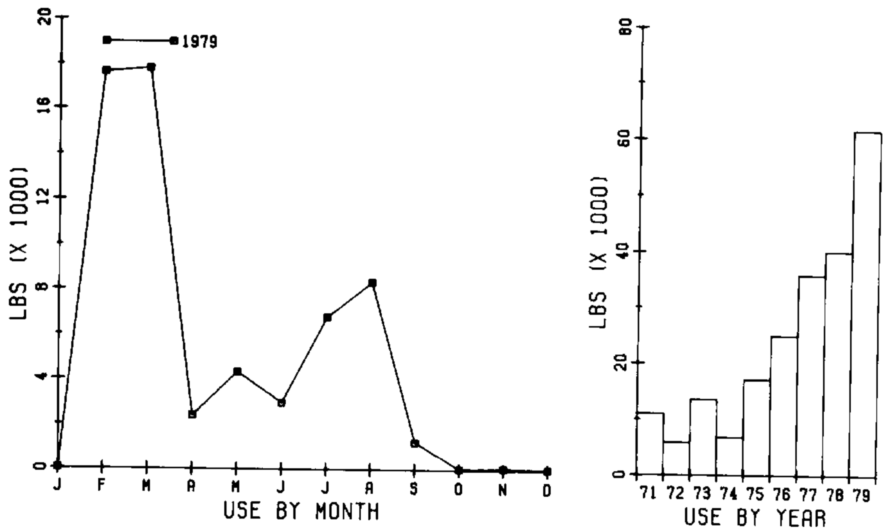

Figure 1-g

PARATHION IN 5 SELECTED COUNTIES

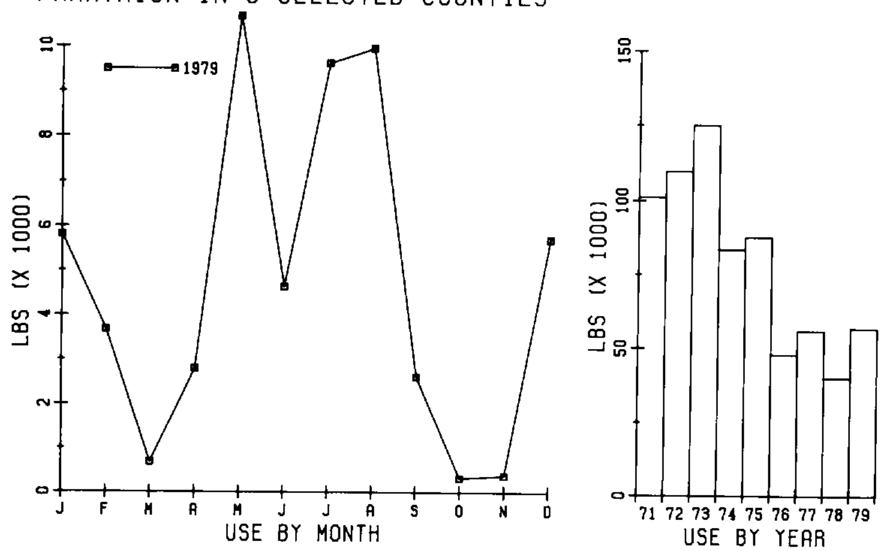

Figure 1-h

DIAZINON IN 5 SELECTED COUNTIES

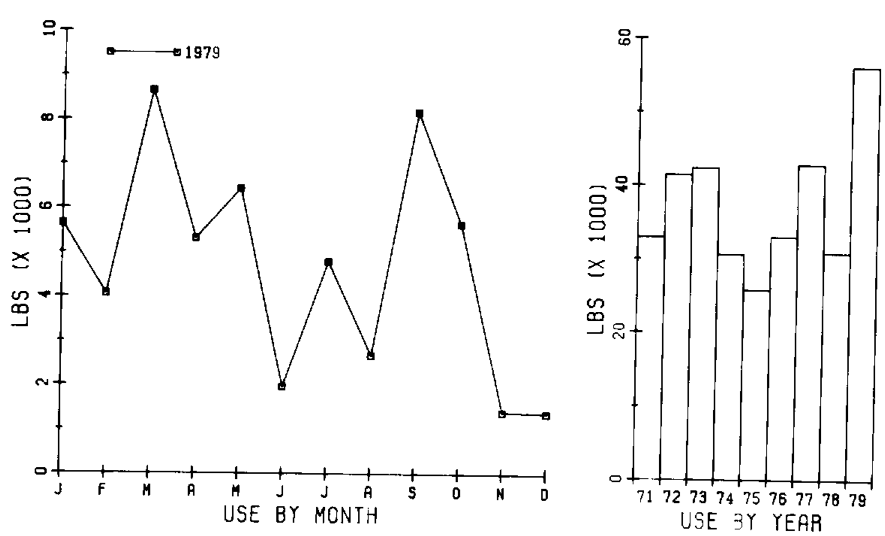

Figure 1-i

OMITE (PROPARGITE) IN 5 SELECTED COUNTIES

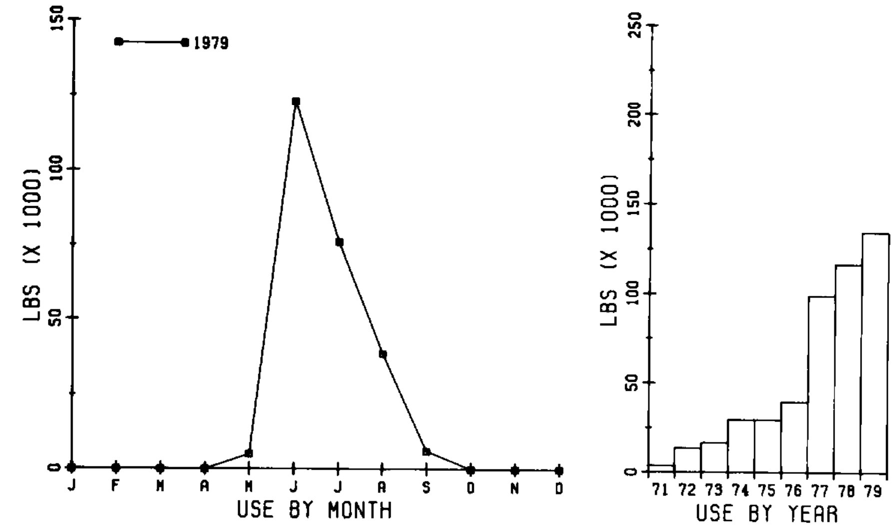

Figure 1-j

CARBARYL (SEVIN) IN 5 SELECTED COUNTIES

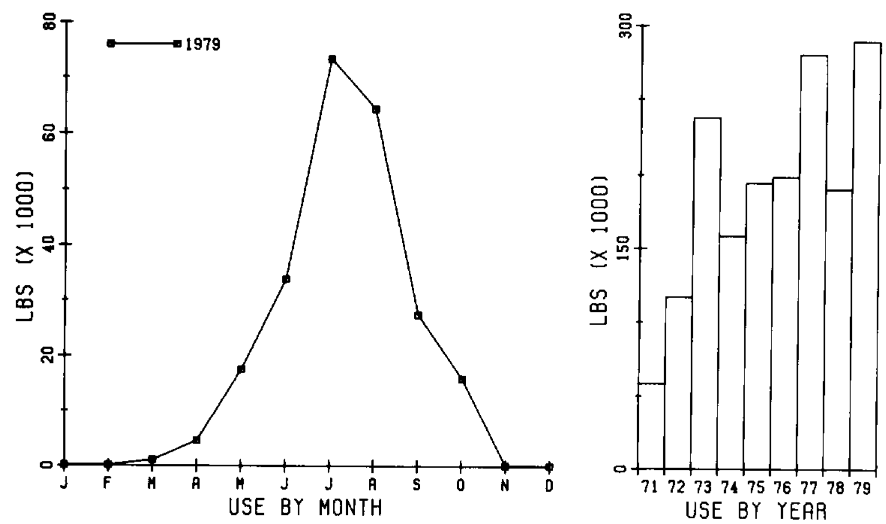

Figure 1-k

XYLENE IN 5 SELECTED COUNTIES

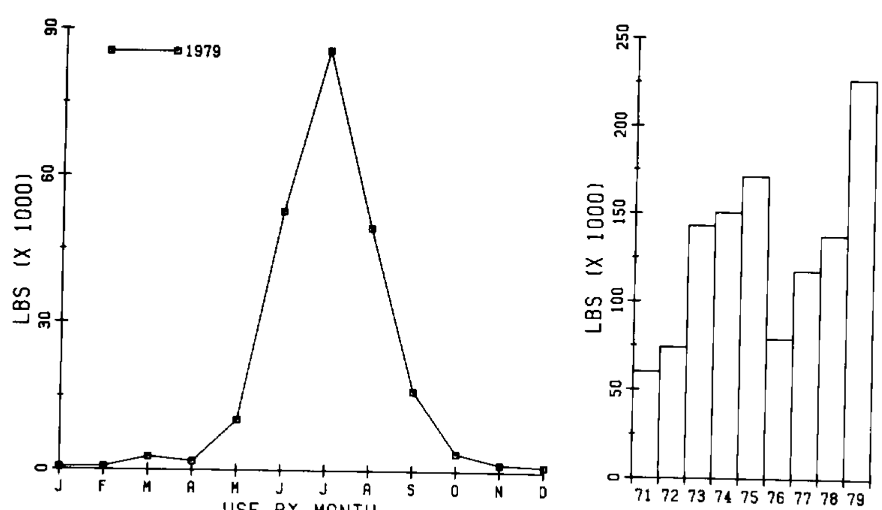

Figure 1-l

AROMATIC PETRO. SOLVENTS IN 5 SELECTED COUNTIES

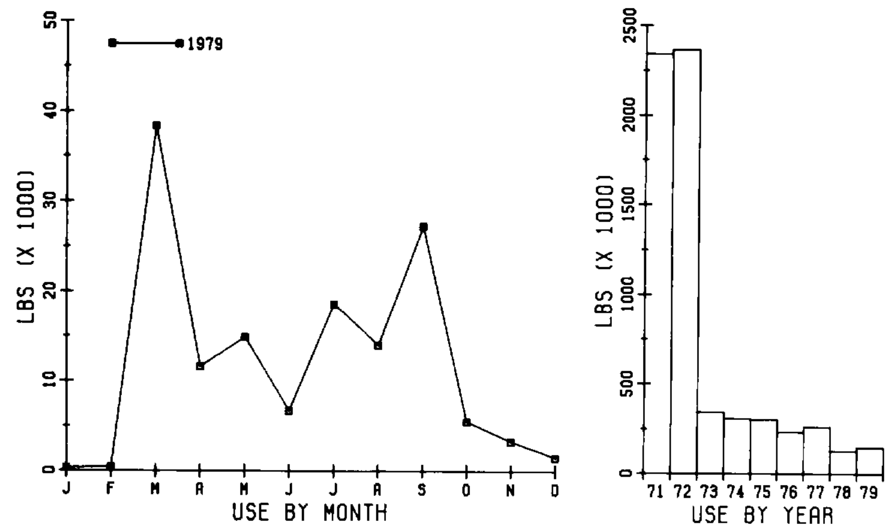

Figure 1-m

TOXAPHENE IN 5 SELECTED COUNTIES

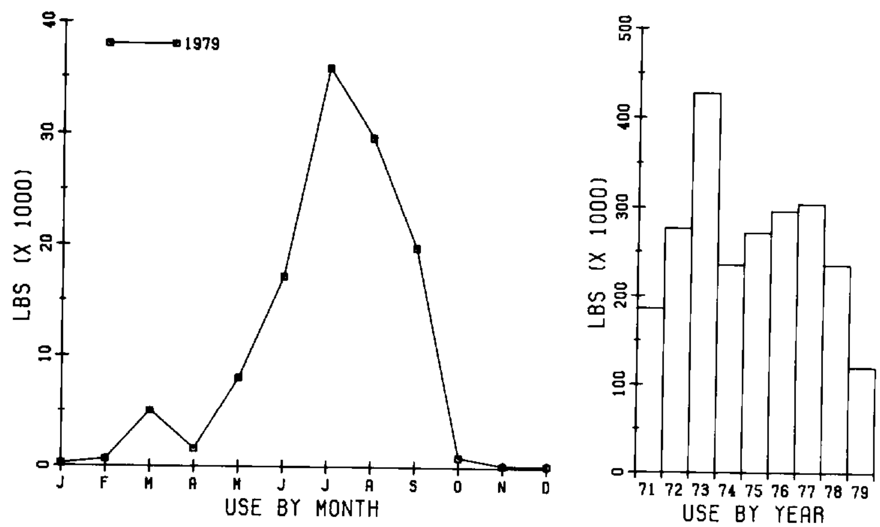

Figure 1-n

DNBP IN 5 SELECTED COUNTIES

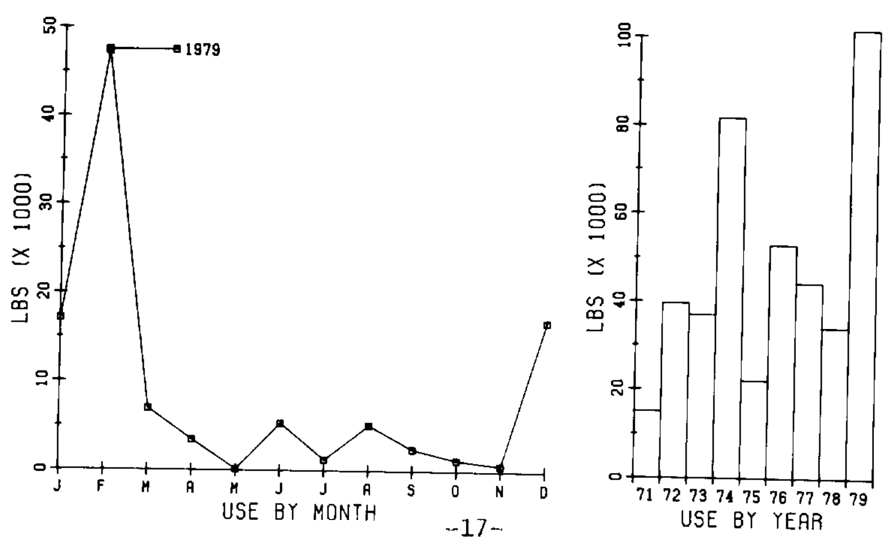

Figure 1-o

D-D MIXTURE IN 5 SELECTED COUNTIES

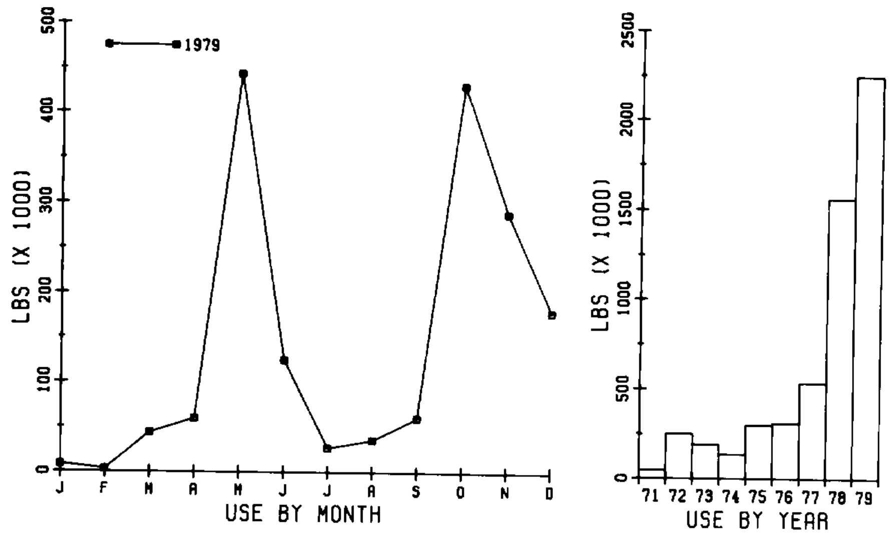

Figure 1-p

PETROLEUM HYDROCARBONS IN 5 SELECTED COUNTIES

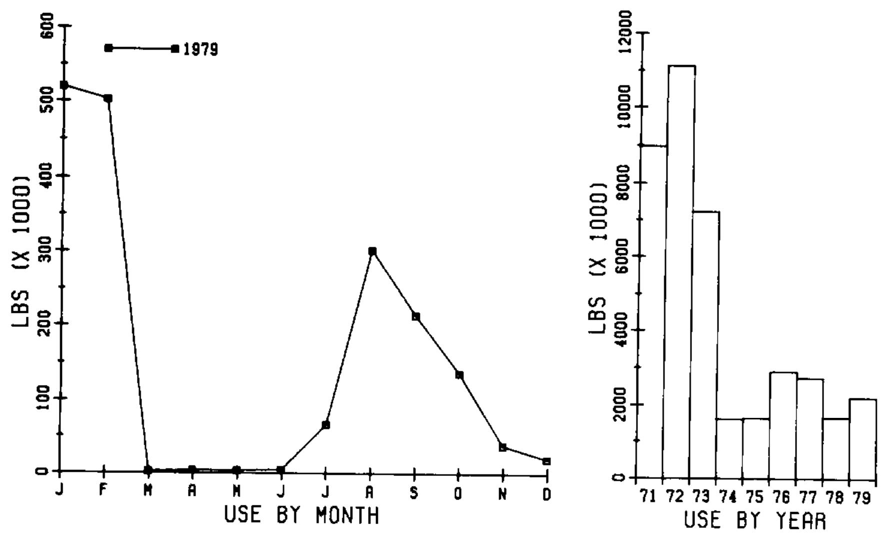

Figure 1-q

PETROLEUM OIL, UNCLAS. IN 5 SELECTED COUNTIES

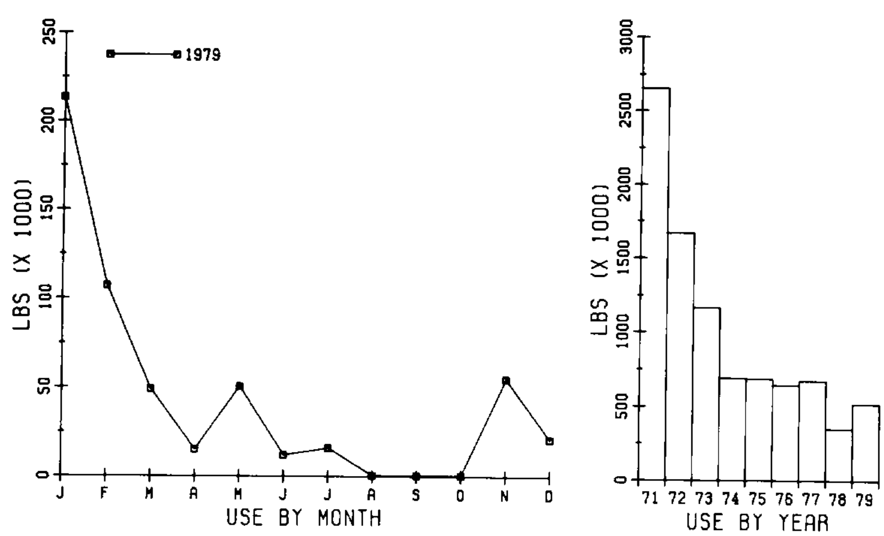

Figure 1-r

DIURON IN 5 SELECTED COUNTIES

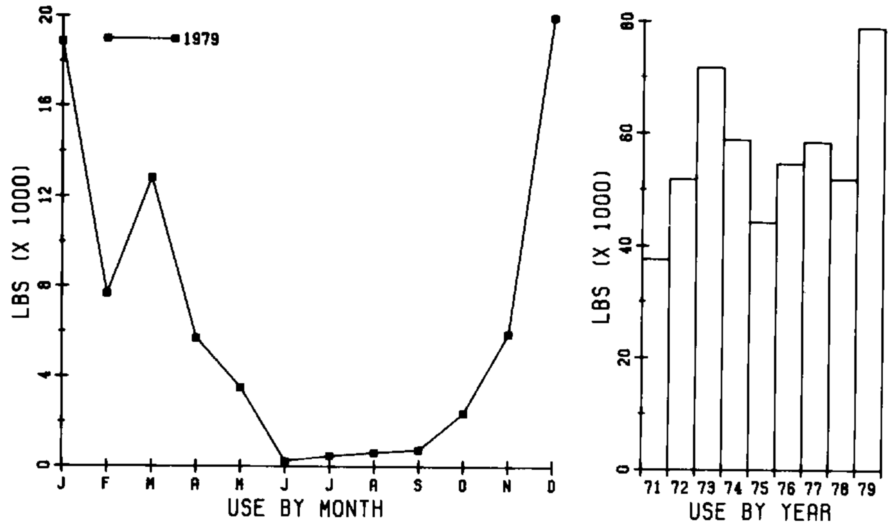

Figure 1-s

ENDOSULFAN IN 5 SELECTED COUNTIES

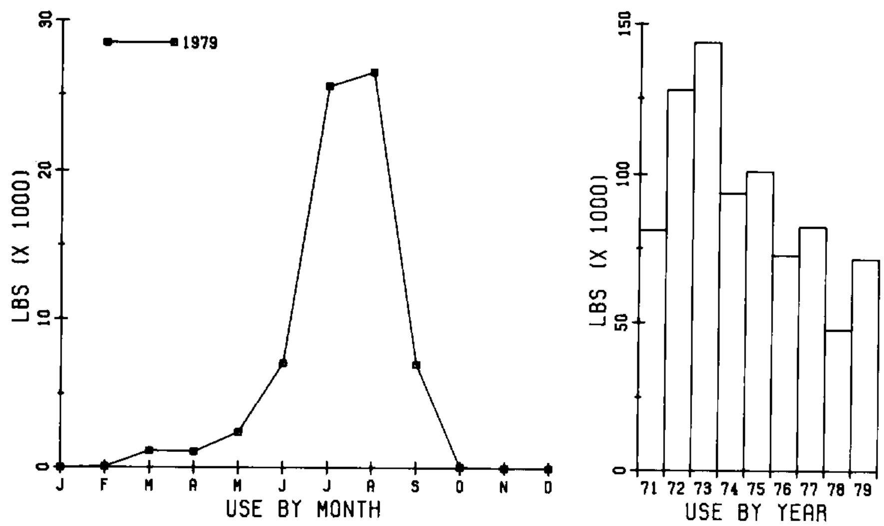

Figure 1-t

METHOMYL IN 5 SELECTED COUNTIES

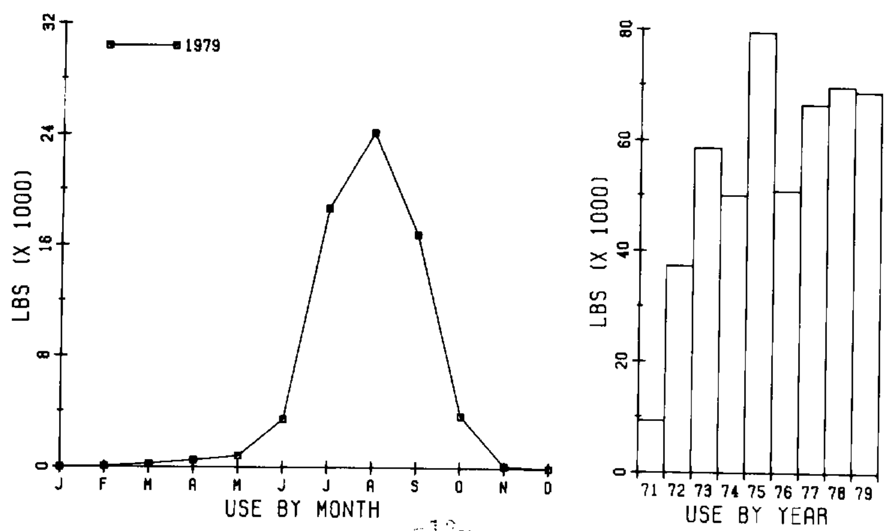

Figure 1-u

PETROLEUM DISTILLATES IN 5 SELECTED COUNTIES

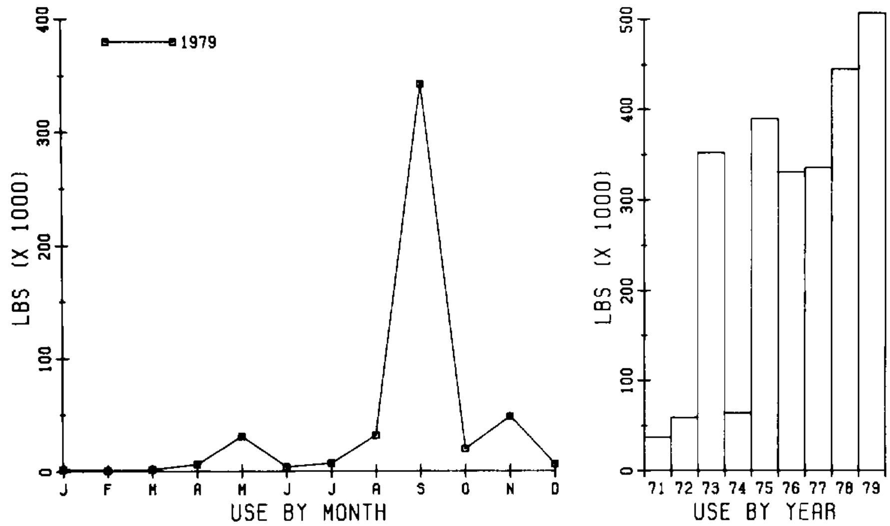

Figure 1-v

METHYL BROMIDE IN 5 SELECTED COUNTIES

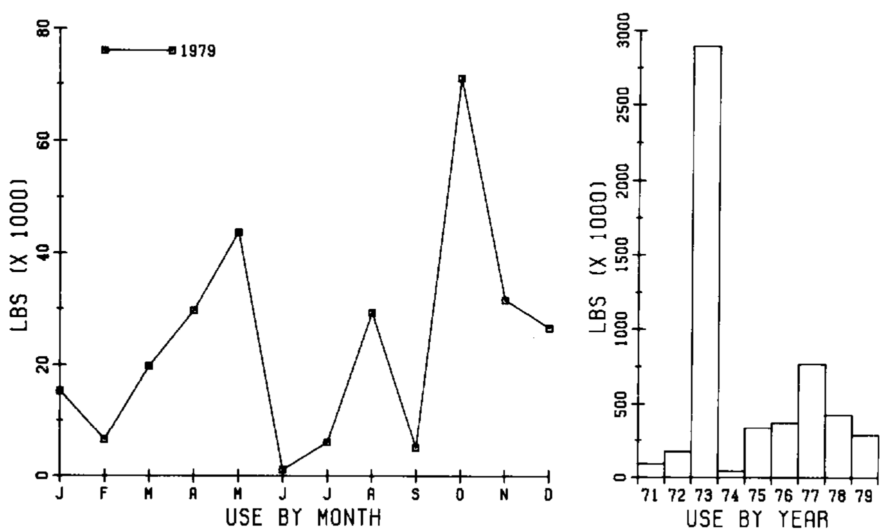

Figure 1-w

ETHYLENE DIBROMIDE IN 5 SELECTED COUNTIES

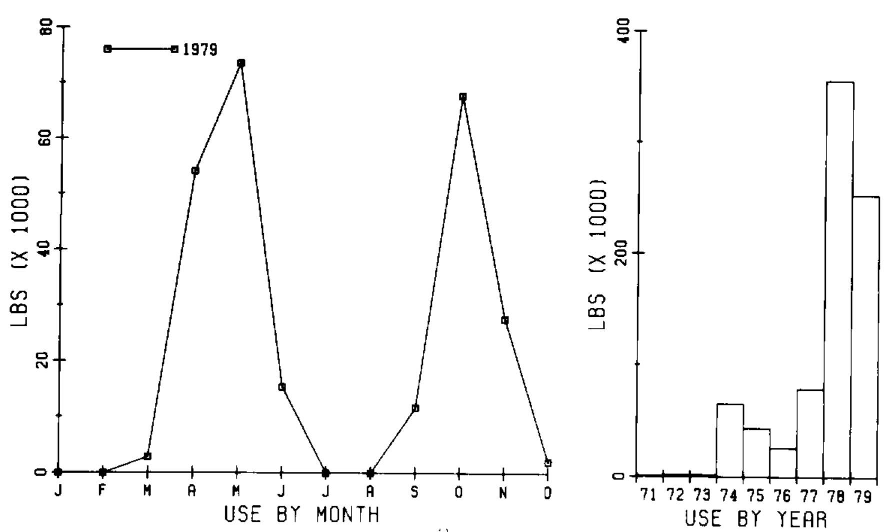

Figure 1-x

CHLOROTHALONIL(DACONIL) IN 5 SELECTED COUNTIES

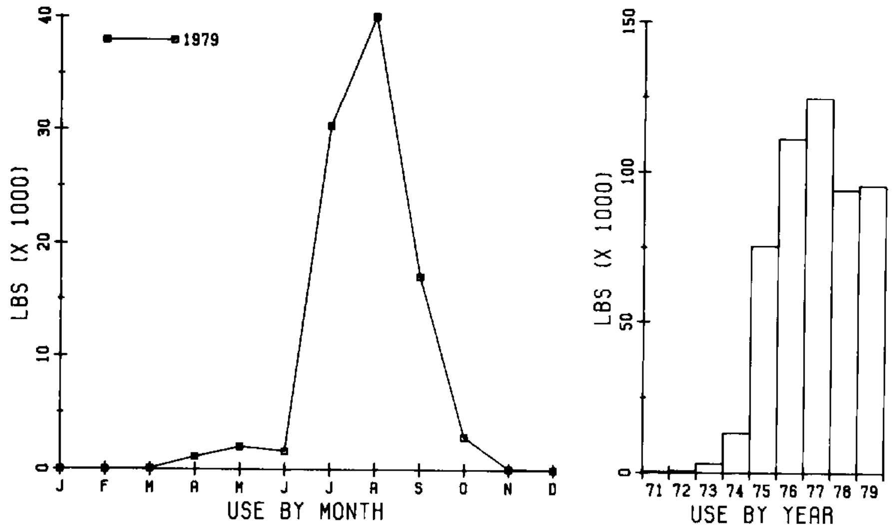

Figure 1-y

XYLENE RANGE AROMATIC SOLVENT IN 5 COUNTIES

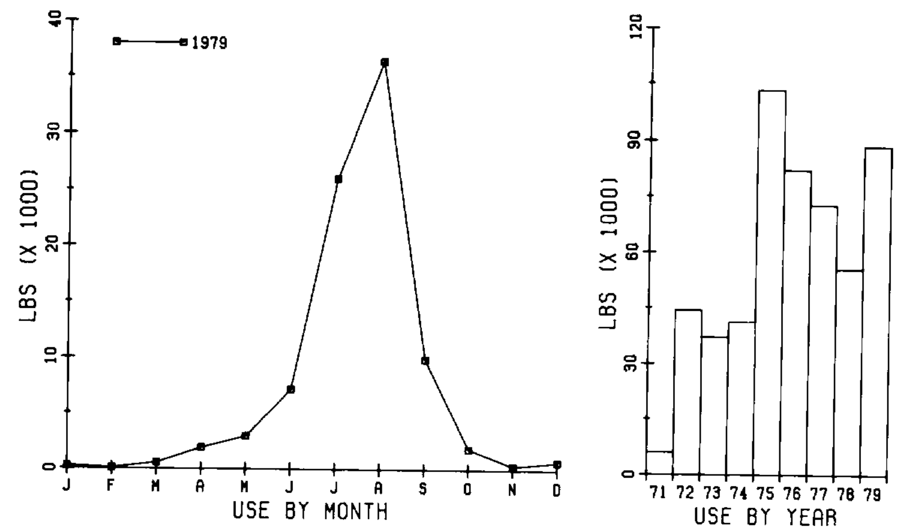

Figure 1-z

AZINOPHOSMETHYL(GUTHION) IN 5 SELECTED COUNTIES

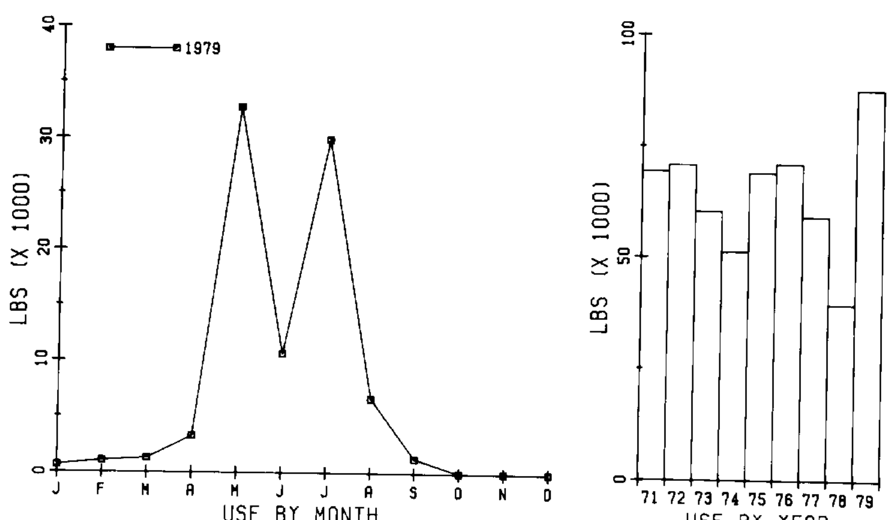

Figure 1-aa

Table 2a. Restricted Materials for Which a Permit is Required for Possession and Use[a]

A. Certain pesticides containing arsenic:
   1. Sodium arsenite
   2. Other pesticides containing inorganic arsenic[b]
B. Pesticides containing cadmium[b]
C. Pesticides containing mercury[b]
D. Carbamates:
   1. Aldicarb (Temik)[b]
   2. Carbaryl (Sevin)[b]
   3. Carbofuran (Furadan)
   4. Methomyl (Lannate)
E. Fumigants:
   1. Chloropicrin[b]
   2. Methyl bromide[b]
   3. Aluminum phosphide (Phostoxin)
   4. Carbon bisulfide
   5. Calcium cyanide
F. Mercury-treated seeds
G. Endrin-treated conifer seeds
H. Avicides:
   1. Avitrol
   2. Starlicide
