TOXIC SUBSTANCES MONITORING PROGRAM

1978

State of California
STATE WATER RESOURCES CONTROL BOARD

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ABSTRACT

Between June and September 1978, collections of benthic invertebrates, forage fish, and predator fish were made at 26 California streams. These samples were analyzed for certain toxic elements, pesticides, and other organic chemicals. Elevated concentrations of arsenic, cadmium, copper, lead, mercury, nickel, zinc, Aldrin, Dieldrin, DDT and its metabolites, Toxaphene, and polychlorinated biphenyls (PCBs) were detected in the tissues of organisms from some streams. Organisms from 12 streams contained toxicant concentrations exceeding recommended guidelines for protection of fish and wildlife. In addition, fish from the Eel River contained mercury levels exceeding the U. S. Food and Drug Administration guideline for human consumption. Suspected sources of these toxicants include natural weathering of geochemical formations and anthropogenic (man-caused) sources such as agricultural pesticide use, industrial waste, and mine drainage.

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INTRODUCTION

The purpose of California's statewide Primary Monitoring Network Program is to determine and to assess values and trends in water quality factors that may affect the beneficial uses of State waters. In recent years, improvements in analytical methods have resulted in documentation which shows that toxic substances are widespread in the environment. Because toxic materials may seriously affect the beneficial uses of State waters, monitoring of these materials is an appropriate element of this program.

From an analytical standpoint, monitoring of toxic substances is exceedingly difficult. The classic approach of water column testing is often ineffective. Toxicants usually occur in very low concentrations in the environment, and water analyses are often not sensitive enough to detect them. Moreover, because of persistence and biomagnification, some materials can have environmental effects that greatly exceed the effects of low concentrations in the water. Also, because toxicant concentrations are not static, instantaneous water sampling is unsatisfactory to determine the presence or absence of these materials with time. Finally, because toxic substances impact living organisms, measurement of toxicants in the water is inadequate to fully ascertain the effects on aquatic biota.

The problems associated with toxic substances monitoring can be partially overcome by analyzing the tissues of aquatic organisms. Tissue analysis is suitable because metabolic processes concentrate (biomagnify) the toxicants. Also, because aquatic organisms are resident in their environments, tissue concentrations of toxicants reflect exposures over time. Because not all toxicants act in a similar manner, these analyses determine which toxicants are accumulated.

California's Primary Monitoring Network includes monitoring stations on Priority I streams, the major surface waters. During 1978, organisms from 26 streams were collected and analyzed for toxic elements and organic substances. This report presents the results of the 1978 sampling series.

GOALS AND OBJECTIVES

The goals and objectives of the Toxic Substances Monitoring Program are as follows:

1. Develop statewide baseline data and report temporal and spatial trends of trace elements and organic substances in aquatic biota.
2. Assess analytical results for the biota and various tissues in order to select optimum sample material for the program.
3. Assess the impacts of accumulated toxicants on aquatic biota and man's uses of the waters.
4. Where problem concentrations of toxicants are detected, attempt to identify sources of toxicants and relate concentrations found in the biota to levels found in the water.
5. Develop data to assist in defining toxicant problem areas, to provide a basis for the design of studies to monitor these areas, and to recommend corrective measures.

SUMMARY AND CONCLUSIONS

SUMMARY

The State Water Resources Control Board (State Board) operates a statewide screening program for toxic substances in surface waters. This ongoing program began in the fall of 1976. Fish and invertebrate organisms such as clams and crayfish from the 28 Priority I State streams are annually collected and analyzed for selected toxic elements and organic compounds.

The report of the first two years' work under this program has been published as Water Quality Monitoring Report No. 79-20, "Toxic Substances Monitoring Program; 1976-1977." This report presents the 1978 data, compares it with data for the previous years, and identifies problem areas. This report also proposes specific actions for subject areas of highest priority to the State Board.

Twenty-six of the total 28 Priority I streams were sampled in 1978. The San Diego and Santa Margarita Rivers were not monitored as the San Diego is stagnant and the Santa Margarita was dry when sampling visits were made. Benthic (bottom-dwelling) invertebrates were collected as were forage and predator fish. Tissues of these specimens were analyzed for elements known to have biological significance; these are arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. Atomic absorption spectrometry was the analytical method employed. Tissues were also analyzed for organic compounds including approximately 70 pesticides and PCBs. Table 1 shows those compounds. Gas chromatography was the analytical method used for pesticide determinations.

Some modifications and improvements were incorporated into the 1978 program. In the previous work, the oldest and largest available fish were collected. Selection of older specimens generally meant that samples consisted of very few individual fish. In 1978, medium-sized, young adult specimens were collected in preference to older fish and, wherever possible, composite samples were made of at least 6 individuals.

Previously, whole fish or whole cross-sections of large fish were homogenized and analyzed for both pesticides and elements. In 1978, fish flesh was used for mercury and pesticides analyses; predator fish livers were used for determining

TABLE 1

Organic Compounds Selected for Analysis

aldrin
anilazine (dyrene)
benefin (benfluraline)
BHC, α
BHC, β
BHC, γ (Lindane)
BHC, δ
carbophenothion
CDEC (vegedex)
chlorbenside
chlordane, tech.
chlordane, α
chlordane, γ
chlordecone (kepone)
chlorobenzilate
chloroneb
chlorpropham (CIPC)
chlorpyrifos (dursban)
DDE, o, p
DDE, p, p'
DDD, o, p
DDD, p, p'
DDMS, p, p'
DDMU, p, p'
DDT, o, p
DDT, p, p'
DEF,
dialifor
diazinon
n-dibutylphthalate
dichlofenthion
dichloran (botran)
dicofol (kelthane)
dieldrin
endosulfan I (thiodan I)
endosulfan II (thiodan II)
endrin
EPN
ethion
fenitrothion (sumithion)
fenthion
fonofos (dyfonate)
heptachlor
heptachlor epoxide
hexachlorobenzene
malathion
methoxychlor
mirex
nitrofen (TOK)
parathion ethyl
parathion methyl
PCB 1221
PCB 1232
PCB 1242
PCB 1248
PCB 1254
PCB 1260
PCNB (quintozene)
perthane
phenkapton (kapton)
phorate (thimet)
prolan
propazine
ronnel
strobane
tetradifon (tedion)
toxaphene
2,4-D isopropyl
2,4-D isobutyl ester
2,4-D n-butyl ester

the elements other than mercury. No changes were made in the tissues of benthic organisms analyzed. Analytical changes included routine use of carbon rod atomic absorption to improve detection limits for the elements and high resolution glass capillary gas chromatography to improve the pesticides analyses.

A detailed discussion of the reasoning and implications behind these changes appears in this report. Briefly, it was felt that use of larger numbers of more normal-sized fish would provide better estimates of mean concentrations of toxicants present in the populations. Use of flesh for mercury and pesticides analyses was intended to enhance interpretation of the data relative to human consumption.

FINDINGS

The U. S. Food and Drug Administration (FDA) has established maximum levels for some toxic substances in human foods. These levels are based upon certain assumptions as to the quantities of food consumed by humans, and upon frequency of consumption. Therefore, the FDA limits are intended to protect people from chronic effects of these toxicants.

Only in one stream did toxicant concentrations in fish exceed the current FDA limit for human consumption. Sculpin flesh from the Eel River contained 1.15 ug/gm (ppm) mercury, exceeding the 1.0 ug/gm limit now in effect. As sculpins are not normally food fish, this finding may have limited applicability to the question of safety for human consumption.

The Environmental Protection Agency (EPA) and National Academy of Science (NAS) have established recommended maximum concentrations of some toxicants for protection of predator species. Because some toxic agents accumulate and concentrate in aquatic food chains, it is assumed that consumption of organisms having high toxicant concentrations would have magnified effects upon consumers of the organisms. According to this assumption, the EPA and NAS guidelines for toxicant concentrations in tissues are not only for protection of the organism containing the material, but also for protection of species that might consume the organism.

Table 2 compares select data to the established EPA, NAS, or FDA guidelines. Organisms from 12 State streams contained mercury, Aldrin, Chlordane, DDT, PCBs, and Toxaphene in concentrations equalling or exceeding these guidelines.

Table 2

Summary of Parameters Exceeding Established
FDA, EPA, or NAS Guidelines

STREAM	TOXICANT	SAMPLE TYPE*	CONCENTRATION ug/gm (ppm)	EPA OR NAS GUIDELINE ug/gm (ppm)	FDA GUIDELINE ug/gm (ppm)
Alamo R.	DDT	F	1.490	1.0	5.0
Cache Cr.	Mercury	P	0.61	0.5	1.0
Eel R.	Mercury	P	1.15	0.5	1.0
Feather R.	PCBs	P	0.696	0.5	2.0
Klamath R.	Mercury	P	0.60	0.5	1.0
Merced R.	DDT	P	1.077	1.0	5.0
Merced R.	Toxaphene	P	1.040	0.1	5.0
New R.	DDT	P	3.368	1.0	5.0
New R.	Toxaphene	P	3.400	0.1	5.0
Sacramento	Aldrin	C	0.133	0.1	0.3
Sacramento	Toxaphene	C	1.040	0.1	5.0
Sacramento	Mercury	P	0.83	0.5	1.0
Salinas R.	Toxaphene	C	0.460	0.1	5.0
San Joaquin	DDT	F	1.268	1.0	5.0
San Joaquin	Toxaphene	F	1.380	0.1	5.0
Stanislaus	Chlordane	C	0.100	0.100	0.3 Tentative
Yuba R.	Mercury	P	0.72	0.5	1.0

* P - Predator Fish; F - Forage Fish; C- _Corbicula_ sp. (freshwater clams)

Besides the organic compounds that could be identified, project samples contained numerous compounds that could not be identified with equipment available to the laboratory. Appendix 2 is a summary of compounds detected. Although some compounds could not be identified, their presence indicates possible pollution. In order to make a statewide comparison, the numbers of compounds appearing in predator fish and in forage fish from each station were averaged. Then, the streams were ranked according to the numbers of compounds found. Of the 26 streams sampled, six had forage and predator fish that averaged 10 or more compounds. The following summary presents the average number of compounds detected in forage and predator fish from each station on those six streams.

Stream	Average Number of Identified Compounds in Predator and Forage Fish	Average Number of Unidentified Compounds in Predator and Forage Fish
New R.	6	10
San Joaquin R.	4	12
Alamo R.	5	9
Santa Ana R.	4	7
Stanislaus R.	3	7
Merced R.	6	4

In most cases, the number of unidentified compounds exceeded the number of compounds that were identified. Fish from the New and San Joaquin Rivers contained the most compounds observed statewide.

The FDA guideline for lead in tissues is 7 ug/gm (ppm). Freshwater clams from the Kings River were highest in 1978, containing 0.6 ug/gm lead. Clams from the Feather and American Rivers and catfish livers from the Stanislaus River had 0.4 ug/gm. Lead concentrations in clams can be directly compared to the FDA guideline, since these organisms are consumed by humans. Concentrations of lead in fish liver cannot be directly compared, since the guidelines are for edible tissues. However, as lead concentrates in liver, the meat of these fish would be much lower in lead than the livers. Therefore, where lead values in liver are below FDA guidelines, the meat should present no hazard.

At present, no FDA, EPA, nor NAS guidelines have been established for the elements arsenic, cadmium, chromium, copper, nickel, silver, and zinc. Levels of these elements were variable in organisms from State streams; however, because no criteria exist with which to compare the values, few conclusions are possible concerning the meaning of the levels found. The data for these elements are summarized later in this report.

In addition to the routine monitoring program, a special study was performed on the Yuba River in 1978. Several species of aquatic organisms were collected and, where possible, different age groups were represented. Mercury concentrations present in various organisms are summarized as follows:

Organism	Age	Tissue	Mean Hg conc. ug/gm (ppm)
Crayfish	--------	tail flesh	0.24
Carp	adult	flesh	0.36
Sacramento Sucker	juvenile	flesh	0.13
" "	adult	flesh	0.49
Smallmouth bass	juvenile	flesh	0.40
" "	adult	flesh	0.76

Only adult smallmouth bass exceeded the 0.5 ug/gm (ppm) EPA limit for protection of predators, although adult suckers contained almost that amount.

Comparison of 1978 Water Analyses With Tissue Analyses

At most of the same stations at which animals were collected and analyzed, pesticides analyses of the water were also performed sometime during 1978. Generally, compounds found in the water were not detected in tissues; also, compounds measured in tissues were rarely detected in the water. One possible explanation is that the water and tissue samples were not taken at the same time and, therefore, do not represent the same exposure conditions. While this explanation may be partially correct, the differences must also be due to the fact that not all pesticides accumulate in tissues. The following summarizes compounds appearing in tissues and water samples during 1978.

Compound	Number of Samples in Which Compound was Detected: Water	Tissue
Atrazine/Simazine	4	
Dacthal	2	2
Phorate	2	
Ethion	1	
Parathion	1	
Lindane	1	
Methoxyclor	1	
DDT and metabolites		26
Dieldrin		8
Toxaphene		5
PCBs		3
Chlordane		1
Aldrin		1
Thiodan		1

Dacthal, a chlorinated compound, was the only pesticide observed both in the water and in tissues. It was observed in the New and Alamo Rivers in Imperial County.

Comparison of 1978 With 1976 and 1977 Data

Cadmium. Although neither EPA nor FDA has established cadmium guidelines for protection of wildlife or humans, cadmium is a toxic element that accumulates in animal tissues, especially kidneys, and inhibits organ function. Because cadmium is excreted very slowly by humans, the World Health Organization (WHO) has recommended that the human daily intake of cadmium should not exceed 0.07 mg. The following is a summary of cadmium values above 0.5 ug/gm (ppm) for the 1977 and 1978 study years.

Stream	Sampling Series	Type Sample	Cd conc. ppm (fresh wt.)
Mokelumne R.	1977	*Corbicula* sp. (freshwater clams)	0.6
" "	1978	*Corbicula* sp.	0.62
Salinas R.	1978	*Corbicula* sp.	0.64
Putah Crk.	1978	predator fish liver (Sculpins)	0.54
San Lorenzo R.	1978	predator fish liver (Sculpins)	0.98

In its Water Quality Criteria, EPA makes the assumption that, on an average, 18.7 grams of fish or shellfish are consumed daily by humans in this country. Follo this assumption, calculations can be made to determine whether the WHO guideline would be exceeded in any of the above streams. Corbicula sp. (freshwater clams) are used to some extent as human food. The highest value found (0.64 ug/gm) was in clams from the Salinas River; 18.7 grams of those clams (less than one ounce) would contain about 0.01 mg of cadmium, one-seventh of the recommended daily intake for humans. These values by themselves would appear not to be excessive from a human health standpoint. However, if cadmium intake from other sources was significant, human health could in an issue. Regarding the health of the aquatic biota, there appears to be cause for concern in some areas. San Lorenzo River fish livers showed the highest concentration of cadmium found statewide. There is an implication that the health of these fish could be impaired by these concentrations; also, any predators which consumed the entire fish would be subject to a high level cadmium intake.

Lead. In 1977, measurable lead concentrations were observed in freshwater clams from the American and Mokelumne Rivers; the values were 0.7 ug/gm (ppm) and 0.6 ug/gm, respectively. The highest lead concentrations observed in 1978 were in freshwater clams from the Kings River. That sample had 0.6 ug/gm lead. The second highest values recorded statewide in 1978 were 0.4 ug/gm (ppm), which were measured in freshwater clams from the Feather and American Rivers and from livers of catfish from the Stanislaus River. Both in 1977 and 1978, American River clams had elevated levels of lead, as compared statewide. This consistency indicates the possibility that the American River may contain relatively high lead concentrations. However, as lead is a very difficult element to measure accurately, more monitoring would be required to distinguish a clear pattern of high lead concentrations in the biota of the American River.

Mercury. Mercury is a toxic element that accumulates in aquatic food chains and can be harmful, especially to predators. For protection of predator species, the EPA has established a recommended guideline of 0.5 ug/gm (ppm) in tissues. The FDA guideline for human consumption is 1.0 ug/gm (ppm). Mercury data for the Toxic Substances Monitoring Program are summarized in Table 3. The only streams listed are those where fish had mercury concentrations equal to or greater than the 0.5 ppm EPA limit. Eight streams had fish exceeding the EPA limit. the Yuba River and in Cache Creek, fish contained more than the EPA limit on all

Table 3

Summary of Mercury Values Equaling or Exceeding 0.5 ppm
EPA Guideline For Protection of Predator Species

Sampling Series

	1976			1977			1978		
Stream	Hg conc. (ppm)	Type Fish*	% Fat	Hg conc. (ppm)	Type Fish	% Fat	Hg conc. (ppm)	Type Fish	% Fat
Yuba R.	1.5	P	0.3	1.98	F	13.2	0.72	P	0.2
Yuba R.				0.77	P	1.95			
Cache Crk.	0.58	F	0.6	0.56	P	0.06	0.61	P	0.3
Russian R.	0.95	P	1.3	0.5	P	0.02			
Sacramento R.	0.79	P	3.1			0.83	0.83	P	.1
Klamath R.				0.87	P	0.78	0.6	P	.1
Mokelumne R.				0.63	P	4.1			
San Lorenzo R.				0.5	F	0.73			
Eel R.							1.15	P	.1

* Denotes type fish having specified mercury level

P = predator fish, F = forage fish

three sampling occasions; Klamath, Russian, and Sacramento River fish had high levels on two of the three samplings; and Mokelumne, San Lorenzo, and Eel River fish had high concentrations on one of the three samplings. The highest concentrations observed statewide were in Yuba and Eel River fish.

DDT and Its Metabolites. DDT degrades in the environment to several other compounds, some of which are called DDD, DDMU, and DDE. These degradation products are toxic, as is DDT, and all are persistent and accumulate and concentrate in aquatic food chains. DDT has been banned by EPA since 1971; therefore, concentrations presently found in the environment are probably residual for the most part. Table 4 compares DDT residues found in the three samplings done to date. Only values exceeding established FDA or EPA guidelines are summarized, although fish from almost all of the sampled streams contained measurable levels of DDT or its degradation products, DDD, DDMU, and DDE. Fish from the Alamo, New and San Joaquin Rivers exceeded the 1.0 ppm EPA guidelines for protection of predator species on all three sampling occasions; Alamo River fish exceeded the 5.0 ppm FDA recommended tolerance for human consumption in the first sampling; in nine streams, fish exceeded the EPA guideline in one of the three samplings.

PCBs. Polychlorinated biphenyls, or PCBs, are chlorinated hydrocarbon compounds that are extremely toxic, carcinogenic, and persistent in the environment. Also, PCBs accumulate and concentrate in food chains. PCBs have primarily been used as dielectric coolant media in power transformers, although the material has been used for various other purposes, including manufacture of carbonless paper. Because of its extreme effects upon the environment, its manufacture and distribution are persently restricted by EPA. For protection of predator species, the NAS has recommended a 0.5 ug/gm (ppm) PCBs limit.

The FDA recommended limit for human consumption is 2.0 ug/gm (ppm) as of August 1979. Improvements in analytical methods made the 1976 PCBs data incompatible with 1977 and 1978 data; therefore, the 1976 data are not discussed. In 1977, the NAS limit was exceeded in fish from the Feather and Tuolumne Rivers; in 1978, only Feather River fish exceeded that guideline. The data are summarized as follows:

Stream	1977			1978		
	PCBs conc. (ppm)	Fish type	% Fat	PCBs conc. (ppm)	Fish type	% Fat
Feather R.	0.9	Forage	8.6	0.7	Predator	4.6
Tuolumne R.	0.61	Forage	1.3			

Table 4

Summary of DDT and Metabolites Exceeding 1.0 ppm
EPA Guideline for Protection of Predator Species

Sampling Series

Stream	1976			1977			1978		
	Total DDT conc. (ppm)	Type Fish*	% Fat	Total DDT conc. (ppm)	Type Fish	% Fat	Total DDT conc. (ppm)	Type Fish	% Fat
Alamo R.	6.7	P**	4.5						
Alamo R.	4.8	F	5.6	3.1	F	0.83	1.5	F	<.1
American R.				1.5	P	1.5			
Cache Crk.	1.4	F	0.6						
Feather R.				3.4	F	8.6			
Kings R.	1.0	F	12.1						
Merced R.							1.1	P	1.2
Mokelumne R.				1.4	P	4.1			
New R.	4.7	F	8.4	1.4	F	0.20	3.4	P	1.2
San Joaquin R.	3.2	F	1.9	2.0	F	0.31	1.3	F	0.7
San Joaquin R.				1.5	P	0.12			
Stanislaus R.	3.2	F	9.6						
Tuolumne R.	1.2	F	9.1						
Tuolumne R.	1.1	P	1.0						
Yuba R.				1.6	F	13.2			

* Denotes type of fish sampled: P = predator fish; F = forage fish
** Also exceeded 5.0 ppm FDA recommended guideline for human consumption

Toxaphene. Toxaphene is a chlorinated hydrocarbon pesticide that is similar to DDT in that the technical formulation is composed of numerous chemical compounds. Like DDT, Toxaphene has been used since the late 1940s; also like DDT, Toxaphene is persistent, toxic, and accumulates in aquatic food chains. Unlike DDT, however, Toxaphene is still registered for use in California, although it is on the EPA "rebuttable presumption" list. Under the "rebuttable presumption" procedure, manufacturers must submit data demonstrating the pesticide's safety in order to continue its EPA registration. Manufacturers have submitted data on Toxaphene; EPA is expected to announce its decision in the fourth quarter of 1979.

Toxaphene was detected only in fish from the 1978, or third, sampling series; fish from previous years may have contained Toxaphene also, but its presence was not definitely confirmed. The apparent higher concentrations of Toxaphene found in 1978 could represent actual conditions or may only reflect that, in 1978, fish muscle tissue was analyzed as opposed to whole fish in the previous years. As the number of samples analyzed was small, more monitoring will be required to determine whether the levels observed in 1978 are representative of the entire fish populations in these streams.

The EPA guideline for protection of predator species is 0.1 ug/gm (ppm). This concentration was exceeded in organisms from all five rivers in which Toxaphene was detected. The rivers are the Sacramento, San Joaquin, Merced, Salinas, and the New. The FDA guideline for human consumption is 5 ug/gm (ppm); that guideline was not exceeded in any 1978 project samples. The following is a summary of the Toxaphene data:

Stream	Toxaphene conc. (ppm)	% Fat	Sample type
Merced R.	1.04	1.2	Predator fish
" "	0.46	0.6	Forage fish
New R.	3.4	1.2	Predator fish
Sacramento R.	1.04	0.4	Benthos
Salinas R.	0.46	0.1	Benthos
San Joaquin R.	1.4	0.7	Forage fish
" " "	0.4	<0.1	Predator fish

Aldrin/Dieldrin. Aldrin and Dieldrin are chlorinated hydrocarbon pesticides that are persistent, toxic, carcinogenic, and accumulate in aquatic food chains. Because of the adverse environmental effects of these pesticides, their usage has been restricted since about 1971. Aldrin degrades in the tissues of aquatic organisms to Dieldrin. The EPA guideline for protection of predator species is 0.1 ug/gm (ppm) of Aldrin and Dieldrin taken together; the FDA guideline for human consumption is 0.3 ug/gm (ppm). Table 5 summarizes Aldrin and Dieldrin data for the three sampling years completed. Only values above 0.1 ppm are summarized. No streams had Aldrin or Dieldrin concentrations exceeding the EPA guideline on more than one of the three sampling occasions, although elevated values were observed in both predator and forage species from the Alamo and Santa Ana Rivers. During 1976, Dieldrin concentrations in Alamo River predator fish exceeded the FDA guideline for human consumption.

Chlordane. Chlordane, like DDT and Dieldrin, is a persistent, toxic, chlorinated hydrocarbon pesticide. Chlordane has been restricted for general use since 1975, although limited uses have been permitted since then. The EPA guideline for protection of predator species is 0.1 ug/gm (ppm). That value was equaled in Stanislaus River freshwater clams in 1978. No other organisms have contained measurable Chlordane levels in any stream or in any sampling series yet completed.

Identification of Toxic Substances Problems

Examination of the 1978 data and comparison with previous data has demonstrated that some areas should be studied in greater depth. Generally, selection of these areas was based upon whether consistently high trends of toxic substances were detected during the three years of the study. Also, where FDA guidelines were exceeded, those areas were chosen even where trends were not apparent. Finally, areas were suggested for further study when the substance in question is one that can be controlled; i.e., Toxaphene is presently being used as a pesticide and, therefore, is subject to regulation. Interpretation of the data has taken into account the fact that all the samplings and analyses were not identical from year to year. Considerable program changes were necessitated by experience and the practical limitations upon capturing adequate samples. Different species of different ages and size were collected; different size

Table 5

Summary of Aldrin and Dieldrin Values
Exceeding EPA Guidelines for Protection of Predator Species

Sampling Series

Stream	1976			1977			1978		
	Aldrin + Dieldrin conc. (ppm)	Sample Type*	% Fat	Aldrin + Dieldrin conc. (ppm)	Sample Type	% Fat	Aldrin + Dieldrin conc. (ppm)	Sample Type	% Fat
Alamo R.	0.25	F	5.6						
Alamo R.	0.32**	P	4.5						
New R.	0.27	F	8.4						
Sacramento R.							0.26	B	0.4
San Joaquin R.	0.11	F	1.9						
Santa Ana R.				0.12	F	3.71			
Santa Ana R.				0.16	P	0.39			

* B = benthos; F = forage fish; P = predator fish
** Also exceeded the 0.3 ppm FDA guidelines for human consumption

composite samples were prepared; dissection procedures were altered during the course of the program; different tissues were analyzed in 1978; and analytical procedures were improved each year.

