

CHAPTER 8. TISSUE CHEMISTRY

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I. INTRODUCTION

Measurement of chemical contaminants in the tissues of selected fish and invertebrates is required under the receiving water monitoring program of Hyperion Treatment Plant's NPDES permit. Under the guidelines of the permit, the fish and the invertebrates were collected from Santa Monica Bay (SMB) by otter trawl, rig fishing, and crab traps. Trawled organisms are closely associated with the sea bottom throughout much of their lives. Thus, they are more likely to bioaccumulate pollutants from contaminated sediments and potential bottom dwelling prey compared to organisms living in the water column. The analysis of pollutants in rig-caught fish, and crabs are important, as fishermen also seek these species and, therefore, assessment of contaminant levels in edible tissue from these organisms is of considerable interest to the public.

Since 1987, as mandated by the Hyperion's NPDES permit, the City of Los Angeles has been monitoring selected priority pollutants in the tissues of fish and invertebrates from Santa Monica Bay. Since then, the tissue chemistry program for trawled fish has used the same target species (honeyhead turbot). For the rig-fish survey, several different species of sport fish were collected during the period. The type of species collected was dependent on their abundance in the Bay during the NPDES permit mandated sampling period.

The current NPDES permit for Hyperion was issued in 1994. In the current permit, the number of trawl stations used for collecting honeyhead turbot was reduced from six to five. The target invertebrate was changed from ridgeback prawns to cancer crabs. Rig fishing was increased from twice/year to three times per year. Additionally, individual fish was analyzed separately and not composited as in 1987.

In addition to the City of Los Angeles's SMB monitoring program, there are other marine monitoring programs conducted in the Southern California Bight (SCB). These programs include surveys of sediment chemistry, benthic macro fauna, water quality, fish, and bioaccumulation of contaminants in the tissues of marine organisms (NRC 1990a, 1990b). A pilot project for a comprehensive regional monitoring program in the Southern California Bight was conducted in the summer of 1994 and was followed by the Southern California Bight 1998 Regional Monitoring (Bight, 1998 Survey). In 1997 the United States Geological Survey (USGS) conducted a sediment core study program in Santa Monica Bay. Finally, in 1998, the Santa Monica Bay Restoration Project (SMBRP) worked in conjunction with the City of Los Angeles and County Sanitation District of Los Angeles to design the SMBRP Seafood Consumption Study. In 2003, the City of Los Angeles has participated the third comprehensive regional monitoring project in the Southern California Bight (Bight2003).

The summer 1997 trawled fish tissue analyses, and 2nd and 3rd trimester 1997 rigfish and crab tissue analyses were resource exchanged to support the City's participation in 1997 USGS sediment core study program and the Southern California Bight 1998 Regional Marine Survey. Additionally, a portion of the 1998 tissue chemistry analyses for SMB trawled fish, rig-fish, and crab samples were resource exchanged for the effort expended for the SMBRP Seafood Consumption Study, as well as the sand dab guild tissue chemistry analyses for the Bight 1998 Survey. In 1999, a complete survey of tissue chemistry samples for SMB, as defined by the Hyperion's NPDES Permit guidelines was resumed.

In this chapter, the results of priority pollutant analyses performed on tissues from selected fish captured by trawling, and rig fishing from February 2001 to September 2002 are reported. The tissue contaminant results are assessed to determine their temporal and spatial distribution in the study area of the Bay. Only one set of invertebrate tissue data in 2001 was reported as the target species crab for the monitoring program during the 2001-2002 surveys.

II. MATERIALS AND METHODS

A. FIELD SAMPLING

Trawling was conducted using a 25-foot head rope length otter trawl. For a detailed description of this procedure see Chapter 7 (Trawl-Caught Fish and Invertebrates).

1. Trawled Fish and Invertebrates

The hornyhead turbot *Pleuronichthys verticalis* is targeted for priority pollutant analyses because it is generally found in high abundance along the 60-m depth contour in Santa Monica Bay. Also, because hornyhead turbot is in a reproductive state throughout the year (Goldberg 1982), there may be less fluctuation in levels of lipids in which contaminants tend to accumulate.

In accordance with the NPDES permit guidelines, Hornyhead turbot was sampled at stations C1, C3, C6, C9a, and Z2 in the winter and summer of 2001 and 2002 (Figure 8-1). During some sampling periods, when the abundance of hornyhead turbot collected was too low to satisfy replication requirements, or the size of individuals captured did not meet the minimum size-class requirement (15 cm), extra 20-minute trawls were conducted at those stations as good-faith efforts. No further attempts were made if these good faith efforts failed to capture the required number of hornyhead turbot at each station.

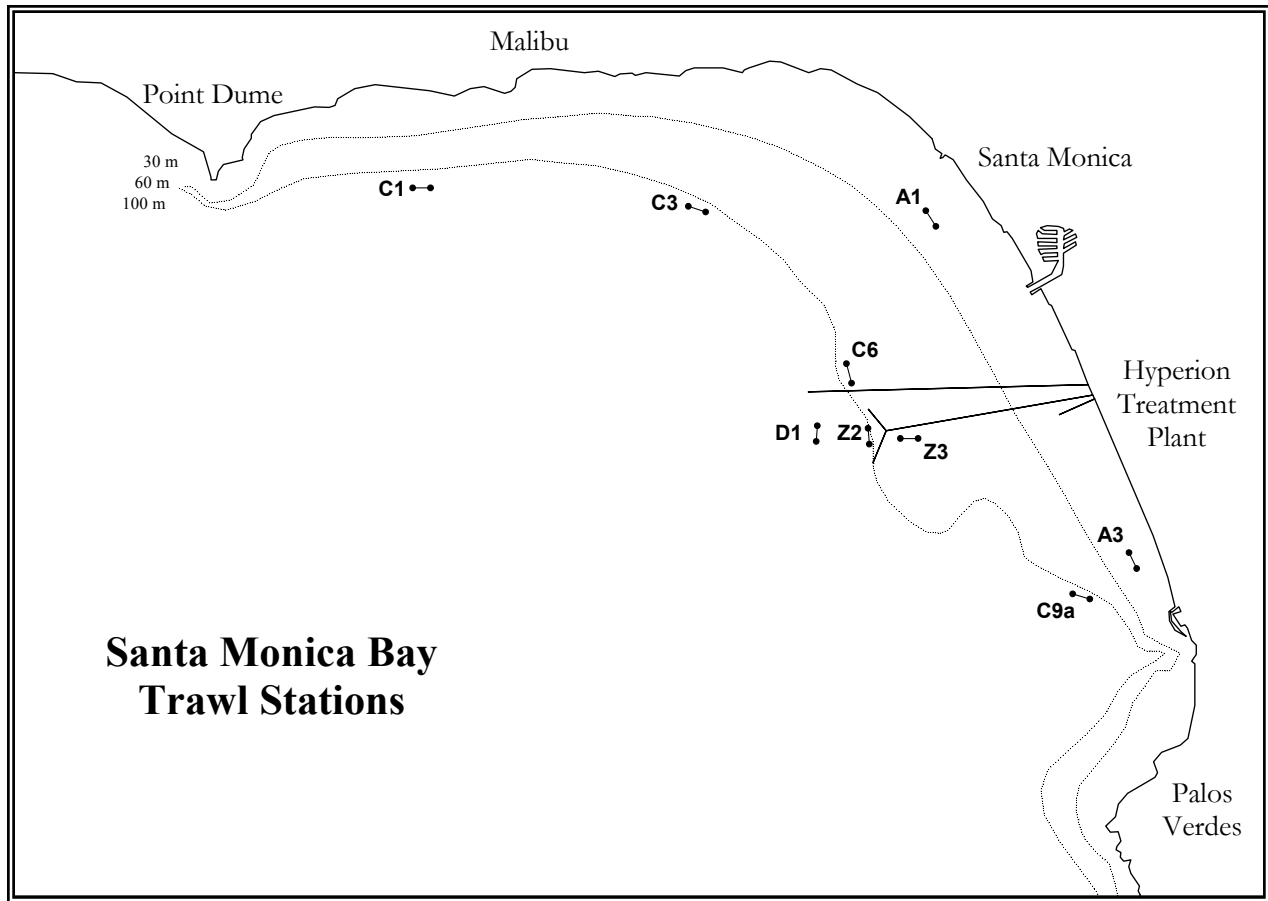


Figure 8-1. Trawl stations in Santa Monica Bay.

Up to three replicates each of hornyhead turbot muscle and liver tissue were composited at each of the five stations. A composite was derived from the tissues of six individuals, each individual measuring between 15 and 23 cm.

Summary of tissue sample collection is shown in Table 8-1a. Except as noted hereafter, three replicate tissue samples were collected at each station during each sampling period. At station C1, no hornyhead turbot was collected during the summer of 2001 and 2002 and only one sample was collected in winter of 2001 and 2002, respectively. One sample each was collected at station C3 in summer of 2001 and 2002 and one sample at C6 in the summer of 2002.

In accordance with the 1994 NPDES permit, crab traps were deployed at each of the three sites; stations Z2 (5-Mile Outfall) and C7 (Short Bank), and off Point Dume along the 60-m contour (Figure 8-1). The traps were deployed for up to two days so that enough crabs could be collected for dissection. One sample of each of the three stations was collected in the winter of 2001. However, for the summer of 2001 and during 2002, attempts to collect crab by trapping were unsuccessful, and no crab samples were collected during the last one and a half years.

Table 8-1a. Locations and species of trawl fish and crab samples collected during 2001 and 2002.

	Station	2001		2002	
		Winter	Summer	Winter	Summer
Trawl Fish	C1	1 ¹	---- ²	1	----
	C3	3	1	3	1
	C6	3	1	3	3
	Z2	3	3	3	3
	C9a	3	3	3	3
	Point Dume	1	----	----	----
Invertebrates	C7 (Short Bank)	1	----	----	----
	Z2 (5-Mile)	1	----	----	----

1. Number of samples
2. ----: No samples.

2. Rig-fishing

Using rod and reel fishing tackle, sportfish were collected at two sites in Santa Monica Bay during 2001 and 2002: 1) the terminus of the 5-Mile Outfall (5M) and 2) Short Bank (SB), a hard-bottom habitat about 4 to 6 km south of the outfall. The choice of species for dissection was based on species abundance and importance to the Santa Monica Bay sport fishery (Table 8-1b). Upon capture, each target fish was identified, examined for abnormalities, measured, and weighed. Selected species were dissected fresh on board the monitoring vessel. The muscle tissue of each individual was analyzed as a separate replicate. Three replicates were required for each species collected at the 5-Mile Outfall and six replicates for each species at Short Bank. However, during each sampling period, the catch of some species did not meet the replicate requirement.

In the past, rig-caught fish were also dissected in the laboratory following the procedures used for hornyhead turbot dissections. However, during 2001 and 2002, rig-caught fish were dissected on board of the monitoring vessel with procedures similar to those used by sport fishermen.

B. LABORATORY ANALYSIS

Specific details regarding priority pollutant tissue analyses are provided in Appendix C. For heavy metal analyses, tissues were acid digested, then analyzed by inductively coupled plasma (ICP) spectroscopy. Tissues for organics were extracted with solvent and extracts were concentrated prior

to analysis. Base/neutral and acid extractable organics (BNA's) were analyzed by gas chromatography/mass spectrometer (GC/MS). Organochlorine pesticides and polychlorinated biphenyls (PCB) were analyzed using a GC with electron capture detectors (ECD). For samples, which were analyzed in duplicates, the average of the duplicate results were reported. When the analysis result was less than the method detection limit for constituents that had detected results during the period, half of the detection limit was used in the average calculations.

Table 8-1b. Locations and species of sportfish samples collected during 2001 and 2002.

Species	Mar. '01	Jun. '01	Sep. '01	Mar. '02	Jun. '02	Sep. '02
Bocaccio	SB¹(6)²	SB(6)	SB(6)	SB(6)	----	SB(5)
White Croaker	---- ³	----	----	----	5M⁴(3)	----
Blue Rockfish	----	----	----	5M(3)	----	----
Brown Rockfish	----	----	----	----	----	5M(3)
Copper Rockfish	----	----	----	5M(3)	----	----
Green Blotched Rockfish	SB(6)	SB(6)	----	----	----	----
Greenspotted Rockfish	----	----	----	SB(6)	SB(6)	SB(6)
Olive Rockfish	----	----	5M(3)	----	----	----
Speckled Rockfish	----	----	----	----	SB(6)	----
Squarespot Rockfish	SB(6)	----	----	----	----	----
Starry Rockfish	----	SB(6)	SB(6)	SB(6)	SB(6)	SB(6)
Vermillion Rockfish	5M(3)	5M(3)	5M(3)	----	5M(3)	----
California Scorpionfish	5M(3)	5M(3)	5M(3)	5M(3)	5M(3)	5M(3)
Fantail Sole	----	----	----	----	----	5M(3)
Ocean Whitefish	5M(3)	5M(3)	----	----	----	----

1. SB: shortbank
2. (): Number of samples.
3. ----: No samples.
4. 5M: 5-Mile

III. RESULTS

A. HORNYHEAD TURBOT

The tissue samples collected were analyzed for nine priority pollutant metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver and zinc), organochlorine pesticides, base/neutral and acid extractable compounds (BNA). Total organic halides (TOX), and lipids were also analyzed. For most hornyhead turbot muscle sampled during 2001 and 2002, cyanide was not analyzed, as sufficient amounts of sample for the analysis could not be collected. Cyanide was not detected in the tissue samples that were analyzed. TOX was analyzed in all tissue samples collected in 2001 and 2002, but it was either not detected or detected at a very low concentration (Table 8-2a and 8-2b).

All nine metals were detected in the 2001 tissue samples (Table 8-2a). In the 2002 survey, all metals except Cd were detected (Table 8-3b).

Of the 87 organic priority pollutant compounds analyzed in hornyhead turbot tissues during these two years, 13 were detected in either muscle or liver in 2001, and 18 were detected in the 2002 survey (Tables 8-2a and 8-2b).

The details of metal and organic pollutant results in hornyhead turbot muscle and liver tissues are presented below.

1. Muscle Tissue

a. Metals

Three metals As, Hg, and Zn were detected in 100% of the hornyhead turbot muscle tissues sampled during 2001 survey (Table 8-2a). Mercury (Hg) was detected in all muscle tissues sampled in 2001, and in most of the samples in 2002 (Table 8-2b). Zinc was detected in 100% of muscle and liver tissues in 2002. Among the detected metals, As had the highest average concentration (5.32 ppm in 2001, and 4.67 ppm in 2002) in muscle followed by Zn (2.84 ppm in 2001, and 2.47 ppm in 2002). In general, the concentrations of all detected metals in hornyhead turbot muscle were similar in 2001 and 2002. However, a change of instrumentation for metal analysis in 2002 raised the detection limits for most of the metals and so as to the lower percentage of detected metals.

The spatial and temporal trend analyses are shown in Figures 8-2 to 8-6 and Figures 8-7 to 8-11, respectively. When no sample was collected or the result was under the detection limit, the space is left blank in the figure.

Table 8-2a. Metals and organics found in muscle and liver tissues of hornyhead turbot in Santa Monica Bay during the 2001 sampling year.

Constituents Detected	Muscle (n = 21)			Liver (n = 21)		
	Frequency %	Average (ppm)	Range (ppm)	Frequency %	Average (ppm)	Range (ppm)
Metals						
Ag	43	0.019	ND - 0.052	100	2.48	0.34 - 7.06
As	100	5.32	2.31 - 9.96	100	4.84	1.54 - 8.93
Cd	0	ND	ND	100	2.06	0.78 - 4.55
Cr	57	0.069	ND - 0.161	95	0.190	ND - 0.346
Cu	33	0.156	ND - 0.335	100	10.08	5.85 - 18.1
Hg	100	0.210	0.034 - 1.14	100	0.276	0.049 - 0.992
Ni	48	0.192	ND - 0.500	48	0.136	ND - 0.454
Pb	67	1.03	ND - 6.30	67	0.92	ND - 2.14
Zn	100	2.84	1.99 - 3.53	100	38.5	30.1 - 62.6
Pesticides and PCBs:						
A-BHC	0	ND	ND	14	0.0008	ND - 0.0051
B-BHC	10	0.0018	ND - 0.0170	14	0.0074	ND - 0.0720
G-BHC	14	0.0006	ND - 0.0031	10	0.0013	ND - 0.0113
D-BHC	14	0.0018	ND - 0.0104	10	0.0052	ND - 0.0510
Heptachlor	0	ND	ND	5	0.0005	ND - 0.0057
O,P'-DDE	48	0.0028	ND - 0.0124	100	0.180	0.0211 - 0.544
P,P'-DDE	100	0.0524	0.0138 - 0.123	100	2.93	0.357 - 8.82
P,P'-DDD	0	ND	ND	33	0.0100	ND - 0.0470
O,P'-DDT	0	ND	ND	5	0.0056	ND - 0.0067
P,P'-DDT	0	ND	ND	10	0.0021	ND - 0.0259
PCB 1254	19	0.0095	ND - 0.0529	90	0.613	ND - 1.48
PCB 1260	14	0.0137	ND - 0.0660	100	0.558	0.0438 - 1.33
α-Chlordane	14	0.0005	ND - 0.0036	33	0.0026	ND - 0.0152
trans-nonachlor	0	ND	ND	33	0.0043	ND - 0.0248
Base/Neutral/Acid extractables:						
*Di-N-Butylphthalate	33	1.85	ND - 6.33	55	2.81	ND - 6.12
*Bis(2-ethylhexyl)phthalate	24	3.50	ND - 53.2	91	11.3	ND - 61.9
Isophorone	0	ND	ND	5	0.23	ND - 0.69
Naphthalene	0	ND	ND	5	2.15	ND - 40.0
Diethylphthalate	0	ND	ND	38	4.65	ND - 13.6
3,3'-Dichlorobenzidine	0	ND	ND	5	1.06	ND - 3.37
Total Organic Halides	0	ND	ND	15	5.40	ND - 17.5
Lipid %	100	1.22	0.44 - 2.03	100	12.7	4.83 - 20.5
* : Compounds detected may be the result of lab contamination.						
n : number of samples analyzed.						
ND : Below detection Limit						

Table 8-2b. Metals and organics found in muscle and liver tissues of hornyhead turbot in Santa Monica Bay during the 2002 sampling year.