   3. Strychnine
I. Rodenticides:
   1. Sodium fluroacetate (Compound 1080)
   2. Strychnine[b]
   3. Zinc phosphide[b]
J. Organic phosphorus compounds:
   1. Azinphosmethyl (Guthion)
   2. Carbophenothion (Trithion)
   3. Bidrin
   4. Azodrin
   5. Monitor
   6. Supracide
   7. Demeton (Systox)
   8. Disulfoton (Di-Syston)[b]
   9. EPN
   10. Ethion
   11. Nemacur
   12. Methyl Parathion
   13. Mevinphos (Phosdrin)
   14. Parathion
   15. Phorate (Thimet)
   16. Phosphamidon
   17. Schradan (OMPA)
   18. Sulfotepp
   19. TEPP
   20. Dialifor (Torak)
   21. Dasanit
   22. Mocap
K. Chlorinated Hydrocarbons:
   1. Aldrin[b]
   2. Benzene hexachloride (BHC)[b]
   3. Chlordane[b]
   4. DDT (TDE)
   5. DDT
   6. Dieldrin[b]
   7. Endosulfan (Thiodan)[b]
   8. Endrin
   9. Heptachlor[b]
   10. Lindane[b]
   11. Toxaphene
L. All other dusts except those products containing only exempt materials[b]
M. Other pesticides:
   1. Paraquat
   2. Sodium cyanide

Restricted herbicides for which a permit is required for possession and use:

(a) 2,4-D
(b) 2,4,5-T
(c) MCPA
(d) 2,4-DP
(e) Silvex
(f) 2,4-DB
(g) Picloram
(h) Propanil
(i) Dicamba (Banvel)

[a] Source: California Department of Food and Agriculture.

[b] Permit not required for home use, structural pest control, industrial and institutional uses, and uses by certain public agencies.

Table 2b. Permit Exemptions. No permit is required for the following materials or situations.

Restricted Materials:

- Materials labeled for use on livestock or poultry;
- Ready-to-use syrups or dry baits containing sodium arsenite;
- Home use, structural pest control, industrial and institutional uses, and uses by certain public agencies;
- Granular formulations of Furdan containing not more than 5% active ingredient;
- Chloropicrin or methyl bromide packaged in containers holding 1.5 lb or less;
- Paraquat for home use only when possessed and used in accordance with registered labeling;
- Mocap except for turf uses; or
- Other dusts--not containing restricted material--in containers holding 25 lbs or less or for use in enclosed areas such as greenhouses.

Restricted Herbicides:

- Up to 1 gal liquid per 25-hr period if containing less than 1.25% active ingredient;
- Up to 1 pt liquid or 1 lb dry per 24-hr period regardless of content of active ingredient;
- Up to 50 lb dry commercial fertilizer, agricultural mineral, or granular material per 24-hr period if containing less than 10% active ingredient;
- A wax block impregnated with a restricted herbicide;
- Up to 1 qt of ready-to-use solution;
