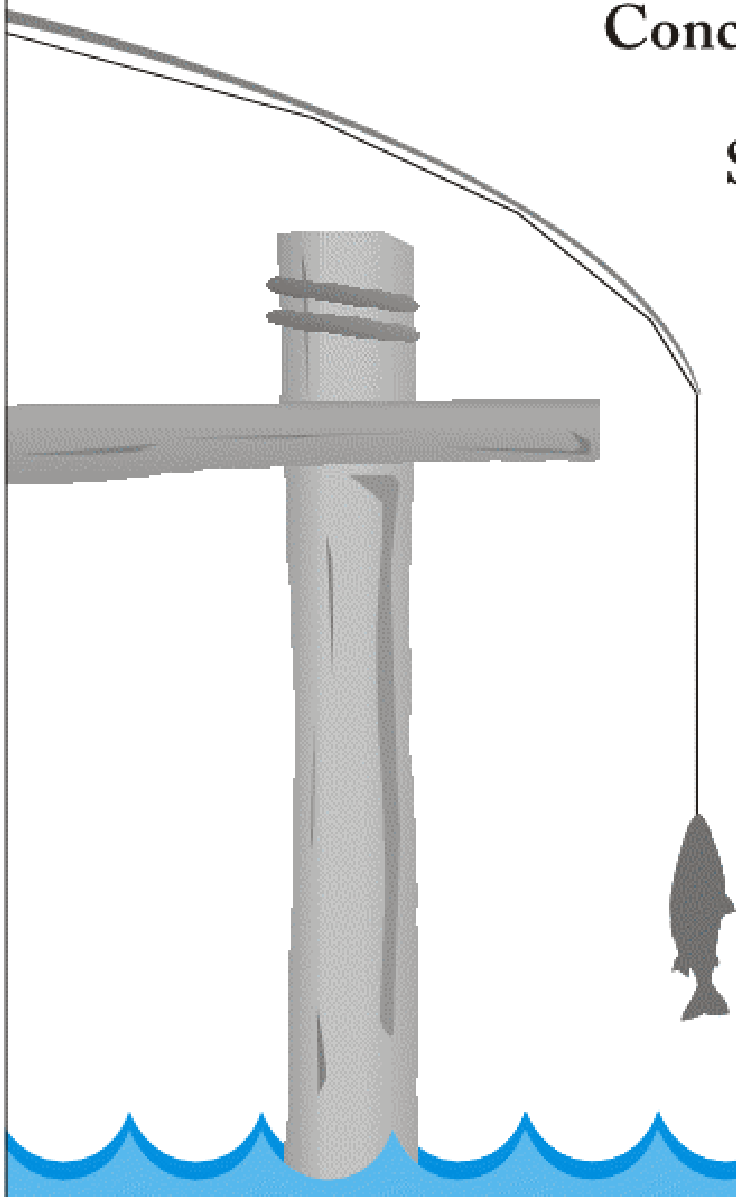
Contaminant Concentrations in Fish from San Francisco Bay 1997



A technical report of the San Francisco Estuary Regional Monitoring Program for Trace Substances

May 1999

San Francisco Estuary Institute

Contaminant Concentrations in Fish from San Francisco Bay, 1997

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A Pilot Study of the
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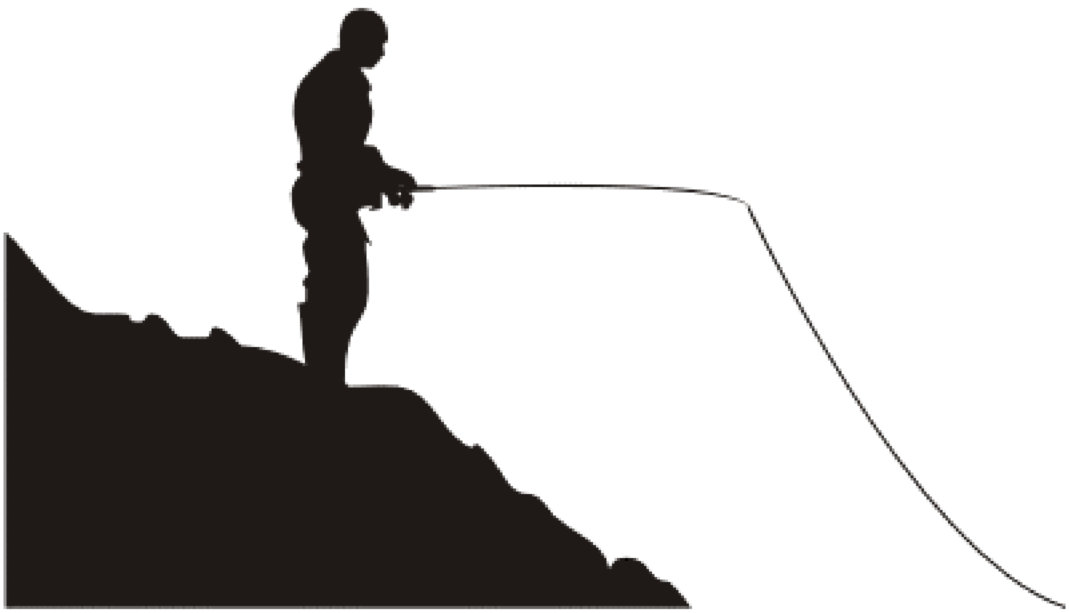

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Introduction

In 1994 the Bay Protection and Toxic Cleanup Program (BPTCP) performed a pilot study to measure concentrations of contaminants in fish in San Francisco Bay (SFRWQCB *et al*., 1995, Fairey *et al*., 1997). Screening values to identify chemicals of potential human health concern were calculated for the study based on U.S. Environmental Protection Agency guidance (U.S. EPA, 1993). The study indicated that there were six chemicals or chemical groups that were of potential human health concern for people consuming Bay-caught fish: PCBs, mercury, DDT, dieldrin, chlordane, and dioxins.

As a result of this pilot study the Office of Environmental Health Hazard Assessment issued an interim health advisory for people consuming fish from San Francisco Bay (OEHHA, 1994a). The advisory states that:

1. Adults should limit consumption of Bay sport fish to, at most, two meals per month.
2. Adults should not eat any striped bass over 35 inches (89 cm).
3. Pregnant women or women that may become pregnant or are breast-feeding, and children under 6 should not eat more than one meal per month, and should not eat any meals of shark over 24 inches (61 cm) or striped bass over 27 inches (69 cm).

The advisory does not apply to salmon, anchovies, herring, and smelt caught in the Bay, other ocean-caught sport fish, or commercial fish. The advice was issued due to concern over human exposure to residues of methylmercury, PCBs, dioxins, and organochlorine pesticides in Bay-caught fish (OEHHA, 1994a).

As a follow-up to the 1994 pilot study, a RMP Fish Contamination Committee, including representatives from government agencies, dischargers, and environmental groups, was set up to design a RMP component to measure fish contamination. The RMP Fish Contamination Committee developed two main objectives for the RMP fish contamination monitoring component:

1. To produce the information needed for updating human health advisories and conducting human health risk assessments.
2. To measure contaminant levels in fish species over time to track trends and to evaluate the effectiveness of management efforts.

A five-year workplan for the RMP fish contamination monitoring component was developed in 1997 and included: 1) a core monitoring program that is intended to be conducted every three years, 2) special studies, which are designed to answer questions that were brought up in the pilot study and will lead to a more scientifically sound and cost-effective monitoring program in the future, and 3) development of a study design and survey instruments to measure the rates at which people consume fish caught in San Francisco Bay. This report describes results for the fish tissue core monitoring program and special studies conducted in 1997. The fish consumption study is currently in progress and results will be presented in a technical report in mid-1999.

The core monitoring program targeted seven species that are frequently caught and eaten by Bay fishers at seven popular fishing areas in the Bay (see Methods for more details). Special studies included in the 1997 sampling were: 1) collecting and analyzing samples to determine variance among individual fish to assist in the future development of a more cost-effective study design; and 2) a study to determine the difference in contaminant concentrations of fillets of white croaker with and without skin. The second study was designed to determine whether removing the skin from muscle fillets could significantly reduce exposure to organic contaminants. This information should be valuable in public information efforts. Due to space limitations, results of analyses of variance among individual fish (#1 above) are not discussed in this report, but will be included in deliberations concerning design of the sampling to be performed in 2000.

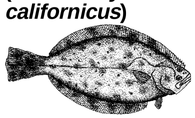
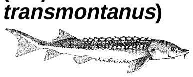
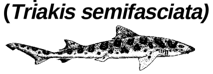
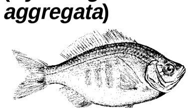
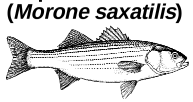
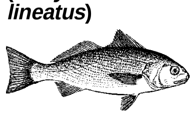
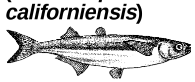
Although the main focus of this study is on human health, it is important to note that the chemicals discussed in this report accumulate in the Bay food web and may also have an effect on other species at high trophic levels. Studies of piscivorous birds and marine mammals in the Bay have found concentrations of persistent contaminants that appear to be high enough to impair the health of these species (Davis *et al*., 1997a; Davis, 1997; Young *et al*., 1998). These species rely almost exclusively on Bay fish for their diet and are therefore much more highly exposed to food web contaminants than humans. An adult cormorant, for example, consumes about 450 g (1 lb) of Bay fish per day.

Methods

The species and fishing locations in the Bay were selected for sampling based on available information on frequencies of catch and consumption by Bay fishers (PSMFC, 1997), continuity with the 1994 pilot study, and to provide a broad geographic coverage of the Bay. The species sampled included jacksmelt (*Atherinopsis californiensis*), shiner surfperch (*Cymatogaster aggregata*), white croaker (*Genyonemus lineatus*), striped bass (*Morone saxatilis*), California halibut (*Paralichthys californicus*), leopard shark (*Triakis semifasciata*), and white sturgeon (*Acipenser transmontanus*). Table 1 summarizes information on the movements and food habits of these species. The locations sampled are shown in Figure 1.

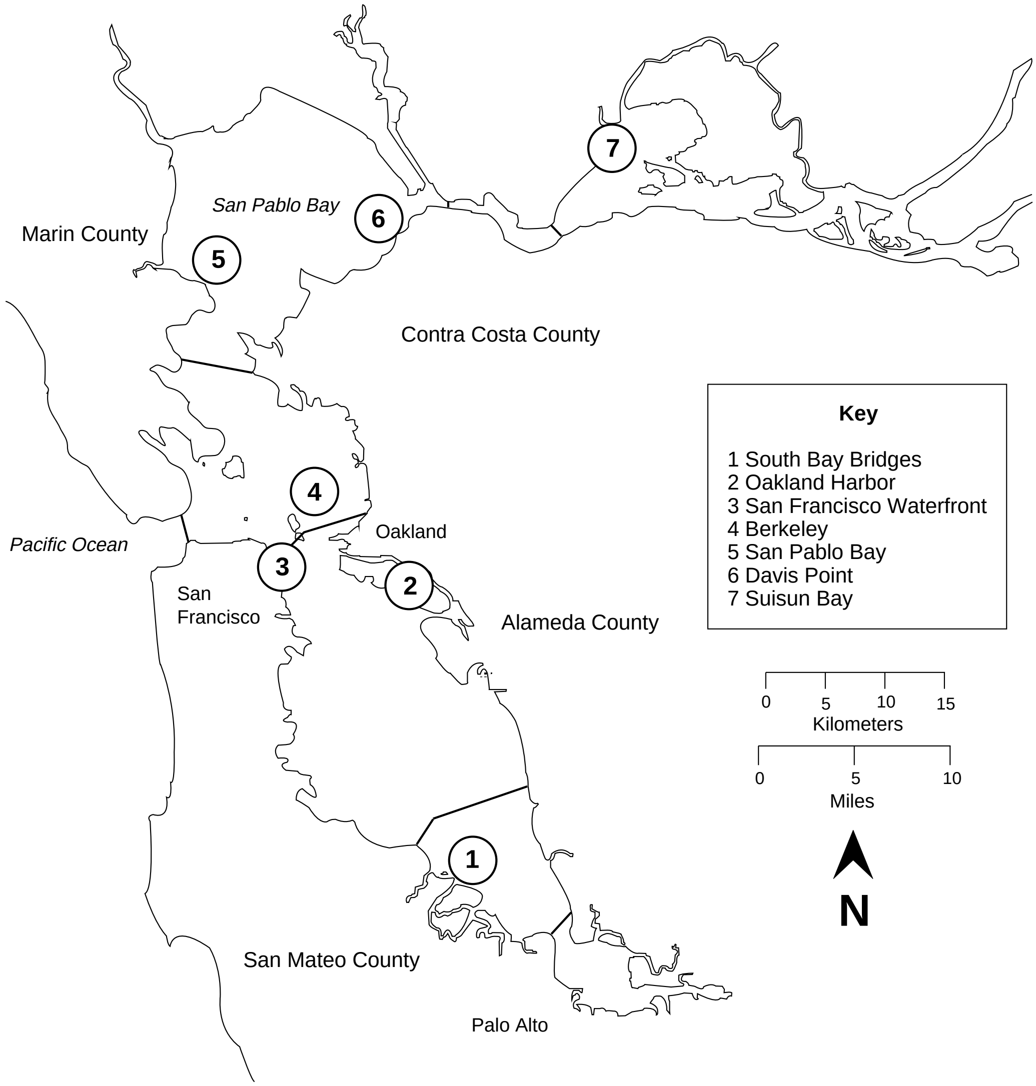
Sampling details are provided in Table 2. Some elements of the original plan devised by the Fish Contamination Committee were not implemented due to an inability to catch fish in certain locations: no white croaker or jacksmelt were caught at the South Bay Bridges location; no white croaker, shiner surfperch, or jacksmelt were caught at Vallejo; and no sturgeon were caught in Suisun Bay. Other deviations from the original plan are indicated in Table 2. Target size classes were based on legal limits, U.S. EPA (1995a) guidance, and growth curves where available. All fish collected were of legal size.

Table 1. Summary of food habits, movements, and approximate ages of the fish species sampled in 1997.

Species	Adult Diet	Movements in the Bay/Delta	Approximate age of fish caught in RMP sampling	References
California halibut (*Paralichthys californicus*) 	Pacific sardine, northern anchovy, white croaker, topsmelt, killifish, CA market squid, crustaceans	Coastal, but adults also occur in SFB year-round. Spawn in coastal waters year round in southern California, but near SFB from Jan–July. Male juveniles may stay in the Bay until they reach ~200mm; females mature later and stay in Bay longer	7–9 years	[1], [2], [3], [4], [5]
white sturgeon (*Acipenser transmontanus*) 	Fish, fish eggs (herring), shellfish, crayfish, various aquatic invertebrates, clams, amphipods, and shrimp	Spawning migration from the lower (Courtland/Freeport) Sacramento to between Knights Landing and several miles above Colusa. Many adults spend most of lives in the Estuary (even though anadromous)—primarily Suisun and San Pablo Bays	12–14 years	[4], [15], [25], [26], [27], [28], [29]
leopard shark (*Triakis semifasciata*) 	Cancer crabs, innkeeper worms, graspid crabs, squid, bay shrimp, ghost shrimp, clams, fish (such as anchovies), fish eggs, octopus spp.	Most are resident in SFB but a portion of population moves out of Bay in fall and winter. Some exchange between SFB and Elkhorn Slough populations	10–12 years	[9], [10], [11], [12], [13], [14], [15], [4]
shiner perch (*Cymatogaster aggregata*) 	Gammarid amphipods comprise bulk of year round diet in SFB, also algae, cumaceans, cyclopoid copepods, bivalve mollusks, polychaetes, smelt eggs, small shiner	Females immigrate from nearshore into SFB to give birth (live-bearers) in June or July. Males mature and emigrate soon after birth, females stay in the Bay for 1st year and give birth before 1st emigration.	Males ~3 years Females ~2 years	[4], [7], [16], [17], [18]
striped bass (*Morone saxatilis*) 	Northern anchovy, shiner perch, bay shrimp, striped bass young of the year, and herring. Diet varies greatly with location in the Bay and Delta	Spawn April-May in two areas—Sacramento River between Colusa and western Delta, San Joaquin between Antioch and Venice Island. Distribution has changed substantially in recent years. Now spend more time in Delta than Bay. Increased summer use of the ocean by adults.	Males ~4 years Females ~3 years	[4], [19], [20], [21], [22]
white croaker (*Genyonemus lineatus*) 	Wide variety of fish (mostly northern anchovy), squid, octopus, polychaetes, crabs, clams, detritus and dead organisms	Spawning occurs in the Gulf of the Farallones, and Central Bay in spring. Juveniles migrate out of the Bay in fall; re-enter and congregate in South Bay in May. Year-round adult population in deep areas of South Bay. Adults in San Pablo Bay during high salinity years.	Males ~8 years Females ~7 years	[8], [23], [24]
jacksmelt (*Atherinopsis californiensis*) 	Algae (*Ulothrix spp., Melosira monoiliformis, Enteromorpha* spp.), copepods, mysids, cirripedian nauplius larvae, small northern anchovy, gammarid amphipods, jacksmelt eggs, heteronereid polychaetes, sessile diatoms, foraminifera	Late winter/early spring immigrate from nearshore into SFB to spawn. Juveniles remain in Bay through summer then emigrate to coast in fall. During low freshwater flows use San Pablo Bay and Carquinez Strait, and in high flow years use South and Central Bay.	5–7 years	[4], [6], [7], [8]

[1] Haaker, 1975; [2] Wertz and Domeier, 1997; [3] Pattison and McAllister, 1990; [4] CA Dept. of Fish and Game Marine Sportfish webpage: http://www.dfg.ca.gov/Mrd/msfindx0.html; [5] Marine Science Institute South Bay Monitoring Program: http://www.sfbaymsi.org; [6] Clark, 1929; [7] Boothe, 1967; [8] Emmett *et al.*, 1991; [9] Russo, 1975; [10] Talent, 1976; [11] Ebert, 1986; [12] Smith and Abramson, 1990; [13] Kusher *et al.*, 1992; [14] Webber and Cech, 1998; [15] CA Dept. of Fish and Game Delta webpage: http://www.delta.dfg.ca.gov/; [16] Anderson and Bryan, 1970; [17] Bane and Robinson, 1970; [18] Odenweller, 1975; [19] Heubach *et al.*, 1963; [20] Stevens, 1966; [21] Thomas, 1967; [22] Collins, 1981; [23] Love *et al.*, 1984; [24] Herbold *et al.*, 1992; [25] Schreiber, 1962; [26] Radtke, 1966; [27] McKechnie and Fenner, 1971; [28] Muir *et al.*, 1988; [29] Schaffter, 1997.

Figure 1. Sampling locations for 1997 RMP fish contamination monitoring.



Fish were collected between May 27, 1997 and July 25, 1997. In addition, special efforts to collect sturgeon only occurred on several days in both March 1997 and October 1997. Collection gear included 25 ft and 16 ft 1.25 in mesh size nylon stretch otter trawls, trammel nets (9 in and 4 in nylon mesh panels), gill nets (0.75 in, 2.25 in, 2.5 in, and 4 in monofilament mesh), and hook and line. Otter trawls were used mostly for the collection of shiner surfperch, white croaker, and halibut. Trawls were run for 15-minute intervals. Gill nets were used most effectively to catch leopard sharks, striped bass, and sturgeon, but at several stations white croaker were caught in the 2.25 in gill net. Jacksmelt were caught exclusively with the 0.75 in gill net. In most cases, gill nets were set through a six-hour tidal cycle. Sampling was performed using an 18 ft Boston Whaler equipped with a hydraulic wench for deployment of deeper water otter trawls. A complete description of the sampling methods and a detailed cruise report are available from the San Francisco Estuary Institute (SFEI).

Table 2. Fish Contamination core monitoring program sampling design. Empty boxes were targeted but fish could not be collected.

Species	White Croaker	Shiner Surfperch	Jacksmelt	Leopard Shark	Striped Bass	California Halibut	White Sturgeon
Target # size classes	1	1	1	3	3	2	2
Target # fish per composite	5	20	5	3	3	3	3
Target size range (cm)	20–30	10–15	21–30	Small: 90-105 Medium: 106-140 Large: >140	Small: 45-59 Medium: 60-82 Large: >82		Small: 117-133 Medium: 134-183
# Size classes caught	1	1	1	2 (small and medium)	2 (small and medium)	1	2 (small and medium)
# Fish per composite	5	20	5	3*	3*	1	3*
Size range (cm)	20–30	10–15	20–30	Small: 91-102 Medium: 108-135	Small: 45-59 Medium: 60-82	55-92	Small: 117-128 Medium: 135-149
Tissue sampled	muscle with skin	muscle with skin	muscle with skin	muscle without skin	muscle without skin	muscle without skin	muscle without skin
South Bay Bridges		3 composites Hg+OCs X 3		2 small 1 medium Hg+OCs X 3	1 small 1 medium (2 fish) 8 individuals OCs X 2 Hg X 10	1 small Hg+OCs X 1	1 small 1 medium (2 fish) 1 individual Hg+OCs X 2 Se X 6
Oakland Harbor	4 composites Hg+OCs X 4 Dioxins X 1	3 composites Hg+OCs X 3	3 composites Hg+OCs X 3				
San Francisco Water Front	3 composites Hg+OCs X 3 Dioxins X 1	3 composites Hg+OCs X 3	3 composites Hg+OCs X 3				
Berkeley	4 composites Hg+OCs X 3 Dioxins X 1	3 composites Hg+OCs X 3	3 composites Hg+OCs X 3	2 small Hg+OCs X 2	1 small 1 medium (2 fish) Hg+OCs X 2	3 small 1 large Hg+OCs X 4	
San Pablo Bay	3 composites Hg+OCs X 3 Dioxins X 3	3 composites Hg+OCs X 3	3 composites Hg+OCs X 3	2 small 1 medium (1 fish) Hg+OCs X 3	2 small (one 12 fish megasample) 1 medium Hg+OCs X 3 Dioxins X 1	1 small 2 large Hg+OCs X 3	1 small 1 medium 1 individual Hg+OCs X 2 Se X 7
Davis Point**					2 small 1 medium 10 individuals OCs X 3 Hg X 13		
Suisun Bay					1 small Hg+OCs X 1		

* Except as noted

** Davis Point not included in original design

Total length of each fish was measured in the field to 0.5 cm. Fish were wrapped in chemically cleaned Teflon sheeting and frozen on dry ice for transportation to the laboratory. Heads and tails from the striped bass, leopard sharks, and sturgeon were removed in the field, leaving the body cavity intact, and wrapped in Teflon before freezing. Prior to dissection, all fish that were frozen whole (croaker, surfperch, and jacksmelt) were remeasured to the nearest 0.5 cm and weighed to 0.1 grams. The ranges of lengths of fish included in composites for each species are listed in Table 2.

Dissection and tissue sample preparation were performed using non-contaminating techniques in a clean room environment. Fillets of muscle tissue were removed in 5 to 10 g portions with Teflon forceps and stainless steel cutting utensils. Equal weight fillets were taken from each fish to composite a total of at least 175 g. Fish samples were dissected and composited in the same manner as in the pilot study (SFRWQCB *et al*., 1995). White croaker were composited using muscle with skin. Shiner surfperch and jacksmelt were prepared for compositing by removing heads, tails, and guts; leaving muscle with skin and skeleton to be included in the composites. Leopard shark, striped bass, halibut, and sturgeon were composited using muscle tissue without skin. All samples were homogenized using a Brinkman Polytron. Sample splits were taken for each analysis after homogenization. Four white croaker muscle composites were analyzed with skin removed in order to evaluate reductions in trace organic concentrations.

Samples were analyzed for mercury, selenium, PCBs, organochlorine pesticides, dibenzodioxins, dibenzofurans, and PCBs 77, 126, and 169 as indicated in Table 2. Analytical methods were described in SFRWQCB *et al*. (1995). Quality assurance reports prepared by the analytical laboratories are available from SFEI. All data met the data quality objectives specified in the RMP QAPP (Lowe *et al*., in press).

U.S. EPA (1995a) defines screening values as concentrations of target analytes in fish or shellfish tissue that are of potential public health concern. Exceedance of screening values should be taken as an indication that more intensive site-specific monitoring and/or evaluation of human health risk should be conducted. Screening values were calculated following U.S. EPA (1995a) guidance. Details about this approach are described in SFRWQCB *et al*. (1995). A consumption rate of 30 g fish/day that applies to recreational fishers was used in calculating screening values. The only changes in screening values from the pilot study were for mercury and PCBs. A screening value of 0.23 µg/g wet for mercury was applied to the 1997 data based on an updated reference dose (U.S. EPA, 1995b). The mercury screening value applied to the 1994 data was 0.140 µg/g wet (SFRWQCB *et al*., 1995). A screening value of 23 ng/g wet for PCBs was applied to the 1997 data based on an updated cancer slope factor (U.S. EPA 1998). The PCB screening value applied to the 1994 data was 3 ng/g wet (SFRWQCB *et al*., 1995).

Statistical analyses were performed using SAS (SAS Institute, 1990). Statistical comparisons were made of results from 1994 and 1997 for each species using the nonparametric Wilcoxon test (Daniel, 1990). In some cases comparison of 1994 and 1997 results were made using parametric analysis of covariance (ANCOVA) to adjust the data for important covariates, such as fish length (Hebert and

Keenleyside, 1995). In these ANCOVAs the subgroups were assumed to have equal slopes, since a statistical comparison of slopes could not be made with the small sample sizes available within each subgroup (e.g., n=3). Nonparametric ANOVA was not powerful enough to detect spatial differences given the small amount of replication, so comparisons among locations were made using parametric ANOVA and ANCOVA and the Tukey-Kramer multiple comparison procedure. Statistical significance for all tests was evaluated using $\alpha=.05$.

Spatial and temporal differences were evaluated using both the wet weight data and data adjusted for length or lipid content. Comparison of differences in wet-weight concentrations among locations (Figure 5) provides an indication of possible variation in human exposure to contaminants from consumption of fish from different locations in the Bay. More detailed analysis than is presented in this report would be required to determine whether observed spatial differences in wet-weight concentrations translate to actual differences in human exposure at the locations sampled.

In addition to the wet-weight data, spatial and temporal comparisons were also made on data adjusted for the length or lipid content of the fish. Significant correlations between length and mercury accumulation were observed for some species and between lipid and trace organic accumulation. These adjusted data provide a better indication of variation in the degree of contamination of different parts of the Bay and over time.

The complete dataset generated from the 1997 sampling is provided in Appendix 1.

Mercury

Introduction

Mercury is one of the primary concerns behind the interim advisory for the Bay. Mercury is a neurotoxicant, and is particularly hazardous for fetuses and children as their nervous systems develop (OEHHA, 1994b). Mercury can cause many types of problems in children, including mental impairment, impaired coordination, and other developmental abnormalities. Similarly, in wildlife species mercury can cause damage to nervous, excretory, and reproductive systems, and early life stages are most sensitive (Wolfe *et al*., 1998).

Mercury exists in the environment in a variety of chemical forms. The most important form of mercury in the aquatic environment is methylmercury, which is readily accumulated by biota and transferred through the food web. Most of the mercury that accumulates in fish tissue is methylmercury (U.S. EPA, 1995a). Methylmercury is also the form of mercury of greatest toxicological concern at concentrations typically found in the environment. The principal sources of mercury to the Bay are historic mercury and gold mining sites (which have resulted in widespread contamination of the Bay and its watershed), fossil fuel combustion, trace impurities in products such as bleach, and direct use of the metal in applications such as thermometers and dental amalgam (SFRWQCB, 1998). Fish, especially long-lived predatory species, accumulate high concentrations of

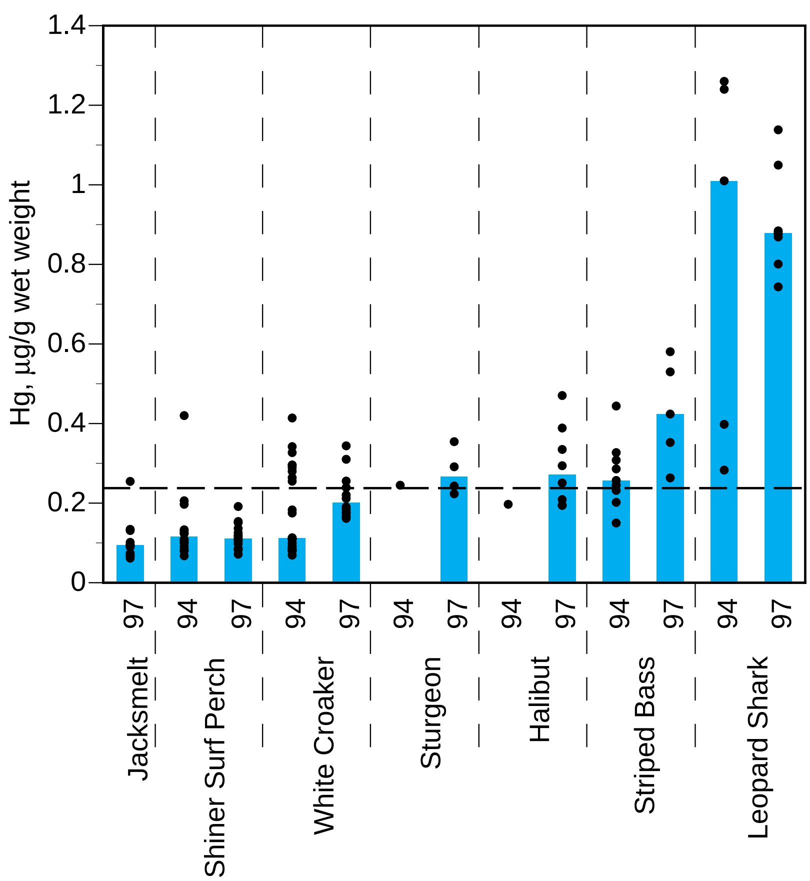
mercury and are fundamental indicators of the human and wildlife health risks associated with mercury in aquatic ecosystems.

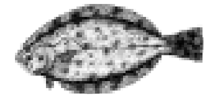
Analytical considerations

The screening value for mercury, 0.23 µg/g wet weight, applies to methylmercury. Because of the higher cost of methylmercury analysis and data indicating that most mercury in fish tissue is present as methylmercury, U.S. EPA (1995a) recommends that total mercury be measured in fish contaminant monitoring programs and the conservative assumption made that all mercury is present as methylmercury in order to be most protective of human health. Total mercury was measured in these samples.

The mercury concentrations in Bay fish were easily measured with the analytical methods employed. The minimum concentration in field samples was 0.06 µg/g wet, 200 times higher than the method detection limit (0.0003 µg/g wet).

Figure 2. Mercury concentrations (µg/g wet) in Bay fish, 1994 and 1997. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. Dotted line indicates screening value (0.23 µg/g wet).





