Chapter 7. Bioaccumulation of Contaminants in Fish Tissues

INTRODUCTION

Bottom dwelling (i.e., demersal) fishes are collected as part of the South Bay Ocean Outfall (SBOO) monitoring program to assess the accumulation of contaminants in their tissues. Bioaccumulation of contaminants in fish occurs through the biological uptake and retention of chemical contaminants derived via various exposure pathways (USEPA 2000). The main exposure routes for demersal fishes include uptake of dissolved chemicals in seawater and the ingestion and assimilation of pollutants contained in different food sources (Rand 1995). Because of their proximity to seafloor sediments, these fish may also accumulate contaminants through ingestion of suspended particulates or sediments that contain pollutants. For this reason, the levels of many contaminants in the tissues of demersal fish are often related to those found in the environment (Schiff and Allen 1997), thus making these types of assessments useful in biomonitoring programs.

The bioaccumulation portion of the South Bay monitoring program consists of two components: (1) liver tissues are analyzed for trawl-caught fishes; (2) muscle tissues are analyzed for fishes collected by hook and line (rig fishing). Species of fish collected by trawling activities (see Chapter 6) are representative of the general demersal fish community, and certain species are targeted based on their prevalence in the community and therefore ecological significance. The chemical analysis of liver tissues in these fish is especially important for assessing population effects because this is the organ where contaminants typically concentrate (i.e., bioaccumulate). In contrast, fishes targeted for capture by rig fishing represent species that are characteristic of a typical sport fisher's catch, and are therefore considered of recreational and commercial importance and more directly relevant to human health concerns. Consequently, muscle tissue is analyzed from these fishes because it is the tissue most often consumed by humans, and therefore the results may have public health implications.

This chapter presents the results of all tissue analyses that were performed on fishes collected in the SBOO region during 2008. All liver and muscle samples were analyzed for contaminants as specified in the NPDES discharge permits that govern the SBOO monitoring program (see Chapter 1). Most of these contaminants are also sampled for the National Oceanic and Atmospheric Administration (NOAA) National Status and Trends Program. NOAA initiated this program to detect and monitor changes in the environmental quality of the nation's estuarine and coastal waters by tracking contaminants thought to be of environmental concern (Lauenstein and Cantillo 1993).

MATERIALS AND METHODS

Field Collection

Fishes were collected during April and October of 2008 at seven trawl and two rig fishing stations (Figure 7.1). Trawl-caught fishes were collected following City of San Diego guidelines (see Chapter 6 for a description of collection methods). Fishes targeted at the rig fishing sites were caught using standard rod and reel procedures. Species analyzed from each station are summarized in Table 7.1 and included brown rockfish (*Sebastes auriculatus*), California scorpionfish (*Scorpaena guttata*), English sole (*Parophrys vetulus*), hornyhead turbot (*Pleuronichthys verticalis*), longfin sanddab (*Citharichthys xanthostigma*), and vermilion rockfish (*Sebastes miniatus*). Efforts to collect targeted fish species at the trawl stations were limited to five 10-minute (bottom time) trawls per site. Occasionally, insufficient numbers of the target species were obtained despite this effort, thus resulting in reduced number of composite samples at a particular station. In order to facilitate the collection of sufficient tissue for subsequent chemical analysis, only fish ≥13 cm in standard length were retained. These fish were sorted into no more than three composite samples per station, each containing a minimum of three individuals. Composite samples were typically made up of a

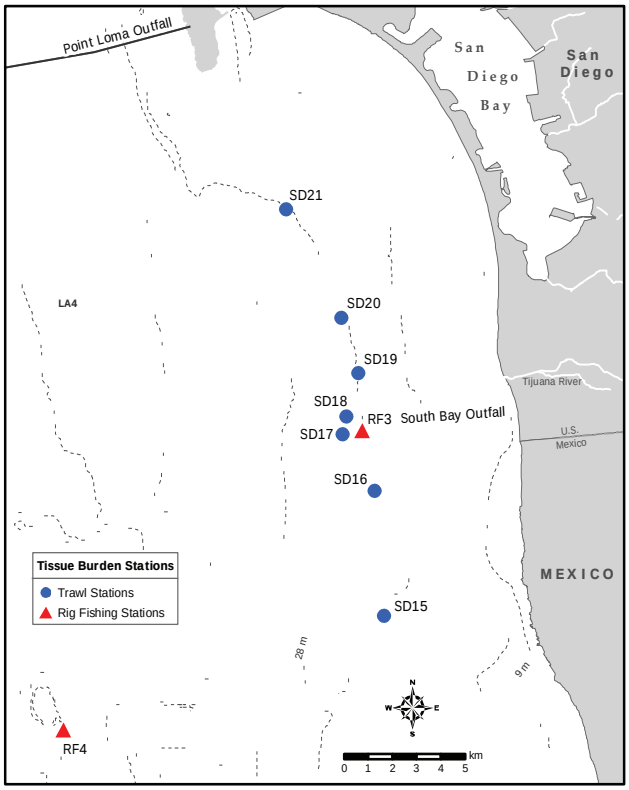

Figure 7.1
Otter trawl and rig fishing station locations for the South Bay Ocean Outfall Monitoring Program.

single species; the only exceptions were samples that consisted of mixed species of rockfish. All fish collected were wrapped in aluminum foil, labeled, sealed in re-sealable plastic bags, placed on dry ice, and then transported to the City's Marine Biology Laboratory where they were held in the freezer at -80°C until dissection and tissue processing.