Constituents Detected	Muscle (n=23)			Liver (n=23)		
	Frequency %	Average (ppm)	Range (ppm)	Frequency %	Average (ppm)	Range (ppm)
Metals						
Ag	0	ND	ND	83	1.96	ND-5.23
As	78	4.67	ND-8.23	74	4.64	ND-9.91
Cd	0	ND	ND	91	1.83	ND-3.01
Cr	0	ND	ND	0	ND	ND
Cu	0	ND	ND	100	8.35	2.64-19.4
Hg	96	0.059	ND-0.120	100	0.190	0.057-0.350
Ni	0	ND	ND	0	ND	ND
Pb	0	ND	ND	0	ND	ND
Zn	100	2.47	2.03-3.17	100	36.1	28.2-51.3
Cyanide	48	0.23	ND-0.71	48	0.29	ND-2.12
Pesticides and PCBs:						
O,P'-DDE	17	0.002	ND-0.009	96	0.120	ND-0.353
P,P'-DDE	100	0.038	0.008-0.102	100	2.22	0.200-7.17
P,P'-DDD	0	ND	ND	39	0.020	ND-0.089
PCB 1254	0	ND	ND	70	1.07	ND-2.53
PCB 1260	0	ND	ND	87	0.872	ND-1.97
D-BHC	0	ND	ND	9	0.004	ND-0.033
Base/Neutral/Acid extractables:						
Isophorone	57	1.54	ND-4.94	48	2.40	ND-9.98
*Di-N-Butylphthalate	0	ND	ND	48	1.63	ND-6.03
Diethylphthalate	22	1.37	ND-3.21	35	2.54	ND-7.70
*Bis(2-ethylhexyl)phthalate	9	1.10	ND-2.21	70	10.8	ND-57.9
Total Organic Halides (TOX)	96	3.80	ND-11.9	91	6.22	ND-13.5
Lipids %	100	1.31	0.24 – 3.00	100	8.89	3.73 – 15.5
n: Number of samples analyzed						
ND : Below detection limit						
*Compounds detected may be the result of lab contamination.						

Spatial distribution of five metals, Zn, As, Cu, Pb, and Hg, at five trawl stations from 1998 to 2002, were assessed (Figures 8-2 to 8-6). Except for sporadic elevated concentration of certain metals in hornyhead muscle at some stations, no clear spatial distribution pattern of metals was observed with the data collected from 1998 to 2002. For example, during this five-year period the highest concentration of Zn was detected in fish collected from station Z2 in winter of 1998, but during the rest of the sampling period the Zn concentration at this station was not elevated (Figure 8-2). Similarly, Hg was elevated in fish tissues collected at station C1 in winter of 1998, but this pattern was not consistent in the rest of the sampling period (Figure 8-6). An elevated Hg level did occur in the winter of 2001 at station C9a.

The temporal trend of Zn, As, Cu, Pb, and Hg concentrations in muscle tissues at stations C1, C3, C6, Z2, and C9a from 1998- 2002 are shown in Figures 8-7 to 8-11. Among these metals, Zn and As generally had the highest concentrations throughout the years, and their concentration levels were similar at all stations and the concentration of As was generally higher than Zn.

Little change in the concentration of Zn in muscle tissue samples at the five trawl stations was observed from 1998 to 2002 (Figure 8-2). The lowest concentration of As was found at the outfall station Z2 throughout this period (Figures 8-3, 8-7 to 8-11). Except station Z2, the highest concentrations of As were found in the winter of 2000. In general, concentration of metals in tissue samples during the period fluctuated, and no significant temporal trend was observed.

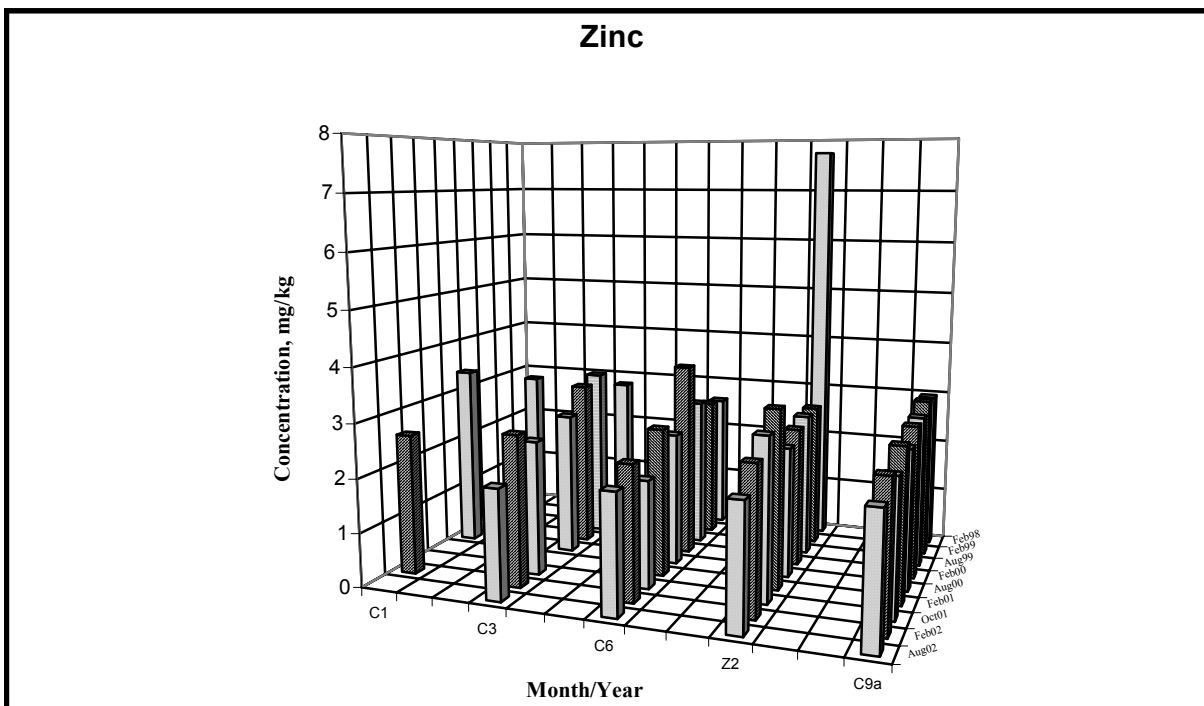


Figure 8-2. Zinc concentration in muscle tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

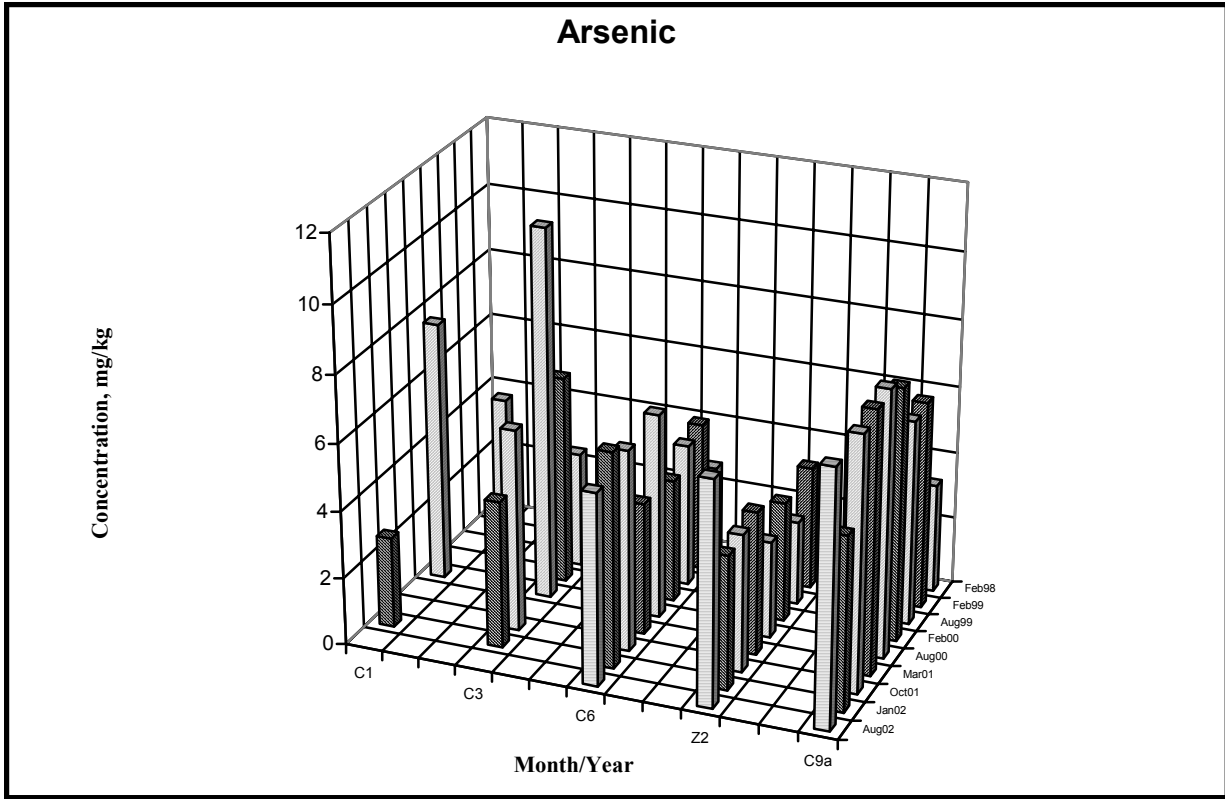


Figure 8-3. Arsenic concentration in muscle tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

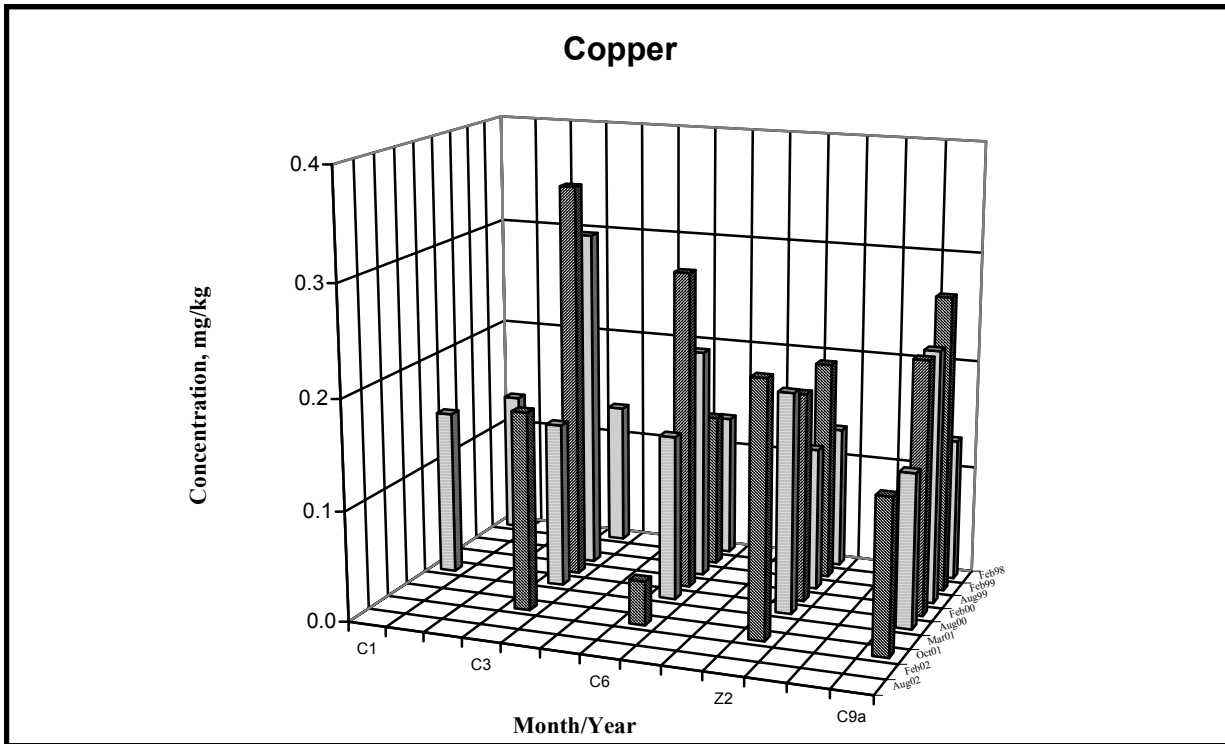


Figure 8-4. Copper concentration in muscle tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

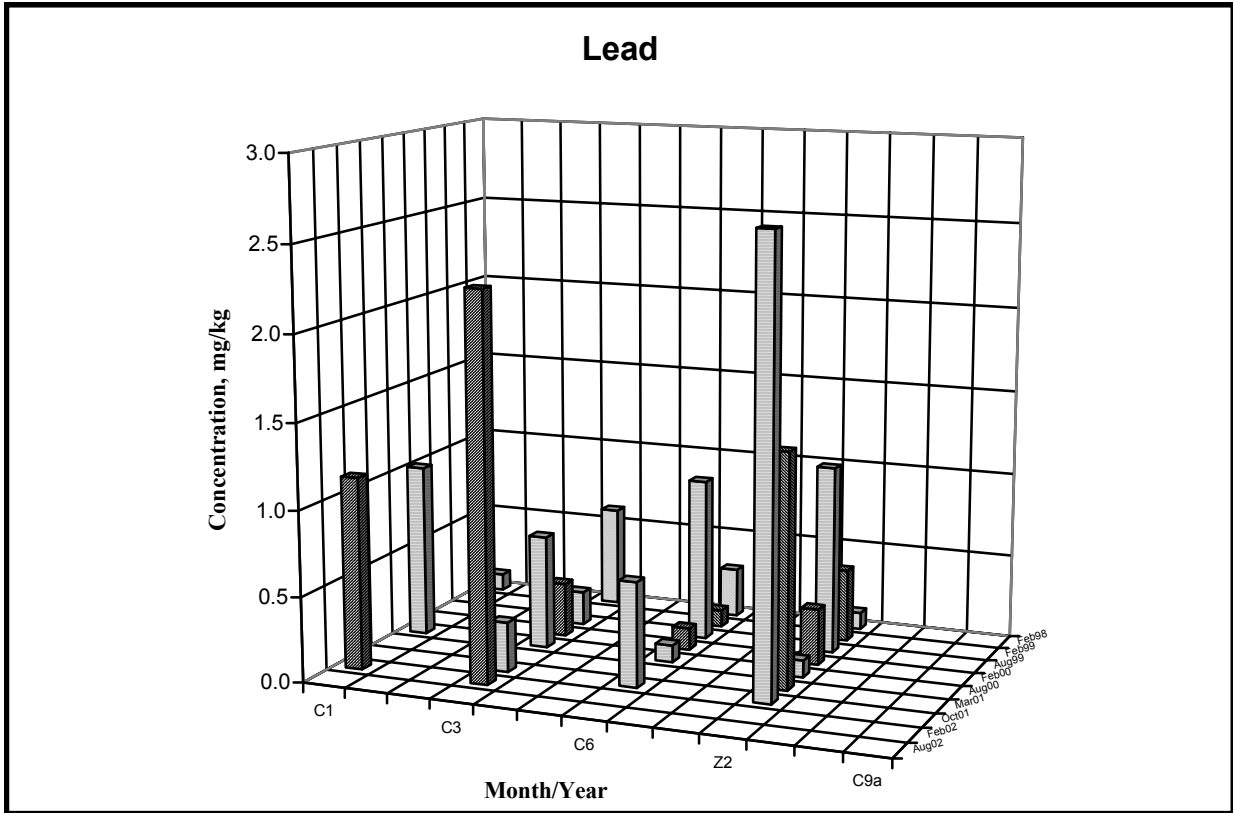


Figure 8-5. Lead concentration in muscle tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