Data distribution and summary statistics

Mercury concentrations were highest in leopard shark, with a median concentration of 0.88 µg/g wet (Table 3a, Figure 2). Striped bass had moderately high concentrations, with a median in composite samples of 0.42 µg/g wet. Mercury was also analyzed in 18 individual striped bass; these samples had a median concentration of 0.46 µg/g wet. The lowest concentrations were measured in jacksmelt (median of 0.09 µg/g wet) and shiner surfperch (0.11 µg/g wet).

Mercury was measured in a total of 84 samples, and 44 (52%) had concentrations higher than the screening value of 0.23 µg/g wet (Table 3b). All collected samples of leopard shark and striped bass exceeded the mercury screening value. One of 12 jacksmelt samples and none of the 15 shiner surfperch samples exceeded the screening value.

Table 3a. Summary statistics by species for mercury and organochlorines. Data are medians.

	Number of Composites Analyzed	Number in Composite	Length (cm)	Mercury (µg/g wet)	Lipid %	Sum of Aroclors (ng/g wet)	Sum of PCB Congeners (ng/g wet)	Sum of DDTs (ng/g wet)	Sum of Chlordanes (ng/g wet)	Dieldrin (ng/g wet)
Halibut	8	1	71	0.27	0.34	ND	14	6.6	1.6	0.2
Jacksmelt	12	5	26	0.09	1.85	45	37	34	3.4	0.8
Leopard Shark	8	3	101	0.88	0.24	13	11	5.3	1.1	0.2
Shiner Surfperch	15	20	12	0.11	2.52	179	134	54	8.8	1.7
Striped Bass	11	3	57	0.42*	0.82	34	27	16	3.0	0.8
Sturgeon	4	3	132	0.27	1.30	33	35	17	4.1	1.0
White Croaker	14	5	25	0.19	7.04	306	237	85	18	4.5

* 5 striped bass composites were analyzed for mercury

Table 3b. Summary of concentrations above screening values for each species. Numerator indicates the number above the screening value, denominator indicates the number of samples analyzed.

	Mercury (µg/g wet)	Sum of Aroclors (ng/g wet)	Sum of DDTs (ng/g wet)	Sum of Chlordanes (ng/g wet)	Dieldrin (ng/g wet)	ITEQs (pg/g wet)
Screening value	0.23	23	69	18	1.5	0.15
Halibut	5/8	1/8	0/8	0/8	0/8	
Jacksmelt	1/12	10/12	0/12	0/12	1/12	
Leopard Shark	8/8	1/8	0/8	0/8	0/8	
Shiner Surfperch	0/15	15/15	4/15	3/15	9/15	
Striped Bass	23/23	7/11	0/11	0/11	2/11	1/1
Sturgeon	3/4	3/4	0/4	0/4	1/4	
White Croaker	4/14	14/14	12/14	8/14	14/14	6/6
All Species	44/84	51/72	16/72	11/72	27/72	7/7

Controlling factors

Within a given species, the older, and therefore larger, fish tend to accumulate higher mercury concentrations. Since fish in this study were not aged, length was used as an index of age. Significant correlations of mercury with length were observed for jacksmelt (data only available from 1997, $R^2 = 0.46$, $p=0.016$), leopard shark (data from 1994 and 1997, $R^2 = 0.80$, $p<0.0001$), and white croaker (1994 and 1997, $R^2 = 0.80$, $p<0.0001$; Figure 3). Composite samples of striped bass from 1994 and 1997 did not show a significant correlation with length (the relationship of length to mercury in striped bass is discussed further below). Mercury was not correlated with length in shiner surfperch. Insufficient data were available for halibut and sturgeon.

The relationship between length and mercury was also examined in more detail in striped bass by measuring mercury concentrations in individual fish from two locations, Davis Point (n = 10) and South Bay (n = 8). These data appear to support a hypothesis that two groups of striped bass were present in the Bay, one with a steeper slope for the mercury:length regression line (Figure 4). The group with the steeper slope included individuals from both Davis Point and South Bay, as did the group with the smaller slope. The sex of the fish was not determined, but sexual dimorphism in this species, which results in females at age 6 being the same size (70 cm) as males at age 7 (Collins, 1981), does not seem pronounced enough to explain this apparent pattern. The average size of the striped bass included in the composite samples was 57 cm (Table 3). This length corresponds to approximately age 4 in males and age 5 in females. The predicted mercury concentration at this length would be 0.84 µg/g wet for the steep slope group and 0.42 µg/g wet for the low slope group. The disparity in age between males and females at this length does not seem large enough to result in a two-fold difference in mercury concentration. It is possible that other sexual differences in behavior or physiology might also explain the apparent existence of two groups. Since the Bay's striped bass population is mobile, moving upstream to freshwater regions and out into the ocean at different points in their life cycle, it is possible that the steep slope group spent more time in habitats with a higher degree of mercury contamination in the food web. In the Hudson River, analysis of PCBs in striped bass muscle, combined with elemental analysis of otoliths as an indication of lifetime use of saline habitats, has identified migratory and non-migratory subpopulations of striped bass with different PCB accumulation patterns (Ashley *et al*., 1998). The apparent existence of different mercury accumulation patterns might be explained by the presence of both migratory and non-migratory striped bass in the Bay. Further sampling of individual striped bass would be needed to establish that subpopulations with different mercury accumulation patterns are indeed present in the Bay. Whether distinct subpopulations exist or not, mercury concentrations in striped bass in the 50–60 cm size range were found to vary over a relatively wide range, from 0.347 µg/g to 0.895 µg/g.

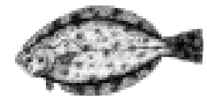


Figure 3. Regressions of mercury concentrations and average fish length in composite samples for each species. Data from 1994 and 1997.

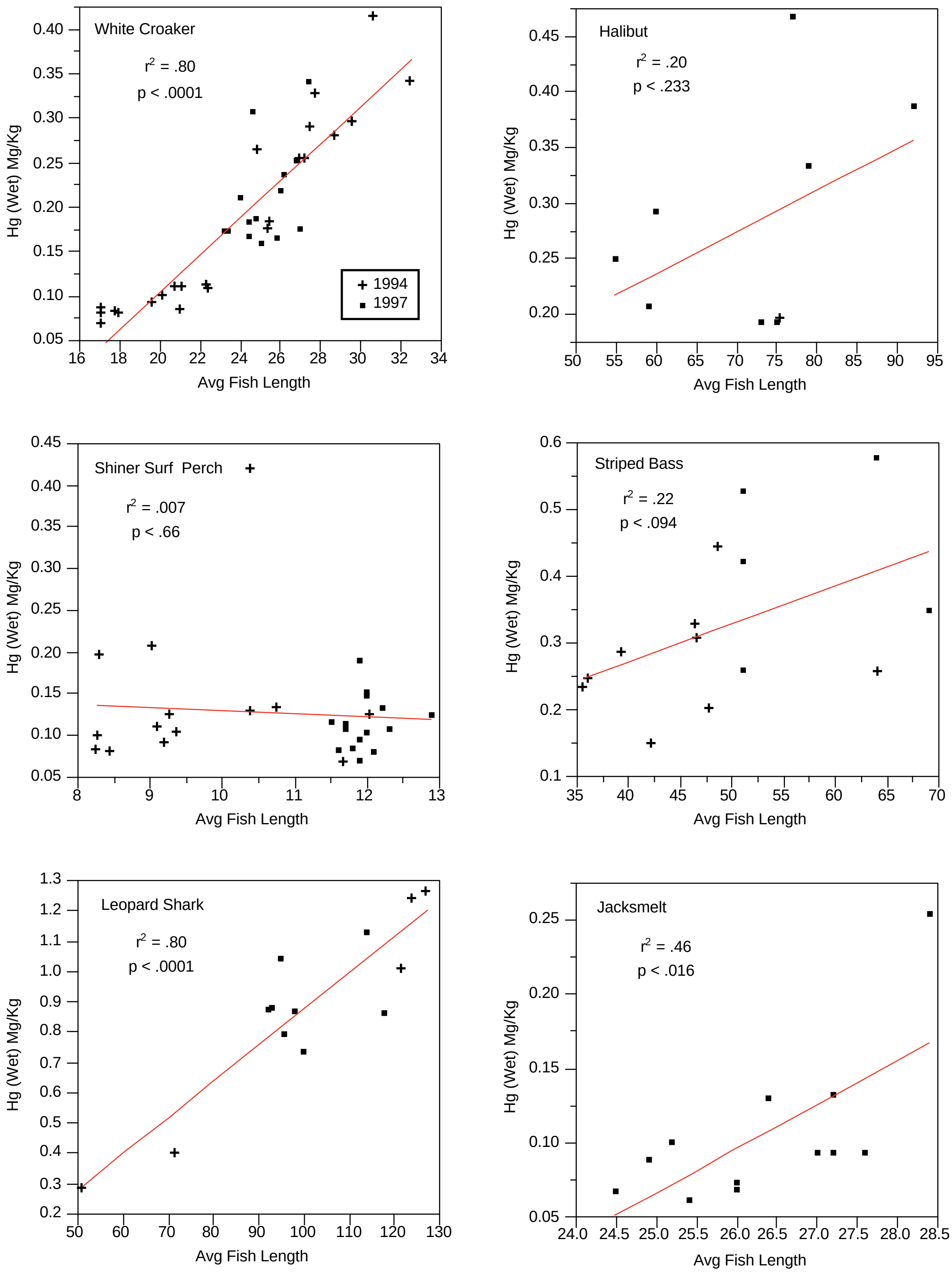
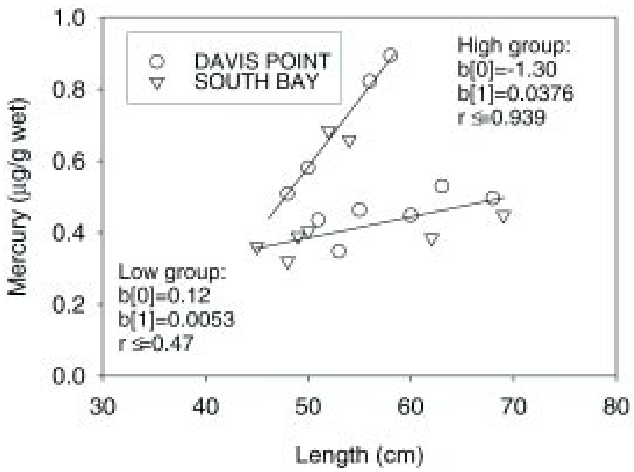


Figure 4. Regressions of mercury concentrations and fish length in individual striped bass from 1997.



Spatial patterns

In order to have confidence that apparent differences among locations accurately reflect conditions in the Bay, it is necessary to have consistent results from replicate samples. Replicate sampling, with three composites consisting of fish of uniform size, was performed at multiple locations for three species: jacksmelt, shiner surfperch, and white croaker.

Wet weight mercury concentrations were elevated at the Oakland Harbor location in shiner surfperch and jacksmelt (Figure 5). In shiner surfperch, the samples from Oakland Harbor (averaging 0.166 µg/g wet) were significantly higher than those from South Bay, Berkeley, and San Pablo Bay (averaging 0.106, 0.093, and 0.106 µg/g wet, respectively). Jacksmelt at Oakland Harbor, which averaged 0.173 µg/g wet, were 2.5 times higher in mercury than jacksmelt from Berkeley, which averaged 0.068 µg/g wet, and this difference was statistically significant. Jacksmelt at the San Francisco Waterfront and San Pablo Bay were also much lower than at Oakland Harbor, averaging 0.086 and 0.094 µg/g wet, respectively, but these differences were not statistically significant. Although mean concentrations of mercury in shiner surfperch and jacksmelt at Oakland Harbor were higher than the other locations, it should be noted that the were still below the screening value of 0.23 µg/g wet.

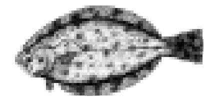


Figure 5. Mercury concentrations (µg/g wet) at each sampling location in 1997. White sturgeon data not shown. Line on plots indicate screening value of 0.23 µg/g wet.

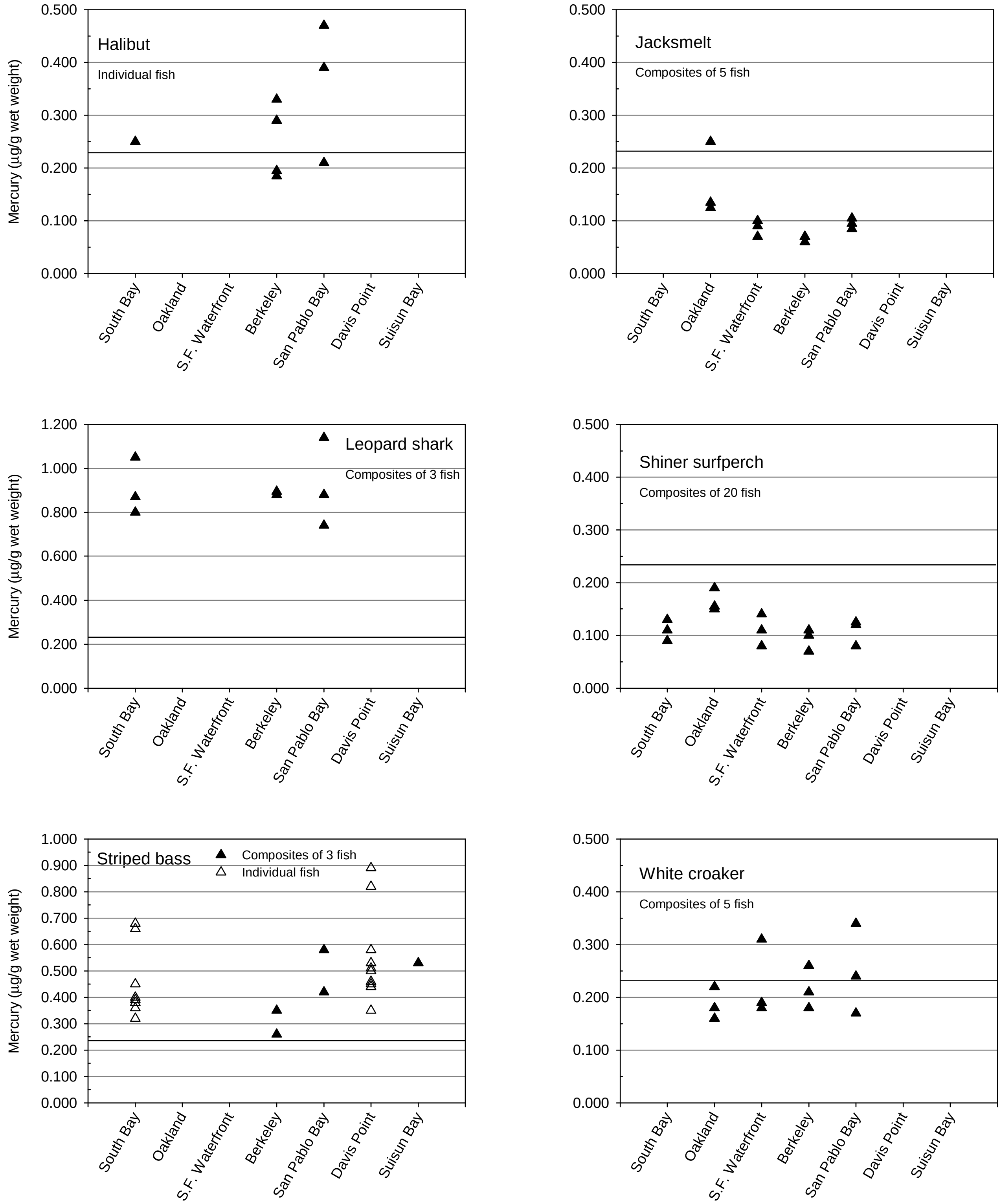
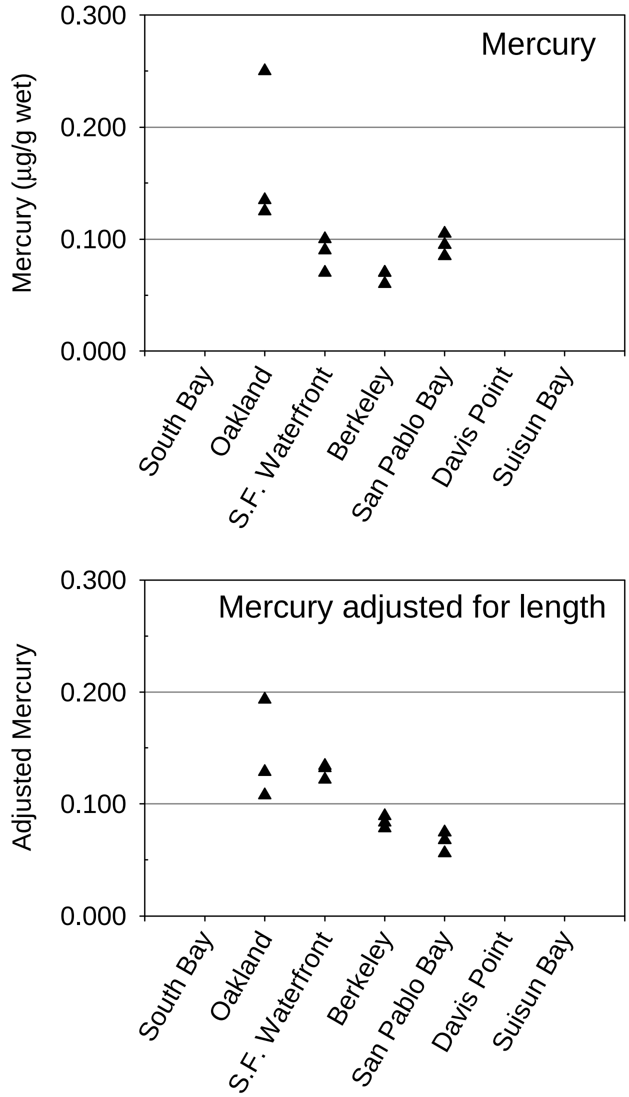


Figure 6. Mean concentrations of mercury (µg/g wet) in jacksmelt at each sampling location (top) and mercury concentrations adjusted for length at each sampling location using analysis of covariance (bottom).



Given the significant relationship between size and mercury accumulation established for some species (Figure 3), taking into account the effect of variation in size among different locations was useful in evaluating spatial variation in these species as an indication of spatial variation in methylmercury accumulation in the Bay. Of the three species for which replicated sampling was performed, a significant relationship between length and mercury was observed for jacksmelt and white croaker (Figure 3). Analysis of covariance was performed on the data for these two species to examine spatial differences on data adjusted for length. In jacksmelt, these results (Figure 6) are different from those described above for the wet weight data. S.F. Waterfront and Oakland Harbor both had significantly higher mean length-adjusted concentrations than San Pablo Bay. The adjusted jacksmelt data suggest that, among the locations sampled, mercury concentrations were elevated near Oakland Harbor and S.F. Waterfront and relatively low at San Pablo Bay. In white croaker, the adjusted mercury data showed no significant spatial variation.

Temporal trends

One of the objectives of the fish monitoring element of the RMP is to track long term trends in concentrations of contaminants that accumulate in the food web of the Bay. Data from two rounds of sampling, in 1994 and 1997, can be compared to provide an indication of possible trends. Although the data do suggest statistically significant decreases for some contaminants, further sampling will be required to establish whether the decreases are indicative of long-term trends.

Given the clear dependence of mercury accumulation on fish length in leopard shark and white croaker, comparisons of data from 1994 and 1997 in these species were made using length-adjusted data. No significant difference was found for either species.

Shiner surfperch did not show a significant relationship with length (Figure 3), so temporal comparisons were made using the raw data, rather than length-adjusted data. Mercury concentrations in shiner surfperch were very similar in 1994 and 1997. For striped bass, the regression of mercury and length was not quite significant at $\alpha=.05$ ($p=0.094$), but could be explained by the apparent existence of different mercury:length relationships for different subpopulations of striped bass in the Bay (Figure 4). While the comparison of concentrations in 1994 and 1997 in striped bass should be adjusted for length, the data available from these two years are insufficient for performing this adjustment due to the small number of samples available, the high variability observed, and the possible existence of a relationship that may not be adequately described by a single linear regression. Unadjusted striped bass mercury concentrations were generally higher in 1997 than in 1994, but this difference was at least to some degree due to the larger size of the fish collected in 1997, as can be seen in Figure 3. Only one sample of both halibut and sturgeon was available from 1994, preventing a statistical comparison with results from 1997. Overall, no significant difference between mercury concentrations in 1994 and 1997 was detected in any of the species.

Polychlorinated Biphenyls (PCBs)

Introduction

The term “polychlorinated biphenyl” refers to a group of 209 individual chemicals (“congeners”) based on substitution of the biphenyl molecule with varying numbers of chlorine atoms. Due to their resistance to electrical, thermal, and chemical processes, PCBs were used in a wide variety of applications (e.g., in electrical transformers and capacitors, vacuum pumps, hydraulic fluids, lubricants, inks, and as a plasticizer) from the time of their initial commercial production in 1929 (Brinkmann and de Kok, 1980). In the U.S. PCBs were sold as mixtures of congeners known as “Aroclors” with varying degrees of chlorine content. By the 1970s a growing appreciation of the toxicity of PCBs led to restrictions on their production and use. In 1979, a final PCB ban was implemented by the U.S. Environmental Protection Agency, prohibiting the manufacture, processing, commercial distribution, and use of PCBs except in totally enclosed applications (Rice and O'Keefe, 1995). A significant amount of the world inventory of PCBs may still be in place in industrial equipment (Rice and O'Keefe, 1995). Leakage from or improper handling of such equipment has led to PCB contamination of runoff from industrial areas. Other sources of PCBs to the Estuary are atmospheric deposition, effluents, and remobilization from sediment (Gunther *et al*., 1987).

In spite of the fact that their use has been restricted for almost two decades, PCBs remain among the environmental contaminants of greatest concern because many of the PCB congeners are potent toxicants that are resistant to degradation and have a strong tendency to accumulate in biota. In general, PCBs are not very toxic in acute exposures, but certain congeners are extremely toxic in chronic exposures. The most toxic PCB congeners are those that closely mimic the potency and mechanism of toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin ("dioxin", one of the most toxic compounds known). These PCB congeners can cause toxic symptoms similar to those caused by dioxin exposure, including developmental abnormalities and growth suppression, disruption of the endocrine system, impairment of immune function, and cancer promotion (Ahlborg *et al*., 1994). The PCBs that most closely mimic the potency of dioxin are three congeners, PCB 77, PCB 126, and PCB 169. PCB 126 is the most potent congener by far, one-tenth as potent as dioxin, and is the congener of greatest concern in aquatic environments. Other toxicologically active PCB congeners and their metabolites exert toxicities through different mechanisms than the dioxin-like congeners (McFarland and Clarke, 1989). U.S. EPA classifies PCBs as a probable human carcinogen (U.S. EPA, 1995a).

The toxicity of PCBs has historically been evaluated for Aroclor mixtures. In recent years toxicological data have begun to accumulate for specific PCB congeners, but overall the toxicological database is more complete for Aroclor mixtures than for PCB congeners (U.S. EPA 1995a). U.S. EPA (1995a) consequently recommends using an Aroclor screening value to evaluate fish tissue contamination. In this monitoring, as in the RMP in general, PCBs were measured on a congener-specific basis. Advantages of congener-specific data are described in Davis *et al*., (1997b) and U.S. EPA (1995a). The congener-specific results were used to estimate Aroclor concentrations (Newman et al. 1998).

Due to their general resistance to metabolism and high affinity for lipids, PCBs and other similar organochlorines reach higher concentrations with increasing trophic level in aquatic environments; this process is known as "biomagnification" (Gobas *et al*., 1993, Suedel *et al*., 1994). The most toxic PCB congeners are also relatively resistant to metabolism (Davis, 1997). Consequently, predatory fish, birds, and mammals (including humans that consume fish) at the top of the food web are particularly vulnerable to the effects of PCB contamination.

Analytical considerations

Two different methods were employed to measure PCBs. A list of 47 PCB congeners was measured by Long Marine Laboratory at the University of

California at Santa Cruz. This list included the congeners that are most abundant in environmental samples, but not PCBs 77, 126, and 169. A more elaborate and expensive technique is required to measure concentrations of these PCBs. Analyses of PCB 77, 126, and 169 were performed along with dioxin analyses by the Hazardous Materials Laboratory, Cal-EPA on a small subset of samples. Results for these congeners are presented and discussed in the section on dioxins.

PCBs were measured on a congener-specific basis. Advantages of congener-specific PCB analysis are discussed in Davis *et al*. (1997b). Screening values, however, for PCBs are expressed as Aroclors. The method of Newman *et al*. (1998) was employed to convert the congener data to Aroclor data. This method is based on comparing ratios of 14 congeners in samples with their ratios in the commercial mixtures Aroclor 1248, 1254, and 1260. The concentrations of Aroclors 1248, 1254, and 1260 were estimated in this manner and summed to obtain the "sum of Aroclors" for each sample. Unless otherwise indicated, PCB data presented in this report are expressed as the sum of Aroclors.

While some PCB congeners could be quantified in each sample, the low concentrations of congeners in 11 of 76 (14%) of samples translated to "not detected" (ND) concentrations of sum of Aroclors. These ND values were excluded from regression analyses of sum of Aroclors and lipid. The detection limit for each congener was 0.25 ng/g wet. MDLs expressed on an Aroclor basis (calculated from the congener data) were 13 ng/g wet for Aroclor 1254 and 1260 and 25 ng/g wet for Aroclor 1248.

Data distribution and summary statistics

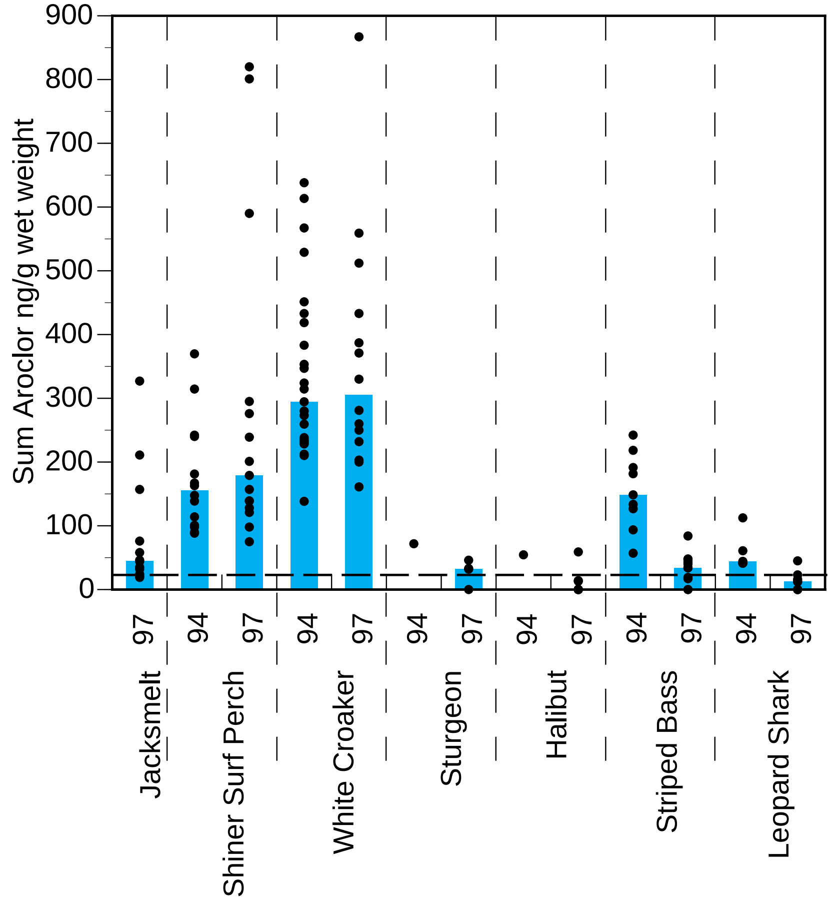
Sum of Aroclor concentrations were highest in white croaker, with a median concentration of 306 ng/g wet, and shiner surfperch, with a median of 179 ng/g wet (Table 3a, Figure 7). Sum of Aroclor concentrations were substantially lower in the other species sampled. The lowest median concentrations were measured in California halibut (not detected) and leopard shark (13 ng/g wet).

Sum of Aroclors was measured in a total of 72 samples; 51 samples had concentrations higher than the screening value of 23 ng/g wet (Table 3b). All of the white croaker and shiner surfperch samples exceeded the screening value. Most of the jacksmelt (10 of 12 samples), striped bass (7 of 11), and sturgeon (3 of 4) samples exceeded the screening value. Halibut (1 of 8) and leopard shark (1 of 8) had the lowest incidence of concentrations above the screening value.

Controlling factors

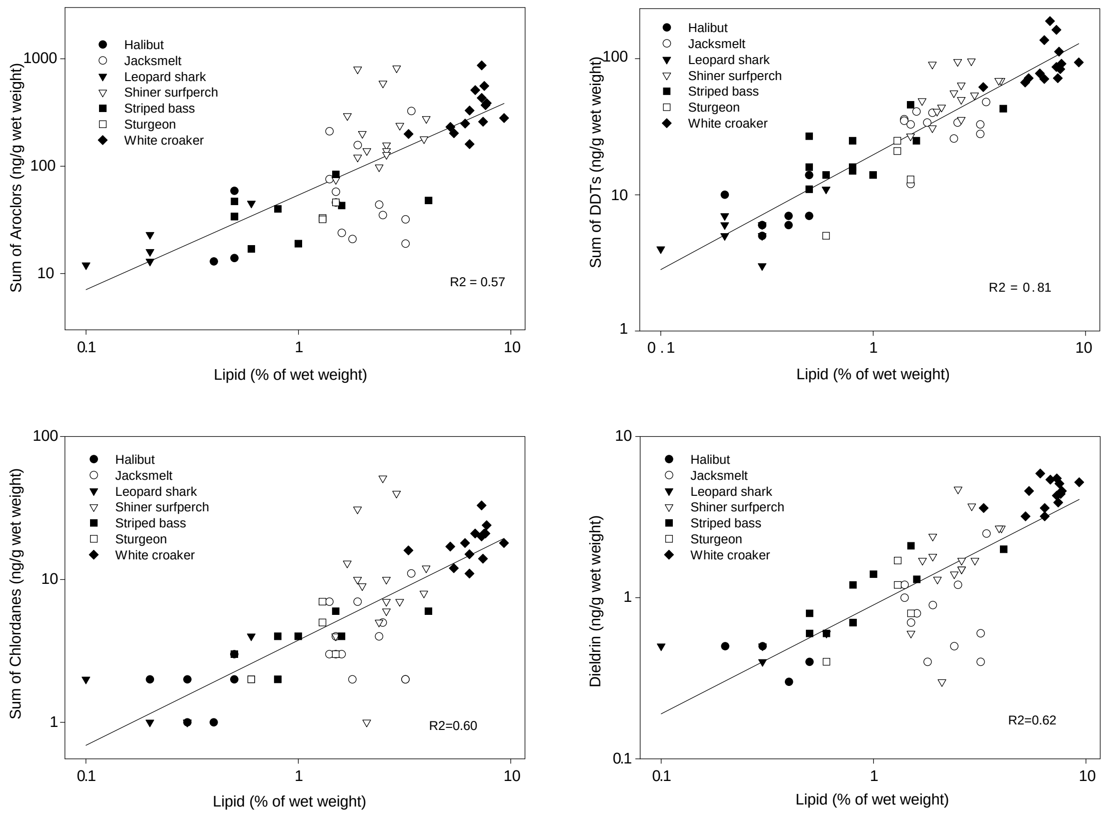
Sum of Aroclor concentrations in the seven species sampled were significantly correlated (R^2=0.57, $p<.0001$) with lipid content (Figure 8). The correlation with lipid was even stronger (R^2=0.69, $p<.0001$) for PCBs expressed as the sum of congeners. The fish with the highest lipid content in their muscle tissue had the highest PCB concentrations.

