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5.0 AVIAN FOOD-WEB EXPOSURE MODEL

Exposure of avian receptors to CoCs depends upon the fate and transport characteristics of the CoCs, distribution of the waste materials throughout the area of concern, and the natural history of the avian indicator species. Avian exposure to CoCs within Ferry Creek, Housatonic Boat Club wetlands, and Milford Point Reference area was evaluated using a food-web modeling approach. Exposure parameters and assumptions used in the avian food-web exposure model are derived from natural history information compiled from the literature for each species (Tables 5-1 through 5-3). Also, site-specific or regional information was obtained through contacts with local wildlife officials. Specific exposure parameters and the rationale for their selection are discussed in the following sections.

The food-web exposure model was used to estimate the exposure of the receptor species through diet, expressed as a total daily dose. In the literature, most RTVs for terrestrial species are reported as the threshold daily dose to an individual. Estimating a site-specific dose (IR_T) allows for direct comparison of exposure estimates with RTVs. Contaminant body-burden data from the sampling of mummichog, fiddler crabs, and insects, plus water concentrations of CoCs, were inputs to the models The heron model also included sediment data as an input variable. The basic structure of the exposure models is:

$$IR_{Total} = \sum_{x} IR_{x} = \sum_{x}\Big[\sum_{m}\Big[\frac{(C_{xm} \bullet IR_{m}) \bullet BF_{xm} \bullet HR}{BW}\Big]\Big] \text{ where: } \qquad \textit{Equation 5-1}$$

IR_{Total} = total ingestion rate of all contaminants (mg/kg bw/day wet weight)

IR_{χ} = ingestion rate of contaminant χ from all media (mg/kg bw/day wet weight)

$C_{\chi m}$ = concentration of CoC_{χ} in $medium_{m}$ (mg/kg wet weight)

IR_{m} = ingestion rate of $medium_{m}$ (kg/day wet weight)

$BF_{\chi m}$ = dietary bioavailability factor of CoC_{χ} in $medium_{m}$ (percent)

HR = proportion of contaminated site relative to receptor species' home range (*i.e.*, exposure fraction) (unitless)

BW = body weight of receptor species (kg)

5.1 INGESTION RATE

Precise information on nutrition requirements and energetics of heron or blackbirds was not available from the literature. Instead daily food and water intake rates have been estimated using an allometric equation based on their body weight in grams (Nagy 1987). These equations for food ingestion, F, in units of grams dry weight per day (Equations 5-2 and 5-3), plus water ingestion, W, in units of liters per day (Equation 5-4) are presented below:

Passerine birds— $F = 0.398 \cdot bw^{0.35}$ *Equation 5-2*

Other birds— $F = 0.648 \cdot bw^{0.651}$ *Equation 5-3*

Water ingestion— $W = 0.059 \cdot bw^{0.67}$ *Equation 5-4*

Data on CoC concentrations in sediment, surface water, and key prey of the avian species were incorporated into the model to estimate total chemical doses ingested according to their respective intake rates. The daily ingestion intake rates used in the dietary model are presented in **Table 5-1**, which also details other exposure parameters used in equations above. Average moisture content of each medium was used to derive the wet weight values that appear in Table 5-1 from the dry weight results calculated by Equations 5-2 and 5-3. Average body weights were also used in equations.

To account for ingestion of different food types by a given receptor, the ingestion dose of all prey items, plus sediment and water, are summed. Hence, the term ($C_{\chi m} \cdot IR_m$) was expanded to specify each ingested medium:

$$\Sigma(C_{\chi m} \cdot IR_m) = (C_{fish} \cdot I_{fish}) + (C_{crab} \cdot I_{crab}) + (C_{insects} \cdot I_{insects}) + (C_{water} \cdot I_{water}) + (C_{sediment} \cdot I_{sediment})$$ *Equation 5-5*

Black-crowned night herons are opportunistic feeders that consume a variety of aquatic species, and even small terrestrial mammals. **Table 5-2** presents information on the composition of their diet. Fish, crustaceans, and insects make up approximately 76% of the black-crowned heron diet. Fish are important dietary items comprising more than half (about 53%) of their total dietary intake; crustaceans comprise about 21%, and terrestrial insects make up 1.5%. These percentages were applied to the total dietary intake to derive ingestion rates for Equation 5.5.

The prey organisms included in Equation 5-5 represent about 75% of the heron diet. Two approaches are provided for dealing with the remaining 25%. In the first, the other 25% is assumed to be food items taken from outside the study area (i.e. non-contaminated); and in the second approach, the remaining 25% is assumed to be as equally contaminated as the other 75%. For this latter approach, risk quotients were elevated by 33% to account for the unsampled items in the heron diet.

To estimate dietary exposure to the black-crowned night heron, samples of crab, fish, and insects were collected from appropriate habitats. Fiddler crabs were collected from all sampling areas, mummichog were collected from Upper and Lower Ferry Creek and the reference area, and terrestrial insects were collected from Upper Ferry Creek and the reference area only. Dietary exposure through fish ingestion was not estimated for the Housatonic Boat Club wetlands. Fish were not sampled in this area because the wetlands drain completely during low tide. Because of the tidal excursions, the exposure of fish to contaminated sediments in that area is not expected to be significant and would be difficult to model.

Table 5-1. Avian food web exposure parameters.

SPECIES	INTAKE RATES (kg/day wet weight [a]) ORGANISMS: FISH	CRUSTACEANS	TERRESTRIAL INSECTS	TOTAL FOOD	INCIDENTAL SEDIMENT	WATER [b] (L/day)	HOME RANGE	BIOAVAILABILITY FACTOR	BODY WEIGHT (kg)
Red-winged blackbird	na	na	0.012	0.023	na	0.008	0.9	COC specific	0.054
Black-crowned night heron	0.133	0.036	0.002	0.172	0.01	0.054	1	COC specific	0.883

(a) Dry to wet weight conversions used mean percent moisture of 78.7% for fish, 68% for crabs, 48% for insects, and 44.5% for sediment.
(b) Values for dietary requirements were derived from allometric equations of Nagy presented in Section 5.

Table 5-2. Percent occurrence of food items (by volume) in the diet of the black-crowned night heron.

Percent Occurrence								
Fish	Crustaceans	Aquatic Insects	Frogs	Mice/ Rats	Birds	Terrestrial Insects	N	Reference
51.5	22	16	6	3	NR	15	117	Palmer 1962
54	21	16	7	17	nr	nr	45	Howell 1932
29[a]	nr	130[a]	nr	12[a]	6[a]	12[a]	17	Wolford & Boag 1971

nr = not reported.

[a] Incidence of occurrence in contents of the 17 stomachs examined.

Given the diet and feeding behavior of these herons, it is unlikely that incidental sediment ingestion is a significant exposure pathway (Beyer, pers. commun., 1995; Ohlendorf, pers. commun., 1995). However, sediment has been observed in the blouses of nestling herons (Parsons, pers. commun., 1995). Therefore, to ensure a conservative approach, sediment ingestion was included as an exposure pathway in the food-web model. To estimate a conservative CoC intake via sediment ingestion, it was assumed to be equivalent to 5% of the total dietary intake. Black-crowned night herons were estimated to consume 0.05 L of water per day based on their body size (Equation 5-4). Total concentrations of CoCs in surface water were used to estimate the dose for this component for the food-web model.

The red-winged blackbird was estimated to consume 23 g of food per day (wet weight) based on allometric equations using the body weight presented in Table 5.1. **Table 5-3** presents a list of the percent plant and animal matter in red-winged blackbird diets. During the spring and summer, insects comprise approximately half of the blackbird diet, versus 9% in fall (Martin et al. 1951; Table 5-3). However, since adults feed their nestlings only insects, this assessment models an exposure diet for the nestlings consisting totally of insects.

Exposure of red-winged blackbirds to CoCs was evaluated based on consumption of insects from wetlands located in the Upper Ferry Creek and the Milford Point reference areas only.

Soil ingestion is not being evaluated as a component of the ingestion exposure pathway for this species. The dietary water requirements for red-winged blackbirds were estimated to be almost 0.01 L of water per day based on their body size (Equation 5-4). Total concentrations in surface water were used to estimate this component for the food-web model.

Data were analyzed statistically to arrive at a conservative value for each data type (i.e., sediment, fish, crustaceans, and insect tissues) for input as a concentration term into the food-web model calculations. A data set for each area was compiled and, if the data met the following criteria, the 95% UCL of the mean was used in the food-web model (US EPA 1992):

- A minimum of five samples was collected in each media (sediment, surface water, fish, crab, and insect tissue) for each area (Ferry Creek, Housatonic Boat Club and Milford Point);
- Not more than 20% of the samples had undetected concentrations;

Table 5-3. Percent of food items in diet of the Red-wing Blackbird.

Animal Food Item

% of Daily Total or % of Total Volume of Prey

Dragonflies/ Damselflies	Grasshoppers/ Crickets	Cicadas	Butterflies/ Moths	Flies	Spiders	Treehoppers/ Aphids	Beetles	Snails	Leaf bugs	Caterpillars	Other Insects	N	Reference
37	2	3	30	13	7	nr	nr	nr	nr	nr	5	nr	Oriens 1985
nr	nr	nr	48	nr	7	5.1	20.5	6	nr	nr	5	8[a]	Oriens 1985
6.4	7.3	nr	35	12.8[b]	4	5.1	10.4	nr	nr	nr	nr	14[a]	Oriens 1985
30	nr	nr	14	10[b]	10	8	13	nr	5	nr	nr	nr	Oriens 1985
14[c]	nr	nr	74[c]	4[c]	nr	nr	nr	nr	nr	nr	nr	nr	Oriens 1985
9[c]	43[c]	nr	9[c]	7[c]	nr	nr	nr	nr	nr	nr	nr	nr	Oriens 1985
nr	5	nr	nr	nr	1	nr	10	nr	nr	6[d]	5[d]	nr	Beal 1900; as cited in Bent 1958

Vegetation Food Item

% Occurrence in Diet

Spring: Ragweed	Spring: Bristlegrass	Spring: Corn	Spring: Oats	Spring: Smartweed	Spring: Wheat	Spring: N	Summer: Ragweed	Summer: Bristlegrass	Summer: Corn	Summer: Oats	Summer: Wild Rice	Summer: Smartweed	Summer: Wheat	Summer: N	Reference
10 - 25	10 - 25	5 - 10	5 - 10	5 - 10	2 - 5	121	10 - 25	10 - 25	5 - 10	5 - 10	5 - 10	5 - 10	2 - 5	281	Martin et al. 1957

In some cases only prey comprising more than 3% of total are shown (Oriens 1985)
nr - not reported

[a] — Nests sampled (food delivered to nestling blackbirds).
[b] — Aquatic.
[c] — Foods delivered to nestling during a three week period.
[d] — Average percent for 12 months.

- Data were normally distributed; and
- 95% UCL was less than the maximum value.

5.2 BIOAVAILABILITY FACTOR

To account for differences in bioavailability of CoCs, a dietary bioavailability factor (BF) was applied to the estimated total daily dose. While it was appropriate to assume 100% bioavailability of CoCs for the screening assessment, subsequent assessments should incorporate more realistic exposure assumptions. The daily dose was multiplied by a BF when calculating ingestion rate (IR_T) for the receptor.

A literature search for any available information on the gastric adsorption efficiency of trace elements and CoCs in birds yielded no useful references. Dietary studies in which the dose was administered in the food source were targeted. However, a recent publication provided the only assimilation data encountered for birds (Ammerman et al. 1995). Studies cited by Ammerman et al. indicate that even for essential nutrient trace elements, such as Cu and Zn, assimilation efficiencies can be low. Less than half of copper in plant food sources was adsorbed by chickens (44%), and only 61% of zinc was utilized. In animal protein sources, bioavailability of copper and zinc in chickens increased to 65% and 85%, respectively. For this assessment, 65% assimilation of copper was assumed for heron and blackbirds. For all other CoCs, the maximum assimilation in birds encountered (85%) was assumed for the bioavailability factor ($Bf_{\chi m}$).

5.3 HOME RANGE

The nearest black-crowned night heron colony is about 3.5 miles (5.6 km) from the Raymark facility. This species has been observed foraging in the tidal areas within 1.9 miles (3 km) of the facility, and along Ferry Creek. Since information pertaining to home range and feeding territory were not available from the literature, assumptions were made regarding habitat use for the food-web model. Although it is generally accepted that black-crowned night herons defend a feeding territory, no information was available on territory size, making it difficult to arrive at a home-range exposure factor (HR) for the food-web model. With regard to wading birds, the size of the feeding territory depends on the bird's ability to defend it, which is positively correlated with body size. Territory size is also dependent on prey distribution, dictating the size of the area a bird must defend to obtain adequate food in an energy-efficient manner (Kushlan 1978). Consequently, the feeding territory of herons depends upon the physical conditions of the habitat. Black-crowned night herons will return to the same area to feed (Parsons, pers. commun., 1995). Therefore, the study area was broken down into three areas for the black-crowned night heron food-web model: (1) Ferry Creek, including upper and lower areas; (2) Housatonic Boat Club wetlands; and (3) Milford Point Reference area. The linear distance from the northern end of Ferry Creek to the southern end of the Housatonic Boat Club wetlands is about 2 km. Therefore, it was logical to evaluate these areas separately. Due to their body size and site fidelity, it was assumed that the birds spent 100% of their time feeding in these areas. Accordingly, a home-range (HR) exposure factor of 1.0 was used in the food- web model. Because there are several other good foraging areas near Charles Island, herons may not be feeding exclusively within the study areas. Therefore, the use of a 100% home-range factor is likely overconservative,

During the breeding season, red-winged blackbirds maintain territories around their nest that contain at least some of the food supplies for breeding (Oriens 1987). For this species, breeding territory size is always less than the wetland/marsh it is nesting in. The size of the nesting territory varies depending on the size of the marsh and the density of the red-winged blackbird population (Bent 1958). Red-winged blackbirds do not stay exclusively within the nesting territory to forage for insects. During the nesting season, most food is obtained from the marsh, although blackbirds also forage in upland areas. Therefore, it was realistic to assume that the red-winged blackbird spends 90% (HR=0.9) of its time foraging in the areas of interest.

5.4 BODY WEIGHT

For body weights, the maximum weights reported in Section 3 were used. These were mean values for both males and females.

6.0 EXPOSURE ASSESSMENT

This risk assessment evaluated three different media associated with potential routes of exposure and measurement endpoints. The concentrations of site-related CoCs in these various media represent a distribution of potential exposure levels to the appropriate ecological receptors. This section provides results of chemical analyses of those three media:

- Surface water,
- Sediment, and
- Biota.

6.1 SURFACE-WATER EXPOSURE CHARACTERIZATION

All of the measurement endpoints in this risk assessment, with the possible exception of the red-winged blackbird food-chain model, are directly affected by surface-water quality to some degree. For herons, water represents a secondary dietary exposure, with additional exposure from wading while feeding. For the other measurement endpoints (e.g., effects to fish and aquatic invertebrates), the concentrations of CoCs in water represent an ambient exposure that may be compared with benchmark values, such as ambient water quality criteria (AWQC) for the protection of aquatic life. Exposure pathways for these species include ingestion, dermal transfer, and uptake via gills.

Table 6-1 presents concentrations of CoCs detected in unfiltered surface-water samples. The highest concentrations of metals were detected in water samples collected from Upper Ferry Creek and the Housatonic Boat Club wetlands. The surface-water sample collected from station SD13 (in Upper Ferry Creek) contained the highest concentrations of chromium, copper, lead, nickel, and zinc detected in Upper Ferry Creek.

Only two organic CoCs were detected in surface-water samples. DDD was detected in samples collected from three locations in Upper Ferry Creek: SD28, SD30, and SD09. PCBs were detected in one sample collected from SD13 at a concentration of 0.072 µg/L. Individual PAH compounds were not detected in surface water at detection limits of 10 µg/L. The results for organic CoCs (i.e., lack of detection) are not surprising, given the hydrophobic nature of these CoCs.

6.2 SEDIMENT-EXPOSURE CHARACTERIZATION

Benthic organisms are generally less mobile than plankton or fish, and they live in or on the sediment. Therefore, these organisms are thought to be generally more subject to the effects of CoCs in sediment. Because of the behavior of most common environmental contaminants, these compounds are typically found in greater concentrations in sediment than in water. Benthic organisms may then take up, concentrate, and/or metabolize these chemicals to either more or less toxic forms. In addition, they may transfer the contaminants to other organisms through the food chain. The importance of the assessment endpoint for benthic invertebrates in this risk assessment lies in (1) their potential to pass contaminants up the food chain, (2) their increased vulnerability to environmental stress, (3) their usefulness as integrators of past and current conditions, and (4) their utility as indicators of localized conditions.

Table 6-1. Concentrations of COCs detected in unfiltered surface water samples.

Contaminant (µg/L)	Upper Ferry Creek (n=10)		Lower Ferry Creek (n=14)		Housatonic Boat Club (n=3)		Reference Area (n=3)		Detection Limits
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Trace Elements									
Arsenic	4.0	93.4	<3.3	93.4	3.6	16.2	<3.3	4.8	3.3
Cadmium	<1.4	<2.4	<1.4	<3.3	<1.4	2.3	<1.4	<1.4	1.4
Chromium	6.6	20.5	7.7	<1.4	12.1	59.2	3.7	15.9	3.2
Copper	<16	121	<13.6	7.7	<34.8	138	<13.8	<35.8	3.8
Lead	5.5	147	<2.1	<13.6	3.0	37.2	<2.1	5.7	2.1
Mercury	<0.2	1.2	<0.2	<2.1	0.57	3.5	<0.2	6.0	0.2
Nickel	<3.6	11.7	<3.6	<0.2	<3.6	<3.6	<3.6	<3.6	3.6
Zinc	>18.4	127	<8.8	<3.3	<62.0	<62.0	<29.8	<29.8	8.8
Organic Compounds									
DDD	<0.1	<0.1	0.003	0.004	<0.1	<0.1	<0.1	<0.1	0.1
Aroclor 1262	<0.5	0.072	<0.5	<1.0	<0.5	<1.0	<0.5	<1.0	0.5

Infaunal oligochaetes and other annelid worms that live in the sediment dominate the benthic community in the study area. Other infaunal taxa such as arthropods (including amphipods) and molluscs generally composed less than 10% of the total abundance. Epibenthic macroinvertebrates such as fiddler crabs (*Uca* spp.) were also present in intertidal and nearshore subtidal regions. The relatively immobile nature of infaunal and epibenthic species, plus their direct contact with the sediments, result in substantial exposure of these organisms to site-related contaminants in the sediments. This continuous exposure of the organisms would occur through contact with contaminated sediment, pore water, and/or overlying water for all life stages over an organism's entire life span.