Tissue Processing and Chemical Analyses

All dissections were performed according to standard techniques for tissue analysis. A brief summary follows, but see City of San Diego (2004) for additional details. Prior to dissection, each fish was partially defrosted and then cleaned with a paper towel to remove loose scales and excess mucus. The standard length (cm) and weight (g) of each fish were recorded (Appendix F.1). Dissections were carried out on Teflon® pads that were cleaned between samples. The tissues (liver or muscle) from each dissected fish were then placed in separate glass jars for each composite sample, sealed, labeled, and stored in a freezer at -20°C prior to chemical analyses. All samples were subsequently delivered to the City's Wastewater Chemistry Services Laboratory for analysis within 10 days of dissection.

The chemical constituents analyzed for each tissue sample were measured on a wet weight basis, and included trace metals, chlorinated pesticides, polychlorinated biphenyl compounds (PCBs), and polycyclic aromatic hydrocarbons (PAHs) (see Appendix F.2). Metals were measured in units of mg/kg and are expressed herein as parts per million (ppm), while pesticides, PCBs, and PAHs were measured as µg/kg and expressed as parts per billion (ppb). Totals for DDT, PCBs, BHC (=lindane and derivatives), chlordane, and PAHs were calculated as the sum of the detected constituents (i.e., total PCB=sum of all congeners detected). The detected values for each individual constituent are listed in Appendix F.3. This report includes estimated values for some parameters determined to be present in a sample with high confidence (i.e., peaks confirmed by mass-spectrometry), but that otherwise occurred at levels below the method detection limit (MDL). A detailed description of the protocols for chemical analyses is available in City of San Diego (2009).

Results and Discussion

Contaminants in Trawl-Caught Fishes

Metals

Twelve metals occurred in >75% of the liver samples analyzed from trawl-caught fishes in 2008, including arsenic, barium, cadmium, chromium, copper, iron, manganese, mercury, selenium, silver, tin, and zinc (Table 7.2). Another five metals (i.e., aluminum, antimony, lead, nickel, thallium) were also detected, but less frequently at rates between 3-69%. Beryllium was not detected in any sample during the year. Tissue concentrations of most metals were <25 ppm over all species. Exceptions occurred for aluminum, iron, and

Table 7.1
Species of fish collected at each SBOO trawl and rig fishing station during April and October 2008.

Station	Composite 1	Composite 2	Composite 3
April 2008			
SD15	Hornyhead turbot	California scorpionfish	(no sample)
SD16	Longfin sanddab	Longfin sanddab	Hornyhead turbot
SD17	Longfin sanddab	Longfin sanddab	Hornyhead turbot
SD18	Longfin sanddab	Longfin sanddab	English sole
SD19	English sole	Longfin sanddab	Longfin sanddab
SD20	English sole	Longfin sanddab	Longfin sanddab
SD21	Longfin sanddab	Longfin sanddab	English sole
RF3	Vermilion rockfish	Brown rockfish	Brown rockfish
RF4	California scorpionfish	California scorpionfish	California scorpionfish
October 2008			
SD15	Hornyhead turbot	(no sample)	(no sample)
SD16	(no sample)	(no sample)	(no sample)
SD17	Hornyhead turbot	Longfin sanddab	California scorpionfish
SD18	Hornyhead turbot	Longfin sanddab	Longfin sanddab
SD19	Hornyhead turbot	Longfin sanddab	Longfin sanddab
SD20	Hornyhead turbot	Longfin sanddab	Longfin sanddab
SD21	Longfin sanddab	Hornyhead turbot	California scorpionfish
RF3	Brown rockfish	Brown rockfish	Brown rockfish
RF4	California scorpionfish	California scorpionfish	California scorpionfish

zinc, which all had concentrations >45 ppm in at least one sample. Several metals occurred in quantities that varied greatly among the different species of fish. For example, arsenic ranged from 14 to 18.5 ppm in English sole livers, but was less than 8 ppm on average in liver samples from California scorpionfish, hornyhead turbot, and longfin sanddab. In contrast, zinc ranged from 94 to 137 ppm in liver samples from California scorpionfish, but was less than 46 ppm on average for each of the other three species. These differences are not unexpected, as it has been well documented that the bioaccumulation of contaminants can vary greatly between fish species due to differences in physiology and life history (see Groce 2002 and references therein).

The distribution of frequently detected metals in fishes collected in the SBOO region was assessed by comparing concentrations in fishes collected at the two stations located within a kilometer of the SBOO (SD17, SD18) to those from stations located farther away to the south (SD15, SD16) or north (SD19–SD21) (Figure 7.2). Because concentrations of contaminants varied so much among the species collected, only intra-species comparisons were used for this evaluation. These comparisons suggest that there was no clear relationship between contaminant loads and proximity to the outfall (Figure 7.2). Contaminant concentrations were similar among stations and most were close to or below the maximum levels detected in the same species prior to discharge. Exceptions occurred for two of the four species; arsenic, cadmium, manganese, and zinc occurred at concentrations above the maximum value reported during the pre-discharge period for hornyead turbot and English sole. However, these relatively high concentrations occurred throughout the region and showed no pattern relative to the outfall.

Table 7.2

Summary of metals in liver tissues of fishes collected at SBOO trawl stations during 2008. Data include the number of detected values (n), as well as minimum (Min), maximum (Max) and mean detected concentrations for each species. Concentrations are expressed as parts per million (ppm); the number of samples per species is indicated in parentheses; nd=not detected. See Appendix F.2 for MDLs and names for each metal represented by periodic table symbol.

	Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	Sn	Zn
California scorpionfish																		
n (out of 3)	2	3	3	3	nd	3	3	3	3	nd	3	3	2	3	2	nd	3	3
Min	4.10	0.11	0.39	0.103	—	2.40	0.20	13.00	89.8	—	0.60	0.189	0.10	0.47	0.07	—	2.94	94.2
Max	36.80	0.54	1.02	0.359	—	2.81	0.49	21.10	263.0	—	1.27	0.347	0.23	0.64	0.22	—	4.25	137.0
Mean	20.45	0.29	0.65	0.212	—	2.58	0.37	17.43	147.9	—	0.84	0.277	0.17	0.57	0.14	—	3.54	117.7
English sole																		
n (out of 4)	3	4	4	4	nd	4	4	4	4	3	4	4	nd	4	nd	nd	4	4
Min	3.09	0.28	14.00	0.089	—	0.90	0.10	5.30	174.0	0.15	2.14	0.057	—	0.95	—	—	1.93	27.6
Max	12.70	0.65	18.50	0.158	—	1.40	0.26	7.85	218.0	0.24	2.32	0.071	—	1.39	—	—	2.39	44.9
Mean	6.44	0.50	16.62	0.108	—	1.06	0.18	6.50	197.5	0.21	2.25	0.062	—	1.26	—	—	2.10	38.1
Hornyhead turbot																		
n (out of 9)	2	4	9	9	nd	9	9	9	9	nd	9	8	nd	9	8	nd	9	9
Min	12.50	0.26	2.22	0.056	—	3.82	0.17	6.98	29.7	—	0.94	0.091	—	0.53	0.09	—	1.71	35.5
Max	13.00	0.68	8.50	0.172	—	12.00	0.27	11.00	99.5	—	2.02	0.198	—	0.99	0.23	—	2.40	59.4
Mean	12.75	0.39	5.07	0.098	—	6.77	0.22	8.47	54.6	—	1.42	0.127	—	0.75	0.14	—	2.08	46.4
Longfin sanddab																		
n (out of 20)	8	14	20	20	nd	20	20	20	20	7	20	20	13	20	18	1	20	20
Min	3.13	0.28	4.47	0.088	—	1.04	0.11	4.78	50.0	0.25	0.78	0.044	0.21	0.56	0.05	0.50	1.99	17.7
Max	49.10	0.97	13.00	0.275	—	3.71	0.31	11.80	157.0	0.41	2.22	0.095	0.62	1.73	0.22	0.50	4.61	35.8
Mean	10.33	0.64	7.77	0.163	—	2.14	0.22	8.40	104.2	0.35	1.44	0.069	0.32	1.10	0.11	0.50	3.40	26.7
All species:																		
Detection rate (%)	42	69	100	100	0	100	100	100	100	28	100	97	42	100	78	3	100	100
Max value	49.10	0.97	18.50	0.359	—	12.00	0.49	21.10	263.0	0.41	2.32	0.347	0.62	1.73	0.23	0.50	4.61	137.0