Figure 7. PCB concentrations in Bay fish, expressed as sum of Aroclors (ng/g wet), 1994 and 1997. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. Line indicates screening value (23 ng/g wet).



Some of the points that deviate from the regression line (Figure 8) indicate other factors controlling PCB concentrations. Sampling location had a strong influence on PCB concentrations in white croaker, shiner surfperch, and jacksmelt, with fish collected from Oakland Harbor having elevated concentrations relative to the other locations. These points have large positive residuals (i.e., they fall well above the regression line). The other noticeable deviation from the regression line are the points for jacksmelt, which, except for the three samples for Oakland Harbor, generally have large negative residuals (i.e., they fall well below the regression line). One possible explanation for the relatively low concentrations of PCBs in jacksmelt is their different trophic position; jacksmelt feed at a lower trophic level (primarily eating crustaceans, zooplankton, and algae) and on pelagic prey, while all of the other species consume benthic prey at higher trophic levels. Persistent organochlorines are known to accumulate to higher concentrations at higher trophic levels (Gobas *et al.*, 1993, Suedel *et al.*, 1994). Other organochlorine concentrations in jacksmelt would be expected to show this same pattern if trophic level were the explanation for the low concentrations; chlordanes and dieldrin do, but DDT does not (Figures 8). Consequently, other factors must also contribute to the generally low trace organic concentrations in jacksmelt.

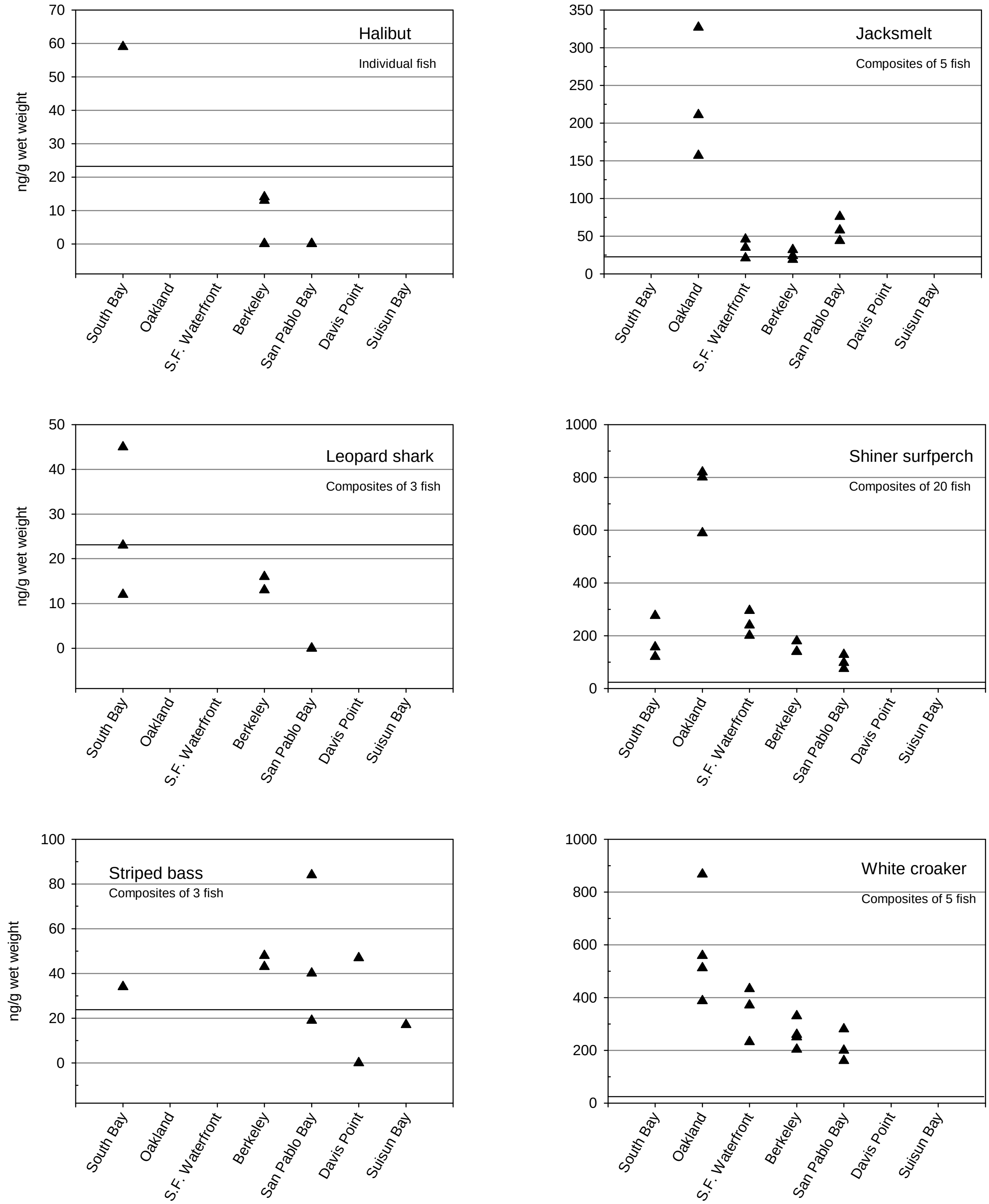
Figure 8. Regressions of concentrations of PCBs (as sum of Aroclors), DDTs, chlordanes, and dieldrin with lipid in all species in composite samples. Data from 1997.



Spatial patterns

Jacksmelt, shiner surfperch, and white croaker had elevated wet weight PCB concentrations at the Oakland Harbor location (Figure 9). Jacksmelt at Oakland Harbor averaged 231 ng/g wet, 4 to 9 times higher than the average concentrations at the other locations. Similarly, shiner surfperch at Oakland Harbor averaged 737 ng/g wet, 3 to 7 times higher than the other locations. In white croaker the contrast between Oakland Harbor and the other locations was not as great, with the average at Oakland Harbor (581 ng/g wet) between 1.7 and 2.7 times higher than the other locations. PCB concentrations in jacksmelt and shiner surfperch at Oakland Harbor were significantly higher than concentrations at all other locations where these species were sampled. PCBs in white croaker were significantly higher at Oakland than at Berkeley and San Pablo Bay. Excluding Oakland Harbor, none of the other sampling locations were significantly different from each other.

Figure 9. PCB concentrations (as sum of Aroclors, ng/g wet) at each sampling location in 1997. White sturgeon data not shown. Line on plots indicates screening value of 23 ng/g wet. Points at zero indicate results below detection limits.



On a lipid weight basis (data not shown) the same general pattern in PCB contamination was observed, with jacksmelt and shiner surfperch at Oakland Harbor significantly higher than at all other locations. In jacksmelt the average lipid weight PCB concentration at Oakland Harbor was 11 times higher than at Berkeley. Lipid weight concentrations of PCBs in white croaker at Oakland were higher than at the other locations, but the pairwise comparisons were not quite significant at an overall $\alpha=.05$ ($p=.05$ for the overall ANOVA).

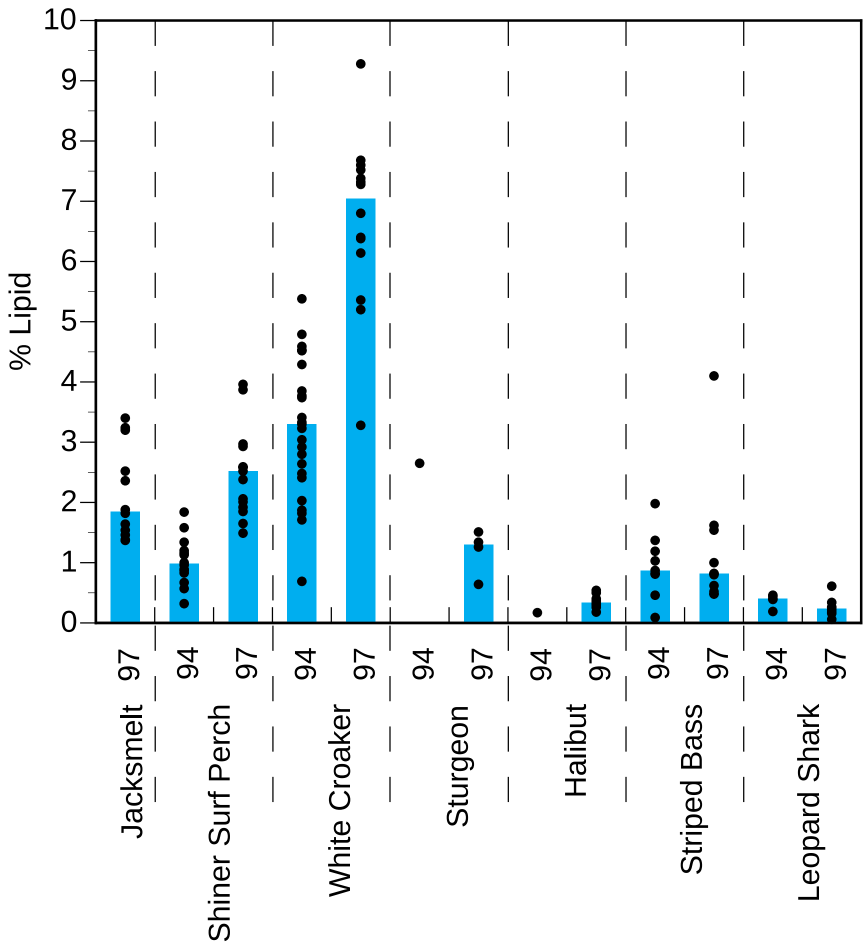
Overall, results from jacksmelt and shiner surfperch indicate distinctly elevated concentrations of PCBs in the food web in Oakland Harbor relative to the other locations sampled. These findings are consistent with observations of high concentrations of PCBs in sediment at this location (Hunt *et al*., 1998). PCB concentrations in Oakland Harbor were up to 11 times higher than the other locations sampled. PCB concentrations at the remaining locations were relatively uniform.

Temporal trends

Comparing the organics data from 1994 and 1997 illustrates the importance of taking into account variation in lipid content. Lipid content was significantly higher in both shiner surfperch and white croaker in 1997 (Figure 10). Shiner surfperch had a median of 2.5% lipid in 1997, compared to 1.0% in 1994. Similarly, white croaker had median lipid content of 7.0% in 1997 and 3.3% in 1994. In spite of these large differences in lipid content, median wet weight PCB concentrations in shiner surfperch and white croaker were very similar in 1994 and 1997 (Figure 7).

Given the dependence of PCB accumulation on lipid content, as shown in Figure 8, and the marked variation in lipid content among the two sampling periods, lipid weight data may provide a better indication of temporal variation in the accumulation of PCBs in the Bay food web. Lipid weight Aroclor concentrations were significantly lower in 1997 than 1994 in shiner surfperch (6.7 µg/g versus 19.8 µg/g, $p=0.02$), white croaker (5.0 µg/g versus 10.5 µg/g, $p<0.0001$), and striped bass (2.7 µg/g versus 17.1 µg/g, $p=0.0012$). A difference in leopard shark was not quite significant at $\alpha=.05$ (from 10.3 µg/g in 1994 to 7.2 µg/g in 1997, $p=0.06$). Insufficient data were available for evaluating temporal variation in the other species. These lipid-normalized data suggest a general decline in PCBs in the Bay from 1994 to 1997. Continued monitoring will be required to determine whether this apparent decline reflects a long-term reduction in PCB contamination of the Bay, is a function of seasonal variation in lipid, or results from interannual variation in PCB contamination of the Bay due to other factors.

Figure 10. Lipid concentrations in Bay fish (% of wet weight), 1994 and 1997. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations.



Effect of Skin Removal

The effect on trace organic concentrations of removing the skin from white croaker fillets was examined using four pairs of composite samples (Table 4). Each composite consisted of 5 individual fish. Fillets without skin were taken from the same fish as fillets with skin. For all pairs of samples substantially lower concentrations of trace organics were measured in the fillets with the skin removed. The average percent reduction for PCBs was 39%, with a range of 11% to 53%. These reductions were associated with decreased amounts of lipid in the fillets without skin. Lipid content was reduced by an average of 33% in the fillets without skin. Skin removal did not result in these white croaker samples being below the screening value for PCBs.

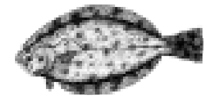


Table 4. Effect of skin removal on concentrations of lipid, PCBs, DDTs, chlordanes, and dieldrin in paired composites. Skin-on and skin-off composites were comprised of tissue from the same set of fish. Concentrations in ng/g wet weight.

	Oakland			S.F. Waterfront			Berkeley			San Pablo Bay			
	Skin On	Skin Off	% Reduction	Skin On	Skin Off	% Reduction	Skin On	Skin Off	% Reduction	Skin On	Skin Off	% Reduction	Average % Reduction
Lipid	7.5	5.5	27	7.3	5.3	28	6.4	4.7	27	9.3	4.7	49	33
Sum of Chlordanes	21	19	9	20	12	41	15	9.4	38	18	10	47	34
Sum of DDTs	113	94	17	87	51	42	137	57	58	94	53	44	40
Dieldrin	5.1	4.2	16	4.3	2.6	40	3.6	2.0	43	5.2	3.4	35	33
Sum of Aroclors	559	499	11	433	237	45	330	156	53	281	150	47	39

DDTs

Introduction

DDT is an organochlorine insecticide that was used very extensively in home and agricultural applications in the U.S. beginning in the late 1940s and continuing in the U.S. until the end of 1972, when all uses, except emergency public health uses, were canceled (U.S. EPA, 1995a). DDT is present as a manufacturing byproduct in technical mixtures of some other pesticides; use of such pesticides containing more than 0.1% DDT was canceled as of December 1988 (U.S. EPA, 1995a). The primary sources of DDT to the Bay are probably continuing transport of contaminated soils and sediments from urban and agricultural sites of historic use and remobilization of residues from Bay sediments.

The terms DDT or DDTs are often used to refer to a family of isomers (i.e., p,p'-DDT and o,p'-DDT) and their breakdown products (p,p'-DDE, o,p'-DDE, p,p'-DDD, and p,p'-DDD). DDT data are often expressed as the sum of these six components, and this approach is recommended by U.S. EPA (1995a). DDT and its metabolites DDE and DDD are neurotoxic and are also classified by U.S. EPA as probable human carcinogens (U.S. EPA, 1995a). Like PCBs, DDTs are very persistent in the environment, resistant to metabolism, have a strong affinity for lipid, and biomagnify in aquatic food webs (Gobas *et al.*, 1993, Suedel *et al.*, 1994).

Analytical considerations

Nine DDT compounds (isomers and metabolites) were analyzed. Following U.S. EPA (1995a) guidance, six of these compounds were summed to derive "sum of DDTs": p,p'-DDT, o,p'-DDT, p,p'-DDE, o,p'-DDE, p,p'-DDD, and o,p'-DDD. The screening value for DDTs (69 ng/g wet) applies to this sum of DDTs. Detectable DDT compounds were present in all of the 72 samples analyzed. Detection limits for these compounds ranged from 0.25 to 1.26 ng/g wet.

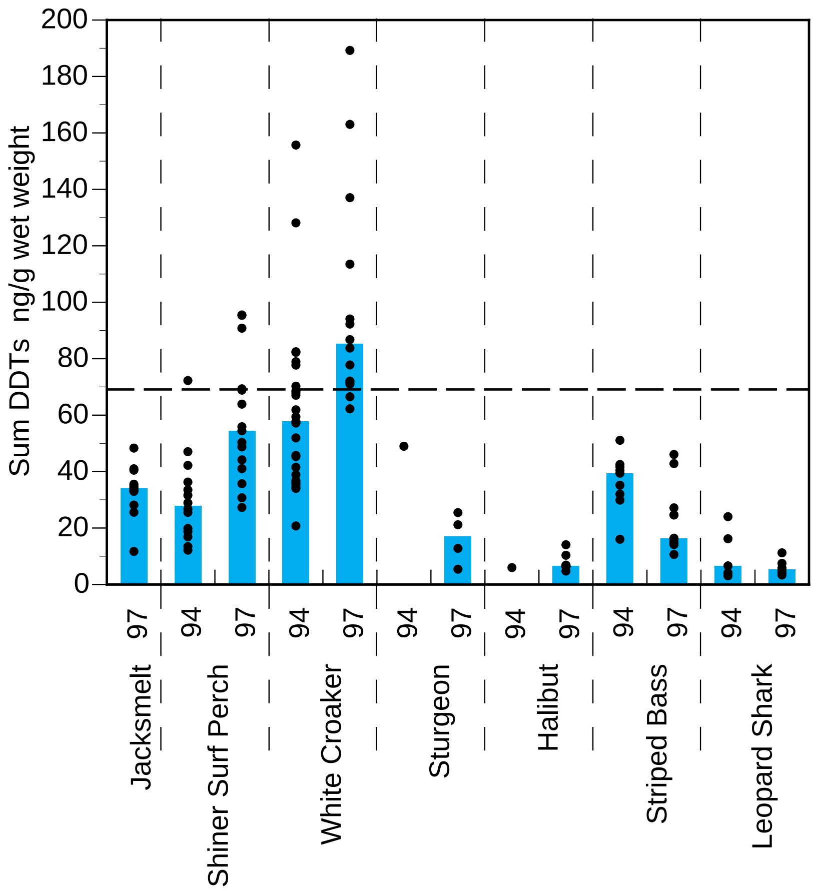
Data distribution and summary statistics

Sum of DDT concentrations were highest in white croaker, with a median concentration of 85 ng/g wet, and shiner surfperch, with a median of 54 ng/g wet

(Table 3, Figure 11). Concentrations were intermediate in jacksmelt (median of 34 ng/g wet), and 17 ng/g wet or lower in the larger species (striped bass, leopard shark, halibut, and sturgeon). Leopard shark had the lowest median concentration (5 ng/g wet).

Sum of DDTs was above the screening value of 69 ng/g wet in 16 of 72 samples (22%) (Table 3b). Twelve of 14 white croaker samples (86%) and 4 of 15 shiner surfperch samples (27%) were above the screening value. None of the other species had concentrations above the screening value.

Figure 11. DDT concentrations in Bay fish, expressed as sum of DDTs (ng/g wet), 1994 and 1997. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. Line indicates screening value (69 ng/g wet).



Controlling factors

Sum of DDT concentrations in the seven species sampled were very closely correlated (R^2=0.85, p<.0001) with lipid content (Figure 8). As observed for the other trace organics, the fish with the highest lipid content in their muscle tissue had the highest DDT concentrations. The correlation of DDT with lipid was the strongest observed for the trace organics analyzed.

Some of the points that deviate from the regression line indicate other factors controlling DDT concentrations. Sampling location had an influence on DDT concentrations in shiner surfperch and white croaker, with fish collected from Oakland Harbor having elevated concentrations relative to the other locations. Most of the Oakland Harbor datapoints for these two species have relatively large positive residuals (i.e., they fall well above the regression line).

Spatial patterns

Wet weight DDT concentrations in shiner surfperch at Oakland Harbor were significantly higher than at three of the other four locations where shiner surfperch were collected (S.F. Waterfront, South Bay, and San Pablo Bay; Figure 12). The shiner surfperch samples from Oakland Harbor averaged 94 ng/g wet, and all measured values were above the 69 ng/g wet screening value. None of the other sampling locations were significantly different from each other. Average DDT concentrations in white croaker and jacksmelt from Oakland Harbor (139 and 41 ng/g wet, respectively) were also higher than at the other locations, but the differences were not statistically significant (though white croaker came close with a p value of 0.065).

The lipid weight DDT data (not shown) showed the same pattern, with DDT in shiner surfperch at Oakland Harbor significantly higher than at all other locations. Lipid weight DDT concentrations in shiner surfperch at Oakland Harbor were approximately twice as high as concentrations at the other locations. No statistically significant spatial variation was observed for lipid weight DDTs in jacksmelt or white croaker.

Overall, results from shiner surfperch indicate elevated concentrations of DDTs in the food web in Oakland Harbor relative to the other locations sampled. The degree of contamination, with concentrations at Oakland Harbor up to two times as high as other Bay locations, however, is much lower than that observed for the PCBs. Excluding Oakland, DDT concentrations at the other locations sampled were relatively uniform.

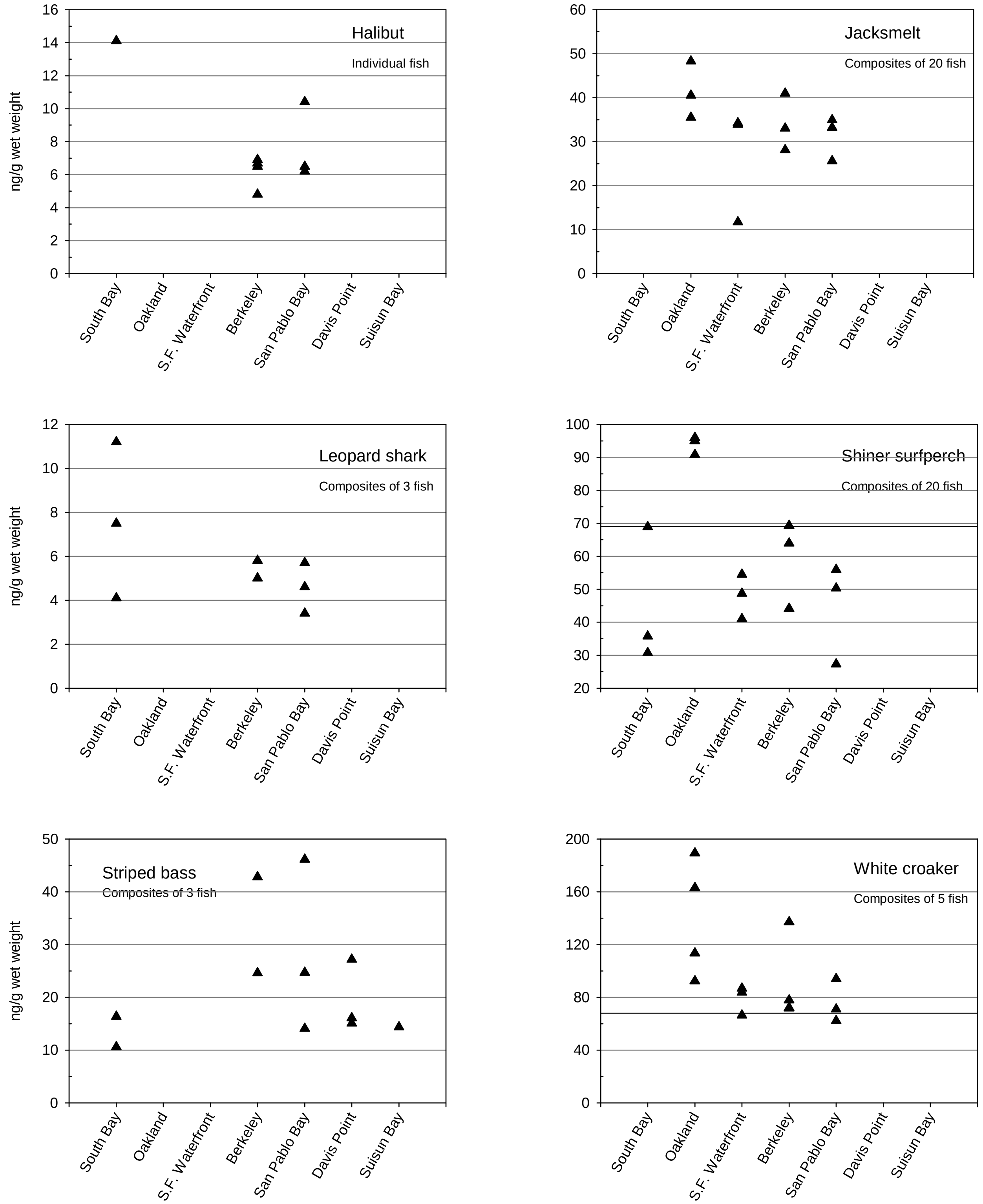
Temporal trends

Lipid weight DDT concentrations were significantly lower in 1997 relative to 1994 in one species, striped bass (2.0 µg/g lipid versus 4.0 µg/g lipid, p=.044). These results are in contrast to those for PCBs, which declined significantly in striped bass, white croaker, and shiner surfperch.

Effect of Skin Removal

The effect on trace organic concentrations of removing the skin from white croaker fillets was examined using four pairs of composite samples (Table 4). The average percent reduction for DDTs was 40%. These reductions were associated with decreased amounts of lipid in the fillets without skin. Skin removal reduced the concentrations for samples from S.F. Waterfront, Berkeley, and San Pablo Bay to below the screening value of 69 ng/g wet; the concentration in the Oakland Harbor sample without skin remained above the screening value. Lipid content was reduced by an average of 33% in the fillets without skin.

Figure 12. Sum of DDTs (ng/g wet) at each sampling location in 1997. White sturgeon data not shown. Line on plots indicate screening value of 69 ng/g wet.



Chlordanes

Introduction

Chlordane is another organochlorine insecticide that was used extensively in home and agricultural applications (including corn, grapes, and other crops) in the U.S. for the control of termites and many other insects (U.S. EPA, 1995a). Like PCB, chlordane is a term that represents a group of a large number (140) of individual compounds (Dearth and Hites, 1991). Restrictions on chlordane use began in 1978, and domestic sales and production ceased in 1988 (U.S. EPA, 1995a). An estimated 70,000 tons of technical chlordane were produced from 1946 until 1988 (Dearth and Hites, 1991). As for DDT, the primary sources of chlordane to the Bay are probably continuing transport of soils and sediments from urban and agricultural sites of historic use and remobilization of residues from Bay sediments.

Chlordane data are usually expressed as the sum of several of the most abundant and persistent components and metabolites of the technical chlordane mixture. Chlordane is neurotoxic and is classified by U.S. EPA as a probable human carcinogen (U.S. EPA, 1995a). Like PCBs and DDT, chlordane compounds are very persistent in the environment, resistant to metabolism, have a strong affinity for lipid, and biomagnify in aquatic food webs (Suedel *et al*., 1994).

Analytical considerations

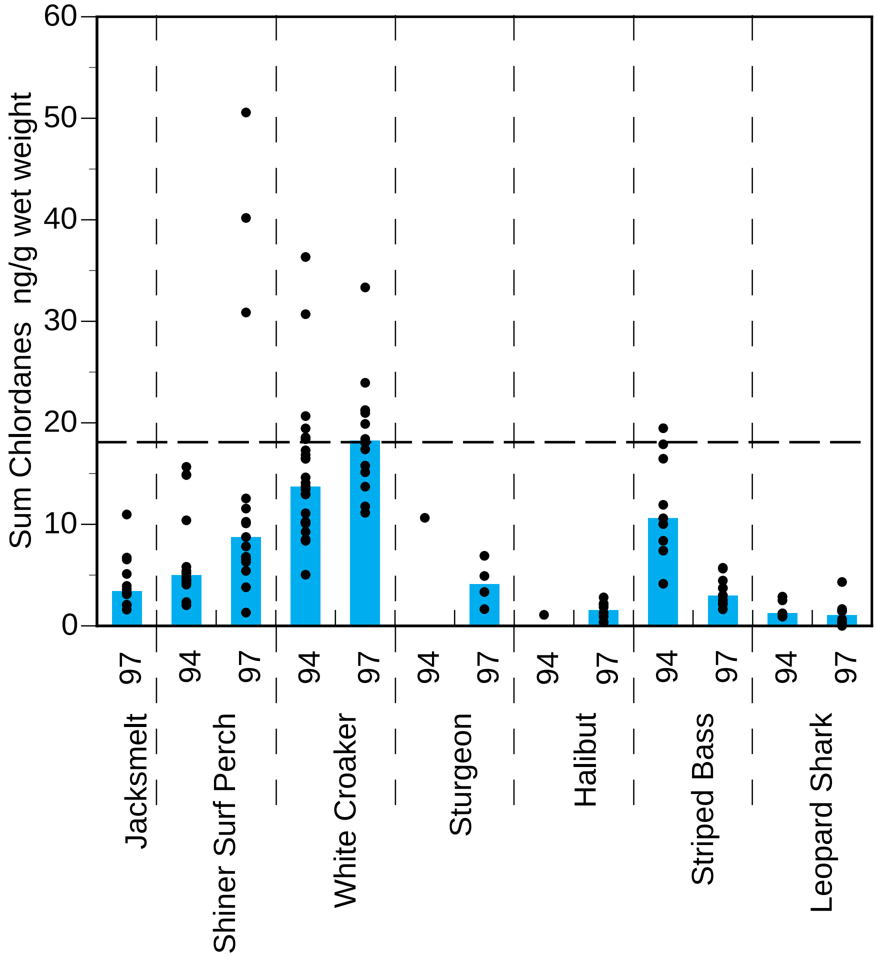
Nine chlordane compounds (components of the technical mixture and metabolites) were analyzed. Five of these compounds were summed to derive “sum of chlordanes”: cis-chlordane, trans-chlordane, cis-nonachlor, trans-nonachlor, and oxychlordane. The screening value for chlordanes (18 ng/g wet) applies to this sum. Detectable chlordane compounds were present in 71 of the 72 samples analyzed. Detection limits for the chlordanes of interest were 0.25 ng/g wet.

Data distribution and summary statistics

Sum of chlordanes concentrations were highest in white croaker, with a median concentration of 18 ng/g wet (Table 3a, Figure 13). Shiner surfperch had the second highest median concentration, 8.8 ng/g wet. The other species sampled had median concentrations of 4.1 ng/g wet or less. Leopard shark had the lowest median concentration, 1.1 ng/g wet.

Sum of chlordanes was above the screening value of 18 ng/g wet in 11 of 72 samples (15%) (Table 3b). Eight of 14 white croaker samples (57%) and 3 of 15 shiner surfperch samples (20%) were above the screening value. None of the other species had concentrations above the screening value.