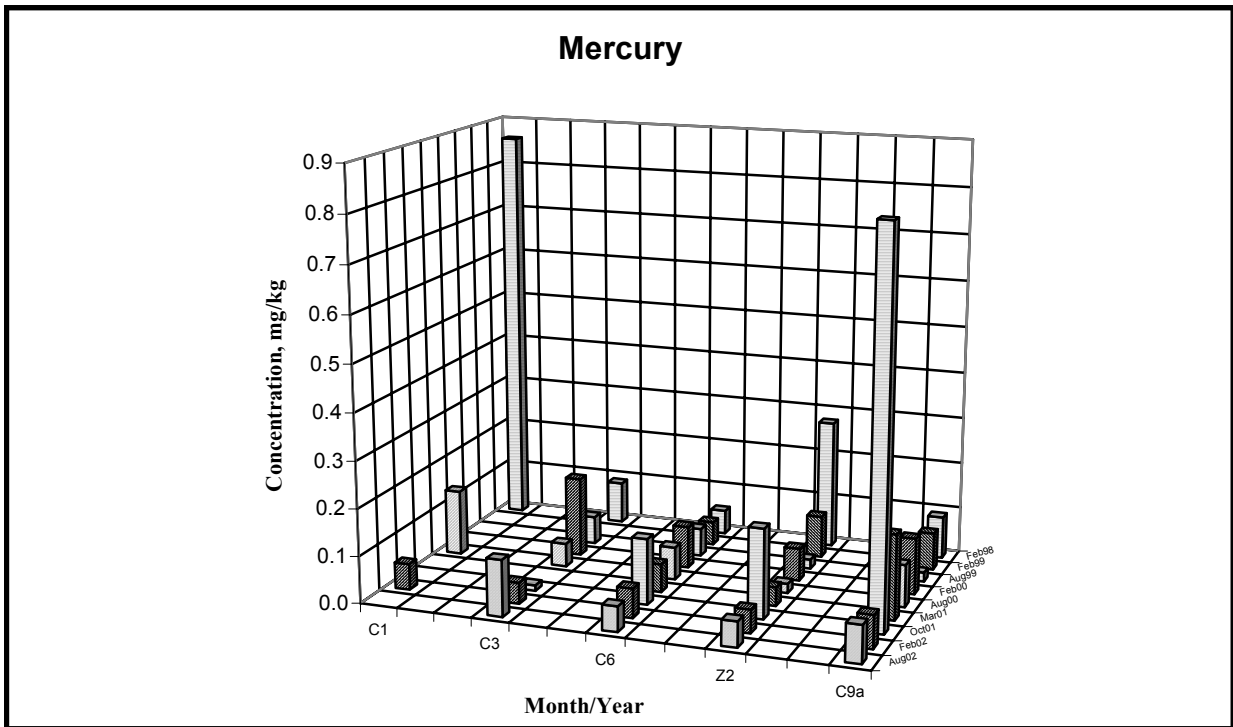


Figure 8-6. Mercury concentration in muscle tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

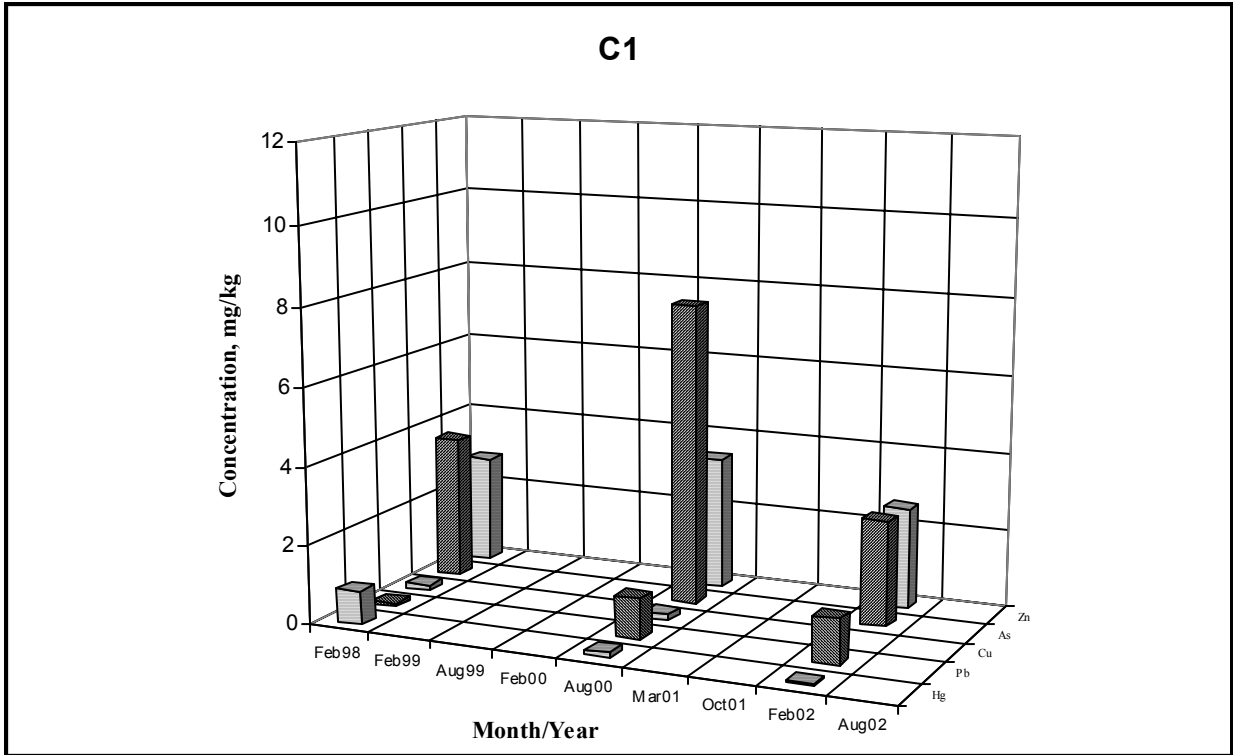


Fig. 8-7. Concentration of 5 metals found in muscle tissues of hornyhead turbot at station C1 during 1998 through 2002 surveys.

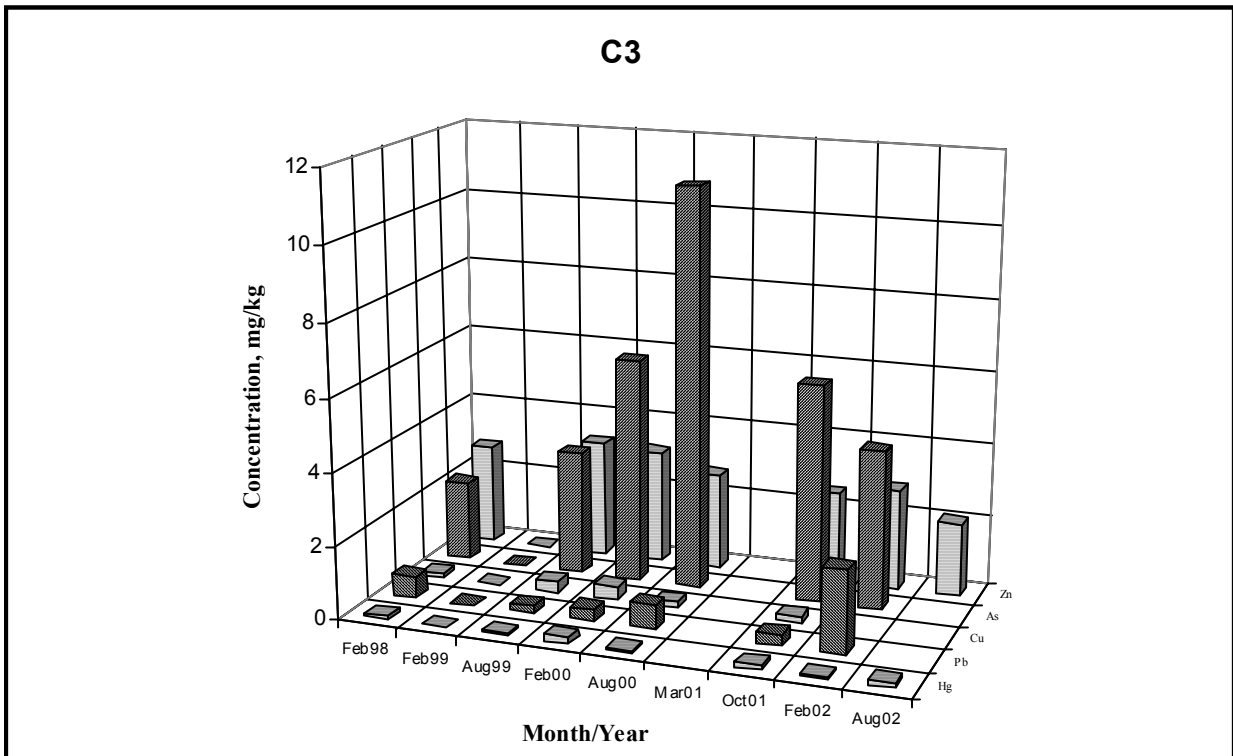


Fig. 8-8. Concentration of 5 metals found in muscle tissues of hornyhead turbot at station C3 during 1998 through 2002 surveys.

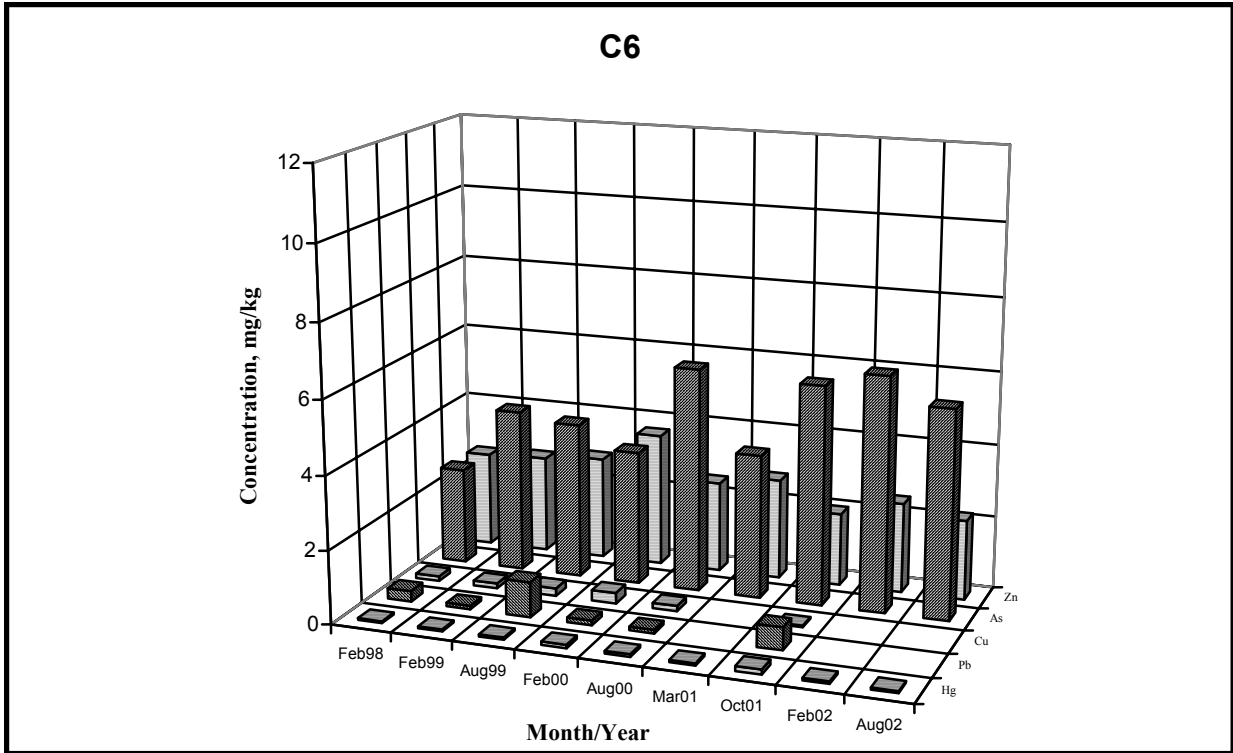


Fig. 8-9. Concentration of 5 metals found in muscle tissues of hornyhead turbot at station C6 during 1998 through 2002 surveys.

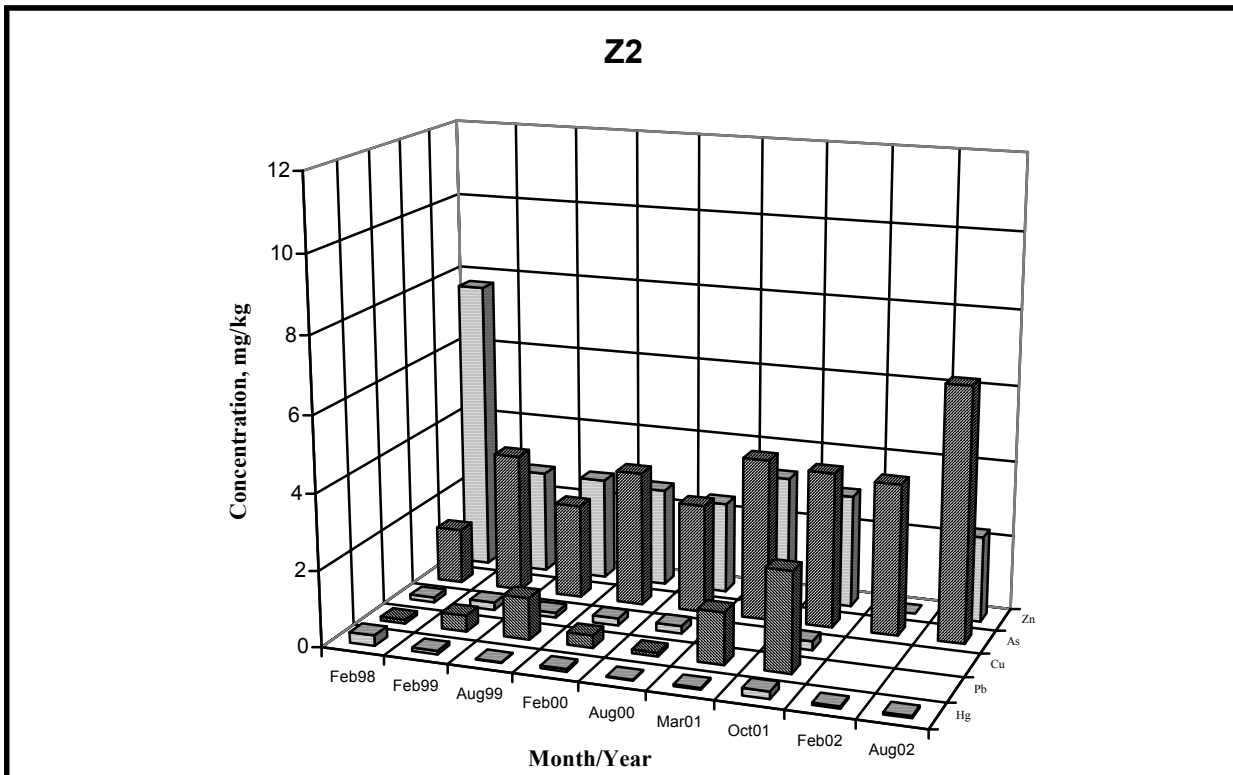


Fig. 8-10. Concentration of 5 metals found in muscle tissues of hornyhead turbot at station Z2 during 1998 through 2002 surveys.

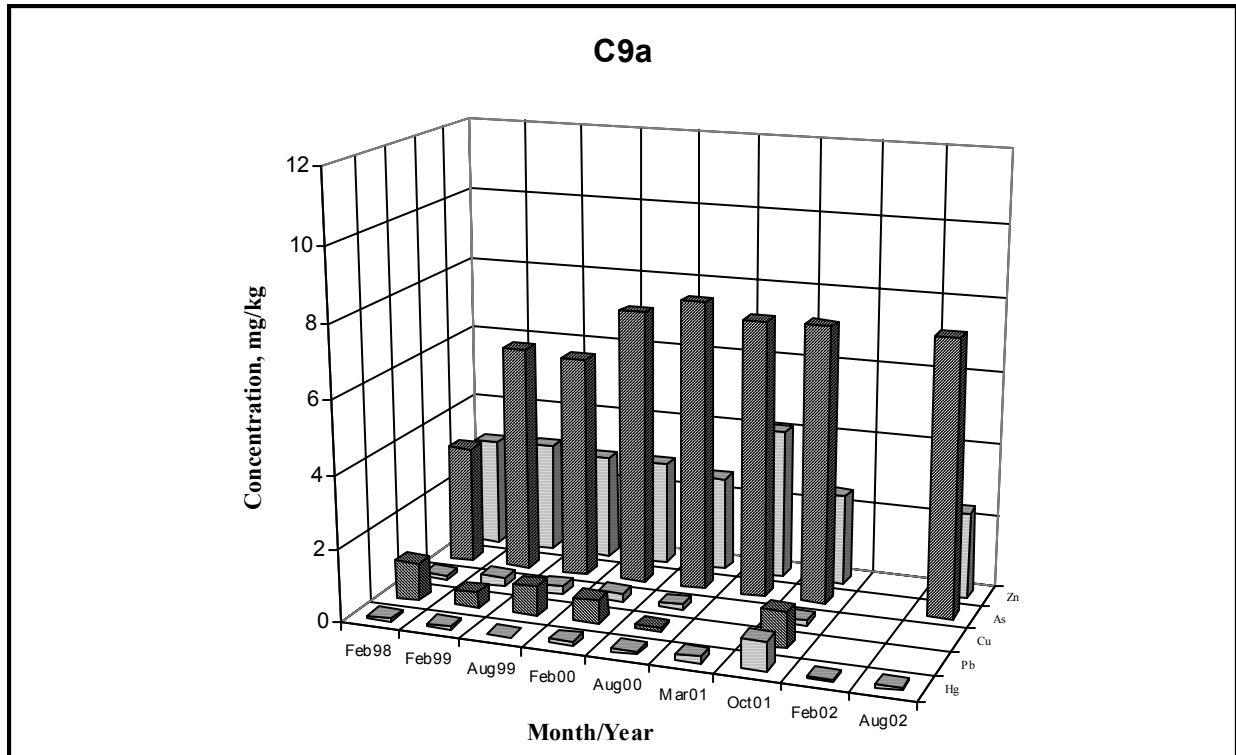


Fig. 8-11. Concentration of 5 metals found in muscle tissues of hornyhead turbot at station C9a during 1998 through 2002 surveys.