- Up to 1 qt of Dicamba (Banvel) per 24-hr period regardless of content of active ingredient.

General:

1. The person in charge of the property to be treated and/or the pest control operator may apply for a permit but no permit shall be valid for possession or use by any operator or person not named in the permit.

2. The person named in a restricted materials permit is authorized to possess materials for which the permit was valid after such permit expires, provided they are stored in accordance with Section 3136.

Refer to Regulations (Table 2a) for specific permit requirements.

The primary routes of pesticide entry into the environment include runoff and sediment transport, subsurface drainage, direct application to water systems, wastewaters, atmospheric transport and spills. Runoff and sediment transport to surface waters are considered to be the major pathways of pesticides to an aquatic system (Nicholson, 1970). The cycling of pesticides and pathways by which they enter an aquatic system are shown in Figure 2. While the aquatic environment has many potential transformational pathways for altering pesticides, the persistence and toxicity of many pesticides can remain a threat to aquatic life for many years.

Persistence can prolong adverse effects on nontarget organisms without prolonging the beneficial effects intended for their use (Figure 3). With a greater persistence, the potential for bioaccumulation and bioamplification increases. There also is little knowledge on the effects of the degradation products on the aquatic environment.

1971-1979 Pesticide Use Trends

The annual use bar graphs (Figures 1-a - 1-aa, right side) show a significant increase in the use of seven of the 27 pesticides during the 9-year period (1971-1979). The seven pesticides include two insecticide-acaricides (carbaryl and omite), two fumigants (ethylene dibromide, D-D mixture), two fungicides (captan, chlorothalonil) and petroleum distillates.

Crop use information for the use of D-D (dichloropropane-dichloropropene) was developed because of its dramatic increase in use and its rank (No. 2) in use in the five counties. The amounts of D-D and crops on which it was applied in 1979 are listed for each county in Table 4.

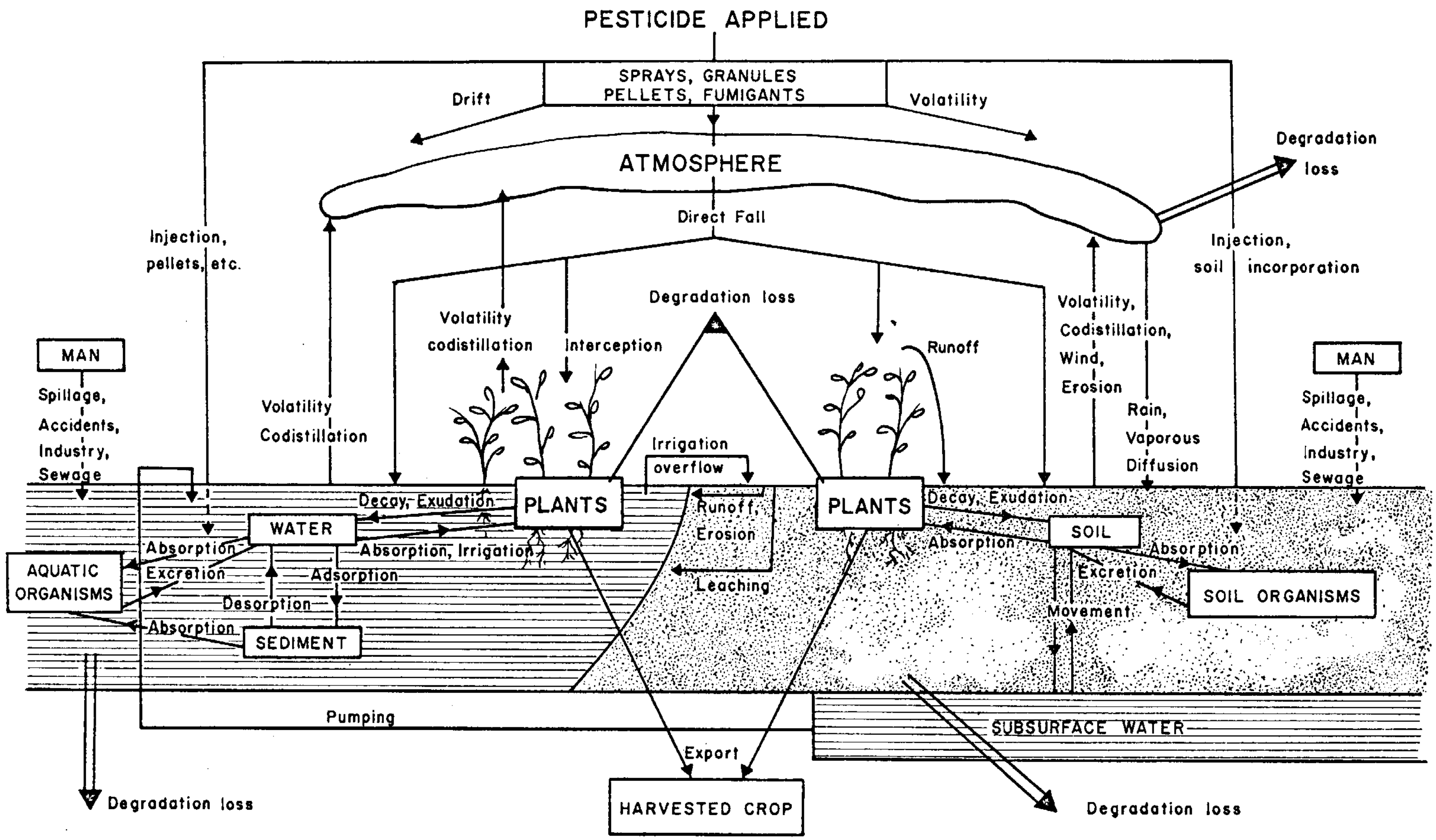

Figure 2. Pesticide Cycling in the Environment

(Taken from SWRCB Publication No. 62, "Pesticides and Toxic Chemicals in Irrigated Agriculture", 1979.)

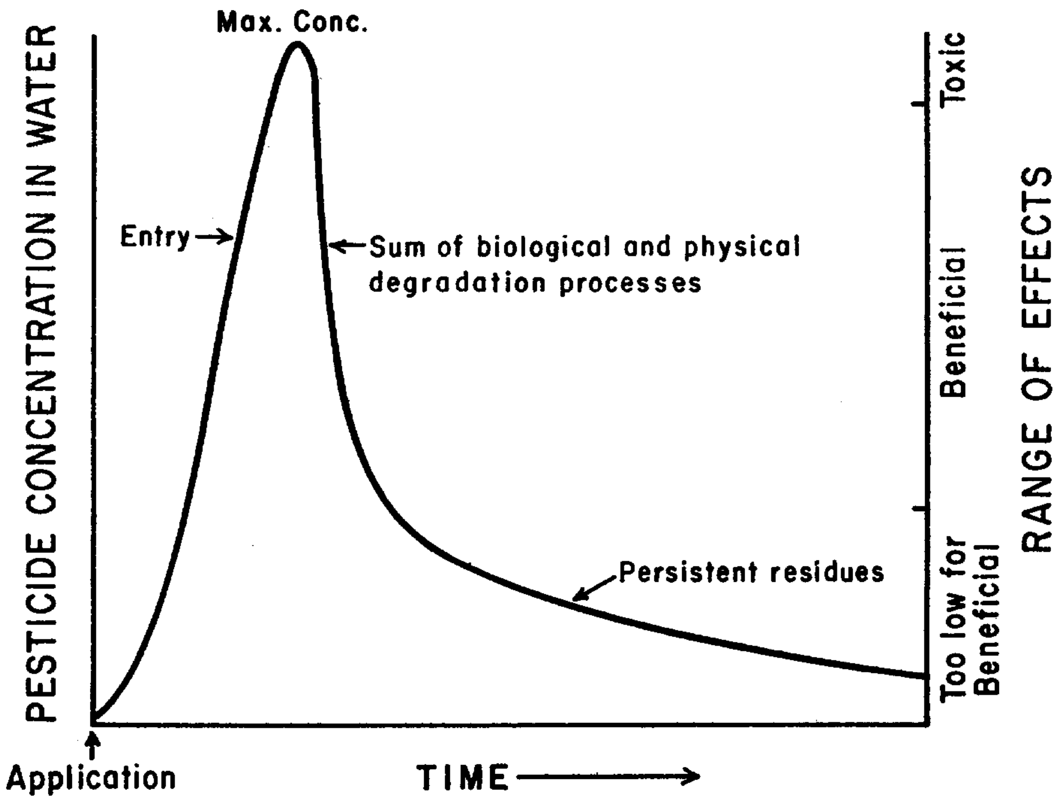

Figure 3. Theoretical Degradation of a Pesticide in the Aquatic Environment.