Figure 13. Chlordane concentrations in Bay fish, expressed as sum of chlordanes (ng/g wet), 1994 and 1997. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. Line indicates screening value (18 ng/g wet).



Controlling factors

Sum of chlordanes concentrations in the seven species sampled were significantly correlated (R^2=0.60, p<.0001) with lipid content (Figure 8). As observed for the other trace organics, the fish with the highest lipid content in their muscle tissue had the highest chlordane concentrations.

Some of the points that deviate from the regression line indicate other factors controlling chlordane concentrations. As seen for other trace organics, sampling location had an influence on chlordane concentrations in jacksmelt, shiner surfperch, and white croaker, with fish collected from Oakland Harbor having elevated concentrations relative to the other locations. Most of the Oakland Harbor datapoints for shiner surfperch and white croaker have relatively large positive residuals (i.e., they fall well above the regression line). The Oakland Harbor datapoints for jacksmelt, though higher than the concentrations from other locations, have smaller positive residuals because jacksmelt in general have negative residuals. As discussed for the PCBs, the relatively low concentrations for jacksmelt may be due to their feeding at a lower trophic level and on pelagic prey, while all of the other species consume benthic prey at higher trophic levels.

Spatial patterns

As with other contaminants, distinct spatial variation was observed for chlordane. For the wet weight results, the clearest spatial variation was found for shiner surfperch, which had significantly higher concentrations at Oakland Harbor than at the other four locations where shiner surfperch were collected (Figure 14). The shiner surfperch samples from Oakland Harbor averaged 41 ng/g wet, and all measured values were well above the 18 ng/g wet screening value. These were the only shiner surfperch samples that exceeded the screening value for chlordane. The average concentration at Oakland Harbor was approximately 8 times higher than the average at San Pablo Bay (5.2 ng/g wet). Excluding Oakland Harbor, none of the shiner surfperch samples from other sampling locations were significantly different from each other. The average concentration in jacksmelt from Oakland Harbor (8.1 ng/g wet) was also significantly higher than the concentrations measured at all other locations, with a maximum of a 3.5-fold difference compared to Berkeley. For white croaker, Oakland Harbor, averaging 25 ng/g wet, was significantly higher than Berkeley and San Pablo Bay, which both averaged 15 ng/g wet, but the magnitude of the difference was not as great as observed for shiner surfperch and jacksmelt.

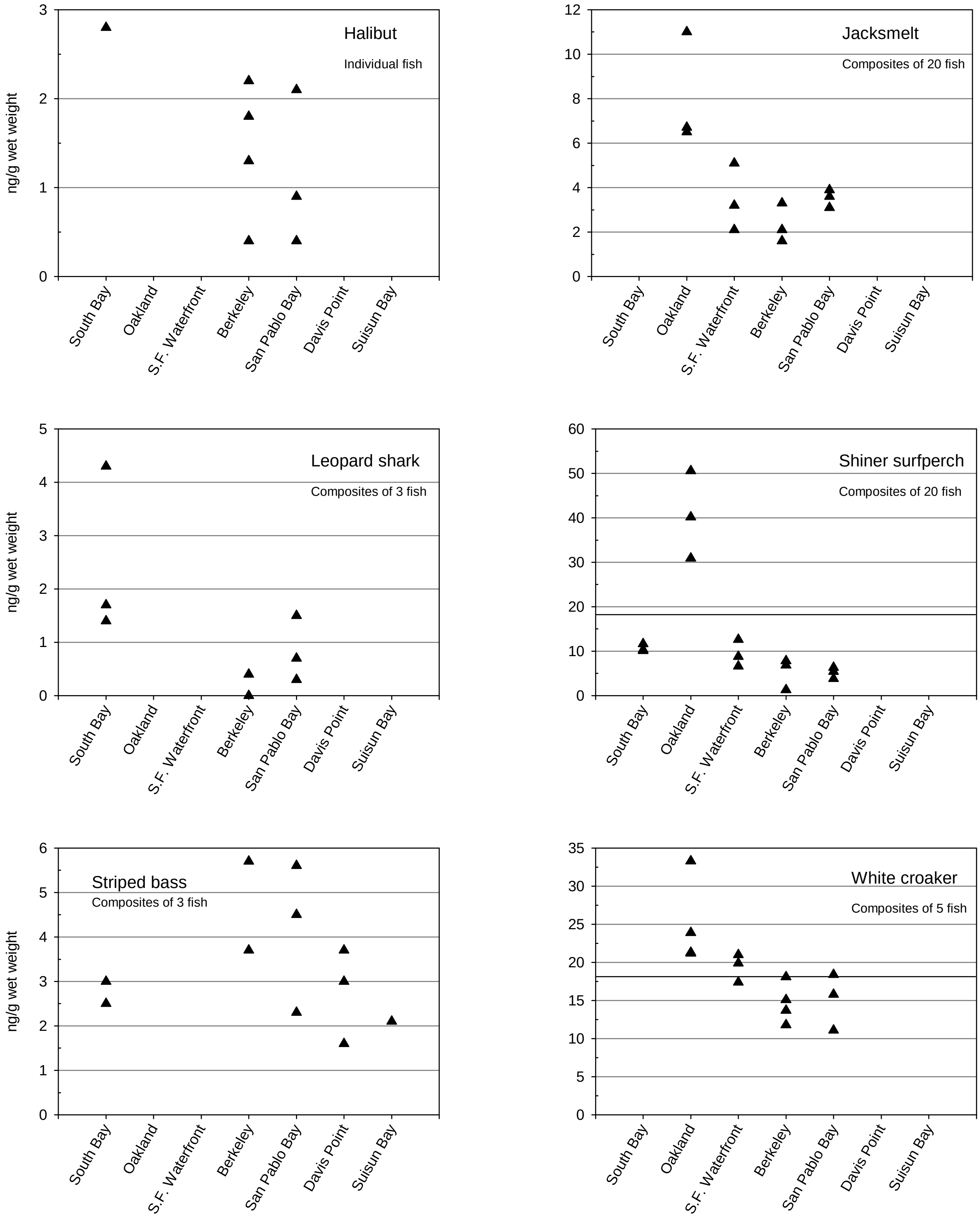
The lipid weight chlordane data (not shown) generally showed similar patterns. Sum of chlordanes in shiner surfperch at Oakland Harbor was significantly higher than at all other locations, and were 9 times higher than Berkeley, the location with the lowest average concentration. In jacksmelt, sum of chlordanes at Oakland Harbor was significantly higher than at Berkeley and S.F. Waterfront, and the differences were of a similar magnitude as for the wet weight data. In contrast to the wet weight data, no statistically significant spatial variation was observed for lipid weight chlordane in white croaker.

Overall, results from jacksmelt and shiner surfperch indicate elevated concentrations of chlordanes in the food web in Oakland Harbor relative to the other locations sampled. The degree of contamination, with concentrations at Oakland Harbor up to 9 times as high as other Bay locations, is similar to that observed for the PCBs. Excluding Oakland, chlordane concentrations at the other locations sampled were relatively uniform.

Temporal trends

Lipid weight sum of chlordanes concentrations were significantly lower in 1997 compared to 1994 in striped bass (0.37 µg/g lipid versus 1.5, p=0.0012) and in white croaker (0.28 µg/g lipid versus 0.41 µg/g lipid, p=0.0008). The difference in concentrations in shiner surfperch (0.29 µg/g lipid in 1997 versus 0.57 µg/g lipid in 1994) was not quite significant at α=.05 (p=0.089). The median concentration in leopard shark was similar in 1997 (0.34 µg/g lipid) to the median in 1994 (0.31 µg/g lipid).

Figure 14. Sum of chlordanes (ng/g wet) at each sampling location in 1997. White sturgeon data not shown. Line on plots indicate screening value of 18 ng/g wet. Points at zero indicate results below detection limits.



Effect of Skin Removal

The effect on trace organic concentrations of removing the skin from white croaker fillets was examined using four pairs of composite samples (Table 4). The average percent reduction for sum of chlordanes was 34%. Skin removal reduced the concentrations for samples from S.F. Waterfront and San Pablo Bay to below the screening value of 18 ng/g wet. These reductions were associated with decreased amounts of lipid in the fillets without skin. Lipid content was reduced by an average of 33% in the fillets without skin.

Dieldrin

Introduction

Dieldrin is an organochlorine insecticide that was widely used in the U.S. from 1950 to 1974, primarily on termites and other soil-dwelling insects, as a wood preservative, in moth-proofing clothing and carpets, and on cotton, corn, and citrus crops (U.S. EPA, 1995a). Restrictions on dieldrin use began in 1974. Most uses in the U.S. were banned in 1985. Dieldrin use for underground termite control continued until voluntarily canceled by industry in 1987 (U.S. EPA, 1995a).

Unlike the other trace organics discussed in this report, which represent groups of chemicals, dieldrin is a single chemical. Dieldrin is neurotoxic and is also classified by U.S. EPA as a probable human carcinogen (U.S. EPA, 1995a). Similar to the other organochlorines described, dieldrin is very persistent in the environment, resistant to metabolism, has a strong affinity for lipid, and readily accumulates in aquatic food webs.

Analytical considerations

Detectable dieldrin was present in 62 of the 72 samples analyzed (86%). The detection limit for dieldrin was 0.25 ng/g wet. Dieldrin concentrations in the fish species sampled (median = 1.2 ng/g wet) are not much higher than the detection limit, and consequently the precision of these measurements is lower than for the other organics discussed in this report.

Data distribution and summary statistics

Dieldrin concentrations were highest in white croaker, with a median concentration of 4.5 ng/g wet (Table 3a, Figure 15). Shiner surfperch had the second highest median concentration, 1.7 ng/g wet. The other species sampled had median concentrations of 1.0 ng/g wet or less. Leopard shark and halibut had the lowest median concentration, 0.2 ng/g wet.

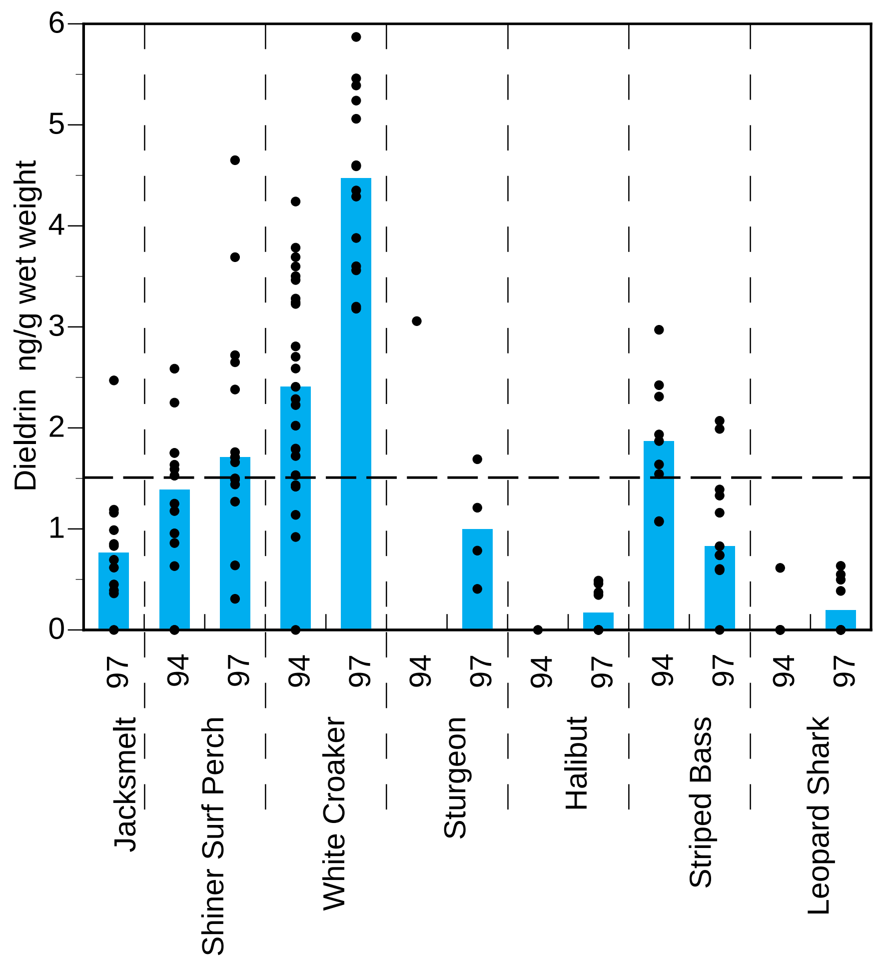
Dieldrin was above the screening value of 1.5 ng/g wet in 27 of 72 samples (37%) (Table 3b). All 14 white croaker samples and 9 of 15 shiner surfperch samples (60%) were above the screening value. Two of 11 striped bass samples (18%), one of four sturgeon samples (25%), and 1 of 12 jacksmelt samples (8%) were above the screening value. None of the other leopard shark or halibut samples had concentrations above the screening value.

Controlling factors

Dieldrin concentrations in the seven species sampled were significantly correlated (R^2=0.64, p<.0001) with lipid content (Figure 8). As observed for the other trace organics, the fish with the highest lipid content in their muscle tissue had the highest dieldrin concentrations.

Other factors controlling dieldrin concentrations are not as apparent as for they are for PCBs, chlordanes, and DDTs. As discussed for the other organics, the relatively large negative residuals for jacksmelt may be due to their feeding at a lower trophic level and on pelagic prey, while all of the other species consume benthic prey at higher trophic levels.

Figure 15. Dieldrin concentrations in Bay fish (ng/g wet), 1994 and 1997. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. Line indicates screening value (1.5 ng/g wet).



Spatial patterns

Unlike the other contaminants discussed, distinct spatial variation was not observed for dieldrin. Average wet weight dieldrin concentrations for jacksmelt, shiner surfperch, and white croaker were all highest at Oakland Harbor, but Oakland was not significantly higher than any other location (Figure 16).

The lipid weight dieldrin data (not shown) exhibited a similar lack of distinct spatial variation. The only significant difference observed was between shiner surfperch at Oakland Harbor and at Berkeley. Average lipid weight dieldrin in jacksmelt was also highest at Oakland Harbor. In white croaker, Berkeley and San Pablo Bay had higher average lipid weight dieldrin concentrations than Oakland Harbor. Overall, the data suggest that dieldrin concentrations are slightly elevated at Oakland Harbor.

Temporal trends

Lipid weight dieldrin concentrations were significantly lower in 1997 for striped bass (0.10 µg/g lipid versus 0.20 µg/g lipid in 1994, $p=0.0062$) and shiner surfperch (0.07 µg/g lipid versus 0.15 µg/g lipid in 1994, $p=0.0173$). Median concentrations in 1997 were lower in white croaker and higher in leopard shark, but these differences were not significant.

Effect of Skin Removal

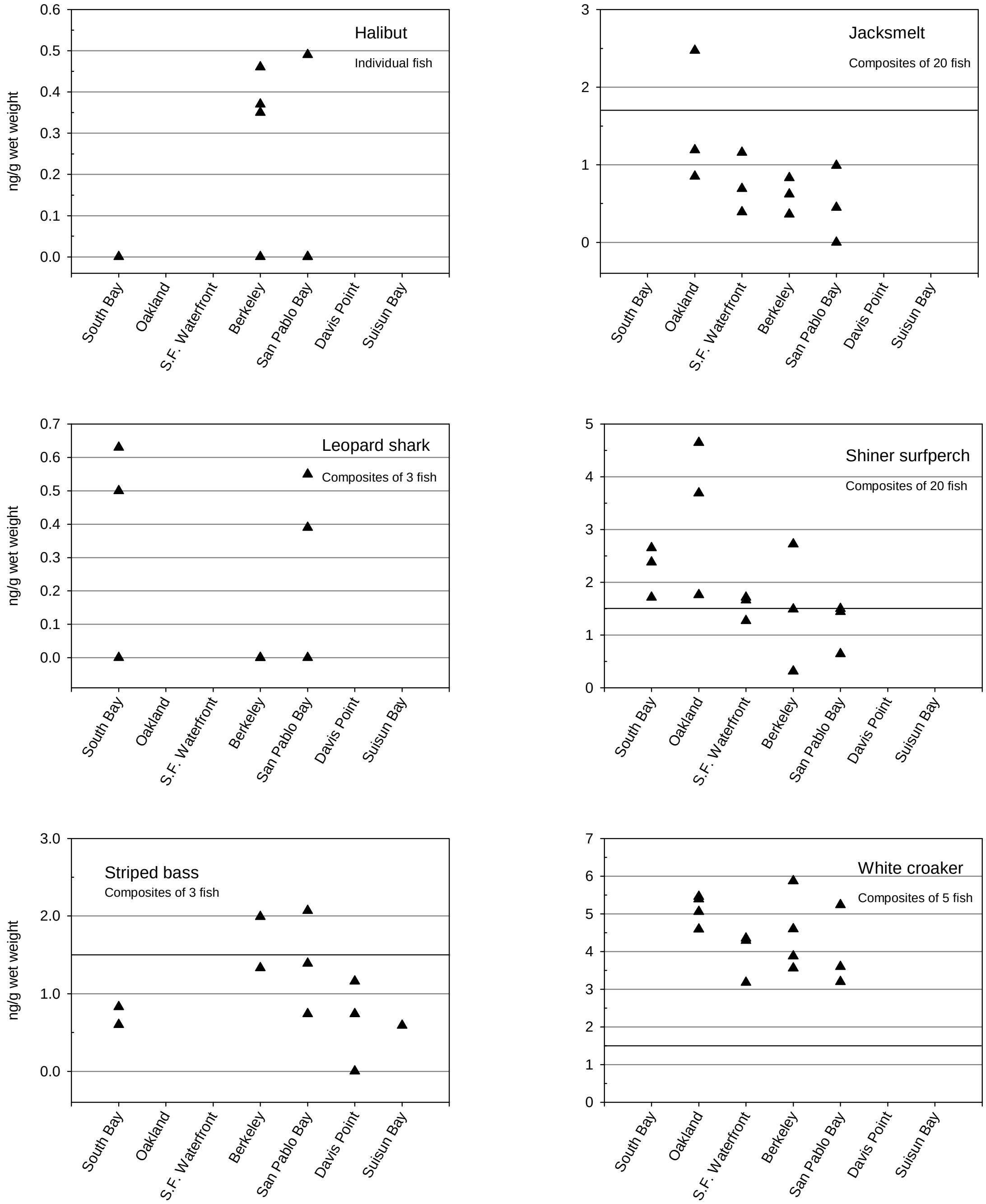
The effect on trace organic concentrations of removing the skin from white croaker fillets was examined using four pairs of composite samples (Table 4). The average percent reduction for dieldrin was 34%. These reductions were associated with decreased amounts of lipid in the fillets without skin. Lipid content was also reduced by an average of 33% in the fillets without skin. Skin removal did not result in these white croaker samples being below the screening value for dieldrin.

Dioxin and Dioxin-Like Compounds

Introduction

Dioxin (2,3,7,8-tetrachlorodibenzo-*p*-dioxin) is one of the most potent toxic chemicals known. Exposure to toxic concentrations of dioxin causes a variety of responses in animals, including developmental abnormalities, embryomortality, disruption of the endocrine system, impairment of the immune system, and cancer promotion.

Figure 16. Dieldrin (ng/g wet) at each sampling location in 1997. White sturgeon data not shown. Line on plots indicate screening value of 1.5 ng/g wet. Points at zero indicate results below detection limits.



Certain other chlorinated organic contaminants are structurally similar to dioxin and consequently elicit similar toxic responses. These are referred to here as "dioxin-like compounds." Dioxin is a member of a large family of compounds known collectively as dibenzodioxins, which consist of 75 chemicals (or congeners) with different numbers and arrangements of chlorine atoms. Six of the other dibenzodioxin congeners have dioxin-like potency (Safe, 1990). Chlorinated dibenzofurans are another family of compounds closely related to dibenzodioxins. Of 135 possible chlorinated dibenzofuran congeners, 10 have dioxin-like potency (Safe, 1990). As mentioned earlier, some PCB congeners also have dioxin-like potency. PCBs 77, 126, and 169 are the most potent, but 8 other congeners also possess some dioxin-like potency and, due to their high concentrations in environmental samples, are significant (Ahlborg *et al*., 1994).

Dibenzodioxins and dibenzofurans are formed as byproducts in combustion or manufacturing processes. The sources of dibenzodioxins and dibenzofurans in the Bay Area are mobile sources (cars, trucks, etc.), residential wood combustion, historically deposited residues in the environment, sewage treatment plants, and industrial discharges (Gervason and Tang, 1998). Dibenzodioxins and dibenzofurans released to the atmosphere can deposit on land surfaces in the watershed and be transported to the Bay in storm runoff, or can deposit directly on the Bay surface. In contrast, as described earlier, PCBs, including the congeners with dioxin-like potency, were intentionally manufactured for a wide variety of applications, and have different sources and a different distribution in the watershed.

Dioxin-like compounds have a common mechanism of action based on binding to a specific cellular receptor. Given this common mechanism of action, it is possible to express the combined potency of complex mixtures of dibenzodioxins, dibenzofurans, PCBs, and other compounds as toxic equivalents (TEQs). In this approach, the relative toxicity of a dioxin-like compound compared to dioxin (toxic equivalency factors, or TEF) is applied to a measured concentration of the chemical to calculate a dioxin TEQ. For example, PCB 126 is one-tenth as potent as dioxin and has a TEF of 0.1. If a sample contains 50 pg/g wet of PCB 126, the dioxin TEQ attributable to PCB 126 in that sample is 5 pg/g wet. Dioxin TEQs for measured dioxin-like compounds with established TEFs can be added to calculate the total dioxin TEQs in a sample. TEQs can be estimated for different groups of dioxin-like compounds. The groups considered in this report and their abbreviations are defined in Table 5.

Like PCBs, dibenzodioxins and dibenzofurans are resistant to metabolism and have a high affinity for lipid. In aquatic environments dibenzodioxins, dibenzofurans, and PCBs reach higher concentrations with increasing trophic level. Consequently, predatory fish, birds, and mammals (including humans that consume fish) at the top of the aquatic food web are particularly vulnerable to the effects of contamination due to dioxin-like compounds.

A key to all of the abbreviations used in this section is provided in Table 5.

Table 5. Abbreviations used in referring to dioxin and dioxin-like compounds.

Dioxin	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
TCDD	tetrachlorodibenzodioxin
PCDD	pentachlorodibenzodioxin
HxCDD	hexachlorodibenzodioxin
HpCDD	heptachlorodibenzodioxin
OCDD	octachlorodibenzodioxin
TCDF	tetrachlorodibenzofuran
PCDF	pentachlorodibenzofuran
HxCDF	hexachlorodibenzofuran
HpCDF	heptachlorodibenzofuran
OCDF	octachlorodibenzofuran
TEQ	dioxin toxic equivalent
TEF	dioxin toxic equivalency factor
ITEQs	dioxin toxic equivalents due to dibenzodioxins and dibenzofurans
PCB TEQs	dioxin toxic equivalents due to all measured dioxin-like PCBs
PCB TEQs (3 PCBs)	dioxin toxic equivalents due to PCBs 77, 126, and 169
total TEQs	dioxin toxic equivalents due to dibenzodioxins, dibenzofurans, and all measured dioxin-like PCBs

Analytical considerations

Concentrations of many of the dioxin-like compounds analyzed were usually below limits of detection, and this affected the overall precision of the dataset. Frequencies of detection for the dibenzodioxins, dibenzofurans, and PCBs 77, 126, and 169 varied among the 1994 and 1997 datasets (Table 6). In the 1997 sampling, larger masses of sample were analyzed in an effort to reduce detection limits. As a result, frequencies of detection for the four compounds that contribute most to ITEQs (2,3,7,8-TCDD, 1,2,3,7,8-PCDD, 2,3,7,8-TCDF, and 2,3,4,7,8-PCDF) were improved in 1997. The largest improvement was observed for 1,2,3,7,8-PCDD, which was not detected in any sample in 1994 but was detected in 80% of the samples in 1997. Results for these four analytes were also generally above the limit of quantitation, which means that the measured concentrations were elevated enough above the limit of detection to be considered quantitative data. Higher lipid content in the 1997 samples may also have contributed to the higher observed frequencies of detection. All reported concentrations of the PCBs 77, 126, and 169 were above the limit of quantitation.

Even though detection limits should have been lower in 1997, several of the less potent dibenzofurans were detected more frequently in 1994 than in 1997. One factor contributing to this was blank contamination in the 1994 samples. Several values for 1,2,3,4,7,8-HxCDF, 1,2,3,4,6,7,8-HpCDF, 1,2,3,4,7,8,9-HpCDF, and 1,2,3,4,6,7,8,9-OCDD in 1994 were qualified to indicate that the analyte was detected in the blank at greater than 10% of the amount in the sample. For the 1997 dataset, no results were qualified because of blank contamination.

Table 6. Frequencies of detection and quantitation for the dibenzodioxins, dibenzofurans, and PCBs 77, 126, and 169 in 1994 and 1997. TEF values from Ahlborg *et al*. (1994).

		Frequency of Detection (%)		Frequency of Quantitation (%)	
TEF	**Analyte**	**1994**	**1997**	**1994**	**1997**
1	2,3,7,8-TCDD	53	80	5	50
0.5	1,2,3,7,8-PCDD	0	80	0	70
0.1	1,2,3,4,7,8-HxCDD	11	0	0	0
0.1	1,2,3,6,7,8-HxCDD	16	70	0	0
0.1	1,2,3,7,8,9-HxCDD	0	0	0	0
0.01	1,2,3,4,6,7,8-HpCDD	11	50	0	0
0.001	1,2,3,4,6,7,8,9-OCDD	53	70	26	20
0.1	2,3,7,8-TCDF	84	100	63	100
0.05	1,2,3,7,8-PCDF	58	70	11	60
0.5	2,3,4,7,8-PCDF	53	100	21	80
0.1	1,2,3,4,7,8-HxCDF	89	10	53	0
0.1	1,2,3,6,7,8-HxCDF	58	0	42	0
0.1	1,2,3,7,8,9-HxCDF	0	0	0	0
0.1	2,3,4,6,7,8-HxCDF	5	0	0	0
0.01	1,2,3,4,6,7,8-HpCDF	63	0	42	0
0.01	1,2,3,4,7,8,9-HpCDF	42	0	16	0
0.001	1,2,3,4,6,7,8,9-OCDF	47	0	26	0
0.0005	PCB-77	100	100	100	100
0.1	PCB-126	100	100	100	100
0.01	PCB-169	68	100	58	100

Dioxin Toxic Equivalents (TEQs)

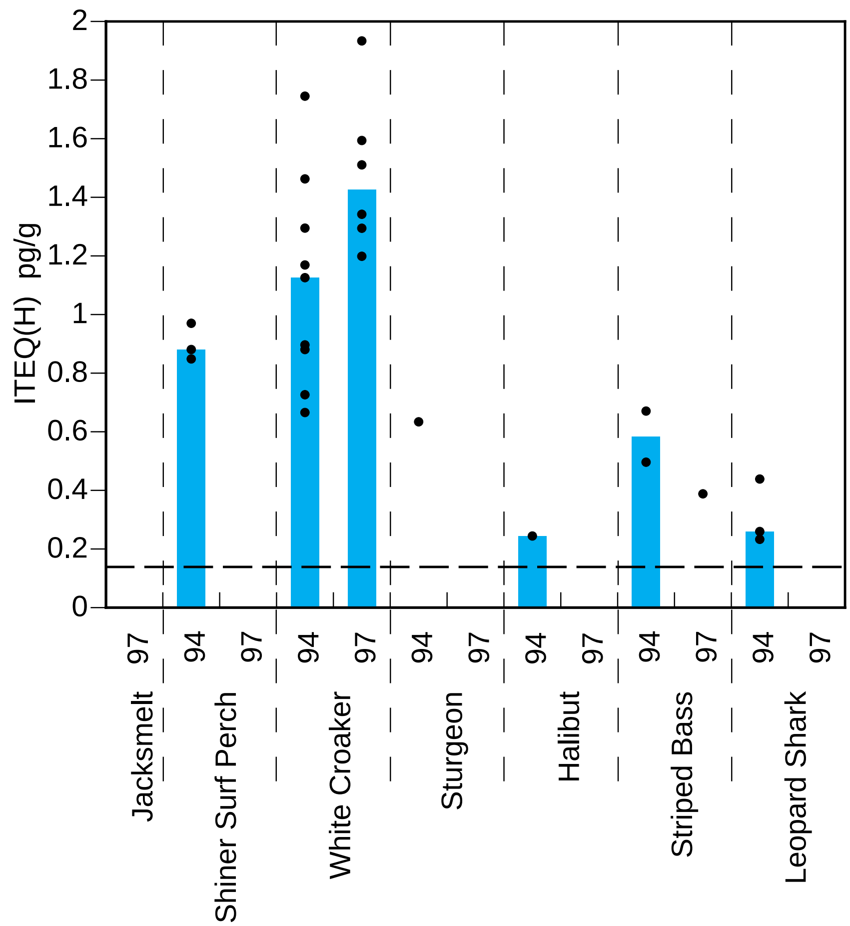
ITEQs (Dibenzodioxins and Dibenzofurans)

Dibenzodioxins and dibenzofurans were measured in six samples of white croaker, each sample consisting of a composite of five white croaker fillets with skin. The median ITEQ in these samples was 1.4 pg/g wet weight, with a minimum of 1.2 pg/g and a maximum of 1.9 pg/g (Figure 17). All of these samples were above the screening value of 0.15 pg/g wet weight (Table 3b).

One striped bass sample was also analyzed for dioxin-like compounds. This sample was a composite of fillets from 12 fish analyzed without skin. The ITEQ for this sample was 0.4 pg/g wet weight.

Concentrations of dioxin-like compounds in the striped bass sample were approaching the limits of detection. In this situation, the handling of results reported as below detection limits (BDL) can have a significant influence on the magnitude of calculated ITEQs. The three commonly-used alternatives for handling BDL values in environmental samples are to substitute 1) the detection limit, 2) half the detection limit (the method generally used in this report), or 3) zero. These different methods would lead to values of 0.6, 0.4, and 0.2 pg/g ITEQ, respectively, in this striped bass sample. At the high end of this range, the ITEQ for the sample is four times higher than the screening value, while at the low end the ITEQ is approximately equal to screening value. For white croaker, handling of BDL values had an insignificant effect (causing variation of approximately 1%) on the ITEQs because the most important compounds were usually detected. Unless otherwise noted, ITEQ data in this report were calculated using BDL values set to half the limit of detection.

Figure 17. ITEQ (dioxin TEQs due to dibenzodioxins and dibenzofurans) concentrations in Bay fish (pg/g wet), 1994 and 1997. Points are concentrations in each composite sample analyzed. Bars indicate median concentrations. Line indicates screening value (0.15 pg/g wet).