Organics

The most frequently detected organic compounds in the muscle tissue of hornyhead turbot during 2001-2002 survey were p,p'-DDE and o,p'-DDE. Only two of the PCB congeners, Aroclor 1254 and 1260, were found in 2001 and none was detected in 2002 (Tables 8-2a and 8-2b). In 2001, low concentration of α -chlordane was also present (Tables 8-2a and 8-2b).

Among the BNA compounds, di-n-butyl phthalate and bis(2-ethylhexyl) phthalate were detected in muscle tissue samples of 2001. Isophorone, diethylphthalate, and bis(2-ethylhexyl) phthalate were found in 2002.

The spatial and temporal distributions of total DDE and total PCB in fish tissue from 1998 to 2002 are shown in Figures 8-12 and 8-13, respectively. The concentrations of these DDT derivatives increased from the north to the south, and its level was highest at stations C9a, followed by Z2. In the last five years level of total PCB was detected only once at station C1 in the summer of 2000.

During 2001-2002 survey, concentrations of total DDE and total PCB in muscle samples was found to decrease at most stations. During the last five-year period, the highest concentrations of DDTs and PCBs were found in fish collected at station Z2 in 1999 (Figure 8-13). In general, as shown from the past five years data, no temporal change in tissue concentration of these two compounds was observed (Figures 8-12 and 8-13).

The concentrations of lipids in muscle samples from 1998 to 2002, are presented in Figure 8-14. In fish muscle, the mean % lipid value was 1.22 in 2001, and 1.31 in 2002 (Tables 8-2a and 8-2b). Percent lipid levels of samples collected during this period showed no systematic pattern and had poor correlation with total DDE and total PCB either spatially or temporarily. Therefore, the normalization of organic pollutant levels in muscle tissues with % lipid levels could not be applied.

2. Liver Tissue

a. Metals

In general, metals occurred with higher frequency and were more concentrated in samples of hornyhead turbot liver than muscle tissue (Tables 8-2a, and 8-2b). All nine metals analyzed were detected in liver tissues of hornyhead turbot in 2001 and six metals were detected in 2002. Among these, Ag, As, Cd, Cu, Hg, and Zn were detected with 100% frequency in the liver tissues in 2001 and three, Cu, Hg, and Zn were detected with 100% frequency in 2002. Ag and Cu, while infrequently detected in hornyhead muscle, were detected in almost all hornyhead liver samples. Cr, Ni, and Pb were not detected in liver tissues in 2002. Levels of As, Ni, Hg, and Pb in liver and muscle tissues were very similar, but the concentration of other metals were much higher in liver (Tables 8-2a and 8-2b). Ag was more than 100 times higher in liver than in muscle tissues. The levels of Cu and Zn in liver were at least 10 times higher than in muscle tissues.

Concentration of all metals, except Cr, Ni, and Pb, in hornyhead turbot liver tissues was similar in 2001 and 2002 (Tables 8-2a and 8-2b). Cr, Ni, and Pb were detected in liver tissue samples of 2001 but not in 2002. The concentration of five metals (Zn, As, Cu, Pb, and Hg) in liver samples at stations C1, C3, C6, Z2, and C9a surveyed from 1998-2002, is shown in Figures 8-15 to 8-19. In general, as with previous five years, no significant spatial distribution pattern of metals concentrations was observed in liver tissues collected in 2001-2002. When no sample was collected or the result was under detection limit, the space in the figure was left blank.

During the 1998-2002 period, no significant spatial distribution pattern of the concentrations of As, Cu, Hg, and Zn was observed (Figures 8-15 to 8-19). An increasing trend of the Pb levels was observed in 2000 and 2001 but no Pb was detected in 2002 (Figure 8-16). Concentration of metals in general, was the highest at the outfall station Z2 and C9a (Figures 8-15 to 8-19). As with the previous five years, no significant temporal trends for metal contamination in the liver of hornyhead turbot was observed in samples collected during 2001-2002 (Figures 8-20 to 8-24).

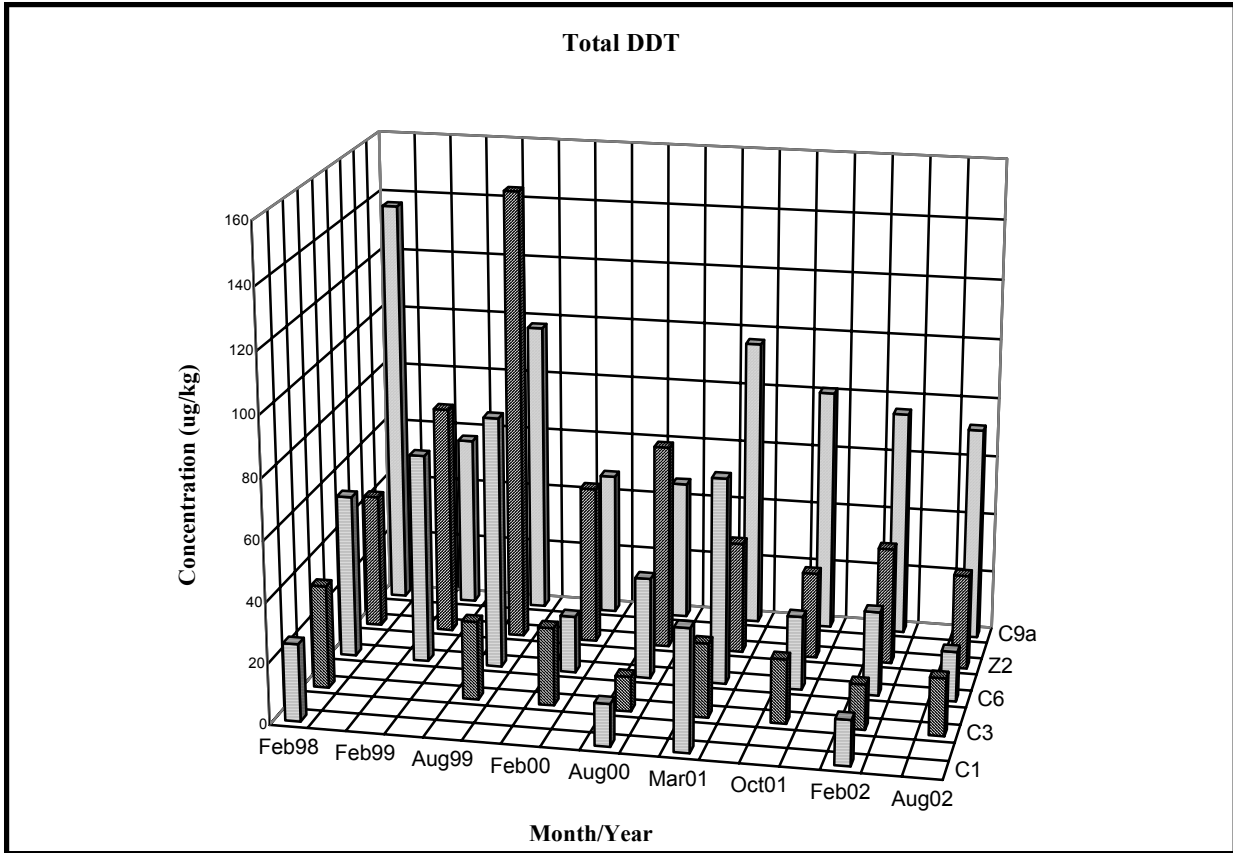


Figure 8-12. Concentrations of total DDT in muscle tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

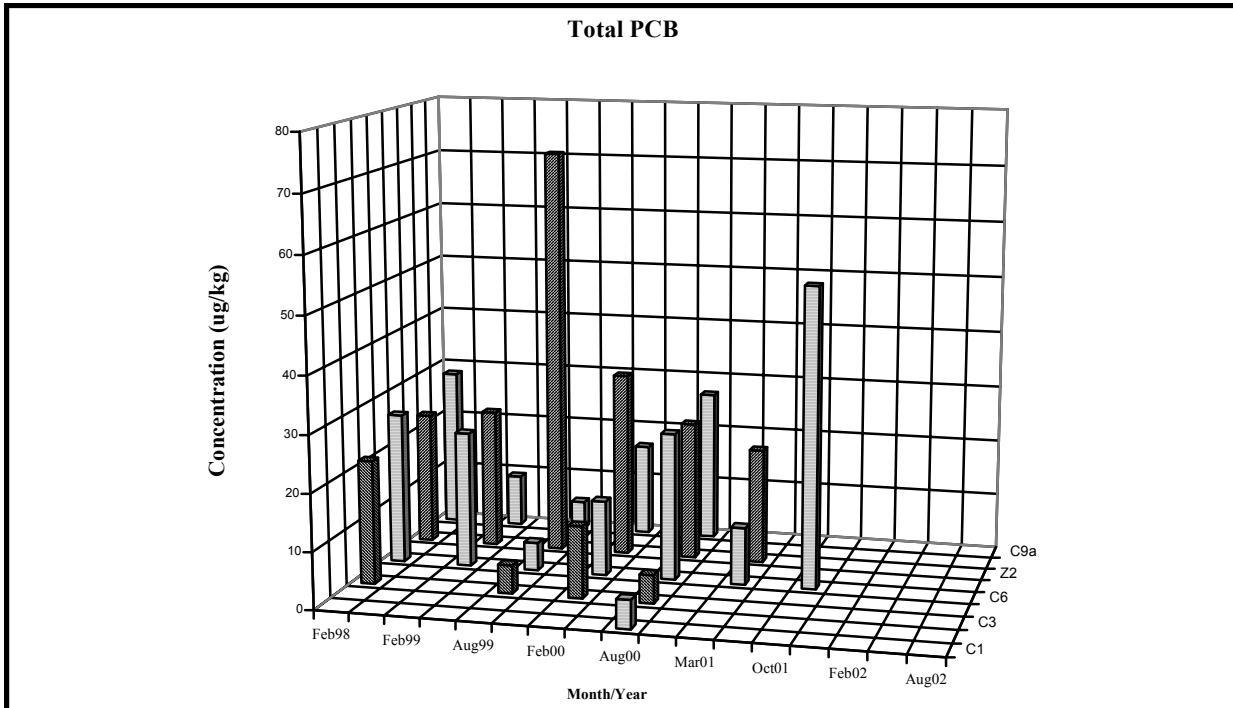


Figure 8-13. Concentrations of total PCB in muscle tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

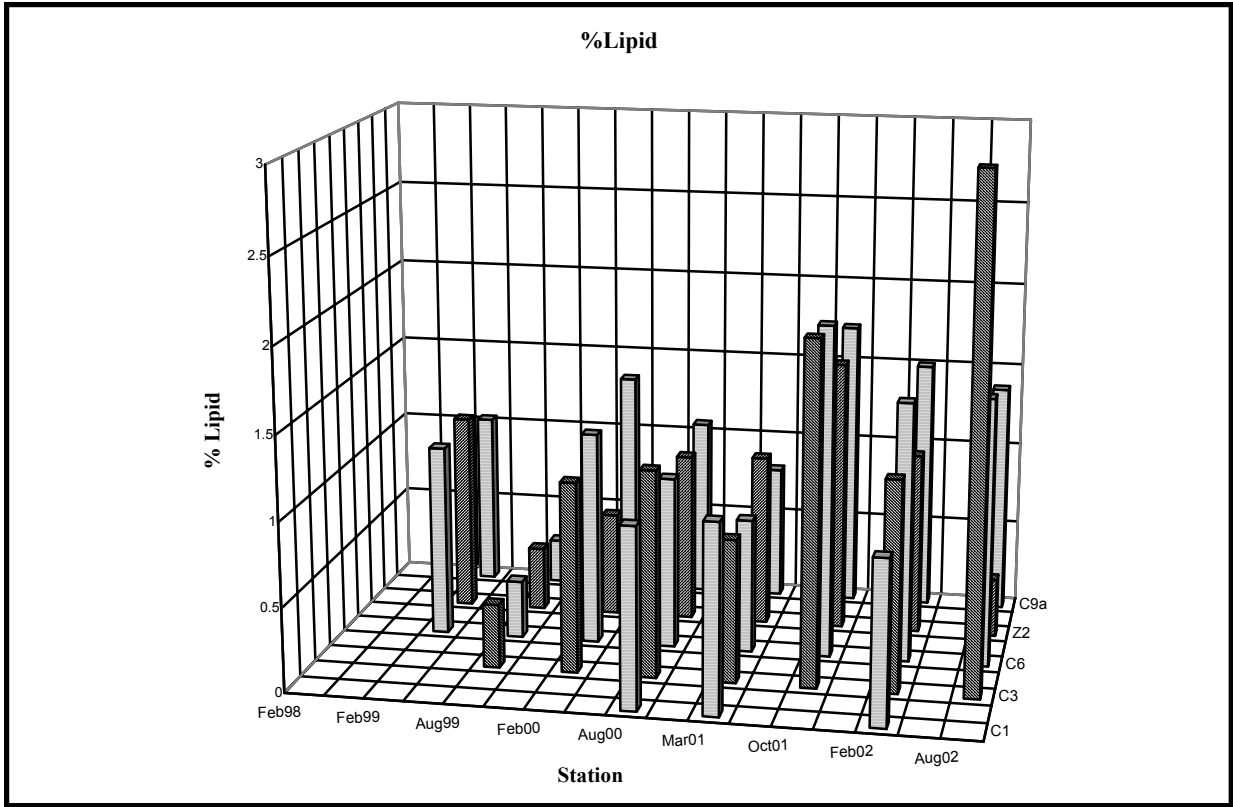


Figure 8-14. Concentrations of %lipid in muscle tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

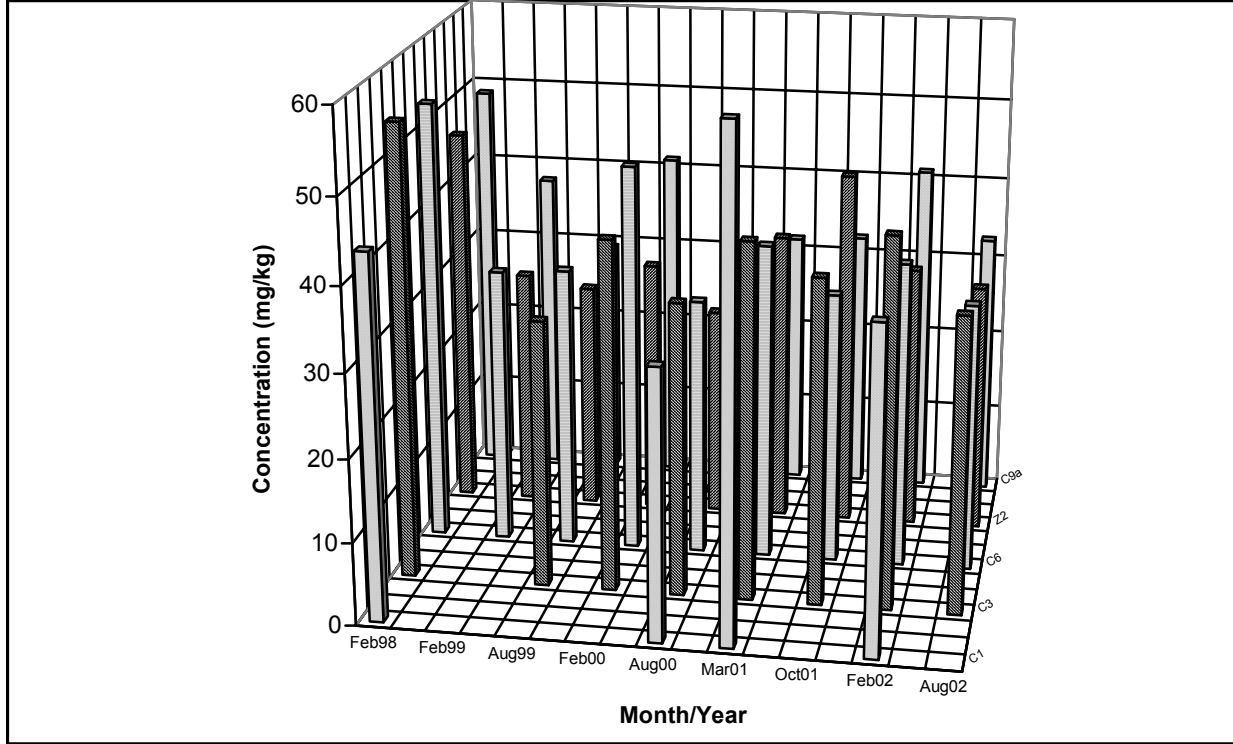


Figure 8-15. Zinc concentration in liver tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