(Taken from SWRCB Publication No. 62, "Pesticides and Toxic Chemicals in Irrigated Agriculture", 1979.)

TABLE 4

1979 D-D Use for Five Bay-Delta Counties

CONTRA COSTA COUNTY

	Crop	Lbs. Applied
1.	Tomato	5,961.6
	Total	5,961.6 lbs.

SACRAMENTO COUNTY

	Crop	Lbs. Applied
1.	Bean	28,183.0
2.	Open Land	13,733.8
3.	Sugarbeet	6,182.4
4.	Tomato	5,667.2
5.	Asparagus	2,782.1
6.	Fallow Farm Land	864.0
7.	Corn	768.0
8.	Sorghum	120.0
	Total	58,300.5 lbs.

SAN JOAQUIN COUNTY

	Crop	Lbs. Applied
1.	Tomato	522,389.9
2.	Sugarbeet	387,364.4
3.	Grapes	139,743.7
4.	Open Land	90,100.5
5.	Beans	90,080.6
6.	Nonagricultural Areas	87,430.4
7.	Asparagus	71,905.6
8.	Almonds	51,266.9
9.	Ornamentals	19,380.2
10.	Beets	16,030.1
11.	Fallow Farm Land	14,030.1
12.	Carrot	13,280.0
13.	Walnut	12,972.5
14.	Peppers (Bell)	9,446.0
15.	Peach	4,457.7
16.	Cherries	3,742.4
17.	Deciduous Ornamental Trees	2,502.4
18.	Pumpkins	2,303.7
19.	Cabbage	736.0
20.	Soil Fumigation	640.0
21.	Potato	400.0
22.	Melons	184.0
23.	Squash	22.1
24.	Apricot	4.6
	Total	1,540,413.7 lbs.

TABLE 4 (continued)

SOLANO COUNTY

Crop	Lbs. Applied
1. Grapes	31,360.0
2. Sugarbeet	29,032.0
3. Fallow Farm Land	22,896.0
4. Tomato	17,817.6
5. Beets	5,440.0
6. Cucumber	4,248.0
7. Nonagricultural Areas	1,728.0
Total	112,521.6 lbs.

YOLO COUNTY

Crop	Lbs. Applied
1. Tomato	300,384.0
2. Sugarbeet	164,420.2
3. Beets	53,248.3
4. Ornamentals	11,200.0
5. Grapes	5,152.0
6. Fallow Farm Land	560.0
7. Sweet Potato	404.8
8. Carrot	360.0
Total	535,729.3 lbs.

The explanation for separating D-D into the subgroups of D-D mixture and 1,2-dichloropropane, 1,3-dichloropropene and related three-carbon compounds in the Use Reports is not clear. They are the same as is "Telone" which was not within the top 50 from which the 27 were selected. The various petroleum hydrocarbons designated (petroleum oil, unclassified; petroleum distillates and aromatic petroleum solvents) also is not clear.

Monthly Application Trends, 1979

Thirteen of the 27 pesticides were applied during a single period in 1979 which extended for several months (Figures 1-a - 1-aa, left side). The thirteen pesticides included seven insecticide-acaricides (omite, carbaryl, toxaphene, endosulfan, dicofol, methomyl, azinophosmethyl), one fumigant (D-D and related three-carbon compounds), one fungicide (captofol), three herbicides (molinate, xylene, and xylene range aromatic solvents), and petroleum distillates. Most of these pesticides were applied in April to October.

The herbicide, DNBP, was also applied during a single period. However, unlike the previous 13 "spring-summer" pesticides, DNBP was used mainly in December through February.

Four pesticides had a distinct bimodal use pattern within the year. D-D and ethylene dibromide were in high use during the spring and fall. Petroleum hydrocarbons were applied primarily during the winter and midsummer-midfall period. Captan was used during the winter and summer. The use of the other eight pesticides was varied throughout the year.

Petroleum Hydrocarbons

The six "petroleum hydrocarbon" type pesticides each had dissimilar monthly use patterns in 1979. Xylene and "xylene range aromatic solvents" were applied in May through October and petroleum distillates toward the end of that period. Petroleum hydrocarbons and aromatic petroleum solvents were applied in winter and summer, and petroleum oil, unclassified, mainly in winter.

The petroleum hydrocarbon groups identified in the use list are active ingredients. The amounts used as "carriers" would have to be added to the quantities in the list to give total petroleum hydrocarbon used in the pesticide operation. This total use amount will be presented in the Third COSBS Progress Report. An additive interaction between active ingredients and petroleum solvents acting as "carriers" is suspected.

Eleven petroleum hydrocarbon pesticides used in California were analyzed recently by gas chromatography/mass spectrometry (Air Resources Board, June 1980, Characterization of Nonsynthetic Hydrocarbon Pesticides by Gas Chromatography/Mass Spectrometry (GC/MS)). Several compounds were identified. Most compounds in the eleven products were unidentified--the chromatographic profiles showed hundreds of compounds to be present. The product names (e.g., Arco Weed Oil) cannot be related readily to the petroleum hydrocarbon designations in the pesticide use table. Most of the petroleum hydrocarbons listed in the pesticide use list are complex mixtures of aliphatic (straight and branched chain) and aromatic (ring and multi-ring) hydrocarbons.

Summary

The tabulated information suggests that work should continue in pursuing information on whether pesticides may contribute towards the decline and unhealthy state of the Bay-Delta striped bass fishery.

The next step will be to plan and execute an analytical program to detect and measure the presence of these pesticides and other toxic substances in the fish and in water.

Tissue analyses of collected striped bass for some toxic substances (pesticides, PCBs, trace elements) are in progress. Some of the results are discussed in another section of this report (Part b.-A Comparison of Striped Bass from Coos River, Oregon, and the San Francisco Bay-Delta).

The task of searching for these pesticides in fish and in water is difficult. For example, several of the fumigants are highly volatile and might not be expected to accumulate in fish, although they could exert a toxic effect. Further, standard methods are not available for their extraction from fish. Work at the Department of Environmental Toxicology, University of California, Davis, is underway to develop new extraction techniques and analytical capabilities for detecting and quantifying these and other toxic compounds.

The efforts to determine if and what toxic substances are causing the observed unhealthiness of the striped bass will also attempt to incorporate these hypotheses in the study plan:

a. The toxic compound may be undetected in the samples because of its physico-chemical nature. It may cause injury to organisms and volatilize or transform rapidly into unknown by-products. It may also cause harm by potentiating toxic effects in the presence of other toxic materials.

b. The compound may be analytically unidentifiable. For example, present techniques and instrumentation may not be able to recover and detect high molecular weight materials.

c. The by-products may be more toxic than the parent materials.

d. The link between the toxic material and biological effects may not be apparent. For example, it is not known whether increased parasitic infestation may result from pollutants damaging a fish's ability to combat parasitism or if parasitism may reduce a fish's ability to expel pollutants from its tissues.

e. The toxic material may be active under various environmental conditions at extremely low concentrations and affect each life stage of the fish differently.

The COSBS team plans to proceed with Part III Cause-and-Effects Laboratory Studies of the program in the spring of 1981. The target toxic materials and conditions for conducting these laboratory exposure tests will be based on the following considerations:

1. Use or production of the pesticide, or other toxic material, over the past 5 years in the Delta.

2. Previous and current measured levels of the toxic material in water and in aquatic organisms in the Bay-Delta.

3. Physico-chemical properties of the substance (e.g., volatility, solubility, partition coefficient).

4. Acute and sublethal toxicity of the substance to young and adult fish.

5. Status of state-of-the-art analytical capability to detect and quantify trace amounts of the substance and its metabolites in water and fish tissues.

6. Ability to work with the substance in the laboratory bioassays and to conduct the experiments in a meaningful way.

7. Data on the synergistic behavior and fate processes of the toxic substance.

The planning and execution of the chronic bioassays will involve extensive coordination and effort in determining the harmful effects of toxic substances on striped bass. Initial discussions on designing the lab studies have begun.

Task II.2 - Comparative Fish Population Surveys

Part a. - 1980 Bay-Delta Striped Bass
Carol Reilly [1/]

In 1978 and 1979, the National Marine Fisheries Service (NMFS) examined over 400 striped bass from the Bay-Delta. It reported high incidences of parasitism and abnormalities (Whipple, 1979). This year fish collections continued in the Bay-Delta to provide a larger data base for assessing the condition of the striped bass population. The 1980 collections showed fish health problems described and reported earlier by NMFS. Final statistical analyses of data are scheduled for completion in spring 1981. While no conclusive remarks can be made at this time, we are reporting a description of this year's observations.

Prespawning striped bass were collected from the Sacramento River near Clarksburg from April 9 to June 13, 1980. Twenty-one female and 19 male fish were collected in fish traps operated by Cal Fish and Game. Fifteen females were ripe prespawners, four were immature size fish, one had abnormally immature ovaries and one was spent. Sixteen males were ripe prespawners and three were immature. The female with abnormally immature ovaries was heavily parasitized with roundworms and cestode larval cysts and was thin. Fifty percent of all fish were heavily parasitized with roundworms and cestode larval cysts which had caused visceral adhesions or pressure necrosis to body organs, excluding the gonads. Twenty-four percent of the females and 11 percent of the males had heavily parasitized gonads. In one case, parasites caused extensive visceral adhesions which may have restricted the full size development of an ovary and, in another case, some dead eggs were found in a ripe ovary. Fifteen fish (38 percent) had signs (varied developmental stages) of lesions. No macroscopic parasites were observed in four fish.

Prespawning striped bass were also collected by gill net in the San Joaquin River near Antioch from April 14 to May 28, 1980, by Cal Fish and Game. Twenty-one female fish and 19 male fish were collected. Fifteen females were ripe prespawners, two were immature, three were spent and one had abnormal ovaries. No parasites were associated with the fish with the abnormal ovaries. Eighteen males were ripe and one was immature. Sixty percent of all fish were heavily parasitized by nematodes (roundworms) and cestode larval cysts which caused visceral adhesions and pressure necrosis to body organs excluding the gonads. Thirty eight percent of the females and 42 percent of males had parasites associated with the gonads. One male had an abnormally small right testis which may have been caused by visceral adhesions associated with a healing lesion on the right mid-ventral body wall. Thirty-five percent of all fish had lesions which appeared to either be forming or healing. One fish with a lesion had no macroscopic parasites.

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Pollutant analyses are underway to determine concentrations of hydrocarbons, heavy metals, PCBs and pesticides in muscle, gonads and liver tissue. Histological examination has also begun on gonad and liver tissue and will continue through to include adrenal, kidney and spleen tissue.

Part b. - A Comparison of Striped Bass from Coos River, Oregon, and San Francisco Bay-Delta
Carol Reilly 1/

Striped bass were collected from the Coos River in Oregon on May 19-27, 1980. The purpose was to obtain data on the health and pollutant concentrations of another stock of striped bass. The Coos Bay striped bass population was chosen because they represent fish from waters less polluted than the Bay-Delta. By comparison, over 80 major outfalls discharge over 500 million gallons of treated wastewater daily into the Bay-Delta, while no outfalls discharge into Coos Bay or into Coos River. Water quality data has also shown no measurable pollution problems exist other than periodic high coliform bacteria counts in the upper Coos Bay area from pastureland runoff (Oregon Department of Environmental Quality, 1980). While there is no data on pesticide use in the Coos Bay area, oyster tissue analyses by the U. S. Environmental Protection Agency have shown very low pesticide residues.

Additional data on pollutants in tissues of Coos Bay organisms and more water quality data will be reviewed as we receive them from the Oregon Department of Environmental Quality. The completion of tissue examinations and tissue analyses for pollutants will determine if the Coos River striped bass are healthier than the Bay-Delta bass.

The striped bass population of Coos Bay, Oregon, originated from the introduced population of San Francisco Bay. Striped bass were first reported caught in Coos Bay in 1914 and by the late 1920's were supporting a commercial fishery. The population has been at a relatively low level during the past 10 years. As a result, the commercial fishery was closed in 1975. The Oregon Department of Fish and Wildlife has estimated the 1980 striped bass adult population to be 15,000 to 20,000 (Bender, 1980).

COSBS staff, with the assistance of the Oregon Department of Fish and Wildlife, collected 41 prespawning adult striped bass. The 41 fish included 16 females, 14 males, and 11 fish with both male and female gonads (hermaphrodites). It is interesting to note that two researchers, Morgan and Gerlach, observed a three percent incidence of hermaphroditism in Coos Bay striped bass in 1950. They reported a

1/ Center for Coastal Marine Studies, University of California, Santa Cruz condition where the testes formed the anterior portion and the ovaries the posterior portion of the gonads in all hermaphrodites. In some cases, they observed both ripe testes and ripe ovaries. This differs from conditions found in 1980 where 27 percent of the samples were hermaphrodites. Nine of the eleven hermaphrodites had dominant ripe ovaries located anterior to the smaller testes. Testes varied in size from distinct ripe bilobed testes to a small band of testicular tissue located posterior to the ovaries. The remaining two hermaphrodites had dominant ripe testes and an adjacent pair of immature ovaries. An extensive literature search has failed to show that the condition observed in these Coos Bay striped bass had been previously reported. The significance of these observations is unknown.

Hermaphroditism has been reported in only one striped bass from San Francisco Bay and Delta in a sample of 400 fish collected in the last three years (Whipple, 1980). Hermaphroditism is prevalent in other Serranids and has been described in one other member of the Morone genus (Dorfman, 1976).

Five hermaphrodites and two females had numerous sacs containing dead eggs within the body cavity. These are believed to be eggs from previous years that were retained by the fish but not completely resorbed. The sacs caused extensive visceral adhesions and some of the dead eggs had become embedded in the liver and spleen. Females and hermaphrodites also appear to be more heavily parasitized by roundworms and cestode larval cysts, but this may be due to the higher mean age of these fish as compared to the younger males. By comparison to the Bay-Delta bass previously examined, the Coos River nonhermaphroditic bass appear less parasitized and from general observations appear in better condition. No signs of lesions or cestode larvae were seen.