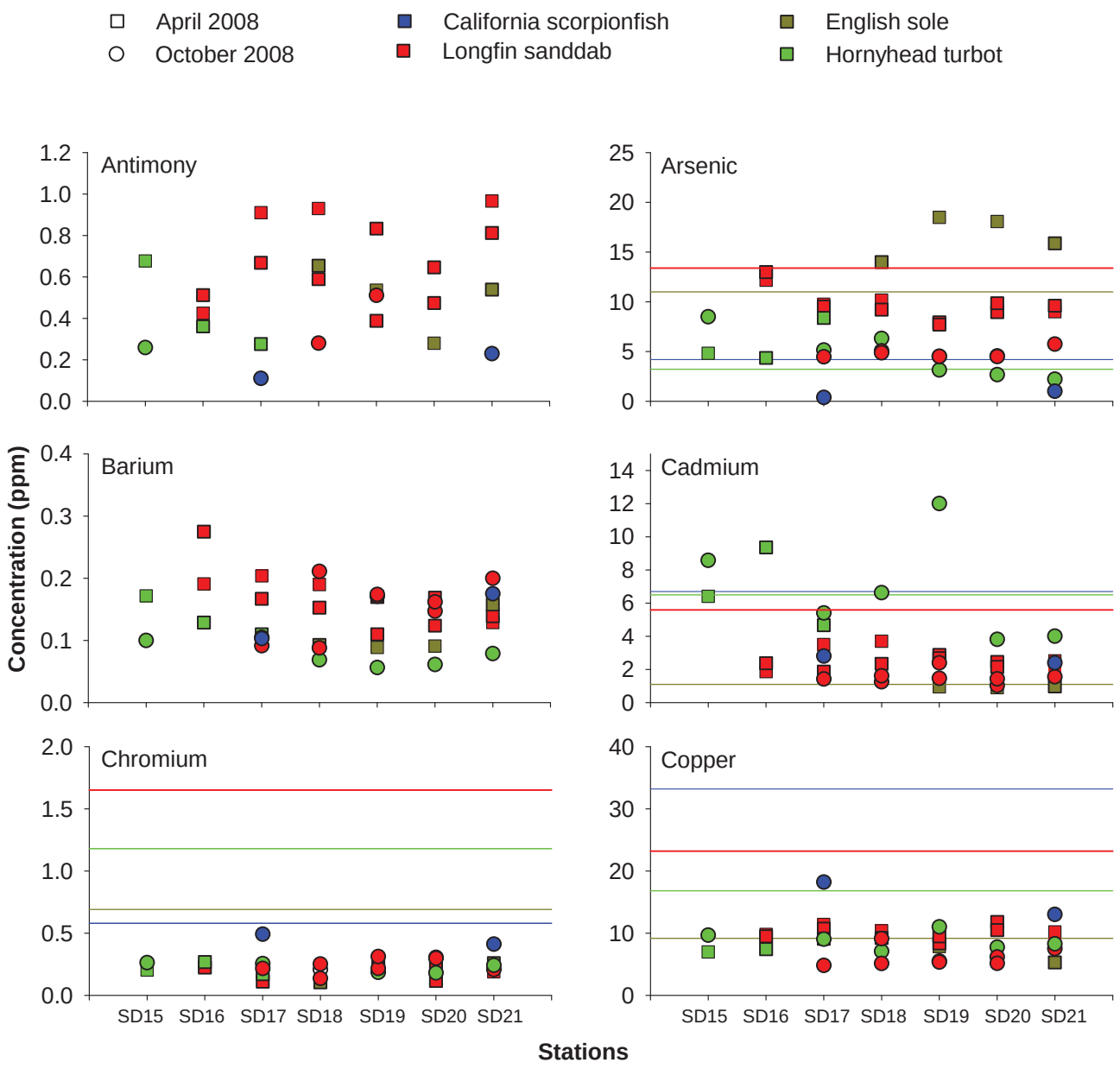

Figure 7.2

Concentrations of frequently detected metals in liver tissues of fishes collected from each SBOO trawl station during 2008. Reference lines are maximum values detected during the pre-discharge period (1995–1998) for each species; antimony, barium, and tin were not detected during the pre-discharge period because of substantially higher detection limits. Therefore, no reference lines are present for these contaminants. Except where samples were not collected (see Table 7.1), missing values=non-detects.

Pesticides

Several chlorinated pesticides were detected in fish tissues during the 2008 trawl surveys (Table 7.3). Individual components of total chlordane and total DDT are listed in Appendix F.2, while detected values of all pesticides are included in Appendix F.3. DDT was found in every tissue sample with total DDT concentrations ranging from about 31 to 1383 ppb. Other pesticides detected in fish tissues during the past year included hexachlorobenzene (HCB) in 83% of the samples at concentrations up to 16 ppb, and chlordane in 42% of the samples at concentrations up to 32 ppb. Pesticide concentrations tended to vary with lipid content, which ranged widely among and within species. For example, California scorpionfish and longfin sanddab liver tissues had

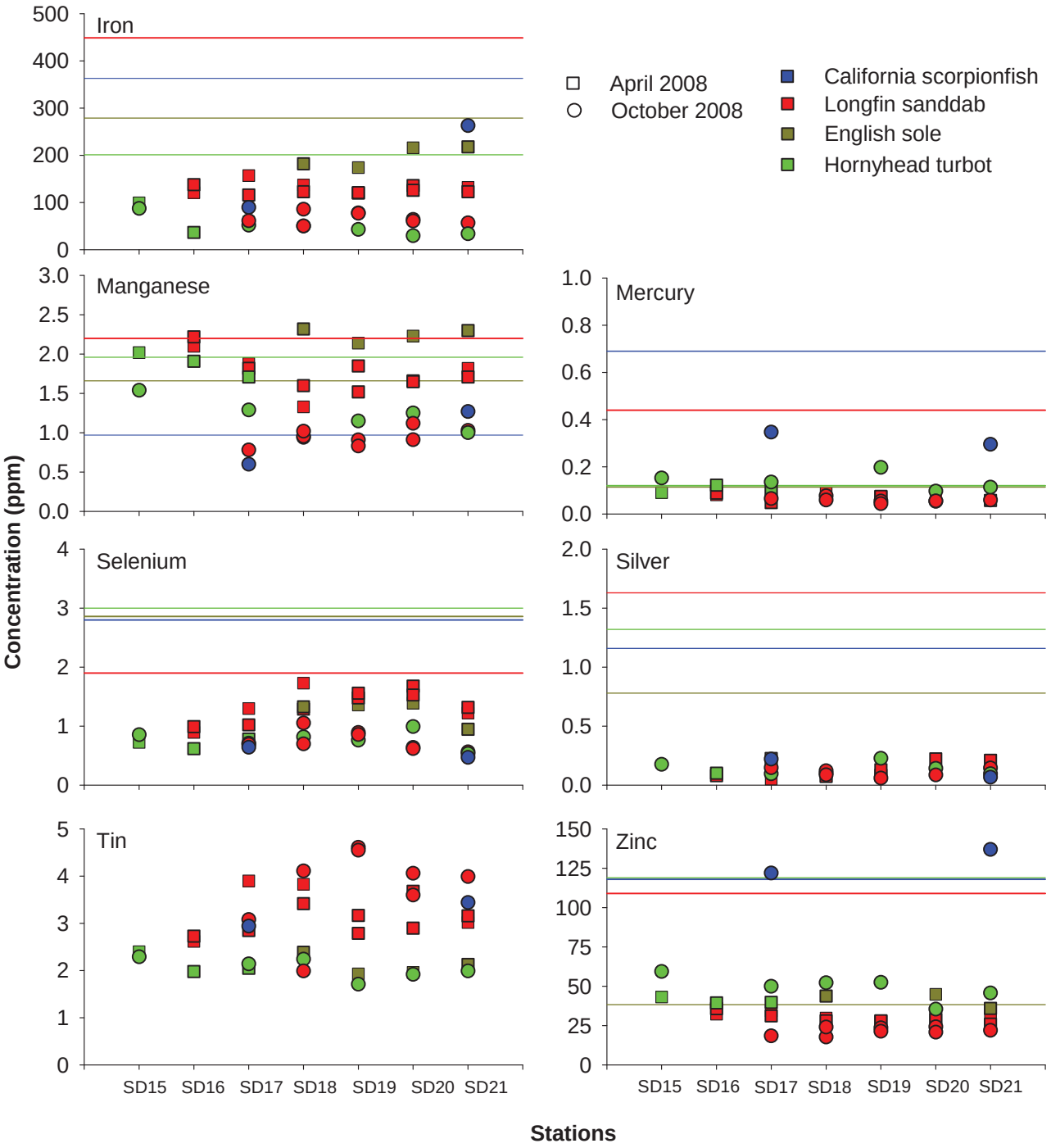

Figure 7.2 *continued*

the highest lipid content, as well as the highest levels of chlordane and DDT.