For some benthic species, such as the eastern oyster *(Crassostrea virginica)* or the fiddler crab, the life-history characteristics suggest that both the free-living larvae and adults would be exposed to site-related, sediment-bound contaminants. Contaminated upland runoff and sediment resuspension during critical spawning and free-living, early life stages could expose larvae to site-related contamination. Free-living, early life stages would also be exposed to contaminated sediment during spat fall (the *en masse* settlement of larvae). Sessile adults could be exposed to site-related contamination if oyster beds near Ferry Creek receive contaminants through sediment transport (and surface-water discharge) from the creek.

6.2.1 Sediment Characteristics

The physical characteristics of sediment critically affect bioavailability of contaminants within that matrix. Information on the characteristics of sediments also helps predict or identify conditions conducive to the sorption of contaminants (i.e., fine-grained, depositional areas). Understanding the characteristics of the sediment matrix also allows for predictions regarding the potential for colonization by specific benthic infauna or epifauna, given a knowledge of their habitat preferences.

Grain Size—Sediment grain-size data are presented in **Figure 6-1**. Results are reported as percent fines, or the percent of material with grain size less than 75µ. The U.S. Bureau of Soils classifies sediment with a grain size less than 62.5µ as silt and clay (Shepard 1948).

Sediment from Lower Ferry Creek and the Housatonic Boat Club generally contained high fractions of fine-grained material. There were notable exceptions, however; the four stations nearest the tide gate generally had lower percentages of fines. The percentage of fines tended to decrease from stations near the mouth of the creek to those out in the river. Values ranged from 34% fines in samples from station SD07 to 100% at SD28. Sediment from Upper Ferry Creek generally contained lower percentages of fine sediment in samples from stations north of, and including, SD12 (10.7% to 41%) than samples from the southern stations (28.7% to 100%). These northern stations tended also to have greater variability. Stations with the highest fines are apparently those in the actual wetland area, out of the main creek channel (e.g., SD04, SD16, SD13). At reference stations, fines ranged from 51% to 100%.

Total Organic Carbon—Results of sediment TOC analyses are presented in **Figure 6-2**. TOC content was moderately uniform in samples from the reference area and Lower Ferry Creek. Nearly all samples had TOC levels between approximately 2% and 5%. TOC in samples from the Housatonic Boat Club wetlands were also moderately uniform, but with notable exceptions. TOC in the HB06 sample was considerably lower than other locations in the wetland. More than half of the samples from the boat club wetlands exceeded 5% TOC, whereas none from the reference area was greater than 5%. Samples from Upper Ferry Creek exhibited the greatest variability. Half of the TOC values were over 5%, and some reached as high as 20%. Conversely, one sample (SD22) fell below 1%. The two highest values, at 20%,

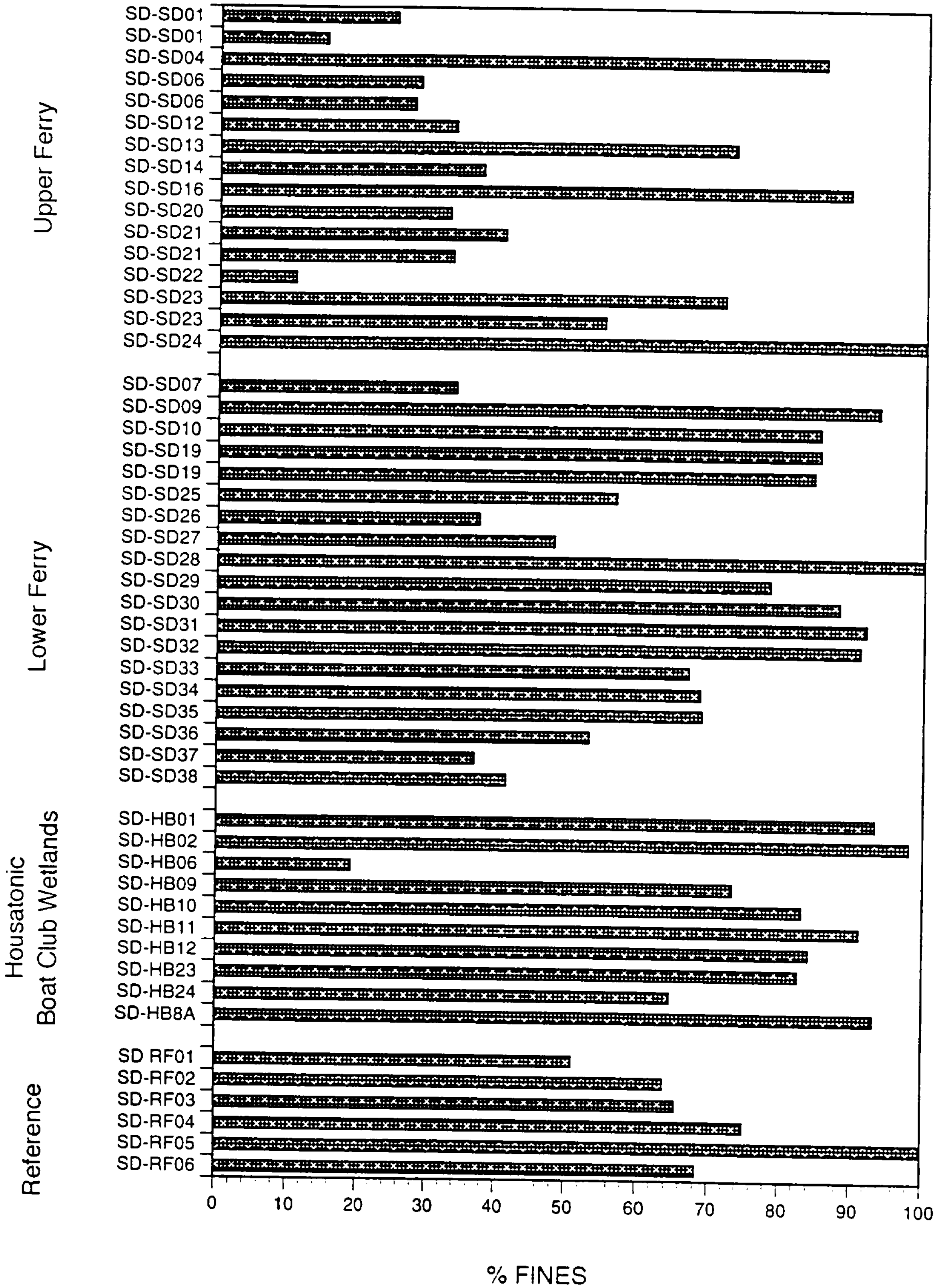

Figure 6-1. Grain size of sediments collected from the Raymark Industries site

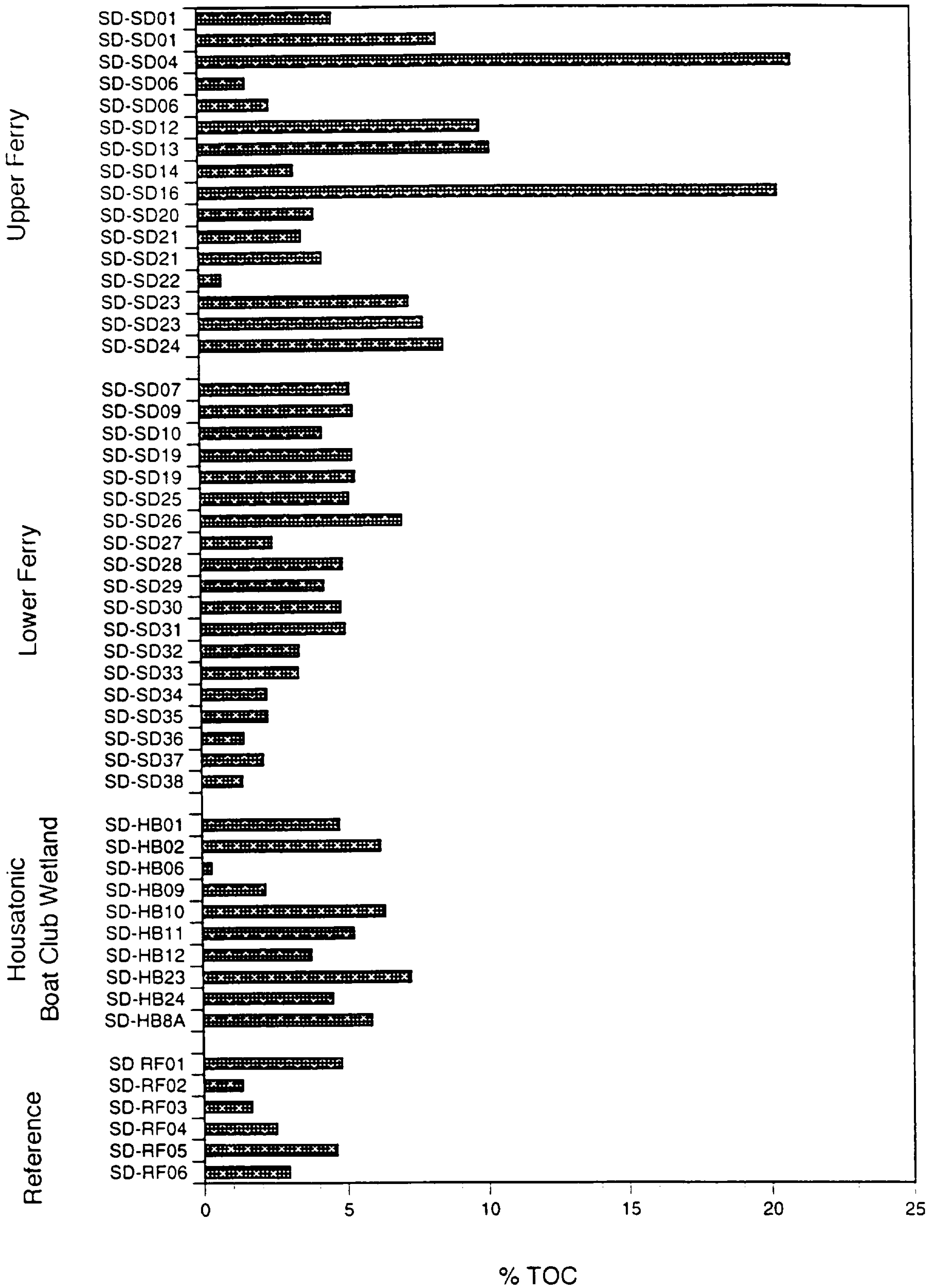

Figure 6-2. Total organic carbon in sediments collected from the Raymark Industries site

were from samples actually located in the vegetated portion of the wetland (SD04 and SD16) and likely represent a large amount of decayed plant debris.

AVS/SEM—As described in Section 3.3.2, comparing the amount of acid-volatile sulfides (AVS) and simultaneously extractable metals (SEM) in the sediment allows a theoretical determination of the potential bioavailability of certain metals. Five divalent metals are predicted not to be potentially bioavailable when the SEM/AVS ratio is less than 1, since there is sufficient sulfide available to bind the metals thus decreasing their bioavailability. These metals are (in increasing order of their binding affinity) nickel, zinc, cadmium, lead, and copper. (Some silver and mercury may also be associated with AVS, although the exact nature of sequestration is still being debated.) Some additional portion of these divalent metals (especially those that can form organometallic compounds) may also be sequestered by organic matter. Therefore, even when the binding capacity of the AVS has been exceeded, not all the metals measured may be readily bioavailable, suggesting that the SEM/AVS ratio is a conservative estimate of bioavailability. Thus the probability of acute lethality may be low when the SEM/AVS ratio is close to 1, and increases as the ratio exceeds 10. When the ratio is less than 1, however, theoretically there is sufficient AVS to bind all the divalent metals present and, therefore, they should not pose an acute lethality risk.

SEM/AVS ratios are shown in **Figure 6-3**. As with TOC, less variability was observed in samples from the reference station and Lower Ferry Creek. The sample from one reference station, RF04, had a ratio approaching 10, suggesting metals may be bioavailable in that sample. Otherwise, all of the samples from the reference area and from Lower Ferry Creek had ratios less than 2. However, in Upper Ferry Creek and the Housatonic Boat Club areas, much greater variability and higher ratios were observed. Most sediment samples had SEM/AVS ratios between 1 and 5, although there were three samples from each area with ratios in excess of 10. Two of these samples, from Upper Ferry Creek (SD04 and SD16), were the same samples that had extremely high TOC and fines content and were also located outside the stream channel in the vegetated area. Samples with high ratios could be expected to have some bioavailable, potentially toxic metals present.

In summary, evaluation of grain size, TOC, and SEM/AVS ratios indicate that there is considerable variability in the nature of the sediment, not only within an area but between areas as well. Generally, the sediment characteristics of Lower Ferry Creek and the reference areas appear to be more homogeneous and similar. The other two areas (Upper Ferry Creek and the boat club wetlands) may be characterized as having sediment much more heterogeneous in nature. Clearly, mesoscale conditions within an area dramatically influence the nature of sediment matrix and thus preclude broad generalizations regarding the bioavailability of contaminants within any given locale. This conclusion is corroborated by the lack of simple gradient patterns in CoC concentrations observed in previously-collected sediment data.

6.2.2 Sediment Contamination

This section discusses the concentrations of sediment CoCs collected only in the August 1995 field-sampling effort for this risk assessment. These concentrations are used later in the ERA to evaluate the measurement endpoints.

Table 6-2 compares targeted and actual measured detection limits. **Table 6-3** summarizes concentrations of inorganics detected in sediment samples from Upper Ferry Creek, Lower Ferry Creek, the Housatonic Boat Club, and the reference areas. **Figures 6-4 through 6-12** present the levels of trace elements observed in each sample. **Figures 6-13 through 6-18** show

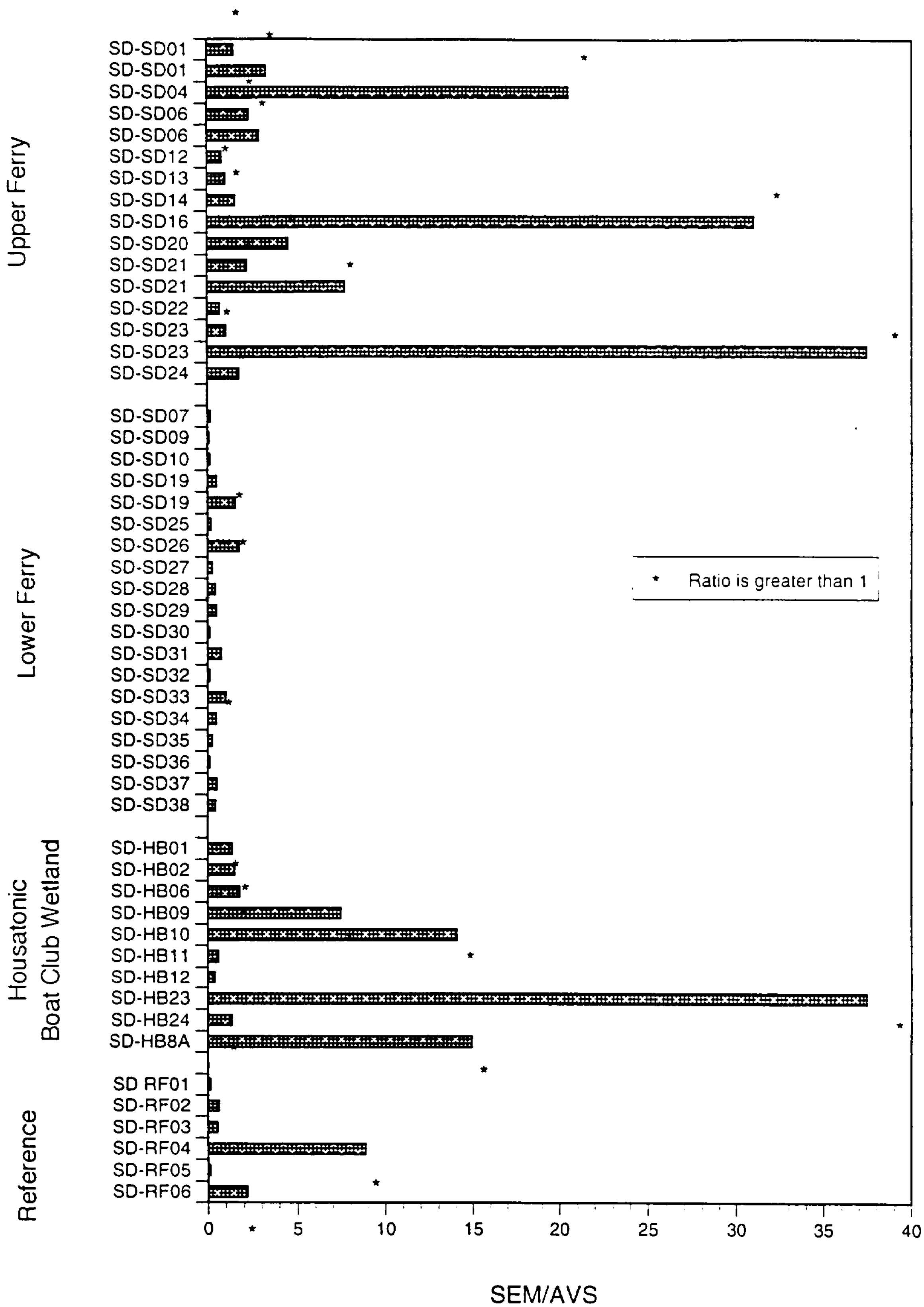

Figure 6-3. Simultaneously extracted metals, acid volatile sulfide ratio of sediments collected from the Raymark Industries site

Table 6-2. Comparison of target detection limits with measured detection limits in sediment.

Analytes	Targeted Detection Limits	Measured Detection Limits
Chemical Parameters		
Metals in mg/kg	2.0	2.0
Arsenic	1.0	04–2.9
Cadmium	2.0	nu
Chromium	5.0	nu
Copper	0.6	nu
Lead	0.1	0.11–0.12
Mercury	8.0	nu
Nickel	2.0	0.71–2.7
Silver	40	nu
Zinc		
LPAH in µg/kg	330	440–9,700
Naphthalene	330	440–9,700
2-Methylnaphthalene	330	440–9,700
Acenaphthylene	330	440–9,700
Acenaphthene	330	440–9,700
Fluorene	330	440–9,700
Phenanthrene	330	440–9,700
Anthracene		
HPAHs in mg/kg	330	440–700
Fluoranthene	330	440–700
Benzo(b)fluoranthene	330	440–700
Pyrene	330	440–9,700
Benzo(a)anthracene	330	440–700
Chrysene	330	440–9,700
Benzo(a)pyrene	330	440–9,700
Dibenz(a,h)anthracene		
PCDDs/PCDF in µg/kg		nu
Pesticides/PCBs in µg/kg	33/67	20–680
Total PCBs	3.3	3.1–17
Total DDT		10–51

nu = no undetected values measured.