Preliminary pollutant analyses of bass ovaries and livers are presented in Tables 5 and 6. The larger Coos River, Oregon, bass had lower concentrations of several pollutants (pesticides) in the ovaries than some of the smaller Bay-Delta bass. Analyses of more fish samples are underway and will determine if this early observation will hold true. Histological examinations to assess tissue damage in gonads, liver, kidney, spleen and adrenal are nearing completion. No preliminary conclusions can be drawn at present. The completion of this work should determine if the Coos Bay striped bass do represent healthier West Coast striped bass from an area comparatively cleaner than the San Francisco Bay-Delta. This information is essential in our efforts to assess the health of the Bay-Delta striped bass and in determining if water quality conditions may have an effect on their condition.

Table 5

TRACE ELEMENT ANALYSES OF STRIPED BASS OVARIES

(ppm wet weight)

Fish Id.	Fish Wt. (g)	Length (cm)	Location	Cu	Zn	Fe
SP 1	12,700	104	Stockton	5.7	55.8	20.0
SP 2	11,800	100	"	1.8	43.6	6.8
09	4,400	61	Antioch	0.37	5.3	2.5
24	4,422	72.5	"	1.9	20.5	11.0
D-63	6,370	79	"	3.7	25.0	12.0
D-67	3,900	68	"	2.9	24.9	9.0
06	7,465	84	Coos River, OR	1.9	21.1	11.0
08	7,003	75.5	" "	2.7	24.8	8.1
11	6,526	75	" "	1.5	22.0	7.5
14	11,804	98.5	" "	2.2	27.0	9.8
15	8,542	84	" "	2.2	19.4	11.0
16	10,896	86	" "	2.2	21.4	12.0
22	19,976	103.5	" "	2.9	21.1	10.0
27	7,432	81	" "	2.9	22.4	11.0
40	10,442	90.5	" "	2.2	25.1	12.0

Note:

1. Ag values ranged from <0.01 - 0.02 ppm ww except for Fish D-67 with 0.06 ppm ww Ag.
2. All Pb values were <0.1 ppm ww.
3. All Cd values were <0.02 ppm ww.

Lab analyses performed by the staff of the Fish and Wildlife Pollution Control Laboratory, Cal Fish and Game.

TABLE 6

Striped Bass Study (L-257-80-P)

PESTICIDE RESIDUE FRESH WEIGHT ppb (ng/g)

Identification (Location)	% Lipid	PCB-1260	Toxaphene	pp' DDE	pp' DDD	pp' DDT	op DDE	op DDD
SP 1 (Stockton)	17	3300	1500	1300	470	180	49	46
SP 2 (Stockton)	9.5	440	<200	170	53	<5	<5	<5
D-63 (Antioch)	23	1600	740	760	360	100	29	40
D-67 (Antioch)	21	2000	1900	650	510	90	<5	37
14 (Coos River, OR)	18	170	<200	120	5	<5	<5	<5
16 (Coos River, OR)	21	140	<200	50	<5	<5	<5	<5
22 (Coos River, OR)	20	140	<200	68	10	<5	<5	<5
09 (Antioch)	24	440	1100	320	180	19	<5	14
24 (Antioch)	24	170	970	290	290	<5	<5	23

TABLE 6 (continued)

Identification (Location)	cis-chlordane	trans-chlordane	trans-nonachlor	oxychlordane	HCB	aldrin	dieldrin	dacthal
SP 1 (Stockton)	120	28	180	30	11	<5	43	<10
SP 2 (Stockton)	14	5	29	<10	5	<5	5	<10
D-63 (Antioch)	120	47	200	25	13	<5	36	16
D-67 (Antioch)	170	40	210	42	15	7	96	22
14 (Coos River, OR)	<5	<5	<5	<10	<5	<5	<5	<10
16 (Coos River, OR)	<5	<5	<5	<10	<5	<5	<5	<10
22 (Coos River, OR)	<5	<5	<5	<10	5	<5	<5	<10
09 (Antioch)	48	9	68	10	8	<5	52	27
24 (Antioch)	77	24	82	37	8	5	31	16

Analyses performed by staff of Fish and Wildlife Pollution Control Laboratory, Cal Department of Fish and Game.

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Part c. - Lake Mead, Nevada, Striped Bass Collections
Judy Sakanari [1/]

In an effort to enhance the fishery potential of Lake Mead, Nevada, the Arizona Department of Fish and Game and the Nevada Department of Wildlife began stocking striped bass into the lake. A total of 65,000 striped bass fingerlings and yearlings were introduced between 1969 and 1972. Most of these fish were taken from the Tracy pump station in California's Sacramento Delta area.

Since its introduction, the bass population appears to have increased substantially. Successful natural reproduction has occurred every year since 1973 resulting in strong year classes. Total catches were 1,500 striped bass in 1973; 6,000 in 1975; 12,000 in 1977; and over 30,000 in 1978. Two years ago, the Nevada Department of Wildlife and the Arizona Department of Game and Fish increased the catch limit from three to five and placed no restrictions on the size of the fish.

Although the catch records are impressive and suggest continued success for future striped bass populations in Lake Mead, they give no indication of the state of health of these fish.

Since 1976, striped bass die-offs were observed annually in Lake Mead from May through August. The mortalities involved mostly male striped bass varying in size from 22 inches to 28 inches. No dead immature bass were observed among the die-off fish (B. Padilla, Nevada Department of Wildlife, pers. comm.).

Because these die-offs occur after the spawning period and because only mature striped bass have been observed in these die-offs, it is hypothesized that the die-offs result from postspawning stresses. To test this hypothesis, collections of Lake Mead striped bass were made. We needed information on how postspawning die-off bass residing in a clean, freshwater system compared to those dying in Suisun Bay. The Lake Mead bass are transplanted fish from the California Delta undergoing fewer osmoregulatory changes (no seasonal fresh to saltwater migrations), and fewer parasitic problems, and living in a comparatively higher water quality system. A review of Lake Mead water quality data suggests this latter premise to be correct. A biological stress factor might be from spawning activities.

Collections of 20 healthy and 20 moribund and/or freshly dead striped bass were planned. However, this summer no die-off was observed in Lake Mead. In spite of this unexpected event, seven live striped bass were collected between July 21 and July 24. In September, 17 more striped bass were shipped to the COSBS laboratory from the Nevada Department of Wildlife. With six other striped bass that had been received in April, a total of 30 striped bass from Lake Mead have been examined.

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Although no moribund or dead fish were collected from Lake Mead, comparisons will be made of the fish sampled from Lake Mead with those sampled from the Carquinez Strait and Suisun Bay areas.

The fish received in April had no apparent macroscopic abnormalities. One fish, however, had parasites (approximately 100 freshwater cestode larvae) in the mesentery. All six of the fish were immature and appeared thinner than Bay-Delta striped bass of similar age.

The seven fish collected in July were immature except for one male fish. Three of the seven fish had pale colored livers and spleens with black areas. In general, these seven fish appeared thin, had few abnormalities and no parasitic infestations.

Of the 17 striped bass collected in September, 14 had abnormal appearing livers. The livers were pale or light yellow, or had what appeared to be necrotic areas. Only two fish had parasites. No other major abnormalities were apparent.

In summary, the Lake Mead striped bass appeared thin, had few parasites, and few skeletal abnormalities. However, over half (57 percent) of the fish had liver abnormalities.

We do not know how well our small sample of 30 bass represents the condition of all Lake Mead striped bass. No previous studies on the Lake Mead bass have ever been conducted.

The absence of a die-off in Lake Mead this summer and the collection of small-sized bass altered our plans to address the questions concerning the causes of the Bay-Delta summer die-offs. We will pursue another collection effort next year should the Lake Mead bass die-offs resume. The information may improve our understanding of the possible causes of the Carquinez Strait and Lake Mead summer mortalities.

Part d. - Collection of Striped Bass During the Annual Summer Carquinez Strait Die-Off, 1980
Judy Sakanari [1/]

Striped bass die-offs have been observed annually for the past 40 years in the area between San Pablo Bay and Suisun Bay. Hundreds of striped bass can be seen washed ashore or floating in the water during the summer months of May through August.

Although the annual die-off has been studied by numerous investigators, the causes of the mortalities have yet to be determined (Kolhorst, 1973, 1975; Silvey and Irwin, 1969).

As part of the Cooperative Striped Bass Study plan, an effort was made to examine die-off bass from Carquinez Strait and Suisun Bay. We needed information about the physiological condition of the bass during the summer die-off period. Previous hypotheses on the causes have included:

1/ Center for Coastal Marine Studies, University of California, Santa Cruz.

1. Sublethal levels of various toxic materials (e.g., petroleum hydrocarbons, pesticides, heavy metals) may interact to lower the resistance of fish to stress (e.g., postspawning stress, osmoregulatory changes).

2. Natural environmental factors may create toxic conditions during the low outflow season. For example, it has been hypothesized that when a series of minus tides occur and mudflats are exposed, benthic organisms die and decompose. As a result, hydrogen sulfide gas is produced in sufficient amounts to be toxic to fish (Silvey and Irwin, 1969).

3. Stressed fish are overcome by their inability to adapt to changes in water temperature, dissolved oxygen levels, pH, and salinity.

Twenty (20) striped bass were collected from June 30 to August 6, 1980. Fifteen (15) fish were caught live, two (2) fish were moribund, and three (3) fish were freshly dead. We attempted to collect 40 fish but were unsuccessful.

All fish were examined for gross defects and anomalies. Measurements (i.e., weights, lengths, and widths), meristic counts, and color pattern definitions were recorded. The age of each fish will be determined by the Department of Fish and Game. Samples of gill, liver, spleen, adrenal gland, kidney, gonad, and lower intestine were taken for histological sectioning. Cultures were taken from the intestine, liver, spleen, and kidney for bacteriological identification. Liver and dorso-lateral musculature samples were taken for hydrocarbon, heavy metal and PCB (polychlorinated biphenyls) analyses. Whenever possible, blood samples were collected for serum protein electrophoresis and hematocrit determinations. Each fish was also examined for parasites. Because tissue decomposition of the dead fish had occurred, only liver and muscle tissues could be sampled for pollutant analyses.

Two of the fifteen live fish had wounds or lesions located on the right side of the fish. Four of the live fish had slight skeletal abnormalities related to the gill rakers. Livers that were abnormally shaped or pale in color were seen in three of the fish. Eleven of the fifteen live fish had few-to-many cestode larvae within their mesenteries. Cestode larvae were also found in the right gonad, liver, spleen, and body cavity of some of these fish; roundworm larvae were also present in two of these fish. The two moribund fish had abnormal livers (hemorrhaged and abnormally shaped); both fish had cestode larvae in their mesenteries. The small sample size has prohibited us from making any conclusions about what may be causing the die-offs. Inspite of the small sample size, the effort has provided us with information on what future work should be done.

Our recommended approach is to establish a more comprehensive and cooperative effort in collecting pre- and postspawning striped bass from Lake Mead, Nevada, and the Bay-Delta next year. As discussed previously, the Lake Mead bass may represent transplanted Bay-Delta bass undergoing fewer stresses (fresh to saltwater transitions, parasitic infestations, and toxic pollutants) but die in the summer. More fish from these two areas are needed for statistical comparisons and for future laboratory studies.

We propose that some of the many hypotheses about the die-off be tested. For example, the hypothesis that hydrogen sulfide gas may have a toxic effect on the bass could be tested by subjecting bass to various concentrations of this toxic gas in the laboratory. Lab conditions (dissolved oxygen, salinity, temperature, and pH) could be set to field conditions. Field data on Bay-Delta water and sediment quality could be obtained through cooperative efforts of the various state monitoring agencies (e.g., Department of Water Resources). Collections of numerous live fish could be achieved with the expertise and support of the Department of Fish and Game and from sportfishing clubs.

Although the Delta summer die-off has occurred for many years and was viewed as an ordinary annual occurrence, it is important to note these facts:

1. Other Delta fish, besides striped bass, die off each summer. This suggests that the die-off factors are not restricted to striped bass.

2. Not all die-off fish were mature spawning fish. This suggests that postspawning stresses may not be a major factor.

3. The annual die-off occurs only in San Francisco Bay and Delta. To the best of our knowledge, other estuarine striped bass populations have had no history of recurring annual die-offs. This includes the striped bass population in Navesink, New Jersey, from where the original stock of 332 young bass was transplanted into Carquinez Strait in 1879. This also suggests that the die-off is not a natural postspawning occurrence.

4. The 1980 Fish and Game striped bass index showed a decline in the striped bass population. Other factors besides Delta outflow and *Neomysis* shrimp abundance appear to be impacting this fishery. Unhealthy striped bass have been documented in this study.

Perhaps the die-off fish represent those unable to recover or adapt to certain environmental changes in the Bay-Delta. In view of an already dwindling adult population estimated at about one million, the continual loss of a few thousand large, reproductively valuable bass each summer may severely impact any future recovery.

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Part e. - Investigation of Lesioned Bay-Delta Striped Bass
Kris Lindstrom [1], Michael Moser, Ph.D. [2], and
Sefton Wellings, M.D., Ph.D. [1]

In June 1980, a special study was undertaken to examine striped bass from the western Delta where numerous lesioned bass have been observed. These observations have been reported by local sportfishermen for many years. Various hypotheses on the cause of these lesions have been suggested. They include lamprey bites, parasitic copepod wounds, red algae, toxic pollutants, and bacterial or fungal infections. The significance of how these lesions might impact the total number of striped bass each year is unknown. However, it is plausible that fish with open lesions may become more susceptible to disease and bacterial infections which may contribute to an early mortality.

A successful effort in documenting the frequency of lesioned fish caught in the western Delta and in identifying the role of parasites in the development of these lesions was made with the assistance of the Department of Fish and Game.

Cal Fish and Game has been conducting surveys on the survival and migration of released chinook salmon since 1978. The surveys have been conducted at the confluence of the Sacramento and San Joaquin Rivers near Chipps Island. During these midwater trawls, striped bass and other fish species are also captured.

The frequency of collecting these lesioned bass was recorded during the 1979 and 1980 surveys (F. Fisher, pers. comm.). This data is summarized in Table 7.

In 1979, the first open lesioned striped bass collected was on May 21. In 1980, the first open lesioned fish was collected on May 22. In spite of different sampling periods for 1979 and 1980, the overall pattern in observing lesioned fish appeared similar (Table 8).

The average length of lesioned fish caught in 1979 was 373 cm (range 140 to 810 cm; age 1.2 to 9.5 years), while the average for the 1980 lesioned fish was 348 cm (104 to 800 cm; 1 to 8 years).

Over 40 lesioned striped bass were examined for parasites, histopathological tissue damage, and bacterial infections. Photographic documentation of the different stages of lesion development was made as the fish underwent thorough macroscopic and microscopic examinations.

1/ Department of Pathology, School of Medicine, University of California, Davis.

2/ Center for Coastal Marine Studies, University of California, Santa Cruz.