As with metals, there was no clear relationship between concentrations of these pesticides in fish tissues and proximity to the outfall (Figure 7.3). In addition, most pesticide concentrations were near or below the maximum levels detected in the same species prior to wastewater discharge. Two of the liver samples had HCB concentrations that were much higher than all the others; these included one elevated value from a hornyhead turbot sample collected at station SD15, and a second elevated value from a longfin sanddab sample collected at station SD17. Due to differences in analytical techniques, HCB was not detected in tissue samples collected during the pre-discharge surveys, and therefore, no pre- vs. post-discharge comparisons

Table 7.3

Summary of chlorinated pesticides, total PCB, and lipids in liver tissues of fishes collected at SBOO trawl stations during 2008. Data include the number of detected values (n), as well as minimum (Min), maximum (Max), and mean detected concentrations for each species. HCB=hexachlorobenzene; tChl=total chlordane; tDDT=total DDT; tPCB=total PCB; nd=not detected. Data are expressed in parts per billion (ppb) for all parameters except lipids, which are presented as percent weight (% wt); the number of samples per species is indicated in parentheses; See Appendix F.2 for MDLs and Appendix F.3 for values of individual constituents summed for total chlordane, total DDT, and total PCB.

	Pesticides				
	HCB	tChl	tDDT	tPCB	Lipids
California scorpionfish					
n (out of 3)	3	2	3	3	3
Min	2.3	10.0	355.1	138.2	16.8
Max	2.7	25.5	744.9	508.4	27.4
Mean	2.5	17.7	598.3	299.6	22.7
English sole					
n (out of 4)	4	1	4	4	4
Min	0.7	1.4	97.0	38.1	3.8
Max	3.3	1.4	288.7	76.1	5.4
Mean	1.6	1.4	198.5	60.7	4.4
Hornyhead turbot					
n (out of 9)	4	nd	9	9	9
Min	0.8	—	31.0	2.6	3.1
Max	16.0	—	237.0	36.8	10.3
Mean	4.9	—	107.0	19.9	6.1
Longfin sanddab					
n (out of 20)	19	12	20	20	20
Min	1.4	2.4	185.3	63.4	12.1
Max	12.0	31.6	1382.6	758.6	46.7
Mean	3.2	11.0	739.2	373.6	24.3
All species:					
Detection rate (%)	83	42	100	100	100
Max value	16.0	31.6	1382.6	758.6	46.7

can be made. However, all HCB concentrations that have been detected in South Bay fishes were below 10 ppb across all of the stations.

PAHs and PCBs

PAHs were not detected in fish liver samples during 2008. In contrast, PCBs occurred in every tissue sample; see Appendix F.3 for a summary of all detected PCB congeners. Total PCBs were highly variable in South Bay fish tissues, ranging from about 3 to 759 ppb, and also tended to vary with lipid content (Table 7.3). For the most part, total PCB concentrations during the year were substantially less than pre-discharge values, with no clear relationship with proximity to the outfall (Figure 7.3).

Contaminants in Fishes Collected by Rig Fishing

Aluminum, antimony, arsenic, barium, chromium, copper, iron, manganese, mercury, selenium, tin, and zinc occurred in ≥75% of the muscle tissue samples collected from the two rig fishing stations in 2008 (Table 7.4). Thallium was only detected in 50% of the samples, while beryllium, cadmium, lead, nickel, and silver were not detected at all. The metals present in the highest concentrations were aluminum (up to 24 ppm), iron (up to 16 ppm), zinc (up to about 6 ppm) and arsenic (up to about 3 ppm). DDT was detected in 92% of the muscle samples, while PCBs and the pesticide HCB were detected in 50–58% of the samples (Table 7.5). Concentrations of these contaminants ranged from <0.1 ppb for HCB to 9.2 ppb for total DDT.

To address human health concerns, contaminant concentrations found in the muscle tissues of fishes collected as part of the SBOO monitoring program were compared to state, national, and international limits and standards (see Table 7.4, Table 7.5). These include: 1) the California Office of Environmental Health Hazard Assessment (OEHHA), which has developed fish contaminant goals for chlordane, DDT, methylmercury, PCBs, and selenium (Klasing and Brodberg 2008); 2) the United States Food and Drug Administration (U.S. FDA), which has set limits on the amount of mercury, total DDT, and chlordane in seafood that is to be sold for human consumption (see Mearns et al. 1991); 3) international standards for acceptable concentrations of various metals and DDT (see Mearns et al. 1991). Of the contaminants detected in these muscle tissues during 2008, the metals arsenic and selenium occurred in concentrations slightly higher than median international standards,