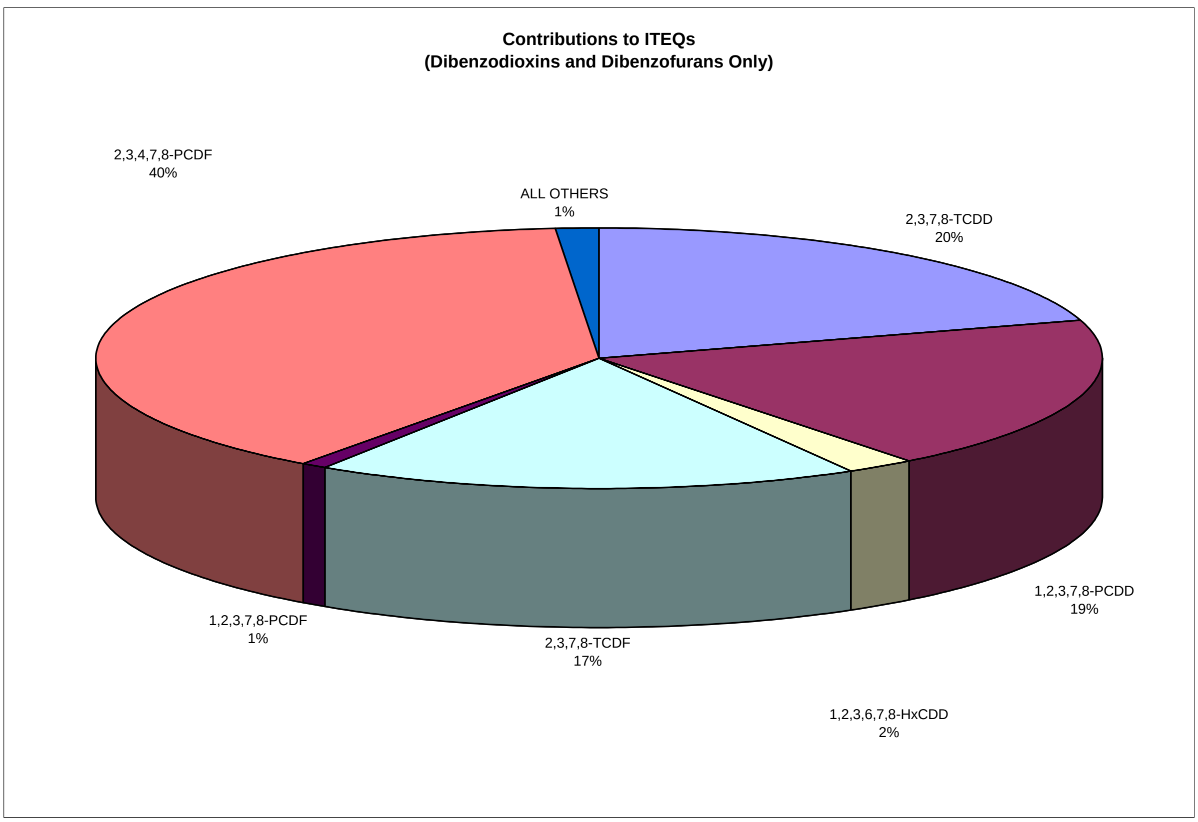


Four dioxin-like compounds accounted for 96% of the ITEQs in these fish samples (Figure 18). The largest contributors to ITEQs were the dibenzofurans. One dibenzofuran, 2,3,4,7,8-PCDF, accounted for 40% of the total ITEQ, due to a combination of relatively high potency and moderately high concentrations. 2,3,4,7,8-PCDF and 2,3,7,8-TCDF combined to account for 57% of ITEQ. Two dibenzodioxin congeners, 2,3,7,8-TCDD and 1,2,3,7,8-PCDD, combined to account for 39% of ITEQ.

PCB TEQs and Total TEQs

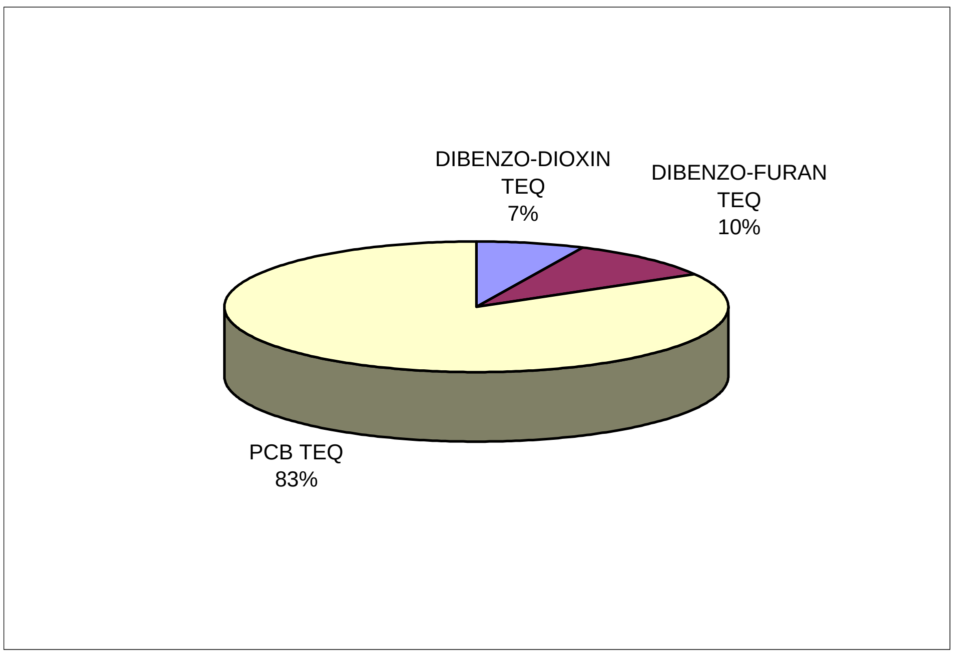
PCBs 77, 126, and 169 were measured in the same samples analyzed for dibenzodioxins and dibenzofurans. PCB congeners, including most of the other dioxin-like PCBs, were measured using a different, less expensive method, and were consequently analyzed in many more samples (a total of 72 samples) than dibenzodioxins, dibenzofurans, and PCBs 77, 126, and 169. These two datasets were combined to evaluate the contribution of all measured dioxin-like PCBs to total TEQs in the six white croaker samples and one striped bass sample.

Figure 18. Contributions of dibenzodioxin and dibenzofuran congeners to ITEQ.



Total TEQs in these seven samples averaged 9.7 pg/g wet weight, with a minimum of 3.7 pg/g and a maximum of 19.7 pg/g. The striped bass sample had the lowest concentration of total TEQs. The relative contributions of dibenzodioxins, dibenzofurans, and PCBs to total TEQs are shown in Figure 19. Dioxin-like PCBs accounted for 83% of total TEQs. PCB 126, the most toxic dioxin-like PCB, alone accounted for an average of 52% of total TEQs. Dibenzofurans and dibenzodioxins accounted for 10% and 7%, respectively, of total TEQs. Dioxin-like PCBs accounted for most of the overall dioxin-like potency in these fish samples.

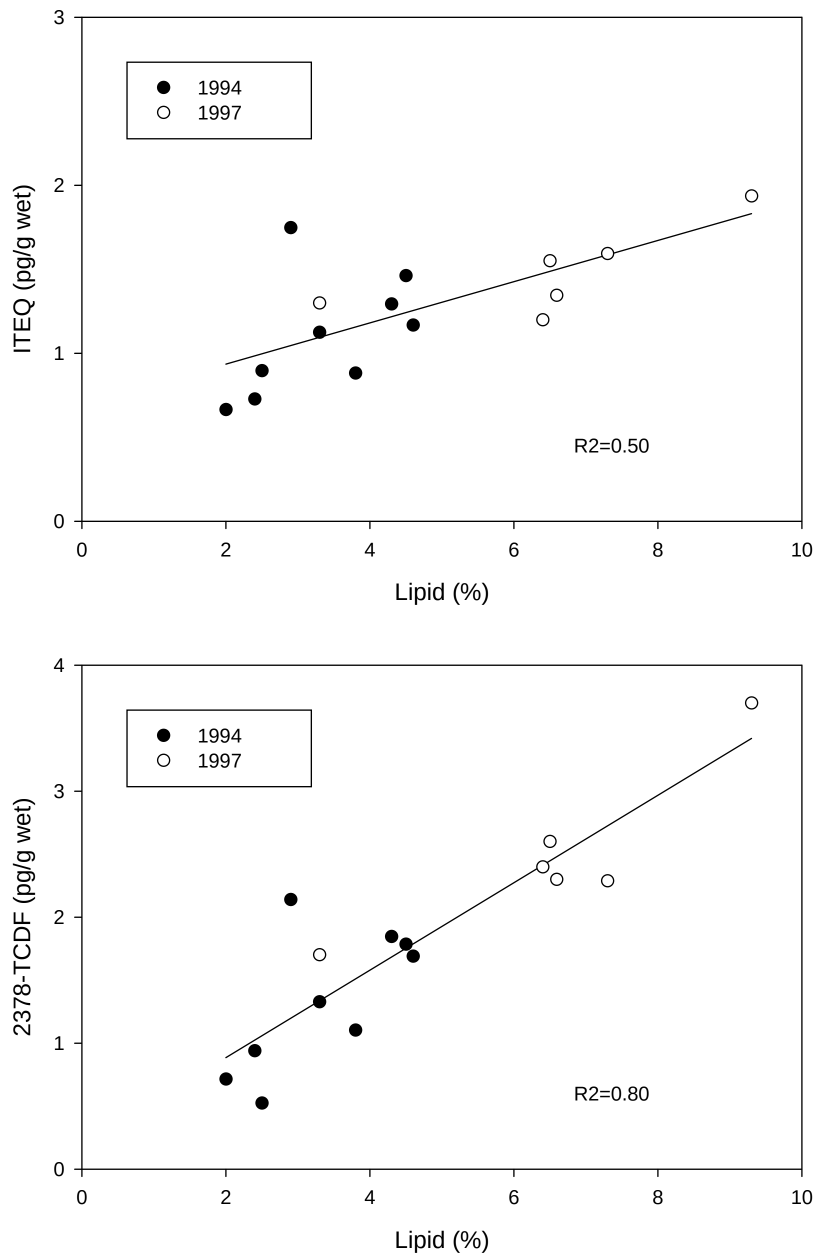
Figure 19. Contributions to total TEQs from dibenzodioxins, dibenzofurans, and dioxin-like PCBs in white croaker analyzed for both dioxin-like compounds and PCB congeners.



Controlling Factors

Lipophilic contaminants such as the dibenzodioxins, dibenzofurans, and PCBs accumulate in biota in proportion to the amount of lipid, or fat, in their tissues. This relationship was supported by the data on dioxin-like compounds in San Francisco Bay white croaker from 1994 and 1997. The dioxin-like compound found at the highest, and therefore most analytically precise, concentrations in Bay samples was 2,3,7,8-TCDF. 2,3,7,8-TCDF was strongly correlated with lipid ($R^2 = 0.81$, $p = 0.000006$) (Figure 20, bottom). Concentrations of other dioxin-like compounds were also correlated with lipid, though not as strongly as 2,3,7,8-TCDF. As a result of these correlations with individual dioxin-like compounds, ITEQs were also significantly correlated with lipid ($R^2 = 0.51$, $p = 0.0029$) (Figure 20, top). Given the strong relationship between concentrations of dioxin-like compounds and lipid content, comparisons made among times, locations, or species must include consideration of variation in lipid content.

Figure 20. Correlations of ITEQ (top) and 2,3,7,8-TCDF (bottom) with lipid in 1994 and 1997 white croaker samples.



Sources of variation

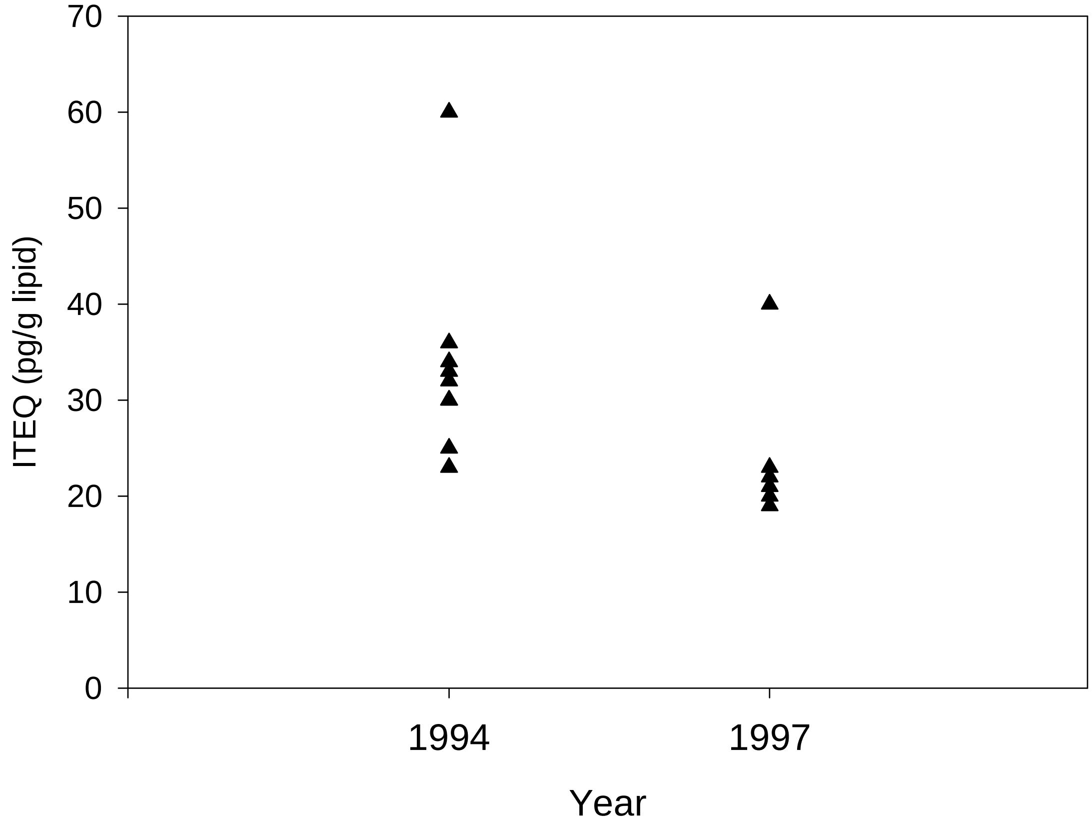
Due to the relatively high expense of analysis of dioxin-like compounds, little replication was included in the sampling design for these compounds. The only replicates available are for duplicate aliquots of a striped bass composite sample, and for three field replicates of white croaker composites from San Pablo Bay. The duplicate striped bass samples provide an indication of analytical variability. Although the concentrations in this sample were too low to allow an evaluation of the less abundant analytes, the agreement between these duplicate samples was close, suggesting that analytical variability for the dioxin dataset is low.

The three field replicates of white croaker composites from San Pablo Bay provide an indication of the combination of analytical variability and variability among fish collected from one location. These samples were collected on three dates between June 23 and July 9, 1997 at the same location near Point San Pablo. Variation among these field replicates was relatively large, especially for the dibenzodioxins and dibenzofurans. ITEQ in these three samples ranged from 1.2 pg/g wet weight to 1.9 pg/g, encompassing the range of concentrations measured in all samples. Total TEQs in these three samples ranged from 3.4 to 5.7 pg/g wet weight; this range was narrow relative to the range for all samples (2.4 to 11.2 pg/g wet weight). Variation in lipid content in these three samples was also relatively large, ranging from 3.3% to 9.3%, but lipid normalization of these three samples did not reduce the observed variability.

Temporal Trends

ITEQs in white croaker expressed on a lipid weight basis were lower in 1997 (with a median of 21 pg/g lipid) than in 1994 (median 32 pg/g lipid) and the difference was statistically significant ($p = 0.0365$, Wilcoxon test; Figure 21). It is not clear, however, whether these lower concentrations are indicative of declining concentrations of dioxin-like compounds in the Bay. One reason for this uncertainty is that measurement of parts per trillion concentrations of chemicals in fish tissue near the limits of detection is a challenging task, and variation in the analytical process may influence the results. In contrast to the results for ITEQs, median lipid normalized concentrations of the most abundant and best-quantified dibenzodioxin or dibenzofuran, 2,3,7,8-TCDF, were nearly identical in 1994 (39 pg/g lipid) and 1997 (38 pg/g lipid). Also contributing to uncertainty about this apparent trend is a lack of understanding of seasonal variation in lipid and the effect of this variation on concentrations of dioxin and other trace organics. Illustrating the importance of accounting for variation in lipid, mean ITEQs expressed on a wet weight basis were higher in 1997 than in 1994 (see Figure 17), suggesting an opposite conclusion than the lipid weight data. This increase in wet weight concentrations was probably due to the significantly higher lipid content of the white croaker fillets in 1997. Finally, results from only two sampling periods are not sufficient to provide a reliable indication of a persistent, long-term trend. In summary, measured lipid weight concentrations of ITEQ were lower in 1997 than in 1994, but analytical uncertainty, the lack of a precise understanding of the relationship between seasonal variation in lipid and concentrations of dioxins, and the existence of data from only two sampling periods hinder definitive conclusions about temporal trends in dioxin-like compounds in the Bay.

Figure 21. Comparison of lipid weight ITEQ in white croaker in 1994 and 1997.



Effect of Skin Removal

The effect of removing the skin from white croaker fillets was examined using two pairs of composite samples (Table 7). One pair of composites was from the Berkeley location and the other was from San Pablo Bay. Each composite consisted of 15 individual fish. For both pairs, substantially lower concentrations of dioxin-like compounds were measured in the fillets with the skin removed. In the samples from Berkeley ITEQ concentrations were reduced by 27% and PCB TEQ (3 PCBs) concentrations by 31%. In the samples from San Pablo Bay ITEQ concentrations were reduced by 53% and PCB TEQ (3 PCBs) concentrations by 47%. These reductions were likely due to decreased amounts of lipid in the fillets without skin, but lipid data were not available for the fillets without skin to support this hypothesis.

Table 7. Comparison of concentrations of dioxin-like compounds in paired composites with and without skin from Berkeley and San Pablo Bay. Skin on and skin-off composites were comprised of tissue from the same set of fish. Concentrations in pg/g wet weight.

Location	**Berkeley**			**San Pablo Bay**		
Number in composite	15	15		15	15	
Tissue type	SKIN ON	SKIN OFF	% REDUCTION	SKIN ON	SKIN OFF	% REDUCTION
2,3,7,8-TCDD	0.3	0.2	33	0.3	0.2	33
1,2,3,7,8-PCDD	0.6	0.5	17	0.6	0.3	50
1,2,3,4,7,8-HxCDD	ND	ND	-	ND	ND	-
1,2,3,6,7,8-HxCDD	0.3	0.2	33	0.3	0.2	33
1,2,3,7,8,9-HxCDD	ND	ND	-	ND	ND	-
1,2,3,4,6,7,8-HpCDD	ND	ND	-	0.1	0.1	0
1,2,3,4,6,7,8,9-OCDD	0.3	0.3	0	0.3	0.3	0
2,3,7,8-TCDF	2.6	1.9	27	2.6	1.2	54
1,2,3,7,8-PCDF	ND	0.2	-	0.3	0.1	67
2,3,4,7,8-PCDF	1.2	0.9	25	1.2	0.6	50
1,2,3,4,7,8-HxCDF	ND	ND	-	0.0	ND	-
1,2,3,6,7,8-HxCDF	ND	ND	-	ND	ND	-
1,2,3,7,8,9-HxCDF	ND	ND	-	ND	ND	-
2,3,4,6,7,8-HxCDF	ND	ND	-	ND	ND	-
1,2,3,4,6,7,8-HpCDF	ND	ND	-	ND	ND	-
1,2,3,4,7,8,9-HpCDF	ND	ND	-	ND	ND	-
1,2,3,4,6,7,8,9-OCDF	ND	ND	-	ND	ND	-
PCB-77	150	95	37	133	68	49
PCB-126	41	28	32	44	23	47
PCB-169	3.4	2.3	32	3.5	1.9	46
ITEQ	1.5	1.1	27	1.5	0.7	53
PCB TEQ (3 PCBs)	4.2	2.9	31	4.5	2.4	47

[a] Listed concentrations are an average of results from analysis of 3 composites with 5 fish in each.

Selenium

Selenium is a trace element that accumulates to concentrations of ecological concern in the Bay food web (Davis *et al*., 1991). The primary sources of selenium are runoff from areas with seleniferous soils and agricultural drainage from such areas, oil refinery wastewater discharges, and sewage treatment plants. Selenium was measured in the 1994 pilot study (SFRWQCB *et al*., 1995) and found to be below the screening value of 11.7 µg/g wet in all 66 samples analyzed. The highest concentration measured in 1994 was 1.0 µg/g wet in the one white sturgeon sample collected that year. To further investigate selenium concentrations in white sturgeon, selenium was measured in thirteen individual white sturgeon in the 1997 sampling. The highest concentration measured was 3.7 µg/g wet, still well below the screening value. The median concentration was 1.0 µg/g wet. The two locations sampled, South Bay and San Pablo Bay, both had median concentrations of 1.0 µg/g wet. Based on these data, selenium concentrations in white sturgeon do not appear to be high enough to pose a hazard to Bay fishers.

Summary and Conclusions

Comparisons to Screening Values

As found in the 1994 pilot study (SFRWQCB *et al*., 1995, Fairey *et al*., 1997), persistent toxic chemicals in Bay fish were found at concentrations of potential human health concern in 1997 RMP sampling.

Mercury exceeded the screening value in 44 of 84 samples. All collected samples of leopard shark and striped bass exceeded the mercury screening value. For some species, including leopard shark and striped bass, the older and larger fish accumulated higher mercury concentrations. Adjustment of the data for variation in length was useful in evaluation of trends in mercury concentrations in space and time. Data obtained for individual striped bass suggest the existence of two groups of striped bass in the Bay, one with higher mercury concentrations than the other. The reason that striped bass of similar size might display this sort of variability is unknown at this time.

Concentrations of trace organics were highest in white croaker and shiner surfperch. Overall, PCBs exceeded the screening value in 51 of 72 samples. All of the white croaker and shiner surfperch samples exceeded the screening value for PCBs. The other trace organics had lower numbers of samples above screening values: 27 of 72 for dieldrin (including all 14 white croaker samples), 16 of 72 for DDTs, and 11 of 72 for chlordanes. Species with low lipid content in their muscle tissue, such as halibut and leopard shark, had the lowest concentrations of trace organics.

Dibenzodioxins and dibenzofurans were measured in six samples of white croaker and one sample of striped bass. ITEQs in these samples were all above the screening value of 0.15 pg/g wet weight. Total TEQs (including the contributions of dioxin-like dibenzodioxins, dibenzofurans, and PCBs) in these seven samples averaged 9.7 pg/g wet weight, with a minimum of 3.7 pg/g and a maximum of 19.7 pg/g. Dioxin-like PCBs accounted for 83% of total TEQs. Dibenzofurans and dibenzodioxins accounted for 10% and 7%, respectively, of total TEQs.

Spatial Patterns

Significant variation in contaminant concentrations among locations was observed in the three species (white croaker, shiner surfperch, and jacksmelt) employed to evaluate spatial patterns. Spatial variation in wet weight concentrations was observed, indicating variation in potential human exposure to contaminants of concern. Oakland Harbor had significantly elevated wet weight concentrations of mercury (in shiner surfperch and jacksmelt), PCBs (shiner surfperch, white croaker, and jacksmelt), DDTs (shiner surfperch), and chlordanes (shiner surfperch, white croaker, and jacksmelt).

Spatial variation was also evaluated by adjusting the data for the important factors length and lipid content. These adjusted data may provide a better indication of spatial and temporal variation in contamination of the Bay. Length-adjusted mercury concentrations were relatively high at Oakland Harbor and S.F. Waterfront (in jacksmelt). Lipid normalized concentrations of PCBs (in jacksmelt and shiner surfperch), DDTs (shiner surfperch), chlordanes (jacksmelt and shiner surfperch), and dieldrin (shiner surfperch) were elevated at Oakland Harbor. Lipid normalized PCB concentrations at Oakland Harbor were 11 times higher than at the sampling location with the lowest PCB concentration. The observation of similar spatial patterns in multiple species support the conclusion that the Oakland Harbor location exhibits elevated concentrations of multiple contaminants. These findings are consistent with observations of high concentrations of PCBs and organochlorine pesticides in sediment at this location (Hunt *et al.*, 1998). Overall, the results of the sampling for spatial patterns suggest that shiner surfperch and jacksmelt are useful indicators of spatial variation in contamination in the Bay.

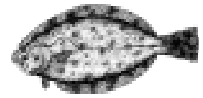
Temporal Trends

Mercury concentrations in 1997 were not significantly different from concentrations in 1994. In 1997 lipid-normalized concentrations of PCBs were significantly lower than in 1994 in shiner surfperch, white croaker, and striped bass, suggesting a possible general decline in PCBs in the Bay. Significantly lower concentrations were also observed for lipid-normalized DDTs (striped bass), chlordanes (striped bass and white croaker), and dieldrin (striped bass and shiner surfperch). Decreasing concentrations of these synthetic chemicals would be consistent with restrictions on their use that have been in place for many years. Lipid-normalized dioxin ITEQs were also significantly lower in 1997 than in 1994.

Continued monitoring will be required to establish whether the apparent decreases observed for PCBs, organochlorine pesticides, and dioxin ITEQs are real indications of declining masses of contaminants in the Bay. Other possible causes of these apparent declines include variation in the physiology or behavior of the fish sampled, changes in the structure of the Bay's food web, variation in analytical methods, or simply short-term fluctuation that is not indicative of a persistent long-term trend. The reason for the large differences in lipid concentrations observed in 1994 and 1997 are not understood and further emphasize the need for continued monitoring to determine trends over time. Continued fish tissue monitoring will also allow detection of changes that have not yet been indicated by results from just two sampling events (1994 and 1997).

Other Conclusions

The use of multiple species for evaluating spatial and temporal trends proved to be valuable. Consistent trends were observed for multiple species, lending greater confidence to conclusions about spatial and temporal variation. The use of multiple species also offers the advantage of increasing the likelihood of obtaining target species, whose distribution in the Bay varies considerably.



Fish size (or age) and lipid content were identified as important factors influencing accumulation of persistent contaminants. Trophic level is probably also an important factor accounting for some of the variation in these results, but the trophic levels of the species sampled in the Bay are not well characterized. Understanding and accounting for these factors is essential to evaluation of spatial and temporal trends in contaminant concentrations.

Substantially lower concentrations of trace organics were measured in white croaker fillets with the skin removed. Concentrations of PCBs, DDTs, chlordanes, dieldrin, and dioxin ITEQs were reduced by 30-50%. These reductions were associated with lipid concentrations that were 33% lower in the fillets without skin. For some samples, skin removal resulted in reduction of chlordane and DDT concentrations to below screening values.

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- Audrey Chiang, Asian-Pacific Environmental Network
- Bob Fujimura, California Department of Fish and Game
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- Steven Zeiger, Marin County Stormwater Pollution Prevention Program

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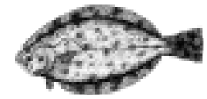

Appendix—Data tables

Table 1. Mercury concentrations in fish tissue, 1997.

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Range of Lengths (cm)	Avg Length (cm)	% Moisture	Hg (µg/g wet)
6/12/97	Berkeley	Halibut	Off	1	75	75	73	0.195
6/13/97	Berkeley	Halibut	Off	1	79	79	71	0.335
6/13/97	Berkeley	Halibut	Off	1	60	60	73	0.294
6/17/97	Berkeley	Halibut	Off	1	73	73	73	0.194
3/28/97	San Pablo Bay	Halibut	Off	1	92	92	72	0.389
6/24/97	San Pablo Bay	Halibut	Off	1	59	59	71	0.209
7/23/97	San Pablo Bay	Halibut	Off	1	77	77	76	0.470
6/3/97	South Bay Bridges	Halibut	Off	1	55	55	73	0.251
6/12/97	Berkeley	Jacksmelt	On+	5	24-28.5	25	71	0.062
6/12/97	Berkeley	Jacksmelt	On+	5	24-27	26	70	0.069
6/12/97	Berkeley	Jacksmelt	On+	5	22-30	26	71	0.074
6/30/97	Oakland	Jacksmelt	On+	5	25-30	27	68	0.134
6/30/97	Oakland	Jacksmelt	On+	5	23-29	26	68	0.131
7/2/97	Oakland	Jacksmelt	On+	5	27-29	28	65	0.255
6/19/97	S.F. Waterfront	Jacksmelt	On+	5	20.5-28.5	25	73	0.090
7/10/97	S.F. Waterfront	Jacksmelt	On+	5	21-30	25	70	0.101
7/11/97	S.F. Waterfront	Jacksmelt	On+	5	21-27	25	68	0.068
7/9/97	San Pablo Bay	Jacksmelt	On+	5	26-28	27	71	0.095
7/9/97	San Pablo Bay	Jacksmelt	On+	5	25-29	27	72	0.094
7/9/97	San Pablo Bay	Jacksmelt	On+	5	26-30	28	72	0.094
6/13/97	Berkeley	Leopard Shark	Off	3	91-93	92	75	0.881
6/13/97	Berkeley	Leopard Shark	Off	3	92-102	98	75	0.877
6/20/97	San Pablo Bay	Leopard Shark	Off	3	99-100	100	74	0.744
6/20/97	San Pablo Bay	Leopard Shark	Off	3	91.5-94	93	74	0.884
7/9/97	San Pablo Bay	Leopard Shark	Off	1	114	114	72	1.138
6/2/97	South Bay Bridges	Leopard Shark	Off	3	93-97	95	69	1.050
6/2/97	South Bay Bridges	Leopard Shark	Off	3	108-135	118	73	0.869
6/2/97	South Bay Bridges	Leopard Shark	Off	3	94-99	96	74	0.801
6/12/97	Berkeley	Shiner Surf Perch	On+	20	11-14.5	12	66	0.072
6/12/97	Berkeley	Shiner Surf Perch	On+	20	11-12.5	12	65	0.109
6/13/97	Berkeley	Shiner Surf Perch	On+	20	10.5-14.5	12	69	0.098
6/5/97	Oakland	Shiner Surf Perch	On+	20	11-14.5	12	64	0.151
6/5/97	Oakland	Shiner Surf Perch	On+	20	10.5-14.5	12	64	0.154
6/5/97	Oakland	Shiner Surf Perch	On+	20	11-14	12	67	0.192
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	11.5-13	12	66	0.136
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	11.5-13	12	65	0.111
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	10.5-13	12	67	0.084
6/23/97	San Pablo Bay	Shiner Surf Perch	On+	20	10.5-14	12	69	0.082
7/9/97	San Pablo Bay	Shiner Surf Perch	On+	20	10-15	12	68	0.116
7/24/97	San Pablo Bay	Shiner Surf Perch	On+	20	10.5-12.5	12	65	0.119
5/27/97	South Bay Bridges	Shiner Surf Perch	On+	20	11-15	13	73	0.126
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	10.5-14.5	12	65	0.086
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	11-15	12	68	0.105

On—Skin on muscle, On+ —Skin on muscle with skeleton, Off—Skin off muscle

Table 1. (continued).