Table 6-3. Concentrations of trace elements detected in sediment samples. (dry weight basis)

Trace Element (mg/kg dw)	Upper Ferry Creek (N=8) Min.	Mean	Max.	Mean HQ_{TEL}	Mean HQ_{AET}	Lower Ferry Creek[a] (N=17) Min.	Mean	Max.	Mean HQ_{TEL}	Mean HQ_{AET}
Arsenic	1.7	7.6	19.1	1.1	0.1	4	7.3	13.7	1	0.1
Cadmium	2.4	6.4	16.2	9.5	2.4	1.6	6.1	11.9	8.9	1.5
Chromium	24.4	140.8	501	2.7	1.5	27.2	176	641	3.4	1.8
Copper	220	1,800	7,000	100	4.8	30.7	593	2,360	31.7	1.5
Lead	139	1,700	6,150	56.3	4.0	11.1	333	1,470	11	0.8
Mercury	0.1	0.39	1	3	1.0	0.21	0.53	2.7	4.1	1.2
Nickel	25.3	97.7	272	6.1	0.9	19.5	51.3	132	3.2	0.5
Silver	nd		nd			1.1	2.2	3.8	3	3.2
Zinc	154	600	1,420	48	1.5	79.1	431.2	1,110	3.5	1.1

Trace Element (mg/kg dw)	Housatonic Boat Club (N=10) Min.	Mean	Max.	Mean HQ_{TEL}	Mean HQ_{AET}	Reference Area (N=6) Min.	Mean	Max.	Mean HQ_{TEL}	Mean HQ_{AET}	Detection Limits[b] Min.	Max.	Targeted Detection (N=17)
Arsenic	2.8	11.2	24	1.6	0.2	2.2	6.8	11.2	0.9	0.1	2	2	2.0
Cadmium	0.49	3.5	6.1	5.1	0.7	1.0	1.2	1.6	1.8	0.4	0.39	2.9	1.0
Chromium	30.1	365	1,060	7	3.8	39	200	304	3.8	2.2	na	na	2.0
Copper	75.1	1,364	5,340	72.9	3.5	102	652.5	1,260	34.9	1.7	na	na	5.0
Lead	22.3	450.4	2,950	14.9	1.0	65.3	97.7	141	3.2	0.3	na	na	0.6
Mercury	0.44	1	1.6	7.5	2.2	0.13	0.6	0.91	4.6	1.5	0.06	0.11	0.1
Nickel	15.5	46	83.1	2.9	0.4	14.7	29	38.1	1.9	0.3	na	na	8.0
Silver	nd		nd			nd		nd			0.71	6.8	2.0
Zinc	79.7	417.6	1,120	3.4	1.0	158	306.5	551	2.5	0.7	na	na	40

a — Includes river stations SD32-38
na — detection limits not applicable; substance was detected in all samples
nd — not detected

results from sampling of sediment for dioxins and furans (reported as a TCDD toxicity equivalent quotients, or TEQs), PCBs, DDTs, plus total PAHs. **Table 6-4** also presents summaries of these organic compounds detected in samples from each of the four sampling areas.

For risk screening comparisons, the Threshold Effect Levels (TELs) (MacDonald et al. 1996) were used. These guidelines represent the lower thresholds below which adverse biological impacts are not expected to be observed. Thus, the TELs are a conservative measure of the potential impact of bulk sediment contamination on the benthic community. Mean Hazard Quotients (HQs) were calculated as the ratio of observed sediment contamination to the TEL benchmark value (HQ_{TEL}s), and are also presented for each area in Tables 6-2 and 6-3. HQ_{TEL}s for a given CoC below 1 suggest little likelihood that adverse biological responses would result from exposure for that CoC.

All inorganic CoCs were detected in at least one sediment sample at a concentration above their respective screening concentrations. Copper and lead concentrations were the most elevated with respect to TELs (Table 6-2). Mean HQ_{TEL}s for these elements (calculated from only the above detection samples) were generally above 10, and reached 100 for copper in Upper Ferry Creek samples. These elevated concentrations for both element are apparently co-located with each other, with the maximum concentrations found in samples from Upper Ferry Creek stations (SD21, SD24, SD13, and SD01) and the Housatonic Boat Club wetland stations (HB01 and HB23). Cadmium, chromium, and zinc were also elevated in comparison with TELs, but to a much lower degree. Mean HQ_{TEL}s for these elements were usually less than 5, but never exceeded 10. Maxima in zinc levels were apparently co-located with those for copper and lead, but at less elevated concentrations. Mean zinc HQ_{TEL}s never exceeded 5.

Chemical analyses indicate that sediment samples collected from Upper Ferry Creek also contained the highest concentrations of organics (Table 6-3). Samples from stations in Upper Ferry Creek (especially, SD01, SD13, SD21, SD23, and SD24) had consistently high levels of TCDD TEQs and/or PCBs†. The mean HQ_{TEL} in Upper Ferry Creek samples for total PCBs was 117.3 and 53.4 for TEQs. The sample from SD24 had the highest total PCB concentration observed. One sample in the Housatonic Boat Club, from station HB23, had elevated sediment concentrations of TCDD TEQs and total PCBs (HQ_{TEL}s of 150 and 180, respectively). These samples are the same ones that generally contained the highest concentrations of metals as well. Three samples from Lower Ferry Creek (from stations SD26, SD28, and SD33) contained elevated total PCB levels, comparable with those seen in samples from the upper creek area (HQ_{TEL}s of 85, 164, and 123, respectively). The samples taken from stations SD26 and SD33 also had the highest TCDD TEQ level observed in Lower Ferry Creek (HQs of 20 and 30, respectively). The trend of very heterogeneous deposition of organic contaminants within each area is quite evident from these data and reinforces the constraints on inferences made from these data.

Generally, the highest concentrations of total PAHs (Figure 6-17) in site-related samples were from Upper Ferry Creek (mean HQ_{TEL} of 20), followed by those from Lower Ferry Creek (mean HQ_{TEL} of 11), and from the Milford Point reference area (mean HQ_{TEL} of 8.6). However, the highest PAH sediment concentration was found in a sample from the Beaver Brook reference station (RF01; HQ_{TEL} of 43), just downstream of a light industrial area. Roadway runoff probably contributes substantial PAH contamination to sediment at this location.

† Aroclor 1262 and Aroclor 1268 were the only PCBs reported above detection limits from the laboratory. The summation of these two Aroclors is used to represent total PCBs throughout this assessment, except where noted.

Table 6-4. Concentrations of organic compounds detected in sediment samples (dry weight basis).

	Upper Ferry Creek					Lower Ferry Creek					Housatonic Boat Club					Reference Area					Detection Limits[a]	
	Min.	Mean (No.)[b]	Max.	Mean HQ_{TEL}	Mean HQ_{AET}	Min.	Mean (No.)[b]	Max.	Mean HQ_{TEL}	Mean HQ_{AET}	Min.	Mean (No.)[b]	Max.	Mean HQ_{TEL}	Mean HQ_{AET}	Min.	Mean (No.)[b]	Max.	Mean HQ_{TEL}	Mean HQ_{AET}	Min.	Max.
Total PAHs (µg/kg)	10,310	34,343	64,800	20.4	3.8	4,110	19,592	50,290	11	2.1	1,710	8,879	21,000	4.2	0.8	1,500	14,467	72,700	8.6	1.6	440	9,700
Total PCBs (µg/kg)	69	4,000 (0)	18,200	117.3	30.8	65	1124 (3)	5,600	32.9	7.5	18	882 (2)	6,100	25.9	5.4	7	28 (1)	99	0.8	0.2	33	350
DDD (µg/kg)	5.4	31 (9)	80	17.1	n/a	1.5	7.47 (4)	32	2.3	n/a	0.34	8.92 (2)	20	2.52	n/a	0.46	3.78 (1)	9.0	1.07	n/a	3.2	17
DDE (µg/kg)	0.33	8.9 (7)	37	6	n/a	0.18	2.97 (3)	7.9	2.1	n/a	1.1	3.21 (2)	6.6	2.26	n/a	0.09	0.72 (2)	1.8	0.51	n/a	2	17
DDT (µg/kg)	0.41	5.68 (12)	16	n/a	n/a	0.31	3.9 (11)	14	n/a	n/a	0.12	4.2 (2)	16	n/a	n/a	0.13	1.1 (1)	4.4	n/a	n/a	2	17
TEQs[c] (ng/kg)	9.03	267	1,099.7	53.4	10.7	0.48	27.2	149	5.4	1.1	0.17	90.2	745.03	18	3.6	0.39	6.6	16.33	1.3	0.3	n/a	n/a

n/a - not applicable; screening guideline not available

[a] — Detection limits for total PAHs and total PCBs are for individual compounds or congeners.
[b] — Number in parantheses is the number of samples with levels below the detection limit.
[c] — TCDD TEQs were calculated using dioxin and furan data; a benchmark of 5 µg/kg was used .for HQ_{TEL} and 25 for HQ_{AET}

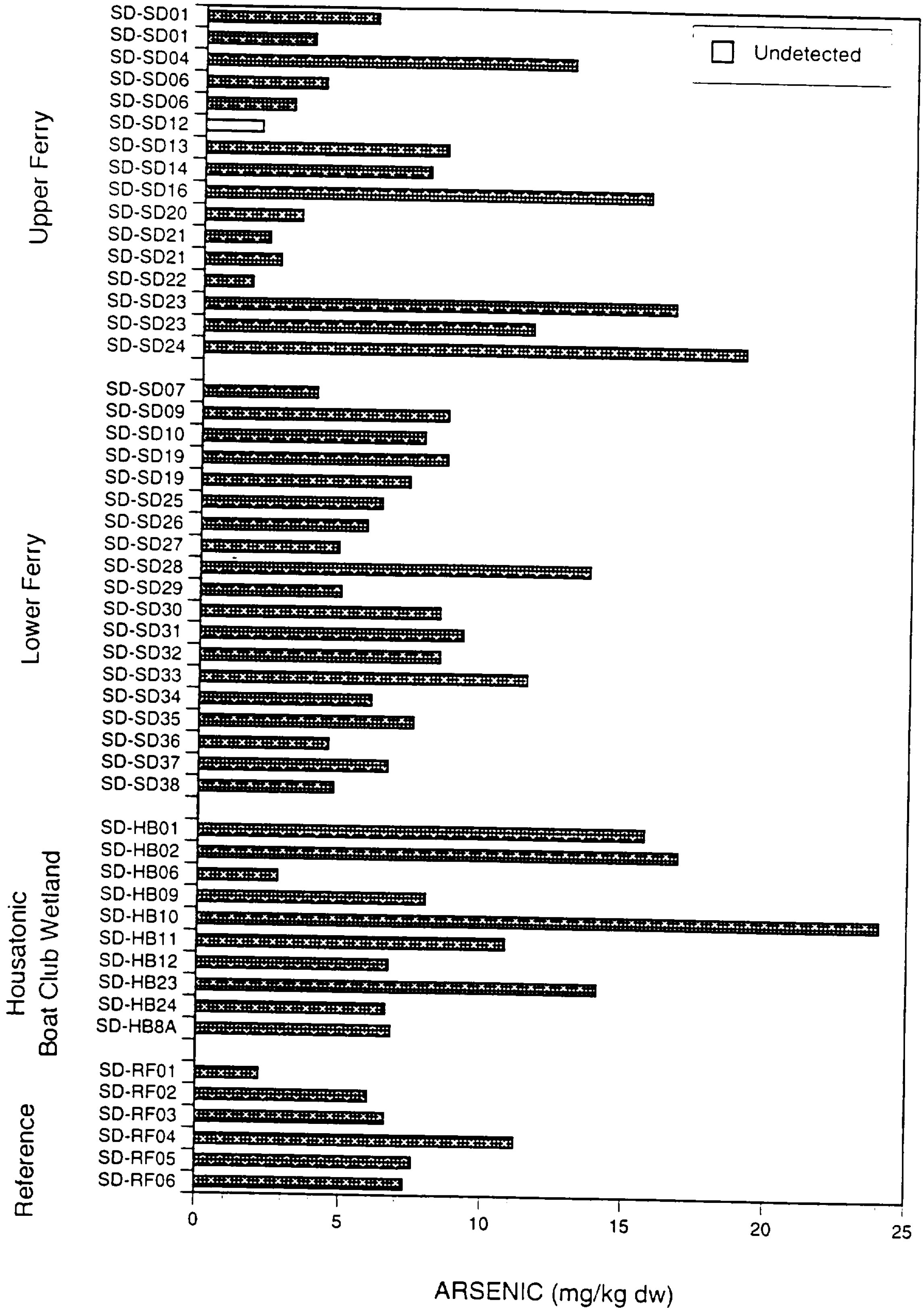

Figure 6-4. Arsenic concentrations in sediment collected from the Raymark Industries site and Milford Pond and Beaver Brook Reference zones.

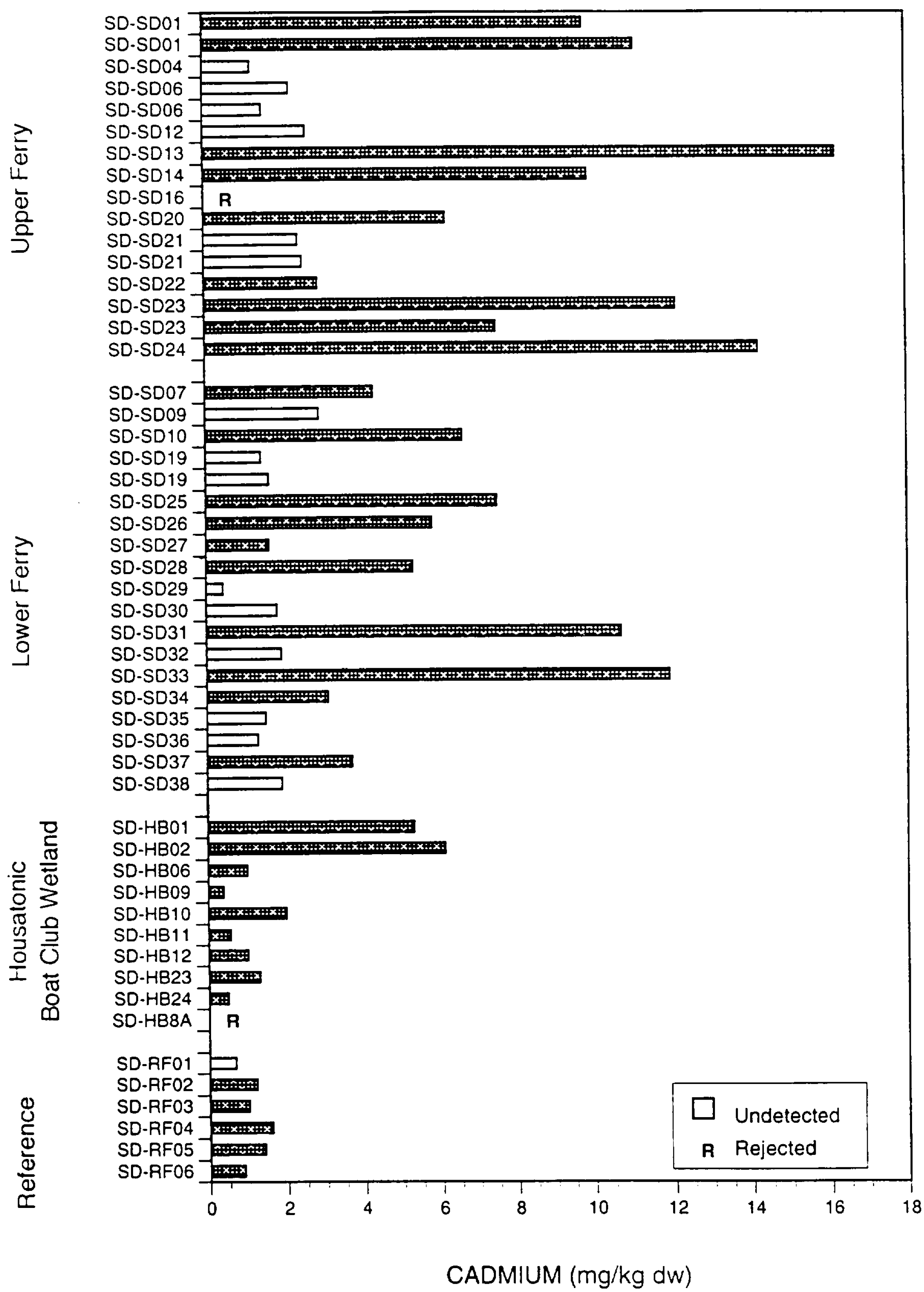

Figure 6-5. Cadmium concentrations in sediment collected from the Raymark Industries site and Milford Pond and Beaver Brook Reference zones.

