Toxic Contamination in Long Island Sound: 2006 Update

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March 2006

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Executive Summary

Overview

Since the implementation of the 1994 Comprehensive Conservation and Management Plan (CCMP), toxic pollutants identified for control efforts for Long Island Sound (LIS) have included heavy metals, chlorinated hydrocarbons such as polychlorinated biphenyls (PCBs) and pesticides, and polycyclic aromatic hydrocarbons (PAHs). This review set out to compare concentrations of Long Island Sound Contaminants of Concern in the water column, the sediments and biota for the period 1994-2005 with those measured over the previous decade. Over the course of this review, our data clearly indicated that the concentrations of these contaminants were not normally distributed. While median concentrations were low, there were several high values, indicative of “hot-spots” that would have significantly skewed calculations of average values. Therefore, we used medians to characterize the data. We were unable to compare our results to those of the prior decade, because prior studies relied upon average values. We recommend that:

- Future contaminant surveys characterize their results using medians.

- Attention be focused on characterizing common characteristics of the “hot-spots”. Our binning of the data by western Long Island Sound (WLIS), central LIS (CLIS), and eastern LIS (ELIS) indicated relatively few trends. While we were not able to characterize the locations of “hot-spots”, we suspect that they are localized in harbors.

Metals

- <u>Water Column</u>: Neither median not maximum metal concentrations exceeded Connecticut Department of Environmental Protection (CTDEP) water quality standards within the water column. Ag concentrations were the highest measured in the U.S. within the East River. However, these concentrations still did not pose a human or ecological health risk.

- <u>Sediments</u>: Median Cd, Cr, Cu, Mn, Hg, Ni, Pb, Ag, and Zn concentrations exceeded the New York State Department of Environmental Conservation (NYSDEC) Low Effects Level (LEL). No median metal concentrations exceeded the NYSDEC Severe Effects Level (SEL), but this level was exceeded by “hot-spot” samples for Sb, As, Cd, Cr, Cu, Pb, Mn, Hg, Ni, Ag, and Zn. Median concentrations of Cu, Pb, Se, Sn and Zn exceeded the 85th national percentile of concentrations determined by the National Oceanic and Atmospheric Administration (NOAA) National Status and Trends (NS&T) program for marine sediments nationwide. Note that no guidelines were available for Se and Sn.

- <u>Biota</u>: Only average concentrations were available for some biota. Average Cu (American lobster) and Hg (Striped bass) concentrations exceeded the U.S. EPA Ecological Effects Value (EEV) in WLIS and CLIS. Average methylmercury concentrations exceeded the U.S. EPA fish tissue criterion for the protection of human health in CLIS.

We note that despite elevated median concentrations of 9 metals in sediments, only Cu and Hg posed ecological or human health risks via their concentrations in biota. These results indicate that the measurement of total metal concentrations in sediments may be a poor predictor of toxicity and bioavailability. We recommend that future measurements characterize the acid volatile sulfide (AVS) to assess the fraction of these metals that are bioavailable. We also note that while median Se and Sn sediment concentrations were higher than the NOAA 85^{th} national percentile, no guidelines are available for these metals.

Recommendation: Pending further evaluations of their bioavailabilities, we recommend that Ni, Ag and Sn be added to the List of Contaminants of Concern. The occurrence and effects of Mn should be further evaluated.

Organics

- Water Column: Organic pollutant concentrations were generally not detectable in the water column. These findings are not surprising given the hydrophobicity of these contaminants.

- Sediments: Median concentrations of total chlordanes exceeded the Effects Range-Median (ERM) in CLIS and ELIS. Median concentrations of total DDT, dieldrin, and endrin exceeded the Effects Range-Low (ERL). Median concentrations of total chlordanes, chlorpyrifos, total DDT, dieldrin, total endosulfans, total HCH and dioxin-like PCBs exceeded the NOAA 85^{th} national percentile.

- Biota: Median concentrations of alpha-chlordane, trans-nonachlor, total endosulfans, and dioxin-like PCBs exceeded the NOAA 85^{th} national percentile for the blue mussel. Average concentrations of total PCBs (scup, bluefish, striped bass, American lobster) exceeded the State of Connecticut Department of Public Health guideline.

We note that although sediment concentrations of chlorpyrifos, total endosulfans, total HCH, or dioxin-like PCBs were among the highest in the nation, no guidelines are available.

Recommendation: We recommend that total endosulfans, endrin, chlorpyrifos be added to the List of Contaminants of Concern. Because very little information is available, further research should address the occurrence and effect of dioxin-like PCBs.

Emerging Contaminants

We recommend that a research and monitoring plan be developed to address emerging contaminants associated with wastewater discharges. LIS is acutely influenced by wastewater discharges, particularly in WLIS. Recent research has indicated the prevalence of novel contaminants associated with consumer products in wastewater-impacted rivers. These contaminants include hormones, pharmaceuticals, musks, and flame retardants. These contaminants have been noted to disrupt hormonal systems in aquatic organisms at exceedingly low concentrations. Very little information is available regarding their concentrations within LIS. Of particular interest are hydrophobic species such as PBDEs and musks because these are likely to bioaccumulate.

1.0 Introduction

One of the goals of the Long Island Sound Study (LISS) is to "protect and restore Long Island Sound from the adverse effects of toxic substance contamination by reducing toxic inputs, cleaning up contaminated sites, and effectively managing risk to human users" (LISS, 1993). To identify the contaminants of concern to LIS, the Long Island Sound Study Toxic Substances Work Group embarked on a historical review of toxic substances in the Sound. The 1993 assessment focused on identifying sources of contaminants, distributions in water, sediments, and biota, and toxicity to resident biota and human health (LISS, 1993). A key outcome was the development of an official List of Contaminants of Concern that included a number of metals, chlorinated hydrocarbons, and polycyclic aromatic hydrocarbons (PAHs) that were either found to exist in unacceptable concentrations in LIS or were suspected of being problematic in the area and warranted additional study. In particular, results of these earlier investigations provided a basis for management strategies aimed at contaminant source reduction, including:

- **Metals:** Cadmium, Chromium, Copper, Lead, Mercury, Zinc
- **Chlorinated Hydrocarbons**
    - PCBs
    - Pesticides: Chlordane, Dieldrin, DDT, DDD, DDE, Heptachlor, Lindane, Trans-nonachlor
- **Polycyclic Aromatic Hydrocarbons**

The objective of this update is to compile and review all data on the levels of potentially toxic substances in the water, sediments, and biota in LIS since 1994, and to compare the levels to applicable standards, criteria, and guidelines.

2.0 Background – the LIS Watershed

Long Island Sound covers a surface area of 3,284 km^2 and holds a total volume of approximately 62×10^9 m^3 (Wolfe et al., 1991). It is the sixth largest estuary in the U.S. in area and third in volume (Robertson et al., 1991). At the eastern end, the Sound connects to the Atlantic Ocean through the Race and Block Island Sound, while on the western end the East River connects it to New York Harbor. The LIS watershed covers 44,100 km^2 and is dominated by the Connecticut River basin that covers 65% of the total LIS drainage area, accounting for 70% of the total freshwater input into LIS. Other freshwater inputs to the Sound include flows from the Thames, Qunnipiac, and Housatonic Rivers (Wolfe et al., 1991).

Anthropogenic pollution in Long Island Sound has a long history. Metal, chemical and weapons manufacturing were among the industries that thrived in the 1800s and early 1900s. Connecticut was known in particular for its brass, silver, machinery, and aircraft engine industries. These all historically contributed to metal contamination in rivers, harbors, and in the Sound. In New York City, countless shops and businesses discharged to city sewer systems and ultimately, the East River and Long Island Sound. Although economic change has resulted in the demise of many of these industries and tougher pollution laws have eliminated the discharge of untreated wastewaters, their legacy remains in some areas. Pollutant loadings today are often related to population pressure, particularly along the shoreline, which has changed the character and volume of pollutant loadings. Approximately 20 million people live within 50 miles of Long Island Sound (LISS, 2006). The LIS watershed is home to over 100 water pollution control plants and numerous industrial facilities (NYSDEC & CTDEP, 2000).

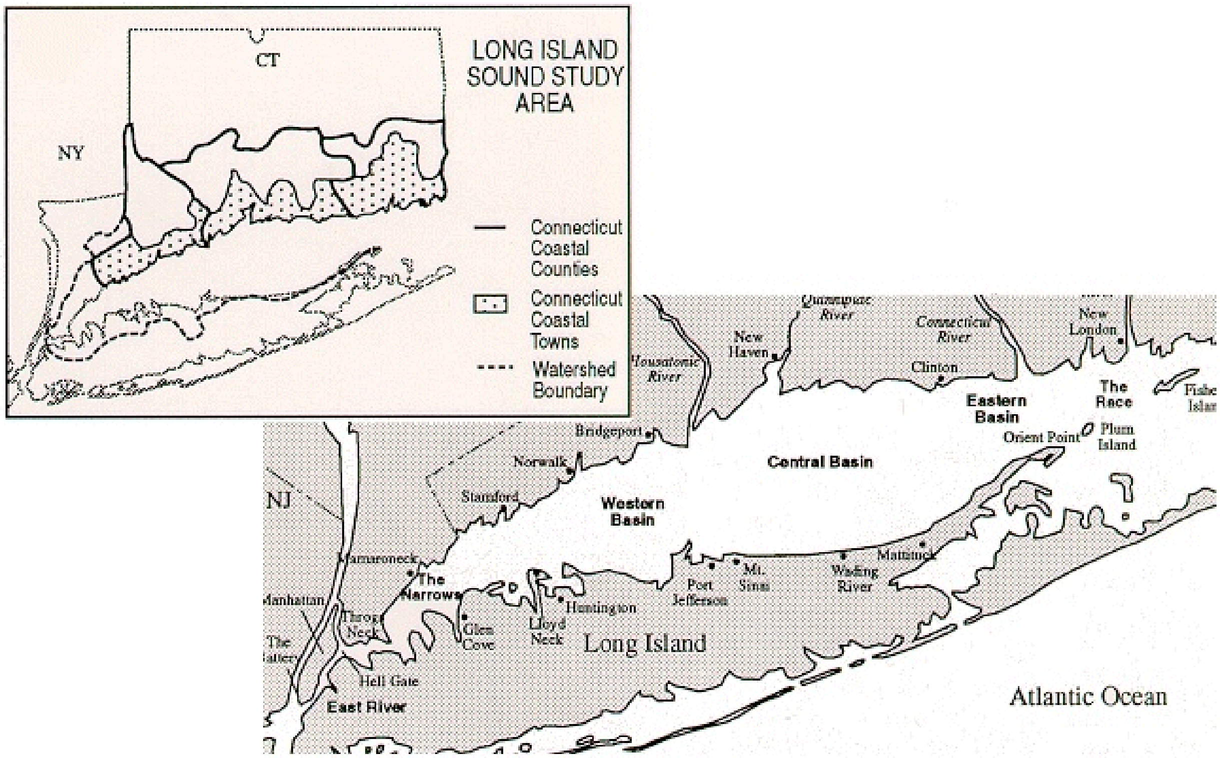
3.0 Methods

An extensive literature review was conducted to gather contaminant concentrations measured in the waters, surface sediments (0-5 cm depth), and biota of LIS. Only databases and studies conducted since 1994 were examined (1994 to 2005). The largest and most comprehensive databases available on sediment quality and tissue pollutant concentrations were from the National Oceanic and Atmospheric Administration National Status and Trends Program and the Environmental Protection Agency (EPA) National Coastal Assessment (NCA). The NS&T information used in this assessment is from NOAA's Mussel Watch Project that includes monitoring information for over 100 organic and inorganic pollutants at nine LIS sites: Throgs Neck, Sheffield Island, Mamaroneck, Huntington Harbor, Hempstead Harbor, Housatonic River, Port Jefferson, New Haven Harbor, and the Connecticut River (NOAA – NS&T, 2005). Post-1993 data included 1996 metal and 1997 organic pollutant sediment and tissue chemistry monitoring results for all the sites except for New Haven Harbor. The last year of data entry for New Haven Harbor was 1990, data that were excluded from this assessment. The NCA sediment and tissue organic and inorganic pollutant data were extracted from the National Coastal Assessment Database (EPA – NCA, 2005). Post-1993 information consisted of 2000 and 2001 pollutant readings collected from 57 sites in Long Island Sound.