In spite of the considerable difficulties involved with interpreting dissimilar data from a rather new program, some findings and conclusions have emerged. Table 6 is a list of streams in which various toxic agents may be affecting beneficial uses of State waters. Statewide, 13 of the 28 streams in the program are recommended for additional study.

The following problem areas were selected as being the issues of most concern warranting immediate follow-up action.

Yuba R. - mercury
Feather R. - PCBs
New R. - Toxaphene
San Lorenzo R. - cadmium
Merced R. - Toxaphene
Sacramento R. - Toxaphene
Salinas R. - Toxaphene
San Joaquin R. - Toxaphene

Action plans have been formulated for resolving the above problems; these plans are detailed in Appendix 3.

RECOMMENDATIONS

In regard to implementation of the Action Plans described in detail in Appendix 3, the State Board's staff has recommended to the State Board that it take action to:

1. Adopt the proposed priority action plans as a guideline for follow-up action to the monitoring report.
2. Authorize the augmentation of one position to the Toxic Monitoring Program to oversee the implementation of the action plans.
3. Request the appropriate Regional Boards to provide the necessary manpower to assist in the studies.

Table 6

Streams and Toxicants
Recommended for Further Study

Stream	Toxicant
Alamo R.	DDT, Aldrin/Dieldrin
Cache Crk.	mercury
Eel R.	mercury
Feather R.	PCBs
Klamath R.	mercury
Merced R.	Toxaphene
New R.	DDT, Toxaphene
Russian R.	mercury
Sacramento R.	mercury, Toxaphene, Aldrin/Dieldrin
Salinas R.	Toxaphene
San Lorenzo R.	cadmium
San Joaquin R.	DDT, Toxaphene
Yuba R.	mercury

4. Provide maximum assistance and top level support to the Department of Fish and Game in expanding its laboratory capability in the shortest time possible.
5. Direct staff to proceed as expeditiously as possible to implement the proposed actions within current laboratory capabilities.

At its September 1979 meeting, the State Board took formal action on recommendations 1, 2, and 3 above, and gave tacit concurrence with recommendations 4 and 5.

In regard to continuation and/or expansion of this toxic substances monitoring program, staff recommends that (1) the basic screening program on Priority I streams continue for at least two more years to enable a useful data base to be assembled; (2) the basic screening program be broadened to include other streams where problems are manifest or may reasonably be expected; (3) resources be made available on a continuing basis for more thorough evaluations of stream segments with identified toxic substances concerns; and (4) the Board devote the necessary resources to studies critically needed to enable staff to evaluate the relative egree of danger to humans or fish posed by the presence of the toxic substances identified.

MATERIALS AND METHODS

FIELD OPERATIONS

Station Locations

Twenty six stations were sampled in 1978 at locations designated by the Department of Water Resources (Department of Water Resources 1976). The sampling locations were the same as those used in previous collections, with the exception of the Merced River station which was moved to the correct site, 8 kilometers upstream (Figure 1).

The upstream and downstream limits of collection were extended in 1978 in order to provide a greater number of fish per composite. The water quality influences within each collection range were similar to those at the designated site as the range was restricted to boundaries defined by tributary confluences.

Collection Scheduling (Table 7)

Each sample collection was scheduled to correspond to the period of base flow for

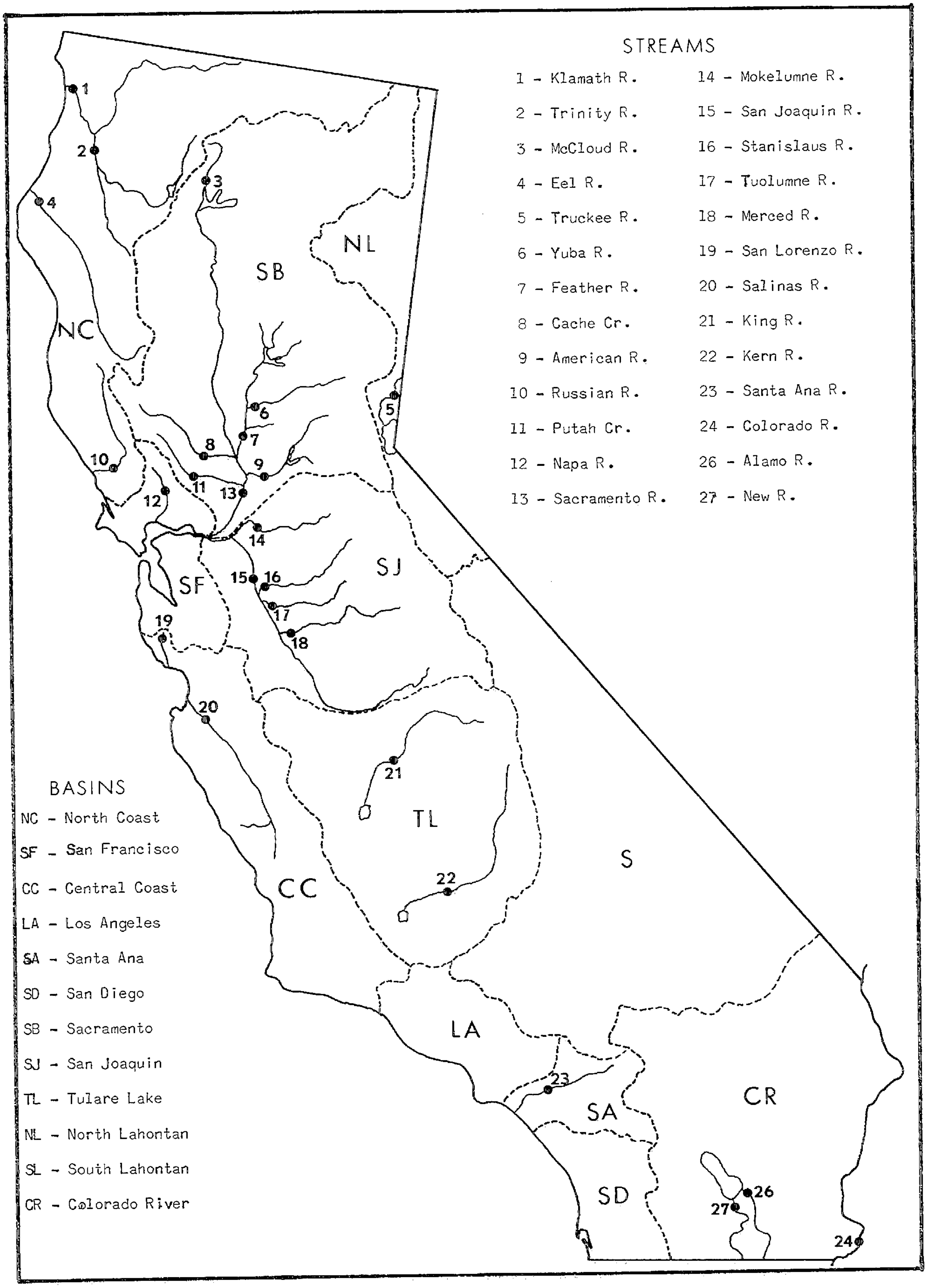


FIGURE 1. Primary monitoring network sampling stations.

TABLE 7. Sample collection dates for primary network rivers monitored in 1978.

Hydrologic Basins	Streams	Collection Dates
North Coastal	Klamath	July 25, 26
	Trinity	July 27, 28
	Eel	July 24
	Russian	July 11, 12
San Francisco	Napa	July 10, 12
North Lahontan	Truckee	August 2
Sacramento R.	McCloud	August 21, 22
	Sacramento	August 24, 25
	Yuba	September 19-23
	Feather	September 6-8
	American	July 30, 31
	Cache	August 29, 30
	Putah	June 13, 14
San Joaquin R.	San Joaquin	August 8, 9
	Mokelumne	July 13
	Stanislaus	August 7, 8
	Tuolumne	August 9, 10
	Merced	September 13-15
Tulare Lake	Kings	September 11, 12
	Kern	September 12, 13
Central Coastal	Salinas	July 19
	San Lorenzo	July 18, 20
Colorado R.	Colorado	June 19, 20
	Alamo	June 21
	New	June 22
Santa Ana R.	Santa Ana	June 23

a particular stream. Appropriate collection dates were estimated using historic streamflow records for water years with runoff similar to that predicted for 1978. The collection schedule was continually adjusted according to the most current streamflow conditions reported by the Department of Water Resources (DWR) and other agencies.

Sample Collection

The collection goal at each station was to obtain samples of a benthic species, a forage fish species, and a predator fish species. Collection techniques were similar to those described previously (Woodard 1979).

Species collection goals were established for all rivers in order to obtain maximum species standardization within the network (Table 8). Tables 9-11 list the organisms collected. When possible, composite samples for each species were constructed using six median-size organisms. The number and size uniformity of organisms in each composite was contingent upon their availability. Replicate composites collected at some stations were analyzed to measure toxicant variability in single species composites collected at the same point in time and space. Table 12 summarizes collection success for 1978.

On-site processing of samples was restricted to sorting collections for uniform composites and examination of individual organisms for external lesions. All samples were placed whole in aluminum foil, double-wrapped, labeled, then frozen by packaging in sliced dry ice.

LABORATORY OPERATIONS

Sample Storage and Preparation

Field samples were kept frozen until processed. Freezer storage of unprocessed samples varied from one day to two weeks.

All hardware used was chemically cleaned before and after laboratory processing of each sample. All organisms prepared for analysis were rinsed in deionized water while in a semi-frozen condition, then dissected on a sheet of aluminum foil within a large glass box. This "clean box" was used to avoid potential contamination from atmospheric fallout. Tissues extracted for analysis were

TABLE 8. Species collection priorities for each hydrologic basin in the California Primary Monitoring Network, 1978 (Toxic Substances Monitoring Program).

Hydrologic Basin	Collection Goal	Benthos	Forage Fish	Predator Fish
North Coast	primary	Freshwater mussels or Asiatic clams	Klamath small scale sucker or Sacramento sucker	Sculpin
	secondary	Crayfish		Green Sunfish
Sacramento	primary	Asiatic clam	Carp	Channel catfish or White catfish
McCloud R. 1/	secondary	Crayfish	Sacramento sucker	Largemouth bass or Smallmouth bass
Putah Crk.	primary	Crayfish	Sacramento sucker	Brown trout
	secondary		Carp	Sculpin
San Joaquin	primary	Asiatic clam	Carp	Channel catfish or White catfish
	secondary	Crayfish	Sacramento sucker	Largemouth bass
Tulare Lake	primary	Asiatic clam	Carp	Channel catfish or White catfish
	secondary	Crayfish	Sacramento sucker	Largemouth bass
North Lahontan	primary	Crayfish	Mountain whitefish	Brown trout
	secondary		Tahoe sucker	Rainbow trout
San Francisco Bay	primary	Asiatic clam	Carp	Cannel catfish or White catfish
	secondary	Crayfish	Sacramento sucker	Green sunfish

TABLE 8. (Cont.) Species collection priorities for each Hydrologic Basin in the California Primary Monitoring Network, 1978 (Toxic Substances Monitoring Program).

Hydrologic Basin	Collection Goal	Benthos	Forage Fish	Predator Fish
Central Coast				
Salinas R.	primary	Asiatic clam	Carp	Channel catfish or White catfish
San Lorenzo R.	primary	Crayfish	Sacramento sucker	Sculpin
Santa Ana	primary	Crayfish	Carp	Green sunfish
Colorado R.	primary	Asiatic clam	Carp	Channel catfish or White catfish
	secondary	Crayfish		Green sunfish

1/ The McCloud River and Putah Creek have different priority species than the other rivers in the Sacramento Basin.

Table 9. Scientific and common names of benthos collected during 1978 Toxic Substances Monitoring Program .

Scientific Name	Common Name
Anodonta californiensis	Freshwater mussel
Corbicula sp.	Asiatic clam
Gonidea angulata	Freshwater mussel
Limnephilus sp.	Caddisfly larvae
Pacifastacus leniusculus	Crayfish
Procambarus clarkii	Red swamp crayfish

Table 10. Scientific and common names of forage fish collected during 1978 Toxic Substances Monitoring Program .

Scientific Name	Common Name	Family
Catostomus occidentalis	Sacramento sucker	Catostomidae
Catostomus rimiculus	Klamath smallscale sucker	Catostomidae
Cyprinus carpio	Carp	Cyprinidae
Ictalurus nebulosus	Brown bullhead	Ictaluridae
Prosopium williamsoni	Mountain whitefish	Salmonidae

Table 11. Scientific and common names of predator fish collected during 1978 Toxic Substances Monitoring Program .

Scientific Name	Common Name	Family
Cottus sp.	Sculpin	Cottidae
Ictalurus catus	White catfish	Ictaluridae
Ictalurus punctatus	Channel catfish	Ictaluridae
Lepomis cyanellus	Green sunfish	Centrarchidae
Micropterus dolomieui	Smallmouth bass	Centrarchidae
Micropterus salmoides	Largemouth bass	Centrarchidae
Salmo trutta	Brown trout	Salmonidae

TABLE 12. Summary of species and composite goals for 1978 (Toxic Substances Monitoring Program).

	Collections Not Obtained		Collections of Primary Species		Collections of Secondary Species		Composites With 6 Individuals	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Benthos	4	(15)	17	(77)	5	(23)	21	(95)
Forage Fish	2	(8)	21	(88)	3	(12)	10	(42)
Predator Fish	2	(8)	18	(75)	6	(25)	14	(58)

discarded if they contacted anything other than chemically cleaned tools or storage containers.

Tissue for metal analyses was stored in plastic vials, whereas tissue for organic analyses was stored in glass jars with glass lids. When there was only a small amount of sample, metal analyses were given priority.

Specific sample preparation procedures were as follows:

Benthos. Benthic samples were analyzed for trace metals and organics, including pesticides. Tissues prepared for these analyses included soft parts of molluscs, crayfish tail flesh, and whole bodies of insect larvae.

Bivalve molluscs and caddisfly larvae were rinsed thoroughly under a stream of deionized water following shell or case removal in order to avoid contamination from sediment that had adhered to the organism.

Benthic composite samples consisted of from 6-25 uniformly sized individuals. Each composite was homogenized to a paste-like texture using a Virtis® mixer equipped with a titanium blade assembly and a glass sample container.

Fish. Metals and pesticides have a tendency to adhere to the skin of fish. Generally, if fish are analyzed with and without skin, the samples containing skin show higher toxicant concentrations. Therefore, skin is a useful organ for concentrating toxicants to measurable levels. However, there are two main problems with the use of skin. First, it is in direct contact with the external environment and is subject to easy contamination. Second, samples analyzed by FDA in developing their guidelines did not include the skin of fish, and many previous studies on fish have determined the level of toxicants in specific organs. If this study included skin in the samples, the data could not be readily compared to FDA guidelines or the findings of other studies. In consideration of the problems and desirability of making comparisons with other data, it was decided to eliminate use of skin.

It was decided to use discreet tissues rather than homogenized combinations of tissues as were used in 1976 and 1977. (Whole fish and whole cross sections of larger fish were used in those years.) Analysis of discreet organs should make data interpretations more meaningful and should reduce data variability. From the standpoint of human consumption, edible tissues (muscle) would be desirable tissues for analysis. Pesticides and mercury accumulate in the fat associated with muscle; therefore, muscle was chosen as the tissue for pesticides and mercury analyses. Unfortunately, the other elements being analyzed do not accumulate well in muscle tissue. Liver, however, is a key organ in which toxic elements accumulate and affect organ function. Livers of predator fish can be easily and cleanly dissected, making good samples. Forage fish on the other hand, have livers that are intertwined with intestines, making clean excision difficult or impossible. It was decided that predator fish livers would be used to analyze for toxic elements other than mercury, including arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc.

Muscle tissue was dissected by first skinning the fish and then coring out a section of fillet in the anterior dorsal quadrant using a carbon steel scalpel. Sample composites of similar size sections of muscle tissue were homogenized in a Virtis® mixer.

Liver was extracted only from predator fish using a carbon steel scalpel and plastic forceps. Whole livers were composited in plastic vials; the samples were partially frozen and then homogenized by crushing with a teflon stirring rod.

TRACE ELEMENT ANALYSIS TECHNIQUES

Analyses for copper and zinc were performed using conventional (flame) atomic absorption spectrophotometry (AAS), whereas cadmium, chromium, lead, nickel, and silver required the more sensitive carbon rod analysis tenchique. Arsenic concentrations were determined by arsene generation and mercury by the cold vapor technique. Samples were analyzed using a Varian model 1200 AAS equipped with a Varian model 63 carbon furnace. The specific digestion technique, instrumentation, and detection limit for each trace element are described (Table 13). All analytical values were corrected using procedural blanks.

Quality control for trace element analysis included taking replicates of every tenth sample through the entire analytical scheme. Additionally, all materials

TABLE 13. Digestion techniques, instrumentation and detection limits for the 1978 primary network trace element analysis program.

Element	Digestion Techniques	Instrumental Analysis	(ug/gm wet wt.)	Reference
Arsenic	Dry Ash w/Mg $(NO_3)_2 \cdot 6H_2O$	$NaBH_4$ Reduction A.A.	0.2	1
Mercury	$H_2SO_4/KMnO_4$	Cold Vapor A.A.	0.015	2
Copper	HNO_3/H_2O_2	Flame A.A.	0.02	3
Zinc	HNO_3/H_2O_2	Flame A.A.	0.5	3
Cadmium	$HClO_4/HNO_3$ wet pressure	Carbon Rod	0.005	3,4
Chromium	$HClO_4/HNO_3$ wet pressure	Carbon Rod	0.1	3,4
Lead	$HClO_4/HNO_3$ wet pressure	Carbon Rod	0.08	3,4
Nickel	$HClO_4/HNO_3$ wet pressure	Carbon Rod	0.7	3,4
Silver	$HClO_4/HNO_3$ wet pressure	Carbon Rod	0.04	3,4

References

1) Uthe, J.F., H.C. Freenan, J.R. Johnson, and P. Michalik. 1974. Comparison of wet ashing and dry ashing for the determination of arsenic in marine organisms, using methylated arsenols for standards. Assoc. Official Analytical Chem., J., 57(6):1363-1365.

2) Hatch, W.R., and W.L. Ott. 1967. Determination of sub-microgram quantities of mercury by atomic absorption spectrophotometry. Analytical Chem. 40(14):2085-2087.

3) Association of Official Agricultural Chemists. 1975. Official methods of analysis. 12th ed. AOAC, Washington, DC. 1094 p.

4) Adrain, W.J. 1971. A new wet digestion method for biological material utilizing pressure. Atom. Absoption Newsletter 10(4):96.

contacting samples during field and laboratory operations were analyzed for excessive trace element content. To insure accurate analyses, Moss Landing Marine Laboratory, Scripps Institution of Oceanography, and the Water Pollution Control Laboratory each analyzed a mussel standard prepared for intercalibration of laboratories participating in the National Mussel Watch Program. The values reported by each laboratory were similar (Table 14).

PESTICIDE AND TRACE ORGANIC SUBSTANCES ANALYSIS TECHNIQUES

Sample extraction procedures and chromatographic conditions were identical to those used previously (Woodard 1979). Pesticides, PCBs and trace organics were analyzed by electron capture gas chromatography using pretested column packing material. Selected samples were analyzed with the high resolution glass capillary column. With these methods, about 70 different compounds can be identified. Unidentified trace organic compounds were also documented during the analysis of each sample.

As with trace element quality control, replicates of every tenth sample were taken through the entire analytical scheme. All materials and solutions contacting the sample after initial extraction were analyzed for organic contamination. To prevent cross-contamination, a solvent blank was passed through each set of glassware before introducing a new sample.

RESULTS AND DISCUSSION

SAMPLE COLLECTIONS

One sample collection was made at each station between mid-June and late-September of 1978 (Table 7). Due to above normal runoff during the 1978 water year, the base flow period came later than usual on most streams. Consequently, the collection schedule often had to be revised; even with these revisions, high water conditions unavoidably hampered some of the collections.

TABLE 14. Analyses of standard reference materials, 1978.

Sample 1/	ug/gm fresh weight					
	Ag	Cd	Cr	Cu	Ni	Zn
MLML	.58	5.6	1.8	6.9	2.0	113
MLML	0.60	6.6	---	5.6	2.5	106
SIO	---	7.9	---	8.7	---	134
WPCL	.58	6.7	2.3	6.7	2.2	141
WPCL	.81	6.6	1.8	6.7	2.5	130
WPCL	.77	6.5	1.6	6.7	2.0	138
WPCL	0.72	---	2.0	---	2.5	---
WPCL	0.60	---	2.4	6.7	2.2	123

1/ MLML - Moss Landing Marine Laboratory

SIO - Scripps Institution of Oceanography

WPCL - Fish and Wildlife Water Pollution Control Laboratory

The biological collections included six species of benthos, five species of forage fish, and seven species of predator fish (Tables 9, 10 and 11). Biological data have been summarized for each station (Appendix 1). Sample quality was improved in 1978 by reducing the number of fish species approximately 50% and increasing the number of fish per composite. Benthos and fish samples that achieved stated collection goals have been summarized (Table 12).

In addition to standard sample collections, ten replicate composites were collected. Three of the replicate composites were analyzed to determine biological variability; the remaining composites were stored for future analysis, if resources permit.

Field Variability

In order to establish acceptable baseline data, residue values must be representative of those values in the resident population. Site specific studies that establish a frequency distribution of individual residue values in a population are necessary to define a representative sample, but this method is costly. Instead, replicate single-species composites were used to estimate within-site variability for some species. If for a species, the difference between replicate composites at one site is greater than the difference between sites, then it may not be safe to assume the sample is representative of the population. Within-site variability of replicates can be caused by differences in behavior, diet, digestive physiology and fat content of those individuals which make up the composite, or by analytical variability.

Results of replicate fish analyses show close agreement between subsamples of catfish population from the Sacramento River and from the San Joaquin River (Table 15). Trace metal analyses of field replicate samples generally gave values within 30% of each other. As expected, this indicates that there is greater variability between field replicate samples than within samples, as shown by the 20% difference between duplicates (see Analytical Variability).

Pesticide analyses of field replicate samples indicate that those with higher fat content generally yield higher pesticide residue values. This too demon-

TABLE 15. Field replicate sample analyses for metals and pesticides, 1978.

Metals (mg/kg fresh weight)

River	Sample	L (mm)	W (gm)	Ag	Cd	Cr	Cu	Ni	Zn	As	Pb	Hg
Sacramento	White Catfish	276	304	<.05	.46	<.1	3.6	<.2	22	<.1	0.1	.80
	Replicate	278	308	<.05	.52	<.1	3.1	<.2	20	<.1	0.2	.52
San Joaquin	White Catfish	222	147	<.03	.08	<.1	4.7	<.2	23	.13	0.1	.42
	Replicate	193	105	<.03	.12	<.1	4.7	.44	16	<.1	0.2	.34
Russian	Sacramento Sucker		NOT ANALYZED (FORAGE FISH)									

Pesticides (ug/kg fresh weight)

River	Sample	L (mm)	W (gm)	% Fat	DDT	DDD	DDE	DDMu	Total DDT	Toxaphene
Sacramento	White Catfish	276	304	< 0.1	20	15	63	34	132	
	Replicate	278	308	0.3	19	26	123	17	185	
San Joaquin	White Catfish	222	147	< .1	56	53	391		500	433
	Replicate	193	105	.2	33	46	607		686	450
Russian	Sacramento Sucker	336	421	<.1	7	5	14		26	
	Replicate	334	406	<.1	<.5	<.5	<.5		<.5	

strates the variability between replicate field samples, which is a result of the nonuniformity of contaminant loads within those individual specimens that make up the replicate samples.

Analytical Variability

Trace Elements. Trace metal analyses on duplicate samples produced results that were generally within 20% of each other (Table 16). Proposed improvements in the sample homogenizing techniques should improve the agreement between duplicate samples in 1979. The intercalibration program has established that techniques used by WPCL produce values that are within the range reported by other laboratories (Table 14).

Pesticides and Organics. Pesticide quality control results show close agreement between duplicative values (Table 17). Recovery of pesticides was determined by spiking 10% of the samples with Endrin at the 120 ppb level. Average recovery was 63% (Table 18). This value is within the generally accepted range for Endrin recovery.

Field and Analytical Variability of Yuba River Samples

Various benthos and fish species from the Yuba River were analyzed in a special study to examine toxicant variability due to (1) the species or organism used, (2) size of the organism selected for the composite, and (3) the precision of the analytical techniques. Nine trace elements (Table 19) as well as DDT and DDE (Table 20) were analyzed in freshwater clams, crayfish, and four fish species (carp, Sacramento sucker, smallmouth bass, and largemouth bass).

Juvenile carp were not captured. However, juveniles of the three remaining species contained less mercury in flesh tissue than adults although the difference between the two in largemouth bass was not great. Adult smallmouth bass and largemouth bass accumulated the most mercury, 0.76 and 0.82 ug/gm (ppm), respectively, and exhibited the least difference between adult and juvenile values. The Sacramento sucker exhibited the greatest difference between levels of mercury in the adult (0.49 ug/gm) and in the juvenile (0.13 ug/gm). Analytical precisi

TABLE 16. Duplicative sample analyses for metals, 1978.