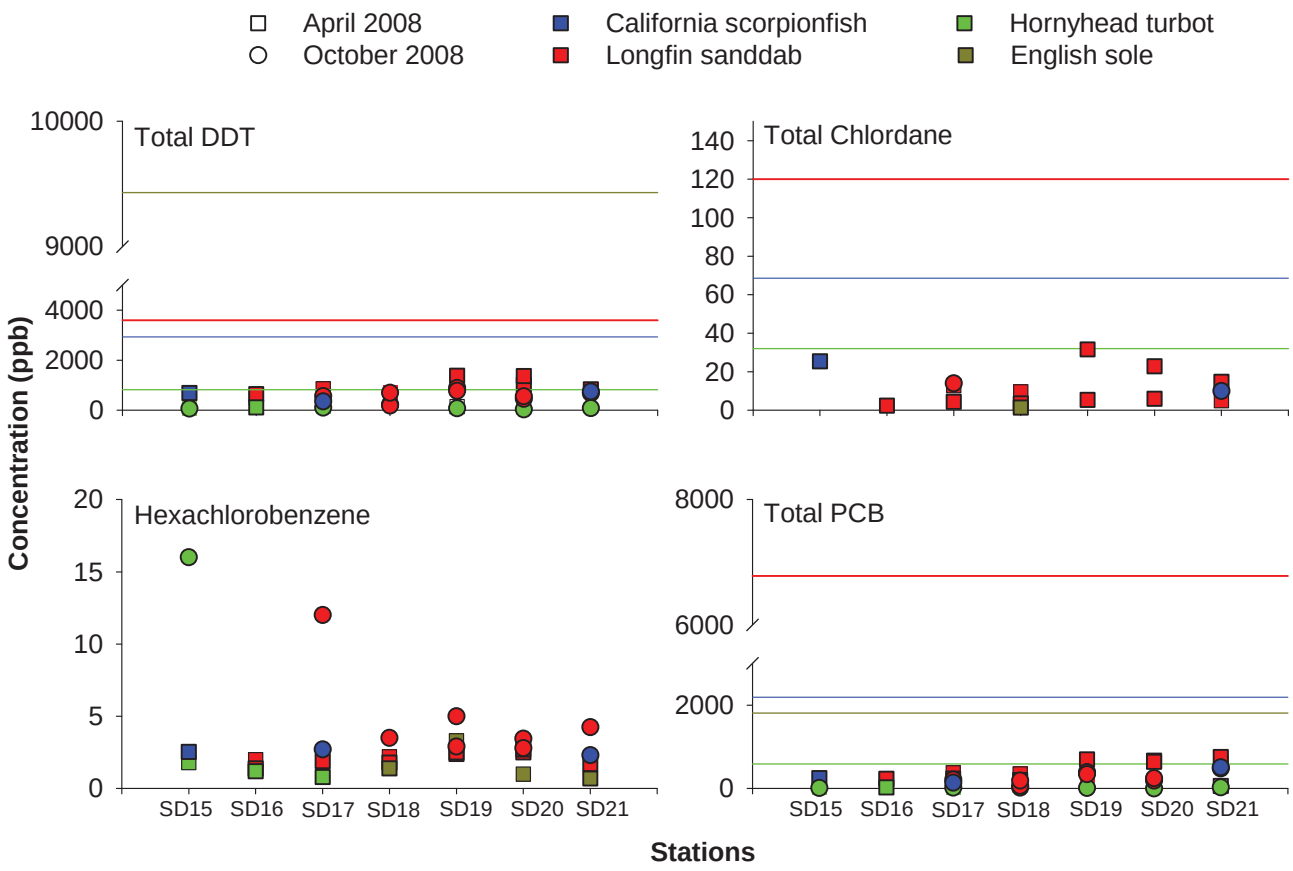

Figure 7.3

Concentrations of frequently detected chlorinated pesticides (total DDT, total chlordane, hexachlorobenzene) and total PCBs in liver tissues of fishes collected from each SBOO trawl station during 2008. Reference lines are maximum values detected during the pre-discharge period (1995–1998) for each species; chlordane and hexachlorobenzene were not detected as frequently during the pre-discharge period because of substantially higher detection limits. Therefore, reference lines for these two contaminants are absent for some or all of the species. Except where samples were not collected (see Table 7.1), missing values=non-detects.

while mercury (as a proxy for methylmercury) exceeded the OEHHA fish contaminant goal. Exceedences for arsenic and selenium occurred in both California scorpionfish and vermilion rockfish muscle tissues, while the exeedance for mercury occurred only in scorpionfish. Additionally, the OEHHA fish contaminant goal for total PCB was exceeded in a single California scorpionfish sample.

In addition to addressing health concerns, spatial patterns were analyzed for total DDT and total PCB, as well as for all metals that occurred frequently in muscle tissue samples (Figure 7.4). Overall, concentrations of DDT, PCB, and various metals in the muscle tissues of fishes captured at rig fishing stations RF3 and RF4 were fairly similar, which suggests that there was no relationship with proximity to the outfall. However, comparisons of contaminant loads in fishes from these stations should be considered with caution since different species of fish were collected at the two sites, and the bioaccumulation of contaminants may differ between species because of differences in physiology, diet, and exposure to contaminant sources due to migration habits and/or other large scale movements. This potential problem may be minimal in the South Bay region as all fish specimens sampled in 2008 belong to the same family (Scorpaenidae), have similar life histories (i.e., bottom dwelling tertiary carnivores), and are therefore likely to have similar mechanisms of exposure to and uptake of contaminants (e.g., direct contact with sediments, similar food sources). However, species such as those reported herein are known to traverse large areas and may be exposed

Table 7.4

Summary of metals in muscle tissues of fishes collected at SBOO rig fishing stations during 2008. Data include the number of detected values (n), as well as minimum (Min), maximum (Max), and mean detected concentrations for each species. Concentrations are expressed as parts per million (ppm); the number of samples per species is indicated in parentheses; nd=not detected. Data are compared to OEHHA fish contaminant goals (OEHHA), U.S. FDA action limits, and median international standards for parameters where these exist. Bold values meet or exceed these standards. See Appendix F.2 for MDLs and names for each metal represented by periodic table symbol.