Additional sources of information included the State of Connecticut Sediment Quality Information Database (SQUID), the EPA and Army Corps of Engineer (ACOE) *Draft Environmental Impact Statement for the Designation of Dredged Material Disposal Sites in Central and Western Long Island Sound* (USEPA – USACOE, 2003), and peer reviewed contaminant studies. Contaminant values extracted from SQUID consisted of entries related to dredging applications from 1994 onwards. For studies that reported contaminant values in a sediment profile graph format, the range of values noted for the upper 0-3 or 0-5 centimeter core depth were included in this analysis as being most relevant to current conditions.

Pollutant data were collected from all sources and grouped by media and location to identify any spatial distribution patterns. General aggregation units were devised for western LIS, central LIS, and eastern LIS (Figure 3-1). Following the longitude approximations established in the 1994 LIS Comprehensive Conservation and Management Plan, samples taken west of longitude -73.5° and east of -73.79° were grouped under WLIS, while those east of -72.33° were grouped under ELIS. Sampling sites located in between were grouped under CLIS (LISS, 1994). SQUID values incorporated in the study were selected according to the dredging/source site designation given by the database: WLIS, CLIS, and ELIS. Contaminant values from studies that reported findings as an LIS average were grouped as such.

Figure 3-1: Long Island Sound Study Area



(Source: LISS, 2006)

Statistical analysis included calculations of simple means, medians, standard deviations, maximums and minimums. These were calculated for the data sets pertaining to the entire Sound as well as to WLIS, CLIS, and ELIS. The results were compared to national guidelines and to the results presented in the 1994 LIS CCMP. Zero or below detection values were included in the calculations as half of the detection limit. Where no detection limit was given, the values were left as zero. For tissue pollutant levels, values given in wet units were adjusted for moisture content depending on tissue type. Dry units were consistently used throughout the analysis.

In total, readings were collected on twenty elements: aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag), thallium (Tl), tin (Sn), titanium (Ti), vanadium (V), zinc (Zn), and zirconium (Zr), and on over 100 organic pollutants.

Water column concentrations reported in the literature were compared to acute and chronic water quality standards for saltwater aquatic life set by the Connecticut Department of Environmental Protection (CTDEP, 2002).

Statistical results for contaminant concentrations measured in LIS sediments were compared to sediment criteria guidelines established by the New York State Department of Environmental Conservation, Division of Fish and Wildlife and Marine Resources (NYSDEC, 1999) and to

NOAA's Sediment Quality Guidelines developed for the National Status and Trends Program (NOAA – Sediment, 1999). The NYSDEC sediment criteria for metals are based on the Lowest Effect Level and Severe Effect Level. Concentrations below the LEL level indicate acceptable concentrations. Those above the LEL, but below the SEL, are determined to be contaminated and are expected to cause moderate effects to benthic life. Values above the SEL are expected to cause significant adverse effects on aquatic life (NYSDEC, 1999). NOAA's sediment criteria for metals are based on the Effects Range-Low and Effects Range-Median values. The ERL value defines the 10^{th} percentile at which contaminant concentrations do not cause adverse effects whereas the ERM establishes the 50^{th} percentile concentrations. Frequent adverse effects are expected to occur at or above the ERM (NOAA, 1999). Sediment contaminant levels were classified based on their exceedance of the more stringent guidelines set by either NYSDEC or NOAA.

Two sets of guidelines were used to assess the human health and ecological risks associated with contaminant concentrations found in biota. Contaminant specific action levels established by the Food and Drug Administration (FDA) (USFDA, 2003) were used to assess the level of human risk associated with the consumption of certain fin fish, mollusks, and crustaceans sampled throughout LIS. Because a complete human health risk evaluation would require more data, targeted studies, and statistically-valid dose estimates, which were beyond the scope of this assessment, median and average values that exceeded the FDA levels in certain aquatic species were identified as potentially posing a human health risk. To evaluate the level of ecological risk posed by tissue contaminant levels, Ecological Effects Values derived from water quality criteria provided the basis for comparison (USEPA – USACOE, 2003). Due to data limitations, tissue contaminant concentrations found at levels exceeding the EEV were identified as potentially posing an ecological risk.

Pollutant levels measured in LIS sediments and in the tissue of blue mussels were also compared to national values reported by NOAA's Status and Trends Program. Concentrations were noted to fall either above or below NOAA's 85^{th} national percentile value for a specific contaminant (NOAA - NS&T, 2005). The 85^{th} percentile value provides a relative indication of contaminant levels for which no sediment or tissue guideline exists and enables LIS values to be compared to values found across the nation's estuaries.

The following breakdown describes the set of guidelines used in this analysis to provide some perspective on the possible risk associated with concentrations measured throughout LIS:

- **Water Column:** CTDEP Water Quality Standards (CTDEP, 2002)
- **Sediments:** NYSDEC Technical Guidance for Screening Contaminated Sediments (NYSDEC, 1999), NOAA Sediment Quality Guidelines (NOAA, 1999), NOAA NS&T 85^{th} National Percentile (NOAA – NS&T, 2005)
- **Tissue:** FDA Action Levels (USFDA, 2003), EEVs (USEPA – USACOE, 2003), NOAA NS&T 85^{th} National Percentile (blue mussel only) (NOAA – NS&T, 2005)

4.0 Results

A comparison of contaminant concentrations was made across the western, central, and eastern parts of LIS for values measured in the water column, sediments, and tissue. The 1994-2005 review includes values reported in the latest studies (latest sampling year: 2002). Key findings are summarized in table format within each of the following sections. Raw findings and master tables are included in the following appendices (**submitted in electronic format**): 1) Appendix A - sediment metal concentrations, 2) Appendix B - sediment organic pollutant concentrations, 3) Appendix C - tissue metal concentrations, and 4) Appendix D - tissue organic pollutant concentrations.

4.1 Water Column

Few studies have measured the concentrations of organic pollutants in LIS and available data usually showed concentrations below the limit of detection. In contrast, studies on dissolved metals in the water column were more abundant, particularly those on mercury cycling. The following sections focus on the water column concentrations compiled for LIS.

4.1.1 Metals

Water column data were available for a few selected metals: Cd, Cu, Fe, Mn, Hg, Ni, Pb, Ag, and Zn (Tables 4-1 and 4-2). Cd, Cu, Pb, Ni, Ag, and Zn concentrations declined west to east, while Fe concentrations increased in the same direction. High concentrations of Ag and Pb in the East River and in WLIS are indicative of the large wastewater flows discharged into that part of the Sound, the effects of which are most noticeable during low freshwater flow conditions (Sweeney and Sañudo-Wilhelmy, 2004). According to Buck et al. (2005), Ag concentrations in the East River are among the highest ever reported in the country. Note, however, that Ag concentrations were always below the CTDEP acute toxicity standard. Dissolved Ag concentrations in ELIS were comparable to those found in less urbanized estuaries, such as in the Peconic Estuary System and in Great South Bay (Buck et al., 2005). Concentrations of Cu, Ni, and Zn measured in WLIS were also comparable to those measured in highly urbanized estuaries (San Francisco Bay, Hudson River). Higher levels of Fe (774 - 2580 nM) were measured at the discharge points of the Housatonic, Quinnipiac, Connecticut, and Thames rivers (Buck et al., 2005). These higher levels indicate that iron inputs to LIS may derive mostly from riverine sources.

Summarized in Table 4-2 are values of total mercury (HgT), filtered and unfiltered, measured throughout LIS. It is important to note that the role of Hg cycling and the formation of methylmercury in estuaries are complex and not yet fully understood. While an estuary may receive high total mercury loadings, the formation of reactive forms (HgR) - the Hg complexes that are labile and that participate in methylation/demethylation processes - is dependant on specific mechanisms that affect its speciation (Rolfhus et al., 2003). Rolfhus and Fitzgerald (2000) noted the distribution of unfiltered HgT to be highest in the western part of the Sound, decreasing from an average of 12.3 to 4.5 pM in ELIS. However, the authors indicated that unfiltered HgR increased from 14% to 71% from west to east. In a subsequent study, Rolfhus et al. (2003) noted that HgT in the Connecticut River was transformed into HgR upon mixing with LIS water (Rolfhus et al., 2003).

Mass balance calculations show that the major wastewater treatments plants that discharge to the Connecticut River (including CT, MA, NH, VT) account for 4% of the total mercury (dissolved and particulate) contribution to LIS. An additional 41% of the total mercury flux to LIS is contributed by the Connecticut River from sources other than wastewater effluents. The primary source is considered to be atmospheric deposition. At the watershed level, riverine export of atmospherically derived mercury accounts for 60-75% of the total mercury entering the Sound.

Dissolved metal levels measured throughout LIS fell well below the State of Connecticut Department of Environmental Protection Water Quality Standards set for aquatic life in saltwater. However dissolved concentrations of Ag entering the Sound from the East River are some of the highest in the nation and other metals are also high relative to other estuaries. These metals may derive from wastewater inputs, river inflow, or remobilization of contaminated sediments.

Table 4-1: Water Column Total Dissolved Metal Concentrations (nM)[1]

	N	Median	Average	Stdev	Max	Min	CT Water Quality Standards[2]		CCMP[3]
East River							**Acute**	**Chronic**	
Cd	22	0.31	0.94	0.85	2.25	0.18	374	83	
Cu	22	23.7	24.4	4.62	35.6	17.0	76	49	
Fe	12	51.9	49.4	17.6	88.3	25.6			
Pb	22	0.27	0.31	0.25	0.95	0.04	1014	39	
Ni	12	34.3	36.6	10.0	54.8	22.3	1261	140	
Ag	20	0.16	0.17	0.07	0.35	0.06	18	-	
Zn	12	44.9	44.9	4.09	51.2	37.1	1376	1239	
Long Island Sound							**Acute**	**Chronic**	**1994**
As	2	18.5	18.5	4.95	22.0	15.0	921	481	
Cd	99	0.21	0.36	0.38	1.99	0.04	374	83	0.66
Cr (hex)	2	6.15	6.15	0.21	6.30	6.00	21153	962	
Cu	99	21.9	22.4	8.44	65.8	8.35	76	49	1.10
Fe	77	23.0	156	431	2580	1.42			
Pb[4]	48	0.07	0.11	0.16	0.77	0.00	1014	39	0.27
Mn	7	154	158	35.7	215	107			
Ni	84	29.2	30.4	15.8	116	9.00	1261	140	8.90
Ag	94	0.03	0.05	0.04	0.22	0.00	18	-	0.04
Zn	64	25.0	28.2	18.7	89.8	3.82	1376	1239	4.80

Table 4-1 (continued): Water Column Total Dissolved Metal Concentrations (nM)[1]

	N	Median	Average	Stdev	Max	Min	CT Water Quality Standards[2]		CCMP[3]
Western Long Island Sound							**Acute**	**Chronic**	**1994**
Cd	28	0.27	0.54	0.49	1.72	0.07	374	83	0.85
Cu	28	24.1	24.4	5.55	33.8	15.9	76	49	34.0
Fe	18	12.8	17.3	12.6	53.6	4.08			
Pb[4]	21	0.04	0.07	0.08	0.26	0.00	1014	39	0.81
Ni	18	37.6	37.9	8.73	50.8	20.8	1261	140	24.0
Ag	26	0.04	0.07	0.06	0.22	0.01	18	-	0.15
Zn	18	32.9	32.1	11.6	50.9	10.5	1376	1239	100
Central Long Island Sound							**Acute**	**Chronic**	
As	1	22.0	22.0		22.0	22.0	921	481	
Cd	46	0.22	0.36	0.36	1.99	0.06	374	83	
Cr (hex)	1	6.00	6.00		6.00	6.00	21153	962	
Cu	46	22.9	24.9	8.89	65.8	11.8	76	49	
Fe	37	27.3	121	301	1300	3.00			
Pb[4]	23	0.07	0.12	0.17	0.77	0.01	1014	39	
Mn	7	154	158	35.7	215	107			
Ni	41	32.8	33.4	19.0	116	11.0	1261	140	
Ag	43	0.03	0.04	0.02	0.11	0.01	18	-	
Zn	40	25.1	31.3	17.4	87.3	4.91	1376	1239	
Eastern Long Island Sound							**Acute**	**Chronic**	
As	1	15.0	15.0		15.0	15.0	921	481	
Cd	25	0.17	0.16	0.07	0.33	0.04	374	83	
Cr (hex)	1	6.30	6.30		6.30	6.30	21153	962	
Cu	25	13.7	15.5	6.48	32.0	8.35	76	49	
Fe	22	41.2	329	683	2580	1.42			
Pb[4]	4	0.12	0.26	0.31	0.72	0.07	1014	39	
Ni	25	21.7	20.2	6.81	32.0	9.00	1261	140	
Ag	21	0.03	0.03	0.02	0.08	0.00	18	-	
Zn	24	16.7	23.0	20.0	89.8	3.82	1376	1239	

[1] Sources: Sweeney and Sañudo-Wilhelmy, 2004; Buck et al., 2005; Breslin and Sañudo-Wilhelmy, 1999; USEPA-ACOE, 2003.
[2] State of Connecticut Department of Environmental Protection Water Quality Standards for aquatic life in saltwater (CTDEP, 2002).
[3] CCMP = Comprehensive Conservation Management Plan (LISS, 1994), values reported for LIS average and western LIS.
[4]Buck et al. 2005: Pb values were mostly non-detect (ND) throughout LIS, particularly in eastern LIS.