River	Sample	mg/kg Fresh Weight								
		Ag	Cd	Cr	Cu	Ni	Zn	As	Pb	Hg
Russian	*Corbicula* sp.	.04	.16	.7	4.2	1.1	13		<0.1	
	Duplicate	<.02	.14	.67	3.4	.80	12		NS	
Colorado	*Corbicula* sp.	.12	.16	<.1	8.5	.2	15		0.2	
	Duplicate	.11	.10	<.1	8.5	.4	18		NS	
Colorado	Channel Catfish	<.03	.12	<.1	3.4	<.2	25		0.2	
	Duplicate	<.03	.12	<.1	4.0	<.2	26		0.3	
Merced	Channel Catfish	<.02	.12	<.06	3.1	<.14	26		0.1	
	Duplicate	<.02	.14	<.06	2.7	.14	24		0.1	
Klamath	*G. angulata*							.47		
	Duplicate							.60		
New	Channel Catfish							<.1		
	Duplicate							<.1		
Napa	Green Sunfish									.09
	Duplicate									.14
Tuolumne	Channel Catfish									.24
	Duplicate									.30
Kings	Largemouth Bass									.09
	Duplicate									.07
Truckee	Brown Trout									.03
	Duplicate									.03

TABLE 17. Duplicative sample results for pesticide and PCB analyses of selected samples, 1978. Concentrations are expressed in ug/kg (ppb) fresh weight.

River	Species	Sample[1/]	L (mm)	W (gm)	DDE	DDD	pp'DDT	Total DDT	Dieldrin	Dacthal
Truckee	*Prosopium williamsoni*	R	279	314	< 5	< 5	< 5	< 5		
		Q			6	< 5	< 5	6		
American	*Micropterus salmoides*	R	262	337	44	< 5	9	53		
		Q			45	< 5	< 5	44		
Salinas	*Cyprinus carpio*	R	213	257	47	8	7	62	7	
		Q			24	6	7	37	7	
Kings	*Micropterus salmoides*	R	158	85	20	< 5	< 5	20		
		Q			17	< 5	< 5	17		
Santa Ana	*Procambarus clarkii*	R	115	---	< 5	< 5	< 5	< 5		
		Q			5	< 5	< 5	5		
Alamo	*Cyprinus carpio*	R	350	1,250	1,360	121	9	1,490	33	460
		Q			816	73	12	901	19	430
Russian	*Catostomus occidentalis*	R	334	406	< 5	< 5	< 5	< 5		
		Q			< 5	< 5	< 5	< 5		

1/ R=routine sample; Q=quality control sample.

Table 18

Recovery of Endrin From Spiked Samples, 1978

Sample No.	Endrin (ppb)	% Recovery
F-10	74	62
P-13	74	62
P-15	82	68
F-20	92	77
P-21	68	57
B-23	72	60
F-26	81	68
P-27	59	49
	$\bar{x}$=75	$\bar{x}$=63

TABLE 19. Trace element concentrations and analytical variability in benthos and fish from the Yuba River, 1978. Mean and standard deviation (where possible) appear in parentheses.

Organism	Tissue	mg/gm Fresh Weight								
		Ag [2/]	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Clam	Body	.04	.41	.36	1.2	8.2		1.4		9.7
		.02	.47	.36	1.3	5.8		1.6		10
		.04	.58	.41	0.9	8.6		.97		9.7
		(.03±.09)	(.49±.09)	(.38±.04)	(1.1±.2)	(7.5±1.5)		(1.3±.3)		(9.8±.2)
Crayfish	Tail	< .04	.24	.20	< .1	17		.9		12
		.06	.20	.10	< .1	13	.25	.2		12
		< .04	.24	.24	< .1	16	.24	.6		12
			(.23±.02)	(.18±.08)		(15±2.1)	(.24)	(.6±.4)		(12±0)
Carp	Flesh						.37			
							.35			
							(.36)			
Sacramento Sucker	[1/] (J) Flesh						.10			
							.15			
							(.13)			
	(A) Flesh						.44			
							.53			
							(.49)			
Smallmouth Bass	(J) Flesh						.37			
							.43			
							(.40)			
	(J) Liver	< .04	< .1	.16	< .1	1.2		.5		14
			< .1							
			< .1							
	(A) Flesh		< .1				.68			
							.76			
							.84			
							(.76±.08)			

[illegible] - juvenile; A - adult

2/ Mean and standard deviation (where possible) appear in parentheses.

TABLE 20. Levels of DDT and DDE and Analytical Variability in Benthos and Fish from the Yuba River, 1978.

			ug/kg (ppb) fresh weight			
Organism		Tissue	DDT	DDE	$\bar{x}$	S.D.
Clam		body	<5	7		
Crayfish		tail	<5	2		
Carp		flesh	8	97		
Sacramento sucker	(J)[1/]	flesh	<5	1		
	(A)	flesh	25	76		
Smallmouth bass	(J)	flesh	<5	10		
	(A)	flesh	<5	8	6.8	2.1
				5		
				9		
				5		
Largemouth bass	(J)	flesh	<5	8		
	(A)	flesh	<5	3	3.0	0
				3		
				3		

1/ J - juvenile; A - adult.

for mercury was acceptable in all species examined.

Corbicula sp. appear to be the most suitable organism in terms of analytical precision for the nine elements of interest. The greater variability of fish and crayfish tissue results is believed to be due to a nonhomogenous tissue slurry. Improved homogenization techniques will be developed during the 1979 sampling period.

Levels of DDT and DDE were similar in clams, crayfish, juvenile sucker, and juvenile and adult smallmouth bass and largemouth bass (Table 20). In these organisms, values for DDT were all <5 ug/kg (ppb) (fresh weight basis), and DDE values were all ≤ 10 ug/kg. The adult carp and sucker exhibited the highest DDT and DDE levels (76 and 97 ug/kg, respectively) which are appreciably greater than the concentrations in other organisms tested.

Quadruplicate analyses of adult smallmouth bass flesh for DDE yielded an average concentration of 6.8 ± 2.1 ppb. Triplicate analyses of adult largemouth bass flesh for DDE yielded an average concentration of 3.0 ± 0 ppb. Both results demonstrate acceptable precision for pesticide analyses.

TRACE ELEMENT, PESTICIDE, AND TRACE ORGANIC RESIDUES

Data from the Toxic Substances Monitoring Program depict the distribution of trace elements and synthetic compounds within the Primary Network stations. The organisms collected and analyzed are from aquatic ecosystems ranging from uncontaminated to highly contaminated. The objectives include identification of areas of signficant contaminant concentrations and a description of temporal changes.

Care must be taken when attempting to summarize these concentration data for fish and benthos. Characterizing the data using methods such as mean and standard deviation, which assume residue values are normally distributed within a population, can be misleading because of the small sample size. More importantly, trace contaminant levels in populations frequently approximate a log normal distribution instead of a normal distribution (Tipton and Cook 1963;

bscher and Smith 1968; Ting and de Vega 1969; Pinder and Smith 1975; Eberhart et al. 1976; and Giesy and Wiener 1977). Since it cannot be assumed that residue values in river populations are normally distributed, a nonparametric or rank type statistical test is more appropriate. Rank tests, however, are only valid within a species-substance grouping because residue values tend to be species dependent (Lucas, Edgington, and Colby 1970; Bussey, Kidd, and Potter 1976; and Giesy and Wiener 1977). At present, rank comparisons cannot be applied because of the lack of consistent species-substance groupings within the primary network. Instead, residue values are simply plotted to allow broad-based comparisons.

Collection of statistically significant data could be improved by network standardization. Three composites of a single species would be collected at each sample site as was done in the California Mussel Watch Program (Stephenson, Martin, and Martin 1978). Single species standardization would eliminate interspecies variability, and the collection and separate analysis of three single-species composites of 15 individuals each would yield a good estimate of population mean concentrations of toxicants. The collection of 45 benthic individuals ld be an attainable goal at most stations; however, such large numbers of fish would not be available at most stations. The desirability and implementation costs of such a program need to be explored in greater detail.

Impact assessment of accumulated toxicants on aquatic biota, although beyond the scope of the present study, is a long-range goal of the program. Further research is necessary to determine body burden effects. For present purposes, however, residues of some toxic substances can be judged excessive using recommended (guideline) levels established by the National Academy of Sciences, National Academy of Engineers (NAS/NAE) in 1974 and by the EPA (1976) and FDA (1978 a, b).

Statewide Distribution of Trace Elements

Except for mercury, trace element monitoring data were acquired using predator fish liver and soft parts of benthos. Mercury analyses used predator fish flesh. Analytical results for each station were tabulated (Appendix 1). Residue values were plotted for each trace element in order to estimate high, common, or low ues and to display distribution patterns.

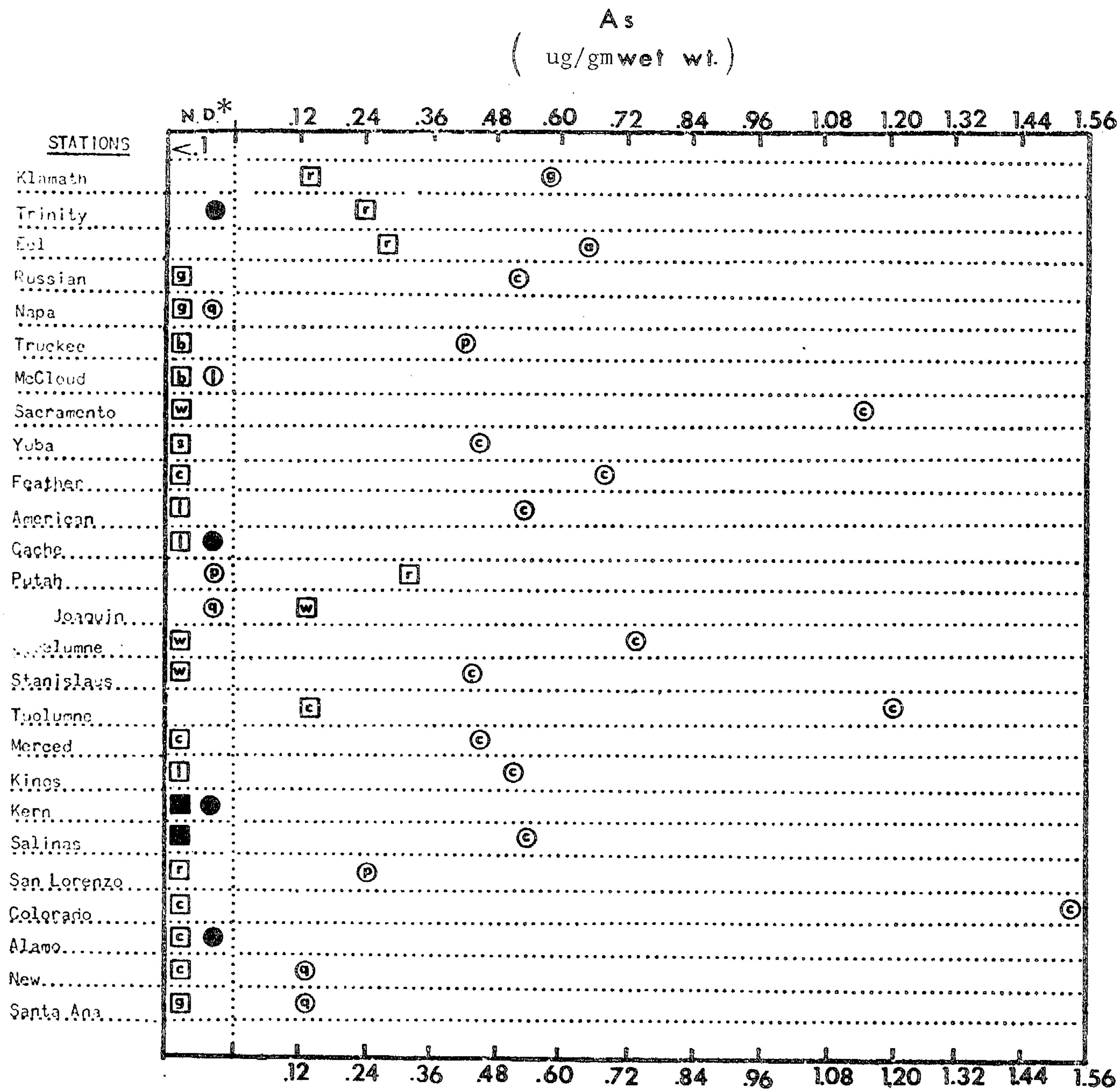
Arsenic (As); (Figure 2). Different forms of arsenic, such as arsenite (As^{3+}), arsenate (As^{5+}), and methylated arsenicals have different toxicities. The American Fisheries Society (AFS) notes that the chemical form of arsenic in water must be known before criteria can be applied because the toxicity of arsenic to both aquatic biota and humans varies considerably with its chemical form and oxidation state (AFS 1978). Additionally, arsenic concentrations in water vary greatly depending upon geological location. Woolson (1975) reports the average arsenic content of freshwater is probably about 1.5-2.0 ug-liter (ppb) whereas Lunds (1977) states that these levels are 0.4 ug/liter.

Walsh et al. (1977) measured arsenic in both forage and predator fish at 100 freshwater, estuarine, and marine locations in the United States between 1971-1973. Values ranged from 0.05 to 0.5 ug/gm (ppm) wet weight. However, they cited values for organisms from other rivers and lakes that contained as much as 1.24 to 3.4 ug/gm arsenic residue. Copeland et al. (1973) analyzed Lake Michigan fish and found the mean arsenic levels in muscle fillets to be 0.29 ug/gm.

Although aquatic organisms bioaccumulate arsenic, the element apparently is not biomagnified through food chains (Penrose 1974; Woolson 1975; Penrose et al. 1977). Evidently, food web accumulation is prevented by conversion of arsenic within the organism to an organic storage form which can then be excreted by either the organism or its predators (including man). Therefore, fish taken from arsenic-contaminated areas may not be potential health hazards to humans. Because these stable organoarsenicals are of low toxicity whereas the inorganic arsenics are highly toxic, analytical techniques to distinguish organic from inorganic arsenic must be developed and used.

During 1978, arsenic residues were higher and more frequently detected in benthos than in fish. Of the former, Corbicula sp. consistently demonstrated higher arsenic values than crayfish and most fish. All sculpin samples contained detectable levels of this element, but most other fish samples were below the detection limit. Three rivers, the Sacramento, Tuolumne, and Colorado, yielded Corbicula sp. which contained arsenic in concentrations $\geq$1.18 ug/gm (ppm) fresh weight. It is not known which form(s) of arsenic this represents. Although evidence has been presented to support metabolization and excretion of arsenic compounds by organisms

FIGURE 2. Arsenic concentrations in tissues of benthos and predator fish; California primary network stations, 1978.



KEY

Predator Fish -□

b - Brown trout
c - Channel catfish
g - Green sunfish
l - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

Benthos -○

a -	*Andonta* sp.	(Freshwater mussel)
c -	*Corbicula* sp.	(Asiatic clam)
g -	*Gonidea* sp.	(Freshwater mussel)
l -	*Limnephilus*	(Caddisfly)
p -	*Pacifastacus* sp.	(Crayfish)
q -	*Procambarus* sp.	(Crayfish)

Solid Symbol - No Sample Collected

* N.D. - Not Detected

as well as background levels in fish that are nearly three times as high, the potential effects of such tissue levels on both the organism and the consumer are unknown. Future surveys will help to determine if these levels are caused by natural or anthropogenic sources.

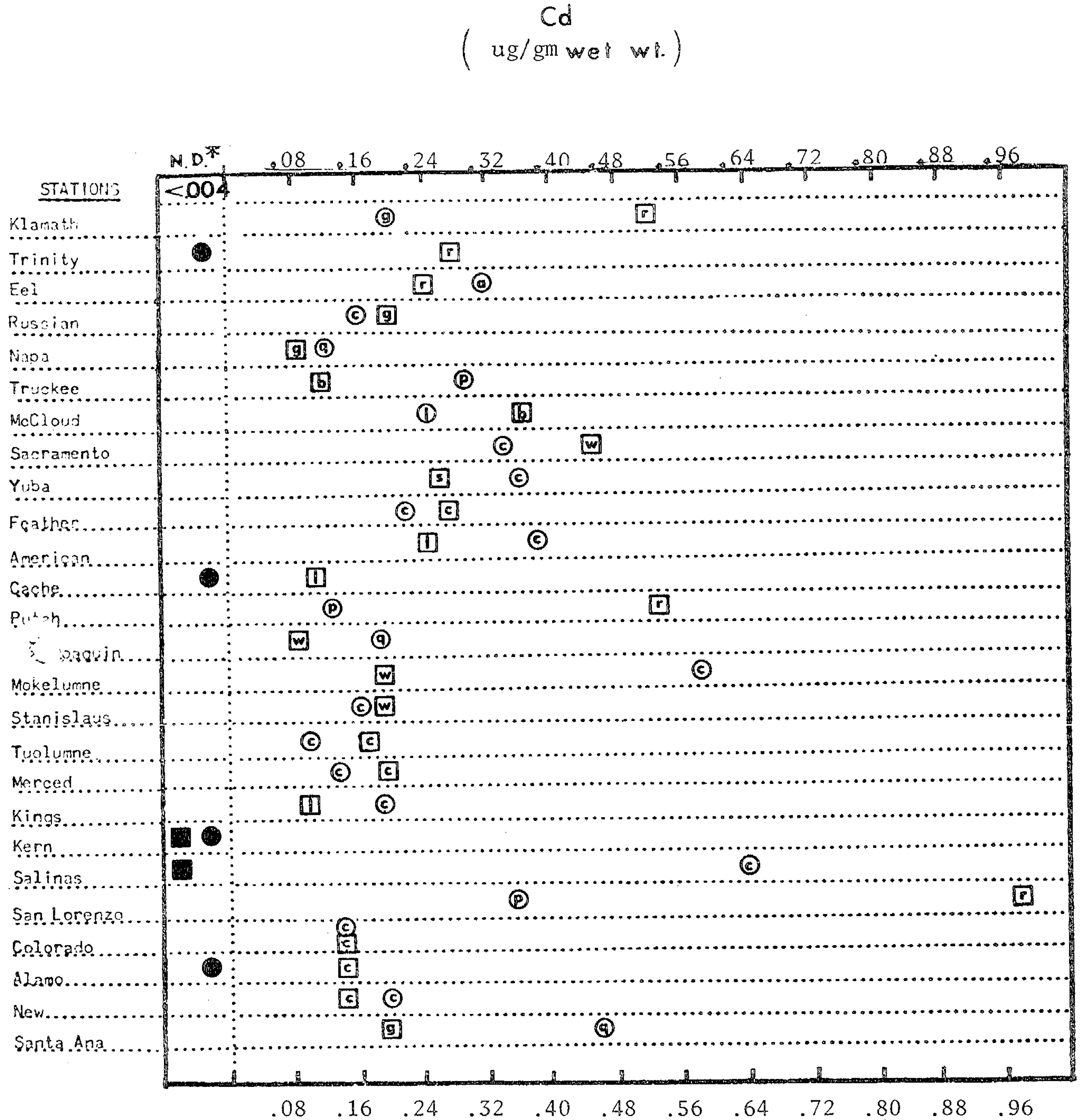
Cadmium (Cd); (Figure 3). Naturally occurring cadmium is generally in the form of a sulfide salt and often is associated with zinc and lead ores. Mines and smelters are often a source, as are wastes from electroplating plants, pigment works, and from textile and chemical factories (EPA 1976). Cadmium is toxic to aquatic organisms, will bioaccumulate in them, and thus can be passed on to consumers. The World Health Organization (WHO) (1973) recommended that daily cadmium intake not exceed 0.07 mg. Most freshwater in the United States contains less than 1 ug/liter (ppb) cadmium, although 3% of the 1,577 water samples examined had a mean cadmium concentration slightly less than 10 ug/liter (EPA 1976).

At the Primary Network stations during 1978, cadmium concentrations in benthos and fish ranged from 0.08 to 0.98 ug/gm (ppm); all samples contained detectable concentrations. Because of its ubiquitous occurrence, these data probably represent background levels for the most part. However, Central Coast Basin rivers were higher than the norm; sculpin from the San Lorenzo River contained 0.98 ug/gm cadmium, the highest value found statewide. However, these values are for liver in a fish of little or no food value. Also, the liver probably concentrates more of the element than the flesh. A more representative sample will be collected in this river in 1979.

Concentrations of cadmium in crayfish from Putah Creek and clams from the Mokelumne and Salinas Rivers were above 0.5 ug/gm (ppm). Because these are food organisms and the cadmium levels were determined in edible tissue , a potential human health hazard may exist in these streams.

Although cadmium levels in fish and benthos from several streams appear to be excessive and thus present concern for public health, it is not known if these body burden concentrations are harmful to the aquatic organisms.

FIGURE 3. Cadmium concentrations in tissues of benthos and predator fish: California primary network stations, 1978.



KEY

Predator Fish - □

b - Brown trout
c - Channel catfish
g - Green sunfish
I - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

Benthos - ○

a - *Andonta* sp. (Freshwater mussel)
c - *Corbicula* sp. (Asiatic clam)
g - *Gonidea* sp. (Freshwater mussel)
I - *Limnephilus* (Caddisfly)
p - *Pacifastacus* sp. (Crayfish)
q - *Procambarus* sp. (Crayfish)

Solid Symbol - No Sample Collected

*N.D. - Not Detected

Chromium (Cr); (Figure 4). Chromium is an abundant element and averages 125 mg/kg (ppm) in the continental crust (NAS/NAE 1974). Two oxidation states, Cr^{6+} and Cr^{3+}, are the most common forms. The hexavalent form is more biologically active though the trivalent form is required for chromium to act as an essential element. Both forms are poorly absorbed in the gastrointestinal tract (AFS 1978). The WHO (1973) estimated that the daily adult intake of chromium in the United States varies from 5 to 100 ug.

Generally, invertebrates are more sensitive to chromium than are fish (AFS 1978). Knoll and Fromm (1960) reported that rainbow trout exposed to 2.5 mg/liter (ppm) hexavalent chromium accumulated insignificant amounts of the metal in muscle tissue. Hall et al. (1978) reported that cutthroat trout from the Pacific Northwest contain from 0.19 to 0.75 ug/gm chromium (mean = 0.397 ug/gm).

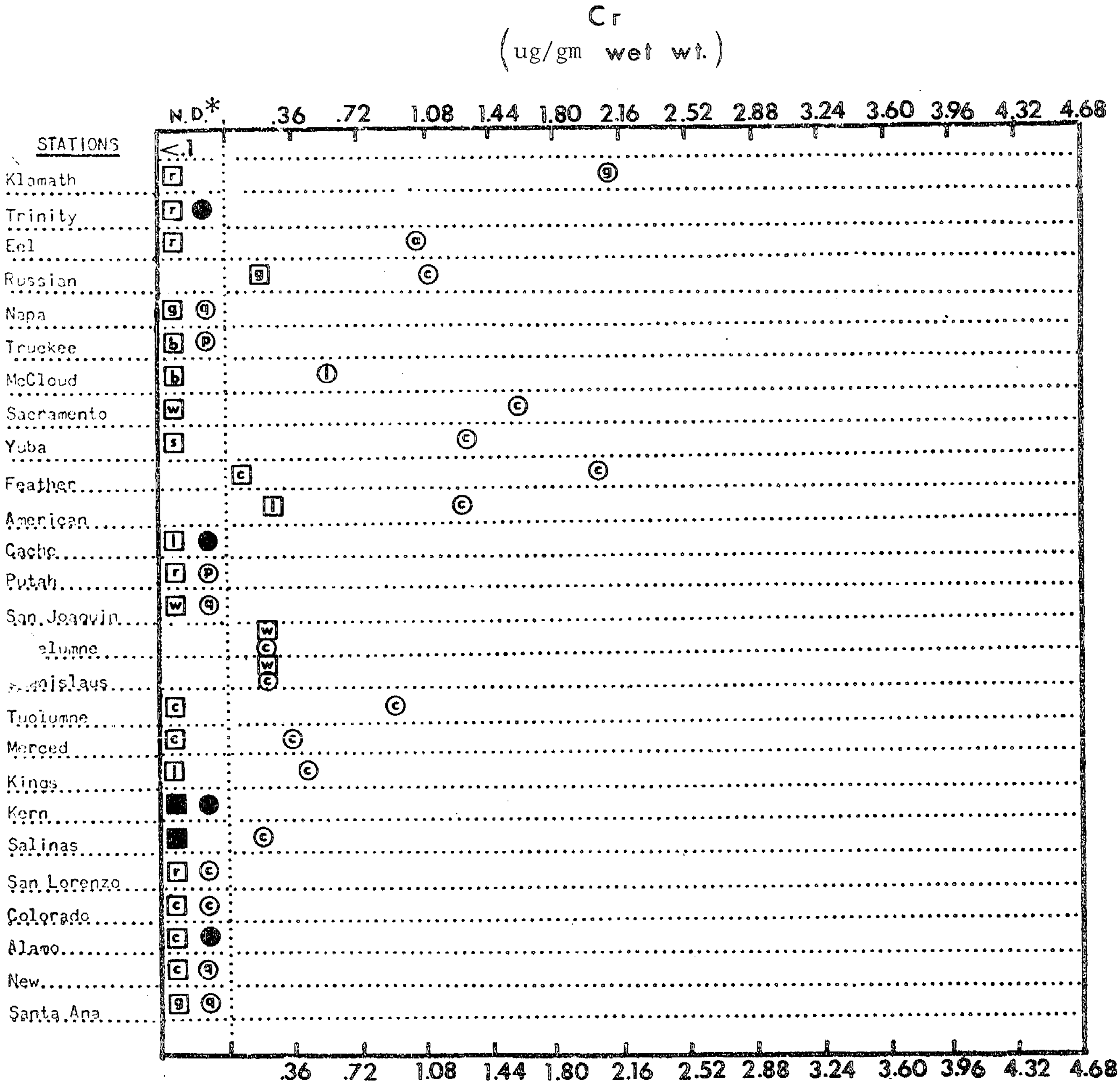
Most fish samples analyzed were below the detection limit (<0.06 ug/gm) of chromium and those containing the element had ≤0.27 ug/gm (fresh weight). Chromium occurred more frequently in benthos than fish. However, nearly all *Corbicula* sp. samples had detectable levels of the element whereas no crayfish samples contained detectable chromium. Benthos samples contained 2.1 ug/gm and, except for Klamath River mussels, the higher values occurred in the Sacramento River Basin.