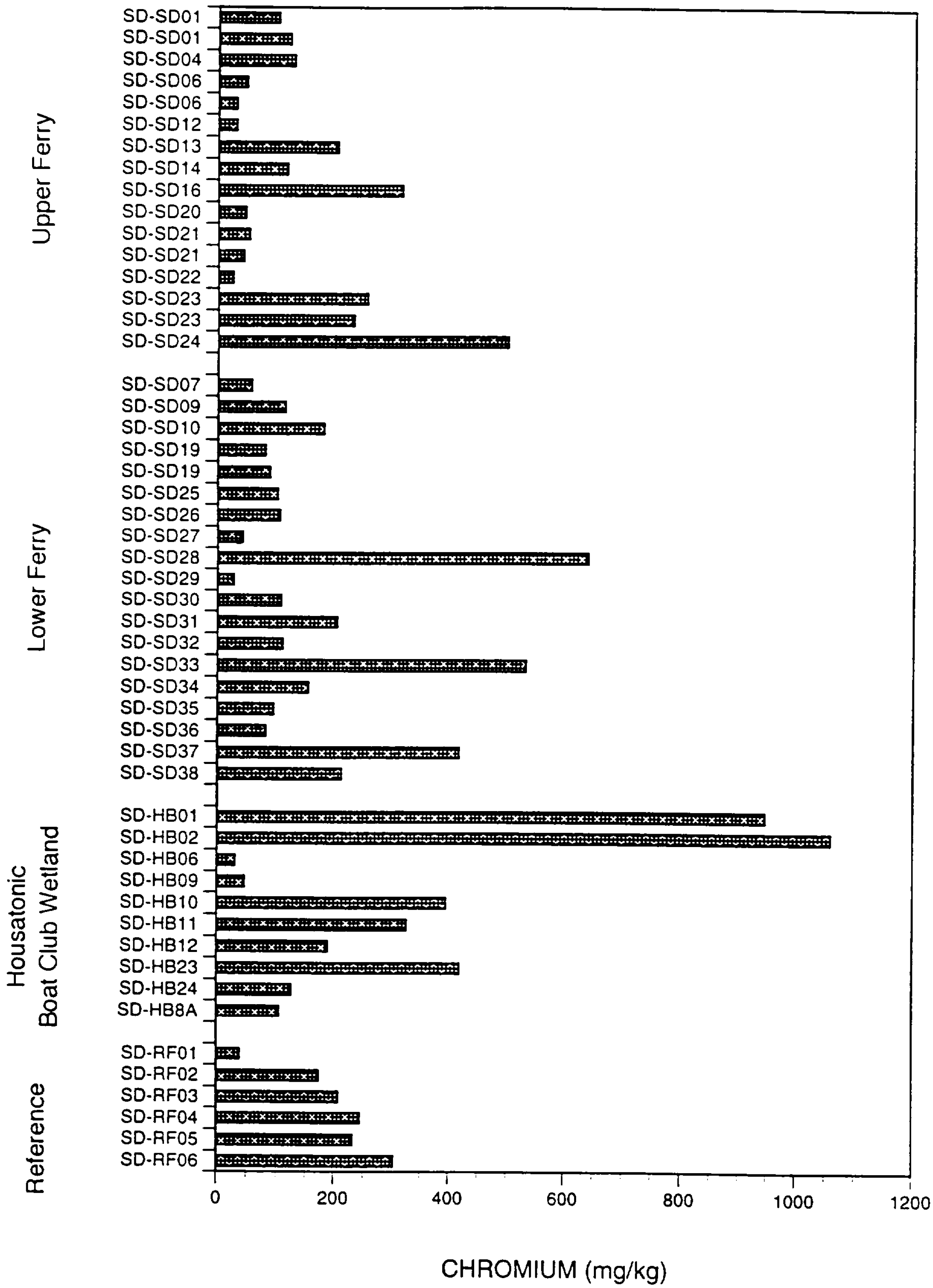

Figure 6-6. Chromium concentrations in sediment collected from the Raymark Industries site and Milford Pond and Beaver Brook Reference zones.

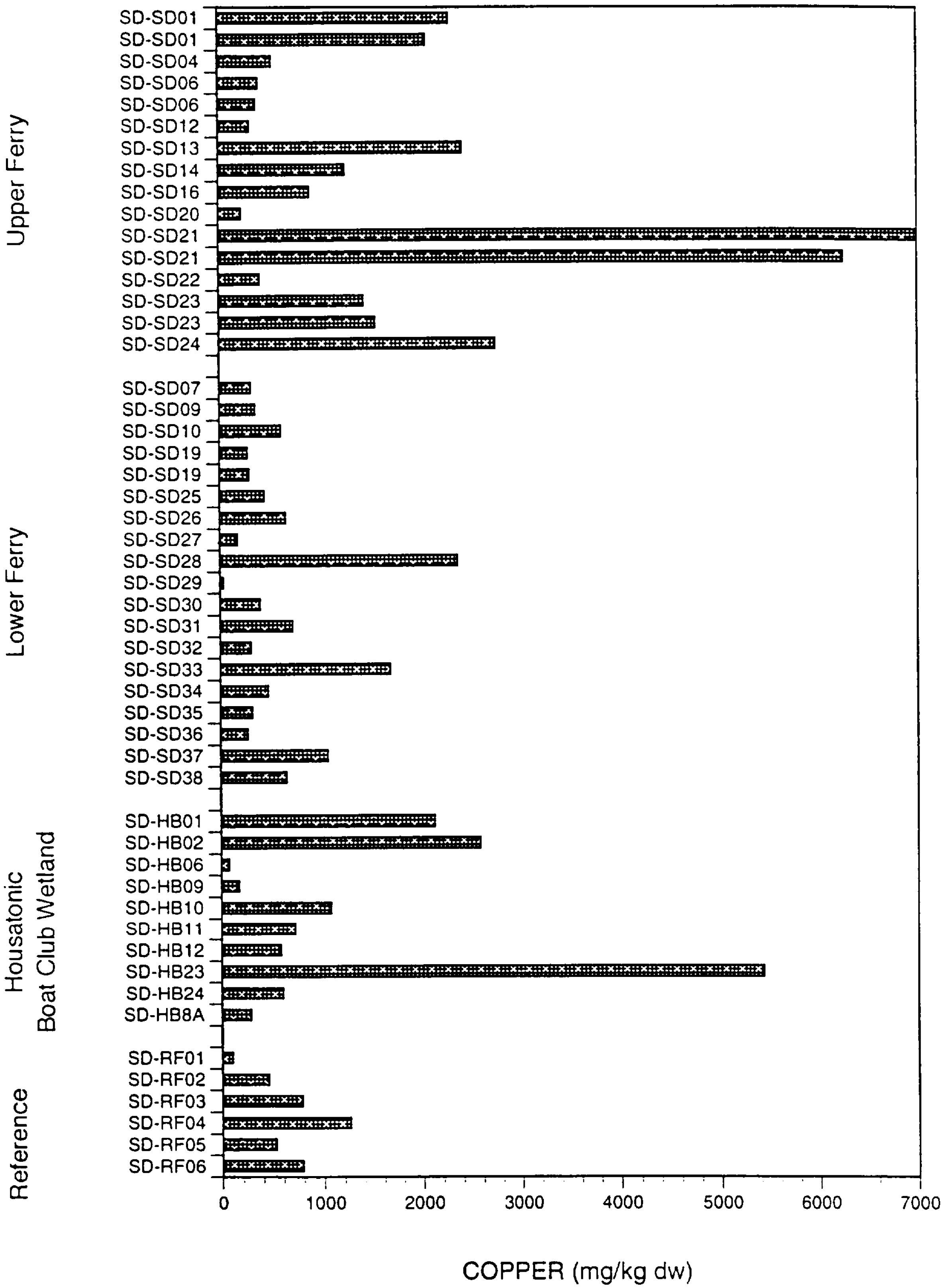

Figure 6-7. Copper concentrations in sediment collected from the Raymark Industries site and Milford Pond and Beaver Brook Reference zones.

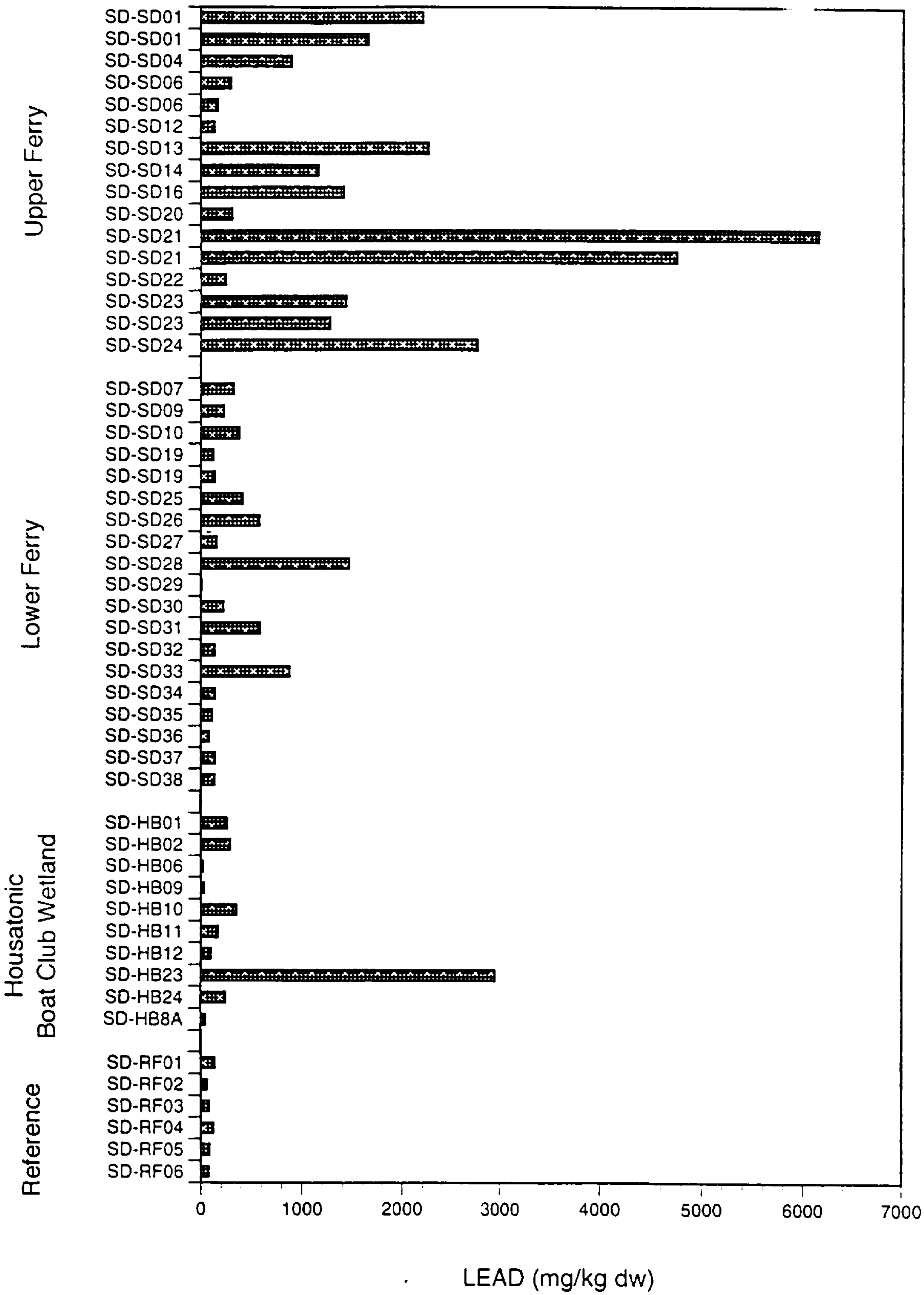

Figure 6-8. Lead concentrations in sediment collected from the Raymark Industries site and Milford Pond and Beaver Brook Reference zones.

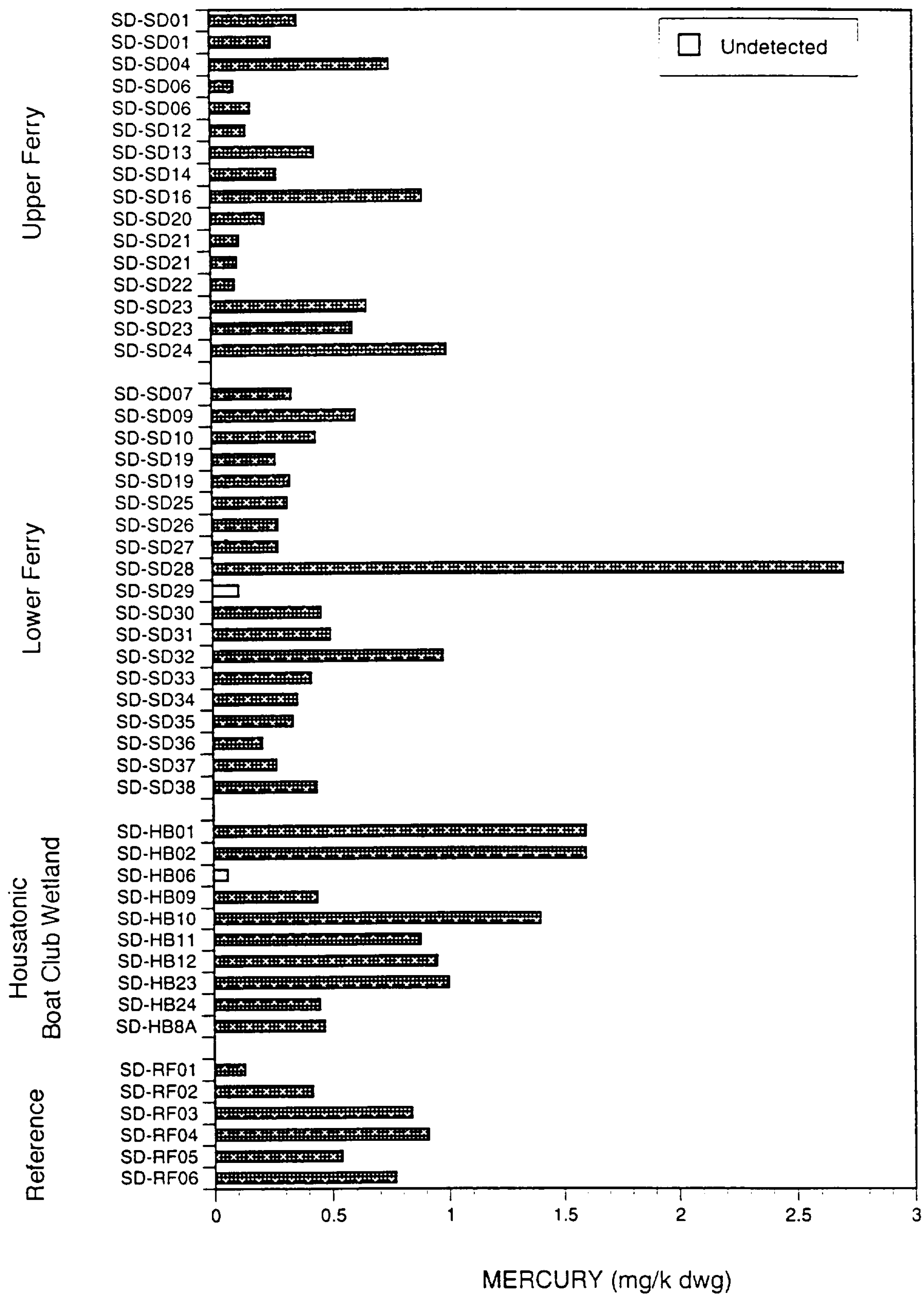

Figure 6-9. Mercury concentrations in sediment collected from the Raymark Industries site and Milford Pond and Beaver Brook Reference zones.

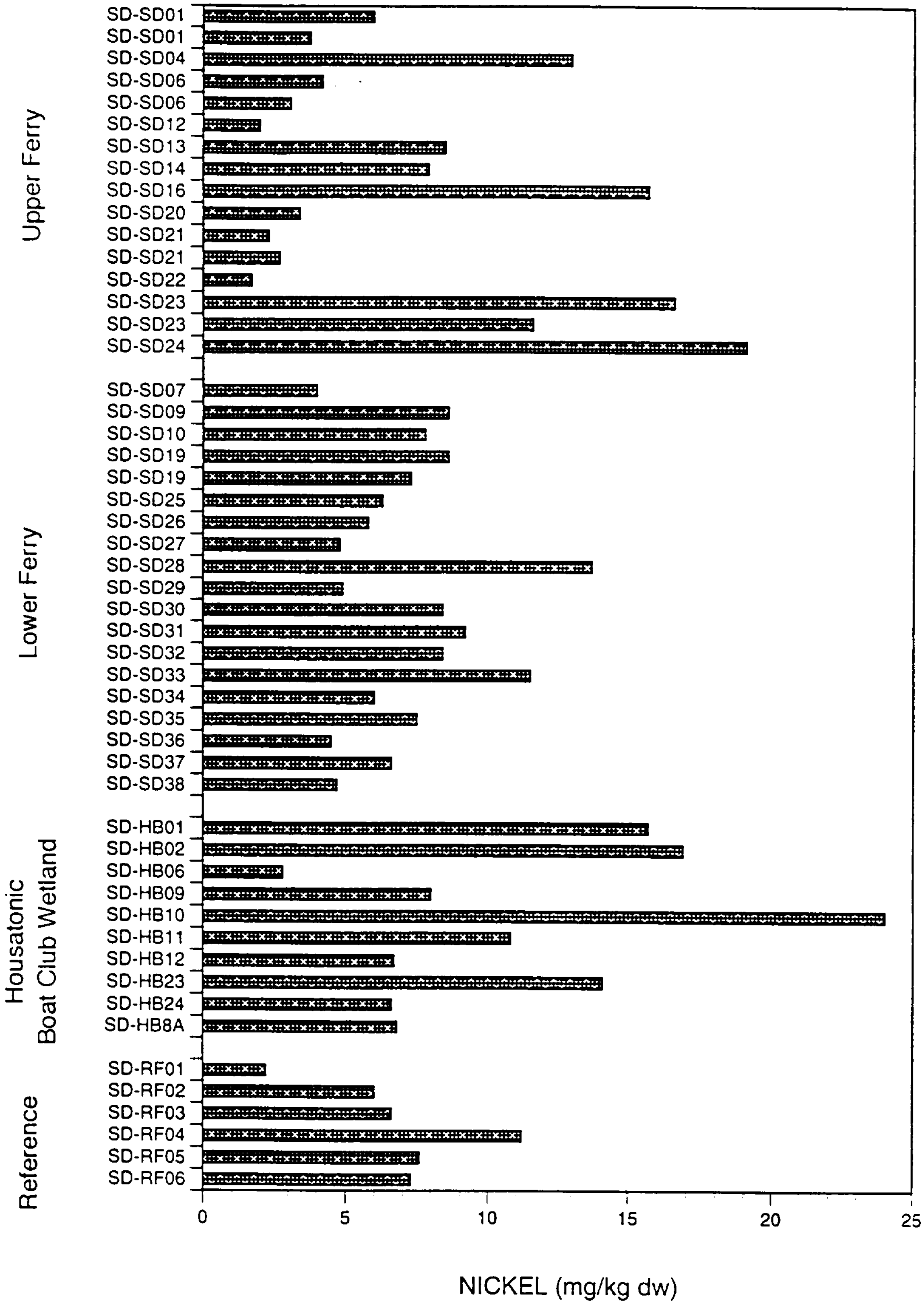

Figure 6-10. Nickel concentrations in sediment collected from the Raymark Industries site and Milford Pond and Beaver Brook Reference zones.