Table 4-2: Water Column Reported Average Mercury Concentrations (pM)

Source	Sampling Year	HgT[1] (filtered)	HgT (unfiltered)
Western Long Island Sound			
Rolfhus and Fitzgerald, 2000 (surface waters)	1995-1997	3.0	12.3
Rolfhus and Fitzgerald, 2000 (vertical profile)[2]	1995-1997	2.1-5.5	3.2-13.4
Central Long Island Sound			
Rolfhus and Fitzgerald, 2000 (surface waters)	1995-1997	3.5	6.3
Rolfhus and Fitzgerald, 2000 (vertical profile)[2]	1995-1997	1.6-6.6	1.6-44.1
Eastern Long Island Sound			
Rolfhus and Fitzgerald, 2000 (surface waters)	1995-1997	4.7	4.5
Rolfhus and Fitzgerald, 2000 (vertical profile)[2]	1995-1997	2.4-4.7	2.8-5.5
Rolfhus et al., 2003[2]	1996/2000		2.9-12.1
Connecticut River			
Rolfhus et al., 2003	1996/2000	4.2	10.9
Balcom et al., 2004 (Haddam, CT)	1996	9.6	
Water Quality Standards[3]			
CT Water Quality Standards	Acute	8974	
CT Water Quality Standards	Chronic	4686	
1994 CCMP[4]			
Hg in Western LIS		20	

[1] HgT = Total mercury, [2] Values presented as a range, [3] State of Connecticut Department of Environmental Protection Water Quality Standards for aquatic life in saltwater (CTDEP, 2002), [4] CCMP = Comprehensive Conservation and Management Plan (LISS, 1993)

4.1.2 Organic Pollutants

Data on water column concentrations of organic pollutants in Long Island Sound are limited. The most recent characterization of water column conditions in LIS was done by the EPA and ACOE in 2000 and 2001 as part of the EIS for dredged material (USEPA – USACOE, 2003). Concentrations of pesticides, PAHs, and PCBs are summarized in Table 4-3. All of the contaminant concentrations fell either below detection limits or at levels below established water quality criteria. While water column concentrations of these hydrophobic pollutants were low, there is growing research on hydrophilic substances that are found in the water column at concentrations that may cause adverse effects to aquatic life. A review of many of these emerging contaminants and reported concentrations is presented in section 4.4.

Table 4-3: Army Corps of Engineers Reported Average Organic Pollutant Concentrations 2000/2001 (µg/L)[1]

Analyte	CLIS[2]	ELIS[3]	CT WQS[4]
	ACOE	ACOE	
Chlordane/Chlorinated Pesticide			
alpha-Chlordane	<.0015	<.0015	--
Heptachlor	<.0015	<.0015	0.0036
Heptachlor epoxide	<.0015	<.0015	0.0036
gamma-Chlordane	<.0015	<.0015	--
DDT/Chlorinated Pesticide			
4,4'-DDD (p,p' DDD)	<.0015	<.0015	
4,4'-DDE (p,p' DDE)	<.0015	<.0015	
4,4'-DDT (p,p' DDT)	<.0015	<.0015	0.001
Dieldrin/Chlorinated Pesticide			
Aldrin[5]	<.0015	<.0015	0.0003
Dieldrin	<.0015	<.0015	0.00019
Endosulfan/Chlorinated Pesticide			
Endosulfan I (alpha-endosulfan)	<.0015	<.0015	0.0087
Endosulfan II (beta-endosulfan)	<.0015	<.0015	0.00087
Endosulfan Sulfate[5]	0.00186	<.0015	110
Endrin/Chlorinated Pesticide			
Endrin	<.0015	<.0015	0.0023
Endrin Aldehyde[5]	<.0015	<.0015	0.76
Endrin Ketone	<.0015	<.0015	--
HCH/Chlorinated Pesticide			
alpha-Hexachlorocyclohexane[5]	<.0015	<.0015	0.0039
beta-Hexachlorocyclohexane[5]	<.0015	<.0015	0.014
delta-Hexachlorocyclohexane	<.0015	<.0015	--
gamma-Hexachlorocyclohexane[5]	<.0015	<.0015	0.019
Other Chlorinated Pesticides			
Methoxychlor	0.00655	0.0045	--
Toxaphene	<0.02	<0.02	0.0002

Table 4-3 (continued): Army Corps of Engineers Reported Average Organic Pollutant Concentrations 2000/2001 (µg/L)[1]

Analyte	CLIS[2] ACOE	ELIS[3] ACOE	CT WQS[4]
High molecular weight PAH[6]			
Benz(a)anthracene[5]	<0.01		0.044
Benzo(a)pyrene[5]	<0.01		0.0044
Benzo(b)fluoranthene[5]	<0.01		0.044
Benzo(e)pyrene	0.0008		--
Benzo(g,h,i)perylene[5]	<0.01		0.44
Benzo(k)fluoranthene[5]	<0.01		0.044
Chrysene[5]	<0.01		0.44
Dibenz(a,h)anthracene[5]	<0.01		0.0009
Fluoranthene[5]	0.001		1.01
Indeno(1,2,3-c,d)pyrene[5]	<0.01		0.044
Perylene	<0.01		--
Pyrene[5]	0.001		4.37
Low molecular weight PAH			
1-methylnaphthalene	0.002		--
1-methylphenanthrene	<0.01		--
2,6-dimethylnaphthalene	0.002		--
2-methylnaphthalene	0.003		--
Acenaphthene[5]	<0.01		2.7
Acenaphthlylene[5]	0.002		4.37
Anthracene[5]	<0.01		0.44
Biphenyl	0.001		--
Fluorene[5]	0.0009		4.37
Naphthalene[5]	0.007		677
Phenanthrene[5]	0.002		4.37
Total PCB[7] (sum of 22 congeners x2)	<.0015	<.0015	0.03

[1] ACOE - Army Corps of Engineers (USEPA – USACOE, 2003), [2] CLIS = Central Long Island Sound, [3] ELIS = Eastern LIS, [4] CT WQS = State of Connecticut Water Quality Standard (CT DEP, 2002), [5] CT WQS reported is for human health water and organisms, [6] PAH = Polycyclic Aromatic Hydrocarbons, [7] PCB = Polychlorinated biphenyls

4.2 Sediments

4.2.1 Metals

Fairly extensive data were available on metal concentrations in LIS sediments (Table 4-4). Highlighted in Table 4-4 are concentrations that exceeded NYSDEC's effects-based criteria (LEL, lowest effect level; or SEL, severe effect level). Comparison of median metal concentrations collected from all the data sources indicates that all metals on the LIS List of Contaminants of Concern may continue to pose an environmental risk within LIS because they exceed the LEL in some areas. In some cases, individual samples exceeded the SEL. Additionally, median concentrations of metals such as Mn, Ni, and Ag, currently not on the LIS list, exceeded the LEL in parts of the Sound. Concentrations of Sn exceeded NOAA's 85th percentile in CLIS and ELIS. Not included in the table are findings for radionuclides done by the EPA and ACOE. Concentrations for Uranium 234, 235, and 238 fell below those values noted to cause adverse effects (USEPA – USACOE, 2003).

Spatial trends indicate that the western and central parts of the Sound continue to exhibit generally higher levels of metal contamination. In WLIS, median levels of Cd, Cr, Cu, Pb, Mn, Hg, Ni, Ag, and Zn exceeded the LEL, while concentrations of Cu, Pb, Sn, and Zn exceeded the NOAA 85th percentile value. In CLIS, Cr, Cu, Pb, Hg, Ni, and Zn median concentrations exceeded the LEL, while Cu and Sn levels exceeded NOAA's 85th percentile. Eastern LIS sediments exhibited generally lower concentrations. Cd, Cr, Cu, Pb, and Mn median values exceeded the LEL, while only Pb exceeded the NOAA 85th percentile. Median levels of Cd were highest in ELIS, while levels of Cu, Cr, Pb, Mn, Hg, Ni, Ag, Sn, and Zn were highest in WLIS.

A review of NOAA NS&T sediment metal values for 1996 (the only year available after 1993), provides an indication of the degree of coastal contamination because these samples were collected in nearshore areas; the data indicate that metal concentrations are high compared to national values. Samples collected from Throgs Neck, Mamaroneck, Sheffield Island, and the Housatonic River contained values higher than the 85th national percentile for Cu, Pb, Sn, and Zn (Table 4-5). Zinc levels, in particular, fell within the high range (above the 85th percentile) at all the NOAA NS&T sites. Medium range concentrations (25-85th percentile) were reported at over half of the sites for all the metals analyzed by NOAA with the exception of arsenic, which was found at low concentrations (<25th percentile) at most of the sites. The findings indicate that Mamaroneck (WLIS) may be particularly high for most metals except Sb. Sediment values at this site fell within the high range for Cr, Cu, Pb, Mn, Sn, and Zn and in the moderate range for As, Cd, Hg, Ni, Se, Ag, and Tl. Concentrations reported for samples taken at the Housatonic River were within the high range for Cu, Pb, Mn, Sn and Zn.

Additional contaminant data on mercury were reported in studies by Hammerschmidt and Fitzgerald (2004) and Varekamp et al. (2000). A summary of surface sediment mercury levels measured throughout LIS is presented in Table 4-6. Levels exceeding the LEL were measured in samples collected throughout the western and central parts of the Sound.