There is no FDA guideline for chromium concentrations in food. Comments regarding chromium levels detected in the network must await further information on bioaccumulation, excessive levels, and the effects of these on aquatic biota and the food chain.

Copper (Cu): (Figure 5). The average crustal concentration of copper, which is higher than that of many elements, is about 50 ug/gm (ppm) (AFS 1978). Ore deposits of this metal are naturally much higher. Additionally, copper is required in plant and animal metabolism and thus it would be expected to appear in the biota in greater concentrations than other unrequired metals.

Generally, copper values ranged from about 0.9 to 13 ug/gm in both fish and bentho All samples were above the detection limit minimum (0.08 ug/gm). However, brown trout from both the Truckee and McCloud Rivers contained markedly more than the general trend, with 50 and 77 ug/gm respectively.

FIGURE 4. Chromium concentrations in tissues of benthos and predator fish; California primary network stations, 1978.



KEY

Predator Fish - □

- b - Brown trout
- c - Channel catfish
- g - Green sunfish
- I - Largemouth bass
- s - Smallmouth bass
- r - Sculpin
- w - White catfish

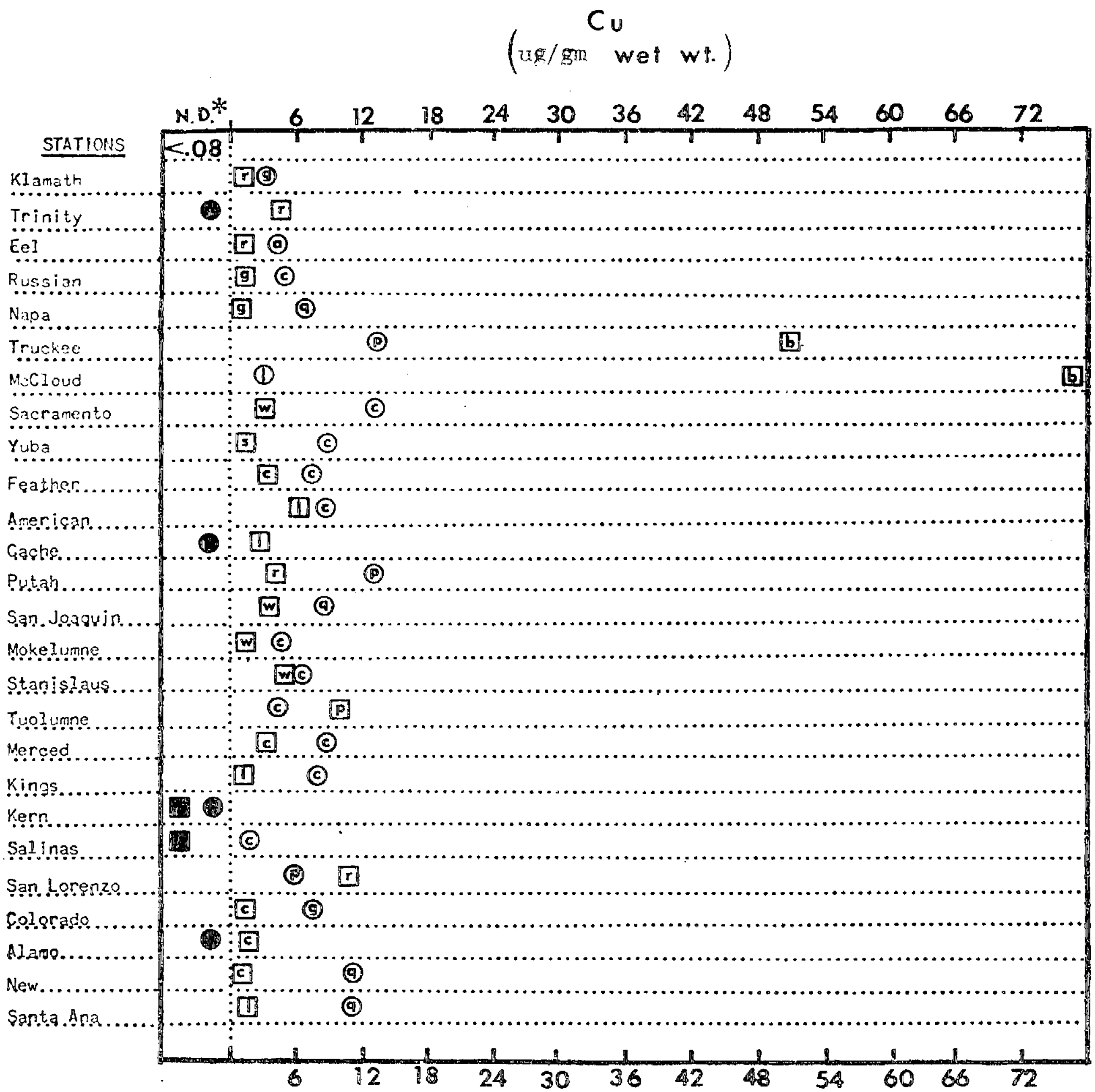
Benthos - ○

- a - Andonta sp. (Freshwater mussel)
- c - Corbicula sp. (Asiatic clam)
- g - Gonidea sp. (Freshwater mussel)
- l - Limnephilus (Caddisfly)
- p - Pacifastacus sp. (Crayfish)
- q - Procambarus sp. (Crayfish)

Solid Symbol - No Sample Collected

*N.D. - Not Detected

FIGURE 5. Copper concentrations in tissues of benthos and predator fish; California primary network stations, 1978.



KEY

Predator Fish - □

b - Brown trout
c - Channel catfish
g - Green sunfish
l - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

Benthos - ○

a - *Andonta* sp. (Freshwater mussel)
c - *Corbicula* sp. (Asiatic clam)
g - *Gonidea* sp. (Freshwater mussel)
l - *Limnephilus* (Caddisfly)
p - *Pacifastacus* sp. (Crayfish)
q - *Procambarus* sp. (Crayfish)

Solid Symbol - No Sample Collected

*N.D. - Not Detected

though the EPA (1976) recommends 1.0 mg/liter (ppm) as the limit of copper in domestic water supplies because of the taste imparted to water at higher concentrations, Sollman (1957) estimated the daily requirements for human adults to be about 2 mg/day. Values reported in this program are for fish liver, probably an organ rarely eaten by humans; whereas copper concentrations in fish flesh would probably be lower.

Because copper is ubiquitous in nature and is a nutritional requirement of both plants and animals, it is unlikely that these concentrations are a problem for either the organism or the consumer. All the values, with possibly the exception of the two brown trout samples, appear to be background levels of copper.

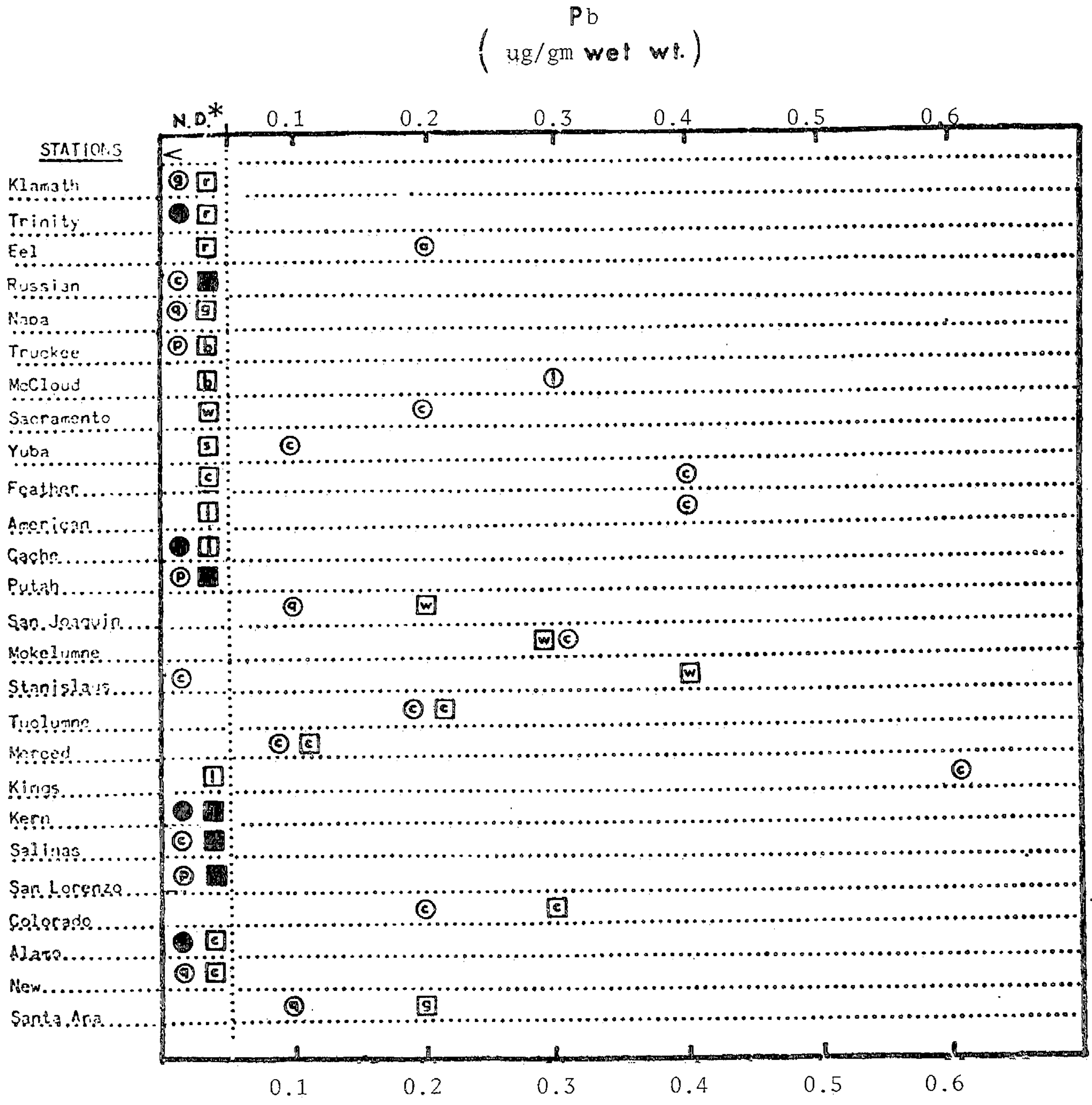
Lead (Pb); (Figure 6). Lead is well known for both its acute and chronic toxicity and its bioaccumulative characteristic. It is not an essential trace element. Lead enters aquatic environments through atmospheric fallout, automobile and industrial emissions, urban runoff, and municipal and industrial waste discharges (EPA 1976). Consequently, the highest lead concentrations would be expected around urban areas where input rates are high.

Unfortunately, lead is one of the most difficult elements to measure accurately, due in part to its ubiquitous nature (Patterson and Settle 1976). With this in mind, many precautions were taken to guard against contamination during collection, sample preparation, and analysis.

Salmon have been found to contain 1.3 ug/gm (ppm) Pb on a dry weight basis (Meranger and Somers 1968), whereas brook trout livers were found to contain from 1.35 to 4.18 ug/gm Pb on a dry weight basis (Pagenkopf and Neuman 1974). Cutthroat trout muscle has been found to contain 0.16-0.54 ug/gm ($\bar{x}$ = 0.30 ug/gm), steelhead trout muscle from 0.69-0.75 ug/gm ($\bar{x}$ = .71 ug/gm), and steelhead trout liver 0.25 ug/gm (Hall, Zook and Meaburn 1978). However, Merlini and Possi (1977) found ionic lead (the toxic form) to be least concentrated in muscle tissue. The FDA (1978a) guideline for lead in foodstuffs is 7 ug/gm (ppm).

The highest lead values found statewide were considerably below the FDA limit. Freshwater clams from the Kings River were highest, containing 0.6 ug/gm (ppm). Freshwater clams from the Feather and American Rivers contained about 0.4 ug/gm (ppm),

FIGURE 6. Lead concentrations in tissues of benthos and predator fish; California primary network stations, 1978.



KEY

Predator Fish - □

b - Brown trout
c - Channel catfish
g - Green sunfish
l - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

Benthos - ○

a - Andonta sp. (Freshwater mussel)
c - Corbicula sp. (Asiatic clam)
g - Gonidea sp. (Freshwater mussel)
l - Limnephilus (Caddisfly)
p - Pacifastacus sp. (Crayfish)
q - Procambarus sp. (Crayfish)

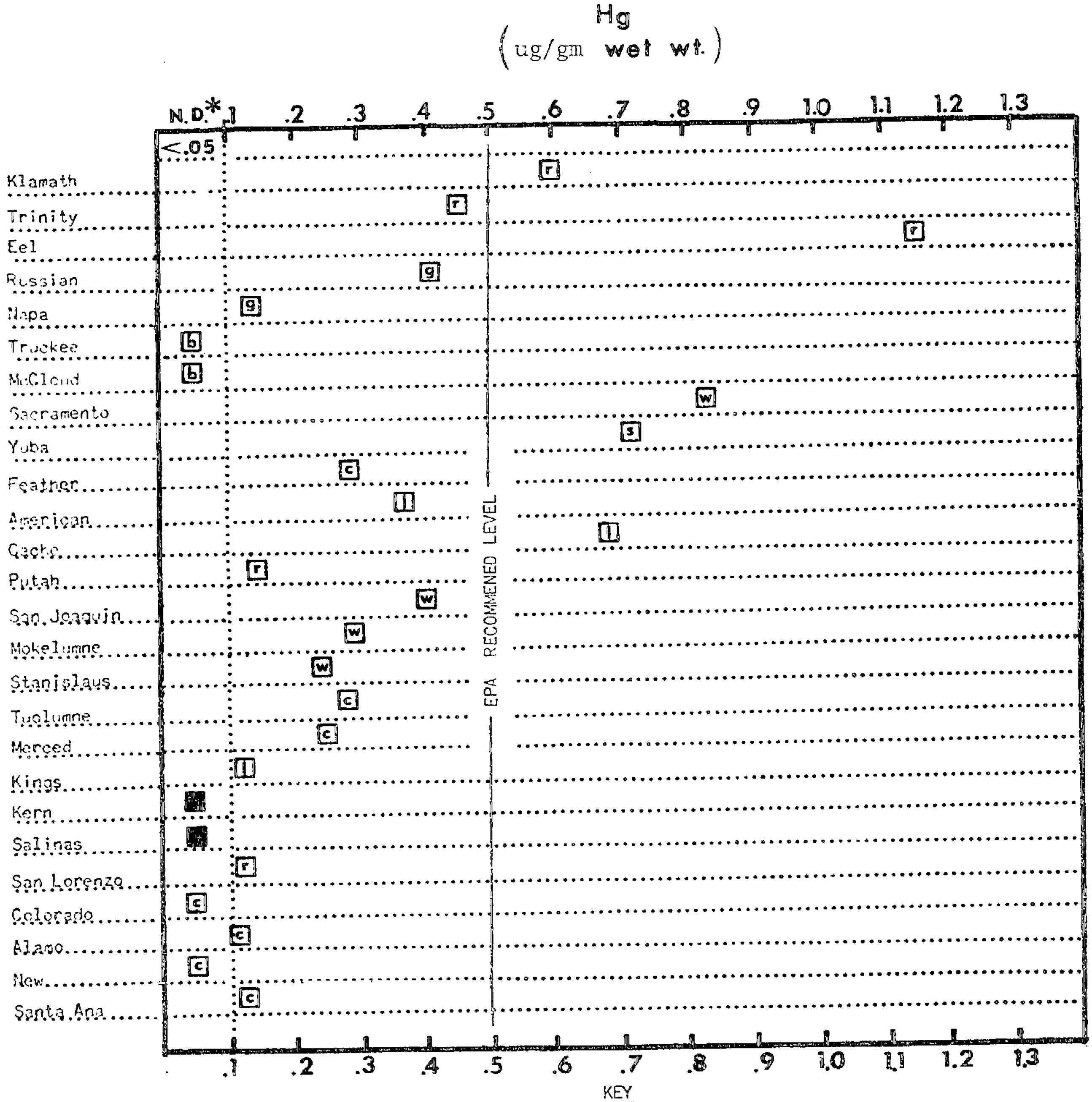
Solid Symbol - No Sample Collected

did the livers of catfish from the Stanislaus River. In fish, because lead concentrates in liver more than in muscle, the meat would have contained even lower concentrations of lead.

Mercury (Hg); (Figure 7). The FDA (1978a) interim guideline for mercury in edible fish has recently been raised from 0.5 ug/gm (ppm) on a fresh weight basis to 1.0 ug/gm. However, the EPA guideline remains at the former level. Although this is total mercury, most mercury in fish is in the form of methylmercury which the organism acquires from methylmercury in the environment (AFS 1978). Methylmercury, a highly toxic form of this metal, can be integrated and concentrated by fish by a factor of up to 27,000 times (McKim et al. 1976). Alkyl compounds, the mercury derivatives most toxic to man, can produce death from ingestion of just milligrams (Berglund and Berlin 1969) whereas a fatal dose of mercuric salts, more toxic than mercurous salts, is 20 mg to 3.0 gm (Stokinger 1963). It is important to note that the most sensitive organ in the most sensitive part of the human life cycle is the fetal brain (AFS 1978). Accordingly, the more conservative guideline level of 0.5 ug/gm was chosen for comparison.

Fish flesh from five rivers contained elevated mercury levels. Four of these, the Klamath, Eel, and Sacramento Rivers and Cache Creek, drain the mercury rich Coastal Geochemical Province and high mercury values in these surface waters may be due to natural weathering of mercury deposits (Barnes et al. 1973; California Department of Health 1973). The Klamath and Yuba Rivers and Cache Creek also exhibited high mercury concentrations during 1977. The Eel River sculpin had over twice the recommended maximum; this may indicate that there is accelerated input from natural sources or perhaps augmented input from some human activity. The Cache Creek watershed, besides draining mercury-rich formations, is affected by the presence of inactive mercury mines as well, which may account for the high levels detected at this station. Mercury input from natural weathering of coastal formations, decades of agricultural and industrial use, and gold mining activities, may also account for the high mercury residue values detected in the Sacramento River. However, the Yuba River watershed is not associated with the Coastal Geochemical Province, yet high mercury values were found there. It is possible that its history of both hard rock and placer gold mining, which used the mercury algamation technique for gold extraction, resulted in a large input of mercury

FIGURE 7. Mercury concentrations in predator fish; California primary network stations, 1978.



KEY

Predator Fish - □

b - Brown trout
c - Channel catfish
g - Green sunfish
l - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

*N.D. - Not Detected

Solid Symbol - No Sample Collected

o the basin which is still being accumulated by the biota.

In addition, mercury levels in fish from four other rivers, the Trinity, Russian, American, and San Joaquin, were between 0.36-.46 ug/gm (ppm). These, as well as the five rivers just reviewed, should be carefully monitored in the coming years. Obviously, consumption of fish from rivers with excessive mercury concentrations may pose hazards to human health. Although sculpin are probably seldom used as food by man, these fish are indicative of the conditions that exist in the Klamath, Trinity, and Eel Rivers. Catfish and bass from the Sacramento and Yuba Rivers and from Cache Creek are human food resources and contain sufficient mercury to be a public health concern.

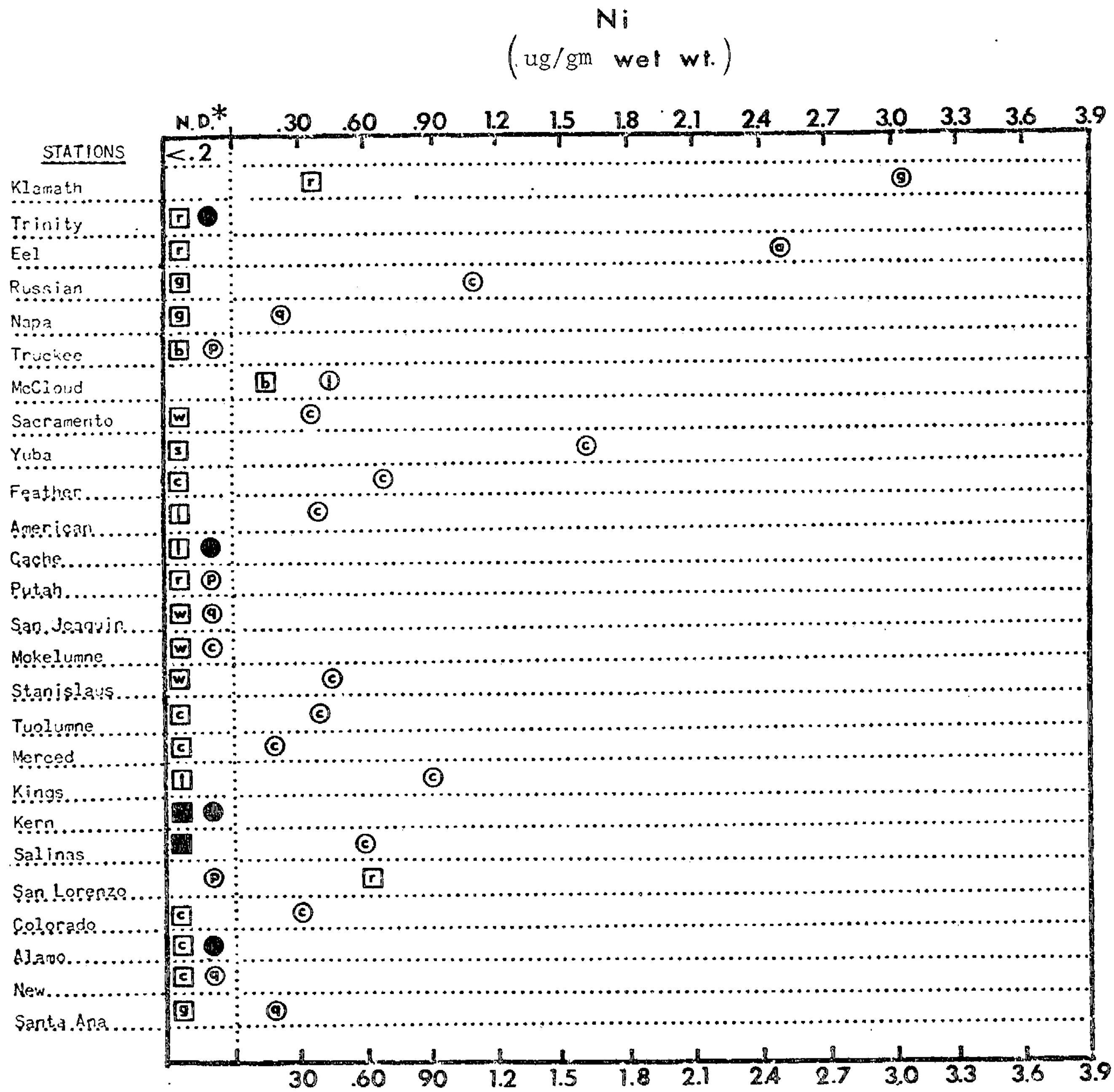
Because organisms from these rivers demonstrate that excessive mercury is present in the water, an effort should be made to determine if this situation is due to weathering of natural deposits or if mercury is entering the water from point sources. If the latter can be located and identified, stringent control measures should be taken immediately.

Nickel (Ni); (Figure 8). Nickel or its salts are relatively nontoxic to humans when taken orally (Nielson 1977). Presently, the EPA National Interim Primary Drinking Water Regulations (1975) do not include a limit for nickel (EPA 1976). It has been reported that, for fish from New York state, nickel concentrations generally were less than 1 ug/gm (ppm) dry weight basis (Tong et al. 1972).

During 1978, nickel was detected in most benthos samples but only in three fish samples. Klamath and Eel River molluscs exhibited the highest values, and these may be due to natural weathering of the mineral rich Coastal Geochemical Province. Corbicula sp. in the Yuba River contained higher levels than benthos from other rivers within the Sacramento Basin; this cannot now be explained. Nevertheless, because nickel has relatively low toxicity to consumers and most biota contain concentrations similar to that reported for fish from another state, there does not appear to be any problem with nickel at this time.

Silver (Ag); (Figure 9). Silver is a rather rare element in geologic formations i has a low solubility (McKee and Wolf 1963). The element is highly toxic to aquatic life and accumulates in fish, especially in the internal organs and gills

FIGURE 8. Nickel concentrations in tissues of benthos and predator fish; California primary network stations, 1978.