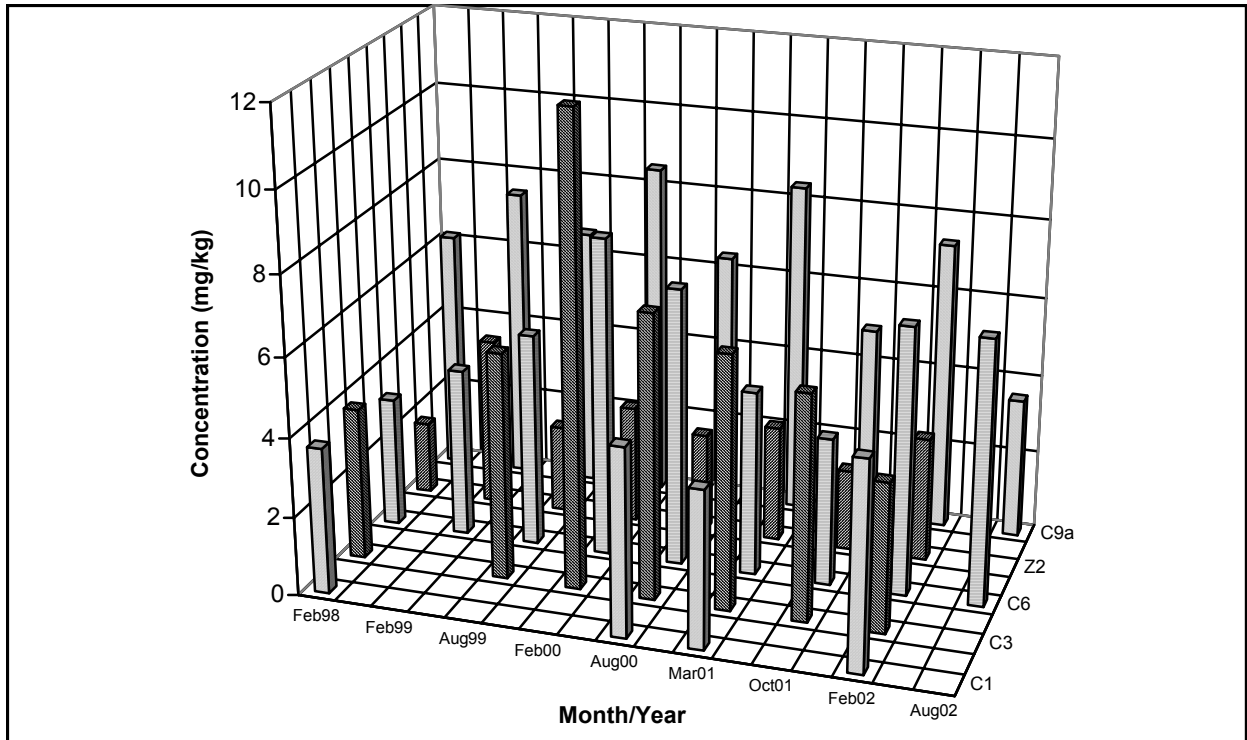


Figure 8-16. Arsenic concentration in liver tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

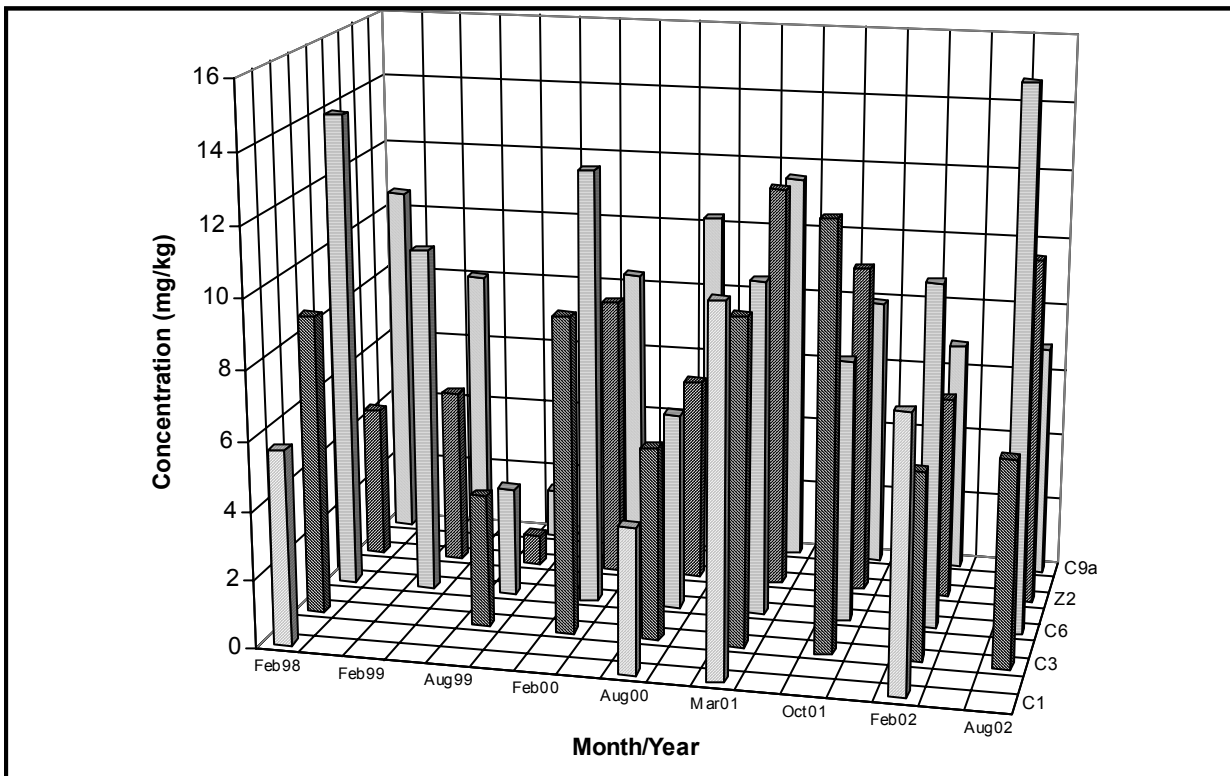


Figure 8-17. Copper concentration in liver tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

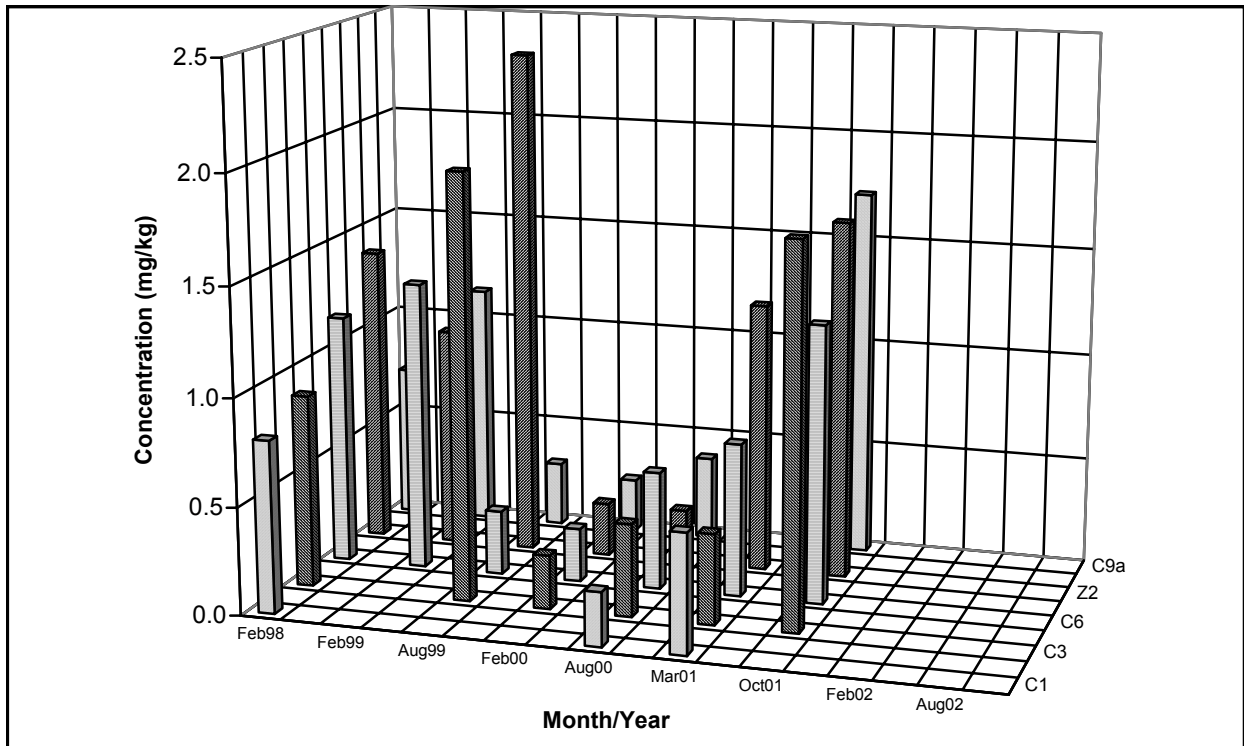


Figure 8-18. Lead concentration in liver tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

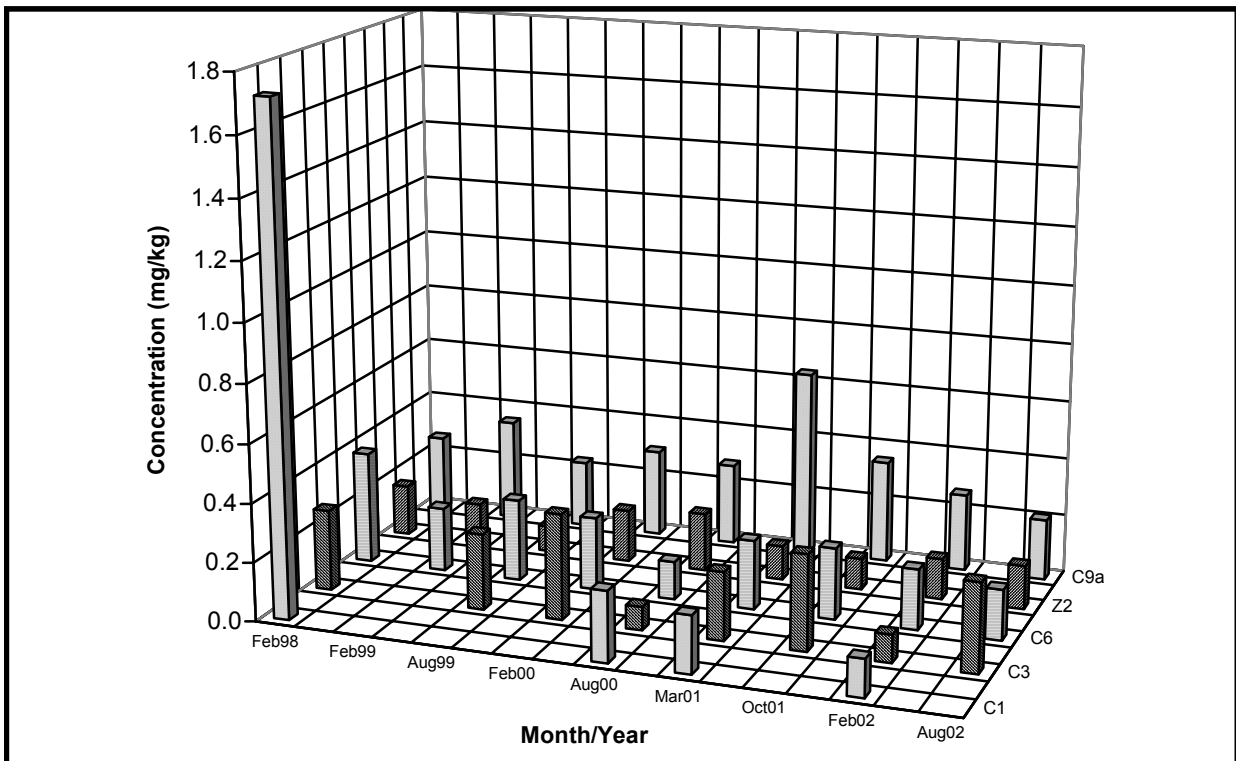


Figure 8-19. Mercury concentration in liver tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

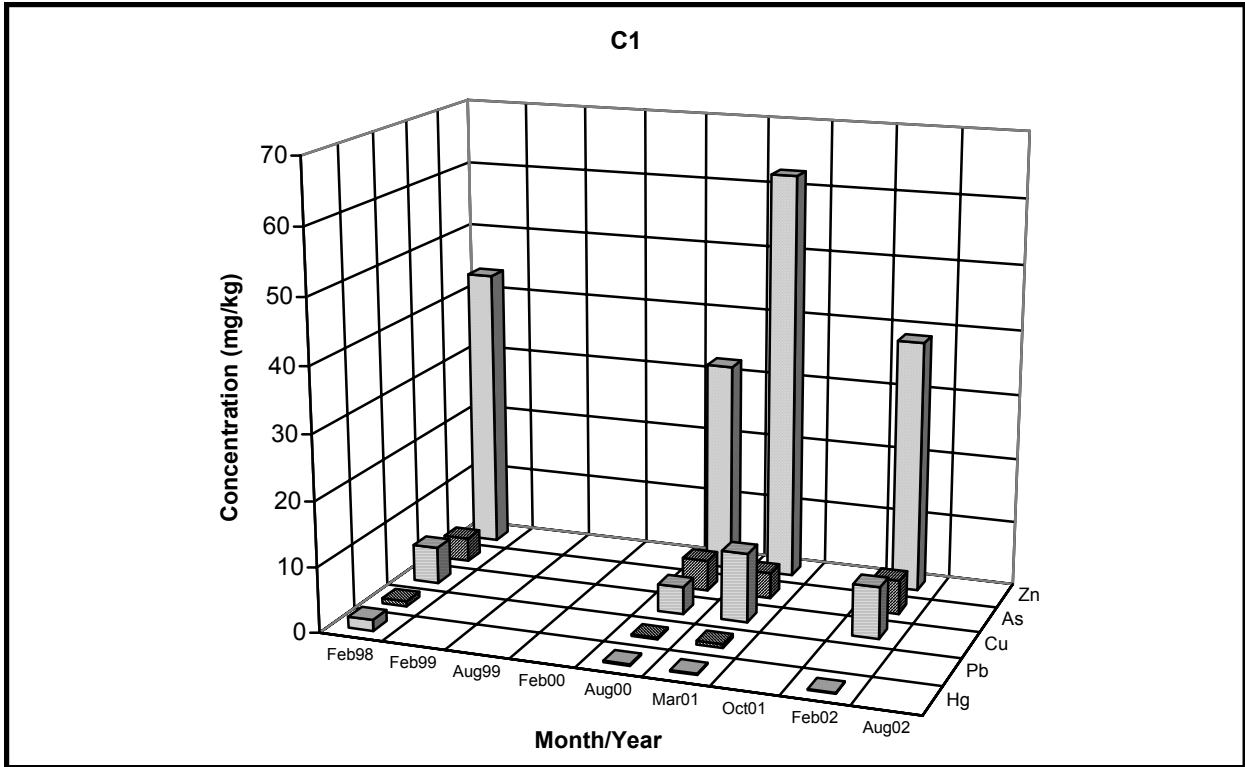


Figure 8-20. Concentrations of five metals found in liver tissues of hornyhead turbot at station C1 during 1998 through 2002 surveys.

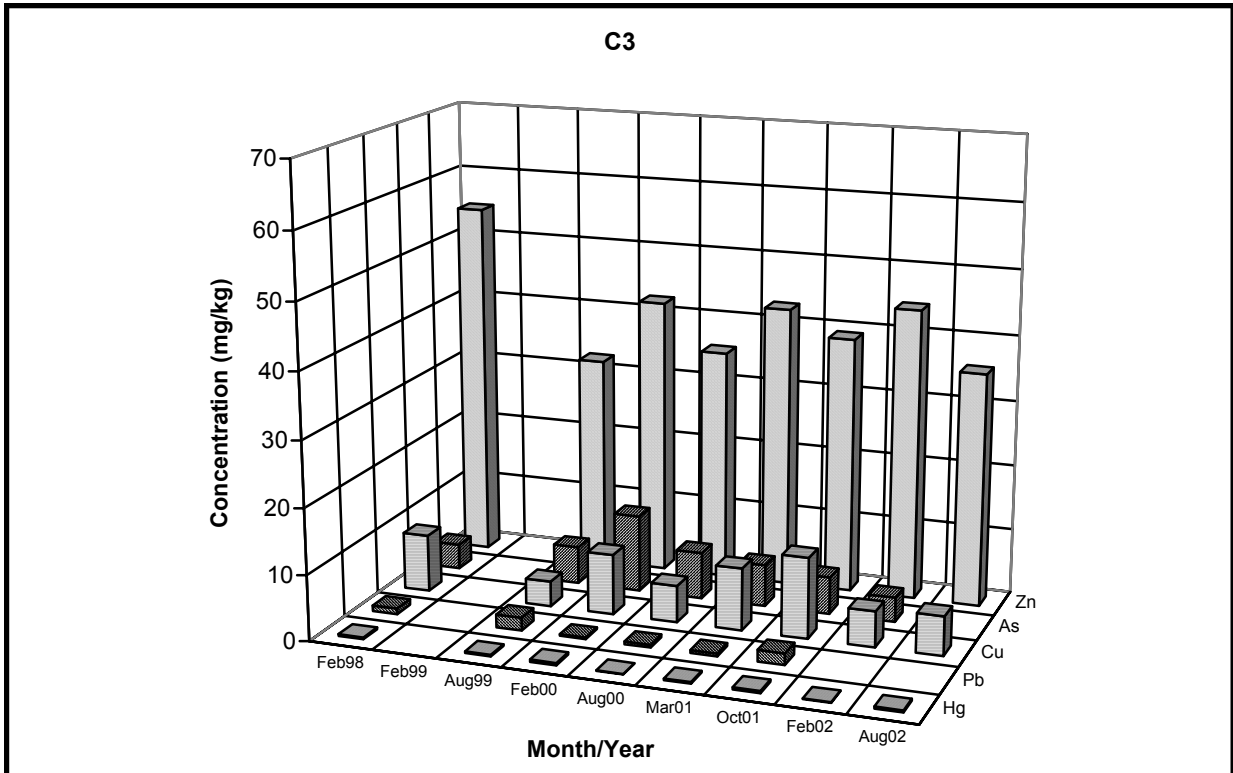


Figure 8-21. Concentrations of five metals found in liver tissues of hornyhead turbot at station C3 during 1998 through 2002 surveys.