Table 4-4: Surface Sediment Total Metal Concentrations (µg/g dry wt)[1]

	N	Median	Average	Stdev	Max	Min	NOAA	Lowest	Severe	ER	ER	1994 CCMP – Average[5]		
Long Island Sound							**85th [2]**	**EL[3]**	**EL[3]**	**Low[4]**	**Median[4]**	**WLIS**	**CLIS**	**ELIS**
Al	159	20100	17814	9092	36100	530								
Sb	87	0.500	1.98	4.44	**28.3**	0.100	1.43	2.00	25.0					
As	911	4.70	5.53	6.17	**88.1**	0	**13.1**	6.00	33.0	8.20	70.0	**9.00**	5.60	**6.20**
Cd	1000	**0.700**	**1.23**	2.18	**40.6**	0	**1.21**	0.600	9.00	1.20	9.60	**1.40**	0.400	0.160
Cr	923	**40.9**	**48.3**	41.1	**340**	0	**110**	26.0	110	81.0	370	**138**	**79.0**	**37.0**
Cu	1021	**55.1**	**87.5**	136	**2620**	0	**45.1**	16.0	110	34.0	270	**121**	**57.0**	9.50
Pb	1019	**39.8**	**62.5**	98.1	**1240**	0	**38.2**	31.0	110	46.7	218	**89.0**	**31.0**	13.0
Mn	106	458	**463**	237	**1222**	25.0	**750**	460	1100					
Hg	923	**0.190**	**0.358**	0.952	**26.0**	0	**4.50**	0.150	1.30	0.150	0.710	**0.700**	**0.210**	0.100
Ni	941	**18.2**	**20.1**	18.3	**260**	0	**38.7**	16.0	50.0	20.9	51.6	**25.0**	**16.0**	8.00
Se	88	0.500	2.00	4.78	40.8	0.050	0.980							
Ag	194	0.635	0.966	1.28	**9.00**	0.050	**5.67**	1.00	2.20	1.00	3.70	**3.00**	0.600	0.390
Tl	8	0.335	0.346	0.088	0.500	0.260	0.550							
Sn	71	3.97	611	2371	11900	0.050	3.21							
V	18	65.2	54.1	26.2	89.9	11.6								
Zn	1021	**125**	**146**	149	**1500**	0	**131**	120	270	150	410	**198**	99.0	35.0
Western Long Island Sound							**85th**	**LEL**	**SEL**	**Low**	**Median**	**WLIS**	**CLIS**	**ELIS**
Al	16	8745	9427	4754	20100	1320								
Sb	19	0.587	1.80	1.99	**6.00**	0.190	1.43	2.00	25.0					
As	144	5.30	5.80	4.91	**20.6**	0	**13.1**	6.00	33.0	8.20	70.0	**9.00**	5.60	**6.20**
Cd	148	**0.755**	**1.50**	2.31	**21.4**	0	**1.21**	0.600	9.00	1.20	9.60	**1.40**	0.400	0.160
Cr	148	**49.1**	**49.7**	34.4	**186**	0	**110**	26.0	110	81.0	370	**138**	**79.0**	**37.0**
Cu	148	**77.0**	**97.5**	90.8	**494**	0	**45.1**	16.0	110	34.0	270	**121**	**57.0**	9.50
Pb	148	**61.9**	**120**	184	**1150**	0	**38.2**	31.0	110	46.7	218	**89.0**	**31.0**	13.0
Mn	19	**593**	**592**	237	**1167**	66.0	**750**	460	1100					
Hg	148	**0.390**	**0.672**	2.16	**26.0**	0	**4.50**	0.150	1.30	0.150	0.710	**0.700**	**0.210**	0.100
Ni	148	**23.4**	**23.3**	16.3	**85.0**	0	**38.7**	16.0	50.0	20.9	51.6	**25.0**	**16.0**	8.00
Se	19	0.500	0.924	1.49	6.57	0.157	0.980							
Ag	23	**1.16**	**2.34**	2.55	**9.00**	0.350	**5.67**	1.00	2.20	1.00	3.70	**3.00**	0.600	0.390
Tl	3	0.350	0.320	0.052	0.350	0.260	0.550							
Sn	12	5.84	5.52	1.48	7.78	2.80	3.21							
Zn	148	**159**	**198**	197	**1500**	0	**131**	120	270	150	410	**198**	99.0	35.0

WLIS = Western Long Island Sound (LIS), CLIS = Central LIS, ELIS = Eastern LIS
Bold - value above NYSDEC Lowest Effects Level
Bold/Underlined - value above NYSDEC Severe Effects Level
SHADED values exceed the NOAA National 85^{th} Percentile value

Table 4-4 (continued): Surface Sediment Total Metal Concentrations (µg/g dry wt)[1]

	N	Median	Average	Stdev	Max	Min	NOAA	Lowest	Severe	ER	ER	1994 CCMP – Average[5]		
Central Long Island Sound							**85th[2]**	**EL[3]**	**EL[3]**	**Low[4]**	**Median[4]**	**WLIS**	**CLIS**	**ELIS**
Al	49	10200	11029	6850	36000	530								
Sb	53	0.500	**2.35**	5.43	**28.3**	0.100	1.43	2.00	25.0					
As	595	4.50	5.42	6.90	**88.1**	0	**13.1**	6.00	33.0	8.20	70.0	**9.00**	5.60	**6.20**
Cd	603	0.512	1.10	2.32	**40.6**	0	**1.21**	0.600	9.00	1.20	9.60	**1.40**	0.400	0.160
Cr	603	**43.2**	**50.4**	42.3	**340**	0	**110**	26.0	110	81.0	370	**138**	**79.0**	**37.0**
Cu	622	**63.8**	**97.2**	146	**2620**	0	**45.1**	16.0	110	34.0	270	**121**	**57.0**	9.50
Pb	621	**36.9**	**49.9**	52.1	**364**	0	**38.2**	31.0	110	46.7	218	**89.0**	**31.0**	13.0
Mn	71	449	**460**	234	**1222**	25.0	**750**	460	1100					
Hg	603	**0.200**	**0.309**	0.388	**3.90**	0	**4.50**	0.150	1.300	0.150	0.710	**0.700**	**0.210**	0.100
Ni	621	**18.8**	**19.5**	18.0	**260**	0	**38.7**	16.0	50.0	20.9	51.6	**25.0**	**16.0**	8.00
Se	53	0.500	2.62	5.94	40.8	0.050	0.980							
Ag	79	0.680	0.978	1.161	**6.95**	0.050	**5.67**	1.00	2.20	1.00	3.70	**3.00**	0.600	0.390
Tl	4	0.385	0.383	0.111	0.500	0.260	0.550							
Sn	43	3.97	941	2984	11900	0.050	3.21							
V	18	65.2	54.1	26.2	89.9	11.6								
Zn	622	**126**	**143**	135	**1460**	0	**131**	120	270	150	410	**198**	99.0	35.0
Eastern Long Island Sound							**85th**	**LEL**	**SEL**	**Low**	**Median**	**WLIS**	**CLIS**	**ELIS**
Al	94	25100	22778	7163	36100	2520								
Sb	15	0.414	0.910	2.24	**8.95**	0.100	1.43	2.00	25.0					
As	172	4.58	5.66	4.14	**17.1**	0	**13.1**	6.00	33.0	8.20	70.0	**9.00**	5.60	**6.20**
Cd	249	**1.10**	**1.38**	1.69	**16.0**	0	**1.21**	0.600	9.00	1.20	9.60	**1.40**	0.400	0.160
Cr	172	**27.6**	**39.7**	41.3	**240**	0	**110**	26.0	110	81.0	370	**138**	**79.0**	**37.0**
Cu	251	**34.4**	**57.8**	128.1	**1570**	0	**45.1**	16.0	110	34.0	270	**121**	**57.0**	9.50
Pb	250	**39.5**	**60.0**	100	**1240**	0	**38.2**	31.0	110	46.7	218	**89.0**	**31.0**	13.0
Mn	16	259	324	171	**742**	122	**750**	460	1100					
Hg	172	0.100	**0.258**	0.472	**3.80**	0	**4.50**	0.150	1.30	0.150	0.710	**0.700**	**0.210**	0.100
Ni	172	14.6	**19.5**	20.5	**145**	0	**38.7**	16.0	50.0	20.9	51.6	**25.0**	**16.0**	8.00
Se	16	0.124	1.24	1.95	6.56	0.050	0.980							
Ag	92	0.585	0.612	0.41	**2.30**	0.060	**5.67**	1.00	2.20	1.00	3.70	**3.00**	0.600	0.390
Tl	1	0.280	0.280		0.280	0.280	0.550							
Sn	16	1.51	178	702	2810	0.241	3.21							
Zn	251	87.0	**124**	141	**1150**	0	**131**	120	270	150	410	**198**	99.0	35.0

WLIS = Western Long Island Sound (LIS), CLIS = Central LIS, ELIS = Eastern LIS
Bold - value above NYSDEC Lowest Effects Level
Bold/Underlined - value above NYSDEC Severe Effects Level
SHADED values exceed the NOAA National 85th Percentile value

[1] Sources: USEPA – NCA, 2005; NOAA NS&T, 2005; CT SQUID - CTDEP, 2005; USEPA – USACOE, 2003, Breslin and Sanudo-Wilhelmy, 1999; Benoit et al., 1999.
[2] NOAA NS&T, 2005.
[3] NYSDEC Lowest Effect Level and Severe Effect Level (NYSDEC, 1999).
[4]NOAA Effects Range-Low and Effects Range Median (NOAA, 1999).
[5]CCMP = Long Island Sound Comprehensive Conservation and Management Plan (LISS, 1994).

Table 4-5: NOAA NS&T Sediment Metal Concentrations – LIS National Percentile Comparison for 1996 Values[1]

	Low Range Concentration (µg/g dry wt) <25th percentile													
WLIS	Ag	As	Cd	Cr	Cu	Hg	Mn	Ni	Pb	Sb	Se	Sn	Tl	Zn
Throgs Neck		X												
Mamaroneck										X				
Hempstead Harbor		X								X	X			
CLIS														
Sheffield Island														
Huntington Harbor		X		X		X	X	X			X			
Port Jefferson		X		X				X		X	X			
Housatonic River														
ELIS														
Connecticut River		X		X	X			X		X	X			
	Medium Range Concentration (µg/g dry wt) >25th, <85th percentile													
WLIS	Ag	As	Cd	Cr	Cu	Hg	Mn	Ni	Pb	Sb	Se	Sn	Tl	Zn
Throgs Neck	X		X	X		X	X	X		X	X		X	
Mamaroneck	X	X	X			X		X			X		X	
Hempstead Harbor	X		X	X	X	X		X	X			X	X	
CLIS														
Sheffield Island	X	X	X	X		X	X	X		X	X		X	
Huntington Harbor	X		X		X		X			X		X	X	
Port Jefferson	X		X		X	X	X		X			X	X	
Housatonic River	X	X	X	X		X		X		X	X		X	
ELIS														
Connecticut River	X		X			X	X		X			X	X	
	High Range Concentration (µg/g dry wt) >85th percentile													
WLIS	Ag	As	Cd	Cr	Cu	Hg	Mn	Ni	Pb	Sb	Se	Sn	Tl	Zn
Throgs Neck					X				X			X		X
Mamaroneck				X	X		X		X			X		X
Hempstead Harbor									X					X
CLIS														
Sheffield Island					X				X			X		X
Huntington Harbor														X
Port Jefferson														X
Housatonic River					X		X		X			X		X
ELIS														
Connecticut River														X

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS, ELIS=Eastern LIS

[1]NOAA NS&T, 2005

Table 4-6: Surface Sediment Mercury Concentrations (ng/g dry wt)

Source		Year	Hg(T)[1]	MMHg[2]	Hg (II)
Long Island Sound					
Mecray and Buchholtz ten Bink, 2000	Depositional areas	1996/1997	**176**		
	LIS Average	1996/1997	119		
Varekamp et al., 2000	LIS Average	1996/1997	140		
1994-2005 Long Island Sound Review	Average	1994-2004	**360**		
1994-2005 Long Island Sound Review	Median	1994-2004	**190**		
Western Long Island Sound					
Hammerschmidt and Fitzgerald, 2004	Average[3]	2001/2002	**313**	2.60	310
Varekamp et al., 2000	Average	1996/1997	**367**		
1994-2005 Long Island Sound Review	Average	1994-2004	**670**		
1994-2005 Long Island Sound Review	Median	1994-2004	**390**		
Central Long Island Sound					
Hammerschmidt and Fitzgerald, 2004	Average[3]	2001/2002	**221**	1.40	220
Varekamp et al., 2000	Average	1996/1997	138		
1994-2005 Long Island Sound Review	Average	1994-2004	**310**		
1994-2005 Long Island Sound Review	Median	1994-2004	**200**		
Eastern Long Island Sound					
Hammerschmidt and Fitzgerald, 2004	Average[3]	2001/2002	50.3	0.300	50.0
Varekamp et al., 2000	Average	1996/1997	20.0		
1994-2005 Long Island Sound Review	Average	1994-2004	**260**		
1994-2005 Long Island Sound Review	Median	1994-2004	100		
Sediment Guidelines/Criteria[4,5]					
NYSDEC Lowest EL			150		
NYSDEC Severe EL			1300		
NOAA ERL			150		
NOAA ERM			710		
NOAA and CCMP Comparison[6,7]					
NOAA National 85th percentile	National		4500		
1994 CCMP	WLIS	Pre 1994	**700**		
1994 CCMP	CLIS	Pre 1994	**210**		
1994 CCMP	ELIS	Pre 1994	100		

Bold - value above the NYSDEC Lowest EL
<u>Bold/Underlined</u> - value above the NYSDEC Severe EL

[1] HgT = Total mercury; [2] MMHg = monomethyl mercury; [3] Hg(T) was calculated: Hg(T) = Hg(II) + MMHg;
[4] NYSDEC, 1999; [5]NOAA, 1999; [6]NOAA NS&T, 2005; [7] CCMP = Long Island Sound Comprehensive Conservation and Management Plan (LISS, 1994).