KEY

Predator Fish - □

b - Brown trout
c - Channel catfish
g - Green sunfish
l - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

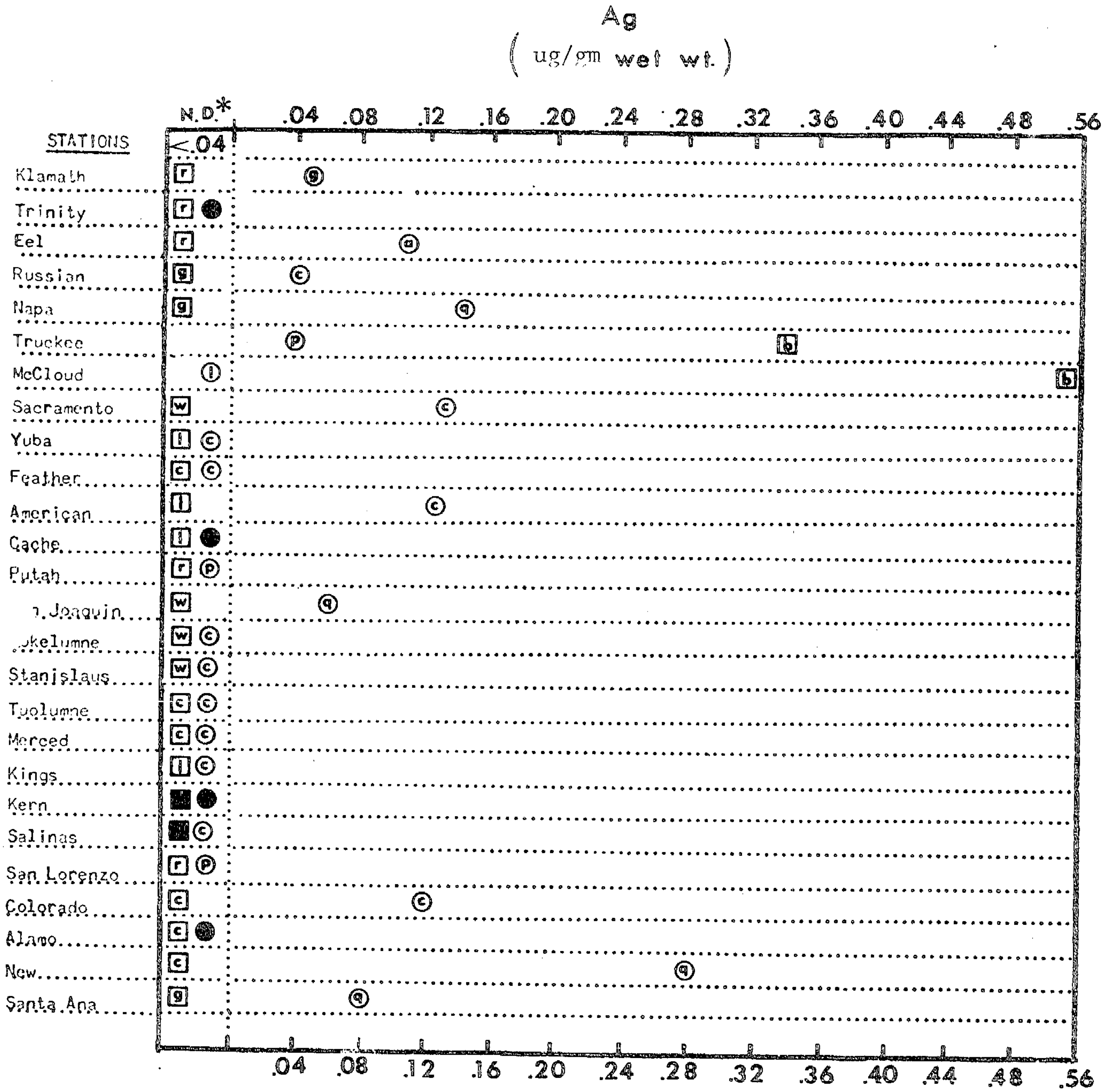
Benthos - ○

a - Andonta sp. (Freshwater mussel)
c - Corbicula sp. (Asiatic clam)
g - Gonidea sp. (Freshwater mussel)
l - Limnephilus (Caddisfly)
p - Pacifastacus sp. (Crayfish)
q - Procambarus sp. (Crayfish)

Solid Symbol - No Sample Collected

*

FIGURE 9. Silver concentrations in tissues of benthos and predator fish; California primary network stations, 1978.



KEY

Predator Fish - □

b - Brown trout
c - Channel catfish
g - Green sunfish
l - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

Benthos - ○

a - *Andonta* sp. (Freshwater mussel)
c - *Corbicula* sp. (Asiatic clam)
g - *Gonidea* sp. (Freshwater mussel)
l - *Limnephilus* (Caddisfly)
p - *Pacifastacus* sp. (Crayfish)
q - *Procambarus* sp. (Crayfish)

Solid Symbol - No Sample Collected

* N.D. - Not Detected

(Coleman and Cearly 1974). These researchers found that, after two months exposu to water containing 7 ug/liter (ppb) Ag, bass had accumulated 0.6 ug/gm (ppm) Ag (ash wt.) in their internal organs. Moreover, concentrations of from 10 to 100 ug/liter (ppb) Ag have inhibited or caused abnormalities in the eggs of *Paracentroutus* although the adults did not appear to be affected by these exposure levels (Wilber 1969). Human sources of silver can include wastes from photographic, silver plating, and other chemical processing operations, and from cloudseeding.

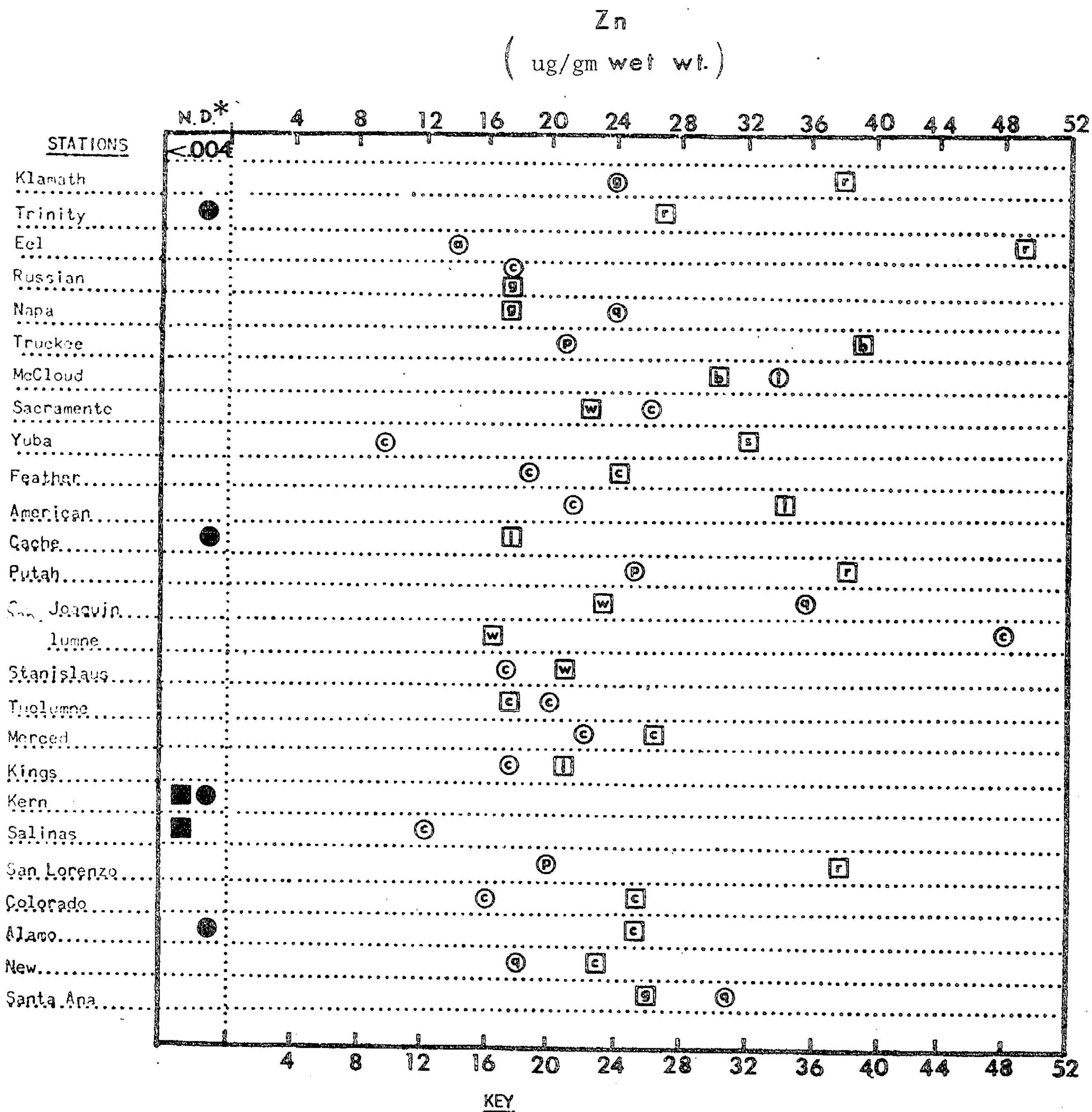
Silver in steelhead trout was found in concentrations averaging from 0.013 to 0.026 ug/gm (ppm) (wet weight basis) in the flesh and 0.54 ug/gm in the liver; in cutthroat trout, silver concentrations in the flesh were found to average 0.22 ug/gm (Hall, Zook and Meaburn 1978).

The 1978 monitoring program detected silver only in benthos in 11 of the 26 rivers, with the exception of the brown trout from the Truckee and McCloud Rivers. These two fish samples exhibited the highest silver concentration for the year. Livers of these fish also contained above normal concentrations of copper. Deposits of copper and silver often occur together in nature, and this may explain the concen trations found in the fish from these two rivers. Benthos values were within the ranges reported for marine molluscs and crustaceans (Hall et al. 1978), although crayfish from the New River were above the norm when compared to other benthos values for 1978.

Because of the acutely toxic potential of silver as well as the adverse effect of tissue accumulation on life cycle stages, special attention should be directed to the fish fauna of the Truckee and McCloud Rivers. The effects of body burden levels of silver on reproduction, physiology, and behavior, as well as on predators, should be investigated.

Zinc (Zn); (Figure 10). Zinc is a very common element and usually occurs in nature as a sulfide often associated with sulfides of lead, copper, cadmium, and iron (EPA 1976). In 1,207 positive tests for zinc in U. S. waters, Kopp and Kroner (1967) report a maximum value of 1,183 ug/liter (ppb) with a mean of 64 ug/liter. The California Basin exhibited the lowest mean zinc value, 16 ug/liter. Lucas, Edgington, and Coley (1970) reported trace metal concentrations in whole f and fish liver samples from three of the Great Lakes. Zinc concentrations, which averaged 30 ug/gm (ppm), varied little between species and lakes.

FIGURE 10. Zinc concentrations in tissues of benthos and predator fish; California primary network stations, 1978.



KEY

Predator Fish - □

b - Brown trout
c - Channel catfish
g - Green sunfish
l - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

Benthos - ○

a - *Andonta* sp. (Freshwater mussel)
c - *Corbicula* sp. (Asiatic clam)
g - *Gonidea* sp. (Freshwater mussel)
l - *Limnephilus* (Caddisfly)
p - *Pacifastacus* sp. (Crayfish)
q - *Procambarus* sp. (Crayfish)

Solid Symbol - No Sample Collected

*N.D. - Not Detected

Zinc is an essential element in animal metabolism especially for humans. Vallee (1957) reports that the daily requirements of preschool-aged children are 0.3 mg Zn/kg of body weight, whereas the human adult average intake ranges from 0 to 15 mg Zn/kg. All samples analyzed contained zinc concentrations well above the detection limit. Fish from the Eel River and benthos from the Mokelumne River exhibited the highest values although even these do not seem remarkable. Because zinc is an essential trace element, these body burdens present no potential hazards to either the fish or their consumers.

Statewide Distribution of Pesticides and Trace Organics

Pesticide use occurs in agriculture, silviculture, animal husbandry, and other activities. Residues from these nonpoint sources are transported to surface waters by spray drift, wind and water erosion, and seepage or infiltration.

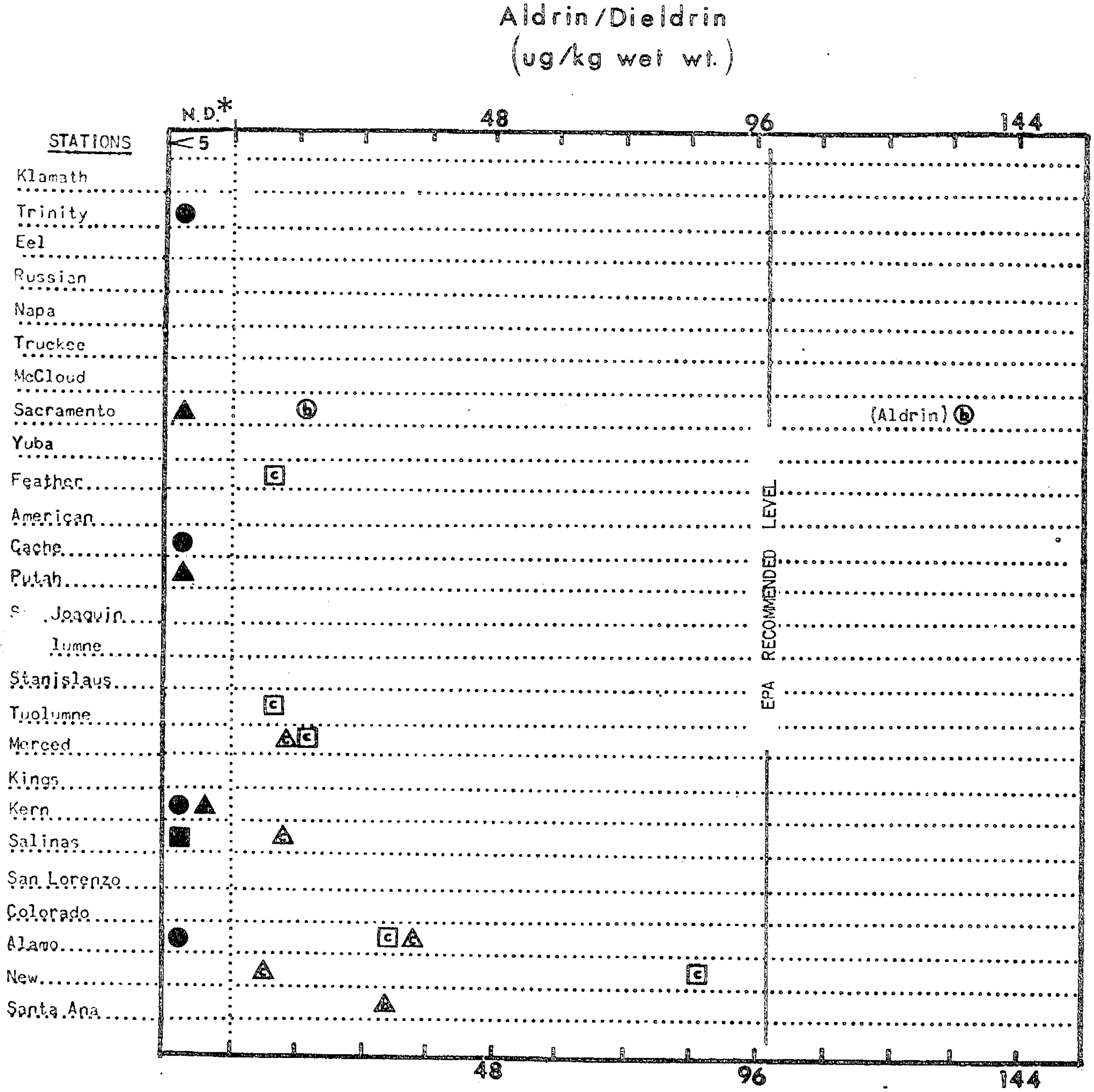
Analyses for 70 different pesticides and organics were conducted during 1978; 12 were detected. Some of the detected pesticides and organics occurred in only a small number of rivers and at low concentrations. Others, however, were widely distributed and occurred at sufficiently high concentrations that the residues, either singly or in combination, may pose a threat to the health of the organism and its predators.

Aldrin/Dieldrin; (Figure 11). Aldrin is metabolically converted to Dieldrin by aquatic organisms. Both Aldrin and Dieldrin are persistent, will bioaccumulate and are carcinogens. The AFS criteria is 0.003 ug/liter (ppb) in water for both freshwater and marine biota (AFS 1978). The EPA guideline for predator protection is 100 ug/kg (ppb) whereas the FDA action level of 300 ug/kg is the maximum concentration for human consumption (AFS 1978; FDA 1978a).

Values of Aldrin in the benthos (*Corbicula* sp.) taken from the Sacramento River (Appendix 1) in 1978 were nearly 50% of the FDA recommended level and exceeded the EPA guideline for protection of predators. This was the only instance of Aldrin contamination in 1978, but this situation requires attention and subsequent action if an increasing trend is demonstrated.

The benthos, forage fish, and predator fish of eight rivers, including the Feather, Sacramento, Tuolumne, Merced, Salinas, Santa Ana, Alamo, and New (Appendix 1) were

FIGURE 11. Aldrin/Dieldrin concentrations in tissues of benthos, forage fish and predator fish; California primary network stations, 1978.



KEY

Predator Fish -□

Forage Fish -△

Benthos -○

b - Brown trout
c - Channel catfish
g - Green sunfish
l - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

b - Brown bullhead
c - Carp
k - Klamath sucker
m - Mountain whitefish
s - Sacramento sucker

a - *Andonta* sp. (Freshwater mussel)
b - *Corbicula* sp. (Asiatic clam)
g - *Gonidea* sp. (Freshwater mussel)
l - *Limnephilus* (Caddisfly)
p - *Pacifastacus* sp. (Crayfish)
q - *Procambarus* sp. (Crayfish)

*N.D. - Values Not Shown Were Below Detection Limits

Solid Symbol - No Sample Collected

found to contain Dieldrin. Values ranged from <5-13 ug/kg (ppb) for benthos, <5-33 ug/kg for forage fish, and <5-86 ug/kg for predator fish. This demonstrates the bioaccumulation potential of Dieldrin. The New and Alamo Rivers were first and second, respectively, with the New River predator fish containing almost one-third of the FDA recommended level for human consumption and 86% of the EPA predator protection level.

EPA orders suspending production and use of Aldrin and Dieldrin should result in a gradual decrease in the concentrations in the environment. However, their use is not regulated in Mexico. Biota from the New and Alamo Rivers need to be closely monitored to determine if tissue levels of Dieldrin continue to increase.

Chlordane. Chlordane is another chemical that is persistent, will bioaccumulate, and is carcinogenic. The AFS criteria for freshwater aquatic life is 0.01 ug/liter (ppb) in water (AFS 1978). The EPA predator protection level is 100 ug/kg (ppb). Shortly, the FDA will establish a guideline of 300 ug/kg for Chlordane in food (Al McCormick, FDA, San Francisco, CA, pers. commun., May 22, 1979).

Benthos (*Corbicula* sp.) from the Stanislaus River contained 100 ug/kg (ppb) of Chlordane, 100% of the EPA guideline, and one-third the FDA guideline. This was the only river of those sampled in both 1977 and 1978 in which Chlordane was detected. EPA restricted the general use of Chlordane in December 1975; thus, a gradual decrease in environmental concentrations should result. Because this compound continued to occur only in this river, source investigations should be conducted.

Dacthal. This chlorinated hydrocarbon, a pre-emergent weed killer, was detected only in forage and predator fish from both the Alamo and New Rivers (Appendix 1). The two highest values were from New River catfish (680 ppb on a fresh weight basis) and Alamo River carp (460 ppb on a fresh weight basis). The FDA currently has no guideline for Dacthal in food (Al McCormick, pers. commun.) nor does the EPA. However, since Dacthal was only detected in these two rivers (both known for their polluted character) and at relatively high concentrations, there may be a cause for concern.

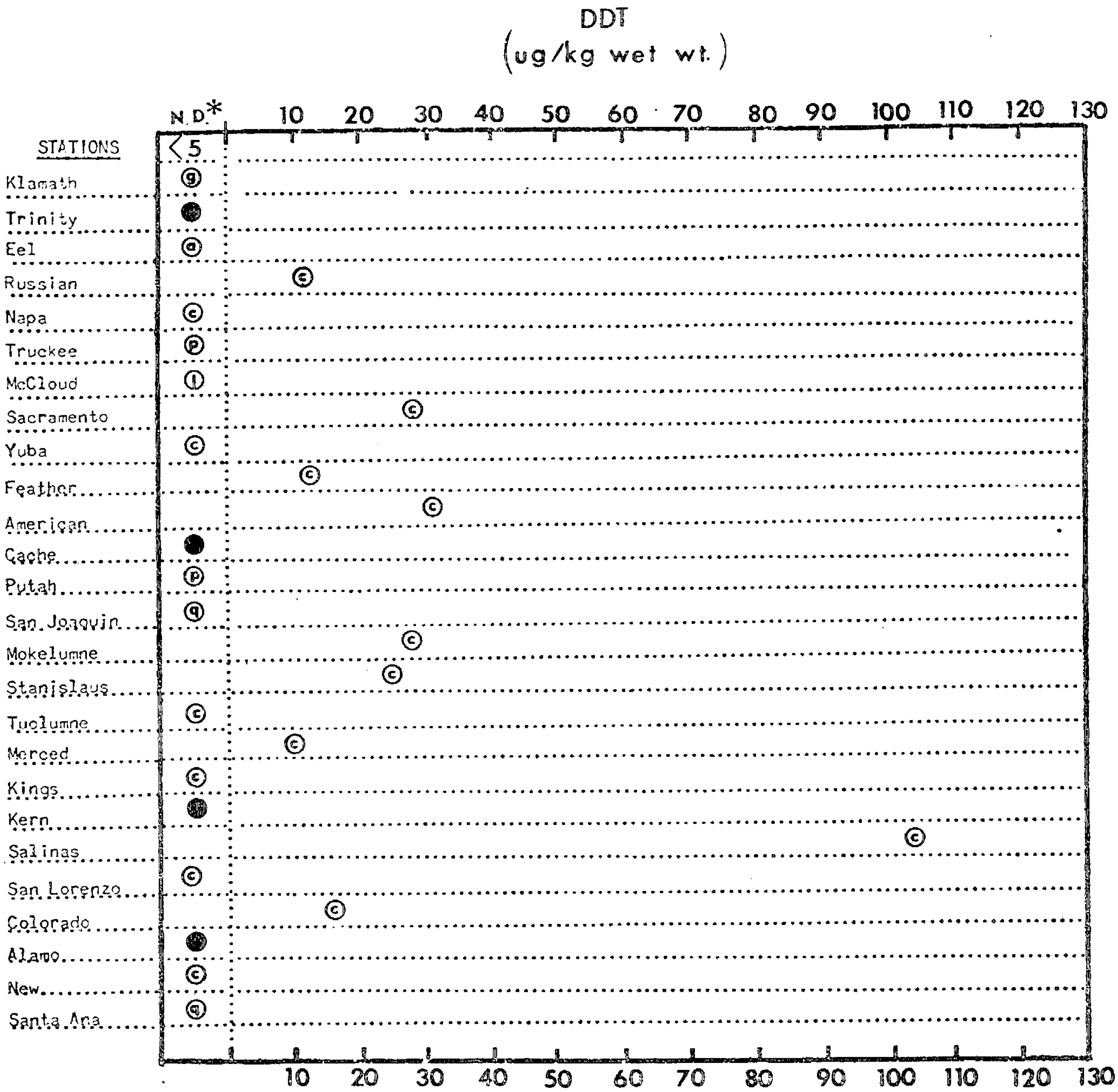
DDT and its Metabolites; (Figures 12-15). Because the use of DDT has been restricted for several years, its metabolites (DDD, DDMU, DDE) generally occur more frequently and at greater concentrations than DDT. However, four rivers, the Feather, San Joaquin, Salinas, and New, contained levels of DDT in the flesh of either benthos or fish, or both, that were appreciably higher than those of the remaining streams (Figures 12-13). All four rivers are in agricultural areas; the occurrence of DDT in them may reflect the continued, and possibly illegal, use of this pesticide.

Total DDT (sum of DDT and its metabolites) values yielded a different picture. The NAS/NAE (1973) recommends that total DDT concentrations in whole fish should not exceed 1000 ug/kg (ppb) (fresh weight) in order to protect predators. The FDA (1978a), on the other hand, has set its guideline for total DDT in food at 5,000 ug/kg. Carp from the San Joaquin and Alamo Rivers and catfish from the Merced River exceeded the 1,000 ug/kg guideline (Figure 15). Additionally, catfish from the Feather and Alamo Rivers approached the guideline value. In 1977, bout 23% of those rivers sampled contained organisms with excessive total DDT sidues whereas in 1978 only 12% of the rivers exhibited excessive total DDT residues in the flesh or organisms. Only the San Joaquin and Alamo Rivers were judged excessive during both years.

Metabolites of DDT will continue to be detected for many years to come. However, DDT itself should decrease. If DDT levels in any river remain static or increase, then source investigations should be conducted and the new input stopped.

Thiodan (Endosulfan). Thiodan is a chlorinated hydrocarbon containing sulfur. The National Research Council of Canada (1975) reported that bioaccumulation of this pesticide is transitory and that up to 99% of the accumulated dose is cleared in less than two weeks. The AFS (1978) believes that because of the bioconcentration and depuration characteristics of Thiodan residues in aquatic organisms, there is relatively low potential for significant and persistent contamination of the aquatic food chain. Only the forage fish (carp) from the San Joaquin River (Appendix 1) contained detectable levels (14 ppb) of Thiodan. At this time, there appears to be no problem with this pesticide in 26 sampled California rivers.

FIGURE 12. DDT concentrations in tissues of benthos; California primary network stations, 1978.