TABLE 7

Open Lesioned Striped Bass Collected, 1979-1980[1/],[2/]

	1979	1980
Date trawling began	April 2	January 14
Date trawling ended	June 28	June 30
Total days of trawling	35	54
Total stripers caught (over 100 mm)	1,482	2,792
Total number caught with open lesions	175	237
Incidence during trawling period	11.8%	8.4%

1/ Data from F. Fisher, California Department of Fish and Game (unpublished data).

2/ The true incidence of lesions may be higher. The reported counts included only external open sores. Red sores and internal cestode rafts on other bass were not documented.

TABLE 8

Monthly Catches of Open Lesioned Striped Bass, 1979-1980 1/

Year		JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1980	Total number of striped bass caught	102	339	50	310	381	1,857	3,039
	Total number of striped bass with lesions	0	0	0	0	6	232	238
	Overall % lesions	0	0	0	0	1.6	12.5	7.8%
1979	Total number of striped bass caught	NC	NC	NC	236	273	1,148*	1,930
	Total number of striped bass with lesions	NC	NC	NC	0	6	169	175
	Overal % lesions	-	-	-	0	2.2	14.7	9.1%

1/ Data from California Department of Fish and Game trawls at Chipps Island, F. Fisher.

NC = No collections were made during this month.

* Includes 63 fish from June 12 with no incidence of lesions being reported.

External Description of the Lesions

The stages of development of the lesions were originally thought to progress from the raised reddish "strawberry" (acute inflammation) to the open lesion with eventual healing and formation of a purplish "scar" (Photos 1 and 2). Examination of the "scars" indicated that tapeworm larvae were present in the muscle tissues beneath the "scar". Such a finding indicates that the scaleless, purple-colored "scars" may be another stage of the lesion which has not fully opened up to the outside. Examination of scales was made from what were thought to be "healed" lesions. By comparing the age of scales in the "healed" area with other scales on the same fish, it was thought that the time of the lesion could be estimated. However, there was no disruption in the growth of the scale, although some irregular scale growth patterns were observed. Additional studies of preserved specimens are continuing to determine the sequence of events resulting in lesion formation and healing.

Parasitological Examinations

Hypotheses explaining the cause and location of the lesions were developed during this special investigation. The first hypothesis was that a parasitic cestode (tapeworm) larva, *Lacistorhynchus tenuis*, belonging to the order Trypanorhyncha, is responsible. This hypothesis was developed on the basis of numerous Trypanorhyncha cestode larvae seen in the fish. The second hypothesis explained the location of the lesions which were predominantly on the right side of the bass. The hypothesis was that the cestode larvae are primarily located along the intestines which are coiled on the right side of the fish.

The approach used to test these hypotheses included identifying the general life cycle of the cestode and examining the anatomy and the immunological response of the fish to this infestation.

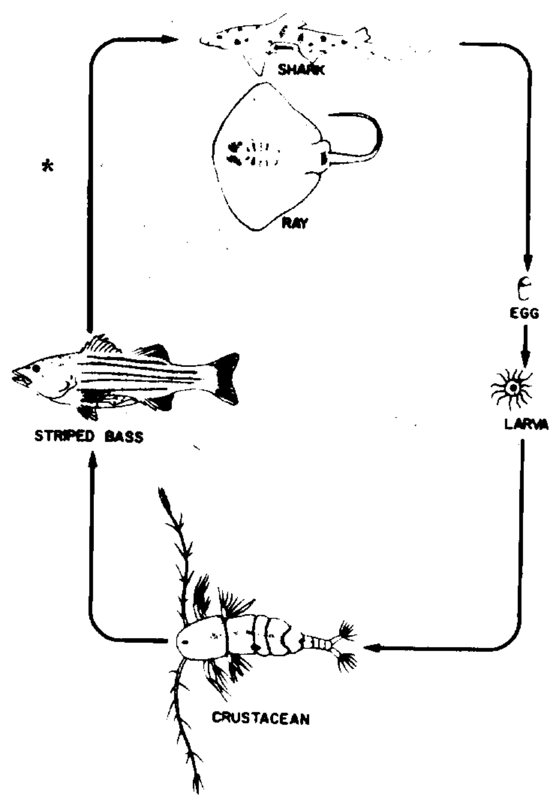
The generalized life cycle of the order Trypanorhyncha is presented in Figure 4. The known final hosts are elasmobranchs (e.g., sharks, skates, and rays). During the adult cestode stage, eggs are released into the water as the elasmobranchs excrete their wastes. The larvae are then ingested by small crustaceans. These crustaceans may be preyed on by fish such as striped bass. Eventually the cestode larvae mature into adults when elasmobranchs feed on the intermediate hosts (e.g., striped bass, perch).

Open lesions in their early stages of development were predominantly located on the right side of the striped bass (Table 9).

Individual larvae were found in the peritoneal walls (inside body wall) and in the muscle tissue (edible portion of the flesh). The number of larvae in the sample also predominated on the right sides of the fish (Photo 3).

FIGURE 4

GENERALIZED LIFE CYCLE OF THE CESTODE ORDER TRYPANORHYNCHA



The adult cestode lives in sharks and rays. Eggs are released into marine waters with subsequent larval development. The larvae are then eaten by small crustaceans. The larvae infect fish such as striped bass when infected crustaceans are eaten. When infected fish are eaten by sharks and rays, the cycle starts again.

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* Hypothesized step.

When comparing the number of cestode larvae in the right peritoneum, swim bladder, and left peritoneum, we again observed more larvae on the right peritoneum. It is hypothesized that lesions do not appear frequently in the muscle above the swim bladder because of the lack of a rich blood supply which would cause a strong host reaction.

The explanation for these observations is the anatomical arrangement of the coiled intestines and position of the stomach of the striped bass. The intestines are located on the right side of the fish and in contact with the inner right peritoneum (Photo 4). As cestode larvae are ingested, they are able to burrow through the intestines and eventually embed into the muscle tissue. Cestode larval "rafts" are embedded along the muscle wall. These rafts have been found in areas where early stages of lesion development, described as "strawberry marks" or a depressed area, have been found (Photo 5).

Lesions have also occurred on the left side of the bass, however, in much less frequency than on the right side. The explanation for this difference appears to be the location of the liver and gonads between the left peritoneum and the coiled intestines. The liver acts as a barrier (Photo 6).

There appears to be a direct relationship between the number of cestode larvae in the fish and the incidence of multiple lesions in a fish. Based on our sample size, bass found with more Trypanorhyncha larvae (75 to over 100 worms) had a greater chance of having more than one lesion than those fish with fewer parasites.

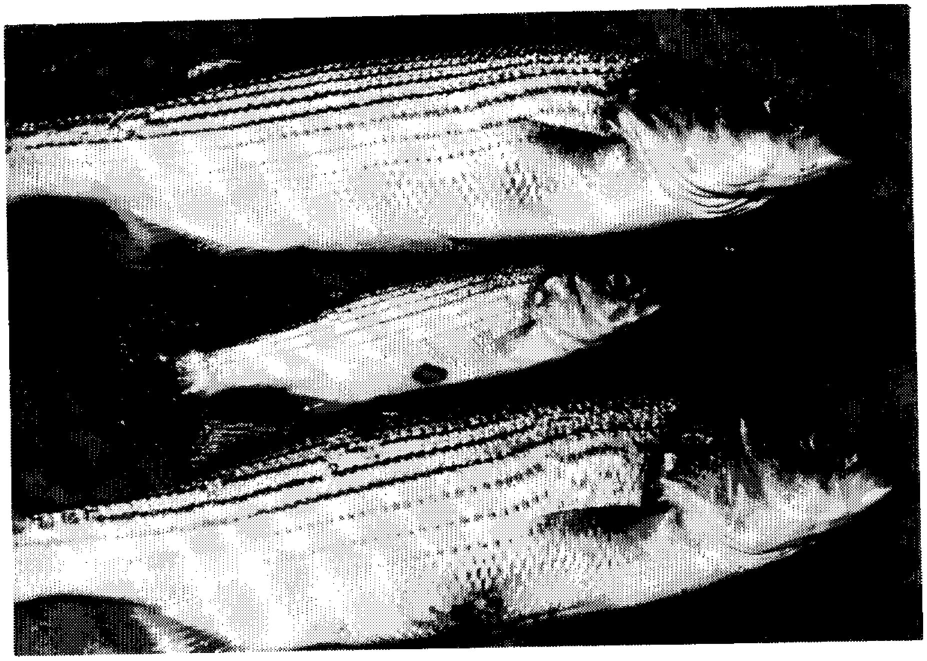


Photo 1. Stages of lesion development. Strawberry patterned bruise can be seen on ventral region, left of pectoral fin in top fish. Open lesions seen on other two bass.

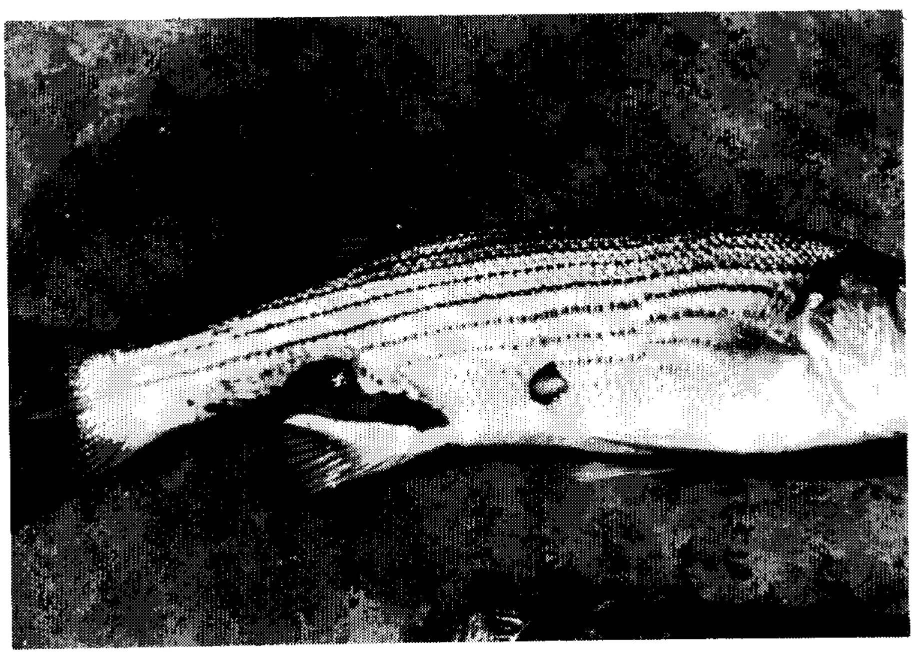


Photo 2. Shapes of lesions. Lesions are not always circular. Multiple lesions expose the body cavity and hemal spines above anal fin.

TABLE 9

Comparison of Left Versus Right-Sided Lesions

	Right Side	Left Side	Right to Left Ratio
Cases of open lesions	14	1	14:1
Cases of red sores	18	1	18:1
No. of cestode larvae along peritoneum	359	41	8.75:1
No. of cestode larvae in muscle tissue	226	50	4.56:1

	Right Peritoneum	Swim Bladder	Left Peritoneum
No. of cestode larvae	359	232	41
Ratio	8.75	5.7	1

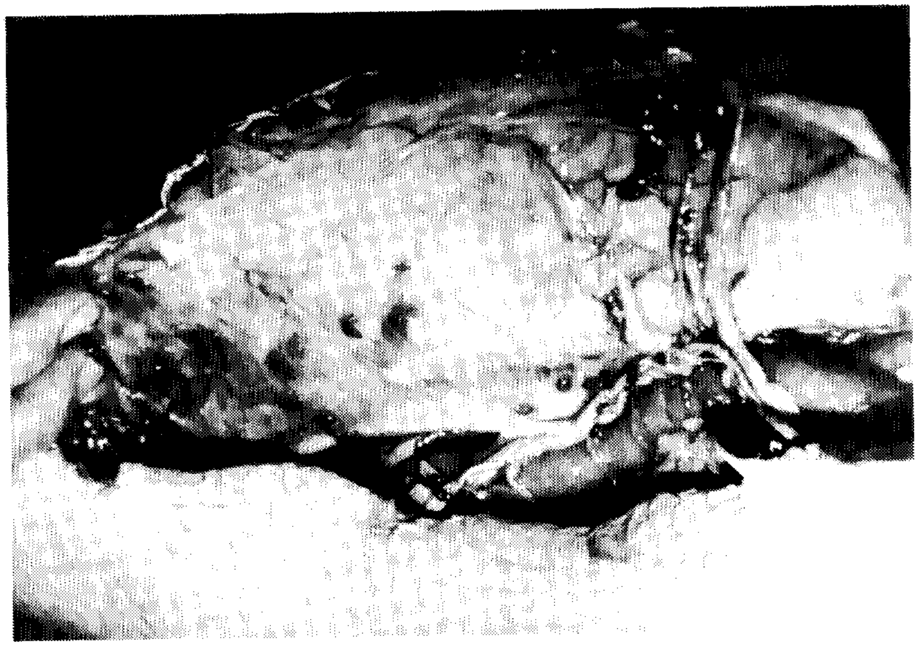


Photo 3. Nematodes and cestode larvae embedded in muscle tissue (internal right musculature and mesenteries). The nematodes are coiled and the cestode larvae appear as dark rice-like grains.

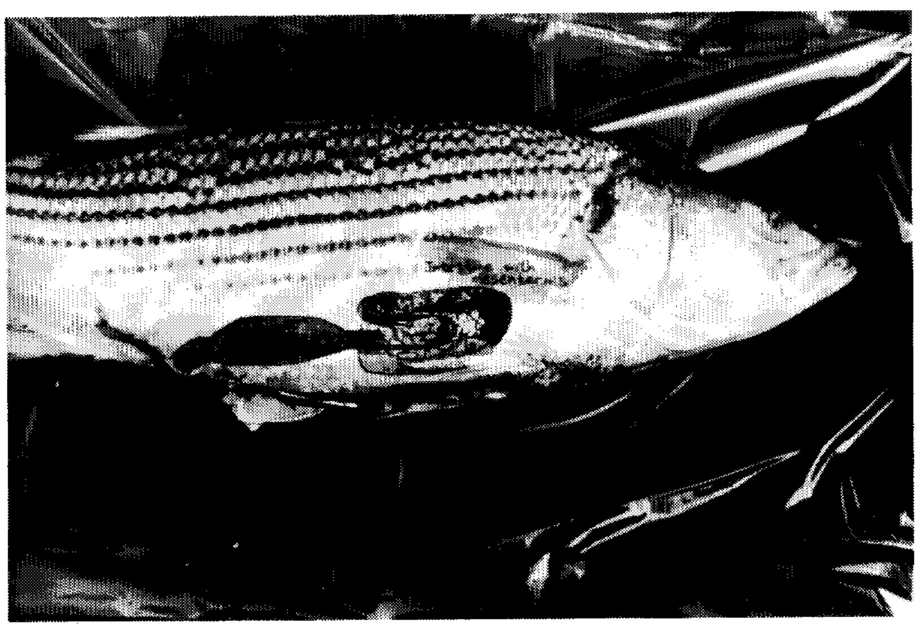


Photo 4. Right-side anatomy of striped bass. Sketch of right-side anatomical arrangement of intestinal tract of bass drawn on a striped bass.