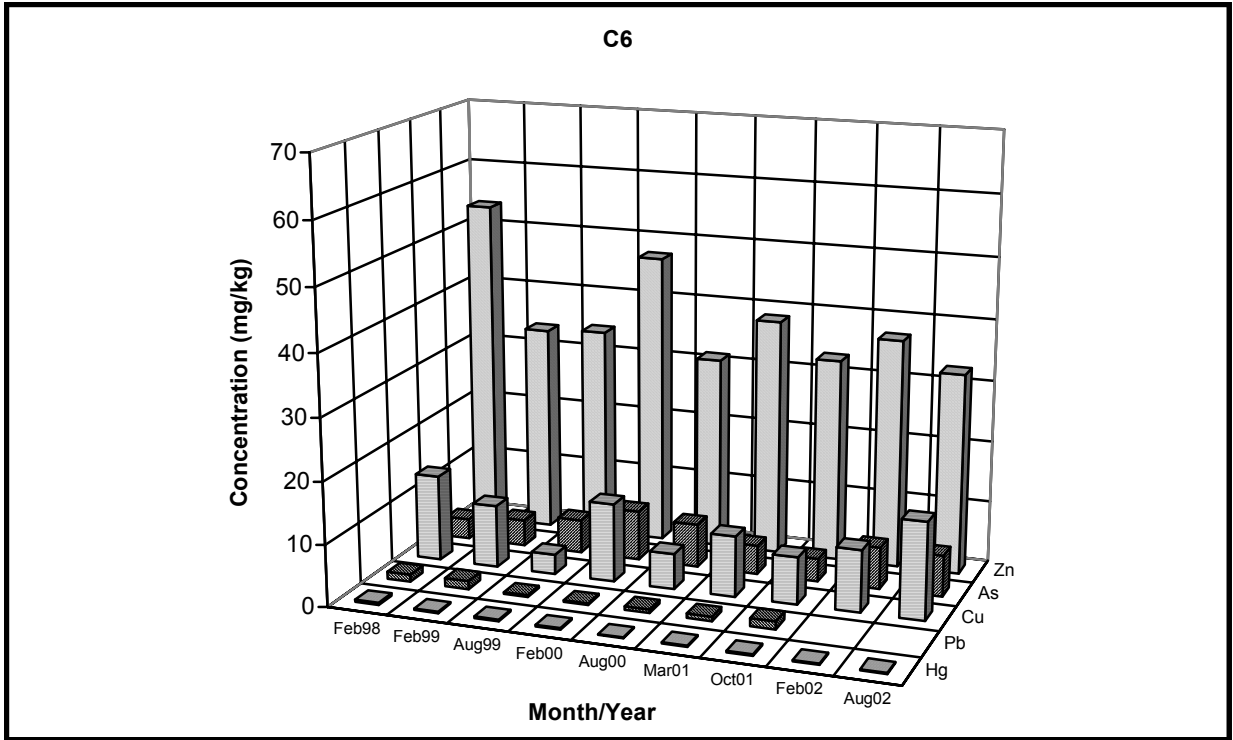


Figure 8-22. Concentrations of five metals found in liver tissues of hornyhead turbot at station C6 during 1998 through 2002 surveys.

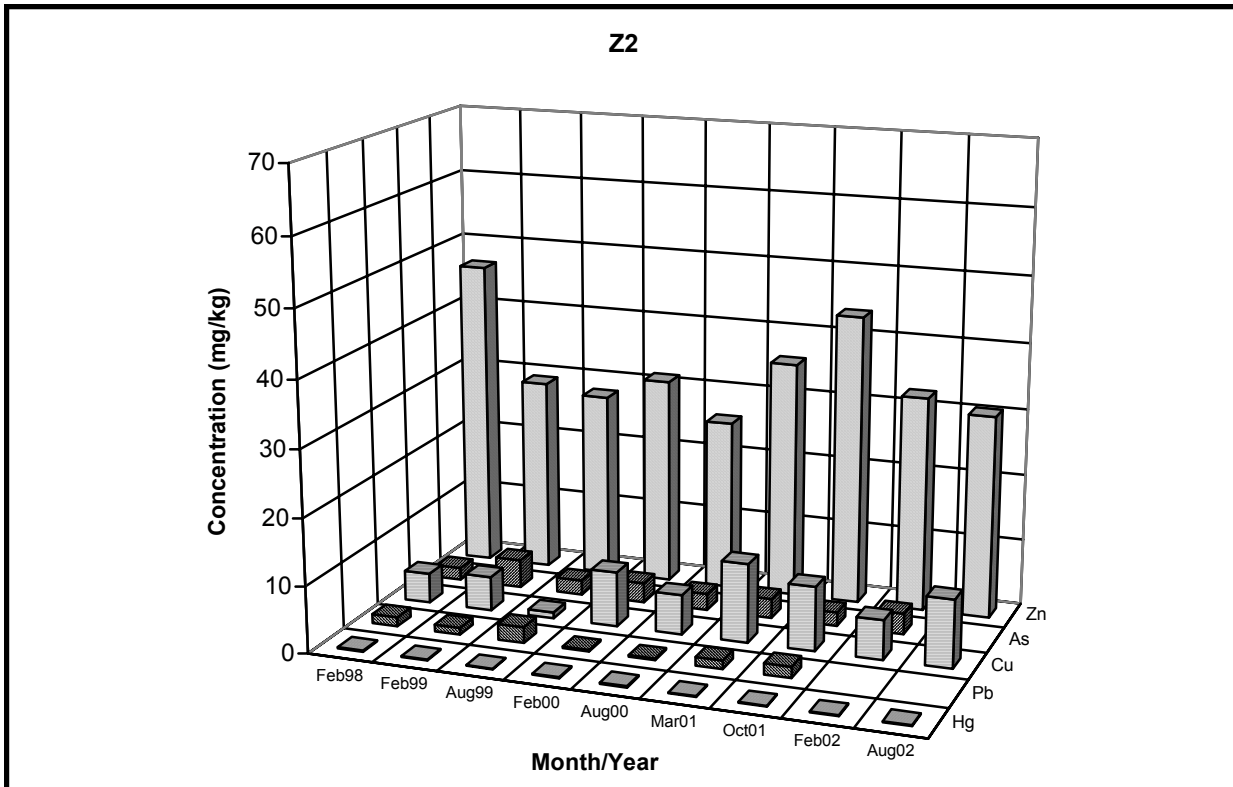


Figure 8-23. Concentrations of five metals found in liver tissues of hornyhead turbot at station Z2 during 1998 through 2002 surveys.

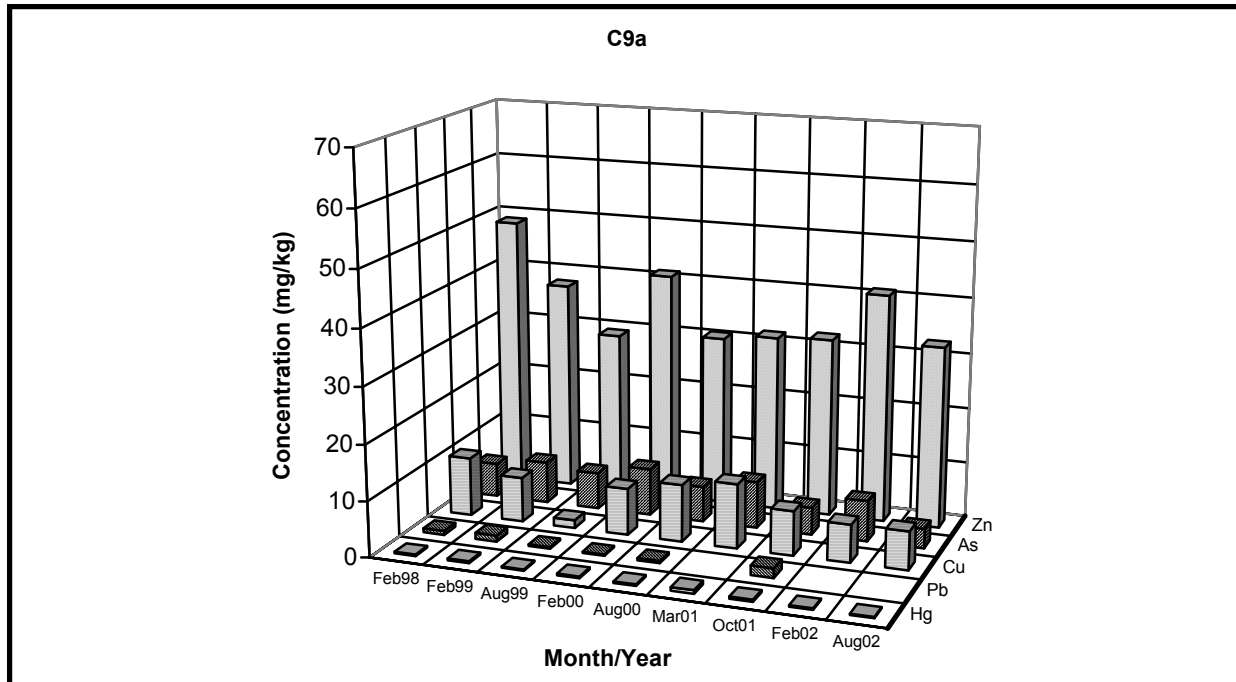


Figure 8-24. Concentrations of five metals found in liver tissues of hornyhead turbot at station C9a during 1998 through 2002 surveys.

b. Organics

As shown in Tables 8-2a, and 8-2b, *o,p'*-DDE, *p,p'*-DDE, and PCB 1260 were detected in 100% of hornyhead turbot liver samples during the 2001 survey and only *p,p'*-DDE was detected in 100% in 2002. All derivatives of DDT (except *o,p'*-DDD) were detected in 2001 but only *o,p'*-DDE, *p,p'*-DDE, and *p,p'*-DDD were found in the liver samples of 2002 (Tables 8-2a and 8-2b). The PCB Aroclor 1254, and Aroclor 1260 were detected at 90% to 100% frequency in 2001, whereas, Aroclor 1254 and Aroclor 1260 were detected at 70% and 87%, respectively, in 2002 samples. Low concentrations of α -chlordane, derivatives of BHC, and trans-nonachlor were also detected in liver samples during 2001 survey but only D-BHC was detected in 2002. Concentrations of total DDT derivatives and PCB Aroclors were several folds higher in liver than in muscle tissues of hornyhead turbot (Tables 8-2a, and 8-2b).

During 2001-2002, two phthalates (bis[2-ethylhexyl] phthalate and di-n-butyl phthalate) were also frequently detected in the hornyhead turbot samples. The detection of these two compounds may be the result of laboratory contamination. Isophorone and diethylphthalate were also detected in both 2001 and 2002 survey. Naphthalene and 3,3-dichlorobenzidine were found only in 2001 at one station.

As has consistently occurred during the last five years, concentrations of total DDT and total PCB in 2001-2002 followed definite spatial trends in Santa Monica Bay (Figures 8-25 to 8-26). DDT concentrations in liver increased from the north to south, and were the highest at station Z2 or C9a. Similar to the previous years, PCB levels were highest at the outfall stations Z2 and near-outfall station C6 (Figure 8-26). During the last five years (from 1998 to 2002), moderate temporal

decrease in total DDT and PCB concentrations with some spikes was observed in the Santa Monica Bay (Figures 8-25 to 8-26). Another trend was that the pollutant levels in winter season were generally lower than the levels in summer season.

The concentration of lipid in hornyhead turbot muscle samples from 1998 to 2002, are presented in Figure 8-14. In hornyhead turbot fish liver the mean %lipid value was 12.7 in 2001, and 8.89 in 2002 (Tables 8-2a and 8-2b). Percent lipid levels of all hornyhead turbot samples showed poor correlation with total DDT, or Aroclor's during the 2001 and 2002 surveys (Figures 8-25 to 8-27).

B. SPORTFISH

A total of 9 species of sportfish were collected from March to September of 2001, and 11 species were collected in 2002. Among the nine metals, (As, Cd, Cr, Cu, Pb, Hg, Ni, Ag and Zn), Hg and Zn were the most frequently detected metals (Tables 8-3a and 8-3b). Of the 84 organic priority pollutants analyzed, p,p'-DDD, o,p'-DDE, p,p'-DDE, and PCB Aroclor 1254 and Aroclor 1260 were detected the most frequently (Tables 8-4a and 8-4b).

1. Metals

Six metals were detected in muscle tissue samples of one or more species of 20 sportfish collected during 2001 and 2002 (Tables 8-3a, 8-3b). Zn was detected in all species collected. Hg was detected in all samples of 2001 and in all samples except Blue Rockfish in 2002. Due to the change of instrumentation and the raise of detection limits in 2002, the metal pollutants except Hg and Zn were not detected in all collected sportfish samples.

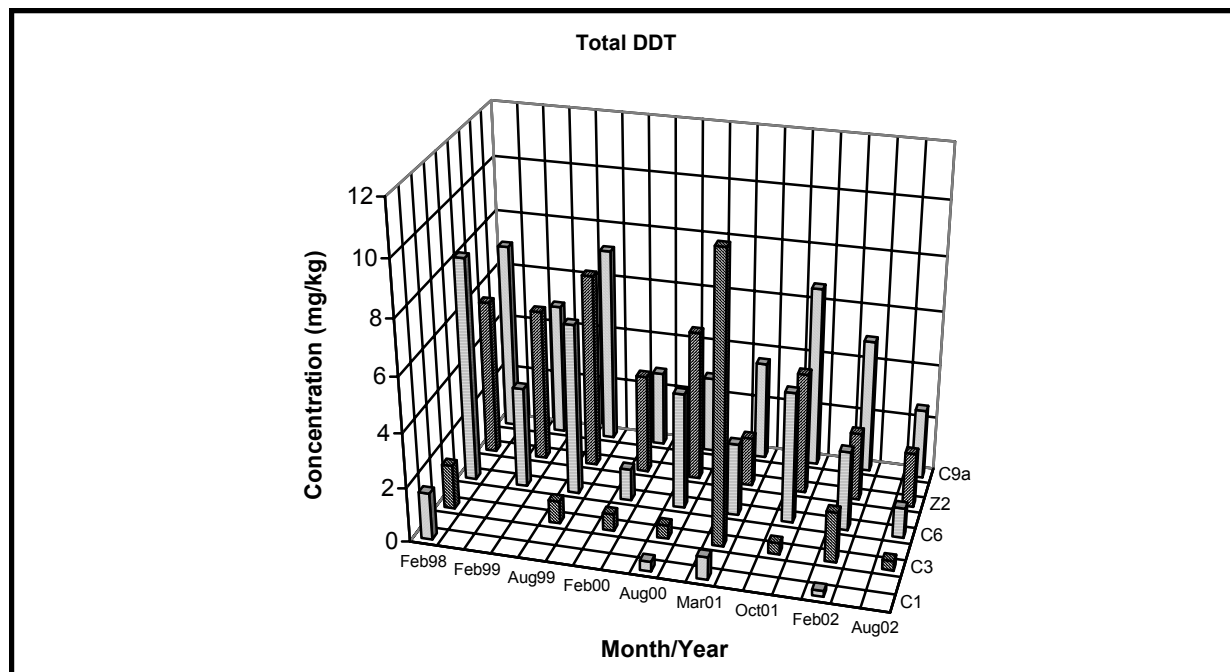


Figure 8-25. Concentration of total DDT in liver tissues of hornyhead turbots at five stations during 1998 through 2002 surveys.