KEY

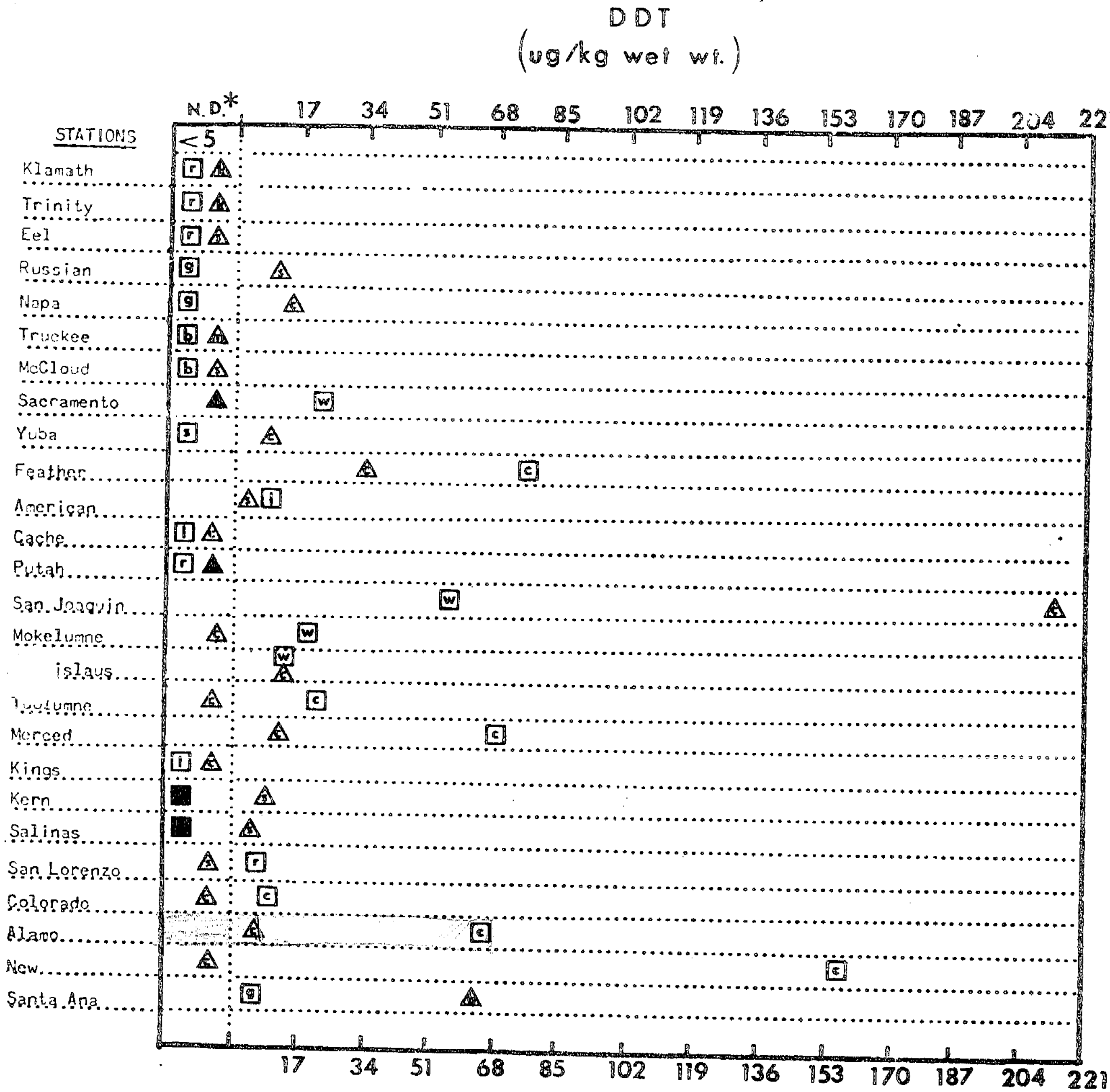
Benthos - ○

a - Andonta sp. (Freshwater mussel)
b - Corbicula sp. (Asiatic clam)
g - Gonidea sp. (Freshwater mussel)
l - Limnephilus (Caddisfly)
p - Pacifastacus sp. (Crayfish)
q - Procambarus sp. (Crayfish)

Solid Symbol - No Sample Collected

*N.D. - Not Detected

FIGURE 13. DDT concentrations in tissues of forage fish and predator fish; California primary network stations, 1978.



KEY

Predator Fish - □

b - Brown trout
c - Channel catfish
g - Green sunfish
l - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

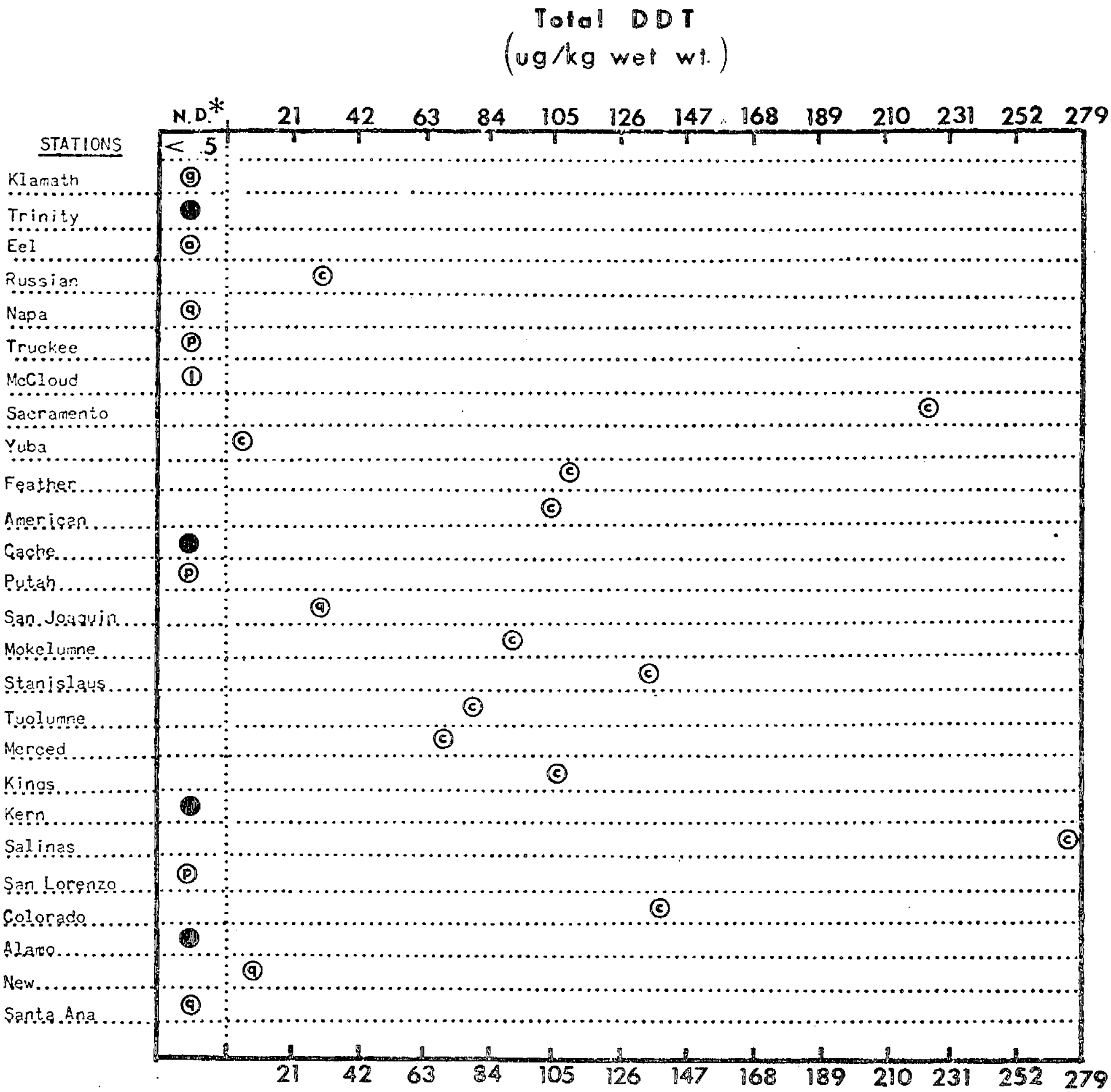
Forage Fish - △

b - Brown bullhead
c - Carp
k - Klamath sucker
m - Mountain whitefish
s - Sacramento sucker

* N.D. - Not Detected

Solid Symbol - No Sample Collected

FIGURE 14. Total DDT concentrations in tissues of benthos; California primary network stations, 1978.



KEY

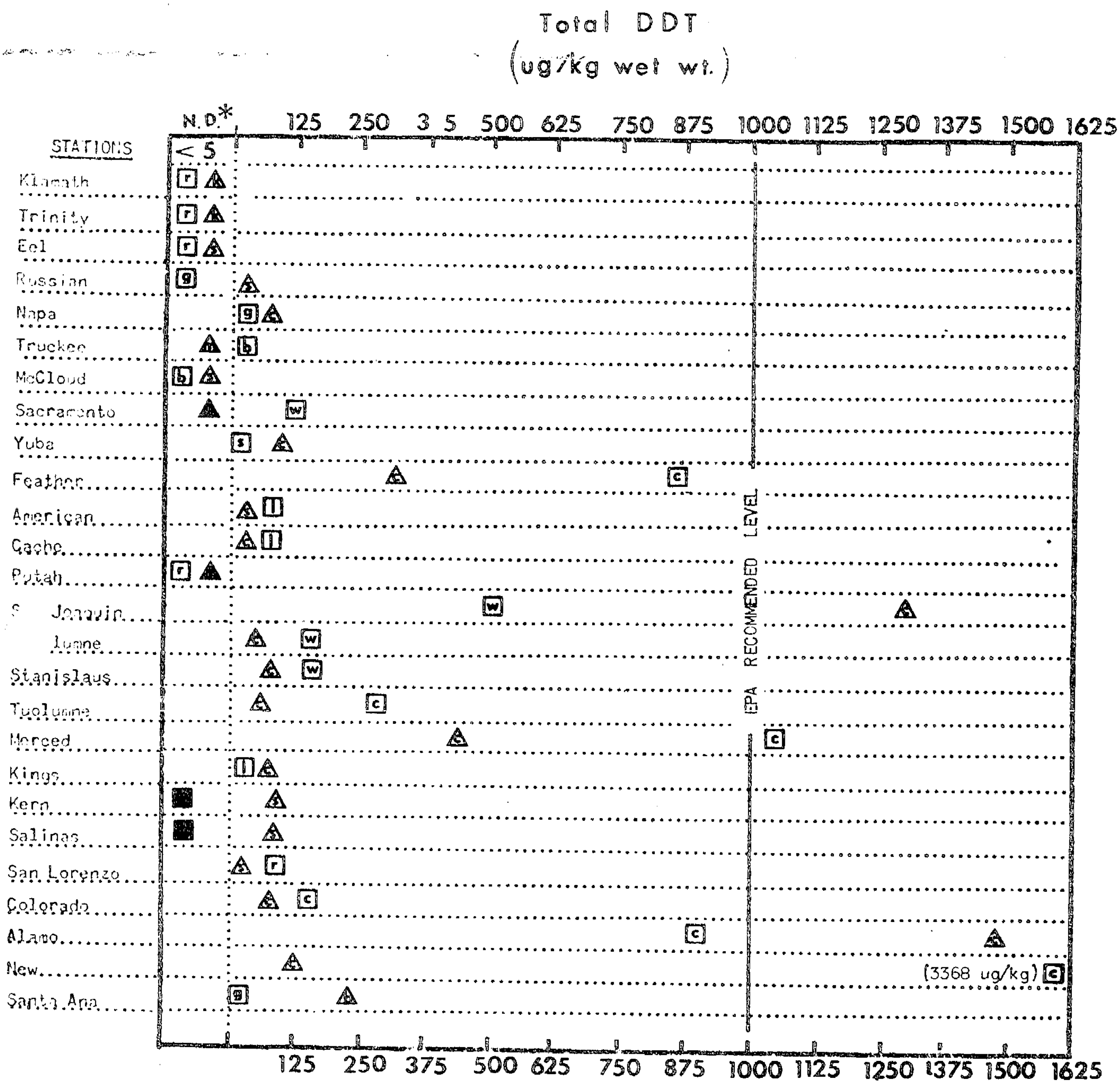
Benthos - ○

a - Andonta sp. (Freshwater mussel)
c - Corbicula sp. (Freshwater mussel)
g - Gonidea sp. (Freshwater mussel)
l - Limnephilus (Caddisfly)
p - Pacifastacus sp. (Crayfish)
q - Procambarus sp. (Crayfish)

Solid Symbol - No Sample Collected

*N.D. - Not Detected

FIGURE 15. Total DDT concentrations in tissues of forage fish and predator fish; California primary network stations, 1978.



Predator Fish -□

b - Brown trout
c - Channel catfish
g - Green sunfish
l - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

Forage Fish -△

b - Brown bullhead
c - Carp
k - Klamath sucker
m - Mountain whitefish
s - Sacramento sucker

*N.D. - Not Detected

Solid Symbol - No Sample Collected

Toxaphene; (Figure 16). Although no Toxaphene was found during the 1977 sampling program, organisms from five rivers, the Sacramento, San Joaquin, Merced, Salinas, and New (Appendix 1), contained detectable levels of Toxaphene in 1978; all exceeded the EPA predator protection guideline of 100 ug/kg (ppb) for edible fish tissue. The FDA (1978a) has set the guideline for Toxaphene at 5,000 ug/kg (ppb) for edible fish tissue.

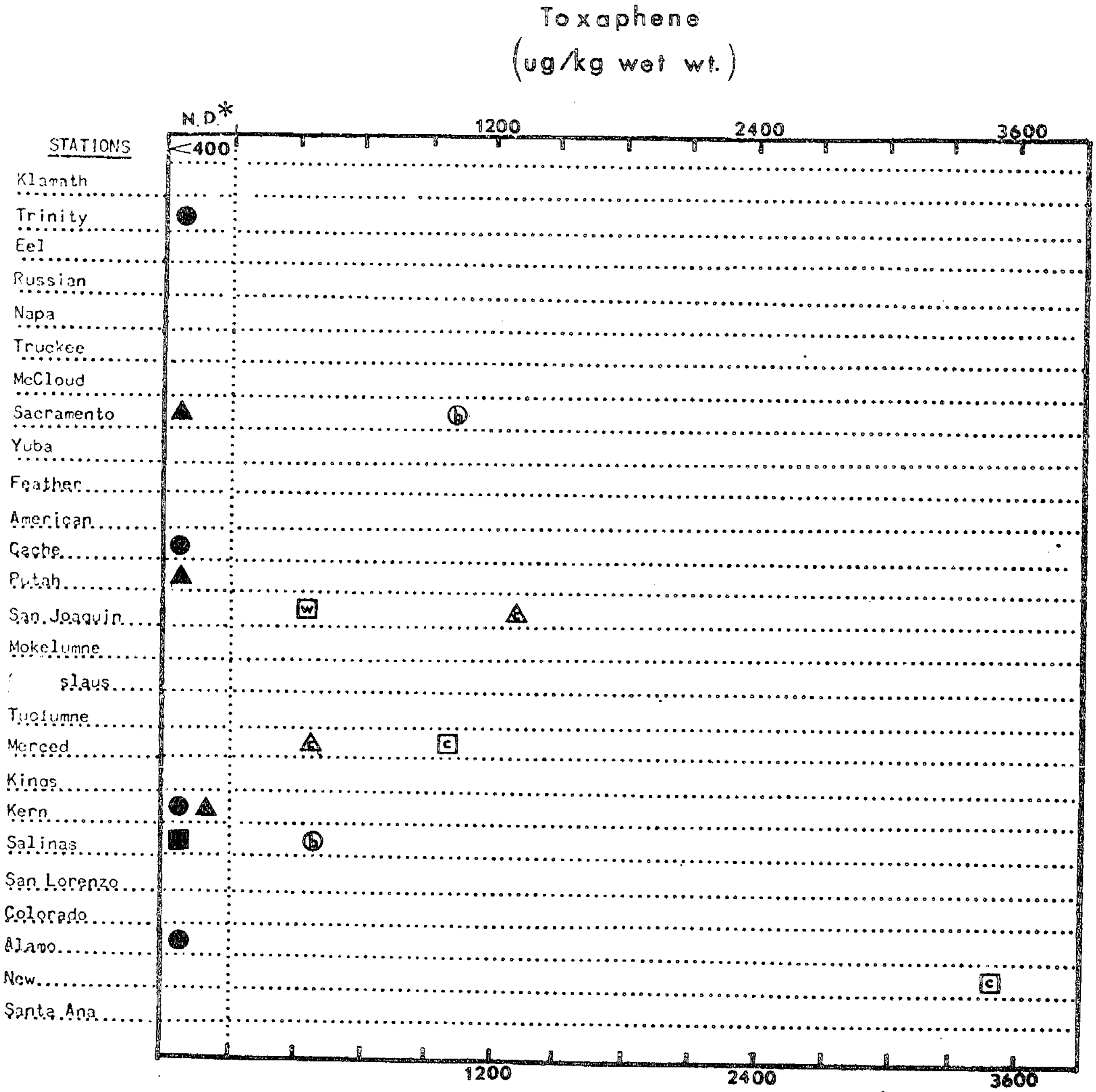
The Salinas River benthos contained 430 ug/kg of this pesticide. The Sacramento, San Joaquin, and Merced Rivers contained benthos, forage fish, or predator fish with Toxaphene concentrations from 1000-3000 ppb, or about 20-25% of the FDA recommended level. Catfish taken from the New River contained 3400 ppb Toxaphene (68% of the FDA recommended level).

Because each of these rivers drain vast agricultural areas and since Toxaphene is currently the most widely used insecticide in the United States (Munson 1976), its levels of detection in these rivers is understandable but alarming, especially since no Toxaphene was detected in 1977.

Because Toxaphene was detected at concentrations from 4 to 34 times the recommended "safe" level for predators, a hazardous situation may exist. The New River, especially, long known to be highly polluted, needs special attention. Biota in both the river and the Salton Sea, as well as the birds and humans that consume these fish may be exposed to high levels of Toxaphene as well as other pesticides and organics. Mayer et al. (1977) found that Toxaphene accumulation from water to fish was 50,000 times in channel catfish. At the present, however, insufficient research has been done to identify the effects of Toxaphene on the biota and their predators. Additional information must be gathered on the adverse effects of this pesticide and, if indicated, restrictive measures should be applied to the continued use of Toxaphene.

PCBs (Figures 17-18). Detectable PCBs residues were documented in *Corbicula* sp., bullhead, and catfish from the American, Santa Ana, and Feather Rivers, respectively. Only the Feather River sample (696 ug/kg or ppb) exceeded the guideline (500 ug/kg) set by NAS/NAE (1973) for the protection of fish and predatory aquatic organisms. However, the International Joint Commission (1975) recommended that the concentration of PCBs in water be sufficiently low to preclude residues greater than 100 ug/kg (ppb) in fish. The Feather River sample is nearly a factor of 7

FIGURE 16. Toxaphene concentrations in tissues of benthos, forage fish, and predator fish; California primary network stations, 1978.



KEY

Predator Fish - □

b - Brown trout
c - Channel catfish
g - Green sunfish
l - Largemouth bass
s - Smallmouth bass
r - Sculpin
w - White catfish

Forage Fish - △

b - Brown bullhead
c - Carp
k - Klamath sucker
m - Mountain whitefish
s - Sacramento sucker

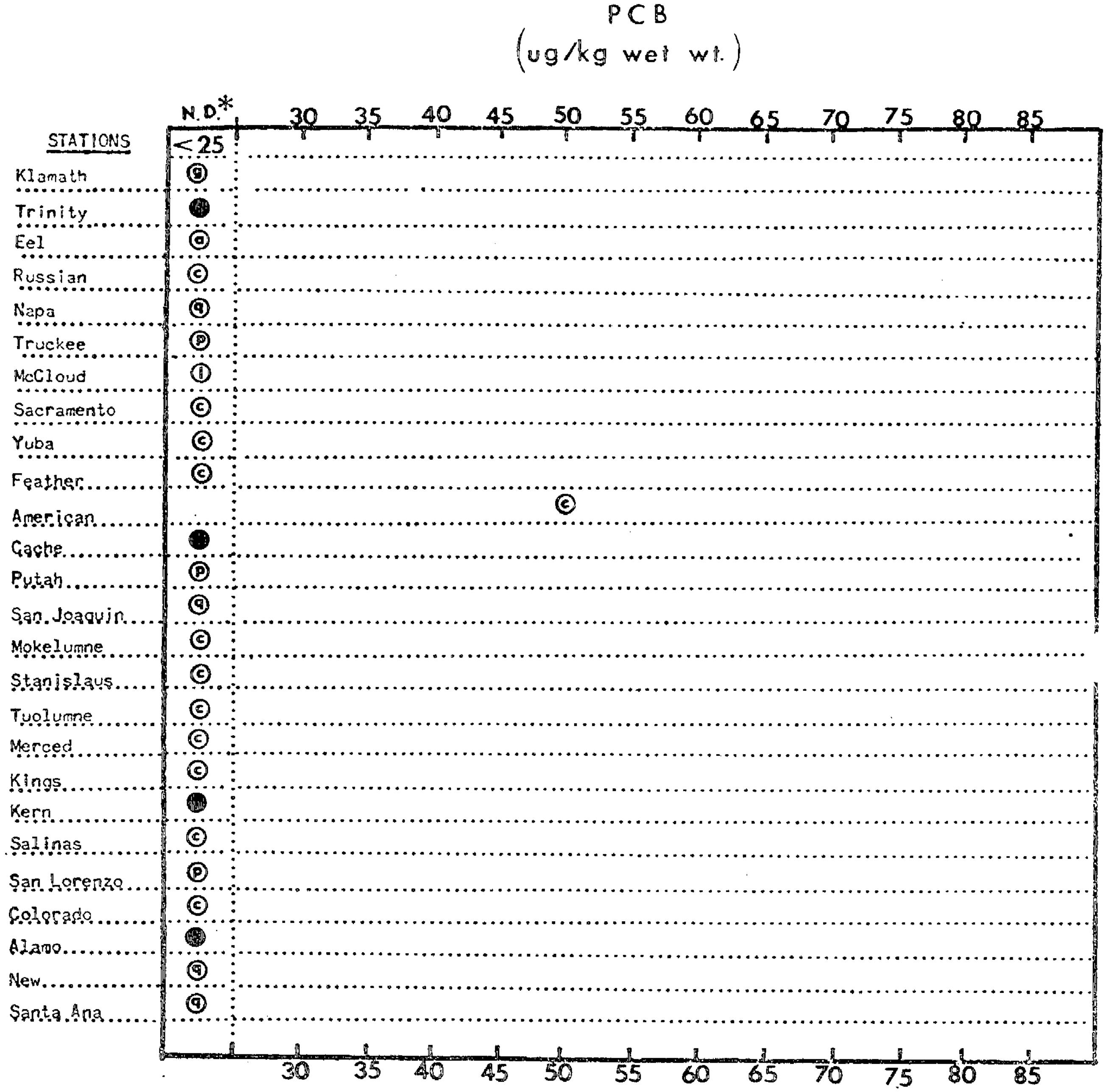
Benthos - ○

a - Andonta sp. (Freshwater mussel)
b - Corbicula sp. (Asiatic clam)
g - Gonidea sp. (Freshwater mussel)
l - Limnephilus (Caddisfly)
p - Pacifastacus sp. (Crayfish)

* N.D. - Values Not Shown Were Below Detection Limits

Solid Symbol - No Sample Collected

FIGURE 17. PCB concentrations in tissues of benthos; California prir v network stations, 1978.



KEY

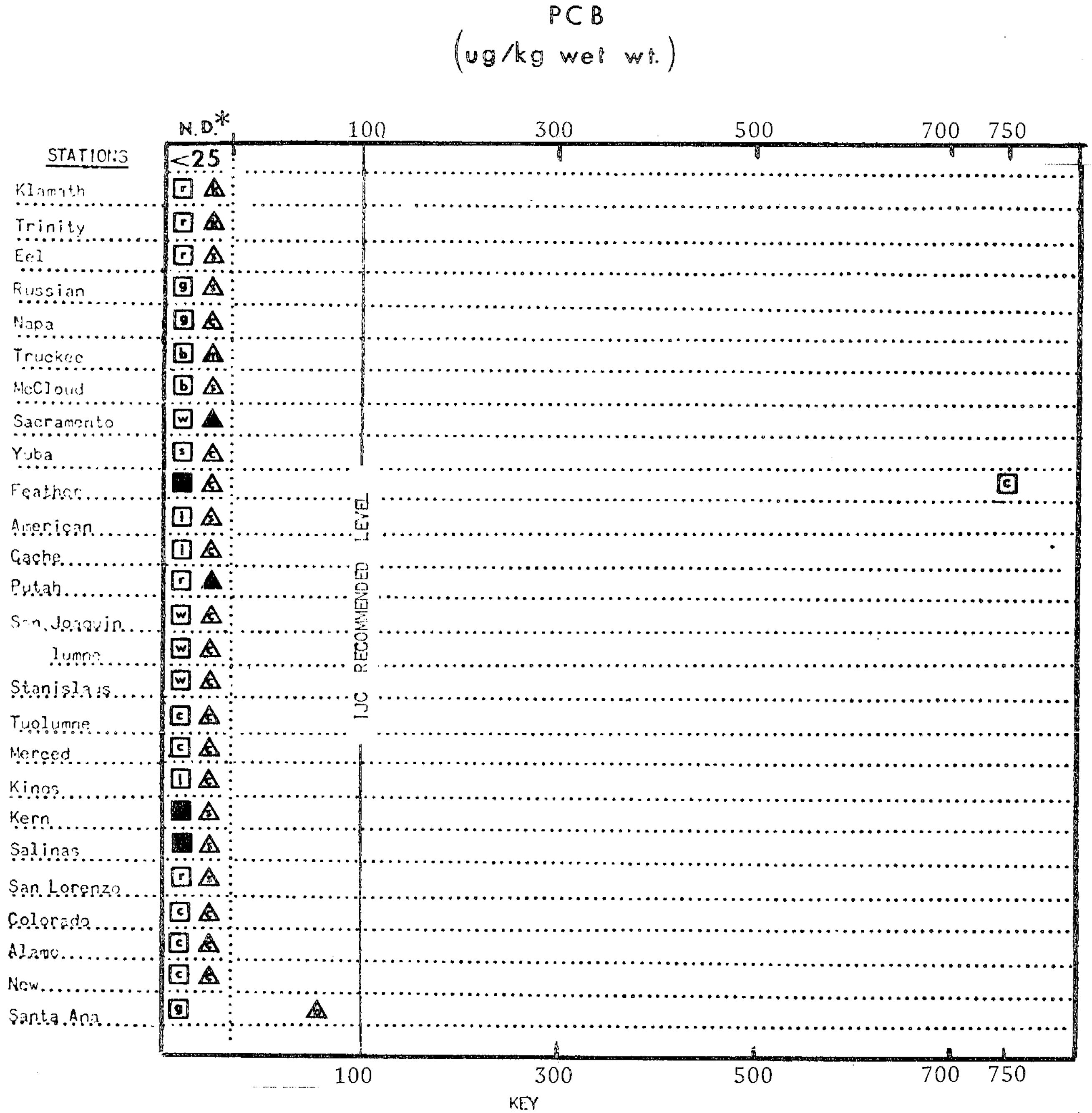
Benthos - ○

a - Andonta sp. (Freshwater mussel)
c - Corbicula sp. (Freshwater mussel)
g - Gonidea sp. (Freshwater mussel)
l - Limnephilus (Caddisfly)
p - Pacifastacus sp. (Crayfish)
q - Procambarus sp. (Crayfish)

Solid Symbol - No Sample Collected

*N.D. - Not Detected

FIGURE 18. PCB concentrations in tissues of forage fish and predator fish; California primary network stations, 1978.