Sediments exhibit contaminant enrichment when concentrations exceed background levels detected in deep sediment cores. In their study, Mecray and Buchholtz ten Bink (2000) noted sediment metal enrichment in LIS of Cr, Cu, Pb, Mn, Ag, and Zn. Cu and Ag concentrations were four to five times higher than natural background levels. Concentrations of Al, Ba, Fe, Ti, V, and Zr were below natural background concentrations. Comparison to 1977 levels, however, showed generally lower sediment concentrations of Cd, Cr, Cu, Hg, and Ag, but higher concentrations of Pb, Mn, Ni, and Zn (Mecray and Buchholtz ten Bink, 2000).

A comparison of LIS 1994-2005 concentrations to the values reported by Mecray and Buchholtz ten Bink (samples taken in 1996 and 1997) is presented in Table 4-7. Higher median concentrations of Cd, Cu, Pb, Hg, Ag, and Zn can be noted. These findings indicate continued Cd, Cu, Pb, Ag, and Zn enrichment in LIS sediments. Concentrations of Al, Cr, Mn, and Ni, however, were lower and even fell below the natural background levels reported by Mecray and Buchholtz ten Bink (2000). While Cr and Ni median concentrations fell below natural background levels, they both exceeded the LEL.

Table 4-7: Surface Sediment Metal Comparison to Mecray and Buchholtz ten Brink, 2000 (ng/g dry wt)

	Long Island Sound (1994-2005)			Mecray and Buchholtz ten Brink, 2000				NOAA	Lowest	Severe	ER	ER
	N	**Median**	**Avg**	**N**	**Median**	**Avg**	**Natural Background**	**85th [1]**	**EL[2]**	**EL[2]**	**Low[3]**	**Median[3]**
Al	159	20100	17814	218	52700	50600	66900					
Cd	1000	**0.700**	**1.23**	218	0.110	0.160	0.180	**1.21**	0.600	9.000	1.20	9.60
Cr	923	**40.9**	**48.3**	218	**66.7**	**67.9**	**59.0**	**110**	26.0	110	81.0	370
Cu	1021	**55.1**	**87.5**	217	**32.9**	**39.1**	8.00	**45.1**	16.0	110	34.0	270
Pb	1019	**39.8**	**62.5**	218	**31.8**	**36.1**	23.0	**38.2**	31.0	110	46.7	218
Mn	106	458	**463**	218	**861**	**977**	**544**	**750**	460	1100		
Hg	923	**0.190**	**0.358**	183	0.120	0.119		**4.50**	0.150	1.300	0.150	0.710
Ni	941	**18.2**	**20.1**	218	**23.0**	**24.8**	25.0	**38.7**	16.0	50.0	20.9	51.6
Ag	194	0.635	0.966	216	0.160	0.270	0.050	**5.67**	1.00	2.20	1.00	3.70
V	18	65.2	54.1	218	72.8	68.4	90.0					
Zn	1021	**125**	**146**	218	95.4	103	68.0	**131**	120	270	150	410

[1]NOAA NS&T, 2005; [2] NYSDEC, 1999; [3]NOAA, 1999.

Bold - value above the NYSDEC Lowest Effects Level
Bold/Underlined - value above the NYSDEC Severe Effects Level
SHADED values exceed the NOAA National 85th Percentile value

In summary, recent data for LIS surface sediments exhibited median concentrations of Cd, Cr, Cu, Pb, Mn, Hg, Ni, Ag, and Zn that generally exceeded the NYSDEC Lowest Effect Level established for sediment quality (Table 4-8). Sediment concentrations of Ag, however, exceeded the LEL only in WLIS. Levels of Cu, Pb, Mn, Ni, Sn, and Zn exceeded NOAA's 85th national percentile. Of these metals, Cd, Cu, Pb, Ag, and Zn median concentrations exceeded natural background concentrations (Mecray and Buchholtz ten Bink, 2000), indicating enriched conditions. Spatial distribution of recent data also indicates metal concentrations to be generally higher in WLIS and CLIS sediments (Figures 4-1 to 4-8).

Table 4-8: Summary of Sediment Metal Contamination

	Median Exceeding the LEL				**Median Exceeding the NOAA 85th Percentile**			
	LIS	**WLIS**	**CLIS**	**ELIS**	**LIS**	**WLIS**	**CLIS**	**ELIS**
Al								
Sb								
As								
Cd	X	X		X				
Cr	X	X	X	X				
Cu	X	X	X	X	X	X	X	
Pb	X	X	X	X	X	X		X
Mn		X		X		X		
Hg	X	X	X					
Se								
Ni	X	X	X			X		
Ag		X						
Tl								
Sn					X	X	X	
Zn	X	X	X			X		

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS, ELIS=Eastern LIS
Bold - analytes currently on List of Contaminants of Concern.

It is important to note that given the variability in data and presence of hotspots, the average measure is not an adequate indicator for determining contamination throughout Long Island Sound. For this reason, it is difficult to compare the 1994-2005 findings to the average contaminant values reported in the 1994 CCMP. It is therefore difficult to assess and quantify the degree to which conditions in sediment quality have changed since 1994.

Based on this analysis, however, we can conclude that levels of Cd, Cr, Cu, Pb, Mn, Hg, Ni, Ag, and Zn generally exceeded sediment criteria in LIS. Metals to be considered for addition to the List of Contaminants of Concern therefore include: Mn, Ni, and Ag. Additionally, Sn levels would benefit from further monitoring as these have been measured at concentrations that exceed NOAA's national 85th percentile.

While the 1994-2005 sediment metal findings indicate conditions that exceed sediment quality guidelines for some contaminants, these concentrations were given as total metal concentrations.

Whether these contaminants were bioavailable depends on partitioning mechanisms and contaminant sequestration. For example, high concentrations of sulfides would have sequestered metals as unavailable metal sulfide precipitates. Sediment toxicity studies are discussed in greater detail in section 4.2.3.

Figure 4-1: Surface Sediment Cadmium Concentrations (1994-2005)

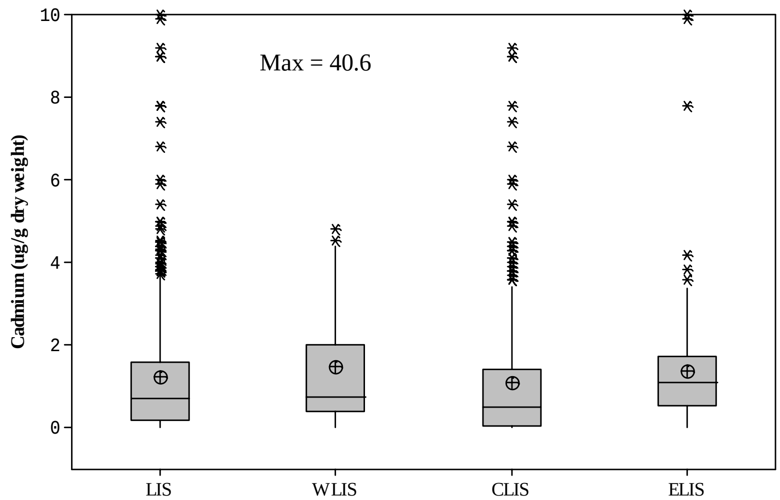


Figure 4-2: Surface Sediment Chromium Concentrations (1994-2005)

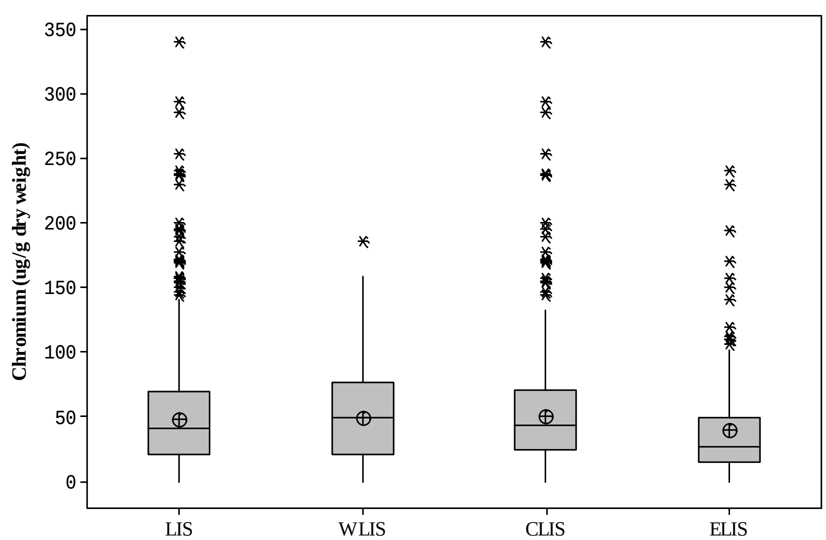


Figure 4-3: Surface Sediment Copper Concentrations (1994-2005)

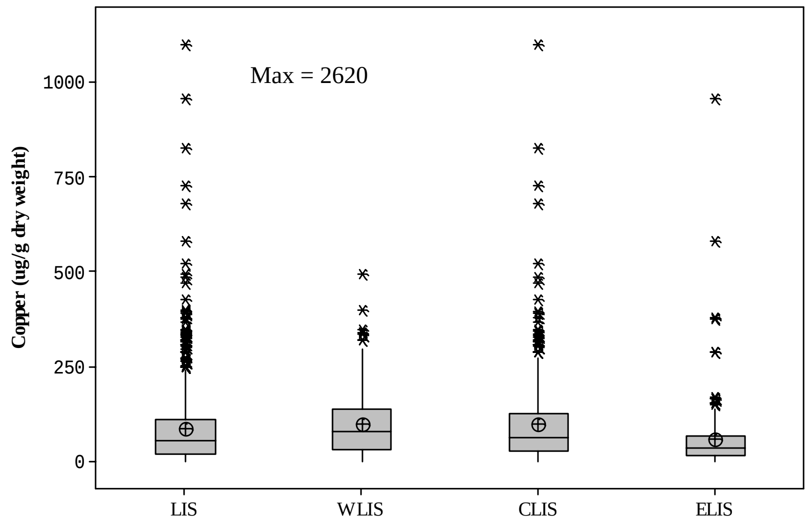


Figure 4-4: Surface Sediment Lead Concentrations (1994-2005)