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Range of Lengths (cm)	Avg Length (cm)	% Moisture	Hg (µg/g wet)
6/13/97	Berkeley	Striped Bass	Off	3	50-52	51	70	0.263
6/18/97	Berkeley	Striped Bass	Off	2	63,75	69	69	0.352
7/8/97	Davis Point	Striped Bass	Off	1	60	60	73	0.448
7/8/97	Davis Point	Striped Bass	Off	1	53	53	74	0.347
7/8/97	Davis Point	Striped Bass	Off	1	51	51	74	0.435
7/8/97	Davis Point	Striped Bass	Off	1	56	56	75	0.823
7/8/97	Davis Point	Striped Bass	Off	1	48	48	75	0.507
7/8/97	Davis Point	Striped Bass	Off	1	50	50	76	0.581
7/8/97	Davis Point	Striped Bass	Off	1	68	68	74	0.495
7/8/97	Davis Point	Striped Bass	Off	1	63	63	76	0.530
7/8/97	Davis Point	Striped Bass	Off	1	58	58	74	0.895
7/8/97	Davis Point	Striped Bass	Off	1	55	55	75	0.462
6/20/97	San Pablo Bay	Striped Bass	Off	3	50-52	51	71	0.424
6/20/97	San Pablo Bay	Striped Bass	Off	3	61-66	64	73	0.581
6/2/97	South Bay Bridges	Striped Bass	Off	1	45	45	78	0.360
6/2/97	South Bay Bridges	Striped Bass	Off	1	50	50	75	0.405
6/2/97	South Bay Bridges	Striped Bass	Off	1	49	49	76	0.390
6/2/97	South Bay Bridges	Striped Bass	Off	1	54	54	75	0.659
6/2/97	South Bay Bridges	Striped Bass	Off	1	62	62	73	0.385
6/3/97	South Bay Bridges	Striped Bass	Off	1	52	52	73	0.684
6/3/97	South Bay Bridges	Striped Bass	Off	1	48	48	75	0.321
6/6/97	South Bay Bridges	Striped Bass	Off	1	69	69	74	0.448
6/27/97	Suisun Bay	Striped Bass	Off	3	50-52	51	76	0.530
10/8/97	San Pablo Bay	Sturgeon	Off	3	117-128	124	72	0.291
10/8/97	San Pablo Bay	Sturgeon	Off	3	140-145	142	76	0.223
3/12/97	South Bay Bridges	Sturgeon	Off	3	119-124	121	79	0.243
3/12/97	South Bay Bridges	Sturgeon	Off	2	135,149	142	82	0.354
6/13/97	Berkeley	White Croaker	On	5	24-28	27	66	0.255
6/13/97	Berkeley	White Croaker	On	5	20-30	24	67	0.185
6/13/97	Berkeley	White Croaker	On	5	21-29	24	70	0.212
6/13/97	Berkeley	White Croaker	On	5	20-29	23	70	0.176
6/11/97	Oakland	White Croaker	On	5	20-28	25	68	0.162
7/2/97	Oakland	White Croaker	On	5	21-30	26	75	0.220
7/2/97	Oakland	White Croaker	On	5	21-27	24	67	0.170
7/11/97	Oakland	White Croaker	On	5	23-30	27	74	0.177
7/1/97	S.F. Waterfront	White Croaker	On	5	22-29	25	66	0.190
7/1/97	S.F. Waterfront	White Croaker	On	5	20-30	25	66	0.310
7/10/97	S.F. Waterfront	White Croaker	On	5	20-30	23	68	0.175
6/23/97	San Pablo Bay	White Croaker	On	5	23-29	26	66	0.239
6/26/97	San Pablo Bay	White Croaker	On	5	23-29	26	66	0.167
7/9/97	San Pablo Bay	White Croaker	On	5	22-30	27	71	0.344

On—Skin on muscle, On+ —Skin on muscle with skeleton, Off—Skin off muscle

Table 2. Selenium concentrations in fish tissue, 1997.

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Range of Lengths (cm)	% Moisture	Se (µg/g)
6/25/97	San Pablo Bay	Sturgeon	Off	1	120.5	78	0.98
10/8/97	San Pablo Bay	Sturgeon	Off	1	140	75	1.90
10/8/97	San Pablo Bay	Sturgeon	Off	1	145	75	0.81
10/8/97	San Pablo Bay	Sturgeon	Off	1	117	75	1.25
10/8/97	San Pablo Bay	Sturgeon	Off	1	141	75	0.82
10/8/97	San Pablo Bay	Sturgeon	Off	1	127	76	0.85
10/15/97	San Pablo Bay	Sturgeon	Off	1	128	77	3.71
3/12/97	South Bay Bridges	Sturgeon	Off	1	117	78	1.87
3/12/97	South Bay Bridges	Sturgeon	Off	1	135	74	1.17
3/12/97	South Bay Bridges	Sturgeon	Off	1	121	80	0.92
3/13/97	South Bay Bridges	Sturgeon	Off	1	119	78	0.70
3/13/97	South Bay Bridges	Sturgeon	Off	1	124	75	1.11
6/4/97	South Bay Bridges	Sturgeon	Off	1	149	80	0.53

Off—Skin off muscle

Table 3. PCB concentrations (ng/g wet) in fish tissue, 1997.
ND = not detected. Aroclor concentrations were estimated from the congener data.

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Range of Lengths (cm)	Avg Length (cm)	% Moisture	% Lipid	Total Aroclors (SFEI)	Aroclor 1248	Aroclor 1254	Aroclor 1260	Sum of PCB Congeners (SFEI)	PCB 005	PCB 008	PCB 018	PCB 027	PCB 028	PCB 029	PCB 031	PCB 033
6/12/97	Berkeley	Halibut	Off	1	75	75	74	0.4	13	ND	ND	13	12	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Halibut	Off	1	79	79	76	0.5	14	ND	14	ND	12	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Halibut	Off	1	60	60	74	0.3	ND	ND	ND	ND	7	ND	ND	ND	ND	ND	ND	ND	ND
6/17/97	Berkeley	Halibut	Off	1	73	73	75	0.3	ND	ND	ND	ND	12	ND	ND	ND	ND	ND	ND	ND	ND
3/28/97	San Pablo Bay	Halibut	Off	1	92	92	77	0.3	ND	ND	ND	ND	8	ND	ND	ND	ND	ND	ND	ND	ND
6/24/97	San Pablo Bay	Halibut	Off	1	59	59	73	0.4	ND	ND	ND	ND	7	ND	ND	ND	ND	ND	ND	ND	ND
7/23/97	San Pablo Bay	Halibut	Off	1	77	77	77	0.2	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	ND	ND	ND
6/3/97	South Bay Bridges	Halibut	Off	1	55	55	74	0.5	59	ND	36	23	34	ND	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	24-28.5	25	74	1.6	24	ND	24	ND	21	ND	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	24-27	26	75	3.2	19	ND	19	ND	14	ND	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	22-30	26	76	3.2	32	ND	32	ND	22	ND	ND	ND	ND	ND	ND	ND	ND
6/30/97	Oakland	Jacksmelt	On+	5	25-30	27	82	1.4	211	35	150	26	137	ND	ND	0.4	ND	1.2	ND	1.8	ND
6/30/97	Oakland	Jacksmelt	On+	5	23-29	26	78	1.9	157	ND	130	27	112	ND	ND	0.4	ND	0.6	ND	0.9	ND
7/2/97	Oakland	Jacksmelt	On+	5	27-29	28	69	3.4	327	44	230	53	211	ND	ND	0.6	ND	1.7	ND	2.1	0.4
6/19/97	S.F. Waterfront	Jacksmelt	On+	5	20.5-28.5	25	75	1.8	21	ND	21	ND	20	ND	ND	ND	ND	ND	ND	ND	ND
7/10/97	S.F. Waterfront	Jacksmelt	On+	5	21-30	25	74	1.5	46	ND	20	26	33	ND	ND	ND	ND	ND	ND	ND	ND
7/11/97	S.F. Waterfront	Jacksmelt	On+	5	21-27	25	75	2.5	35	ND	18	17	24	ND	ND	ND	ND	ND	ND	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	26-28	27	75	1.5	58	ND	37	21	36	ND	ND	ND	ND	ND	ND	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	25-29	27	71	1.4	76	ND	55	21	46	ND	ND	ND	ND	ND	ND	0.3	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	26-30	28	74	2.4	44	ND	26	18	27	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	91-93	92	76	0.2	16	ND	16	ND	9	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	92-102	98	75	0.2	13	ND	13	ND	8	ND	ND	ND	ND	ND	ND	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	99-100	100	75	0.3	ND	ND	ND	ND	3	ND	ND	ND	ND	ND	ND	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	91.5-94	93	76	0.3	ND	ND	ND	ND	5	ND	ND	ND	ND	ND	ND	ND	ND
7/9/97	San Pablo Bay	Leopard Shark	Off	1	114	114	78	0.3	ND	ND	ND	ND	4	ND	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	93-97	95	76	0.2	23	ND	23	ND	12	ND	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	108-135	118	77	0.6	45	ND	28	17	19	ND	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	94-99	96	77	0.1	12	ND	12	ND	6	ND	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	11-14.5	12	71	3.9	179	ND	130	49	110	ND	ND	ND	ND	0.3	ND	0.5	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	11-12.5	12	77	2.6	139	ND	88	51	91	ND	ND	ND	ND	0.3	ND	0.5	ND
6/13/97	Berkeley	Shiner Surf Perch	On+	20	10.5-14.5	12	77	2.1	139	ND	83	56	96	ND	ND	ND	ND	0.3	ND	0.5	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	11-14.5	12	77	2.5	590	ND	480	110	423	ND	ND	0.3	ND	1.5	ND	1.4	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	10.5-14.5	12	77	2.9	820	ND	680	140	515	ND	ND	0.3	ND	1.4	ND	2.2	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	11-14	12	78	1.9	801	31	600	170	486	ND	ND	ND	ND	1.3	ND	2.2	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	11.5-13	12	77	2.0	201	ND	140	61	131	ND	ND	ND	ND	0.4	ND	0.8	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	11.5-13	12	76	3.0	239	ND	180	59	152	ND	ND	ND	ND	0.4	ND	0.6	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	10.5-13	12	78	1.7	295	22	210	63	184	ND	ND	ND	ND	0.4	ND	1.9	ND
6/23/97	San Pablo Bay	Shiner Surf Perch	On+	20	10.5-14	12	78	2.6	128	ND	99	29	77	ND	ND	ND	ND	ND	ND	0.4	ND
7/9/97	San Pablo Bay	Shiner Surf Perch	On+	20	10-15	12	76	2.4	98	ND	74	24	58	ND	ND	ND	ND	ND	ND	0.3	ND
7/24/97	San Pablo Bay	Shiner Surf Perch	On+	20	10.5-12.5	12	76	1.5	75	ND	51	24	45	ND	ND	ND	ND	ND	ND	0.3	ND
5/27/97	South Bay Bridges	Shiner Surf Perch	On+	20	11-15	13	68	4.0	276	ND	180	96	172	ND	ND	ND	ND	0.3	ND	0.6	ND
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	10.5-14.5	12	79	1.9	121	ND	73	48	81	ND	ND	ND	ND	0.3	ND	0.2	ND
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	11-15	12	79	2.6	157	ND	110	47	111	ND	ND	ND	ND	0.4	ND	0.7	ND
6/13/97	Berkeley	Striped Bass	Off	3	50-52	51	73	4.1	48	ND	30	18	33	ND	ND	ND	ND	ND	ND	ND	ND
6/18/97	Berkeley	Striped Bass	Off	2	63,75	69	72	1.6	43	ND	25	18	28	ND	ND	ND	ND	ND	ND	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	50-53	51	77	0.5	47	ND	30	17	29	ND	ND	ND	ND	ND	ND	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	60-68	64	75	0.8	ND	ND	ND	ND	7	ND	ND	ND	ND	ND	ND	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	48-56	53	77	0.8	ND	ND	ND	ND	11	ND	ND	ND	ND	ND	ND	ND	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	50-52	51	75	1.0	19	ND	19	ND	21	ND	ND	ND	ND	ND	ND	ND	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	61-66	64	77	0.8	40	ND	25	15	23	ND	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Striped Bass	Off	3	49-52	50	78	0.5	34	ND	19	15	22	ND	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Striped Bass	Off	2	62,69	66	75	0.5	34	ND	18	16	22	ND	ND	ND	ND	ND	ND	ND	ND
6/27/97	Suisun Bay	Striped Bass	Off	3	50-52	51	78	0.6	17	ND	17	ND	14	ND	ND	ND	ND	ND	ND	ND	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	117-128	124	74	1.3	33	ND	33	ND	33	ND	ND	ND	ND	ND	ND	ND	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	140-145	142	77	1.3	32	ND	32	ND	28	ND	ND	ND	ND	ND	ND	ND	ND
3/12/97	South Bay Bridges	Sturgeon	Off	3	119-124	121	79	0.6	ND	ND	ND	ND	10	ND	ND	ND	ND	ND	ND	ND	ND
3/12/97	South Bay Bridges	Sturgeon	Off	2	135,149	142	75	1.5	46	ND	32	14	31	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	White Croaker	On	5	24-28	27	70	6.4	330	ND	200	130	220	ND	ND	ND	ND	0.6	ND	1.1	ND
6/13/97	Berkeley	White Croaker	On	5	20-30	24	72	7.4	260	ND	190	70	162	ND	ND	ND	ND	0.3	ND	0.7	ND
6/13/97	Berkeley	White Croaker	On	5	21-29	24	72	6.1	250	ND	180	70	164	ND	ND	ND	ND	0.6	ND	0.5	ND
6/13/97	Berkeley	White Croaker	On	5	20-29	23	68	5.4	203	ND	120	83	141	ND	ND	ND	ND	0.4	ND	0.4	ND
6/11/97	Oakland	White Croaker	On	5	20-28	25	70	7.5	559	49	370	140	364	ND	ND	0.6	ND	2.0	0.8	2.6	0.5
7/2/97	Oakland	White Croaker	On	5	21-30	26	68	7.3	867	57	570	240	589	ND	ND	0.8	ND	2.8	ND	2.8	0.5
7/2/97	Oakland	White Croaker	On	5	21-27	24	69	7.7	387	47	230	110	265	ND	ND	0.9	ND	1.7	ND	2.3	0.4
7/11/97	Oakland	White Croaker	On	5	23-30	27	72	6.8	512	62	310	140	338	ND	ND	1.0	ND	2.7	ND	2.9	ND
7/1/97	S.F. Waterfront	White Croaker	On	5	22-29	25	70	7.3	433	33	290	110	268	ND	ND	0.4	ND	0.8	ND	2.5	ND
7/1/97	S.F. Waterfront	White Croaker	On	5	20-30	25	70	7.6	371	51	190	130	253	ND	ND	0.4	ND	1.1	ND	4.5	0.3
7/10/97	S.F. Waterfront	White Croaker	On	5	20-30	23	73	5.2	232	ND	150	82	153	ND	ND	ND	ND	0.6	ND	0.5	ND
6/23/97	San Pablo Bay	White Croaker	On	5	23-29	26	69	9.3	281	ND	200	81	182	ND	ND	ND	ND	0.4	ND	0.8	ND
6/26/97	San Pablo Bay	White Croaker	On	5	23-29	26	66	6.4	161	ND	100	61	115	ND	ND	ND	ND	0.3	ND	0.7	ND
7/9/97	San Pablo Bay	White Croaker	On	5	22-30	27	73	3.3	200	ND	100	100	145	ND	ND	ND	ND	0.4	ND	0.4	ND
6/13/97	Berkeley	White Croaker	Off	5	24-28	NA	69	4.7	156	ND	98	58	108	ND	ND	ND	ND	ND	ND	ND	ND
6/11/97	Oakland	White Croaker	Off	5	20-28	NA	65	5.5	499	39	340	120	312	ND	ND	0.4	ND	1.6	ND	2.0	0.5
7/1/97	S.F. Waterfront	White Croaker	Off	5	22-29	25	72	5.3	237	ND	180	57	158	ND	ND	ND	ND	0.5	ND	1.5	ND
6/23/97	San Pablo Bay	White Croaker	Off	5	23-29	NA	67	4.7	150	ND	110	40	100	ND	ND	ND	ND	ND	ND	0.4	ND

On—Skin on muscle, On+ —Skin on muscle with skeleton, Off—Skin off muscle

Table 3. PCB concentrations (ng/g wet) in fish tissue, 1997 (continued).
ND = not detected. Aroclor concentrations were estimated from the congener data.

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Avg Length (cm)	% Lipid	Sum of PCB Congeners (SFEI)	PCB 044	PCB 049	PCB 052	PCB 056/60	PCB 066	PCB 070	PCB 074	PCB 087	PCB 095	PCB 097	PCB 099	PCB 101	PCB 105
6/12/97	Berkeley	Halibut	Off	1	75	0.4	12	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	0.5	0.9	ND
6/13/97	Berkeley	Halibut	Off	1	79	0.5	12	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	0.6	1.1	ND
6/13/97	Berkeley	Halibut	Off	1	60	0.3	7	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	0.4	0.6	ND
6/17/97	Berkeley	Halibut	Off	1	73	0.3	12	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	0.6	1.0	ND
3/28/97	San Pablo Bay	Halibut	Off	1	92	0.3	8	ND	ND	0.6	ND	ND	ND	ND	ND	ND	ND	0.3	0.7	ND
6/24/97	San Pablo Bay	Halibut	Off	1	59	0.4	7	ND	ND	0.3	ND	ND	ND	ND	ND	0.3	ND	0.4	0.6	ND
7/23/97	San Pablo Bay	Halibut	Off	1	77	0.2	11	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	0.5	0.9	ND
6/3/97	South Bay Bridges	Halibut	Off	1	55	0.5	34	ND	ND	0.7	ND	ND	ND	ND	0.3	1.1	ND	1.4	2.4	0.4
6/12/97	Berkeley	Jacksmelt	On+	5	25	1.6	21	0.3	0.3	2.6	ND	0.6	0.4	0.3	0.5	0.9	0.3	1.0	1.7	0.4
6/12/97	Berkeley	Jacksmelt	On+	5	26	3.2	14	ND	ND	0.4	0.5	0.3	ND	ND	0.3	0.6	ND	0.7	1.2	0.3
6/12/97	Berkeley	Jacksmelt	On+	5	26	3.2	22	ND	ND	0.6	0.6	0.4	ND	ND	0.4	0.6	0.3	1.0	1.6	0.4
6/30/97	Oakland	Jacksmelt	On+	5	27	1.4	137	1.9	1.8	6.1	1.6	3.9	2.4	1.8	3.0	5.6	2.4	6.4	11.9	2.6
6/30/97	Oakland	Jacksmelt	On+	5	26	1.9	112	1.1	1.0	4.0	0.8	2.4	1.2	1.2	2.3	3.8	1.7	5.2	9.7	2.5
7/2/97	Oakland	Jacksmelt	On+	5	28	3.4	211	2.4	2.5	7.3	2.3	4.4	3.0	2.0	3.9	8.5	3.1	10.2	18.1	4.0
6/19/97	S.F. Waterfront	Jacksmelt	On+	5	25	1.8	20	ND	ND	2.1	0.5	0.4	ND	ND	0.3	0.7	ND	1.0	1.3	0.3
7/10/97	S.F. Waterfront	Jacksmelt	On+	5	25	1.5	33	ND	0.3	0.6	ND	0.3	0.3	ND	0.3	1.1	ND	1.1	2.1	ND
7/11/97	S.F. Waterfront	Jacksmelt	On+	5	25	2.5	24	ND	0.3	0.6	ND	0.4	0.3	ND	0.3	0.9	0.3	1.0	1.8	0.3
7/9/97	San Pablo Bay	Jacksmelt	On+	5	27	1.5	36	0.3	0.3	2.4	ND	0.5	0.3	0.2	0.5	1.3	0.4	1.6	2.3	0.5
7/9/97	San Pablo Bay	Jacksmelt	On+	5	27	1.4	46	0.3	0.3	0.9	0.5	0.9	0.7	0.4	0.7	1.4	0.5	2.0	3.1	0.7
7/9/97	San Pablo Bay	Jacksmelt	On+	5	28	2.4	27	ND	ND	1.7	0.6	0.3	ND	ND	0.5	0.9	0.3	1.1	1.7	0.3
6/13/97	Berkeley	Leopard Shark	Off	3	92	0.2	9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.6	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	98	0.2	8	ND	ND	0.5	ND	ND	ND	ND	ND	ND	ND	0.6	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	100	0.3	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	93	0.3	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.4	ND	ND
7/9/97	San Pablo Bay	Leopard Shark	Off	1	114	0.3	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	95	0.2	12	ND	ND	0.8	ND	0.3	ND	ND	ND	ND	ND	1.0	ND	0.2
6/2/97	South Bay Bridges	Leopard Shark	Off	3	118	0.6	19	ND	ND	ND	ND	0.4	ND	ND	ND	ND	ND	1.4	ND	0.3
6/2/97	South Bay Bridges	Leopard Shark	Off	3	96	0.1	6	ND	ND	0.5	ND	ND	ND	ND	ND	ND	ND	0.6	ND	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	12	3.9	110	0.5	0.7	1.9	2.3	0.9	1.3	0.8	1.2	2.5	0.6	4.5	6.9	2.1
6/12/97	Berkeley	Shiner Surf Perch	On+	20	12	2.6	91	0.4	0.6	3.3	1.5	0.7	1.0	0.8	1.1	2.0	0.5	3.6	5.8	1.7
6/13/97	Berkeley	Shiner Surf Perch	On+	20	12	2.1	96	0.4	0.6	4.6	1.7	0.9	1.1	0.8	1.0	2.1	0.5	3.6	5.7	1.7
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	2.5	423	2.3	4.7	8.9	0.6	4.8	5.5	3.4	9.1	11.1	5.5	22.7	39.5	5.9
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	2.9	515	2.7	5.3	10.5	4.6	6.0	6.1	4.1	11.4	13.5	6.2	27.8	46.9	12.6
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	1.9	486	2.4	4.5	10.4	3.8	5.5	4.6	4.0	11.6	11.4	5.0	26.6	46.5	11.9
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	2.0	131	0.7	0.8	3.9	2.3	1.1	1.5	1.1	2.4	3.1	0.8	5.6	10.3	2.9
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	3.0	152	0.8	1.1	3.5	0.9	1.1	1.9	1.2	2.9	4.4	1.1	7.5	13.3	4.2
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	1.7	184	1.3	1.5	4.7	1.6	1.6	2.5	1.4	4.2	5.4	2.4	7.2	16.1	3.9
6/23/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	2.6	77	0.4	0.5	1.8	1.3	0.8	0.9	0.6	1.0	2.1	0.6	3.4	5.1	1.3
7/9/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	2.4	58	0.3	0.4	1.2	0.9	0.5	0.6	0.4	0.8	1.5	0.4	2.5	3.7	1.0
7/24/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	1.5	45	0.2	0.3	2.1	0.3	0.4	0.5	0.4	0.5	1.1	0.3	2.0	2.5	0.8
5/27/97	South Bay Bridges	Shiner Surf Perch	On+	20	13	4.0	172	0.5	0.9	2.3	1.4	1.3	1.4	0.9	1.7	3.6	1.0	7.4	10.5	2.8
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	12	1.9	81	0.3	0.4	1.1	0.4	0.7	0.6	0.4	0.6	1.8	0.5	3.5	5.0	1.0
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	12	2.6	111	0.5	0.7	1.9	1.0	1.2	1.3	0.8	1.3	2.5	0.8	4.7	7.1	1.9
6/13/97	Berkeley	Striped Bass	Off	3	51	4.1	33	ND	0.3	1.1	ND	0.3	0.4	ND	0.4	1.6	0.3	1.4	2.4	ND
6/18/97	Berkeley	Striped Bass	Off	2	69	1.6	28	ND	0.3	1.0	ND	ND	ND	ND	0.3	1.3	ND	1.2	2.0	ND
7/8/97	Davis Point	Striped Bass	Off	3	51	0.5	29	ND	0.3	0.9	ND	0.3	ND	ND	0.4	1.2	0.2	1.1	1.8	0.4
7/8/97	Davis Point	Striped Bass	Off	3	64	0.8	7	ND	ND	ND	ND	ND	ND	ND	ND	0.5	ND	0.5	0.7	ND
7/8/97	Davis Point	Striped Bass	Off	3	53	0.8	11	ND	ND	0.5	ND	ND	ND	ND	ND	0.5	ND	0.5	1.0	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	51	1.0	21	ND	ND	1.2	ND	0.3	ND	ND	ND	0.7	ND	0.8	1.5	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	64	0.8	23	ND	ND	0.8	ND	ND	ND	ND	0.3	1.0	ND	1.0	1.6	0.2
6/2/97	South Bay Bridges	Striped Bass	Off	3	50	0.5	22	ND	ND	0.4	ND	ND	ND	ND	ND	0.6	ND	0.9	1.2	0.3
6/2/97	South Bay Bridges	Striped Bass	Off	2	66	0.5	22	ND	ND	0.6	ND	ND	ND	ND	ND	1.0	ND	0.9	1.6	ND
6/27/97	Suisun Bay	Striped Bass	Off	3	51	0.6	14	ND	ND	0.7	ND	ND	ND	ND	ND	0.7	ND	0.6	0.9	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	124	1.3	33	ND	0.3	1.3	ND	ND	ND	ND	0.3	2.2	ND	1.4	2.2	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	142	1.3	28	ND	0.3	1.0	ND	ND	ND	ND	0.3	1.9	ND	1.1	1.8	0.3
3/12/97	South Bay Bridges	Sturgeon	Off	3	121	0.6	10	ND	ND	ND	ND	ND	ND	ND	ND	0.5	ND	0.5	0.6	ND
3/12/97	South Bay Bridges	Sturgeon	Off	2	142	1.5	31	ND	0.3	1.1	ND	0.3	ND	ND	0.4	1.9	ND	1.1	2.1	0.3
6/13/97	Berkeley	White Croaker	On	5	27	6.4	220	1.3	1.5	4.6	4.5	3.2	1.9	1.5	3.0	6.2	2.5	8.5	13.8	2.9
6/13/97	Berkeley	White Croaker	On	5	24	7.4	162	0.9	1.0	2.8	3.6	2.1	1.4	0.9	2.0	5.2	2.0	6.3	9.9	2.4
6/13/97	Berkeley	White Croaker	On	5	24	6.1	164	0.9	1.1	2.3	1.2	2.2	1.5	1.0	1.7	4.6	1.5	6.4	9.8	2.0
6/13/97	Berkeley	White Croaker	On	5	23	5.4	141	0.7	1.0	2.4	0.8	1.1	1.0	0.6	1.4	5.9	1.1	5.1	8.2	1.4
6/11/97	Oakland	White Croaker	On	5	25	7.5	364	3.8	3.8	7.7	3.9	6.1	4.5	2.8	6.1	13.0	5.8	15.0	25.0	7.0
7/2/97	Oakland	White Croaker	On	5	26	7.3	589	4.5	5.6	11.5	5.6	8.8	5.0	4.4	9.0	18.1	8.1	24.2	41.3	10.1
7/2/97	Oakland	White Croaker	On	5	24	7.7	265	2.8	3.0	7.6	2.7	5.9	3.1	2.7	5.0	9.0	3.7	10.5	19.1	4.7
7/11/97	Oakland	White Croaker	On	5	27	6.8	338	3.8	4.3	11.1	3.2	7.4	3.7	3.5	5.8	10.6	4.7	13.6	24.1	5.6
7/1/97	S.F. Waterfront	White Croaker	On	5	25	7.3	268	1.6	1.9	5.0	5.5	3.5	3.0	1.7	3.7	7.3	3.6	10.0	17.0	4.3
7/1/97	S.F. Waterfront	White Croaker	On	5	25	7.6	253	1.7	2.0	6.0	2.0	3.8	3.2	1.9	4.1	6.4	2.9	8.1	16.3	4.1
7/10/97	S.F. Waterfront	White Croaker	On	5	23	5.2	153	1.1	1.2	4.3	1.2	2.5	1.7	1.3	2.7	4.8	1.8	6.5	10.6	2.7
6/23/97	San Pablo Bay	White Croaker	On	5	26	9.3	182	1.0	1.1	3.3	4.0	2.3	1.6	0.9	2.2	5.6	1.8	6.9	10.6	2.5
6/26/97	San Pablo Bay	White Croaker	On	5	26	6.4	115	0.7	0.9	4.7	2.7	1.5	1.0	0.7	1.6	3.5	1.4	4.4	7.0	1.5
7/9/97	San Pablo Bay	White Croaker	On	5	27	3.3	145	0.9	1.0	2.1	0.7	1.7	1.0	0.9	1.3	3.6	1.2	5.3	7.8	1.7
6/13/97	Berkeley	White Croaker	Off	5	NA	4.7	108	0.7	0.8	6.4	0.8	1.6	0.8	0.8	1.5	2.7	1.2	4.1	6.5	1.6
6/11/97	Oakland	White Croaker	Off	5	NA	5.5	312	2.4	3.1	6.8	5.2	5.1	3.7	2.4	4.9	10.7	4.2	12.9	21.3	5.8
7/1/97	S.F. Waterfront	White Croaker	Off	5	25	5.3	158	0.9	1.1	3.1	3.7	2.1	1.8	1.0	2.2	4.8	1.9	6.1	10.3	2.6
6/23/97	San Pablo Bay	White Croaker	Off	5	NA	4.7	100	0.6	0.6	1.9	2.5	1.2	0.9	0.5	1.2	3.5	1.2	4.0	5.8	1.3

On—Skin on muscle, On+ —Skin on muscle with skeleton, Off—Skin off muscle

Table 3. PCB concentrations (ng/g wet) in fish tissue, 1997 (continued).
ND = not detected. Aroclor concentrations were estimated from the congener data.