KEY

Predator Fish - □	Forage Fish - △
b - Brown trout	b - Brown bullhead
c - Channel catfish	c - Carp
g - Green sunfish	k - Klamath sucker
l - Largemouth bass	m - Mountain whitefish
s - Smallmouth bass	s - Sacramento sucker
r - Sculpin	
w - White catfish	

Solid Symbol - No Sample Collected

* N.D. - Not Detected

greater than the 100 ug/kg guideline, and the samples from the American and Santa Ana Rivers are 50% and 74% of this level, respectively. Clearly, the Feather River sample contained excessive PCB residues.

Although only three (12%) of the rivers sampled in 1978 yielded biota which contained detectable PCB residues, 14 (54%) of these same rivers had PCB residues in their biota during 1977. This probably reflects the change to skinless fillets (1978) from whole-body cross-sections (1977) for analysis of PCB residues in fish tissue.

Corbicula sp. analysis techniques remained unchanged for both years, and the values for this organism can be compared. In 1977, the Corbicula sp. from the Sacramento and Stanislaus Rivers contained 79 and 64 ug/kg (ppb) (fresh weight), respectively, of PCB residues, whereas in 1978, Corbicula sp. from the American River contained 50 ug/kg of PCB residues. Corbicula sp. from both the Sacramento and Stanislaus Rivers contained no detectable PCBs in 1978. Each value is below the 100 ug/kg (ppb) guideline set by the International Joint Commission.

Regional Patterns of Trace Element, Pesticide, and PCB Distribution

The 1977 Toxic Substances Monitoring Program data is currently the most complete source of background levels for heavy metals, pesticides, and organics in California freshwater biota. Although levels of these contaminants for 1977 and 1978 can be compared in the benthos (Table 21), no similar comparison can be made for either the forage or predator fish. The 1977 samples consisted of whole fish cross-sections - which introduced contamination to the sample and made the results highly variable - whereas the 1978 fish samples utilized muscle fillets in both forage and predator fish as well as liver from the latter. Although data for 1978 fish cannot be compared with 1977, the results obtained for 1978 are more precise and more accurately reflect the conditions which existed in the 26 rivers during 1978.

Three trace metals, cadmium, copper, and zinc, were detected in both benthos and fish in all basins. Arsenic, chromium, lead, nickel, and silver were detected in most basins also, but generally these occurred more frequently in benthos than fish. Only predator fish flesh was analyzed for mercury, and it, too, occurred in most basins with northern California stations exhibiting the highest values;

TABLE 21. Summary of elements (ug/gm fresh weight) in benthos from 1977 and 1978 (Toxic Substances Monitoring Program).

Element and Year 1/	No. Stations Represented	Samples Analyzed	Detection Limit (DL) in mg/kg	Number of Samples			
				<DL No.(%)	DL to 0.5 mg/kg No.(%)	0.5 to 1.0 mg/kg No.(%)	≥1.0 mg/kg No.(%)
Arsenic							
1977	26	22	0.2	2 (9)	5 (23)	11 (50)	4 (18)
1978	26	22	0.1	4 (18)	7 (32)	8 (36)	3 (14)
Cadmium							
1977	26	23	0.03	9 (39)	13 (56)	1 (4)	0
1978	26	22	0.01	0	20 (91)	2 (9)	0
Chromium							
1977	26	23	0.2	10 (44)	4 (17)	6 (26)	3 (13)
1978	26	22	0.1	8 (36)	4 (18)	3 (14)	7 (32)
Copper							
1977	26	21	0.1	0	0	0	21 (100)
1978	26	22	0.1	0	0	0	22 (100)
Lead							
1977	26	22	0.3	20 (91)	0	2 (9)	0
1978	26	22	0.1	9 (40)	22 (55)	1 (5)	
Mercury							
1977	26	23	0.02	8 (35)	15 (65)	0	0
1978	NOT ANALYZED						
Nickel							
1977	26	23	0.2	6 (26)	3 (13)	9 (37)	5 (22)
1978	26	22	0.2	6 (27)	8 (37)	4 (18)	4 (18)
Silver							
1977	26	23	0.07	21 (91)	2 (9)	0	0
1978	26	22	0.04	10 (45)	12 (55)	0	0
Zinc							
1977	26	21	1.0	0	0	0	21 (100)
1978	26	22	1.0	0	0	0	22 (100)

1/ Copper and zinc analyses were conducted using flame atomic absorption spectrophotometry (AA), silver and mercury analyses used flameless AA, and carbon rod analysis were employed for the remaining metals.

Sacramento and San Joaquin basins were intermediate, and central and southern California stations yielded the lowest levels.

Detectable levels of pesticides and PCBs occurred primarily in areas of heavy agricultural activity and near industrialized urban centers, respectively.

North Coast Basin Most metals in the biota from this region occurred in concentrations that were typical of those for the remainder of the State; Mercury in fish flesh and nickel in benthos are the two exceptions. Excessive mercury concentrations throughout the basin may be due to natural weathering of the mineral rich Coastal Geochemical Province (Barnes 1973; California Department of Health 1973). Two of the four fish samples contained mercury concentrations greater than the EPA interim guideline (0.5 ug/gm wet weight) and the other two were above 0.4 ug/gm (Figure 7). If sculpin are representative of mercury concentrations in food fish, then clearly a potential hazard to human health exists in at least the Klamath and Eel Rivers in the vicinity of the sampling stations.

Nickel values in benthos from the Klamath and Eel Rivers were also considerably higher than the general trend for this metal (Figure 8). This may be due to natural eroding of the same deposits that are causing high mercury concentrations to occur in fish from these rivers. Because nickel is relatively nontoxic to humans, no problem with these levels is foreseen at this time.

Pesticides and PCBs either did not occur or only at very low levels in this basin. Except for the Russian River, streams in this region are isolated from agricultural activities. The Klamath, Trinity, and Eel Rivers are influenced primarily by silvicultural practices.

San Francisco Basin Metals, pesticides, and PCBs either occurred at concentrations typical of other streams or were not detected at all in the Napa River (the only stream sampled in this basin).

North Lahontan Basin Concentrations of most metals in fish and benthos from the Truckee River (the only river sampled in this basin) either followed the trend in other rivers or they were not detected. However, in brown trout livers, per and silver were detected at the second highest level of all rivers sampled in 1978, and zinc was third highest. Because copper and zinc are essential elements for animal metabolism, these levels probably pose no threat to the animal or the consumer. Silver is highly toxic and the detected amount of .34 ug/gm (ppm) may be detrimental to fish.

With the exception of DDE, which had a low concentration of 25 ug/kg (ppb), pesticides and organics were not detected in fauna from this river.

Sacramento Basin Nearly all benthos samples and many fish samples from the seven rivers sampled in this basin contained various concentrations of trace metals. Arsenic, chromium, lead, nickel, and silver occurred primarily in benthos; the remaining metals were detected in both fish and benthos (except mercury where only fish samples were used).

Corbicula sp. from the Sacramento River contained 1.18 ug/gm (ppm) arsenic. This was nearly twice as high as the trend for benthos in the basin. Lead in the benthos the American and Feather Rivers was 0.4 ug/gm (ppm), the second highest value found in benthos statewide. Nickel in the benthos from the Yuba River was more than twice as high as in the benthos of other rivers where it was detected, but this does not appear to be a serious problem. Concentrations of the other metals (except mercury) appear unremarkable.

Mercury concentration in fish of this basin (Figure 7) is undoubtedly the most serious concern. The fish in the Sacramento and Yuba Rivers and in Cache Creek contained excessive levels (>.5 ppm) of mercury. Consumption of contaminated fish can pose serious health problems to the very young and to pregnant females. Special attention should be given to determining the source of this mercury contamination and to implementing control measures if possible.

Pesticides and PCBs were found in the basin, but distribution and concentration varied considerably. The presence of these contaminants is related to agricultural and industrial activity in the watershed. Pesticides were generally below guideline levels, but some (DDT and its metabolites in the Feather, Toxaphene in the .ramento, and Aldrin/Dieldrin in both rivers) were present in sufficient quantities in either fish or benthos to warrant special attention in coming years.

The concentration of PCBs detected in channel catfish from the Feather River (Figure 18) appears to be of special concern. PCB levels in those fish were seven times the level recommended for protection of wildlife. Identification, if possible, of the PCB source needs to be done immediately and corrective action taken.

San Joaquin Basin Generally, metal concentrations in the biota of this basin were not extraordinary. However, arsenic in Corbicula sp. from the Tuolumne River exhibited the second highest value in the State (1.2 ug/gm) and was about twice as high as values for biota from the other rivers in the basin. The highest lead value found statewide was in freshwater clams from the Kings River (0.6 ug/gm). The highest concentration in fish liver, 0.4 ug/gm (ppm), was measured in Stanislaus River catfish. Cadmium and zinc in the Mokelumne River were higher than the norm, probably due to the influence of the Penn Mine (Finlayson 1979). The mercury values in San Joaquin River fish were the highest in the basin (0.38 ug/gm), which is approaching the EPA interim guideline of 0.5 ug/gm for the protection of predators.

No PCBs were found in these rivers, but pesticides were detected in biota from throughout the basin, a reflection of the predominant agricultural influence. Organisms in the Tuolumne and Merced Rivers contained Aldrin/Dieldrin. Stanislaus River Corbicula sp. was again the only instance of Chlordane contamination, as it was in 1977. Stanislaus and Merced River fish contained appreciably more total DDT than other rivers in the basin though even these were below guideline levels. The San Joaquin biota contained both Thiodan and Toxaphene, and the latter pesticide occurred in Merced benthos too. Obviously, agricultural pesticide use significantly affects the pollutant load in those streams that drain the Central Valley farm lands. Continued monitoring is a necessity as more chemicals are restricted from further use, as new guidelines for the protection of fish and public health are implemented, and as the next generation of pesticides is broadly applied.

Tulare Lake Basin Trace element residues were relatively low again in 1978 in the biota of the Kings and Kern Rivers when compared to other valley rivers in the State.

The heavy agricultural activity that occurs in this basin was not reflected in pesticides residue values, apparently because of the location of the monitoring site. The stations are upstream of most agricultural return waters. No PCBs were detected.

Central Coast Basin Again this year, cadmium was the only metal of notable importance in the aquatic fauna of this basin. The two highest values in the State for 1978 came from the only two rivers sampled in this basin, the Salinas and San Lorenzo. It appears that naturally occurring cadmium deposits in the two drainages may be responsible for the concentrations of this metal found in the biota.

The Salinas River benthos contained appreciably more DDT and its metabolites than did the San Lorenzo River. This simply reflects the differences in land use around the two; agriculture dominates the former and not the latter. PCBs were not detected.

Colorado River Basin For the most part, trace metal contamination of aquatic fauna of this basin did not appear unusual, but there are exceptions. Arsenic in *Corbicula* sp. from the Colorado River was the highest in the State this year (1.58 ug/gm). The 1977 values were also high (1.1 ug/gm). The salt concentrating effect of irrigation may be a prime contributing factor. Silver in New River crayfish 28 ug/gm) was about twice that of the norm.

The Imperial Valley agricultural area, which has a year-round growing season, materially affects the pesticide load of streams in this region. Additionally, the Alamo and New Rivers flow from Mexico where contaminants are even more loosely controlled (if at all) than in the United States. Although no PCBs were found in basin aquatic fauna, total DDT in predator fish from the New River was highest in the State and forage fish from the Alamo River ranked second. Both were above the EPA guideline for the protection of predators but below the FDA action level. Dieldrin was found in both the Alamo and New Rivers at levels greater than that recommended by the EPA for predator protection and approached one-third the FDA recommended level for human consumption. The fish of these rivers also contained appreciable levels of Dacthal, the only two instances in the State for this sampling period. Catfish from the New River contained 34 times the EPA predator protection level and 68% of the FDA recommended level of Toxaphene. Because of the bioaccumulation characteristic of this chemical, Toxaphene may be injuring predator species associated with the New River and the Salton Sea.

Santa Ana Basin Trace metals in the samples from the Santa Ana River (the only river sampled in this basin) were unremarkable.

Dieldrin as well as DDT and its metabolites were found in the biota of this river, but at relatively low levels.

PCBs were detected in fish from only two rivers in 1978; one was the Santa Ana. Brown bullheads, a forage fish, contained 74% of the recommended maximum level of PCBs (100 ug/kg). These are food fish and, therefore, a potential problem exists. Continued monitoring will provide the information necessary for future decision-making and action.

Temporal Trends of Trace Element, Pesticide, and PCB Distribution

Sample data reflect conditions at a particular point in time and space. If the data for a specific site differ greatly with time, it can be concluded that some event(s) has occurred. Such a conclusion assumes that the analyses have been properly performed and the sample is representative.

Both fish size and tissues sampled have varied since the beginning of the program; this precludes precise comparison of annual monitoring data. With respect to mercury residues in predator fish, 73% of the 1978 values were greater than or equal to 1977 values; however, this does not necessarily mean that there was increased mercury input in 1978. The 1977 samples contained skin, scale, and bone in addition to flesh (used solely in 1978), and thus diluted the mercury concentrations typically sequestered in the flesh (Friberg et al. 1971). Some spot-check analyses of 1977 mixed tissue samples with and without skin revealed increased mercury concentrations in skinless fillets.

Comparison of chlorinated hydrocarbon residues in fish for 1977 and 1978 generally shows that most residue values were reduced (some were eliminated) in 1978. This reduction is presumed to result from the omission of lipid-containing mesentery and skin from 1978 samples. For instance, PCBs occurred in 44% of the 1977 fish samples but in only 8% of the 1978 samples. In 1978, Toxaphene residues did increase; however, this increase cannot be fully attributed to pesticide usage. Although Toxaphene was not detected in previous analyses, the higher PCB residues during those years may have masked the Toxaphene peak in the chromatographs.

ıtrary to the changes in methodology that have evolved with fish tissue analyses, benthos tissue analyses methods have remained relatively consistent. The only exception was trace element instrumentation; a different and more sensitive instrument was used each sampling period. This more sensitive analytical technique allowed fewer less-than-detection-limit values to be recorded in 1978 (Table 21).

The percentage of detectable pesticide and PCB residue values in benthos increased in 1978. Since analytical techniques and tissue preparation for benthos have remained relatively consistent, it is possible that the increased runoff during the 1978 water year contributed to greater pesticide input to rivers via increased discharge from pesticide laden irrigation canals and drains.

PROGRAM DEVELOPMENT

During the 1979 collection series, sample collections will include only benthos and predator fish; forage fish collections will be discontinued. However, a greater effort will be made to collect crayfish as these organisms occur statewide, although of the same species. If crayfish can be collected at most stations, this would permit better geographical and temporal comparisons of elements and organics in the aquatic fauna of the sampled streams to be made. Additionally, other crayfish tissues will be investigated for their applicability and suitability to the program.

Composite samples will continue to be taken and will consist of a minimum of six median size individuals, when possible. Sample preparation will remain unchanged except that all samples will be placed in glass bottles with glass lids. This will permit the taking of one sample for both element and pesticide analyses as well as leaving just a single container for archive purposes. Improved techniques of homogenizing tissues will also be investigated as will freeze drying and ball-mill mixing of tissue samples for archive storage.

Elements to be analyzed remain unchanged. Arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc will be analyzed in molluscs and crayfish and in predator fish samples. Mercury analyses will include mollusc and crayfish samples as well as predator fish flesh samples. Additionally, up to six predator fish liver samples will be selected for mercury analysis. These liver samples will be representative of the various contamination levels found in flesh analyses.

Pesticides and other chlorinated organic compounds will be analyzed in mollusc, crayfish, and predator fish flesh samples. Additionally, as many as 12 predator fish liver samples, representative of various levels of contamination found in flesh, will be analyzed.

In a special study, New River fish flesh samples will be analyzed for phenoxy herbicides such as 2,4-D. Two column confirmation will be used for identification of unknown compounds, and high resolution glass capillary column chromatography will be employed to enhance the resolution of unknowns.

Quality control will continue to include analysis of laboratory intercalibration samples as well as field and laboratory replicates. Archive material will be suitably prepared and maintained in a rental cold storage facility.

A literature search for pertinent publications on new methods of tissue analysis for trace elements and organic compounds will be continued. Resources permitting, this will be extended to include the body burden effects of these contaminants on both the organism and the consumer.

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APPENDIX I
1978 DATA

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Klamath River Station No. 1

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	*Gonidea angulata*	80			6	83.1	<.1	
Forage Fish	*Catostomus rimiculus*	226	169	III	4		.1	
Predator Fish	*Cottus* sp. Flesh	139	37	IV	10	80.5	<.1	
	Cottus sp. Liver							

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.05	.53	.2	2.1	3.2		3.1	<.1	24
Predator Fish Liver	<.02	.15	.5	<.06	2.2		.36	<.1	38
Predator Fish Flesh						.60			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos					5	<5	<5		5			
Forage Fish Flesh					<5	<5	<5		<5			
Predator Fish Flesh					<5	<5	<5		<5			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Trinity River Station No. 2

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	No sample							
Forage Fish	Catostomus rimiculus	239	192	III	6		3.2	
Predator Fish	Cottus sp. Flesh	134	33	IV	5	83.9	1.9	
	Cottus sp. Liver							

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos									
Predator Fish Liver	<.02	.24	.28	<.06	4.5		<.14	<.1	27.
Predator Fish Flesh						.46			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos												
Forage Fish Flesh					<5	<5	<5		<5			
Predator Fish Flesh					<5	<5	<5		<5			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

McCloud River Station No. 3

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	*Limnephilus* sp.	20	0.5		24	73.7	2.2	
Forage Fish	*Catostomus occidentalis*	164	95	II	4		<.1	
Predator Fish	*Salmo trutta* Flesh	189	78	III	7	77.5	.1	
	Salmo trutta Liver					82.6		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	<.03	<.1	.24	.56	3.6		.45	0.3	33
Predator Fish Liver	.56	<.1	.36	<.06	77		.14	<.1	29
Predator Fish Flesh						.03			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos					< 5	< 5	< 5		< 5			
Forage Fish Flesh					< 5	< 5	< 5		< 5			
Predator Fish Flesh					< 5	< 5	< 5		< 5			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Eel River Station No. 4

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Andonta californiensis	52	2.0		8	89.9	<.1	
Forage Fish	Catostomus occidentalis	251	157	III	6		<.1	
Predator Fish	Cottus sp. Flesh	131	30	III	6	84.2	<.1	
	Cottus sp. Liver							

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.11	.67	.32	1.0	4.0		2.5	.2	14
Predator Fish Liver	<.02	.27	.24	<.06	1.8		<.14	<.1	49
Predator Fish Flesh						1.15			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos					<5	<5	<5		<5			
Forage Fish Flesh					<5	<5	<5		<5			
Predator Fish Flesh					7	<5	<5		7			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Truckee River Station No. 5

	Physical Data: Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	Tissue Data: % H_2O	% Fat	
Benthos Pacifastacus leniusculus	90			8	79.6	<.1	
Forage Fish Prosopium williamsoni	279	314	III	6		.7	
Predator Fish Salmo trutta Flesh	200	130	II	6	79.2	.1	
Salmo trutta Liver					84.5		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.04	.41	.3	<.06	13		<.2	<.1	21
Predator Fish Liver	.34	<.1	.1	<.06	50		<.14	<.1	39
Predator Fish Flesh						.03			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos					< 5	< 5	< 5		< 5			
Forage Fish Flesh					< 5	< 5	< 5		< 5			
Predator Fish Flesh					25	< 5	< 5		25			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Yuba River
Station No. 6

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	*Corbicula* sp.	22			18	90.7		
Forage Fish	*Cyprinus carpio*	435	1267	V	6		.3	
Predator Fish	*Micropterus dolomieu* Flesh	244	271	III	5	73.5	.2	
	Micropterus dolomieu Liver							

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.02	.47	.36	1.3	8.4		1.6	0.1	9.7
Predator Fish Liver	< .05	< .1	.26	< .10	1.7		< .2	< .1	32
Predator Fish Flesh						.72			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan II	Toxaphene
Benthos					7	< 5	< 5		7			
Forage Fish Flesh					99	< 5	12		111			
Predator Fish Flesh					7	< 5	< 5		7			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Feather River Station No. 7

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	*Corbicula* sp.	27			10	86.2	.7	
Forage Fish	*Cyprinus carpio*	300	294	III	2		.7	
Predator Fish	*Ictalurus punctatus* Flesh	383	863	IV	4	77.5	4.6	
	Ictalurus punctatus Liver					82.1		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	<.02	.69	.22	2.0	6.9		.73	.4	18
Predator Fish Liver	<.03	<.1	.28	.14	3.4		<.2	<.1	24
Predator Fish Flesh						.29			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos				<5	94	<5	12	<5	106	<50		
Forage Fish Flesh				<5	200	59	34	<5	293	<50		
Predator Fish Flesh				7	540	140	76	109	865	696		

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Cache Creek Station No. 8

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	No sample							
Forage Fish	*Cyprinus carpio*	450	1753	IV	4		.1	
Predator Fish	*Micropterus salmoides* Flesh	268	463	III	3	79.4	.3	
	Micropterus salmoides Liver					77.4		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos									
Predator Fish Liver	<.03	<.1	.1	<.1	2.7		<.2	<.1	17
Predator Fish Flesh/Liver						.61			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan I	Toxaphene
Benthos												
Forage Fish Flesh					8	6	<5	6	20			
Predator Fish Flesh					22	18	<5	8	48			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

American River Station No. 9

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	*Corbicula* sp.	26			24	87.6	<.1	
Forage Fish	*Catostomus occidentalis*	300	354	III	6		<.1	
Predator Fish	*Micropterus salmoides* Flesh	262	337	III	5	82.0	<.1	
	Micropterus salmoides Liver					80.3		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.10	.53	.38	1.2	7.7		.56	.4	21
Predator Fish Liver	<.03	<.1	.24	.23	6.7		<.2	<.1	34
Predator Fish Flesh						.36			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos					64	11	30		105	50		
Forage Fish Flesh					36	<5	5		41	<50		
Predator Fish Flesh					44	<5	9		53	<50		

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Russian River Station No. 10

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Corbicula sp.	27			20	84.4	<.1	
Forage Fish	Catostomus occidentalis	336	421	IV	7		<.1	
Predator Fish	Lepomis cyanellus Flesh	95	16	II	9	81.7	<.1	
	Lepomis cyanellus Liver							

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.04	.54	.16	1.1	4.2		1.1	<.1	18
Predator Fish Liver	<.02	<.1	.2	.12	1.8		<.14		18
Predator Fish Flesh						.41			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos					11	13	12		36			
Forage Fish Flesh					14	5	7		26			
Predator Fish Flesh					<5	<5	<5		<5			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Putah Creek Station No. 11

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Pacifastacus leniusculus	115			10	81.8	<.1	
Forage Fish	No sample							
Predator Fish	Cottus sp. Flesh	123	8	III	15	85.2	<.1	
	Cottus sp. Liver							

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	<.02	<.1	.12	<.10	13		<.19	<.1	25
Predator Fish Liver	<.02	.33	.54	<.06	5.1		<.14		38
Predator Fish Flesh						.13			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos					<5	<5	<5		<5			
Forage Fish Flesh												
Predator Fish Flesh					<5	<5	<5		<5			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Napa River Station No. 12

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	*Procambarus clarki*	110			2	80.9	<.1	
Forage Fish	*Cyprinus carpio*	495	2,650	VI	7		<.1	
Predator Fish	*Lepomis cyanellus* Flesh	130	53	III	9	82.2	<.1	
	Lepomis cyanellus Liver					82.6		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.14	<.1	.14	<.10	6.5		.28	<.1	24
Predator Fish Liver	<.02	<.1	.08	<.06	.9		<.14	<.1	17
Predator Fish Flesh						.12			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp' DDE	pp' DDD	pp' DDT	DDMU	Total DDT	PCB	Thiodan I	Toxaphene
Benthos					<5	<5	<5		<5			
Forage Fish Flesh					25	12	9		46			
Predator Fish Flesh					5	<5	<5		5			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Sacramento River Station No. 13