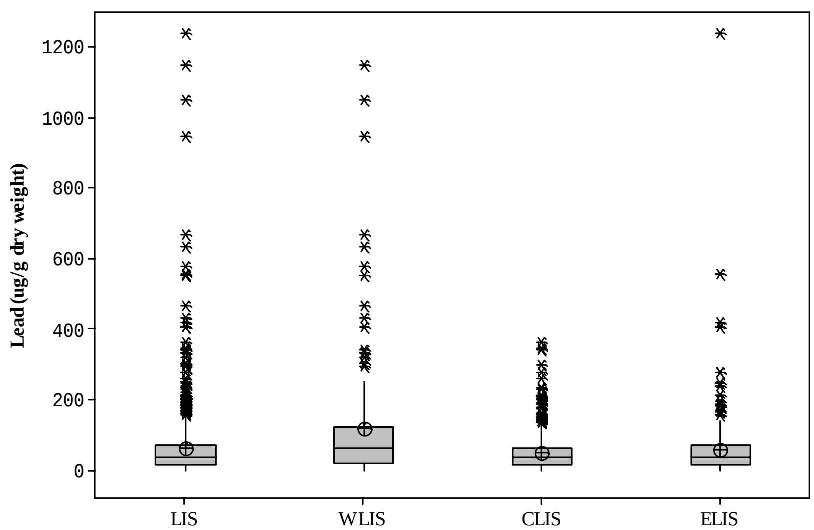


Figure 4-5: Surface Sediment Manganese Concentrations (1994-2005)

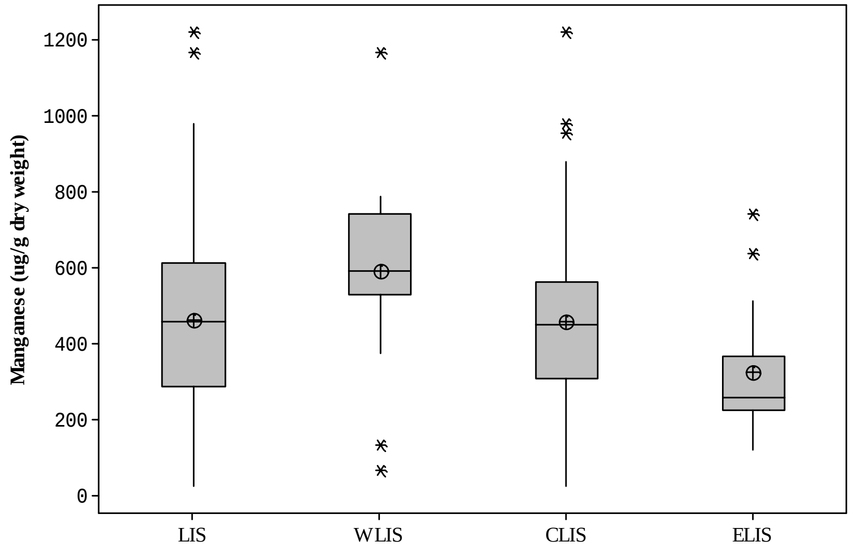


Figure 4-6: Surface Sediment Mercury Concentrations (1994-2005)

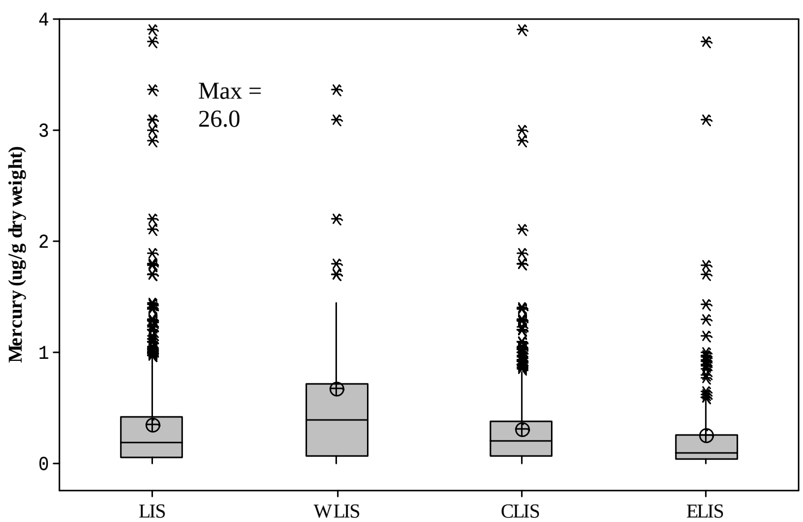


Figure 4-7: Surface Sediment Silver Concentrations (1994-2005)

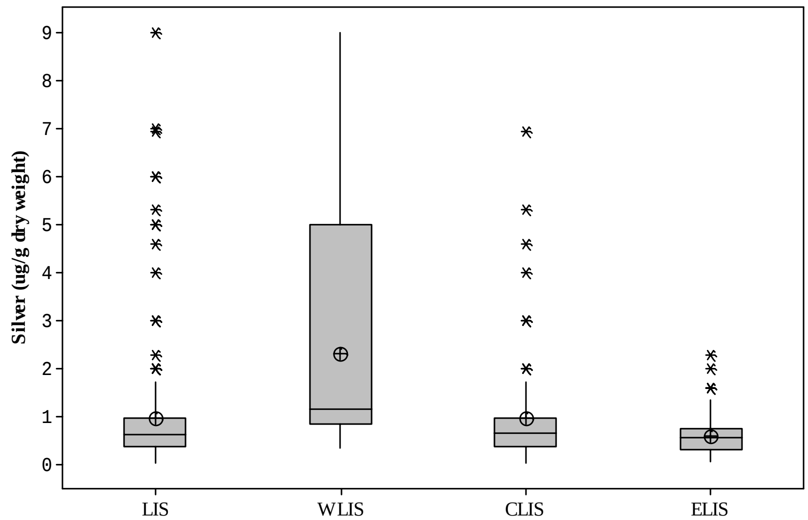
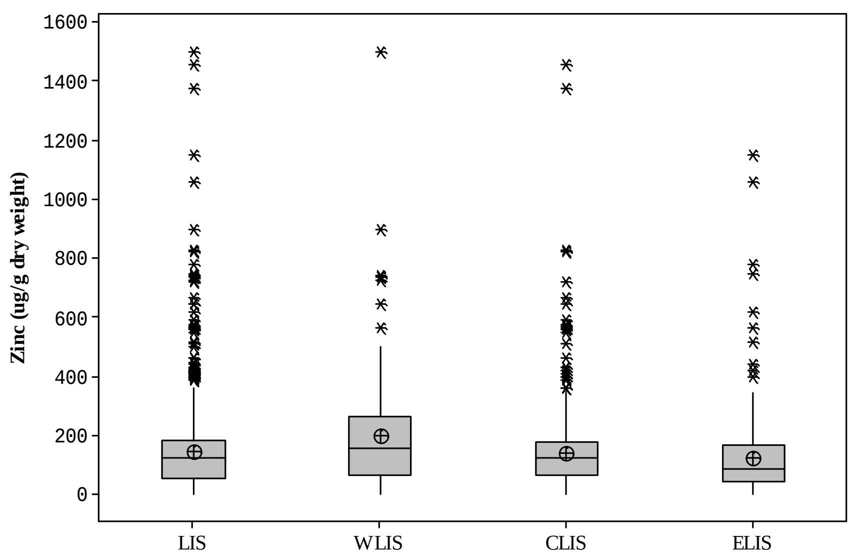


Figure 4-8: Surface Sediment Zinc Concentrations (1994-2005)



4.2.2 Organic Pollutants

Median LIS sediment contaminant concentrations exceeded ERL values for several organic pollutants. Contaminants exceeding their corresponding ERL in LIS included: total chlordanes, total DDT, dieldrin, and endrin (Table 4-9). Median levels of total chlordanes exceeded the ERM value in CLIS and ELIS, while median dieldrin levels exceeded the ERM value in CLIS. In addition to the category of organic pollutants exceeding the ERL and ERM guidelines, median concentrations of other categories of pollutants exceeded the NOAA 85th national percentile. These categories included total chlordanes, chlorpyrifos, total DDT, dieldrin, total endosulfans, endrin, total HCH, and PCB 169.

Spatial trends in organic pollutant concentrations varied widely. Median concentrations of total chlordanes, total DDT, dieldrin, endosulfans, and total HCH were highest in CLIS and lowest in WLIS. The median level of endrin was highest in ELIS and lowest in WLIS, while the median level of chlorpyrifos was highest in CLIS and lowest in ELIS. PAH levels were highest in WLIS, but lowest in CLIS. Total PCBs and dioxin-like PCB median levels were highest in WLIS and lowest in ELIS.

In Robertson et al.'s (1991) study of contaminant levels in LIS, organic pollutant values for low and high molecular weight PAHs, total PCBs, total DDT, and total chlordanes exceeded the national mean at all of the sites sampled by the NOAA NS&T program in LIS (findings based on fine-grained sediment fraction). Total dieldrin, however, exceeded the mean at only five sites. Values reported in the 1994 CCMP for LIS average total PCBs, DDT, PAH, and chlordanes were 249, 36, 7814, and 7.7 ng/g dry weight, respectively. These values are also based on measurements taken from NOAA's NS&T program and were adjusted for the fine-grained sediment fraction (LISS, 1994). Do to the data adjustments, however, these values cannot be compared to the other sets of values included in Table 4-9. It is therefore unclear if recent sediment contaminant values were lower than those observed over the past decade.

The presence of high levels of organic pollutants reported in the studies included in this evaluation indicates that these contaminants continue to pose a sediment quality problem in some areas of LIS. The spatial distribution of the data also suggests that concentrations of several pesticides were higher in CLIS and ELIS than WLIS (Figures 4-9 to 4-14). Given the lack of comparability with pre-1994, data, it is difficult to assess if sediment quality has improved. Tissue contaminant data (see section 4.3.2), however, showed lower concentrations of total DDT and total PAH concentrations measured in blue mussels (comparison of pre-1994 to 1994-2005 values). However, tissue contaminant levels do not necessarily indicate improving sediment conditions, but may reflect changes in bioavailability.

Table 4-9: Surface Sediment Organic Pollutant Concentrations (ng/g dry weight) (1994-2005)[1]

Analyte	Long Island Sound						NOAA Guidelines[2]		NOAA[3]
Pesticides	**N**	**Median**	**Avg**	**Stdev**	**Max**	**Min**	**ERL**	**ERM**	**85th**
Total chlordanes[4]	910	**20.0**	**21.7**	28.4	**284**	0	0.500 [5]	6.00 [5]	**2.90**
Alpha-Chlordane	893	0	0.796	3.40	38.7	0			1.01
Heptachlor	904	3.55	5.65	7.18	50.0	0			0.210
Trans-nonachlor	88	0.278	0.483	0.782	5.14	0			0.970
Chlorpyrifos	7	0.370	0.430	0.522	1.46	0			0.370
Total DDT[6]	920	**16.0**	**21.6**	30.7	**305**	0	1.58	46.1	**18.2**
Dieldrin	910	**5.00**	**5.90**	6.29	**50.0**	0	0.020 [5]	8.00 [5]	**1.40**
Endosulfans[7]	909	15.0	17.9	26.1	375	0			0.340
Endrin	910	**0.500**	**4.32**	16.9	**250**	0	0.020 [5]	45.0 [5]	**0.070**
Total HCH[8]	866	20.0	25.8	47.0	995	0			0.700
Lindane	80	0.230	0.425	0.859	6.60	0			
Methoxychlor	36	0.290	0.304	0.132	0.640	0.111			
Mirex	88	0.217	0.355	0.974	9.00	0			0.350
PAHs									
Total PAH[9]	893	590	3820	11471	**204587**	0	4022	44792	2547
Total HPAH[10]	892	400	**2989**	9592	**199873**	0	1700	9600	**2108**
Benz(a)anthracene	881	30.0	231	610	**5330**	0	261	1600	195
Benzo(a)pyrene	881	20.0	224	562	**5600**	0	430	1600	207
Chrysene	881	30.0	276	719	**5700**	0	384	2800	243
Dibenz(a,h)anthracene	881	10.0	**64.0**	329	**5600**	0	63.0	260	53.3
Fluoranthene	881	60.0	576	1644	**19000**	0	600	5100	403
Pyrene	881	60.0	550	1574	**24000**	0	665	2600	393
Total LPAH[11]	894	130	**834**	3054	**52305**	0	552	3160	462
2-methylnaphthalene	881	10.0	36.4	200	**4050**	0	70.0	670	36.0
Acenaphthene	881	10.0	**72.7**	404	**8900**	0	16.0	500	12.8
Acenaphthylene	881	10.0	**66.3**	369	**9050**	0	44.0	640	18.2
Anthracene	881	10.0	**108**	382	**5700**	0	85.3	1100	65.5
Fluorene	881	10.0	**79.4**	407	**8700**	0	19.0	540	**22.3**
Naphthalene	881	10.0	108	763	**15000**	0	160	2100	50.2
Phenanthrene	900	21.6	**296**	1206	**25000**	0	240	1500	180
PCBs									
Total PCB[12]	916	5.00	**40.6**	149	**2728**	0	22.7	180	**63.2**
Dioxin-Like PCBs									
PCB 77	80	0.230	0.542	2.31	20.7	0			
PCB110/77	9	2.40	10.0	15.0	41.0	0.500			77.9
PCB126	80	0.230	0.274	0.279	1.50	0			6.20
PCB169	8	3.40	5.08	5.79	17.9	0.400			2.50
Dioxin									
2,3,7,8 TCDD	12	0.0005	0.0008	0.0009	0.0035	0.0002			