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Avg Length (cm)	% Lipid	Sum of PCB Congeners (SFEI)	PCB 110	PCB 118	PCB 128	PCB 132	PCB 137	PCB 138	PCB 141	PCB 149	PCB 151	PCB 153	PCB 156	PCB 157	PCB 158
6/12/97	Berkeley	Halibut	Off	1	75	0.4	12	0.4	0.6	ND	ND	ND	1.7	ND	1.0	0.5	2.7	ND	ND	0.3
6/13/97	Berkeley	Halibut	Off	1	79	0.5	12	0.6	0.8	ND	ND	ND	2.2	ND	1.0	0.5	3.2	ND	ND	0.3
6/13/97	Berkeley	Halibut	Off	1	60	0.3	7	0.5	0.5	ND	ND	ND	1.4	ND	0.6	0.3	2.0	ND	ND	ND
6/17/97	Berkeley	Halibut	Off	1	73	0.3	12	0.5	0.8	0.4	ND	ND	1.9	ND	0.9	0.4	2.6	ND	ND	0.3
3/28/97	San Pablo Bay	Halibut	Off	1	92	0.3	8	0.3	0.4	ND	ND	ND	1.1	ND	0.7	0.3	2.1	ND	ND	ND
6/24/97	San Pablo Bay	Halibut	Off	1	59	0.4	7	0.4	0.4	ND	ND	ND	1.1	ND	0.5	0.3	1.5	ND	ND	ND
7/23/97	San Pablo Bay	Halibut	Off	1	77	0.2	11	0.6	0.6	ND	ND	ND	1.5	ND	0.9	0.4	2.2	ND	ND	0.3
6/3/97	South Bay Bridges	Halibut	Off	1	55	0.5	34	1.5	2.1	0.7	0.4	ND	5.7	0.5	2.3	1.2	8.6	ND	ND	0.6
6/12/97	Berkeley	Jacksmelt	On+	5	25	1.6	21	1.2	1.4	0.4	0.4	ND	2.5	ND	1.4	0.6	3.6	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	26	3.2	14	0.8	1.0	0.3	0.3	ND	2.5	ND	1.2	0.4	3.2	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	26	3.2	22	1.0	1.7	0.4	0.4	ND	4.3	0.2	1.3	0.7	5.4	ND	ND	0.3
6/30/97	Oakland	Jacksmelt	On+	5	27	1.4	137	8.1	10.4	2.4	2.4	0.6	17.6	1.0	9.8	4.0	23.3	1.0	0.3	1.8
6/30/97	Oakland	Jacksmelt	On+	5	26	1.9	112	5.8	9.2	2.2	1.8	0.5	16.8	0.9	8.5	3.7	23.0	0.8	0.4	1.7
7/2/97	Oakland	Jacksmelt	On+	5	28	3.4	211	13.6	15.5	3.3	3.8	0.7	30.0	2.1	14.0	6.9	39.8	1.2	ND	3.1
6/19/97	S.F. Waterfront	Jacksmelt	On+	5	25	1.8	20	0.9	1.3	0.3	0.3	ND	2.7	ND	1.3	0.5	4.3	ND	ND	ND
7/10/97	S.F. Waterfront	Jacksmelt	On+	5	25	1.5	33	1.2	1.3	0.4	0.7	ND	4.4	0.6	2.8	1.3	6.8	ND	ND	1.7
7/11/97	S.F. Waterfront	Jacksmelt	On+	5	25	2.5	24	1.1	1.2	0.5	0.5	ND	2.9	0.4	1.9	0.8	4.1	ND	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	27	1.5	36	1.8	1.9	0.8	0.7	ND	5.2	0.4	2.6	1.2	7.6	ND	ND	0.5
7/9/97	San Pablo Bay	Jacksmelt	On+	5	27	1.4	46	2.1	3.0	0.8	0.9	ND	8.5	0.4	2.7	1.5	10.3	0.3	ND	0.6
7/9/97	San Pablo Bay	Jacksmelt	On+	5	28	2.4	27	1.2	1.4	0.6	0.5	ND	3.8	0.3	1.8	0.9	5.8	ND	ND	0.4
6/13/97	Berkeley	Leopard Shark	Off	3	92	0.2	9	ND	0.7	0.3	ND	ND	2.6	ND	ND	ND	4.3	ND	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	98	0.2	8	ND	0.8	ND	ND	ND	2.3	ND	ND	ND	4.0	ND	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	100	0.3	3	ND	0.3	ND	ND	ND	1.0	ND	ND	ND	1.5	ND	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	93	0.3	5	ND	0.5	ND	ND	ND	1.4	ND	ND	ND	2.5	ND	ND	ND
7/9/97	San Pablo Bay	Leopard Shark	Off	1	114	0.3	4	ND	0.4	ND	ND	ND	1.0	ND	ND	ND	1.9	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	95	0.2	12	ND	1.2	0.3	ND	ND	3.2	ND	ND	ND	4.6	ND	ND	0.3
6/2/97	South Bay Bridges	Leopard Shark	Off	3	118	0.6	19	0.3	1.7	0.7	ND	ND	4.2	ND	ND	ND	7.4	0.3	ND	0.6
6/2/97	South Bay Bridges	Leopard Shark	Off	3	96	0.1	6	ND	0.6	ND	ND	ND	1.8	ND	ND	ND	2.9	ND	ND	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	12	3.9	110	4.5	6.7	1.8	1.4	0.4	20.9	1.6	4.6	4.0	22.1	1.3	ND	1.7
6/12/97	Berkeley	Shiner Surf Perch	On+	20	12	2.6	91	2.8	5.6	1.4	0.9	0.5	13.6	1.1	3.5	2.9	19.9	1.1	0.3	1.4
6/13/97	Berkeley	Shiner Surf Perch	On+	20	12	2.1	96	3.1	5.0	1.4	1.0	0.5	13.4	1.3	4.5	2.9	19.3	1.1	0.5	1.3
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	2.5	423	26.6	37.4	8.4	5.2	1.8	68.8	5.2	21.7	13.2	80.8	4.9	1.0	5.7
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	2.9	515	32.5	46.9	11.6	8.7	2.3	88.5	6.9	24.3	15.9	92.5	6.8	0.4	7.4
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	1.9	486	22.2	42.7	10.0	5.6	2.5	82.9	6.0	21.2	13.2	102.0	6.0	0.9	8.0
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	2.0	131	4.6	9.8	2.0	1.3	0.9	19.8	1.8	5.5	3.9	25.7	1.8	0.4	2.1
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	3.0	152	7.0	13.5	2.7	1.7	0.9	24.0	2.2	5.5	4.6	28.1	2.3	ND	2.5
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	1.7	184	12.1	13.0	2.6	3.1	0.9	30.6	3.2	8.0	5.2	32.8	2.4	ND	2.6
6/23/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	2.6	77	3.6	4.9	1.4	1.0	ND	14.9	1.1	3.3	2.7	14.1	0.7	ND	1.1
7/9/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	2.4	58	2.5	3.8	1.0	0.7	ND	11.8	0.6	2.3	2.0	12.0	0.6	ND	0.9
7/24/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	1.5	45	1.9	2.5	1.0	0.5	ND	7.1	0.5	2.2	1.6	10.3	0.6	ND	0.8
5/27/97	South Bay Bridges	Shiner Surf Perch	On+	20	13	4.0	172	6.1	10.3	2.9	1.9	0.6	29.3	2.0	7.2	6.1	39.0	1.7	0.4	2.4
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	12	1.9	81	2.6	4.6	1.7	0.8	0.2	11.6	0.8	3.9	2.3	18.2	0.6	0.3	1.0
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	12	2.6	111	4.7	6.9	0.6	1.4	0.3	20.4	1.3	4.6	4.0	22.9	1.0	ND	1.5
6/13/97	Berkeley	Striped Bass	Off	3	51	4.1	33	1.4	2.1	0.9	ND	ND	5.0	0.6	2.6	1.1	7.6	ND	ND	0.5
6/18/97	Berkeley	Striped Bass	Off	2	69	1.6	28	1.2	1.7	0.6	ND	ND	4.3	0.5	2.2	0.9	6.4	ND	ND	0.4
7/8/97	Davis Point	Striped Bass	Off	3	51	0.5	29	1.5	1.6	0.6	0.5	ND	4.4	0.4	2.1	1.0	6.0	ND	ND	0.4
7/8/97	Davis Point	Striped Bass	Off	3	64	0.8	7	0.6	0.5	ND	ND	ND	1.3	ND	0.7	0.3	1.7	ND	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	53	0.8	11	0.6	0.6	0.4	ND	ND	1.6	ND	1.1	0.4	2.5	ND	ND	0.3
6/20/97	San Pablo Bay	Striped Bass	Off	3	51	1.0	21	0.9	1.1	0.5	0.3	ND	2.9	0.2	1.6	0.7	4.3	ND	2.6	0.4
6/20/97	San Pablo Bay	Striped Bass	Off	3	64	0.8	23	1.2	1.4	0.5	0.4	ND	3.8	0.4	1.3	0.8	5.2	ND	ND	0.4
6/2/97	South Bay Bridges	Striped Bass	Off	3	50	0.5	22	0.9	1.2	0.6	0.3	ND	2.7	0.3	1.4	0.8	3.8	ND	2.6	0.2
6/2/97	South Bay Bridges	Striped Bass	Off	2	66	0.5	22	1.0	1.2	0.5	0.3	ND	3.2	0.3	1.8	0.8	4.7	ND	ND	0.3
6/27/97	Suisun Bay	Striped Bass	Off	3	51	0.6	14	0.8	0.9	0.2	0.3	ND	2.3	ND	1.1	0.5	3.3	ND	ND	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	124	1.3	33	1.5	1.0	ND	0.3	ND	6.2	0.3	3.5	1.6	8.0	ND	ND	0.6
10/8/97	San Pablo Bay	Sturgeon	Off	3	142	1.3	28	1.9	0.8	0.5	0.7	ND	5.0	0.3	2.7	1.3	5.8	ND	ND	0.4
3/12/97	South Bay Bridges	Sturgeon	Off	3	121	0.6	10	0.5	0.2	0.3	ND	ND	1.6	ND	1.1	0.4	2.2	ND	ND	ND
3/12/97	South Bay Bridges	Sturgeon	Off	2	142	1.5	31	1.8	0.9	0.5	0.7	ND	5.6	0.3	2.7	1.3	6.2	ND	ND	0.4
6/13/97	Berkeley	White Croaker	On	5	27	6.4	220	9.8	11.6	2.2	4.6	0.9	30.8	3.4	17.0	7.2	41.0	2.0	0.7	2.6
6/13/97	Berkeley	White Croaker	On	5	24	7.4	162	9.2	8.2	2.6	3.9	0.5	28.0	2.3	11.0	6.1	26.3	1.4	ND	2.0
6/13/97	Berkeley	White Croaker	On	5	24	6.1	164	8.7	8.7	2.8	3.3	0.4	26.2	2.2	11.8	5.9	28.9	1.0	0.4	1.9
6/13/97	Berkeley	White Croaker	On	5	23	5.4	141	6.3	7.2	1.5	2.6	0.4	21.1	2.6	10.9	4.6	25.9	1.1	1.0	1.9
6/11/97	Oakland	White Croaker	On	5	25	7.5	364	24.5	22.6	5.9	10.0	1.1	54.8	5.6	22.6	12.9	53.9	3.8	ND	4.2
7/2/97	Oakland	White Croaker	On	5	26	7.3	589	34.4	38.5	10.4	14.3	2.0	85.5	9.2	39.4	20.4	106.0	5.2	0.4	7.6
7/2/97	Oakland	White Croaker	On	5	24	7.7	265	13.8	15.6	4.8	5.4	1.1	33.0	4.0	20.5	7.7	41.8	2.2	0.7	3.1
7/11/97	Oakland	White Croaker	On	5	27	6.8	338	18.0	20.7	6.0	6.9	1.3	44.1	4.5	25.2	10.2	55.6	3.1	0.7	3.9
7/1/97	S.F. Waterfront	White Croaker	On	5	25	7.3	268	17.0	15.3	4.1	6.8	1.0	44.1	4.2	17.0	9.7	45.0	2.5	ND	3.9
7/1/97	S.F. Waterfront	White Croaker	On	5	25	7.6	253	12.2	12.8	4.1	4.4	1.0	30.7	4.0	18.8	6.2	40.0	2.2	0.4	3.0
7/10/97	S.F. Waterfront	White Croaker	On	5	23	5.2	153	7.7	8.8	3.0	3.0	0.7	19.0	2.5	11.6	4.8	24.1	1.6	0.6	1.9
6/23/97	San Pablo Bay	White Croaker	On	5	26	9.3	182	10.2	8.8	2.7	4.1	0.6	30.8	2.5	12.0	6.9	30.5	1.7	ND	2.2
6/26/97	San Pablo Bay	White Croaker	On	5	26	6.4	115	5.2	5.8	2.3	2.4	0.5	14.5	1.6	8.8	3.6	19.1	1.1	ND	1.3
7/9/97	San Pablo Bay	White Croaker	On	5	27	3.3	145	5.8	7.0	3.3	2.4	0.5	17.5	2.0	10.2	4.7	24.4	0.9	0.5	1.7
6/13/97	Berkeley	White Croaker	Off	5	NA	4.7	108	4.6	5.4	2.2	2.0	0.4	14.1	1.6	8.1	3.4	18.6	0.9	0.3	1.3
6/11/97	Oakland	White Croaker	Off	5	NA	5.5	312	21.1	19.1	5.6	8.1	1.0	47.7	4.7	20.9	11.0	47.7	2.7	ND	4.3
7/1/97	S.F. Waterfront	White Croaker	Off	5	25	5.3	158	10.3	8.9	2.5	3.9	0.5	26.9	2.4	10.1	5.6	25.1	1.3	ND	2.2
6/23/97	San Pablo Bay	White Croaker	Off	5	NA	4.7	100	5.5	4.9	1.6	2.1	ND	16.5	1.4	7.0	3.6	16.7	0.9	ND	1.1

On—Skin on muscle, On+ —Skin on muscle with skeleton, Off—Skin off muscle

Table 3. PCB concentrations (ng/g wet) in fish tissue, 1997 (continued).
ND = not detected. Aroclor concentrations were estimated from the congener data.

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Avg Length (cm)	% Lipid	Sum of PCB Congeners (SFEI)	PCB 170	PCB 174	PCB 177	PCB 180	PCB 183	PCB 187	PCB 189	PCB 194	PCB 195	PCB 201	PCB 203	PCB 206	PCB 209
6/12/97	Berkeley	Halibut	Off	1	75	0.4	12	0.4	0.3	0.4	1.5	0.5	1.5	ND	0.3	ND	0.4	0.4	ND	ND
6/13/97	Berkeley	Halibut	Off	1	79	0.5	12	0.4	ND	0.4	1.3	0.5	1.5	ND	ND	ND	0.3	ND	ND	ND
6/13/97	Berkeley	Halibut	Off	1	60	0.3	7	0.3	ND	0.3	1.0	0.3	1.0	ND	ND	ND	ND	ND	ND	ND
6/17/97	Berkeley	Halibut	Off	1	73	0.3	12	0.5	ND	0.5	1.6	0.5	1.5	ND	ND	ND	0.3	0.3	ND	ND
3/28/97	San Pablo Bay	Halibut	Off	1	92	0.3	8	0.3	ND	0.3	1.2	0.4	1.3	ND	ND	ND	0.3	ND	ND	ND
6/24/97	San Pablo Bay	Halibut	Off	1	59	0.4	7	0.3	ND	0.3	0.9	0.3	0.9	ND	ND	ND	ND	ND	ND	ND
7/23/97	San Pablo Bay	Halibut	Off	1	77	0.2	11	0.4	ND	0.5	1.4	0.5	1.7	ND	0.2	ND	0.3	0.3	ND	ND
6/3/97	South Bay Bridges	Halibut	Off	1	55	0.5	34	1.0	0.4	1.2	3.2	1.3	4.2	ND	0.5	ND	0.7	0.7	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	25	1.6	21	0.4	ND	0.4	1.1	0.4	1.0	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	26	3.2	14	0.3	ND	0.4	0.9	0.4	1.2	ND	ND	ND	0.2	0.3	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	26	3.2	22	0.3	0.3	0.7	1.4	0.6	1.9	ND	ND	ND	0.4	0.4	ND	ND
6/30/97	Oakland	Jacksmelt	On+	5	27	1.4	137	1.3	0.8	3.8	4.9	2.8	6.7	ND	0.5	0.2	0.7	0.8	0.2	ND
6/30/97	Oakland	Jacksmelt	On+	5	26	1.9	112	1.5	0.8	2.4	5.1	2.9	6.7	ND	0.6	ND	0.8	0.7	ND	ND
7/2/97	Oakland	Jacksmelt	On+	5	28	3.4	211	2.4	1.7	3.9	9.8	5.3	12.0	ND	1.1	0.4	1.6	1.6	0.6	ND
6/19/97	S.F. Waterfront	Jacksmelt	On+	5	25	1.8	20	0.5	0.3	0.5	1.5	0.6	1.4	ND	0.3	ND	0.4	0.3	ND	ND
7/10/97	S.F. Waterfront	Jacksmelt	On+	5	25	1.5	33	0.9	1.0	1.1	3.3	1.4	3.5	ND	0.5	ND	0.7	0.7	ND	ND
7/11/97	S.F. Waterfront	Jacksmelt	On+	5	25	2.5	24	0.7	0.6	0.7	2.2	0.8	2.0	ND	0.4	ND	0.5	0.4	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	27	1.5	36	0.8	0.5	1.0	2.6	1.1	3.1	ND	0.4	ND	0.7	0.5	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	27	1.4	46	0.9	0.5	1.2	2.8	1.3	4.0	ND	0.5	ND	0.8	0.6	0.3	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	28	2.4	27	0.7	0.4	0.9	2.0	0.9	2.4	ND	0.3	ND	0.6	0.4	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	92	0.2	9	0.5	ND	ND	1.8	0.6	0.9	ND	0.3	ND	ND	0.3	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	98	0.2	8	0.4	ND	ND	1.7	0.5	0.9	ND	0.3	ND	ND	0.3	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	100	0.3	3	ND	ND	ND	0.6	ND	0.4	ND	ND	ND	ND	ND	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	93	0.3	5	0.3	ND	ND	1.1	0.4	0.8	ND	ND	ND	ND	ND	ND	ND
7/9/97	San Pablo Bay	Leopard Shark	Off	1	114	0.3	4	0.2	ND	ND	0.9	0.3	0.5	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	95	0.2	12	0.5	ND	ND	1.7	0.6	1.5	ND	0.3	ND	0.2	0.3	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	118	0.6	19	0.8	ND	0.3	2.8	1.1	2.7	ND	0.4	ND	0.4	0.5	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	96	0.1	6	0.3	ND	ND	1.0	0.4	1.0	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	12	3.9	110	3.1	0.7	3.1	10.5	3.5	8.9	ND	1.2	ND	1.6	1.3	0.4	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	12	2.6	91	2.9	0.5	2.7	9.5	3.2	8.2	0.2	1.3	0.3	1.4	1.4	0.3	ND
6/13/97	Berkeley	Shiner Surf Perch	On+	20	12	2.1	96	3.1	0.8	3.1	10.6	3.4	8.2	ND	1.4	0.4	1.6	1.5	0.4	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	2.5	423	8.2	1.9	7.9	30.4	10.5	25.0	0.3	2.7	1.0	2.7	4.1	0.7	0.2
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	2.9	515	9.5	2.2	8.3	31.3	10.9	24.3	0.5	3.4	1.3	3.2	4.7	1.3	0.4
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	1.9	486	10.7	1.5	9.2	34.0	11.6	27.7	0.7	4.6	1.8	3.8	5.9	1.3	0.7
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	2.0	131	3.8	0.6	3.5	11.6	4.1	9.5	0.3	1.5	0.4	1.6	1.7	0.3	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	3.0	152	3.9	0.6	3.6	12.0	4.2	10.7	ND	1.4	0.4	1.5	1.7	0.5	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	1.7	184	4.3	0.9	3.5	14.3	4.7	10.0	0.2	1.6	0.5	1.7	1.9	0.5	ND
6/23/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	2.6	77	1.8	0.4	2.1	6.5	2.4	5.8	ND	0.7	ND	0.9	0.9	0.3	ND
7/9/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	2.4	58	1.4	ND	1.6	5.3	2.0	4.9	ND	0.6	ND	0.7	0.8	0.3	ND
7/24/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	1.5	45	1.4	ND	1.5	4.2	1.7	4.5	ND	0.6	ND	0.6	0.7	ND	ND
5/27/97	South Bay Bridges	Shiner Surf Perch	On+	20	13	4.0	172	5.2	1.0	6.1	17.4	6.4	18.6	ND	2.3	0.6	2.8	2.7	0.8	0.3
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	12	1.9	81	2.6	0.6	3.2	8.7	3.5	10.1	ND	1.2	0.4	1.4	1.5	0.4	ND
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	12	2.6	111	2.9	0.6	3.7	10.1	4.0	11.3	ND	1.2	0.4	1.5	1.5	0.4	ND
6/13/97	Berkeley	Striped Bass	Off	3	51	4.1	33	0.8	0.6	0.9	3.1	1.1	3.2	ND	0.4	ND	0.6	0.5	ND	ND
6/18/97	Berkeley	Striped Bass	Off	2	69	1.6	28	0.7	0.5	0.8	2.7	1.0	2.8	ND	0.4	ND	0.5	0.5	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	51	0.5	29	0.7	0.5	0.8	2.5	0.9	2.9	ND	0.4	ND	0.5	0.5	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	64	0.8	7	0.3	ND	ND	0.8	0.3	0.7	ND	ND	ND	ND	ND	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	53	0.8	11	0.3	ND	0.4	1.1	0.4	1.3	ND	ND	ND	0.3	ND	ND	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	51	1.0	21	0.4	0.3	0.5	1.5	0.6	1.8	ND	ND	ND	0.3	0.3	ND	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	64	0.8	23	0.6	0.3	0.7	2.2	0.8	2.4	ND	0.3	ND	0.5	0.4	ND	ND
6/2/97	South Bay Bridges	Striped Bass	Off	3	50	0.5	22	0.7	0.3	0.8	2.1	0.7	2.4	ND	0.3	ND	0.4	0.4	ND	ND
6/2/97	South Bay Bridges	Striped Bass	Off	2	66	0.5	22	0.6	0.4	0.8	2.2	0.8	2.5	ND	0.3	ND	0.5	0.5	ND	ND
6/27/97	Suisun Bay	Striped Bass	Off	3	51	0.6	14	0.4	0.2	0.4	1.4	0.5	1.6	ND	0.2	ND	0.3	0.3	ND	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	124	1.3	33	0.4	0.4	1.1	2.0	1.2	3.6	ND	0.3	ND	0.4	0.3	ND	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	142	1.3	28	0.4	0.3	1.1	1.4	0.9	2.8	ND	ND	ND	0.2	ND	ND	ND
3/12/97	South Bay Bridges	Sturgeon	Off	3	121	0.6	10	0.3	ND	0.6	1.2	0.5	1.5	ND	ND	ND	0.3	0.2	ND	ND
3/12/97	South Bay Bridges	Sturgeon	Off	2	142	1.5	31	0.6	0.4	1.2	2.1	1.0	3.1	ND	0.4	ND	0.4	0.4	ND	ND
6/13/97	Berkeley	White Croaker	On	5	27	6.4	220	5.8	4.3	6.2	19.7	6.4	18.3	ND	ND	0.8	3.8	3.4	1.0	0.6
6/13/97	Berkeley	White Croaker	On	5	24	7.4	162	3.4	2.8	4.3	11.9	4.1	11.3	ND	1.6	0.4	2.4	1.8	0.7	0.4
6/13/97	Berkeley	White Croaker	On	5	24	6.1	164	3.8	3.3	4.8	15.0	4.8	15.0	ND	1.6	0.5	2.5	2.0	0.5	0.4
6/13/97	Berkeley	White Croaker	On	5	23	5.4	141	3.8	3.2	4.1	13.1	4.2	11.8	ND	1.9	0.5	2.7	2.4	0.8	0.4
6/11/97	Oakland	White Croaker	On	5	25	7.5	364	6.8	5.9	7.2	22.6	7.8	20.1	0.3	3.2	1.0	4.4	3.9	1.5	0.5
7/2/97	Oakland	White Croaker	On	5	26	7.3	589	13.0	9.2	12.6	46.0	14.5	39.1	0.6	5.7	1.9	6.8	6.8	2.3	1.0
7/2/97	Oakland	White Croaker	On	5	24	7.7	265	5.7	4.2	6.4	18.6	6.4	16.2	0.3	2.4	0.8	2.9	3.1	0.7	0.4
7/11/97	Oakland	White Croaker	On	5	27	6.8	338	6.8	4.9	7.4	22.5	7.8	21.4	0.4	3.5	1.1	4.0	4.1	1.1	0.6
7/1/97	S.F. Waterfront	White Croaker	On	5	25	7.3	268	5.9	4.4	6.0	20.1	6.5	17.4	ND	2.4	0.7	3.4	3.0	0.9	0.3
7/1/97	S.F. Waterfront	White Croaker	On	5	25	7.6	253	7.4	4.1	12.8	23.9	7.3	17.4	0.4	3.1	1.0	3.2	3.7	0.6	0.3
7/10/97	S.F. Waterfront	White Croaker	On	5	23	5.2	153	3.8	2.8	3.8	12.3	4.1	9.8	ND	1.8	0.5	2.3	2.3	0.6	0.3
6/23/97	San Pablo Bay	White Croaker	On	5	26	9.3	182	3.9	3.0	5.1	14.2	4.9	14.7	ND	1.8	0.4	2.8	2.1	1.1	0.3
6/26/97	San Pablo Bay	White Croaker	On	5	26	6.4	115	2.7	1.9	3.1	9.0	3.1	9.2	ND	1.4	0.4	1.9	1.7	0.6	0.4
7/9/97	San Pablo Bay	White Croaker	On	5	27	3.3	145	4.2	3.2	5.2	14.8	5.2	15.3	ND	2.4	0.7	3.2	3.2	1.1	0.5
6/13/97	Berkeley	White Croaker	Off	5	NA	4.7	108	2.8	2.1	3.1	9.6	3.1	8.6	ND	1.4	0.3	1.8	1.6	0.4	ND
6/11/97	Oakland	White Croaker	Off	5	NA	5.5	312	5.9	4.7	6.4	20.2	6.5	17.5	ND	2.6	0.7	3.4	3.4	1.4	ND
7/1/97	S.F. Waterfront	White Croaker	Off	5	25	5.3	158	3.3	2.5	3.5	11.6	3.7	9.4	ND	1.3	0.3	1.9	1.7	0.6	ND
6/23/97	San Pablo Bay	White Croaker	Off	5	NA	4.7	100	2.1	1.6	3.0	7.9	2.7	8.4	ND	0.9	ND	1.5	1.1	0.5	ND

On—Skin on muscle, On+ —Skin on muscle with skeleton, Off—Skin off muscle

Table 4. Pesticide concentrations (ng/g wet) in fish tissue, 1997. ND = not detected.