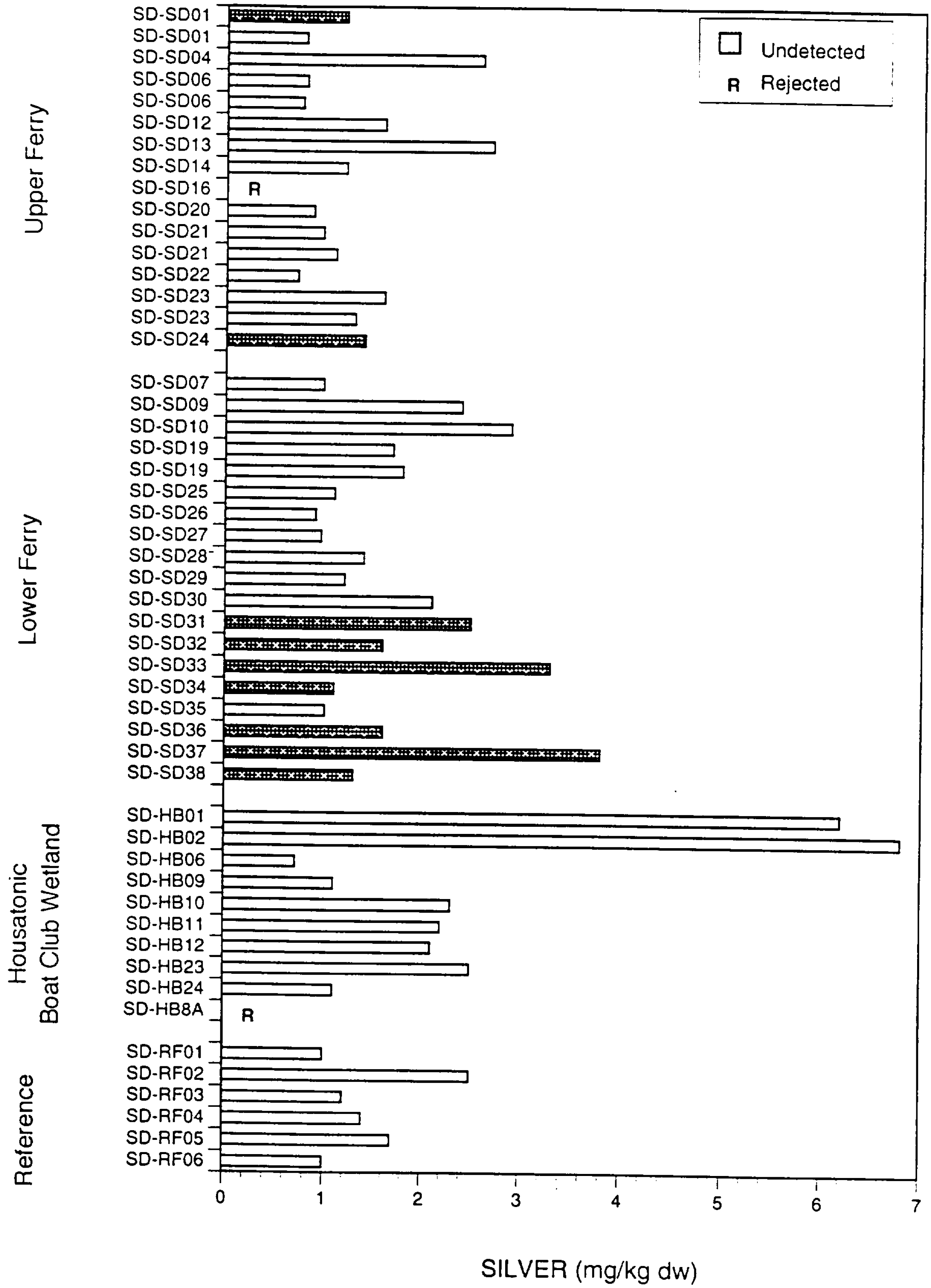

Figure 6-11. Silver concentrations in sediment collected from the Raymark Industries site and Milford Pond and Beaver Brook Reference zones.

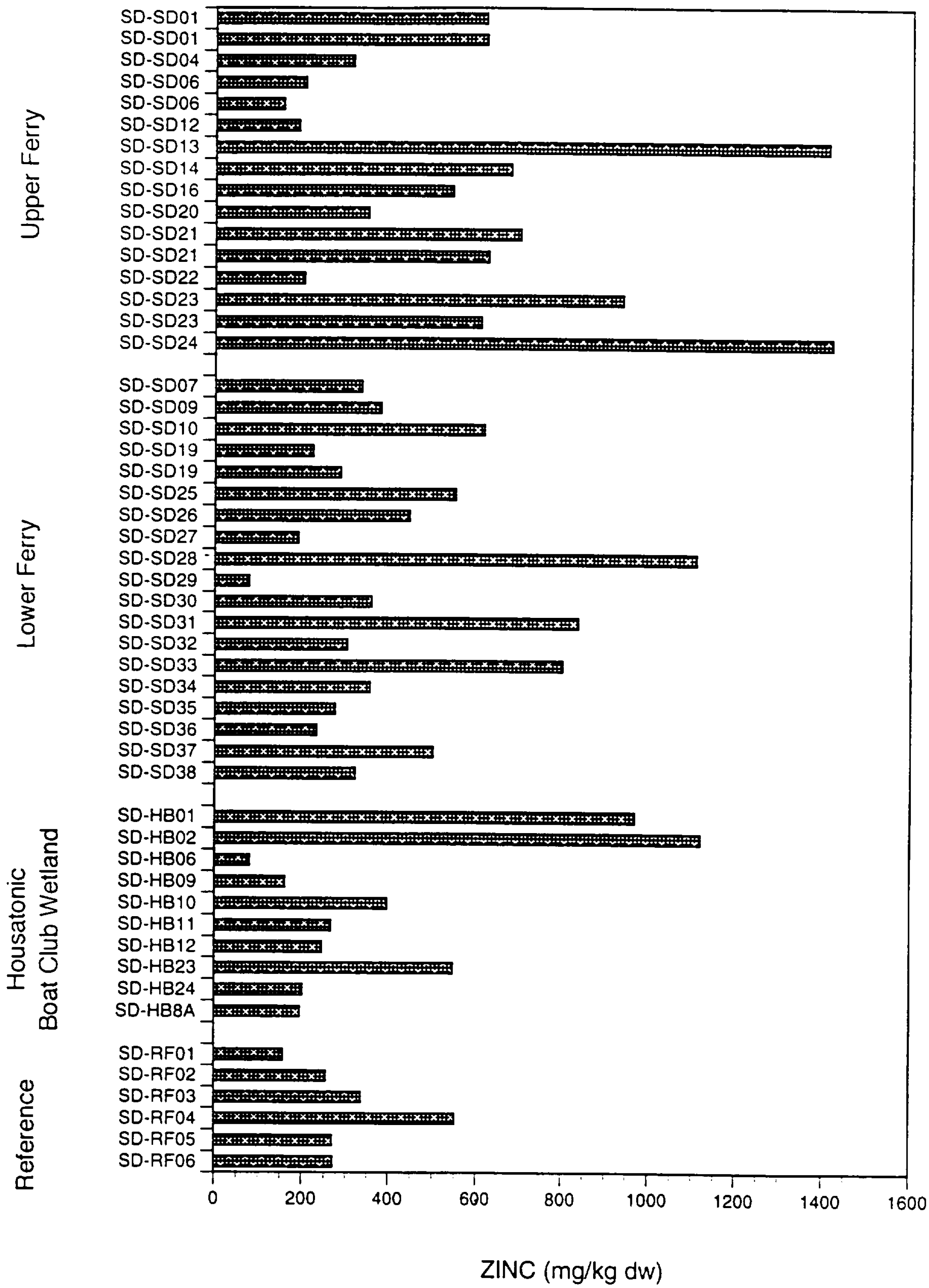

Figure 6-12. Zinc concentrations in sediment collected from the Raymark Industries site and Milford Pond and Beaver Brook Reference zones.

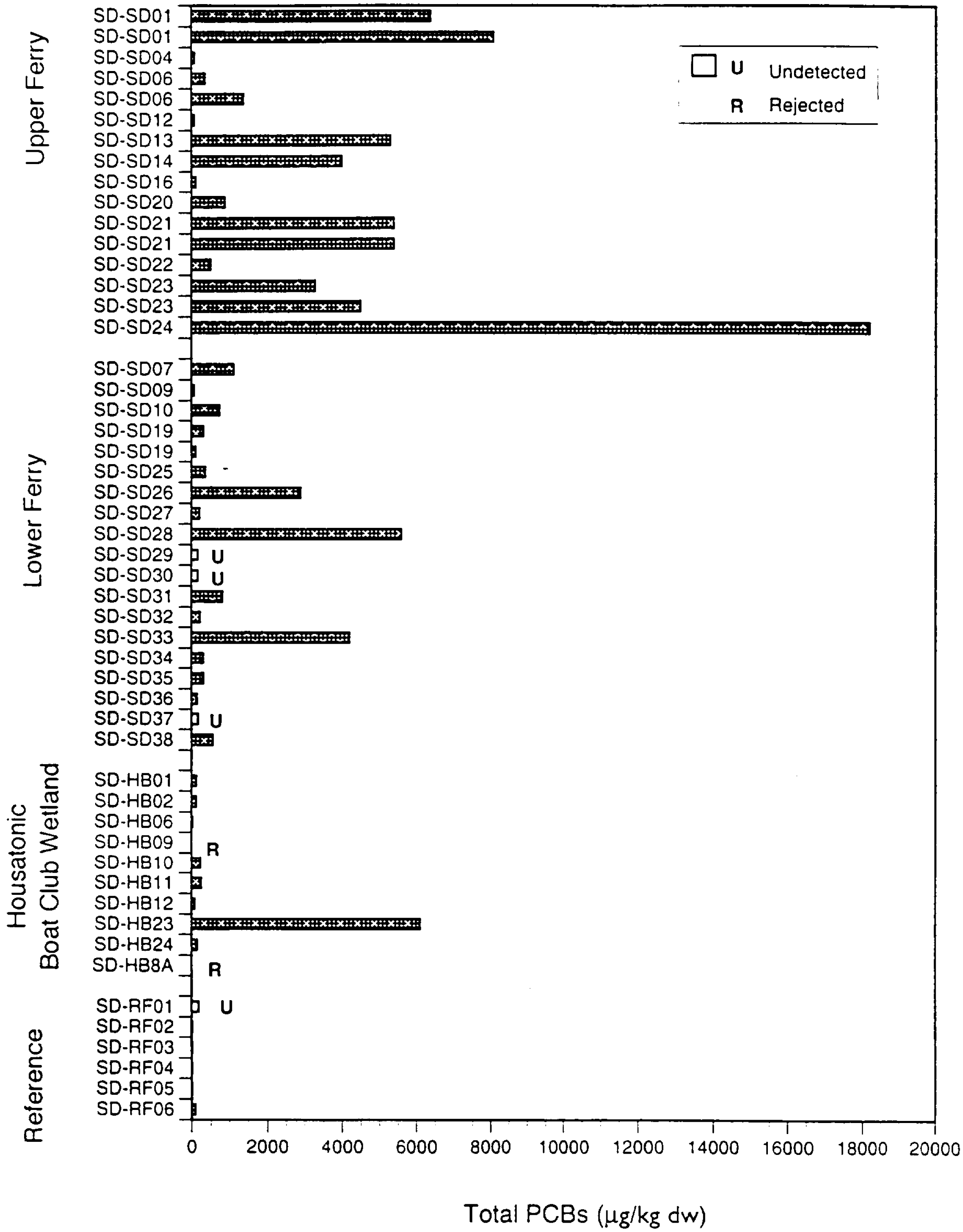

Figure 6-13. Total PCB concentrations in sediment collected from the Raymark Industries site and Milford Point and Beaver Brook Reference zones.

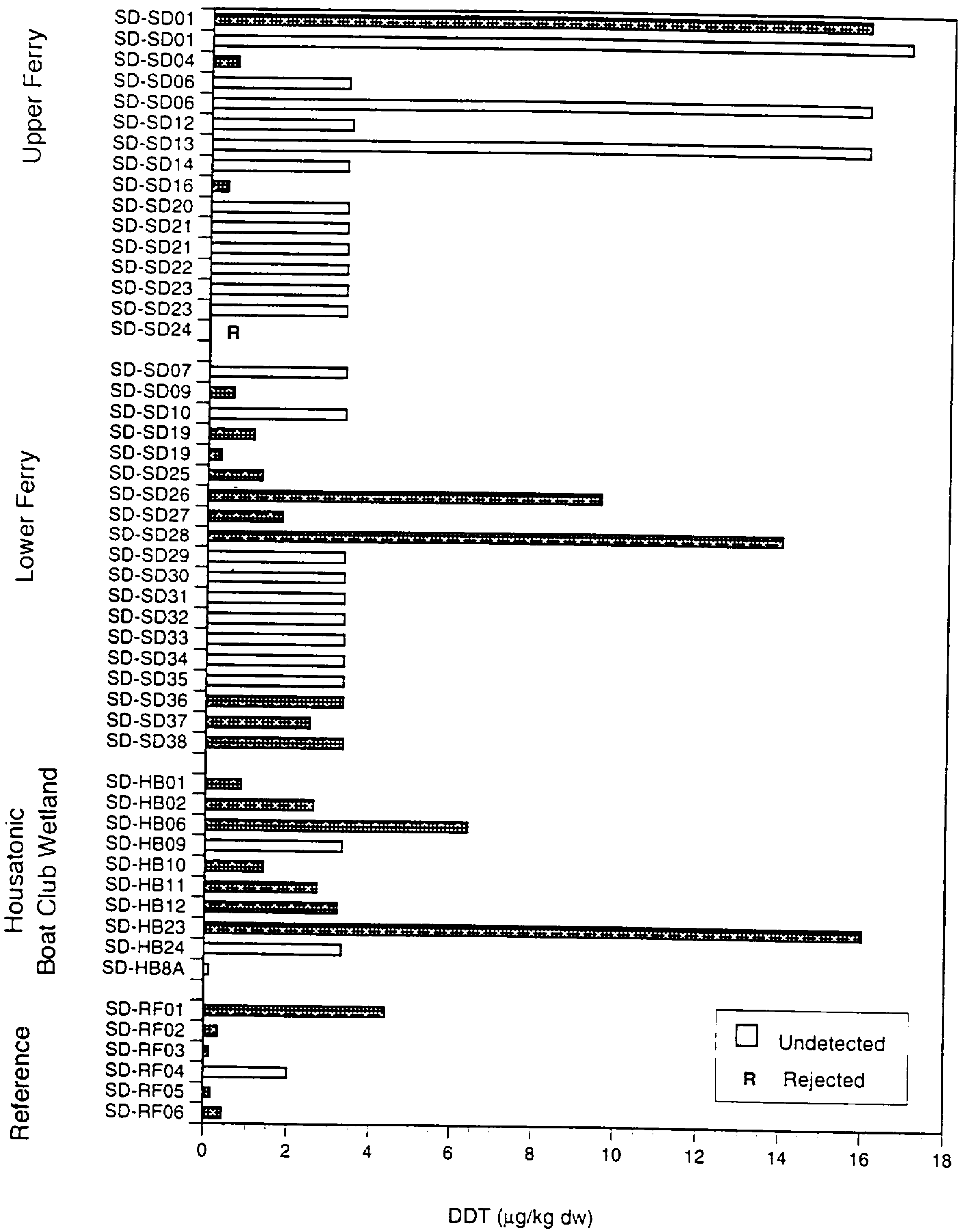

Figure 6-14. DDT concentrations in sediment collected from the Raymark Industries site and Milford Point and Beaver Brook Reference zones.

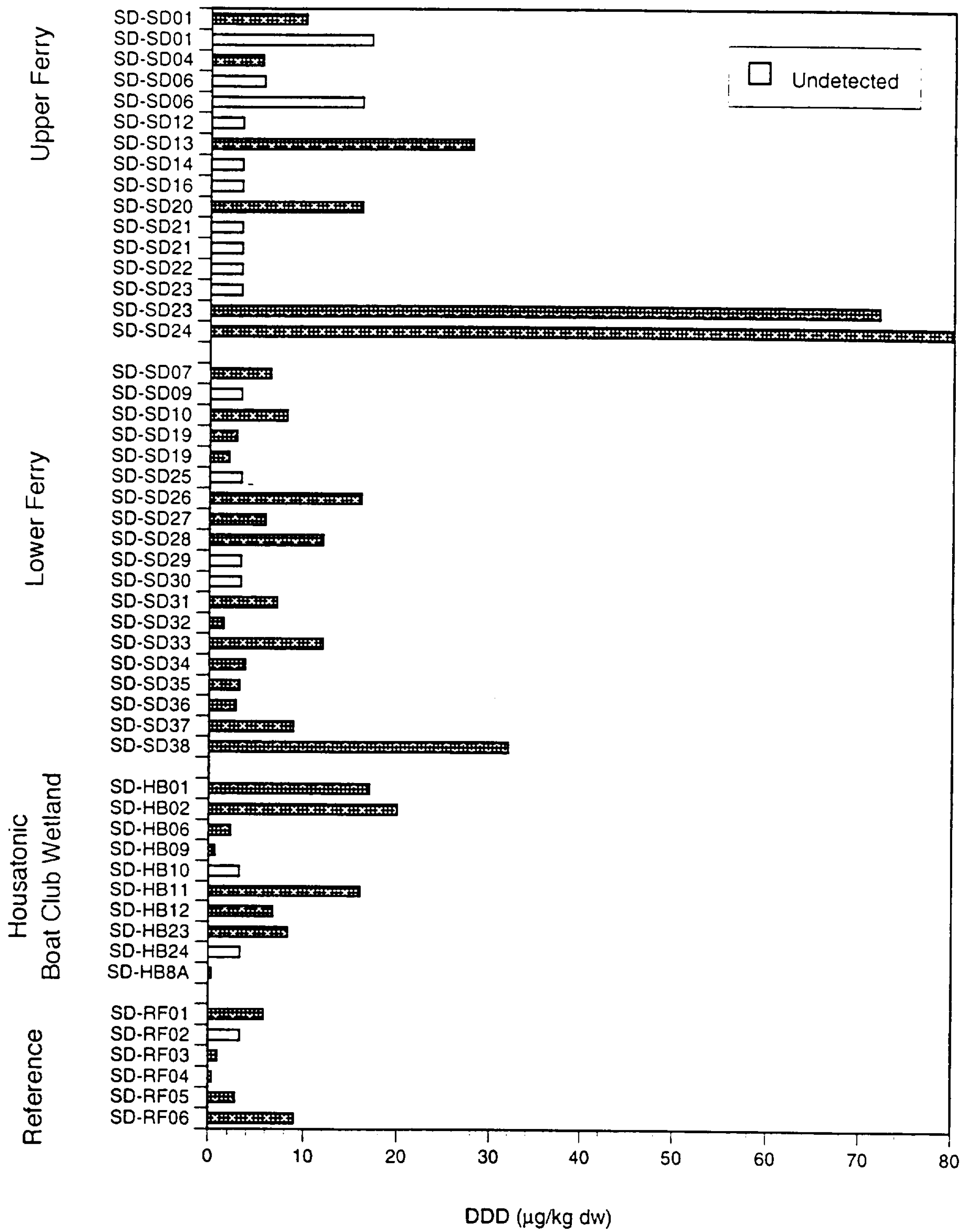

Figure 6-15. DDD concentrations in sediment collected from the Raymark Industries site and Milford Point and Beaver Brook Reference zones.