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS, ELIS=Eastern LIS
Bold - value above the NOAA Effects Range-Low (ERL)
Bold/Underlined - value above the NOAA Effects Range-Median (ERM)
SHADED values exceed the NOAA National 85th Percentile value

Table 4-9 (continued): Surface Sediment Organic Pollutant Concentrations (ng/g dry weight) (1994-2005)

Analyte	Western Long Island Sound						NOAA Guidelines[2]		NOAA[3]
Pesticides	**N**	**Median**	**Avg**	**Stdev**	**Max**	**Min**	**ERL**	**ERM**	**85th**
Total chlordanes[4]	145	**2.43**	**12.0**	17.9	**86.7**	0	0.500 [5]	6.00 [5]	**2.90**
Alpha-Chlordane	138	0	0.603	2.83	28.0	0			1.01
Heptachlor	141	0.600	3.01	4.89	25.0	0			0.210
Trans-nonachlor	20	0.465	0.860	0.999	3.60	0			0.970
Chlorpyrifos	4	0.421	0.377	0.281	0.668	0			0.370
Total DDT[6]	149	**4.58**	**18.4**	39.8	**305**	0	1.58	46.1	**18.2**
Dieldrin	145	**0.289**	**3.12**	5.02	**25.0**	0	0.020 [5]	8.00 [5]	**1.40**
Endosulfans[7]	145	0.680	9.25	18.1	150	0			0.340
Endrin	145	**0.324**	**2.07**	4.32	**22.5**	0	0.020 [5]	45.0 [5]	**0.070**
Total HCH[8]	132	2.05	13.4	23.1	131	0			0.700
Lindane	16	0.330	0.661	0.903	3.00	0			
Methoxychlor	3	0.330	0.316	0.024	0.331	0.289			
Mirex	20	0.309	0.733	1.97	9.00	0			0.35
PAHs									
Total PAH[9]	142	1688	**6402**	19973	**204587**	0	4022	44792	2547
Total HPAH[10]	141	1430	**5203**	18072	**199873**	0	1700	9600	**2108**
Benz(a)anthracene	138	89.0	**303**	627	**4500**	0	261	1600	195
Benzo(a)pyrene	138	97.9	308	540	**3400**	0	430	1600	207
Chrysene	138	131	373	736	**5300**	0	384	2800	243
Dibenz(a,h)anthracene	138	11.9	88.6	358	**4050**	0	63.0	260	53.3
Fluoranthene	138	220	**837**	2132	**19000**	0	600	5100	403
Pyrene	138	243	**735**	1578	**14000**	0	665	2600	393
Total LPAH[11]	143	279	**1233**	4138	**42350**	0	552	3160	462
2-methylnaphthalene	138	10.0	67.8	350	**4050**	0	70.0	670	36.0
Acenaphthene	138	11.0	**109**	443	**4050**	0	16.0	500	12.8
Acenaphthylene	125	16.3	**71.0**	365	**4050**	0	44.0	640	18.2
Anthracene	138	27.9	**146**	432	**4050**	0	85.3	1100	65.5
Fluorene	138	11.0	**111**	440	**4050**	0	19.0	540	**22.3**
Naphthalene	138	10.0	76.3	375	**4050**	0	160	2100	50.2
Phenanthrene	161	110	**524**	1487	**11510**	0	240	1500	180
PCBs									
Total PCB[12]	149	0	**69.2**	274	**2728**	0	22.7	180	**63.2**
Dioxin-Like PCBs									
PCB 77	16	0.330	0.447	0.586	2.30	0			
PCB110/77	3	30.0	26.9	15.9	41.0	9.70			77.9
PCB126	16	0.330	0.334	0.318	1.00	0			6.20
PCB169	4	3.95	4.93	2.56	8.70	3.10			2.50
Dioxin									
2,3,7,8 TCDD	4	0.00125	0.00163	0.00133	0.00350	0.00051			

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS, ELIS=Eastern LIS
Bold - value above the NOAA Effects Range-Low (ERL)
Bold/Underlined - value above the NOAA Effects Range-Median (ERM)
SHADED values exceed the NOAA National 85th Percentile value

Table 4-9 (continued): Surface Sediment Organic Pollutant Concentrations (ng/g dry weight) (1994-2005)

Analyte	Central Long Island Sound						NOAA Guidelines[2]		NOAA[3]
Pesticides	**N**	**Median**	**Avg**	**Stdev**	**Max**	**Min**	**ERL**	**ERM**	**85th**
Total chlordanes[4]	593	**30.0**	**21.8**	26.0	**284**	0	0.500 [5]	6.00 [5]	**2.90**
Alpha-Chlordane	583	0	0.876	3.46	36.0	0			1.01
Heptachlor	591	10.0	6.52	6.76	50.0	0			0.210
Trans-nonachlor	52	0.290	0.443	0.756	5.14	0			0.970
Chlorpyrifos	2	0.737	0.737	1.02	1.46	0.015			0.370
Total DDT[6]	599	**30.0**	**22.7**	25.7	**238**	0	1.58	46.1	**18.2**
Dieldrin	593	**10.0**	**6.68**	6.47	**50.0**	0	0.020 [5]	8.00 [5]	**1.40**
Endosulfans[7]	592	30.0	19.5	19.2	150	0			0.340
Endrin	593	**0.500**	**4.69**	19.1	**250**	0	0.020 [5]	45.0 [5]	**0.070**
Total HCH[8]	570	30.0	26.3	25.3	200	0			0.700
Lindane	49	0.268	0.441	0.953	6.60	0			
Methoxychlor	26	0.290	0.315	0.150	0.640	0.111			
Mirex	52	0.232	0.283	0.286	1.50	0			0.350
PAHs									
Total PAH[9]	587	390	2888	6953	**55520**	0	4022	44792	2547
Total HPAH[10]	587	260	**2274**	5826	**49790**	0	1700	9600	**2108**
Benz(a)anthracene	579	10.0	186	530	**5330**	0	261	1600	195
Benzo(a)pyrene	579	10.0	186	495	**4000**	0	430	1600	207
Chrysene	579	19.4	226	634	**5700**	0	384	2800	243
Dibenz(a,h)anthracene	579	10.0	39.6	148	**2770**	0	63.0	260	53.3
Fluoranthene	579	50.0	442	1121	**9900**	0	600	5100	403
Pyrene	579	50.0	455	1448	**24000**	0	665	2600	393
Total LPAH[11]	587	120	**614**	1819	**24580**	0	552	3160	462
2-methylnaphthalene	579	10.0	22.4	60.7	**917**	0	70.0	670	36.0
Acenaphthene	579	10.0	**34.6**	111	**1470**	0	16.0	500	12.8
Acenaphthylene	600	10.0	**59.6**	382	**9050**	0	44.0	640	18.2
Anthracene	579	10.0	74.3	232	**2910**	0	85.3	1100	65.5
Fluorene	579	10.0	**47.4**	184	**2500**	0	19.0	540	**22.3**
Naphthalene	579	10.0	101	844	**15000**	0	160	2100	50.2
Phenanthrene	575	10.0	198	666	**8940**	0	240	1500	180
PCBs									
Total PCB[12]	595	5.00	**39.2**	119	**1100**	0	22.7	180	**63.2**
Dioxin-Like PCBs									
PCB 77	49	0.268	0.702	2.93	20.7	0			
PCB110/77	6	1.10	1.57	1.30	3.80	0.500			77.9
PCB126	49	0.268	0.301	0.286	1.50	0			6.20
PCB169	3	1.40	6.83	9.58	17.9	1.20			2.50
Dioxin									
2,3,7,8 TCDD	12	0.00040	0.00042	0.00015	0.00066	0.00021			

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS, ELIS=Eastern LIS

Bold - value above the NOAA Effects Range-Low (ERL)

Bold/Underlined - value above the NOAA Effects Range-Median (ERM)

SHADED values exceed the NOAA National 85th Percentile value

Table 4-9 (continued): Surface Sediment Organic Pollutant Concentrations (ng/g dry weight) (1994-2005)

Analyte	Eastern Long Island Sound						NOAA Guidelines[2]		NOAA[3]
Pesticides	**N**	**Median**	**Avg**	**Stdev**	**Max**	**Min**	**ERL**	**ERM**	**85th**
Total chlordanes[4]	172	**<u>20.4</u>**	**<u>29.5</u>**	39.2	**<u>245</u>**	0	0.500 [5]	6.00 [5]	**2.90**
Alpha-Chlordane	172	0	0.679	3.61	38.7	0			1.01
Heptachlor	172	1.59	4.81	9.28	50.0	0			0.210
Trans-nonachlor	16	0.111	0.144	0.157	0.449	0			0.970
Chlorpyrifos	1	0.029	0.029		0.029	0.029			0.370
Total DDT[6]	172	**11.5**	**20.7**	37.0	**<u>290</u>**	0	1.58	46.1	**18.2**
Dieldrin	172	**3.75**	**5.55**	5.94	**<u>40.0</u>**	0	0.020 [5]	8.00 [5]	**1.40**
Endosulfans[7]	172	10.3	19.5	44.7	375	0			0.340
Endrin	172	**1.41**	**4.95**	15.0	**<u>125</u>**	0	0.020 [5]	45.0 [5]	**0.070**
Total HCH[8]	164	10.5	34.1	94.3	995	0			0.700
Lindane	15	0	0.121	0.141	0.358	0			
Methoxychlor	7	0.233	0.259	0.068	0.358	0.184			
Mirex	16	0	0.113	0.139	0.358	0			0.350
PAHs									
Total PAH[9]	164	750	**4919**	13824	**<u>98035</u>**	0	4022	44792	2547
Total HPAH[10]	164	528	**3644**	9687	**<u>57500</u>**	0	1700	9600	**2108**
Benz(a)anthracene	164	46.8	**327**	813	**<u>4660</u>**	0	261	1600	195
Benzo(a)pyrene	164	45.5	287	757	**<u>5600</u>**	0	430	1600	207
Chrysene	164	50.0	371	941	**<u>5600</u>**	0	384	2800	243
Dibenz(a,h)anthracene	164	10.0	129	625	**<u>5600</u>**	0	63.0	260	53.3
Fluoranthene	164	49.3	**826**	2476	**<u>16000</u>**	0	600	5100	403
Pyrene	164	52.3	**732**	1936	**<u>11600</u>**	0	665	2600	393
Total LPAH[11]	164	178	**1275**	4875	**<u>52305</u>**	0	552	3160	462
2-methylnaphthalene	164	0	59.0	312	**<u>2790</u>**	0	70.0	670	36.0
Acenaphthene	164	10.0	**177**	810	**<u>8900</u>**	0	16.0	500	12.8
Acenaphthylene	156	10.0	**88.2**	323	**<u>2790</u>**	0	44.0	640	18.2
Anthracene	164	13.6	**195**	654	**<u>5700</u>**	0	85.3	1100	65.5
Fluorene	164	10.0	**165**	773	**<u>8700</u>**	0	19.0	540	**22.3**
Naphthalene	164	15.3	**160**	700	**<u>6800</u>**	0	160	2100	50.2
Phenanthrene	164	38.4	**414**	2046	**<u>25000</u>**	0	240	1500	180
PCBs									
Total PCB[12]	172	0	20.5	61.6	**<u>563</u>**	0	22.7	180	**63.2**
Dioxin-Like PCBs									
PCB 77	15	0	0.121	0.141	0.358	0			
PCB110/77									77.9
PCB126	15	0	0.121	0.141	0.358	0			6.20
PCB169	1	0.400	0.400		0.400	0.400			2.50
Dioxin									
2,3,7,8 TCDD									