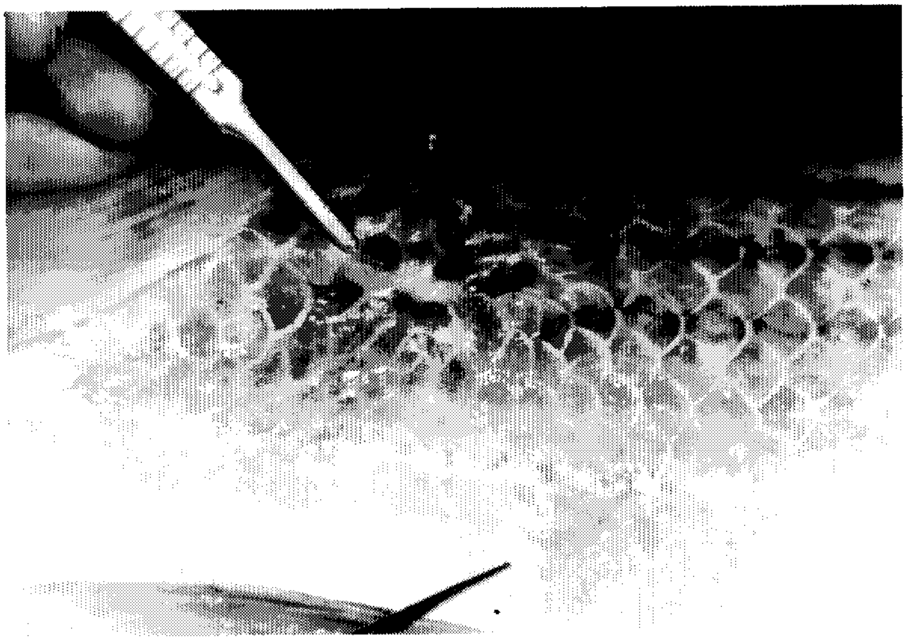


Photo 5. "Strawberry" mark stage of lesion development. A strawberry mark or depressed area on surface of a specimen. Rafts of cestode larvae are usually located beneath these areas.

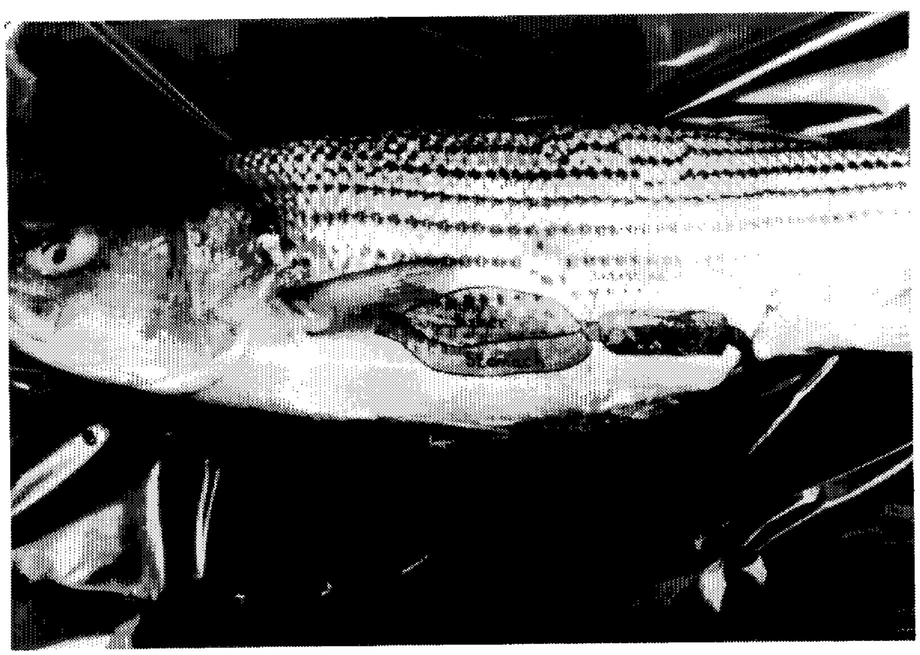


Photo 6. Left-side anatomy of striped bass. The left-sided anatomical arrangement of the liver and intestinal tract was sketched on this striped bass. The liver acts as a varrier in cestode larvae infestation on the left side of the bass.

At this time, we hypothesize that the lesions are the result of an immunological response of the infected striped bass. These Trypanorhyncha worms are a common parasite to marine and Bay fishes. For example, the adult cestode worms are found in leopard sharks and larval forms in shiner perch and blue rockfish. They have been found on the Atlantic Coast in striped bass (Linton, 1924), as well as on the Pacific Coast of the United States and the Mediterranean Sea. At this time, we are only aware that striped bass from San Francisco Bay and Delta are afflicted with these lesions. Other species of Bay-Delta fish have not been observed with these lesions nor striped bass from other regions in the United States.

Histological Examinations

Histological examination of the lesions showed that the most probable cause was a reaction of the bass to parasitic invasion of the musculature. This was indicated by an inflammatory response in which white blood cells (macrophages) are dominant in the area of the wound. The reaction to the presence of the parasite in the tissue adjacent to the body cavity lining (peritoneal surface) results in the formation of altered connective tissue cells (pearls of metaplastic mesothelium). This occurs in the area where the tapeworm larvae are burrowing out of the intestine and results in the formation of a visceral adhesion (abnormal connective tissue between the intestine and the body wall). These thickened areas of altered connective tissue surround areas of fat and body cavity lining (Photo 7). As a result, a cyst is formed and encapsulates around the parasite. Many of the encapsulated parasites are not viable.

The reaction to the parasite's presence in the musculature of the body wall results in extensive degeneration and necrosis (cell death) of muscle. This process manifests itself as a localized cyst beneath the skin or a large plug of dead (necrotic) muscle under the skin (Photo 8). For such an extensive amount of muscle necrosis to occur without accompanying adverse effects on other tissue is highly unusual. Such a finding would tend to eliminate the hypothesis that the primary cause of the lesion is bacterial infection, since these are often found to have systemic effects (affect other tissues such as the liver, spleen, kidney, etc.).

Bacteriological Examinations

Collection of bacteriological samples from the lesions, followed by laboratory culture and biochemical tests, resulted in the identification of three different bacteria. These are the known fish pathogen *Aeromonas hydrophila* subspecies *hydrophila* along with another subspecies of *Aeromonas hydrophila*, as yet unidentified, and the bacterium *Bacillus* sp. Scanning electron microscopic examination of one of the lesioned fish (Photo 9) showed the presence of rod-shaped bacteria. Cultures of the unidentified bacteria have been sent to the National Fish Health Laboratory for confirmatory identification. It is suspected that *Aeromonas* may play a role in the proliferation of the lesion as it develops as a secondary invader of the lesion once the inflammatory response to the parasite is initiated and the skin surface is broken or the intestinal wall is perforated (Photo 10).

Photo 7. Visceral adhesions and parasitic worm rafts embedded in muscle wall. Visceral adhesion (abnormal connective tissue between the intestine and body wall) acts as a bridge for cestode larvae and nematode migration to the peritoneum (inside body wall). A raft of parasitic worms are seen embedded in the muscle wall.

Photo 8. A cyst of encapsulated cestode larvae. This cyst was removed from the muscle wall.

Photo 9. Bass lesion with rod-shaped bacteria present. (Scanning electronmicroscope photograph at 5,000 times magnification.)

Photo 10. Lesion and bacteria infection on a bass. A small lesion (left) and a bacteria infection (right) on a diseased bass.

Conclusions

1. The incidence of lesions in striped bass may be related to the physiological state of the fish, specific location in the Delta and the time of the year. The occurrence of lesions starts about the third week in May and extends through to at least (when sampling stopped) June.

2. The lesions in the striped bass appear to be of a biological nature although chemical or physical water quality may play a role in the etiology of the affliction. The development of lesions are related to infection by the tapeworm, Lacistorhynchus tenuis. It is hypothesized that the lesions are formed as the result of immunologic responses by the striped bass to the cestode rafts in the muscle tissue. Since this common fish parasite appears to affect only the San Francisco Bay-Delta striped bass, in this way we also hypothesize that this severe immunological response results from the combined effects of toxic materials, water temperature, and salinity adversely stressing the striped bass.

3. There is no direct evidence indicating fish die as a result of the lesions, but circumstantial evidence (lack of many older scarred fish) suggests that they may suffer early mortality. Work is being continued to determine if the lesions do heal.

4. The evidence we have collected to date suggests no direct, observable relationship between the incidence of lesions and the annual summer die-off of striped bass in the lower Delta.

5. Resolving the lesioned bass problem will require investigating the relationship between biological and water quality factors which may influence the life cycle of the parasite and the susceptibility of the striped bass to lesion formation.

Recommendations for Action

1. That the Department of Fish and Game conduct trawling surveys off Chipps Island throughout the year. This will extend documentation on the seasonal incidence of lesions. More bass are also needed for study.

2. Determine what Bay-Delta factors impact the life cycle of the cestode Lacistorhynchus tenuis. Progressive water quality changes in the Bay-Delta over the years may have enhanced the abundance of this parasite. Interruption of their life cycle and inducing certain environmental conditions may reduce or eliminate this problem.

3. In view of data indicating only Bay-Delta striped bass have these open lesions, immediately initiate work to determine the synergistic effects of toxic substances and other water quality variations on the immunological response of the striped bass to Lacistorhynchus tenuis.

4. Initiate a study to determine the presence and seasonal abundance of potential fish pathogens such as Aeromonas. Seasonal sampling should be made to determine their presence in fresh waters of the Delta as well as the estuarine and marine environments.

SUMMARY OF STRIPED BASS STUDIES CONDUCTED BY THE NATIONAL MARINE FISHERIES SERVICE - TIBURON LABORATORY [1/]

PRINCIPAL INVESTIGATOR: Jeannette A. Whipple, Ph.D.

STAFF: Maxwell Eldridge

Pete Benville

Brian Jarvis

Michael Bowers

Mark Kobe

Karen Taberski

Robert Hamilton

Rahel Fischer

1/ Tiburon Laboratory
Southwest Fisheries Center
National Marine Fisheries Service

Summary prepared from six-month Research Report to NOAA-Office of Marine Pollution Assessment, June 1, 1980.

In 1978, we initiated studies on the effects of selected inherent factors such as the condition of spawning adults and their genotypes on gametic viability of eggs. Our previous research on effects of aromatic petroleum hydrocarbons showed that fish during spawning condition were extremely sensitive to short, low-level exposures (Struhsaker, 1977; Whipple et al., 1978). There were also subsequent deleterious effects on survival and growth of eggs and larvae from exposed females.

In the spring of 1978, samples of prespawning adult striped bass were collected off Antioch, California, on the San Joaquin River during their upstream spawning migration and after they passed through the heavily industrialized Carquinez Strait area. Postspawning adults were collected in San Francisco Bay near the Tiburon Laboratory.

A total of 73 migrating, prespawning striped bass and 100 postspawning fish were collected and 165 parameters measured for each fish. Complete autopsies were performed and subsamples taken for various measurements. The purpose of this sampling was: (1) to determine the condition of parental fish just prior to spawning and to ascertain whether certain measures of parental condition correlated with measures of gametic viability, and (2) to identify factors which might relate to the annual "fish kill" of adult striped bass in the Carquinez Strait during the summer (Kohlhorst, 1973).

Initial results indicated that fish were generally in poor condition and heavily burdened with pollutants and parasites (some pathogenic to man).

Because of these results, we proposed to continue research on the probable long-term chronic impact of pollutants on the striped bass population and were funded for F. Y. 1979 from the Marine Sanctuaries Act 202 through the Office of Marine Pollution Assessment.

Research results from a total of 300 fish collected during 1978-1979 (Whipple, 1979) indicate that prespawning fish, their gonads and gametes, and postspawning fish are being deleteriously affected during their migration through the San Francisco Bay-Delta Estuary, and that the degree of this effect is determined by interaction of the parental genotype with environmental stress factors, including pollutants.

Results show:

1. A high percentage of the parental fish are in poor condition, as indicated by low body condition factors, macroscopic observations of abnormalities during autopsy, body lesions (approximately 35 percent), level of parasitism (approximately 50 percent showing parasitic damage to organs), and the blood cells (low numbers of lymphocytes, high numbers of granulocytes), among other physiological parameters. Liver and ovary tissues sampled were found to contain levels of zinc up to 90 ppm wet weight in ovaries and petrochemicals (aromatic and aryl cyclohexane petroleum hydrocarbons) up to 10 ppm wet weight in livers. There was a correlation between the poor condition of the parental fish and their ability to reproduce (12 percent of adult females did not ripen), 20 percent of those ripening had damaged ovaries (parasitism or dead eggs in ovaries), and fecundity and viability of eggs were reduced in the adults in worse condition and/or with high pollutant content.

2. Preliminary sample analyses of liver, muscle, testes, and ovaries of young adult striped bass for PCBs (Gadbois, Gloucester NMFS, pers. comm.) show the presence of PCBs (3-19 ppm WW in liver and 1 to 13 ppm ovaries; 1 ppm in testes; 0.3 to 0.6 ppm in muscle). Larger adults are expected to have higher levels and are currently being analyzed. Although levels of PCBs appear to be declining from previous years, they may be sufficiently high (particularly in concert with other pollutants) to cause deleterious effects on the striped bass population.

3. Striped bass collected from 1978-1980 appear to show increasingly poor health.

4. Striped bass at different seasons and from different areas vary physiologically and probably in susceptibility to pollutants and parasites.

5. There is genotypic variability in serum proteins, egg pigments (varying shades of yellow to blue-green), melanistic color patterns and certain meristic characters. The variability in some of these characteristics appears to correlate with different physiological types, varying in their resistance to environmental pollutants and parasitism.

6. There appear to be intraspecific, subpopulational differences associated with different river systems and different migrating schools.

7. Older, larger fish are generally less healthy and more heavily parasitized, and contain higher levels of pollutants.

8. Male and female fish vary in physiological condition and uptake of pollutants in liver and gonads, but both are heavily parasitized and show other similar effects.

9. The growth, reproduction and gametic viability have been reduced, probably in part by pollutants.

10. Reproduction has been affected as follows: Some adult fish do not mature, have reduced fecundity (number of eggs/fish), increased mortality of gametic eggs, parasitic damage to ovaries and eggs, inviable eggs (e.g., soft chorion).

11. In the laboratory studies, low levels (50-300 ppb) of petrochemicals (benzene) affected fish at both short and longer exposures.

12. Laboratory studies showed significant differences in the effects of benzene on fishes of different life history stages. The order of decreasing susceptibility to short-term, low-level exposures is as follows: (1) gametic (unfertilized) eggs, (2) adult female in spawning condition, (3) larvae (again varying with age), (4) spawned, fertilized eggs, (5) nonspawning adults, and (6) juveniles. The differences may be in part due to variation in rate of uptake and in metabolic rate. Over longer exposures, delayed effects seem to occur in all stages.