	Al	Sb	As	Ba	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Tl	Sn	Zn
Brown rockfish																		
n (out of 5)	3	4	5	5	nd	nd	5	5	5	nd	5	5	nd	5	nd	3	5	5
Min	5.15	0.225	0.58	0.078	—	—	0.143	0.58	3.10	—	0.106	0.105	—	0.156	—	0.607	1.64	3.30
Max	18.70	0.538	0.91	0.195	—	—	0.203	1.81	9.72	—	0.176	0.165	—	0.258	—	0.815	2.01	5.34
Mean	14.15	0.311	0.75	0.116	—	—	0.176	1.41	6.16	—	0.148	0.127	—	0.205	—	0.718	1.86	4.47
California scorpionfish																		
n (out of 6)	5	4	6	6	nd	nd	6	6	6	nd	6	6	nd	6	nd	3	6	6
Min	4.67	0.232	**1.43**	0.079	—	—	0.109	0.72	4.22	—	0.111	0.113	—	0.235	—	0.685	1.81	4.41
Max	13.00	0.515	**2.65**	0.227	—	—	0.222	1.97	16.00	—	0.203	**0.231**	—	**0.345**	—	0.753	2.28	6.39
Mean	8.31	0.390	**2.06**	0.138	—	—	0.142	1.16	7.88	—	0.152	0.183	—	0.282	—	0.730	1.94	5.23
Vermilion rockfish																		
n (out of 1)	1	1	1	1	nd	nd	1	1	1	nd	1	1	nd	1	nd	nd	1	1
Min	24.00	0.555	**2.45**	0.183	—	—	0.222	1.76	10.70	—	0.259	0.066	—	**0.319**	—	—	2.08	5.38
Max	24.00	0.555	**2.45**	0.183	—	—	0.222	1.76	10.70	—	0.259	0.066	—	**0.319**	—	—	2.08	5.38
Mean	24.00	0.555	**2.45**	0.183	—	—	0.222	1.76	10.70	—	0.259	0.066	—	**0.319**	—	—	2.08	5.38
All species:																		
Detection rate (%)	75	75	100	100	0	0	100	100	100	0	100	100	0	100	0	50	100	100
Max	24.00	0.555	2.65	0.227	—	—	0.222	1.97	16	—	0.259	**0.231**	—	**0.345**	—	0.815	2.28	6.39
OEHHA*												0.22		7.4				
U.S. FDA Action Limit**												1						
Median IS**			1.4				1	20				0.5		0.3			175	70

* From the California Office of Environmental Health Hazard Assessment (OEHHA) (Klasing and Brodberg 2008).

** From Mearns et al. 1991. U.S. FDA mercury action limits and all international standards (IS) are for shellfish, but are often applied to fish.

Table 7.5

Summary of chlorinated pesticides, total PCB, and lipids in muscle tissues of fishes collected at SBOO rig fishing stations during 2008. Data include the number of detected values (n), as well as minimum (Min), maximum (Max), and mean detected concentrations for each species. HCB=hexachlorobenzene; tDDT=total DDT; tPCB=total PCB. Values are expressed in parts per billion (ppb) for all parameters except lipids, which are presented as percent weight (% wt); the number of samples per species is indicated in parentheses. Data are compared to OEHHA fish contaminant goals (OEHHA), U.S. FDA action limits, and median international standards for parameters where these exist. Bold values meet or exceed these standards. See Appendix F.2 for MDLs and Appendix F.3 for values of individual constituents summed for total DDT and total PCB.

	Pesticides			
	HCB	**tDDT**	**tPCB**	**Lipids**
Brown rockfish				
n (out of 5)	2	4	2	5
Min	0.05	1.8	0.6	0.1
Max	7.20	9.2	1.0	0.6
Mean	3.62	3.8	0.8	0.3
California scorpionfish				
n (out of 6)	3	6	4	6
Min	0.10	1.7	0.4	0.2
Max	1.00	8.5	**5.2**	1.6
Mean	0.50	4.6	2.1	0.8
Vermilion rockfish				
n (out of 1)	1	1	1	1
Min	0.10	7.7	2.1	0.9
Max	0.10	7.7	2.1	0.9
Mean	0.10	7.7	2.1	0.9
All species:				
Detection rate (%)	50	92	58	100
Max	7.20	9.2	**5.2**	1.6
OEHHA*		21	3.6	
U.S. FDA Action Limit**		5000		
Median IS**		5000		

* From the California Office of Environmental Health Hazard Assessment (OEHHA) (Klasing and Brodberg 2008).

** From Mearns et al. 1991. U.S. FDA action limits and all international standards (IS) are for shellfish, but are often applied to fish.

to contaminants present instead in other locations. For example, it has been previously reported that California scorpionfish tagged in Santa Monica Bay have been recaptured as far south as the Coronado Islands (e.g., Hartmann 1987, Love et al. 1987).

Summary and Conclusions

Several trace metals, the pesticides DDT, HCB, and various chlordane components, and a combination of PCB congeners were detected in liver tissue samples collected from four different species of fish in the SBOO region during 2008. Many of the same metals, DDT, HCB, and PCB congeners were also detected in muscle tissues during the year, although often less frequently and/or in lower concentrations. Tissue contaminant values ranged widely within and among species and stations. However, all were within the range of values reported previously for the Southern California Bight (SCB) (see Mearns et al. 1991, City of San Diego 1996–2001, Allen et al. 1998). In addition, while some muscle tissue samples from sport fish collected in the area had concentrations of arsenic and selenium above the median international standard for shellfish, and some had concentrations of mercury and total PCB that exceeded OEHHA fish contaminant goals, concentrations of mercury and DDT were below FDA human consumption limits.