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Corbicula sp.	38			5	85.0	.4	
Forage Fish	No sample							
Predator Fish	Ictalurus catus Flesh	276	304	V	6	82.1	<.1	
	Ictalurus catus Liver							

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.13	1.18	.34	1.6	13		.34	.2	26
Predator Fish Liver	<.05	<.1	.46	<.1	3.6		<.2	< 0.1	22
Predator Fish Flesh						.83			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp' DDE	pp' DDD	pp' DDT	DDMU	Total DDT	PCB	Thiodan I	Toxaphene
Benthos	133			13	85	22	29	91	227			1040
Forage Fish Flesh												
Predator Fish Flesh	< 5			< 5	63	15	20	34	132			< 400

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Mokelumne River Station No. 14

			Physical Data				Tissue Data		
			Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	*Corbicula* sp.		25			30	87.0	.3	
Forage Fish	*Cyprinus carpio*		482	1,700	VI	4		<.1	
Predator Fish	*Ictalurus catus*	Flesh	200	219	IV	6	81.1	<.1	
	Ictalurus catus	Liver					84.8		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	<.02	.80	.62	.24	5.0		<.2	.3	48
Predator Fish Liver	<.03	<.1	.2	.26	2.0		<.2	.3	16
Predator Fish Flesh						.28			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos					48	19	29		96			
Forage Fish Flesh					21	25	<5		46			
Predator Fish Flesh					122	25	20		167			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

San Joaquin Station No. 15

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Procambarus clarki	120			5	81.3	<.1	
Forage Fish	Cyprinus carpio	389	1,180	VI	5		.7	
Predator Fish	Ictalurus catus Flesh	222	147	IV	6	80.6	<.1	
	Ictalurus catus Liver					84.8		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.06	<.1	.18	<.1	8.8		<.2	0.1	35
Predator Fish Liver	<.03	.13	.08	<.1	4.7		<.2	0.2	23
Predator Fish Flesh						.38			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos					38	<5	<5		38		<5	<400
Forage Fish Flesh					862	191	215		1268		14	1380
Predator Fish Flesh					391	53	56		500		<5	430

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Stanislaus River
Station No. 16

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Corbicula sp.	33			5	91.0	.1	
Forage Fish	Cyprinus carpio	393	1,208	V	5		.1	
Predator Fish	Ictalurus catus Flesh	241	188	IV	5	86.1	.4	
	Ictalurus catus Liver					82.4		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	<.02	.47	.18	.24	5.4		.48	<.1	17
Predator Fish Liver	<.03	<.1	.2	.27	4.7		<.2	0.4	21
Predator Fish Flesh						.23			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos		100			84	21	26		131			
Forage Fish Flesh		<25			64	15	15		94			
Predator Fish Flesh		<25			107	12	12		131			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Tuolumne River Station No. 17

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Corbicula sp.	50			10	88.5	<.1	
Forage Fish	Cyprinus carpio	391	1,146	IV	5		<.1	
Predator Fish	Ictalurus punctatus Flesh	319	377	III	6	79.3	<.1	
	Ictalurus punctatus Liver					83.2		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	<.04	1.2	0.1	.88	9.3		.4	0.2	20
Predator Fish Liver	<.03	.13	0.14	<.1	4.0		<.2	0.2	17
Predator Fish Flesh						.27			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp' DDE	pp' DDD	pp' DDT	DDMU	Total DDT	PCB	Thiodan x	Toxaphene
Benthos				<5	56	24	<5		80			
Forage Fish Flesh				<5	49	10	<5		59			
Predator Fish Flesh				7	203	36	28		267			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Merced River
Station No. 18

	Physical Data				Tissue Data		
	Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos Corbicula sp.	20			10	86.3	.3	
Forage Fish Cyprinus carpio	372	1,155	IV	5		.6	
Predator Fish Ictalurus punctatus Flesh	350	400	III	2	85.2	1.2	
Ictalurus punctatus Liver					85.5		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	<.04	.47	.2	.36	8.0		.2	0.1	22
Predator Fish Liver	<.03	<.1	.12	<.06	3.1		<.14	0.1	26
Predator Fish Flesh						.25			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos				<5	59	<5	10	<5	69			<400
Forage Fish Flesh				9	371	45	14	15	445			460
Predator Fish Flesh				13	873	80	68	56	1077			1040

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

San Lorenzo River
Station No. 19

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Pacifastacus leniusculus	110			4	84.6	<.1	
Forage Fish	Catostomus occidentalis	295	385	III	7		<.1	
Predator Fish	Cottus sp. Flesh	110	43	III	10	78.2	1.2	

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	<.04	.24	.36	<.08	10		<.2	<0.1	20
Predator Fish Liver	<.03	<.1	.98	<.06	4.9		.62		38
Predator Fish Flesh						.11			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos					<5	<5	<5		<5			
Forage Fish Flesh					<5	7	<5		7			
Predator Fish Flesh					20	<5	9		29			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Salinas River
Station No. 20

	Physical Data				Tissue Data		
	Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos Corbicula sp.	17			25	88.4	.1	
Forage Fish Cyprinus carpio	213	257	III	6		.1	
Predator Fish No sample							

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	<.04	.56	.64	.28	3.1		.6	<.1	12
Predator Fish Liver									
Predator Fish Flesh									

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos				<5	115	61	103		279			460
Forage Fish Flesh				7	47	8	7		62			<400
Predator Fish Flesh												

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Kings River
Station No. 21

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Corbicula sp.	20			20	90.8	.1	
Forage Fish	Cyprinus carpio	240	247	II	6		.1	
Predator Fish	Micropterus salmoides Flesh	158	85	II	6	82.1	.1	
	Micropterus salmoides Liver					78.0		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	<.04	.51	.22	.56	6.7		.9	0.6	17
Predator Fish Liver	<.03	<.1	0.1	<.1	3.4		<.2	<.1	21
Predator Fish Flesh						.08			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos					100	6	< 5		106			
Forage Fish Flesh					58	< 5	< 5		58			
Predator Fish Flesh					20	< 5	< 5		20			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Kern River
Station No. 22

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	No sample							
Forage Fish	Catostomus occidentalis	272	278	III	3		<.1	
Predator Fish	No sample							

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos									
Predator Fish Liver									
Predator Fish Flesh									

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan X	Toxaphene
Benthos												
Forage Fish Flesh					56	6	12		74			
Predator Fish Flesh												

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Santa Ana River Station No. 23

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Procambarus clarki	115			5	81.4	.1	
Forage Fish	Ictalurus nebulosis	205	110	III	1		1.1	
Predator Fish	Lepomis cyanellus Flesh	137	60	I+	6	78.6	<.1	
	Lepomis cyanellus Liver					81.1		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.08	.13	.46	<.08	9.8		.2	0.1	31
Predator Fish Liver	<.03	<.1	.2	<.1	3.4		<.2	0.2	26
Predator Fish Flesh						.10			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos				<5	<5	<5	<5		<5	<50		
Forage Fish Flesh				28	73	101	60		234	74		
Predator Fish Flesh				<5	<5	6	8		14	<50		

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Colorado River Station No. 24

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Corbicula sp.	48			10	87.6	.1	
Forage Fish	Cyprinus carpio	385	1,175	III	4		.2	
Predator Fish	Ictalurus punctatus Flesh	287	834	III	5	80.3	.2	
	Ictalurus punctatus Liver					80.0		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.12	1.58	.12	< .10	8.5		.3	0.2	16
Predator Fish Liver	< .03	< .1	.12	< .10	3.7		< .2	0.3	25
Predator Fish Flesh						< .05			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp' DDE	pp' DDD	pp' DDT	DDMU	Total DDT	PCB	Thiodan X	Toxaphene
Benthos					115	12	16		143			
Forage Fish Flesh					110	< 5	< 5		110			
Predator Fish Flesh					140	24	11		175			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

Alamo River
Station No. 26

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	No sample							
Forage Fish	Cyprinus carpio	350	1,250	II	1		<.1	
Predator Fish	Ictalurus punctatus Flesh	175	525	I	2	84.0	.1	
	Ictalurus punctatus Liver							

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos									
Predator Fish Liver	<.02	<.1	.12	<.06	2.9		<.14	<.1	25
Predator Fish Flesh						.07			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos												
Forage Fish Flesh			460	33	1360	121	9		1490			
Predator Fish Flesh			220	28	711	105	66		882			

APPENDIX I. Trace Metal and Pesticide Concentrations in Aquatic Organisms Sampled During the 1978 Water Year at:

New River
Station No. 27

		Physical Data				Tissue Data		
		Mean Length (mm)	Mean Weight (gm)	Age Group	Number in Composite	% H_2O	% Fat	
Benthos	Procambarus clarki	105			6			
Forage Fish	Cyprinus carpio	140	60	I+	1		.1	
Predator Fish	Ictalurus punctatus Flesh	330	550	III	1	77.2	1.2	
	Ictalurus punctatus Liver					78.5		

	Trace Metal Concentrations Expressed as mg/kg Fresh Weight								
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Benthos	.28	.13	.2	< .10	11		< .2	< .1	18
Predator Fish Liver	< .02	< .1	.12	< .06	2.7		< .14	< .1	23
Predator Fish Flesh						< .05			

	Pesticide Concentrations (Expressed as PPB Fresh Weight Basis)											
	Aldrin	Chlordane	Dacthal	Dieldrin	pp'DDE	pp'DDD	pp'DDT	DDMU	Total DDT	PCB	Thiodan Σ	Toxaphene
Benthos			< 5	< 5	11	< 5	< 5		11			< 400
Forage Fish Flesh			70	7	82	42	< 5		124			< 400
Predator Fish Flesh			680	86	2940	269	159		3368			3400

APPENDIX 2

SUMMARY OF ORGANIC COMPOUNDS DETECTED IN 1978 SAMPLES

Qualitative and quantitative analysis of identified and unidentified compounds in California primary network river station samples as determined by gas chromatography in florisil extracts.

River	Number of GC Compounds					Compounds Calculated as DDE in ppb				
	Identified Elution		Unidentified Elution			Identified Elution		Unidentified Elution		
	6%	15%	6%	15%	% Total	6%	15%	6%	15%	% Total
Klamath										
Benthos	1	0	1	2	75	15	0	6	18	61
Forage Fish	0	0	0	1	100	0	0	0	8	100
Predator Fish	0	0	0	1	100	0	0	0	10	100
Trinity										
Benthos	- -	- -	- -	- - -	- - NO SAMPLE -	- -	- -	- - -	- -	
Forage Fish	0	0	0	1	100	0	0	0	15	100
Predator Fish	0	0	1	0	100	0	0	10	0	100
Pit										
Benthos	0	0	0	0	--	0	0	0	0	--
Forage Fish	1	0	0	3	75	4	0	0	129	96
Predator Fish	0	0	0	3	100	0	0	0	80	100
Eel										
Benthos	0	0	0	0	--	0	0	0	0	--
Forage Fish	0	0	0	0	--	0	0	0	0	--
Predator Fish	1	0	0	2	66	7	0	0	17	70
Truckee										
Benthos	0	0	0	1	100	0	0	0	9	100
Forage Fish	0	0	7	2	100	0	0	61	20	100
Predator Fish	1	0	1	0	50	25	0	6	0	19

Qualitative and quantitative analysis of identified and unidentified compounds in California primary network river station samples as determined by gas chromatography in florisil extracts.

River	Number of GC Compounds					Compounds Calculated as DDE in ppb				
	Identified Elution		Unidentified Elution			Identified Elution		Unidentified Elution		
	6%	15%	6%	15%	% Total	6%	15%	6%	15%	% Total
Yuba										
Benthos	- - NO SAMPLE - -									
Forage Fish	2	0	0	0	0	111	0	0	0	0
Predator Fish	1	0	2	3	83	7	0	23	19	85
Feather										
Benthos	2	0	4	0	67	106	0	326	0	75
Forage Fish	3	0	4	3	70	293	0	210	431	69
Predator Fish	- - NEGATIVE PEAK INTERFERENCE - -									
Cache Creek										
Benthos	- - NO SAMPLE - -									
Forage Fish	3	0	0	2	40	35	0	0	57	61
Predator Fish	3	0	1	2	50	182	0	11	67	30
American										
Benthos	3	0	4	2	66	262	0	93	52	35
Forage Fish	2	0	5	2	77	101	0	80	14	48
Predator Fish	2	0	3	1	66	97	0	39	5	31
Russian										
Benthos	3	0	3	3	66	78	0	28	32	43
Forage Fish	3	0	1	3	57	56	0	6	27	33
Predator Fish	0	0	0	1	100	0	0	0	13	100

Qualitative and quantitative analysis of identified and unidentified compounds in California primary network river station samples as determined by gas chromatography in florisil extracts.

River	Number of GC Compounds					Compounds Calculated as DDE in ppb				
	Identified Elution		Unidentified Elution			Identified Elution		Unidentified Elution		
	6%	15%	6%	15%	% Total	6%	15%	6%	15%	% Total
Putah Creek										
Benthos	0	0	0	0	--	0	0	0	0	--
Forage Fish	- -	- -	- -	- -	- - NO SAMPLE	- -	- -	- -	- -	- -
Predator Fish	0	0	0	0	100	0	0	0	0	100
Napa										
Benthos	0	0	0	0	--	0	0	0	0	--
Forage Fish	3	0	1	1	40	63	0	14	15	31
Predator Fish	1	0	0	3	75	43	0	0	29	4
Sacramento										
Benthos	6	1	3	5	53	- -	NEGATIVE PEAKS -	-		
Forage Fish	- -	- -	- -	- -	- - NO SAMPLE	- -	- -	- -	- -	- -
Predator Fish	5	0	1	1	28	181	0	32	30	25
Mokelumne										
Benthos	3	0	5	2	70	157	0	112	25	46
Forage Fish	3	0	2	2	57	65	0	25	14	37
Predator Fish	3	0	6	1	70	66	0	63	15	54
San Joaquin										
Benthos	1	0	0	1	50	61	0	0	10	14
Forage Fish	4	1	8	7	75	- -	NEGATIVE PEAKS -	-		
Predator Fish	4	0	5	4	69	216	0	32	53	28

Qualitative and quantitative analysis of identified and unidentified compounds in California primary network river station samples as determined by gas chromatography in florisil extracts.

River	Number of GC Compounds					Compounds Calculated as DDE in ppb				
	Identified Elution		Unidentified Elution			Identified Elution		Unidentified Elution		
	6%	15%	6%	15%	% Total	6%	15%	6%	15%	% Total
Stanislaus										
Benthos	4	0	4	1	55	167	0	47	20	28
Forage Fish	3	0	5	4	75	99	0	39	26	39
Predator Fish	3	0	3	2	62	535	0	30	20	8
Tuolumne										
Benthos	2	0	6	3	81	140	0	94	32	47
Forage Fish	2	0	2	1	60	106	0	34	26	36
Predator Fish	3	1	5	5	71	296	205	58	73	20
Merced										
Benthos	2	0	6	3	81	339	0	56	37	21
Forage Fish	5	1	2	2	40	463	9	51	18	12
Predator Fish	5	1	3	2	45	- - NEGATIVE PEAKS - -				
San Lorenzo										
Benthos	0	0	0	0	--	0	0	0	0	--
Forage Fish	1	0	0	0	0	29	0	0	0	0
Predator Fish	2	0	3	2	71	73	0	73	13	54
Salinas										
Benthos	4	0	2	3	55	446	0	30	63	17
Forage Fish	3	1	1	1	33	94	148	15	6	7
Predator Fish	- - - - - - - - - NO SAMPLE - - - - - - - - - -									

Qualitative and quantitative analysis of identified and unidentified compounds in California primary network river station samples as determined by gas chromatography in florisil extracts.

River	Number of GC Compounds					Compounds Calculated as DDE in ppb				
	Identified Elution		Unidentified Elution			Identified Elution		Unidentified Elution		
	6%	15%	6%	15%	% Total	6%	15%	6%	15%	% Total
Kings										
Benthos	1	0	3	2	83	166	0	96	21	41
Forage Fish	1	0	3	0	75	93	0	23	0	19
Predator Fish	1	0	1	0	50	53	0	5	0	8
Kern										
Benthos	- - - - - - - - - - - - - NO SAMPLE - - - - - - - - - - - -									
Forage Fish	2	0	3	2	71	206	0	15	35	19
Predator Fish	- - - - - - - - - - - - - NO SAMPLE - - - - - - - - - - - -									
Santa Ana										
Benthos	0	0	0	0	100	0	0	0	0	100
Forage Fish	4	1	11	1	70	306	104	255	27	40
Predator Fish	2	0	2	0	50	16	0	11	0	40
Alamo										
Benthos	- - - - - - - - - - - - - NO SAMPLE - - - - - - - - - - - -									
Forage Fish	3	2	3	2	50	1802	574	40	76	4
Predator Fish	3	2	11	2	72	876	320	179	97	18
New										
Benthos	1	0	3	0	75	15	0	43	0	74
Forage Fish	2	2	6	0	60	120	95	55	0	20
Predator Fish	4	3	12	2	73	2150	895	1400	69	32

APPENDIX 3

ACTION PLANS

ACTION PLAN - FEATHER RIVER -- PCBs

Strategy Phase	Item	Description	Completion Deadline	Estimated Cost ($)	Labor Required (Man Months)	Org.*
I	1	Problem Screening	Completed 1978			
II		Problem Confirmation				
	1	Research locations of powerplant operations on the Feather River and its tributaries. Research other possible sources, such as manufacturing facilities and disposal facilities	10/31/79	4,000	1.5	R5
	2	Sample fish and benthos of different species and sizes to define mean PCBs concentrations appearing in the biota. In addition to the regular sampling station, sample Bear River near its confluence with the Feather. Perform laboratory analyses.	3/31/80	8,400	2.0	DFG
III		Source Investigation				
	1	Sample fish and/or water and sediments downstream of any suspected power facilities or other sources. Perform laboratory analyses.	10/31/80	10,000	3.0	DFG
IV		Source Control				
	1	Inform Board and other regulatory agencies of any controllable sources; write brief report on Action Plan results.	12/31/80	- -	1.0	3
	2	If any sources are identified, such as sediment beds below power facilities, the appropriate Health and Fish and Game authorities would act to protect fish, wildlife, and humans. The State and Regional Boards would examine alternatives for removal of the materials, including perhaps, applying for federal clean-up funds.	?	?		SB DHS R5 DFG
V		Follow up Monitoring				
	1	Fish, water, and sediments would be monitored as necessary to measure the effectiveness of control actions taken.	?	?		R5 DFG
		TOTAL COST OF IMPLEMENTING ACTION PLAN THROUGH June 30,1980		$12,400		
		COSTS NOW IDENTIFIABLE AFTER June 30, 1980		$10,000		

* Organization or agency recommended to implement the strategy: R3, R5, R7 = Reg' Boards 3, 5, 7; SB = State Board; DFG = Department of Fish and Game; DHS = Department of Health Services; DFA = Department of Food and Agriculture.

ACTION PLAN - NEW RIVER -- TOXAPHENE

Strategy Phase	Item	Description	Completion Deadline	Estimated Cost ($)	Labor Required (Man Months)	Org.*
I		Problem Screening	Complete 1978			
II		Problem Confirmation				
	1	Analyze 1979 toxic substances program samples to determine whether toxaphene is present.	10/31/79	**		DFG
III		Source Investigation				
	1	Determine whether sources within Mexico or in California are responsible by sampling near the International Boundary and at regular sampling station at Salton Sea Inlet. Sample water and/or sediments and biota if feasible. Analyze samples.	9/1/80	5,000	1.0	DFG
	2	If California sources are suspected, sample drainages as necessary to determine sources.	11/1/80	10,000	3.0	R7
IV		Source Control				
	1	Inform Board and other regulatory agencies of any controllable sources; write brief report on Action Plan results	12/1/80	- -	1.0	SB
	2	Institute Best Management Practices.	12/31/80	- -		R7
	3	Improve pesticide application procedures or restrict usage.	12/31/81	- -		DFA
V		Follow up Monitoring				
	1	Fish, water and sediments would be monitored as necessary to measure the effectiveness of control actions taken.	?	?		SB R7
		TOTAL ESTIMATED COST OF IMPLEMENTING ACTION PLAN THROUGH June 30,1980		0		
		COSTS NOW IDENTIFIABLE AFTER June 30, 1980		$15,000		

* Organization or agency recommended to implement the strategy: R3, R5, R7 = Regional Boards 3, 5, 7; SB = State Board; DFG = Department of Fish and Game; DHS = Department of Health Services; DFA = Department of Food and Agriculture.

** Analyses to be covered under existing Toxic Substances Program.

ACTION PLAN - SAN LORENZO RIVER--CADMIUM

Strategy Phase	Item	Description	Completion Deadline	Estimated Cost ($)	Labor Required (man-months)	Org.*
I		Problem Screening	Completed 1978			
II		Problem Confirmation				
	1	Research previous publications on cadmium sources in the area.	10/31/79	2,000	0.5	R3
	2	Collect fish and benthos and analyze them to provide an estimate of the average cadmium concentration in the biota.	11/30/79	**		DFG
III		Source Investigation				
	1	Examine geological and mining records to determine locations of cadmium bearing ores and mining activities.	12/21/79	4,000	1.5	R3
	2	Perform aerial surveillance, identifying and photographing sources.	4/1/80	1,500	0.5	SB
	3	Follow-up aerial surveillance with ground reconnaissance to verify sources.	6/1/80	5,000	2.0	R3
	4	Sample locations shown to be most probable sources. Perform laboratory analyses (assumes 50 samples--Cd+Hg).	10/1/80	5,000	1.5	DFG
IV		Source Control				
	1	Inform Board and other regulatory agencies of any controllable sources, write brief report on Action Plan results.	11/1/80	--	1.0	SB
	2	Institute actions to protect public health.	12/1/80	--		DHS
	3	Institute actions to eliminate any controllable inputs.	?	?		R3
V		Follow-up Monitoring				
	1	Where control actions are taken, perform fish monitoring as necessary to measure the effectiveness of control actions.	?	?		R3
		TOTAL ESTIMATED COST OF IMPLEMENTING ACTION PLAN through June 1980		$12,500		
		COSTS NOW IDENTIFIABLE AFTER JULY 1, 1980		$ 5,000		

* Organization or agency recommended to implement the strategy: R3, R5, R7 = Regional Boards 3, 5, 7; SB = State Board; DFG = Department of Fish and Game; DHS = Department of Health Services; DFA = Department of Food and Agriculture.

** Samples collected in 1979 as part of existing Toxic Substances Program.

ACTION PLAN - YUBA RIVER--MERCURY

trategy Phase	Item	Description	Completion Deadline	Estimated Cost ($)	Labor Required (man-months)	Org.*
I		Problem Screening	Completed 1977			
II		Problem Confirmation	Completed 1978			
III		Source Investigation				
	1	Research the locations of abandoned mines in the watershed.	10/31/79	3,000	1.0+	R5
	2	Research the geology of the watershed to determine where mercury bearing formations may exist.	10/31/79	3,000	1.0+	R5
	3	Perform aerial surveillance, identifying and photographing sources.	12/1/79	1,500	0.5	SB
	4	Follow-up aerial surveillance with ground reconnaissance to verify sources.	12/31/79	5,000	2.0	R5
	5	Sample locations shown by research and aerial surveillance to be most probable sources. Perform laboratory analyses of samples (assumes 50 samples).	5/1/80	5,000	1.5	DFG
IV		Source Control				
	1	Inform Board and other regulatory agencies of any controllable sources, write brief report on Action Plan results.	6/1/80	--	1.0	SB
V		Follow-up Monitoring				
	1	Where control actions are taken, perform fish monitoring as necessary to measure the effectiveness of control actions.	?	?		
		TOTAL COST OF IMPLEMENTING ACTION PLAN through 6/30/80		$17,500		

* Organization or agency recommended to implement the strategy: R3, R5, R7 = Regional Boards 3, 5, 7; SB = State Board; DFG = Department of Fish and Game; DHS = Department of Health Services; DFA = Department of Food and Agriculture.

ACTION PLAN - TOXAPHENE IN SACRAMENTO, SAN JOAQUIN, MERCED, AND SALINAS RIVERS

Strategy Phase	Item	Description	Completion Deadline	Estimated Cost ($)	Labor Required (man-months)	Org.*
I		Problem Screening	Completed 1978			
II		Problem Confirmation				
	1	Perform additional sampling to determine whether toxaphene is common in aquatic organisms, or whether its presence in 1978 was unusual.	2/15/80	**		DFG
III		Source Investigation				
	1	Examine records of the Department of Food and Agriculture to determine use patterns of toxaphene in California.	3/1/80	--	0.5	DFA SB
	2	Based upon use information, sample rivers, drains, or croplands as necessary to determine sources.	8/1/80	?	?	DFA SB DFG
IV		Source Control				
	1	Inform Board and other regulatory agencies of any controllable sources, write brief report on Action Plan results.	10/1/80	--	1.0	SB
	2	Institute Best Management Practices.	12/31/80			SB
	3	Improve application techniques or restrict application.	12/31/80			DFA
V		Follow-up Monitoring				
	1	Monitor as necessary to measure of effectiveness of control action.	?	?		DFG R5
		TOTAL ADDITIONAL COST OF IMPLEMENTING ACTION PLAN through June 30, 1980		-0-		

* Organization or agency recommended to implement the strategy: R3, R5, R7 = Reg[illegible] l Boards 3, 5, 7; SB = State Board; DFG = Department of Fish and Game; DHS = Depar[illegible]ent of Health Services; DFA = Department of Food and Agriculture.

** Sampling and analyses to be conducted as part of the existing Toxic Substances Monitoring Program.