13. Striped bass larvae (yolk-sac and feeding stages) appear to continually bioaccumulate benzene/metabolites through uptake from water and food until death occurs.

The overall decline in the striped bass population may be partially attributable to decrease in reproduction and fecundity with increases in pollution, interacting with water diversion and low outflow years to increase mortality of eggs and larvae. Some mortality in the adult population also occurs, possibly because the adults are highly stressed from the interaction of pollutant and parasitic stress with spawning stress. The adults experience further stress as they migrate downstream through the Carquinez Strait after spawning, encountering salinity and pollution stresses in the null zone, and a proportion of "weaker" fish die. The interaction of these factors may explain the annual "fish kill" in summer.

1980 is the third year of collection of striped bass from the San Francisco Bay-Estuary under additional funding of the Marine Sanctuaries Act 202 for F. Y. 1980 and because of the establishment of the Cooperative Striped Bass Study with the State Water Resources Control Board.

As previously described in this Second Progress Report, a comparative sample of striped bass was taken from Coos River, Oregon. Efforts were also made to sample the Umpqua and Smith Rivers, however, attempts were unsuccessful.

Results of the Oregon sample are being analyzed. Generally, the fish exhibit characteristics differing from the San Francisco Bay population, including hermaphroditism. The parasitic assemblage in the hermaphroditic males and females captured from Oregon had few parasites, at least from gross observations, and were in better condition than the San Francisco Bay fish.

The 1980 samples of striped bass from the San Francisco Bay area show a continuing trend of high parasitic infections, lesions and other abnormalities as described above. Pollutant analyses are underway.

Additional results from sample analyses and histology have been completed and results are supportive of previous conclusions. Tissue damage in field-captured fish occurs in liver, gonads and several other tissues. Details of these analyses will be reported in the next progress report and upcoming publications.

Results and Discussion:

Results from sampling done thus far in 1980 are similar to those from 1978 and 1979. Slight increases in frequencies of parasitic damage and lesions are probably due to improved observation. Subsamples and data from more recent samples are still being analyzed and the following results are preliminary and not conclusive.

General Observations on Condition and Parasitism from Autopsies:

Fish collected from San Francisco Bay during their prespawning migration continue to show relatively high levels of parasitism and poor condition. Data analyzed so far show 57 percent of the fish with levels of parasitism causing organ and tissue damage, and 37 percent with lesions (most healed or healing in older fish). Fifteen percent of the females and 5 percent of the males showed extensive damage to gonads. The condition of many fish is poor, with several appearing emaciated. Some fish showed extensive visceral adhesions associated with healed lesions and subsequently high levels of parasitism. Some of these parasites are pathogenic to man (e.g., anisakids).

Data and Factor Analysis:

The analyses are proceeding with additional data for 1978 fish being added. The 1978 data base is now being reanalyzed. Analyses of 1979 fish are now complete. Analyses of 1980 fish will be completed by spring. Co-variance analyses of related sets of variables (factors) are also being run. All computer programs necessary to complete analyses are available and have been tested.

Genotypic Variability:

1. Serum Proteins. Some of the 1978 data on serum proteins is questionable, particularly that on polymorphism of transferrin. Improved methods of serum protein differentiation (using cellulose acetate) and quantification using a densitometer and the reading of charts should help clarify this issue. Albumin polymorphism appears to occur, as previously observed. Profiles of serum proteins from both fresh blood and freeze-dried tissues have been run on cellulose acetate. Approximately 10 serum proteins can be differentiated using the densitometer. Analyses are as yet incomplete, but it is apparent that there is variation among ages, sizes, spawning stages, sexes and other parameters. Heavily diseased fish appear to have significantly lowered quantities of serum proteins. With further analyses of data from our relatively large sample of fish, we hope to clarify the sources of variability in the serum proteins and to determine which, if any, are genetically variable and which may be a manifestation of environmental stress (e.g., parasites, pollutants).

2. Color Patterns (melanistic variability). We are continuing the assessment of variability in color patterns due to breakage of lateral stripes. Frequencies of different types appear to vary among different locations (e.g., rivers).

3. Meristics. These data have not been analyzed for 1980 fish.

4. Egg Color. Variation in egg color still occurs. We believe this variation to be associated with both genotypic and environmental-maturation factors.

5. Hermaphroditism (possibly genotypic). In three years of sampling and in over 400 fish only one fish from the San Francisco Bay area exhibited hermaphroditism. In the sample of 41 fish taken from the Coos River, Oregon, two fish appeared to be functional hermaphrodites (both testes and ovaries - only testes were ripe) and nine fish were predominantly female but showed varying amounts of testicular tissue (some ripe) in the posterior section of the ovaries. The latter case was always associated with a condition of high parasitism and occlusion of the cloacal region. Further analyses of these fish are planned.

6. Some other differences between the Oregon and San Francisco Bay fish were noted. Further analyses should show if these differences are significant. Except for hermaphrodites, the Oregon fish were at least superficially very similar to those from San Francisco Bay.

Parental - Congenital Variability:

1. Condition Factors. Calculations have not been completed. Many fish from San Francisco Bay appeared to be in poor condition. Most Oregon fish appeared to be deeper-bodied, but analyses must be done before conclusions can be made.

2. Pollutant Uptake. Subsamples for pollution analyses were expanded. Samples of muscle, liver, and gonads were taken for every fish for three types of pollutants: (1) petrochemicals, (2) heavy metals, and (3) PCBs. Additional subsamples were taken for analyses of the 129 EPA priority pollutants, and further gas chromatography/mass spectrometry.

   a. Heavy metal analyses of liver and gonad samples for fish collected in 1978 and 1979 continued. Additional analyses for mercury were made. These data will be reported when all samples are completed.

   b. Petrochemicals, primarily benzene and alkylated benzenes, were found in liver and gonad tissue, and this class of compounds appears to be one of the major groups of pollutants found in the San Francisco Bay striped bass. Mass spectrometry verification of samples for benzene and toluene in striped bass tissues was accomplished.

   c. Preliminary PCB analysis of muscle showed that smaller fish probably do not have levels dangerous to man. Larger fish are now being analyzed. Recent data from Gadbois (personal communication) show that high levels of PCBs occurred in ovaries of prespawning females, and relatively high levels in liver tissues (up to 13.0 ppm and 19.0 ppm, respectively). PCB analyses will continue with additional fish of different sizes sampled at different seasons. We believe that the highest PCB levels in muscle will probably coincide with the highest levels of lipid in the muscle, probably in larger fish during the nonspawning season and after maximum feeding has occurred.

The variability in levels shows the danger in extrapolating from a few fish, not representative of different ages and life history stages. Also, the life history stage of fish containing PCB levels affecting man (high levels in muscle, lower in liver and gonads) is probably different from the stage at which the fish itself is most affected (high levels in organs, lower in muscle).

3. Parasitism and Disease. Dr. Mike Moser has been given samples of fish collected during 1979 and has begun identification and quantification of the parasite assemblage in striped bass. His results to date support our previous conclusions that roundworm larval parasites are often at levels damaging to the fish. He has also found that cestode larvae are causing lesions in fish. Tissue samples have been made into slides for identification of parasitic damage to organs and tissues. The analysis of data on parasitism is proceeding and data is being entered on coding sheets. Samples taken in 1980 will also be identified and further work on identification of possible bacterial and viral infections will be pursued.

4. Hormones. We have hired a new biologist-chemist with a specialty in toxicology and biochemistry to pursue studies on pollutant effects on hormones. Many of the secondary physiological effects we observe appear to be related to hormones and steroid metabolism.

5. Blood Studies. We are continuing the examination of several blood parameters as being indicative of the physiological condition of the fish and also because some pollutants may damage hemopoietic organs and blood cells. Differential blood cell counts and examinations of white blood cells are continuing, and continue to show many fish with possible abnormal conditions. Tissue sections and kidney and spleen prints are being examined as well. The serum proteins are discussed above. Hematocrit is also being assessed. Effects on blood were observed, but data analyses are as yet incomplete.

   A complete set of photographs of different blood cell types and blood conditions in different fish has been taken. Descriptions of each type of cell are also being done, since no complete description of blood cells in striped bass is available. The blood cells are also being studied in the context of variability among different life history stages, sexes, etc.

   The uptake of benzene in blood in laboratory exposure studies has been measured and found to be relatively high.

6. Tissues. Samples of several tissues and organs from fish collected in the field and from fish used in laboratory exposure experiments have been made and are in the process of being examined by Dr. Wellings to determine criteria for assessing tissue damage in relation to all other parameters measured for each fish, including pollutant load. Tissue slides have been made for light microscopy of the following organs/tissues: gill, liver, spleen, kidney, adrenal gland, ovaries, testes, and miscellaneous other tissues. Further analyses will be done. Additional samples of suspected tumors are being collected and will be studied with electron microscopy.

Gametic Eggs and Egg Viability:

Egg samples will be assessed this winter using various measures of viability, including size, maturation, vitellogenesis, chorionic membrane, calorimetry, lipid analyses, pigments, chromosomes, etc. The condition of the eggs will be examined in the context of parental condition and genotype.

General Conclusions:

Several parameters being measured to study the relationship of pollutant load to physiological condition of the fish and gametic viability indicate a strong correlation. We are now in the stage of completing sample and data analyses. Field sampling has been discontinued by NMFS and assumed by SWRCB. We will concentrate on laboratory studies, analyzing samples, and planning experiments to test selected pollutants (in varying conditions) on fish in the laboratory.

HEALTH ADVISORIES ON THE HUMAN CONSUMPTION OF SAN FRANCISCO BAY-DELTA STRIPED BASS

Marv Jung [1/]

As the Cooperative Striped Bass Study team continues to document the poor health of the striped bass, the public has become increasingly concerned about the safety of consuming these fish. Press reports on lesioned bass, parasitic roundworms and tapeworms, and other abnormalities and newspaper reports contradicting these documented facts have confused the general public. At this time, we hope to clarify this issue by stating the State Department of Health Services' advisories on the consumption of fish, in particular, striped bass taken from the San Francisco Bay-Delta (Table 10). We hope the public acknowledges the fact that, although the fish may be eaten, the striped bass do have serious fish health problems. Public concern should not be limited to human health. The continual decline of the population and state of health of the fishery are also serious concerns. Factors being investigated in this study and factors in addition to the exportation of Delta water are adversely impacting this valuable resource. It is the common primary goal of the State Water Resources Control Board, the National Marine Fisheries Service, and the California Department of Fish and Game to determine and correct these factors for the protection and enhancement of the Bay-Delta striped bass fishery.

1/ Toxic Substances Control Program, State Water Resources Control Board.

TABLE 10

FISH HEALTH PROBLEMS AND HUMAN CONSUMPTION ADVISORIES

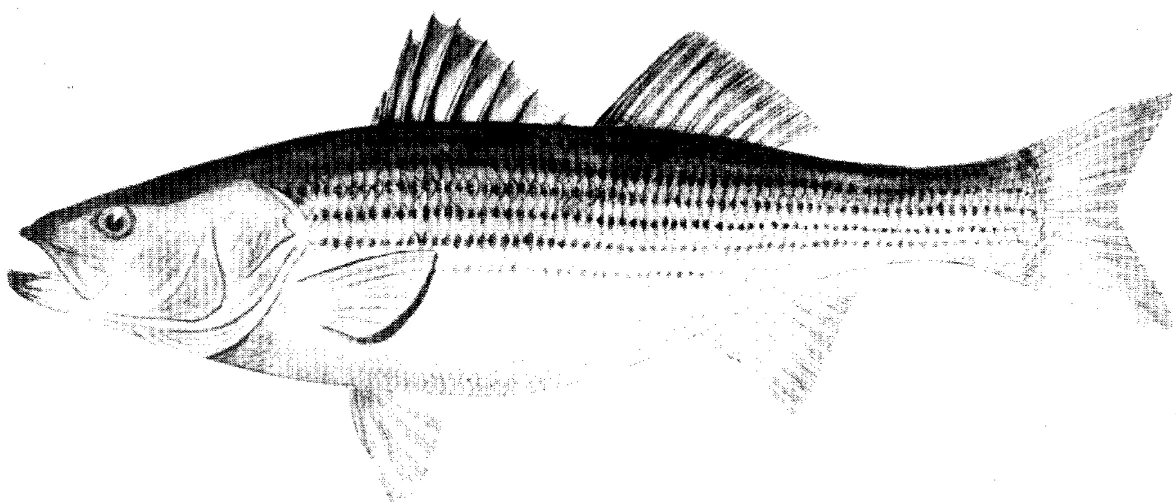
SCIENTIFICALLY DOCUMENTED STRIPED BASS HEALTH PROBLEMS	HYPOTHESIZED CAUSE	INFORMATION ON THE SAFETY OF CONSUMING STRIPED BASS
Lesions on sides of fish and internal parasitic tapeworm larvae in flesh and intestines.	Lesions are hypothesized to be an immunologic response of the fish to the presence of these tapeworm larvae.	No health problem to humans. This particular tapeworm larva (Lacistorhynchus tenuis; Order: Trypanorhyncha) cannot live in or harm humans. It is a common adult tapeworm found in sharks, rays, and skates. The cestode larvae are found in shiner perch, herring, and some rockfishes.
Presence of internal parasitic larval roundworm (anisakid nematodes) in flesh and intestines, liver, and body cavity of fish.	This common marine parasite is transmitted in the food web. The health advisories and recommendations apply to all marine and bay fishes since it is a common parasitic nematode.	State Department of Health Advisories (August 6, 1979): 1. Striped bass should only be consumed thoroughly cooked (this applies also to other marine and bay fishes). 2. Fish to be used in raw fish dishes should be used only after having been frozen for 60 hrs. at $-4^{o}F$ ($-20^{o}C$). Many home freezers cannot achieve this low temperature. It may be necessary to use a commercial freezer to ensure that these parasites are destroyed. Other recommendations: 1. Remove the larvae by examining thin slices of the flesh over a light source. The larvae will appear as shadows. 2. Cook or smoke thoroughly. Most curing, and marinating will not destroy these larval roundworms.

TABLE 10 (continued)

SCIENTIFICALLY DOCUMENTED STRIPED BASS HEALTH PROBLEMS	HYPOTHESIZED CAUSE	INFORMATION ON THE SAFETY OF CONSUMING STRIPED BASS
Mercury found in striped bass flesh in 1970-71.	Natural and anthropogenic sources.	State Department of Health Advisories since 1972 and still in effect: 1. No one should consume more than one meal per week of striped bass from the Bay-Delta fishery if the fish weighs more than four pounds. 2. Pregnant women and young children should not consume any striped bass from the Bay-Delta fishery
"Obviously diseased or sick"		State Department of Health Advisory (August 6, 1979): No obviously diseased or sick fish should be consumed by anyone in any manner of preparation.

Third Progress Report

COOPERATIVE STRIPED BASS STUDY



California State Water Resources Control Board
Toxic Substances Control Program
Special Projects Report No. 83-3sp

February 1983

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• Cover Artwork:

Susan Smith
National Marine Fisheries Service
Tiburon, CA