The frequent occurrence of metals and chlorinated hydrocarbons in SBOO fish tissues may be due to multiple factors. Mearns et al. (1991) described the distribution of several contaminants, including arsenic, mercury, DDT, and PCBs as being ubiquitous in the SCB. In fact, many metals occur naturally in the environment, although little information is available on background levels in fish tissues. Brown et al. (1986) determined that no areas of the SCB are sufficiently free of chemical contaminants to be considered reference sites. This has been supported by more recent work regarding PCBs and DDTs (e.g., Allen et al. 1998, 2002). The lack of contaminant-free reference areas in the SCB clearly pertains to the South Bay region, as demonstrated by the presence of many contaminants in fish tissues prior to wastewater discharge (see City of San Diego 2000b).

Other factors that affect the accumulation and distribution of contaminants include the physiology and life history of different fish species (see Groce 2002 and references therein). Exposure to

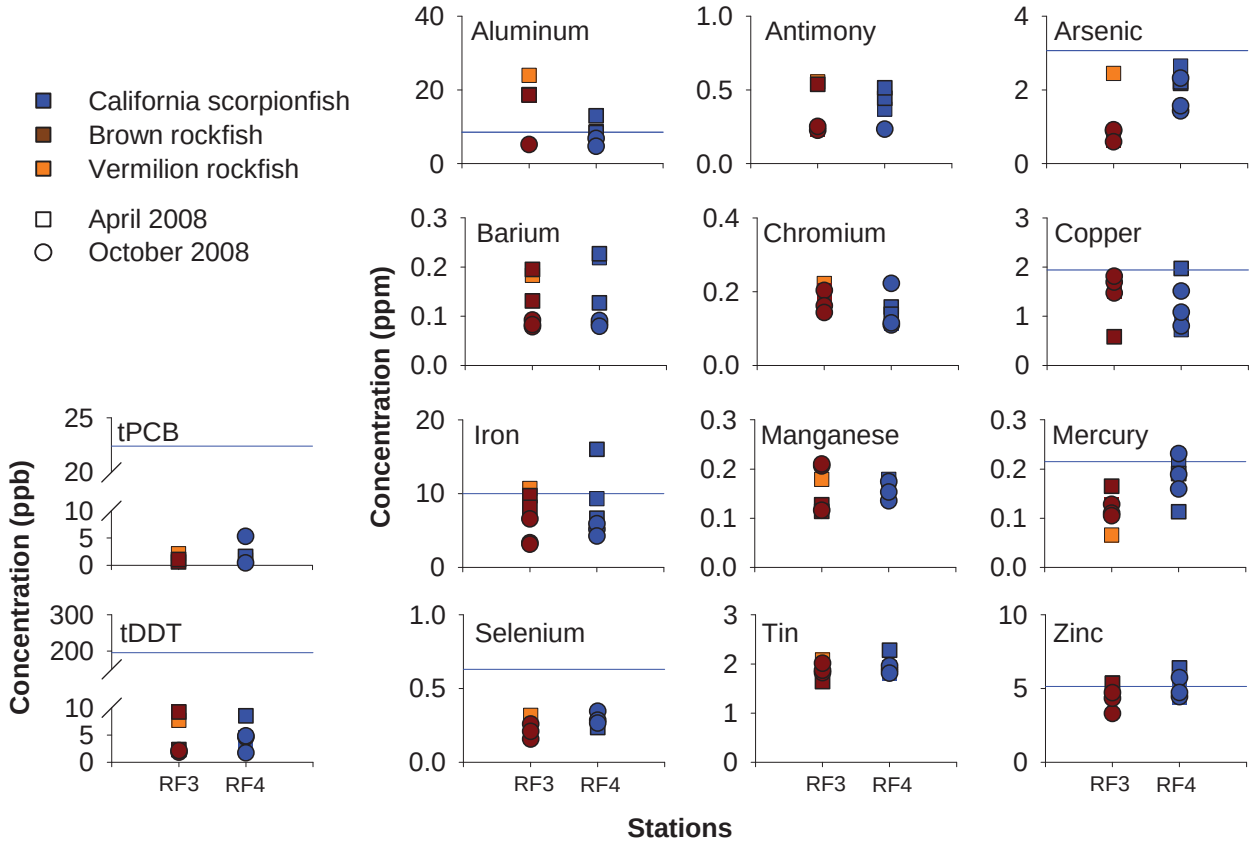

Figure 7.4
Concentrations of frequently detected metals, total DDT, and total PCB in muscle tissues of fishes collected from each SBOO rig fishing station during 2008. Reference lines are maximum values detected during the pre-discharge period (1995–1998) for California scorpionfish. Vermilion and brown rockfish were not collected during that period. All missing values=non-detects.

contaminants can vary greatly between different species and among individuals of the same species depending on migration habits (Otway 1991). Fishes may be exposed to contaminants in an area that is highly contaminated and then move into an area that is not. This is of particular concern for fishes collected in the vicinity of the SBOO, as there are many point and non-point sources that may contribute to contamination in the region (see Chapters 2–4); some monitoring stations are located near the Tijuana River, San Diego Bay, and dredged materials disposal sites, and input from these sources may affect fish in surrounding areas.

Overall, there was no evidence that fishes collected in 2008 were contaminated by the discharge of wastewater from the SBOO. Although several individual tissue samples contained concentrations of some metals that exceeded pre-discharge maximums, concentrations of most contaminants were not substantially different from pre-discharge levels (see City of San Diego 2000b). In addition, the few tissue samples that did exceed pre-discharge values were widely distributed among the sampled stations and showed no patterns that could be attributed to wastewater discharge. Finally, there was no other indication of poor fish health in the region, such as the presence of fin rot, other indicators of disease, or any physical anomalies (see Chapter 6).

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