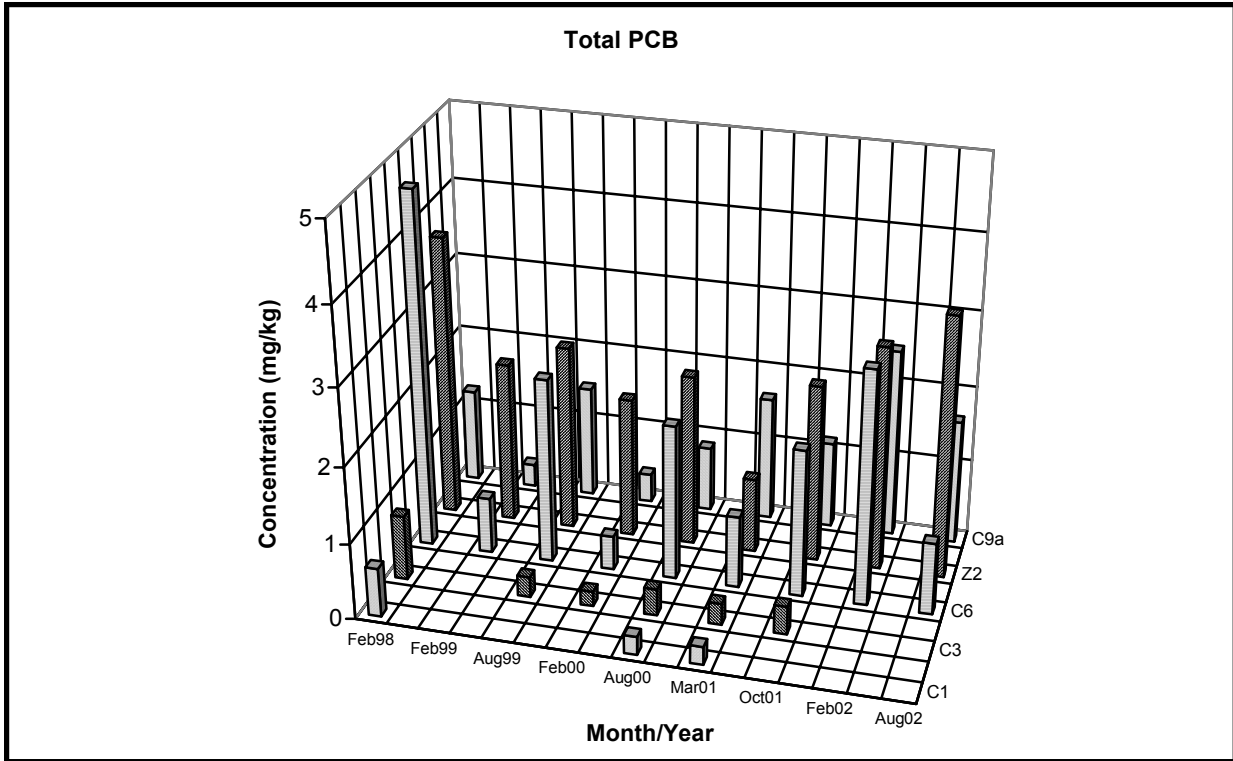


Figure 8-26. Concentration of total PCB in liver tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

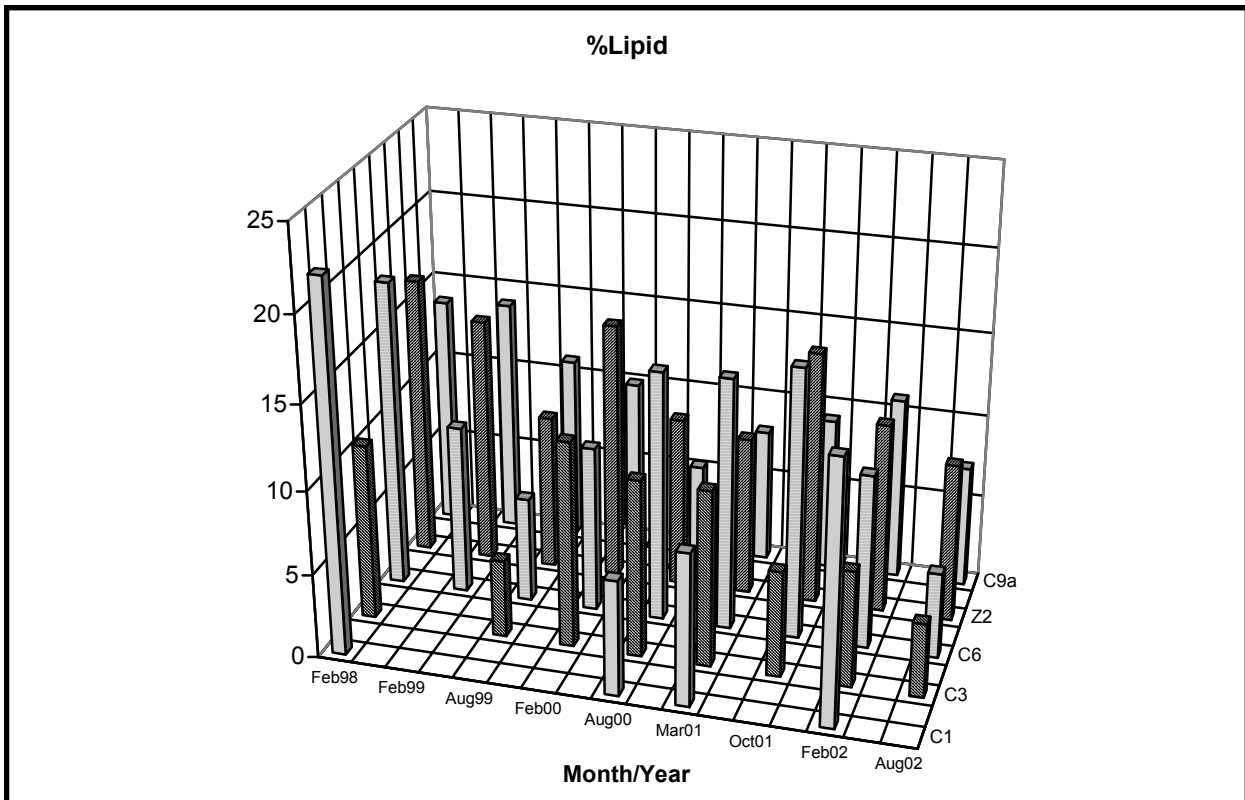


Figure 8-27. Concentration of %lipid in liver tissues of hornyhead turbot at five stations during 1998 through 2002 surveys.

Among the metals, the concentration of Zn was highest (2.06 – 7.84 mg/kg) in all species of sportfish collected during 2001 and 2002. Arsenic level was also high in tissues of most of the sportfish species.

Since white croaker and scorpion fish were the most frequently collected species from 1998 to 2002, (CLA, EMD 1998 - 2000), the trend of tissue concentration of five metals (As, Cu, Hg, Pb, and Zn) in these two species collected at 5-Mile Outfall (station Z2) was assessed (Figures 8-28 and 8-29). However, no significant temporal trend with respect to metal concentration was observed. All five metals were detected in muscle tissues of white croaker in 1999. Only mercury and zinc were found in white croaker samples in 2002 and no metals were detected in 1998, 2000, and 2001. The concentration of metals during 1998 and 2002 were variable for scorpion fish (Figure 8-29) with only mercury and zinc were detected in 2002 survey.

2. Organics

The organic compounds, p,p'-DDE and PCB Aroclor 1254 followed by o,p'-DDE, p,p'-DDD, and PCB Aroclor 1260 were the most frequently detected pollutants in sportfish collected during the 2001-2002 monitoring period (Tables 8-4a and 8-4b).

In 2001 and 2002, the highest levels of DDT derivatives and PCB Aroclors were found in the starry rockfish. In 2001, α -Chlordane was detected in some sportfish tissues but not in 2002 and was found only in 2002.

While the concentrations detected for DDT derivatives and PCB Aroclors were well below the DDT (5 ppm) and PCB (2 ppm) concentration levels set by the Food and Drug Administration (FDA), some have exceeded the standard limits of 0.100 ppm used by the California Office of Environmental Health Hazard Assessment for sportfish (OEHHA 1991). Concentrations of DDT derivatives exceeding 0.100 ppm guidelines were found in muscle tissues of all sportfish species in 2001 and in all species except blue rockfish, copper rockfish, and vermilion rockfish in 2002. Total DDT and PCB concentrations as high as 1.80 ppm and 0.811 ppm, respectively, were found in some tissue samples of sport fish muscles collected in 2001 and 2002 (Tables 8-4a and 8-4b). However, average concentrations of PCB and DDT derivatives in sportfish tissues surveyed, were all below 0.100 ppm level.

Table 8-3a. Metals in sportfish from Santa Monica Bay during fiscal year 2001. Data are reported in mg/kg

CONSTITUENTS DETECTED	VERMILLION Mar. - Sep. 2001, n = 9		CALIFORNIA SCORPIONFISH Mar.-Sep. 2001, n = 9		OCEAN WHITEFISH Mar.-May 2001, n = 6	
	AVG (ppm)	RANGE (ppm)	AVG (ppm)	RANGE (ppm)	AVG (ppm)	RANGE (ppm)
Ag	ND	ND	ND	ND	ND	ND
As	0.635	ND-2.48	0.453	ND-1.28	3.07	0.664-10.8
Cd	ND	ND	ND	ND-0.235	ND	ND
Cr	0.099	ND-0.233	0.107	0.051-0.151	0.131	0.045-0.303
Cu	0.396	ND-0.846	0.423	ND-0.698	0.242	ND-0.558
Hg	0.094	0.027-0.209	0.490	0.196-1.04	0.099	0.038-0.164
Ni	ND	ND	ND	ND	ND	ND
Pb	0.362	ND-2.09	0.496	ND-2.480	0.129	ND-0.369
Zn	3.80	2.98-5.40	4.37	2.96-7.84	3.25	2.80-3.79
CN	ND	ND	ND	ND	NS	NS
CONSTITUENTS DETECTED	SQUARESPOT ROCKFISH Mar. 2001, n = 6		STARRY ROCKFISH Jun.-Sep. 2001, n = 12		BOCACCIO Mar.-Sep. 2001, n = 17	
	AVG (ppm)	RANGE (ppm)	AVG (ppm)	RANGE (ppm)	AVG (ppm)	RANGE (ppm)
Ag	ND	ND	ND	ND	0.020	ND-0.076
As	ND	ND	0.107	ND-0.487	ND	ND
Cd	ND	ND	ND	ND	ND	ND
Cr	0.171	0.138-0.211	0.075	0.044-0.124	0.110	ND-0.523
Cu	ND	ND	0.302	ND-1.28	0.225	ND-0.428
Hg	0.345	0.225-0.766	0.499	0.286-0.968	0.230	0.132-0.376
Ni	ND	ND	ND	ND-0.213	ND	ND
Pb	ND	ND-0.263	1.06	ND-4.51	0.500	ND-2.56
Zn	3.37	3.05-3.92	3.03	2.24-4.15	3.27	2.84-4.33
CN	NS	NS	NS	NS	NS	NS
CONSTITUENTS DETECTED	GREENBLOTCHED ROCKFISH Mar. - Jun. 2001, n = 12		OLIVE ROCKFISH Sep. 2001, n = 3			
	AVG (ppm)	RANGE (ppm)	AVG (ppm)	RANGE (ppm)		
Ag	ND	ND	ND	ND		
As	0.852	ND-1.95	ND	ND		
Cd	ND	ND	ND	ND		
Cr	ND	ND-0.170	0.139	0.092-0.219		
Cu	ND	ND-0.457	0.548	0.428-0.653		
Hg	0.226	0.109-0.512	0.089	0.043-0.171		
Ni	ND	ND	ND	ND		
Pb	0.415	ND-2.61	1.263	0.296-2.547		
Zn	3.06	2.06-3.84	3.16	2.90-3.33		
CN	NS	NS	NS	NS		

n : Number of samples analyzed
 ND : Below MDL
 NS : No sample

Table 8-3b. Metals in sportfish from Santa Monica Bay during fiscal year 2002. Data are reported in mg/kg

	BLUE ROCKFISH		CALIFORNIA SCORPIONFISH		COPPER ROCKFISH	
	Mar. 2002, n = 3		Mar. - Sep. 2002, n = 9		Mar. 2002, n = 3	
CONSTITUENTS	AVG	RANGE	AVG	RANGE	AVG	RANGE
DETECTED	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Ag	ND	ND	ND	ND	ND	ND
As	ND	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND	ND
Cr	ND	ND	ND	ND	ND	ND
Cu	ND	ND	ND	ND	ND	ND
Hg	ND	ND	0.200	0.094-0.326	0.096	0.061-0.133
Ni	ND	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND	ND
Zn	2.86	2.81-2.94	3.33	2.84-4.26	3.30	3.17-3.55
CN	ND	ND	ND	ND-0.22	ND	ND

	BOCACCIO		GREENSPOTTED ROCKFISH		VERMILLION	
	Mar. - Sep. 2002, n = 11		Jun. - Sep. 2002, n = 18		Jun. 2002, n = 3	
CONSTITUENTS	AVG	RANGE	AVG	RANGE	AVG	RANGE
DETECTED	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Ag	ND	ND	ND	ND	ND	ND
As	ND	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND	ND
Cr	ND	ND	ND	ND	ND	ND
Cu	ND	ND	ND	ND	ND	ND
Hg	0.164	0.100-0.236	0.162	0.058-0.281	0.042	0.029-0.051
Ni	ND	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND	ND
Zn	3.22	2.64-3.97	3.08	2.18-3.94	2.85	2.67-3.03
CN	ND	ND	ND	ND	ND	ND

n : Number of samples analyzed
 ND : Below MDL
 NS : No sample

Table 8-3b (Continued). Metals in sportfish from Santa Monica Bay during fiscal year 2002. Data are reported in mg/kg

CONSTITUENTS DETECTED	WHITE CROAKER Jun. 2002, n = 3		BROWN ROCKFISH Sep. 2002, n = 3		FANTAIL SOLE Sep. 2002, n = 3	
	AVG (ppm)	RANGE (ppm)	AVG (ppm)	RANGE (ppm)	AVG (ppm)	RANGE (ppm)
Ag	ND	ND	ND	ND	ND	ND
As	ND	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND	ND
Cr	ND	ND	ND	ND	ND	ND
Cu	ND	ND	ND	ND	ND	ND
Hg	0.146	0.122-0.164	0.116	0.094-0.145	0.221	0.137-0.278
Ni	ND	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND	ND
Zn	3.09	2.72-3.57	3.43	3.09-3.93	3.80	2.97-4.52
CN	ND	ND	ND	ND	ND	ND

CONSTITUENTS DETECTED	SPECKLED ROCKFISH Jun. 2002, n = 6		STARRY ROCKFISH Mar. - Sep. 2002, n = 18	
	AVG (ppm)	RANGE (ppm)	AVG (ppm)	RANGE (ppm)
Ag	ND	ND	ND	ND
As	ND	ND	ND	ND
Cd	ND	ND	ND	ND
Cr	ND	ND	ND	ND
Cu	ND	ND	ND	ND
Hg	0.056	0.036-0.067	11.526	0.118-202
Ni	ND	ND	ND	ND
Pb	ND	ND	ND	ND-74.2
Zn	2.65	2.49-2.72	2.88	2.34-3.55
CN	ND	ND-0.41	ND	ND

n : Number of samples analyzed
 ND : Below detection limit
 NS : No sample

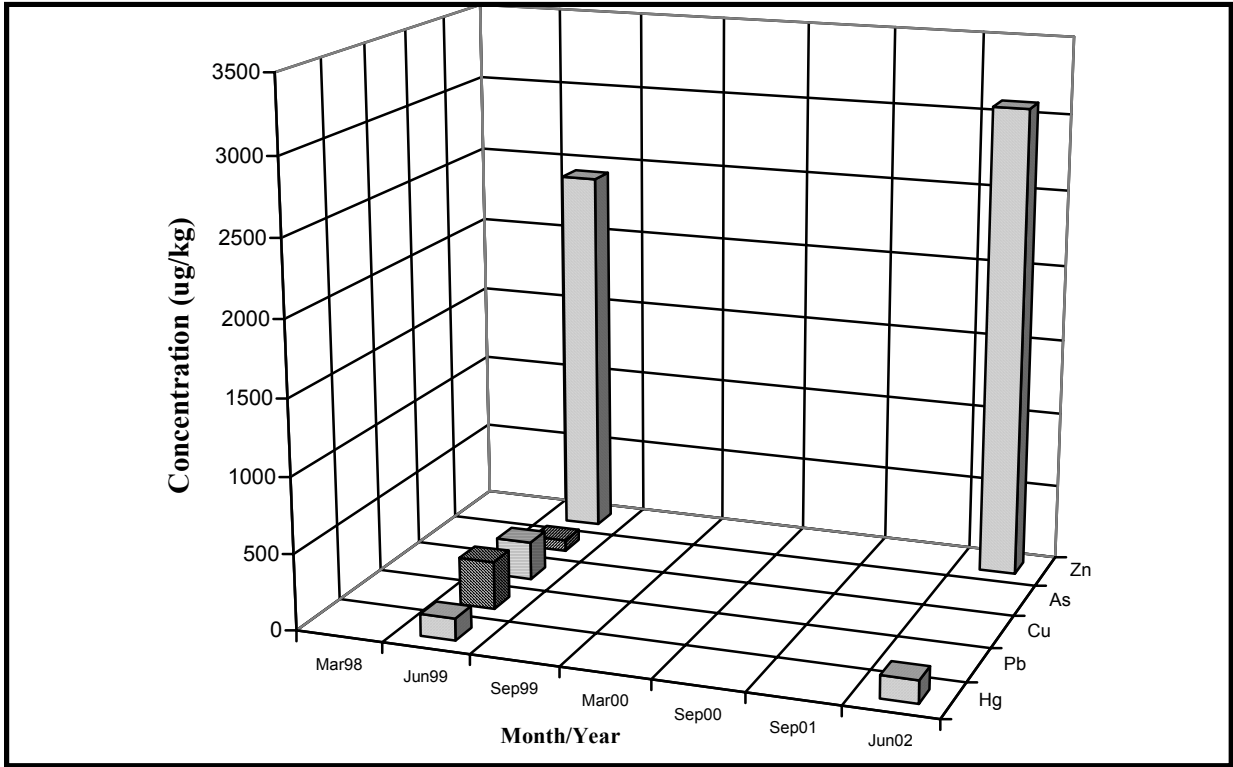


Figure 8-28. Concentration of five metals in muscle tissues of white croakers at 5-Mile Outfall during 1998 through 2002 surveys.