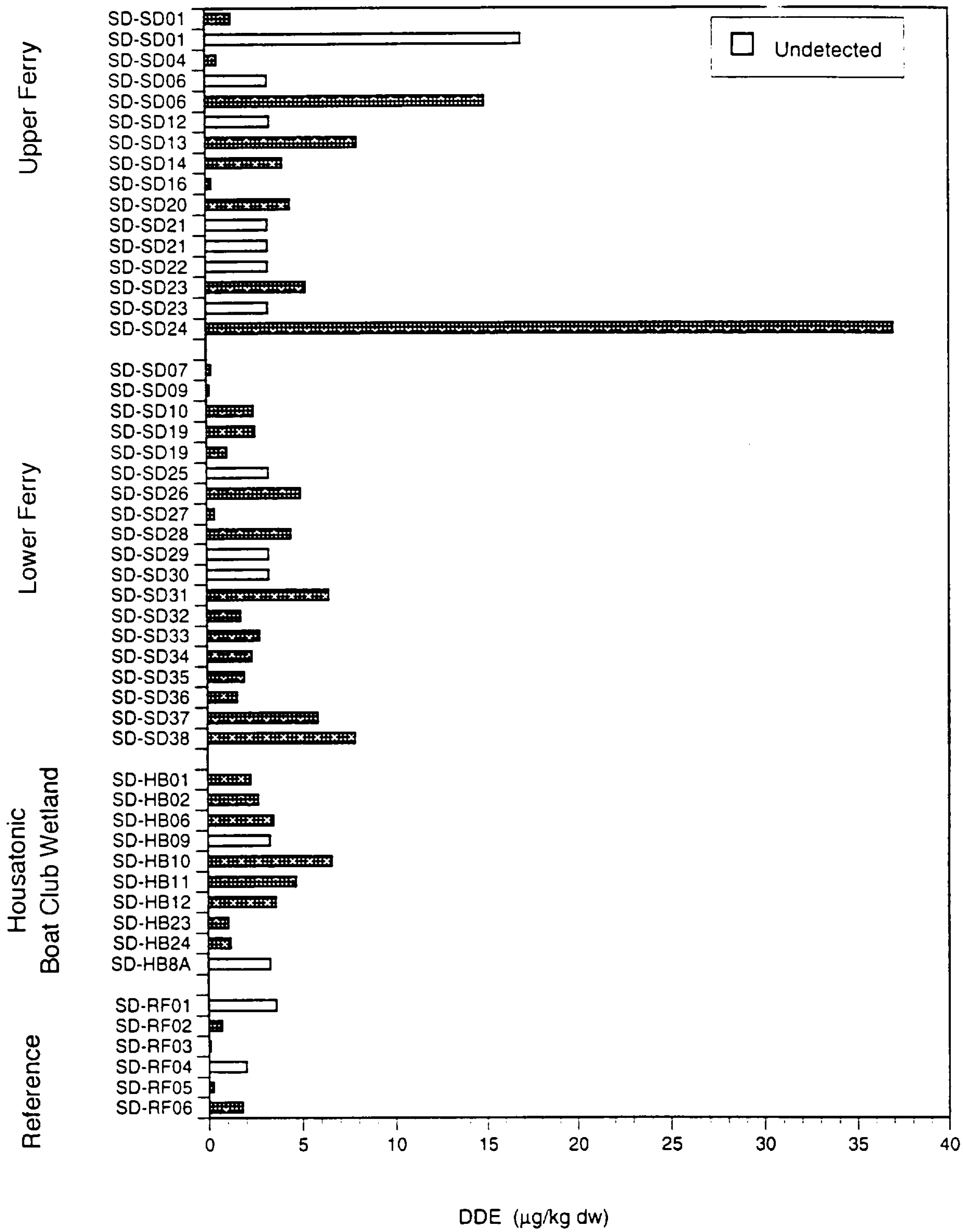

Figure 6-16. DDE concentrations in sediment collected from the Raymark Industries site and Milford Point and Beaver Brook Reference zones.

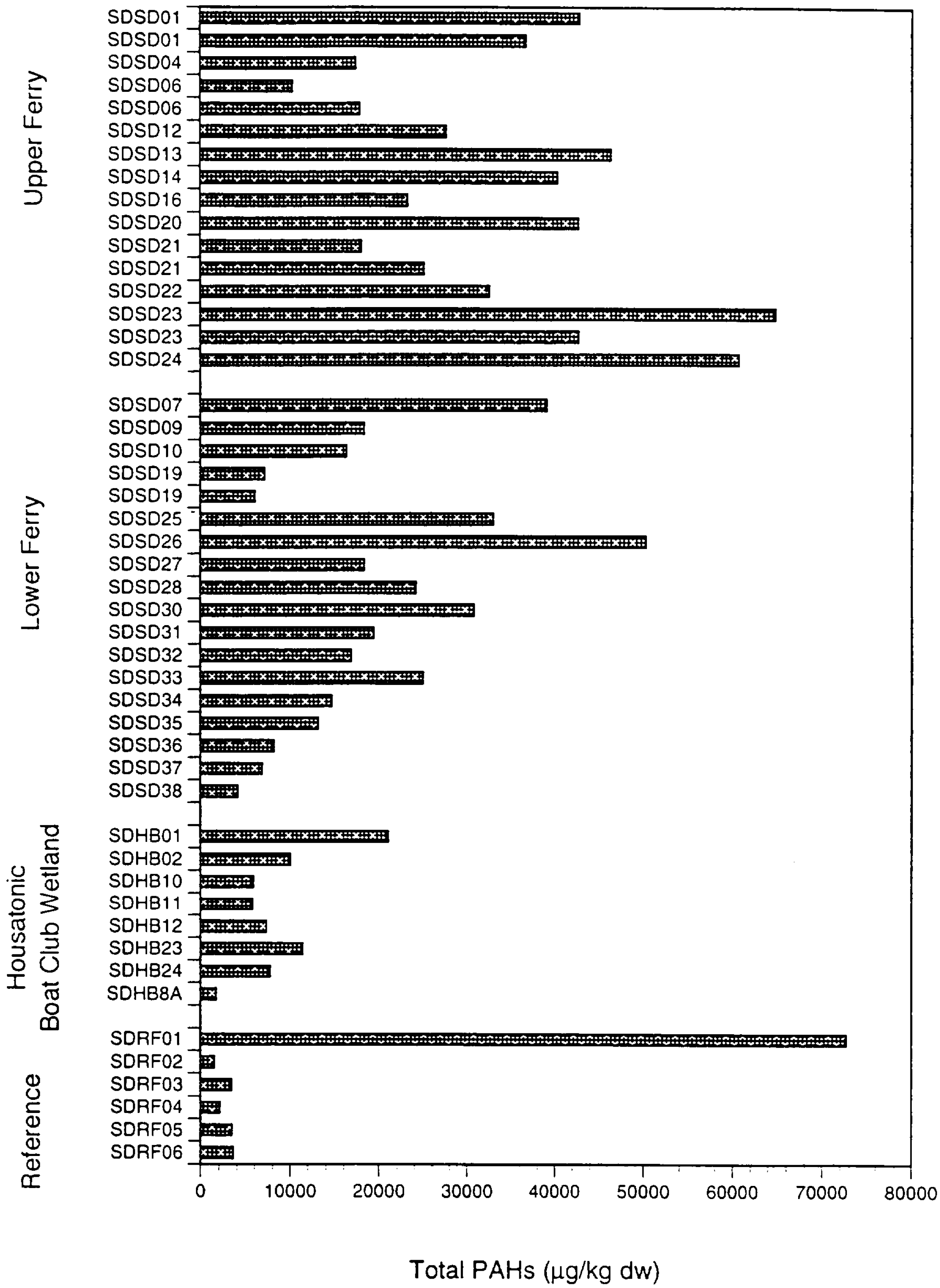

Figure 6-17. Total PAH concentrations in sediment collected from the Raymark Industries site and Milford Point and Beaver Brook Reference zones.

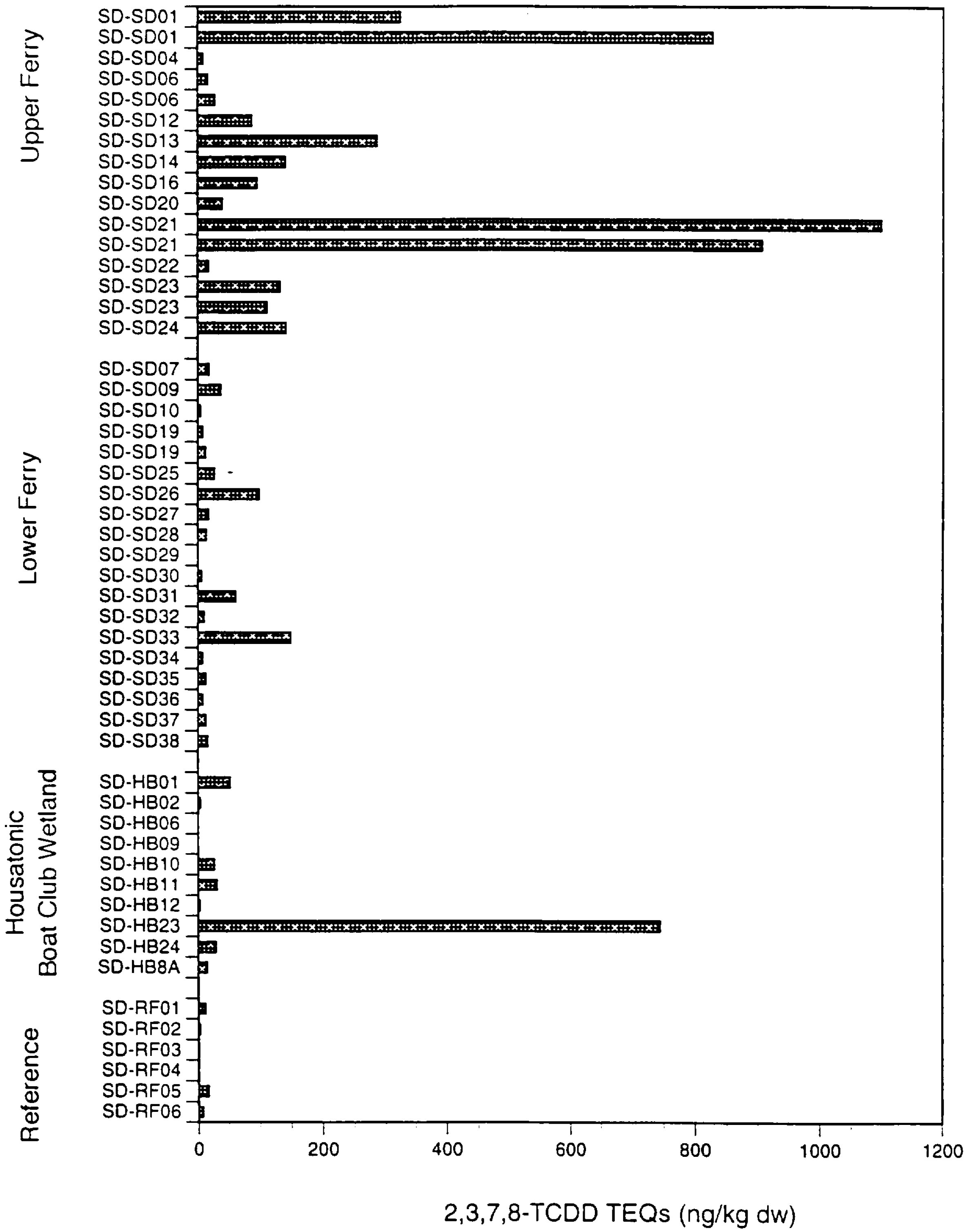

Figure 6-18. Dioxin concentrations in sediment collected from the Raymark Industries site and Milford Point and Beaver Brook Reference zones.

6.3 FOOD-WEB EXPOSURE CHARACTERIZATION

The biota tissue sampling—fish, crab, and insect tissue—represents three potential food-web transfer routes for site-related contamination. Because these tissue samples are a component of other measurement endpoints in this risk assessment, the following sections present only results of the chemical analysis of these tissues. Their use as dietary inputs to the avian food-web model was discussed previously.

6.3.1 Fish Tissue Body Burdens

The life history of the mummichog and the habitat features in the study area indicate that many reaches offer ideal habitat for the mummichog. Their presence in nearshore shallow waters and benthic feeding habits indicate likely exposure to site-related contamination. These fish could be exposed by consuming benthic organisms that have accumulated contaminants from the sediments, direct exposure to contaminated sediment and surface water, and incidental ingestion of contaminated sediments and water. Exposure could occur year-round to all life stages since the species is not known to migrate and tolerates a wide variety of salinity and temperatures. Because their home range is limited and they do not migrate, samples of mummichog should represent localized conditions.

Results from fish tissue chemical analysis are presented in **Figures 6-19 through 6-22**. Targeted and measured detection limits are compared in **Table 6-5**; observed tissue concentration ranges are summarized in **Table 6-6**. Nine metals were detected in fish tissue samples from all locations. Variability in body burdens within an area (e.g., Upper Ferry Creek) was high, possibly reflecting the extremely heterogeneous pattern of contaminant distribution. For instance, there was an order-of-magnitude range in lead levels among the four composite samples from Upper Ferry Creek. Statistical tests of mean body burdens for Upper and Lower Ferry Creek samples versus the reference area fish (Kruskal-Wallis) indicate that mean tissue levels of cadmium, copper, lead, and zinc were significantly elevated in Upper Ferry Creek fish, while silver body burdens were significantly depressed. For cadmium, copper, and lead, tissue body burdens were significantly higher in Upper Ferry Creek fish than Lower Ferry Creek fish. Lower Ferry creek fish contained significantly higher mean levels of arsenic than reference fish. Upper Ferry Creek fish also had the highest mean levels of detected PAHs and dioxin TEQs; mean body burdens were significantly greater than either the reference fish or Lower Ferry Creek fish on either a wet-weight or lipid-weight basis. Because of problems with detection limits, tissue concentrations of PCBs were not evaluated in any detail.

6.3.2 Crab Tissue Body Burdens

Results from crab-tissue chemical analysis are presented in **Figures 6-23 through 6-24**. Table 6-5 compares targeted and measured detection limits; **Table 6-7** summarizes actual measured tissue concentrations. Eight metals were detected in crab tissues from all locations. Copper and lead levels were the most elevated, particularly in the boat club wetland sample. Copper was twice the level measured in the reference sample collected from Milford Point, while lead was 14 times higher. Copper and lead were also higher than the reference concentrations in the Upper Ferry Creek sample, but not as elevated as the boat club sample. The only other substantial difference observed in body burdens of metals was that Cd levels in the sample from Upper Ferry Creek were two orders of magnitude greater than those in the reference sample. Aroclor 1260 was also detected in crab tissue. The sample from the boat club wetland contained the highest level of PCBs, greater than 20 times the concentrations detected at the reference area. Ferry Creek samples had concentrations of PCBs two to four times greater than the reference sample. A variety of high-molecular-weight PAHs were detected in crab samples from all stations. The highest levels occurred in the Upper Ferry Creek sample, followed by the Lower Ferry Creek sample. Dioxins and furans were also observed in all samples. The highest TCDD TEQ was in the boat club sample. Although this sample had a TCDD TEQ greater than the reference sample, most of the difference can be attributed to higher furan concentrations. The TCDD TEQ for the Upper Ferry Creek sample was about twice the reference values.

Because of the limited number of samples, statistical tests of crab body-burden data are extremely limited. Mean tissue body burdens of the three site-related samples (Upper & Lower Ferry Creek plus the boat club wetlands) were tested against the value obtained in the reference samples by Students *t*-test. Wet weight values were tested for trace elements while both wet-weight and lipid-normalized values were tested for the organics. The only detectable difference using this approach was in body burdens of chromium, mercury, and lead.

6.3.3 Insect Tissue Body Burdens

Results from insect-tissue chemical analysis are presented in **Figure 6-25**. Seven metals were detected in the insect composite samples. Targeted detection limits and measured detection limits are compared in Table 6-5. The actual tissue concentrations detected appear in **Table 6-8**. Levels of metals appear generally comparable between the two samples, except that lead was three times greater in the reference sample than in the sample collected at Ferry Creek. No chlorinated compounds were detected, and only two PAHs (phenanthrene and indeno-pyrene) were detected in each sample. The TCDD TEQ was about 60% greater in the Ferry Creek sample than the reference sample. This difference was largely due to dioxins: the dioxin contribution to the total TCDD TEQ in the Ferry Creek sample was twice that in the reference sample, while the TEQ contribution from the furans was similar in both samples.