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Range of Lengths (cm)	Avg Length (cm)	% Moisture	% Lipid	Total DDTs (SFEI)	o,p'-DDD	o,p'-DDE	o,p'-DDT	p,p'-DDD	p,p'-DDE	p,p'-DDMS	p,p'-DDMU	p,p'-DDT	p,p'-Dichlorobenzophenone
6/12/97	Berkeley	Halibut	Off	1	75	75	74	0.4	6.9	ND	ND	ND	1.5	5.4	ND	1.6	ND	ND
6/13/97	Berkeley	Halibut	Off	1	79	79	76	0.5	6.7	ND	ND	ND	1.3	5.3	ND	ND	ND	ND
6/13/97	Berkeley	Halibut	Off	1	60	60	74	0.3	4.8	ND	ND	ND	1.1	3.7	ND	ND	ND	ND
6/17/97	Berkeley	Halibut	Off	1	73	73	75	0.3	6.5	ND	ND	ND	1.3	5.1	ND	5.1	ND	ND
3/28/97	San Pablo Bay	Halibut	Off	1	92	92	77	0.3	6.5	ND	ND	ND	1.1	5.4	ND	ND	ND	ND
6/24/97	San Pablo Bay	Halibut	Off	1	59	59	73	0.4	6.2	ND	ND	ND	1.0	5.2	ND	ND	ND	ND
7/23/97	San Pablo Bay	Halibut	Off	1	77	77	77	0.2	10.4	ND	ND	ND	2.2	8.1	ND	1.2	ND	ND
6/3/97	South Bay Bridges	Halibut	Off	1	55	55	74	0.5	14.1	ND	ND	ND	2.5	11.6	ND	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	24-28.5	25	74	1.6	41.0	ND	ND	ND	4.9	34.3	ND	5.9	1.8	ND
6/12/97	Berkeley	Jacksmelt	On+	5	24-27	26	75	3.2	28.1	ND	ND	ND	1.1	27.0	ND	3.9	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	22-30	26	76	3.2	33.0	ND	ND	ND	2.6	29.2	ND	2.5	1.2	ND
6/30/97	Oakland	Jacksmelt	On+	5	25-30	27	82	1.4	35.5	ND	ND	ND	5.1	29.0	ND	3.8	1.4	ND
6/30/97	Oakland	Jacksmelt	On+	5	23-29	26	78	1.9	40.5	ND	ND	ND	4.5	33.7	ND	3.3	2.3	ND
7/2/97	Oakland	Jacksmelt	On+	5	27-29	28	69	3.4	48.3	ND	ND	ND	10.4	36.0	ND	7.1	1.9	ND
6/19/97	S.F. Waterfront	Jacksmelt	On+	5	20.5-28.5	25	75	1.8	34.2	ND	ND	ND	1.5	31.4	ND	4.3	1.4	ND
7/10/97	S.F. Waterfront	Jacksmelt	On+	5	21-30	25	74	1.5	11.7	ND	ND	ND	3.1	8.6	ND	1.6	ND	ND
7/11/97	S.F. Waterfront	Jacksmelt	On+	5	21-27	25	75	2.5	33.9	ND	ND	ND	3.3	27.3	ND	4.9	3.3	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	26-28	27	75	1.5	33.2	ND	ND	ND	4.5	27.6	ND	3.3	1.1	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	25-29	27	71	1.4	34.9	ND	ND	ND	5.1	29.8	ND	3.5	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	26-30	28	74	2.4	25.6	ND	ND	ND	3.8	21.8	ND	6.1	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	91-93	92	76	0.2	5.8	ND	ND	ND	1.0	4.8	ND	1.7	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	92-102	98	75	0.2	5.0	ND	ND	ND	ND	5.0	ND	1.3	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	99-100	100	75	0.3	3.4	ND	ND	ND	ND	3.4	ND	ND	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	91.5-94	93	76	0.3	4.6	ND	ND	ND	ND	4.6	ND	ND	ND	ND
7/9/97	San Pablo Bay	Leopard Shark	Off	1	114	114	78	0.3	5.7	ND	ND	ND	ND	5.7	ND	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	93-97	95	76	0.2	7.5	ND	ND	ND	1.1	6.4	ND	1.9	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	108-135	118	77	0.6	11.2	ND	ND	ND	1.3	9.9	ND	1.9	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	94-99	96	77	0.1	4.1	ND	ND	ND	ND	4.1	ND	ND	ND	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	11-14.5	12	71	3.9	69.3	3.7	1.0	ND	13.6	51.0	ND	8.4	ND	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	11-12.5	12	77	2.6	63.9	1.6	0.9	1.0	9.1	49.0	ND	5.5	2.3	ND
6/13/97	Berkeley	Shiner Surf Perch	On+	20	10.5-14.5	12	77	2.1	44.1	ND	0.8	1.0	2.0	40.3	ND	1.9	ND	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	11-14.5	12	77	2.5	95.4	3.9	ND	1.1	31.8	53.6	7.0	20.3	5.0	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	10.5-14.5	12	77	2.9	95.5	3.7	ND	1.6	29.0	58.6	6.5	17.1	2.6	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	11-14	12	78	1.9	90.8	2.9	ND	1.9	21.0	60.8	ND	12.1	4.2	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	11.5-13	12	77	2.0	41.0	1.4	ND	ND	7.1	31.1	ND	9.1	1.4	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	11.5-13	12	76	3.0	54.5	2.1	ND	ND	8.9	41.8	ND	4.1	1.7	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	10.5-13	12	78	1.7	48.7	2.7	ND	0.9	15.5	28.3	ND	5.2	1.3	ND
6/23/97	San Pablo Bay	Shiner Surf Perch	On+	20	10.5-14	12	78	2.6	50.3	2.5	ND	ND	11.1	35.7	ND	4.9	1.0	ND
7/9/97	San Pablo Bay	Shiner Surf Perch	On+	20	10-15	12	76	2.4	55.9	3.9	ND	ND	20.1	30.9	ND	5.6	1.0	ND
7/24/97	San Pablo Bay	Shiner Surf Perch	On+	20	10.5-12.5	12	76	1.5	27.3	ND	ND	ND	4.4	21.8	ND	3.3	1.1	ND
5/27/97	South Bay Bridges	Shiner Surf Perch	On+	20	11-15	13	68	4.0	68.9	2.6	ND	ND	9.9	54.3	ND	8.2	2.0	ND
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	10.5-14.5	12	79	1.9	30.7	ND	ND	ND	6.3	22.2	ND	ND	2.3	ND
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	11-15	12	79	2.6	35.7	1.3	ND	ND	4.9	29.5	ND	4.7	ND	ND
6/13/97	Berkeley	Striped Bass	Off	3	50-52	51	73	4.1	42.8	2.8	ND	ND	5.1	32.7	ND	7.7	2.2	ND
6/18/97	Berkeley	Striped Bass	Off	2	63,75	69	72	1.6	24.6	ND	ND	ND	3.8	19.3	ND	6.8	1.5	ND
7/8/97	Davis Point	Striped Bass	Off	3	50-53	51	77	0.5	27.2	ND	ND	ND	2.9	23.2	ND	1.9	1.1	ND
7/8/97	Davis Point	Striped Bass	Off	3	60-68	64	75	0.8	16.1	ND	ND	ND	2.1	14.0	ND	1.9	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	48-56	53	77	0.8	15.1	ND	ND	ND	3.0	11.0	ND	3.8	1.1	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	50-52	51	75	1.0	14.1	ND	ND	ND	3.7	10.4	ND	4.6	ND	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	61-66	64	77	0.8	24.7	ND	ND	ND	3.5	19.9	ND	4.9	1.2	ND
6/2/97	South Bay Bridges	Striped Bass	Off	3	49-52	50	78	0.5	16.4	ND	ND	ND	2.4	12.8	ND	1.6	1.2	ND
6/2/97	South Bay Bridges	Striped Bass	Off	2	62,69	66	75	0.5	10.6	ND	ND	ND	1.8	8.8	ND	6.6	ND	ND
6/27/97	Suisun Bay	Striped Bass	Off	3	50-52	51	78	0.6	14.4	ND	ND	ND	2.1	11.4	ND	2.1	0.9	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	117-128	124	74	1.3	25.5	1.6	ND	ND	4.7	17.9	ND	4.2	1.3	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	140-145	142	77	1.3	21.2	1.3	ND	ND	3.7	14.7	ND	3.8	1.5	ND
3/12/97	South Bay Bridges	Sturgeon	Off	3	119-124	121	79	0.6	5.4	ND	ND	ND	1.1	4.4	ND	ND	ND	ND
3/12/97	South Bay Bridges	Sturgeon	Off	2	135,149	142	75	1.5	12.8	ND	ND	ND	3.4	9.4	ND	3.4	ND	ND
6/13/97	Berkeley	White Croaker	On	5	24-28	27	70	6.4	137.1	ND	1.6	1.3	35.3	93.2	ND	9.7	5.7	ND
6/13/97	Berkeley	White Croaker	On	5	20-30	24	72	7.4	72.1	ND	1.1	ND	16.1	52.0	ND	8.7	2.9	ND
6/13/97	Berkeley	White Croaker	On	5	21-29	24	72	6.1	77.8	ND	0.9	ND	21.6	50.3	ND	13.5	4.9	ND
6/13/97	Berkeley	White Croaker	On	5	20-29	23	68	5.4	71.7	ND	ND	ND	17.0	50.8	ND	8.2	3.9	ND
6/11/97	Oakland	White Croaker	On	5	20-28	25	70	7.5	113.5	1.8	2.9	ND	32.6	72.2	ND	9.9	4.0	ND
7/2/97	Oakland	White Croaker	On	5	21-30	26	68	7.3	163.0	2.4	1.6	ND	42.3	114.0	7.2	21.4	2.8	ND
7/2/97	Oakland	White Croaker	On	5	21-27	24	69	7.7	92.3	2.0	1.3	ND	30.4	54.4	7.7	9.8	4.2	ND
7/11/97	Oakland	White Croaker	On	5	23-30	27	72	6.8	189.2	3.4	1.9	1.6	88.4	88.1	11.0	13.4	5.8	12.5
7/1/97	S.F. Waterfront	White Croaker	On	5	22-29	25	70	7.3	86.8	ND	1.3	ND	21.0	61.6	ND	12.5	2.9	ND
7/1/97	S.F. Waterfront	White Croaker	On	5	20-30	25	70	7.6	83.8	2.1	1.0	ND	20.0	57.9	ND	7.7	2.7	8.0
7/10/97	S.F. Waterfront	White Croaker	On	5	20-30	23	73	5.2	66.5	ND	0.9	ND	17.8	45.0	ND	8.6	2.8	ND
6/23/97	San Pablo Bay	White Croaker	On	5	23-29	26	69	9.3	94.1	ND	1.3	ND	23.5	64.5	ND	12.6	4.7	ND
6/26/97	San Pablo Bay	White Croaker	On	5	23-29	26	66	6.4	71.0	ND	ND	ND	13.9	54.9	ND	6.1	2.2	ND
7/9/97	San Pablo Bay	White Croaker	On	5	22-30	27	73	3.3	62.2	ND	ND	ND	16.7	41.1	ND	10.9	4.4	ND
6/13/97	Berkeley	White Croaker	Off	5	24-28	NA	69	4.7	57.0	ND	ND	ND	16.6	37.7	ND	8.3	2.7	ND
6/11/97	Oakland	White Croaker	Off	5	20-28	NA	65	5.5	93.7	ND	1.2	ND	25.5	64.3	ND	14.9	2.7	ND
7/1/97	S.F. Waterfront	White Croaker	Off	5	22-29	25	72	5.3	50.7	ND	ND	ND	11.6	37.7	ND	6.7	1.4	ND
6/23/97	San Pablo Bay	White Croaker	Off	5	23-29	NA	67	4.7	53.0	ND	ND	ND	11.7	41.3	ND	8.2	ND	ND

On—Skin on muscle, On+ —Skin on muscle with skeleton, Off—Skin off muscle

Table 4. Pesticide concentrations (ng/g wet) in fish tissue, 1997 (continued). ND = not detected.

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Avg Length (cm)	% Lipid	Total Chlordanes (SFEI)	alpha-Chlordane	cis-Chlordane	gamma-Chlordane	trans-Chlordane	cis-Nonachlor	trans-Nonachlor	Heptachlor	Heptachlor Epoxide	Oxychlordane	alpha-HCH	beta-HCH	delta-HCH	gamma-HCH
6/12/97	Berkeley	Halibut	Off	1	75.0	0.4	1.3	ND	0.3	ND	ND	0.3	0.7	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Halibut	Off	1	79.0	0.5	1.8	ND	0.3	ND	0.8	ND	0.7	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Halibut	Off	1	60.0	0.3	0.4	ND	ND	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND
6/17/97	Berkeley	Halibut	Off	1	73.0	0.3	2.2	ND	0.3	ND	0.5	0.3	0.6	ND	ND	0.5	ND	ND	ND	ND
3/28/97	San Pablo Bay	Halibut	Off	1	92.0	0.3	0.9	ND	ND	ND	ND	ND	0.4	ND	ND	0.5	ND	ND	ND	ND
6/24/97	San Pablo Bay	Halibut	Off	1	59.0	0.4	0.4	ND	ND	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND
7/23/97	San Pablo Bay	Halibut	Off	1	77.0	0.2	2.1	ND	0.3	ND	0.7	0.3	0.8	ND	ND	ND	ND	ND	ND	ND
6/3/97	South Bay Bridges	Halibut	Off	1	55.0	0.5	2.8	ND	0.8	ND	ND	0.7	1.3	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	25.0	1.6	3.3	ND	0.5	ND	0.7	0.6	1.2	ND	ND	0.3	ND	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	26.0	3.2	2.1	ND	ND	ND	1.2	ND	0.8	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	26.0	3.2	1.6	ND	0.3	ND	ND	ND	1.0	ND	ND	0.3	ND	ND	ND	ND
6/30/97	Oakland	Jacksmelt	On+	5	27.0	1.4	6.7	ND	1.3	ND	1.1	1.0	2.8	ND	ND	0.5	ND	ND	ND	ND
6/30/97	Oakland	Jacksmelt	On+	5	26.0	1.9	6.5	ND	1.0	ND	1.2	1.2	2.7	ND	ND	0.4	ND	ND	ND	ND
7/2/97	Oakland	Jacksmelt	On+	5	28.0	3.4	11.0	ND	1.8	ND	2.5	1.2	4.5	ND	ND	0.9	ND	ND	ND	ND
6/19/97	S.F. Waterfront	Jacksmelt	On+	5	25.0	1.8	2.1	ND	0.3	ND	0.8	0.4	0.6	ND	ND	ND	ND	ND	ND	ND
7/10/97	S.F. Waterfront	Jacksmelt	On+	5	25.0	1.5	3.2	ND	0.5	ND	1.4	0.4	0.4	ND	ND	0.5	ND	ND	ND	ND
7/11/97	S.F. Waterfront	Jacksmelt	On+	5	25.0	2.5	5.1	ND	0.6	ND	1.2	0.7	1.6	ND	ND	1.0	ND	ND	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	27.0	1.5	3.9	ND	0.5	ND	1.6	0.7	1.1	ND	ND	ND	ND	ND	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	27.0	1.4	3.1	ND	0.5	ND	0.7	0.3	1.7	ND	ND	ND	ND	ND	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	28.0	2.4	3.6	ND	0.4	ND	1.0	0.7	1.5	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	92.0	0.2	0.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	98.0	0.2	0.4	ND	ND	ND	ND	ND	0.4	ND	ND	ND	ND	ND	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	100.0	0.3	0.3	ND	ND	ND	ND	ND	0.3	ND	ND	ND	ND	ND	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	93.0	0.3	1.5	ND	0.3	ND	ND	0.2	0.6	ND	ND	0.3	ND	ND	ND	ND
7/9/97	San Pablo Bay	Leopard Shark	Off	1	114.0	0.3	0.7	ND	ND	ND	ND	0.2	0.4	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	95.0	0.2	1.4	ND	0.4	ND	ND	0.4	0.7	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	118.0	0.6	4.3	ND	0.9	ND	0.5	0.7	1.8	ND	ND	0.5	ND	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	96.0	0.1	1.7	ND	0.4	ND	0.3	0.3	0.7	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	12.0	3.9	7.8	ND	1.6	ND	2.5	0.6	2.7	ND	ND	0.4	ND	ND	ND	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	12.0	2.6	6.8	ND	1.3	ND	2.1	0.9	2.1	ND	ND	0.3	ND	ND	ND	ND
6/13/97	Berkeley	Shiner Surf Perch	On+	20	12.0	2.1	1.3	ND	0.3	ND	0.3	ND	0.8	ND	ND	ND	ND	ND	ND	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	12.0	2.5	50.6	0.6	13.6	0.4	4.9	9.7	17.9	ND	ND	4.5	ND	ND	ND	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	12.0	2.9	40.2	0.7	10.6	ND	5.0	5.2	17.3	ND	ND	2.1	ND	ND	ND	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	12.0	1.9	30.9	0.5	8.3	0.6	3.5	5.3	12.2	ND	ND	1.6	ND	ND	ND	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12.0	2.0	8.8	ND	2.0	ND	1.9	1.6	2.8	ND	ND	0.4	ND	ND	ND	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12.0	3.0	6.6	ND	1.3	ND	1.5	0.8	2.6	ND	ND	0.4	ND	ND	ND	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12.0	1.7	12.6	ND	3.7	0.4	2.7	1.4	4.7	ND	ND	ND	ND	ND	ND	ND
6/23/97	San Pablo Bay	Shiner Surf Perch	On+	20	12.0	2.6	6.3	ND	1.6	ND	1.3	0.6	2.6	ND	ND	0.3	ND	ND	ND	ND
7/9/97	San Pablo Bay	Shiner Surf Perch	On+	20	12.0	2.4	5.4	ND	1.5	ND	1.3	0.5	2.2	ND	ND	ND	ND	ND	ND	ND
7/24/97	San Pablo Bay	Shiner Surf Perch	On+	20	12.0	1.5	3.8	ND	0.8	ND	0.9	0.6	1.2	ND	ND	0.3	ND	ND	ND	ND
5/27/97	South Bay Bridges	Shiner Surf Perch	On+	20	13.0	4.0	11.6	ND	2.3	ND	2.7	1.4	4.6	ND	ND	0.6	ND	ND	ND	ND
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	12.0	1.9	10.1	ND	2.2	ND	1.7	2.5	2.8	ND	ND	0.9	ND	ND	ND	ND
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	12.0	2.6	10.3	ND	2.5	ND	1.9	1.2	4.2	ND	ND	0.4	ND	ND	ND	ND
6/13/97	Berkeley	Striped Bass	Off	3	51.0	4.1	5.7	ND	1.3	ND	0.8	0.8	2.3	ND	ND	0.5	ND	ND	ND	ND
6/18/97	Berkeley	Striped Bass	Off	2	69.0	1.6	3.7	ND	0.8	ND	0.5	0.8	1.7	ND	ND	ND	ND	ND	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	51.0	0.5	3.0	ND	0.6	ND	ND	0.9	1.6	ND	ND	ND	ND	ND	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	64.0	0.8	1.6	ND	0.5	ND	ND	0.4	0.8	ND	ND	ND	ND	ND	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	53.0	0.8	3.7	ND	0.8	ND	0.5	0.8	1.3	ND	ND	0.3	ND	ND	ND	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	51.0	1.0	4.5	ND	0.9	ND	0.5	0.9	1.4	ND	ND	0.6	ND	ND	ND	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	64.0	0.8	2.3	ND	0.7	ND	ND	0.5	1.1	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Striped Bass	Off	3	50.0	0.5	3.0	ND	0.6	ND	0.4	0.6	1.2	ND	ND	0.2	ND	ND	ND	ND
6/2/97	South Bay Bridges	Striped Bass	Off	2	66.0	0.5	2.5	ND	0.6	ND	0.4	0.6	1.0	ND	ND	ND	ND	ND	ND	ND
6/27/97	Suisun Bay	Striped Bass	Off	3	51.0	0.6	2.1	ND	0.4	ND	0.3	0.4	1.0	ND	ND	ND	ND	ND	ND	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	124.0	1.3	6.9	ND	1.9	ND	1.4	1.3	2.3	ND	ND	ND	ND	ND	ND	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	142.0	1.3	4.9	ND	1.5	ND	1.0	0.9	1.6	ND	ND	ND	ND	ND	ND	ND
3/12/97	South Bay Bridges	Sturgeon	Off	3	121.0	0.6	1.6	ND	0.4	ND	0.3	0.3	0.7	ND	ND	ND	ND	ND	ND	ND
3/12/97	South Bay Bridges	Sturgeon	Off	2	142.0	1.5	3.3	ND	0.9	ND	0.6	0.6	1.2	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	White Croaker	On	5	27.0	6.4	15.1	ND	3.6	0.5	2.8	2.6	5.6	ND	ND	0.6	0.8	ND	ND	0.8
6/13/97	Berkeley	White Croaker	On	5	24.0	7.4	13.7	ND	3.0	0.4	3.9	1.3	5.0	ND	ND	0.5	ND	ND	ND	ND
6/13/97	Berkeley	White Croaker	On	5	24.0	6.1	18.1	ND	4.8	ND	3.1	3.3	5.3	ND	ND	1.5	ND	ND	ND	ND
6/13/97	Berkeley	White Croaker	On	5	23.0	5.4	11.8	ND	2.9	ND	2.1	2.2	3.8	ND	ND	0.7	ND	ND	ND	ND
6/11/97	Oakland	White Croaker	On	5	25.0	7.5	21.2	0.6	4.9	0.6	5.8	2.4	6.6	0.5	ND	1.0	ND	ND	ND	ND
7/2/97	Oakland	White Croaker	On	5	26.0	7.3	33.3	0.7	6.6	0.8	7.5	4.4	12.6	0.5	ND	1.7	ND	ND	ND	ND
7/2/97	Oakland	White Croaker	On	5	24.0	7.7	23.9	0.4	5.7	0.6	6.4	3.5	7.5	ND	ND	0.9	ND	ND	ND	ND
7/11/97	Oakland	White Croaker	On	5	27.0	6.8	21.3	0.3	5.3	0.8	4.0	3.2	7.2	0.3	ND	1.2	ND	ND	ND	ND
7/1/97	S.F. Waterfront	White Croaker	On	5	25.0	7.3	19.9	0.5	5.0	0.8	5.5	1.8	6.8	ND	ND	0.9	ND	ND	ND	ND
7/1/97	S.F. Waterfront	White Croaker	On	5	25.0	7.6	21.0	0.6	5.8	0.9	5.0	2.7	6.1	ND	ND	1.5	ND	ND	ND	ND
7/10/97	S.F. Waterfront	White Croaker	On	5	23.0	5.2	17.4	ND	4.2	0.4	5.4	2.5	4.6	ND	ND	0.7	ND	ND	ND	ND
6/23/97	San Pablo Bay	White Croaker	On	5	26.0	9.3	18.4	0.3	4.0	0.4	5.7	1.8	6.0	ND	ND	1.0	ND	ND	ND	ND
6/26/97	San Pablo Bay	White Croaker	On	5	26.0	6.4	11.1	ND	2.8	ND	1.5	1.8	4.3	ND	ND	0.8	ND	ND	ND	ND
7/9/97	San Pablo Bay	White Croaker	On	5	27.0	3.3	15.8	ND	2.5	ND	2.2	3.7	4.6	ND	ND	2.8	ND	ND	ND	ND
6/13/97	Berkeley	White Croaker	Off	5	NA	4.7	9.4	ND	2.1	ND	2.0	1.6	3.3	ND	ND	0.5	ND	ND	ND	ND
6/11/97	Oakland	White Croaker	Off	5	NA	5.5	19.3	0.5	4.2	0.5	5.1	2.2	7.0	ND	ND	0.9	ND	ND	ND	ND
7/1/97	S.F. Waterfront	White Croaker	Off	5	25.0	5.3	11.7	0.3	3.2	0.5	2.9	1.0	4.1	ND	ND	0.6	ND	ND	ND	ND
6/23/97	San Pablo Bay	White Croaker	Off	5	NA	4.7	9.8	ND	1.9	ND	3.1	0.8	3.4	ND	ND	0.5	ND	ND	ND	ND

On—Skin on muscle, On+ —Skin on muscle with skeleton, Off—Skin off muscle

Table 4. Pesticide concentrations (ng/g wet) in fish tissue, 1997 (continued). ND = not detected.

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Avg Length (cm)	% Lipid	Aldrin	Dieldrin	Endrin	Chlorpyrifos	Dacthal	Endosulfan I	Endosulfan II	Endosulfan Sulfate	Hexachlorobenzene	Methoxychlor	Mirex	Oxadiazon
6/12/97	Berkeley	Halibut	Off	1	75	0.4	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Halibut	Off	1	79	0.5	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Halibut	Off	1	60	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/17/97	Berkeley	Halibut	Off	1	73	0.3	ND	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/28/97	San Pablo Bay	Halibut	Off	1	92	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/24/97	San Pablo Bay	Halibut	Off	1	59	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/23/97	San Pablo Bay	Halibut	Off	1	77	0.2	ND	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/3/97	South Bay Bridges	Halibut	Off	1	55	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	25	1.6	ND	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	26	3.2	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Jacksmelt	On+	5	26	3.2	ND	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/30/97	Oakland	Jacksmelt	On+	5	27	1.4	ND	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/30/97	Oakland	Jacksmelt	On+	5	26	1.9	ND	0.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/2/97	Oakland	Jacksmelt	On+	5	28	3.4	ND	2.5	ND	1.3	ND	ND	ND	ND	ND	ND	ND	ND
6/19/97	S.F. Waterfront	Jacksmelt	On+	5	25	1.8	ND	0.4	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND
7/10/97	S.F. Waterfront	Jacksmelt	On+	5	25	1.5	ND	0.7	ND	1.4	ND	ND	ND	ND	ND	ND	ND	ND
7/11/97	S.F. Waterfront	Jacksmelt	On+	5	25	2.5	ND	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	27	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	27	1.4	ND	1.0	ND	1.4	ND	ND	ND	ND	ND	ND	ND	ND
7/9/97	San Pablo Bay	Jacksmelt	On+	5	28	2.4	ND	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	92	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Leopard Shark	Off	3	98	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	100	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/20/97	San Pablo Bay	Leopard Shark	Off	3	93	0.3	ND	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/9/97	San Pablo Bay	Leopard Shark	Off	1	114	0.3	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	95	0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	118	0.6	ND	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Leopard Shark	Off	3	96	0.1	ND	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	12	3.9	ND	2.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/12/97	Berkeley	Shiner Surf Perch	On+	20	12	2.6	ND	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Shiner Surf Perch	On+	20	12	2.1	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	2.5	ND	4.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	2.9	ND	3.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/5/97	Oakland	Shiner Surf Perch	On+	20	12	1.9	ND	1.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	2.0	ND	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	3.0	ND	1.7	ND	1.2	ND	ND	ND	ND	ND	ND	ND	ND
6/19/97	S.F. Waterfront	Shiner Surf Perch	On+	20	12	1.7	ND	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/23/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	2.6	ND	1.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/9/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	2.4	ND	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/24/97	San Pablo Bay	Shiner Surf Perch	On+	20	12	1.5	ND	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5/27/97	South Bay Bridges	Shiner Surf Perch	On+	20	13	4.0	ND	2.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	12	1.9	ND	2.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.6
6/2/97	South Bay Bridges	Shiner Surf Perch	On+	20	12	2.6	ND	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	Striped Bass	Off	3	51	4.1	ND	2.0	ND	ND	ND	ND	ND	ND	0.6	ND	ND	ND
6/18/97	Berkeley	Striped Bass	Off	2	69	1.6	ND	1.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	51	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	64	0.8	ND	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/8/97	Davis Point	Striped Bass	Off	3	53	0.8	ND	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	51	1.0	ND	1.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/20/97	San Pablo Bay	Striped Bass	Off	3	64	0.8	ND	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Striped Bass	Off	3	50	0.5	ND	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/2/97	South Bay Bridges	Striped Bass	Off	2	66	0.5	ND	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/27/97	Suisun Bay	Striped Bass	Off	3	51	0.6	ND	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	124	1.3	ND	1.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10/8/97	San Pablo Bay	Sturgeon	Off	3	142	1.3	ND	1.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/12/97	South Bay Bridges	Sturgeon	Off	3	121	0.6	ND	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3/12/97	South Bay Bridges	Sturgeon	Off	2	142	1.5	ND	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.9
6/13/97	Berkeley	White Croaker	On	5	27	6.4	ND	3.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	White Croaker	On	5	24	7.4	ND	3.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/13/97	Berkeley	White Croaker	On	5	24	6.1	ND	5.9	ND	ND	ND	ND	ND	6.0	ND	ND	ND	ND
6/13/97	Berkeley	White Croaker	On	5	23	5.4	ND	4.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/11/97	Oakland	White Croaker	On	5	25	7.5	ND	5.1	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND
7/2/97	Oakland	White Croaker	On	5	26	7.3	ND	5.5	ND	1.5	ND	ND	ND	ND	0.4	ND	ND	ND
7/2/97	Oakland	White Croaker	On	5	24	7.7	ND	4.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/11/97	Oakland	White Croaker	On	5	27	6.8	ND	5.4	ND	ND	ND	ND	ND	ND	0.8	ND	ND	ND
7/1/97	S.F. Waterfront	White Croaker	On	5	25	7.3	ND	4.3	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND
7/1/97	S.F. Waterfront	White Croaker	On	5	25	7.6	ND	4.4	ND	ND	ND	ND	ND	ND	0.5	ND	ND	ND
7/10/97	S.F. Waterfront	White Croaker	On	5	23	5.2	ND	3.2	ND	ND	ND	ND	ND	ND	0.3	4.7	ND	ND
6/23/97	San Pablo Bay	White Croaker	On	5	26	9.3	ND	5.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/26/97	San Pablo Bay	White Croaker	On	5	26	6.4	ND	3.2	ND	ND	ND	ND	ND	ND	0.4	ND	ND	ND
7/9/97	San Pablo Bay	White Croaker	On	5	27	3.3	ND	3.6	ND	ND	ND	ND	1.7	2.5	ND	ND	ND	ND
6/13/97	Berkeley	White Croaker	Off	5	NA	4.7	ND	2.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/11/97	Oakland	White Croaker	Off	5	NA	5.5	ND	4.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7/1/97	S.F. Waterfront	White Croaker	Off	5	25	5.3	ND	2.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6/23/97	San Pablo Bay	White Croaker	Off	5	NA	4.7	ND	3.4	ND	1.8	ND	ND	ND	ND	ND	ND	ND	ND

On—Skin on muscle, On+ —Skin on muscle with skeleton, Off—Skin off muscle

Table 5. Dibenzodioxin, dibenzofuran, and PCB 077, 126, and 169 concentrations (pg/g) in fish tissue, 1997. ND = not detected, units expressed as wet weight.

Date	Station	Fish Species	Tissue Analyzed	# Homogenized	Range of Lengths (cm)	Avg Length (cm)	% Lipid	ITEQ	PCB TEQ (3 PCBs)	PCB TEQ	TOTAL TEQ	2,3,7,8-TCDD	1,2,3,7,8-PCDD	1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDD	1,2,3,7,8,9-HxCDD	1,2,3,4,6,7,8-HpCDD	1,2,3,4,6,7,8,9-OCDD	2,3,7,8-TCDF	1,2,3,7,8-PCDF	2,3,4,7,8-PCDF	1,2,3,4,7,8-HxCDF	1,2,3,6,7,8-HxCDF	1,2,3,7,8,9-HxCDF	2,3,4,6,7,8-HxCDF	1,2,3,4,6,7,8-HpCDF	1,2,3,4,7,8,9-HpCDF	1,2,3,4,6,7,8,9-OCDF	PCB 077	PCB 126	PCB 169
6/13/97	Berkeley	White Croaker	On	15	20-30	25	6.6	1.5	4.2	6.9	8.4	0.33	0.55	ND	0.29	ND	ND	0.31	2.60	ND	1.20	ND	ND	ND	ND	ND	ND	ND	150	41	3
6/11/97	Oakland	White Croaker	On	15	20-30	26	7.2	1.6	11.2	18.1	19.7	0.50	0.62	ND	ND	ND	ND	ND	2.29	ND	0.95	ND	ND	ND	ND	ND	ND	ND	310	110	6
7/1/97	S.F. Waterfront	White Croaker	On	15	20-30	24	6.7	1.3	6.8	10.3	11.7	0.35	0.54	ND	0.22	ND	0.12	0.32	2.30	0.24	0.89	ND	ND	ND	ND	ND	ND	ND	240	66	3
6/23/97	San Pablo Bay	White Croaker	On	5	23-29	26	9.3	1.9	5.7	8.2	10.2	0.36	0.72	ND	0.41	ND	0.16	0.29	3.70	0.45	1.50	ND	ND	ND	ND	ND	ND	ND	170	56	5
6/26/97	San Pablo Bay	White Croaker	On	5	23-29	26	6.4	1.2	3.4	5.0	6.2	0.26	0.44	ND	0.27	ND	0.12	0.25	2.40	0.24	0.85	ND	ND	ND	ND	ND	ND	ND	120	33	3
7/9/97	San Pablo Bay	White Croaker	On	5	22-30	27	3.3	1.3	4.3	6.4	7.7	0.25	0.52	ND	0.36	ND	0.11	0.37	1.70	0.21	1.10	0.04	ND	ND	ND	ND	ND	ND	110	42	3
6/13/97	Berkeley	White Croaker	Off	15	20-30	25	NA	1.1	2.9	NA	NA	0.20	0.45	ND	0.23	ND	ND	0.25	1.90	0.24	0.87	ND	ND	ND	ND	ND	ND	ND	95	28	2
6/23/97	San Pablo Bay	White Croaker	Off	15	22-30	26	NA	0.7	2.4	NA	NA	0.15	0.29	ND	0.17	ND	0.07	0.30	1.20	0.14	0.55	ND	ND	ND	ND	ND	ND	ND	68	23	2

On	Skin on muscle
Off	Skin off muscle
TCDD	tetrachlorodibenzodioxin
PCDD	pentachlorodibenzodioxin
HxCDD	hexachlorodibenzodioxin
HpCDD	heptachlorodibenzodioxin
OCDD	octachlorodibenzodioxin
TCDF	tetrachlorodibenzofuran
PCDF	pentachlorodibenzofuran
HxCDF	hexachlorodibenzofuran
HpCDF	heptachlorodibenzofuran
OCDF	octachlorodibenzofuran
TEQ	dioxin toxic equivalent
TEF	dioxin toxic equivalency factor
ITEQs	dioxin toxic equivalents due to dibenzodioxins and dibenzofurans
PCB TEQs	dioxin toxic equivalents due to all measured dioxin-like PCBs
PCB TEQs (3 PCBs)	dioxin toxic equivalents due to PCBs 77, 126, and 169
total TEQs	dioxin toxic equivalents due to dibenzodioxins, dibenzofurans, and all measured dioxin-like PCBs