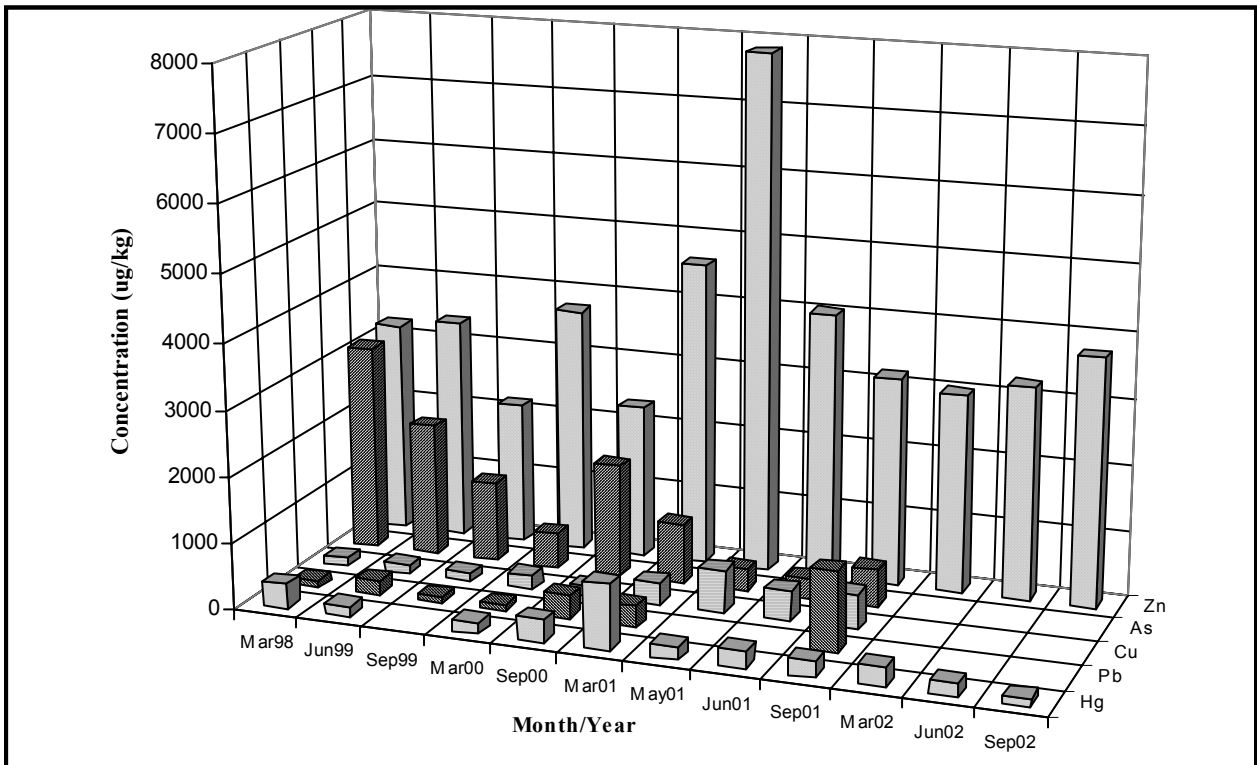


Figure 8-29. Concentration of five metals in muscle tissues of scorpionfish at 5-Mile Outfall during 1998 through 2002 surveys.

Table 8-4a. Organic pollutants measured in sportfish from Santa Monica Bay during 2001. Bold numbers indicate DDT and PCB levels that exceed the 0.100 ppm limit set by OEHHHA (1991).

CONSTITUENTS DETECTED	VERMILION Mar. - Sep. 2001, n = 9		CALIFORNIA SCORPIONFISH Mar. 2001, n = 9		OCEAN WHITEFISH Mar. - May 2001, n = 6	
	AVG	RANGE	AVG	RANGE	AVG	RANGE
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Pesticides and PCBs:						
B-BHC	0.0015	ND-0.0118	0.001	ND-0.0101	0.003	ND-0.0100
G-BHC	ND	ND-0.0024	ND	ND	ND	ND
D-BHC	0.0012	ND-0.0650	0.001	ND-0.0078	0.003	ND-0.0110
O,P'-DDE	0.0070	ND-0.0217	0.005	ND-0.0238	0.000	ND-0.0029
P,P'-DDE	0.134	0.0483-0.255	0.377	0.0895-0.790	0.114	0.0228-0.178
P,P'-DDD	0.0021	ND-0.0101	0.001	ND-0.0033	ND	ND
O,P'-DDT	ND	ND	ND	ND	0.001	ND-0.0067
P,P'-DDT	ND	ND	ND	ND-0.0012	ND	ND
PCB 1254	0.0301	ND-0.0670	0.101	ND-0.419	0.046	ND-0.170
PCB 1260	0.0288	ND-0.0748	0.128	0.0724-0.209	0.075	ND-0.113
α -Chlordane	ND	ND	0.003	ND-0.0155	ND	ND
trans-Nonachlor	ND	ND	0.001	ND-0.0042	ND	ND
Base/Neutral/Acid extractables:						
Di-n-butylphthate	2.74	ND-8.83	5.62	ND-29.0	11.7	ND-58.5
Bis(2-ethylhexyl)phthalate	5.38	ND-19.2	ND	ND-3.0	ND	ND-1.58
Lipid %	1.09	0.52-1.86	1.44	0.52-2.25	1.11	0.69-1.86
TOX (mg/kg)	ND	ND	ND	ND	ND	ND

CONSTITUENTS DETECTED	SQUARESPOT ROCKFISH Mar. 2001, n = 6		STARRY ROCKFISH Jun. - Sep. 2001, n = 12		BOCACCIO Mar.- Sep. 2001, n = 17	
	AVG	RANGE	AVG	RANGE	AVG	RANGE
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Pesticides and PCBs:						
A-BHC	ND	ND-0.0008	ND	ND	ND	ND
B-BHC	ND	ND-0.0013	ND	ND	ND	ND-0.0020
Aldrin	ND	ND	ND	ND	ND	ND-0.0018
O,P'-DDE	0.0108	0.0038-0.0246	0.0027	ND-0.0163	0.0058	0.0014-0.0012
P,P'-DDE	0.291	0.156-0.530	0.3910	0.0213-1.613	0.185	0.0740-0.340
P,P'-DDD	0.0039	0.0020-0.0088	ND	ND-0.0046	0.0012	ND-0.0060
P,P'-DDT	0.0006	ND-0.0021	ND	ND	0.0006	ND-0.0015
PCB 1254	0.0540	0.0366- 0.101	0.0620	ND-0.350	0.0210	ND-0.0600
PCB 1260	0.0142	ND-0.0477	0.0420	ND-0.191	ND	ND-0.0188
α -Chlordane	0.0013	ND-0.0029	ND	ND	ND	ND
trans-Nonachlor	0.0009	ND-0.0023	ND	ND	ND	ND
Base/Neutral/Acid extractables:						
*Di-n-butylphthate	ND	ND-4.1	ND	ND-2.9	2.26	ND-9.56
*Bis(2-ethylhexyl)phthalate	1.49	ND-4.19	ND	ND-1.58	ND	ND-1.61
Lipid %	0.90	0.8-1.08	1.15	0.68-2.04	0.98	0.75-1.47
TOX (mg/kg)	ND	ND	ND	ND	ND	ND

Table 8-4a. (Continued) Organic pollutants measured in sportfish from Santa Monica Bay during 2001. Bold numbers indicate DDT and PCB levels that exceed the 0.100 ppm limit set by OEHHA (1991).

CONSTITUENTS DETECTED	GREENBLOTCHED ROCKFISH Mar. - Jun. 2001, n = 12		OLIVE ROCKFISH Sep. 2001, n = 3	
	AVG	RANGE	AVG	RANGE
	(ppm)	(ppm)	(ppm)	(ppm)
Pesticides and PCBs:				
O,P'-DDE	0.0013	ND-0.0040	0.0063	ND-0.0139
P,P'-DDE	0.1750	ND- 0.5940	0.1040	0.0507- 0.1890
P,P'-DDD	0.0020	ND-0.0061	ND	ND
P,P'-DDT	0.0009	ND-0.0022	ND	ND
PCB 1254	0.0170	ND-0.0578	0.0215	ND-0.0545
PCB 1260	ND	ND-0.0275	ND	ND
α -Chlordane	0.0009	ND-0.0041	ND	ND
trans-Nonachlor	0.0006	ND-0.0016	ND	ND
Base/Neutral/Acid extractables:				
*Di-n-butylphthate	ND	ND-3.6	ND	ND
*Bis(2-ethylhexyl)phthalate	10.75	ND-113	1.82	ND-2.52
Lipid %	1.15	0.67-1.52	0.96	0.88-1.03
TOX (mg/kg)	ND	ND	ND	ND
*Compounds detected may be the result of sampling or lab contamination n : Number of samples analyzed ND : Below detection limits				

Table 8-4b. Organic pollutants measured in sportfish from Santa Monica Bay during 2002. Bold numbers indicate DDT and PCB levels that exceed the 0.100 ppm limit set by OEHHA (1991).

CONSTITUENTS DETECTED	BLUE ROCKFISH Mar. 2002, n = 3		CALIFORNIA SCORPIONFISH Mar.-Sep. 2002, n = 9		COPPER ROCKFISH Mar. 2002, n = 3	
	AVG	RANGE	AVG	RANGE	AVG	RANGE
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Pesticides and PCBs:						
P,P'-DDE	0.029	0.021-0.041	0.120	0.023- 0.300	0.054	0.049-0.059
Base/Neutral/Acid extractables:						
Isophorone	1.13	ND-1.51	ND	ND-1.42	1.29	1.10-1.47
Diethylphthalate	6.25	4.66-7.52	2.93	ND-7.46	6.41	6.08-7.01
Bis(2-ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND-2.67
Lipid %	1.81	1.67-1.89	1.50	0.77-2.44	1.07	0.96-1.26
TOX (mg/kg)	4.53	4.25-5.09	4.69	3.38-6.11	1.85	1.31-2.52
CONSTITUENTS DETECTED	BOCACCIO Mar.-Sep. 2002, n = 11		GREENSPOTTED ROCKFISH Jun.-Sep. 2002, n = 18		VERMILLION Mar.-Sep. 2001, n = 3	
	AVG	RANGE	AVG	RANGE	AVG	RANGE
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Pesticides and PCBs:						
O,P'-DDE	0.006	0.002-0.022	ND	ND	ND	ND
P,P'-DDE	0.103	0.031-0.233	0.103	0.042- 0.286	0.056	0.039-0.088
Methoxychlor	ND	ND-0.006	ND	ND	ND	ND
Base/Neutral/Acid extractables:						
Isophorone	1.53	ND-4.01	3.05	ND-7.36	ND	ND-1.627
* Diethylphthalate	2.55	ND-6.37	2.28	ND-5.88	ND	ND
*Bis(2-ethylhexyl)phthalate	ND	ND-4.02	2.11	ND-18.24	ND	ND
Lipid %	1.34	0.66-2.09	1.37	0.65-1.86	0.84	0.54-1.01
TOX (mg/kg)	4.44	2.43-7.53	4.19	2.77-7.34	2.88	1.99-4.05
*Compounds detected may be the result of lab contamination						
n : Number of samples analyzed						
ND : Below detection limits						

Table 8-4b. (Continued) Organic pollutants measured in sportfish from Santa Monica Bay during 2002. Bold numbers indicate DDT and PCB levels that exceeded the 0.100 ppm limit set by OEHHA (1991).

CONSTITUENTS DETECTED	WHITE CROAKER Jun. 2002, n = 3		BROWN ROCKFISH Sep. 2002, n = 3		FANTAIL SOLE Sep. 2002, n = 3	
	AVG	RANGE	AVG	RANGE	AVG	RANGE
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Pesticides and PCBs:						
O,P'-DDE	ND	ND	0.004	ND-0.006	ND	ND
P,P'-DDE	0.119	0.073-0.209	0.106	0.088-0.139	0.056	0.010-0.139
O,P'-DDD	ND	ND	ND	ND-0.004	ND	ND
Base/Neutral/Acid extractables:						
Isophorone	2.11	ND-4.25	1.329	ND--2.99	ND	ND
Lipid %	1.11	1.00-1.25	2.00	1.53-2.24	1.137	0.850-1.580
TOX (mg/kg)	7.05	5.51-9.23	5.09	2.64-8.13	4.49	4.07-4.82
CONSTITUENTS DETECTED	SPECKLED ROCKFISH Jun. 2002, n = 6		STARRY ROCKFISH Mar. - Sep. 2002, n = 18			
	AVG	RANGE	AVG	RANGE		
	(ppm)	(ppm)	(ppm)	(ppm)		
Pesticides and PCBs:						
D-BHC	ND	ND	ND	ND-0.008		
O,P'-DDE	ND	ND-0.005	0.003	ND-0.022		
P,P'-DDE	0.063	0.016-0.154	0.315	0.052-1.78		
Arochlor 1254	ND	ND	ND	ND-0.605		
Arochlor 1260	ND	ND	ND	ND-0.206		
Base/Neutral/Acid extractables:						
Isophorone	ND	ND-1.14	1.16	ND-2.90		
*Diethylphthalate	ND	ND	2.19	ND-6.03		
*Bis(2-ethylhexyl)phthalate	ND	ND-3.13	2.07	ND-20.3		
Lipid %	1.44	0.93-1.74	1.59	0.99-2.62		
TOX (mg/kg)	5.77	4.90-6.53	4.92	3.24-6.55		
*Compounds detected may be the result of lab contamination						
n : Number of samples analyzed						
ND : Below detection limits.						

IV. DISCUSSION

In general, tissue contaminant concentrations in 2001-2002 were similar to those measured in previous years (CLA, EMD 1989 - 2000). Metals measured in the tissues of fish did not necessarily correspond to areas where sediment concentrations were high (Hoenicke 1993). Concentrations of five metals (Zn, As, Hg, Cu, and Pb) in sediments, in trawl fish from Z2 and C6 (outfall and near outfall stations), and in the reference area C1 were compared (Table 8-5a and 8-5 b). Similar to the finding of Hoenicke 1993, no significant correlation was observed between the sediment level and tissue bioaccumulation for these metals. Also, there were no clear temporal trends in tissue metal contaminations; differences over time were probably the result of natural variation.

The question of safe seafood consumption is of great concern with regard to the amounts of trace contaminants in fish from the Bay. The pollutants of greatest concern are the chlorinated hydrocarbons, mainly DDT and its breakdown products, and congeners of PCB (OEHHA 1991). The FDA sets limits for safe consumption of food containing these compounds at 5.0 ppm for DDT, and 2.0 ppm for PCB (see Mearns et al. 1991). All fish tissues analyzed in 2001, and 2002 met these limits.

The State of California, Office of Environmental Health Hazard Assessment (OEHHA) reported assessing the risk to humans of eating fish caught at various locations in Southern California (OEHHA, 1991). Risk estimates were calculated based on a person consuming an average of 23 g/day of muscle over a 70-year period. A trigger level for muscle concentrations exceeding 0.100 ppm was set for total DDT and PCB. This limit is well below those set by the FDA, and reflects both a more conservative approach to protecting public health and an increase of knowledge about the effects of these contaminants.

Many of the sportfish collected in 2001-2002 could not meet this more restrictive limit recommended by OEHHA. In the 2001 and 2002 surveys, all 14 sportfish species except blue rockfish, copper rockfish, and vermillion had average concentrations of DDT derivatives greater than 0.100 ppm (Tables 8-4a and 8-4b). Among the 14 sportfish species collected in 2001 and 2002, only

Table 8-5a. Correlation of metal concentrations (mg/kg) in muscle tissues of trawl fish and in sediment during 2001 Santa Monica Bay monitoring.

	Station C1		Station C6		Station Z2	
	Sediment	Tissue	Sediment	Tissue	Sediment	Tissue
Zinc	66.0	2.67	14.1	2.56	49.8	3.14
Arsenic	5.01	2.31	3.57	4.44	4.33	4.18
Copper	11.7	ND	6.48	ND	21.0	0.19
Mercury	0.269	0.062	0.178	0.082	0.093	0.117
Lead	59.5	1.13	11.5	0.23	11.6	1.79

ND - Below Detection Limit

Table 8-5b. Correlation of metal concentrations (mg/kg) in muscle tissues of trawl fish and in sediment during 2002 Santa Monica Bay monitoring.

	Station C1		Station C6		Station Z2	
	Sediment	Tissue	Sediment	Tissue	Sediment	Tissue
Zinc	61.6	2.56	43.5	2.33	46.4	2.48
Arsenic	ND	3.06	ND	5.23	ND	4.92
Copper	11.8	ND	20.5	ND	22.7	ND
Mercury	0.10	0.05	0.17	0.06	0.16	0.05
Lead	7.41	ND	16.8	ND	9.48	ND

ND - Below Detection Limit

California scorpionfish in 2001 had PCB levels greater than 0.100 ppm.

The tissue concentrations of metals, particularly mercury are also of public health concern. The mercury level in fish tissue was compared with the “action levels” for fish consumption set by the Food and Drug Administration (FDA). Although mercury was detected in almost all sportfish tissue sampled, except blue rockfish in 2002, the mercury concentrations in all samples were well below the FDA action level (1.0 mg/kg). The concentrations were also below the California State Department of Health Services advisory limit of 0.5 mg/kg for sportfish (Tables 8-4a, and 8-4b). The FDA has not set the action levels for the other detected metals. An International Action Limit Median is used by other nations for a similar purpose (Mearns et al. 1991). These International Action Limit Median for the metals in mg/kg are as follows: Ag, 1.4; Cr, 1.0; Cu, 20; Hg, 1.0; and Zn, 70. The average concentrations of all detected metals in the muscle tissues of hornyhead turbot or individual species of sportfish (except Hg in starry rockfish) surveyed in 2001 and 2002, were below the International Median value during 2001 and 2002. In the liver tissues of hornyhead turbot, silver levels exceeded the 1.4 ppm limit in 2001 and 2002 surveys.

These data reported herein are helping to build our knowledge of contaminants in sportfish and invertebrates from the Bay. Such data may be used to further refine levels of risk associated with consumption of these fish, and when appropriate, to modify health advisories. The existing monitoring performed by the City should be supplemented by additional collections of sportfish from piers and jetties by appropriate agencies. Several of these species (e.g., white croaker and scorpionfish) not only are the main catch for subsistence fishermen, but can also have very high levels of total DDT and total PCB (Tables 8-4a, 8-4b, and SCAG 1988).

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