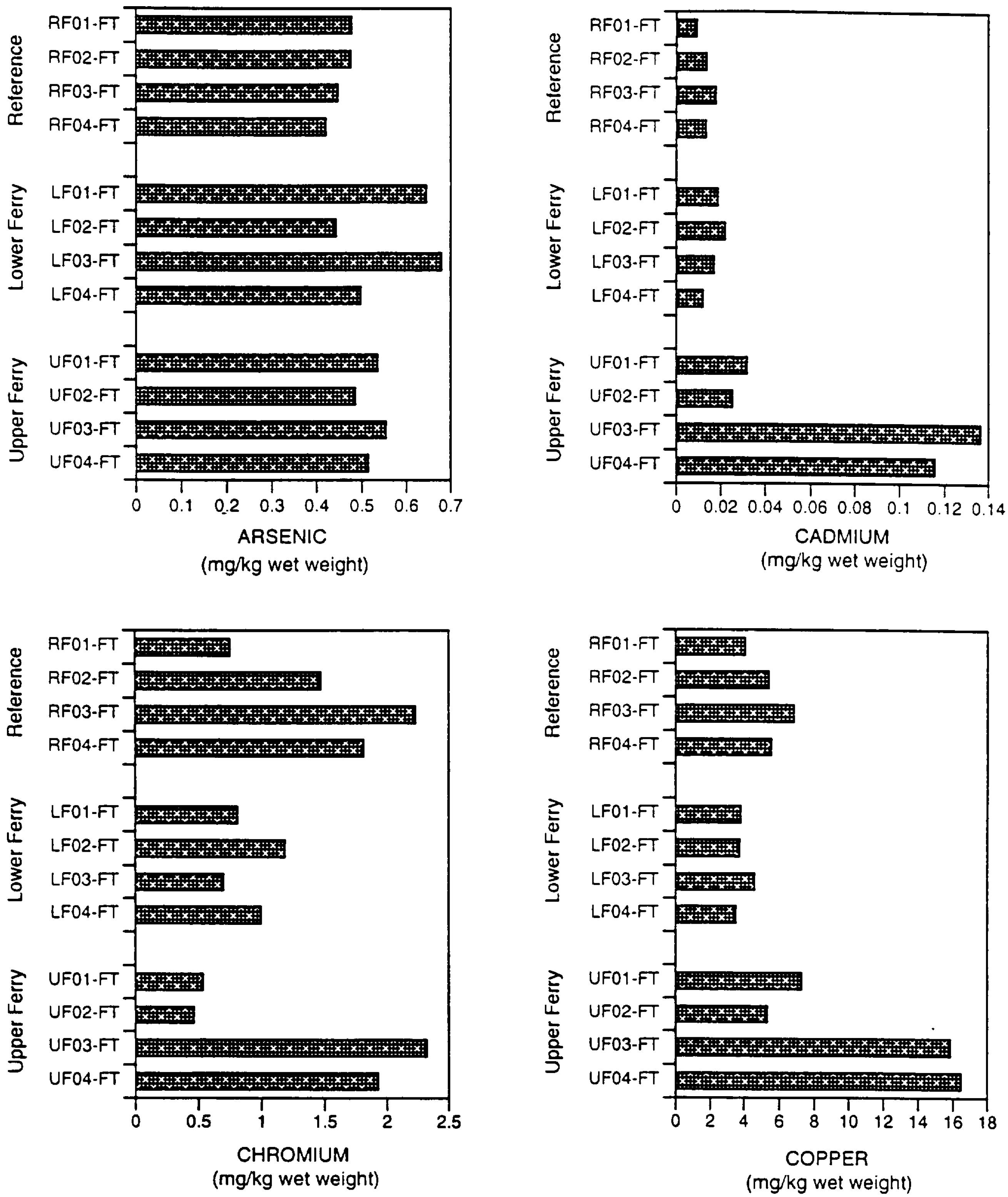

Figure 6-19. Arsenic, cadmium, chromium, and copper tissue concentrations in mummichog collected from Ferry Creek and Milford Point reference zones.

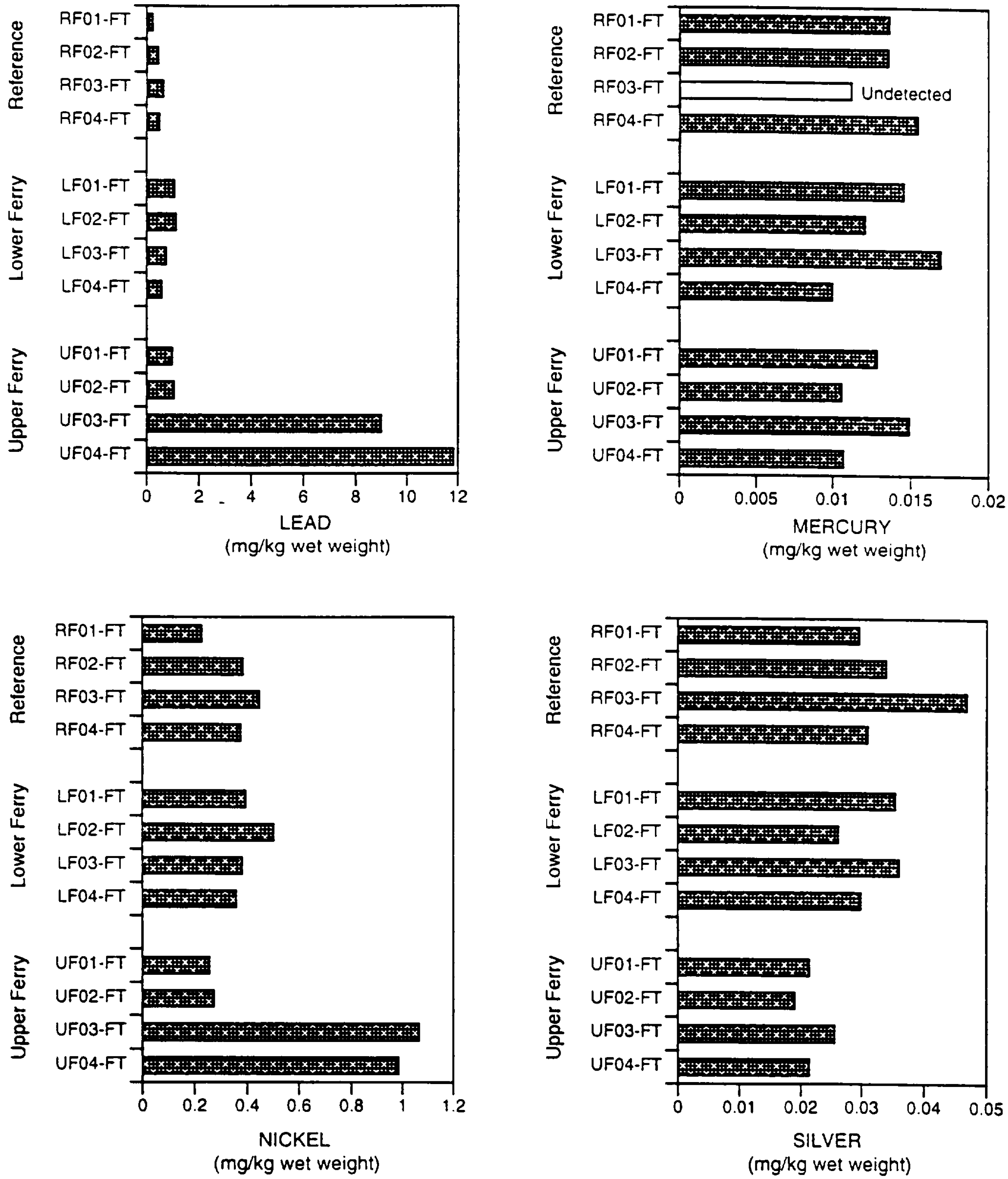

Figure 6-20. Lead, mercury, nickel, and silver tissue concentrations in mummichog collected from Ferry Creek and Milford Point reference zones.

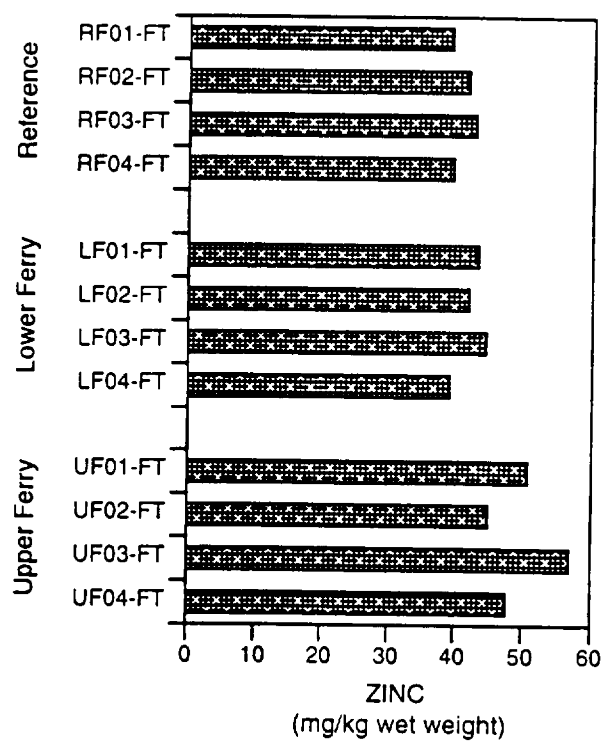

Figure 6-21. Zinc tissue concentrations in mummichog collected from Ferry Creek and Milford Point reference zones.

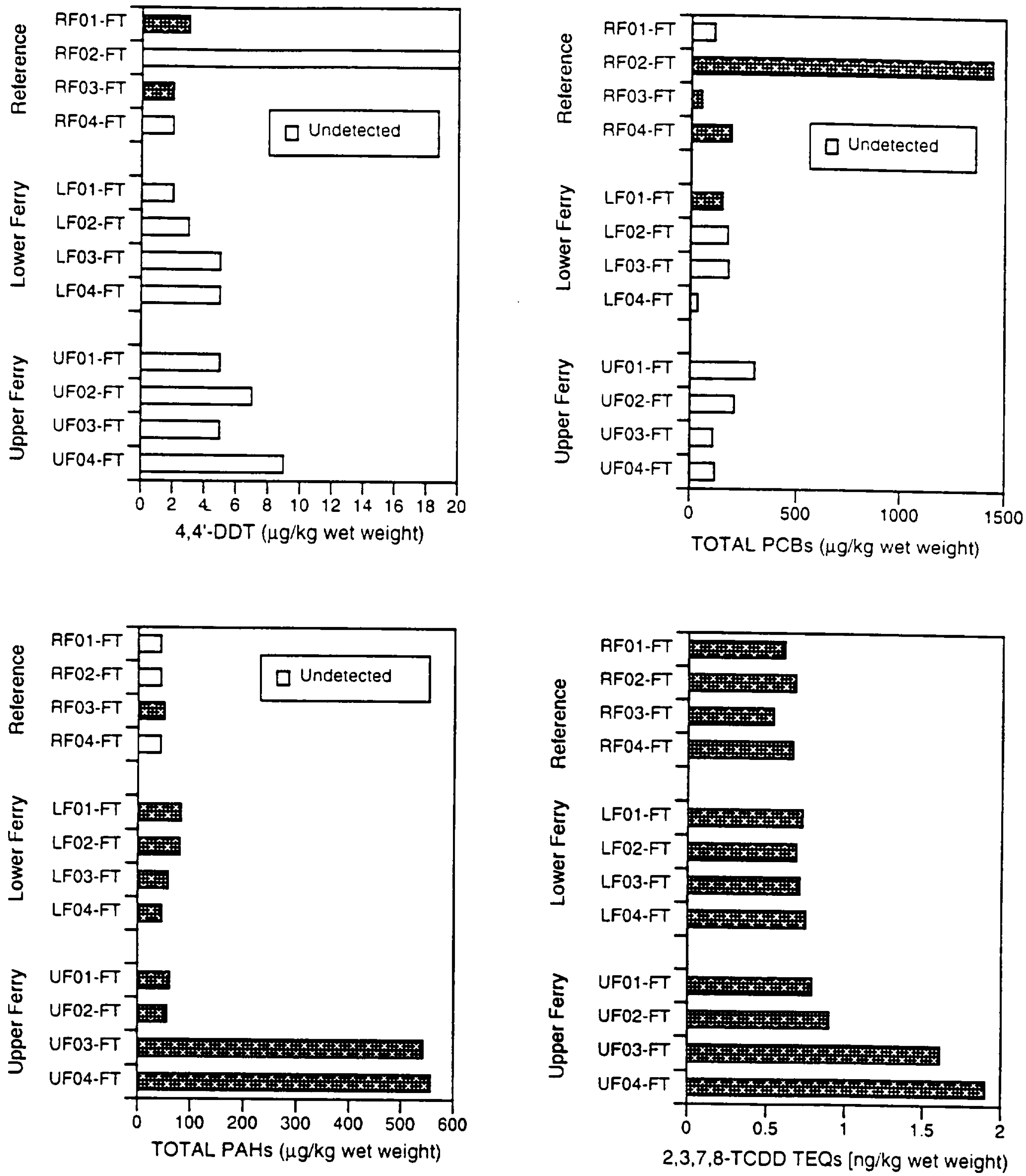

Figure 6-22. DDT, PCB, PAH and TCDD TEQ tissue concentrations in mummichog collected from Ferry Creek and Milford Point reference zones.

Table 6-5. Comparison of targeted detection limits with measured detection limits in fish, crab, and insect tissues.

ANALYTES	DETECTION LIMITS FOR FISH TISSUE		DETECTION LIMITS FOR CRAB TISSUE		DETECTION LIMITS FOR INSECT TISSUE	
	TARGETED	MEASURED	TARGETED	MEASURED	TARGETED	MEASURED
CHEMICAL PARAMETERS						
Metals in µg/kg						
Arsenic	0.5	nu	0.5	nu	0.5	0.24
Cadmium	0.02	nu	0.02	nu	0.5	0.24
Chromium	0.2	nu	0.2	nu	0.2	nu
Copper	0.05	nu	0.05	nu	0.05	nu
Lead	1.1	nu	55	nu	3.5	nu
Mercury	3	nu	592	0.02	37	0.02
Nickel	0.2	nu	0.2	nu	0.5	nu
Silver	0.02	nu	0.02	nu	0.02	nu
Zinc	0.5	nu	0.5	nu	0.5	nu
LPAHs in µg/kg						
Naphthalene	na	5.0	10093	5.0	634	20
2-Methylnaphthalene	na	5.0	259	nr	16	nr
Acenaphthylene	na	5.0	259	5.0	16	20
Acenaphthene	na	5.0	7593	5.0	477	20
Fluorene	na	5.0	259	5.0	26	20
Phenanthrene	na	5.0	1296	5.0	81	nu
Anthracene	na	5.0	6111	5.0	3837	20
HPAHs in µg/kg						
Fluoranthene	na	5.0	741	5.0	47	20
Benzo(b)fluoranthene	a	5.0	a	nu	a	100
Pyrene	na	5.0	37	5.0	2.3	20
Benz(a)anthracene	na	5.0	37	5.0	2.3	100
Chrysene	na	5.0	183	2.0	12	100
Benzo(a)pyrene	na	5.0	2222	nu	140	100
Dibenz(a,h)anthracene	na	5.0	37	5.0	2.3	100
PCDDs/PCDF in µg/kg	0.05	nu	0.01		0.01	
Pesticides/PCBs in µg/kg						
Total PCBs	140	10 - 600	631	10	39	40-80
Total DDT	160	2 - 20	20	2.20	1.3	8

na = not applicable
nu = no undetected values measured
nr = not recorded
a = not listed in QAPP Table 4-2.

Table 6-6. Concentrations of trace metals, PCBs, DDTs, and PAHs in fish tissues (wet weight)

Analyte	Milford Point		Lower Ferry Creek		Upper Ferry Creek	
	Min	Max	Min	Max	Min	Max
Trace Elements (mg/kg)						
Arsenic	0.42	0.48	0.44	0.68	0.49	0.55
Cadmium	0.009	0.018	0.012	0.02	0.023	0.14
Chromium	0.75	2.23	0.70	1.19	0.46	2.32
Copper	4.09	6.82	3.54	4.62	5.34	16.46
Lead	0.24	0.64	0.57	1.13	0.98	11.83
Mercury	0.011	0.015	0.01	0.017	0.01	0.015
Nickel	0.23	0.446	0.36	0.50	0.26	1.07
Silver	0.03	0.047	0.026	0.036	0.019	0.026
Zinc	39.27	42.8	39.2	44.5	44.98	56.57
DDTs and PCBs (µg/kg)						
4,4'-DDD	5 UJ	5	5 UJ	4	2 U	5 UJ
4,4'-DDE	5 UJ	10	5 UJ	6	5 UJ	6
4,4'-DDT	2 UJ	3	2 U	5 UJ	5 U	9 U
Aroclor 1016	10 U	20U	10 U	10 U	10 U	40 UJ
Aroclor 1221	10 U	20 U	10 U	10 U	10 U	180 UJ
Aroclor 1232	10 U	20 U	10 U	40 UJ	10 U	80 UJ
Aroclor 1242	10 U	20 U	10 U	40 UJ	10 U	40 UJ
Aroclor 1248	10 U	60 U	10 U	120 UJ	20 U	100 UJ
Aroclor 1254	10 U	80 U	10 U	80 UJ	50 U	120 UJ
Aroclor 1260	20	430	10 U	50	80 U	200 UJ
PCDDs and PCDFs (ng/kg)						
Total TCDD	.07 U	.1 U	0.1 U	0.3 U	.1 U	.2 U
Total PeCDD	.1 U	.16 NJ4	0.1 U	0.2 U	.1 U	.52 NJ4
Total HxCDD	.2 U	.98 NJ4	0.2 U	0.73 NJ4	.3 U	2.9
Total HpCDD	1.1 NJ4	3.4	3.2 NJ4	4.6	1.8	20.4
Total TCDF	1.4 NJ4	3 NJ3	0.2 U	0.54	.41 NJ4	4.7 NJ4
Total PeCDF	1.9	4.1 NJ4	0.88	1.4	1.3	6.9 NJ4
Total HxCDF	.68 NJ4	1.6 NJ4	0.39 J4	1.5 NJ4	.74 NJ4	9.3
Total HpCDF	1	3.2	1.1	2.2	.57 NJ4	8.4
2,3,7,8-TCDD TEQs	0.533	0.673	0.683	0.743	0.786	1.9
PAHs (µg/kg)						
2-Methylnaphthalene	5 U	5 U	5 U	5 U	5 U	5 U
Acenaphthene	5 U	5 U	5 U	5 U	5 U	5 U
Acenaphthylene	5 U	5 U	5 U	5 U	5 U	5 U
Anthracene	5 U	5 U	5 U	5 U	5 U	8
Benzo(a)anthracene	5 U	5 U	5 U	5 U	5 U	28
Benzo(a)pyrene	5 U	5	5 U	7	5 U	46
Benzo(b)fluoranthene	5 U	7	5 U	7	5 U	114
Benzo(g,h,i)perylene	5 U	5 U	5 U	5 U	5 U	34
Benzo(k)fluoranthene	5 U	5 U	5 U	10	5 U	5 U
Chrysene	5 U	5 U	5 U	8	5 U	62
Dibenz(a,h)anthracene	5 U	5 U	5 U	5 U	5 U	7
Fluoranthene	5 U	5 U	5 U	12	7	86
Fluorene	5 U	5 U	5 U	5 U	5 U	6
Indeno(1,2,3-cd)pyrene	5 U	5	5 U	5 U	5 U	41
Naphthalene	5 U	5 U	5 U	5 U	5 U	6
Phenanthrene	5 U	5 U	5 U	7	6	55
Pyrene	5 U	5 U	6	11	7	62
Total PAHs		12	6	60	21	546
%Lipids	1.75 U	1.96	1.35 U	1.69	1.46	1.71
%Solids	22.1	22.7	19.9	21.2	21.1	21.4

U — Undetected at the concentration not greater than the value shown.
J4 — Estimate due to interferences associated with standard.
NJ4 — Estimated maximum Possible Concentration; result is considered tentative.

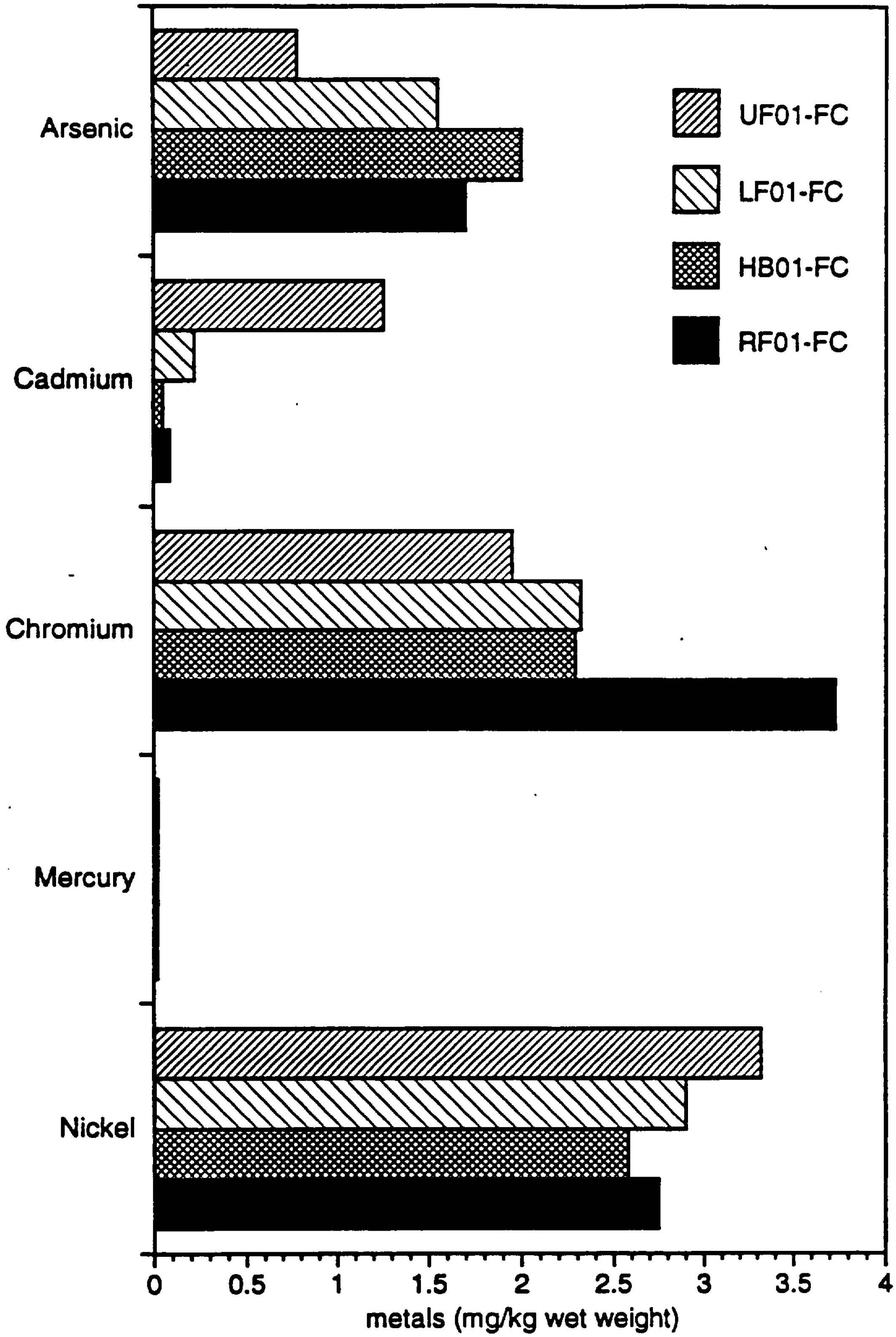

Figure 6-23. Metals concentrations in crab tissues collected from the Ferry Creek and Housatonic Boat Club Wetland and Milford Point Reference areas.

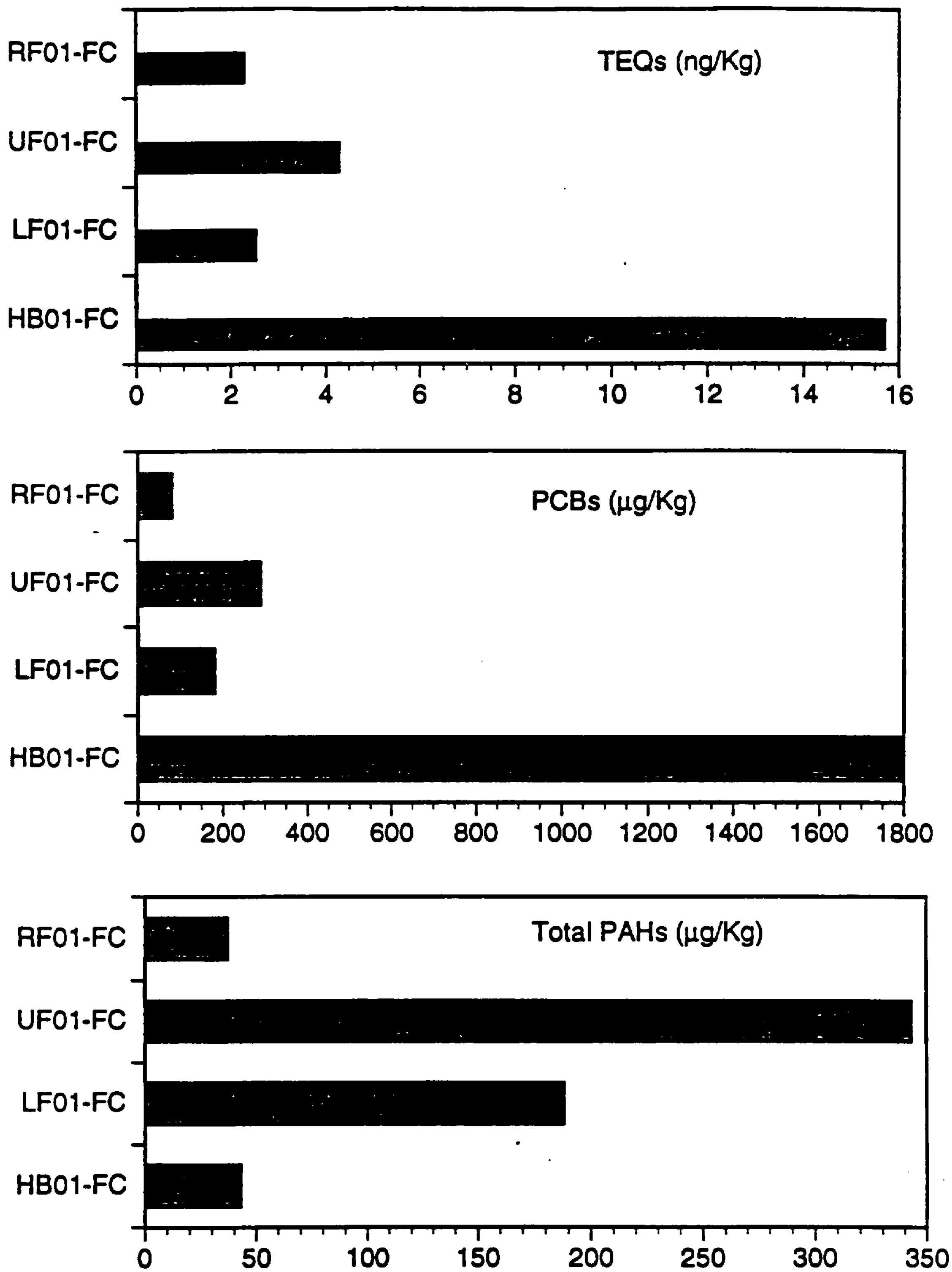

Figure 6-24. Concentrations of organics in crab tissues collected from the Ferry Creek and Housatonic Boat Club Wetland and Milford Point Reference areas.

Table 6-7. Concentrations of trace metals, PCBs, DDTs, and PAHs in crab tissues (wet weight)

Analyte	Milford Point	Boat Club wetlands	Lower Ferry Creek	Upper Ferry Creek
Trace Elements (mg/kg)				
Arsenic	1.70	2.00	1.55	0.73
Cadmium	0.09	0.05	0.22	1.26
Chromium	3.73	2.29	2.32	1.95
Copper	52.65	102.72	53.99	72.23
Lead	3.66	52.49	6.12	15.84
Mercury	0.02	0.02 U	0.02 U	0.02 U
Nickel	2.75	2.53	2.90	3.32
Silver	nr	nr	nr	nr
Zinc	23.48	27.14	27.14	27.37
DDTs and PCBs (µg/kg)				
4,4'-DDD	3 U	2 U	2 U	2 U
4,4'-DDT	2 U	20 U	3 U	5 U
4,4'-DDE	2 U	2 U	2 U	4 U
Aroclor 1016	10 U	10 U	10 U	10 U
Aroclor 1221	10 U	10 U	10 U	10 U
Aroclor 1232	10 U	10 U	10 U	10 U
Aroclor 1242	10 U	10 U	10 U	10 U
Aroclor 1248	10 U	10 U	10 U	10 U
Aroclor 1254	10 U	10 U	10 U	10 U
Aroclor 1260	60	1300	160	290
PCDDs and PCDFs (ng/kg)				
Total TCDD	0.09 NJ4	0.2 U	0.4 NJ4	0.2 U
Total PeCDD	1.3 NJ4	0.64 NJ4	1.5 NJ4	1.8 NJ4
Total HxCDD	504	3.2	8.1 NJ4	8.6
Total HpCDD	7.9	6.1	19.5 NJ4	42.8
Total TCDF	11.2 NJ4	40 NJ4	10.1 NJ4	11.7 NJ4
Total PeCDF	11 NJ4	69.1 NJ4	12.1 NJ4	17.4 NJ4
Total HxCDF	6.5 NJ4	52.1	9.7 NJ4	19 NJ4
Total HpCDF	7.3 NJ4	16.5 NJ4	6.9 NJ4	16.3
2,3,7,8-TCDD TEQs	2.29	15.7	2.52	4.28
PAHS (µg/kg)				
Naphthalene	5 J	5 UJ	6 J	5 UJ
Acenaphthylene	5 UJ	5 UJ	5 UJ	5 UJ
Acenaphthene	5 UJ	5 UJ	5 UJ	5 UJ
Fluorene	5 UJ	5 UJ	5 UJ	5 UJ
Phenanthrene	5 UJ	5 UJ	8 J	16 J
Anthracene	5 UJ	5 UJ	5 UJ	5 UJ
Fluoranthene	5 UJ	5 UJ	20 J	53 J
Pyrene	5 UJ	5 UJ	27 J	54 J
Benzo(a)anthracene	5 UJ	5 J	8 J	20 J
Chrysene	5 UJ	13 J	16 J	31 J
Benzo(b)fluoranthene	9 J	12 J	20 J	33 J
Benzo(k)fluoranthene	6 J	6 J	15 J	27 J
Benzo(a)pyrene	6 J	7 J	17 J	30 J
Indeno(1,2,3-cd)pyrene	5 J	5 UJ	20 J	35 J
Dibenz(a,h)anthracene	5 UJ	5 UJ	10 J	9 J
Benzo(g,h,i)perylene	6 J	5 UJ	21 J	44 J
Total PAHs	37	43	188	352
% Lipd	1.06	0.93	1.21	0.97
%Solids	32.7	32.2	32.2	31

nr — not reported
U — Undetected at the concentration not greater than the value shown.
NJ4 — Estimated maximum Possible Concentration; result is considered tentative.

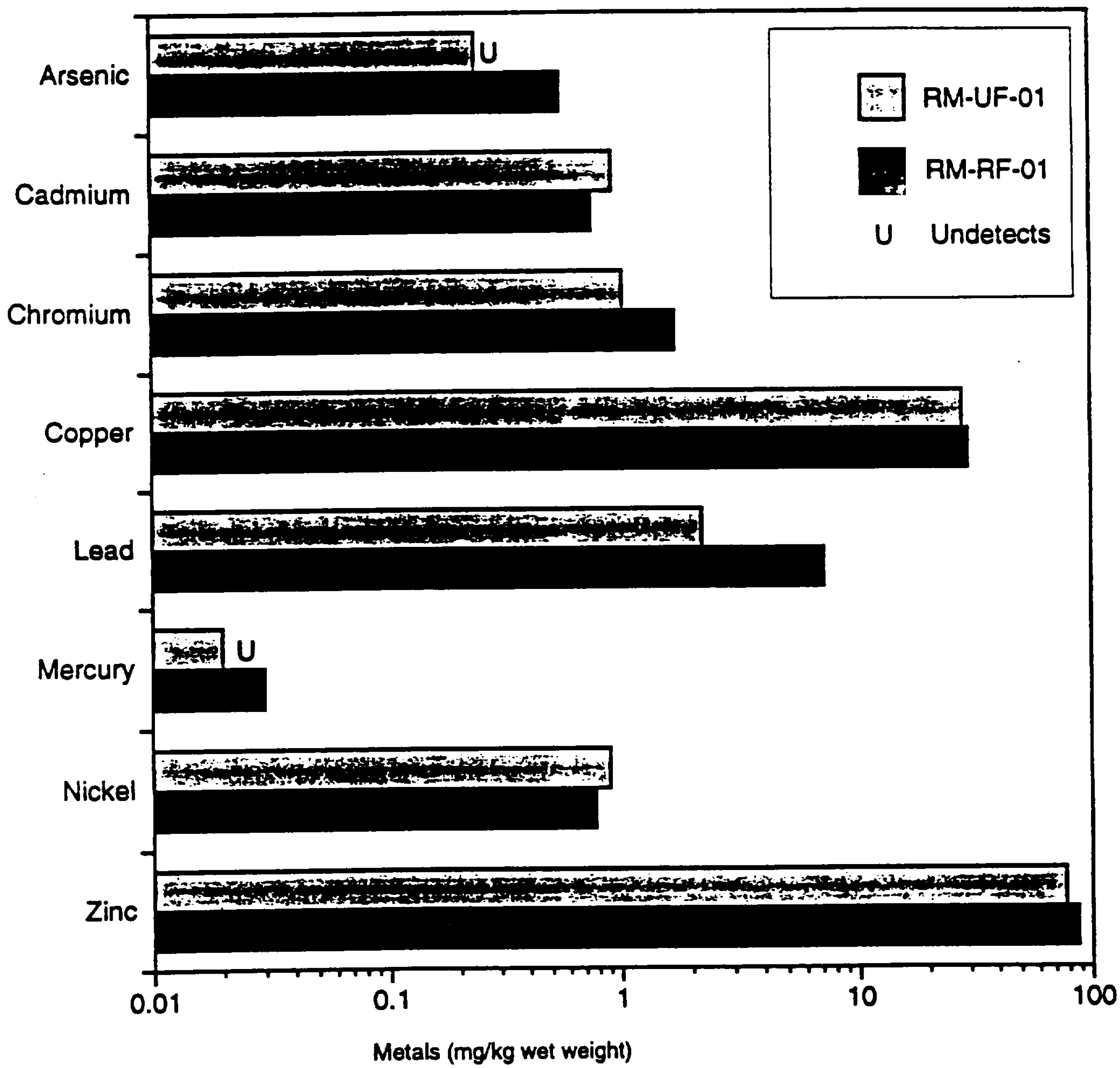

Figure 6-25. Metals concentrations in insect tissues collected from the Ferry Creek and Milford Point Reference areas.

Table 6-8. Concentrations of trace metals, PCBs, DDTs, and PAHs in insect tissue composites (wet weight).

Analyte	Milford Point	Upper Ferry Creek
Trace Elements (mg/kg)		
Arsenic	0.56	0.24 U
Cadmium	0.76	0.94
Chromium	1.73	1.04
Copper	29.69	26
Lead	7.20	2.22
Mercury	0.03 UJ	0.02 UJ
Nickel	0.73	0.90
Zinc	87.05	77.6
DDTs and PCBs (µg/kg)		
4,4'-DDD	8 U	8 U
4,4'-DDT	8 U	8 U
4,4'-DDE	8 U	8 J
Aroclor 1016	40 U	40 U
Aroclor 1221	40 U	40 U
Aroclor 1232	40 U	40 U
Aroclor 1242	40 U	40 J
Aroclor 1248	40 U	40 U
Aroclor 1254	40 U	40 U
Aroclor 1260	40 U	80 U
PCDDs and PCDFs (µg/kg)		
Total TCDD	0.8 J	0.84J
Total PeCDD	2.3 J	0.65 UJ
Total HxCDD	8 J	4.6 UJ
Total HpCDD	32.5 J	66.3 J
Total TCDF	7.2 J	3.2 J
Total PeCDF	5.1 UJ	3.7 J
Total HxCDF	4.4 UJ	5.3 UJ
Total HpCDF	2.8 UJ	13.9 J
2,3,7,8-TCDD TEQs	**1.38**	**2.23**
PAHs (µg/kg)		
Naphthalene	20 U	20 U
Acenaphthylene	20 U	20 U
Acenaphthene	20 U	20 U
Fluorene	20 U	20 U
Phenanthrene	47	26
Anthracene	20 U	20 U
Fluoranthene	20 U	20 U
Pyrene	20 U	20 U
Benzo(a)anthracene	100 U	100 U
Chrysene	100 U	100 U
Benzo(b)fluoranthene	100 U	100 U
Benzo(k)fluoranthene	108	100 U
Benzo(a)pyrene	100 U	100 U
Indeno(1,2,3-cd)pyrene	186	150
Dibenz(a,h)anthracene	100 U	100 U
Benzo(g,h,i)perylene	100 U	100 U
Total PAHs	341	176
% Lipid	12.0	7.8
%Solids	55.8	47.3

U — Undetected at the concentration not greater than the value shown.
J — Estimate