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS, ELIS=Eastern LIS
Bold - value above the NOAA Effects Range-Low (ERL)
<u>Bold/Underlined</u> - value above the NOAA Effects Range-Median (ERM)
SHADED values exceed the NOAA National 85^{th} Percentile value

[1]Sources: NOAA NS&T, 2005; USEPA – NCA, 2005; USEPA – USACOE, 2003; SQUID - CT DEP, 2005.
[2] NOAA, 1999.
[3] NOAA NS&T, 2005.
[4] Total chlordanes (sum of 4)= alpha chlordane + heptachlor + heptachlor epoxide + trans-nonachlor
[5]Adams et al., 1998
[6]Total DDT (6) =2,4'-DDD (o,p'-DDD) + 2,4'-DDE (o,p'-DDE) + 2,4'-DDT (o,p'-DDT) + 4,4'-DDD (p,p' DDD) + 4,4'-DDE (p,p' DDE) + 4,4'-DDT (p,p' DDT)
[7]Endosulfans(4) = Endosulfan + Endosulfan I (alpha-endosulfan) + Endosulfan II (beta-endosulfan) + Endosulfan Sulfate
[8]Total HCH = Hexachlorocyclohexane = alpha-HCH + beta-HCH, delta-HCH, gamma-HCH, Lindane,
[9]Total polycyclic aromatic hydrocarbon (PAHs) ➔ NCA, NOAA, and SQUID = low molecular weight PAH + high molecular weight PAH; ACOE = sum of 16 PAHs
[10]Total high molecular weight PAH (HPAH) (12) = Benz(a)anthracene +Benzo(a)pyrene +Benzo(b)fluoranthene +Benzo(e)pyrene+Benzo(g,h,i)perylene +Benzo(k)fluoranthene +Chrysene +Dibenz(a,h)anthracene +Fluoranthene +Indeno(1,2,3-c,d)pyrene +Perylene +Pyrene
[11] Total low molecular weight PAH (LPAH) (12) = 1,6,7-Trimethylnaphthalene +1-methylphenanthrene +2,6-dimethylnaphthalene +2-methylnaphthalene +Acenaphthylene +Acenaphthene +Anthracene +Biphenyl +Dibenzothiophene +Fluorene +Naphthalene +Phenanthrene
[12] Total Polychlorinated biphenyls (PCB) =sum of 18 congeners x 2, ACOE Total PCB = sum of 22 congeners [NOAA: PCBs 8,8/5,18,28,44,52,66,87,101,101/90,105,118,128,138,153,153/132,168,170,170/190,180,187,195,195/208,206,209. ACOEs: 49,87,183,184]

Figure 4-9: Surface Sediment Total Chlordane Concentrations (1994-2005)

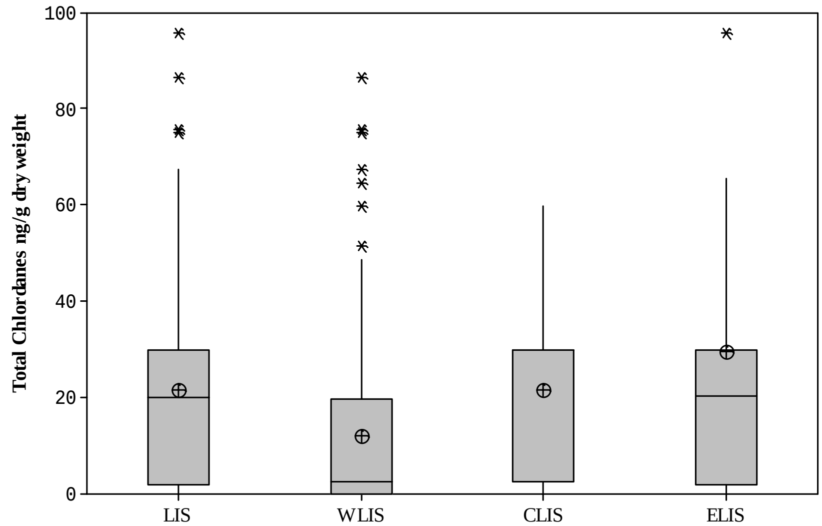


Figure 4-10: Surface Sediment Total DDT Concentrations (1994-2005)

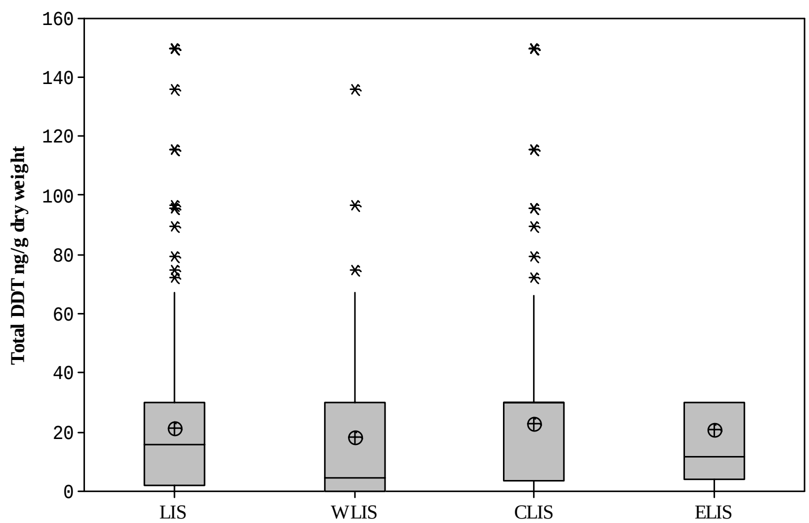


Figure 4-11: Surface Sediment Total Endosulfans Concentrations (1994-2005)

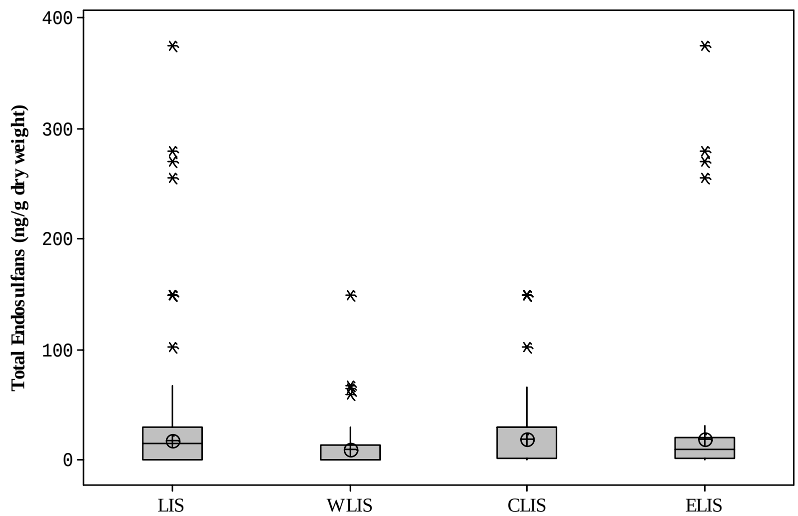


Figure 4-12: Surface Sediment Total HCH Concentrations (1994-2005)

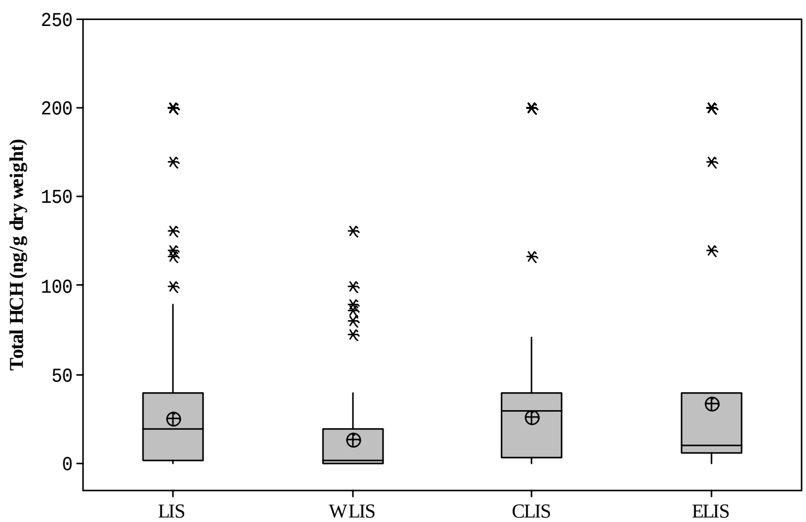


Figure 4-13: Surface Sediment Endrin Concentrations (1994-2005)

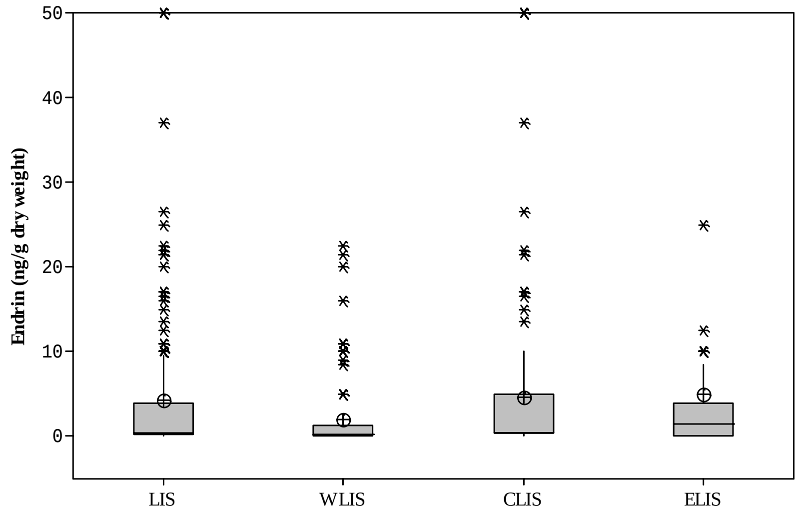
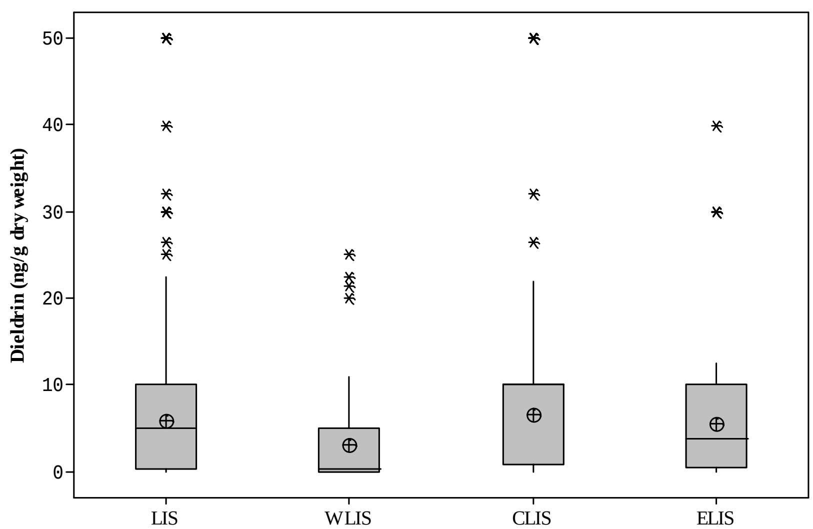


Figure 4-14: Surface Sediment Dieldrin Concentrations (1994-2005)



4.2.3 Sediment toxicity

Sediment toxicity tests are used as indicators of contaminant availability and hence the potential to cause adverse effects to biota. Wolfe et al.'s (1996) sediment toxicity evaluation (samples taken in 1991) of the Hudson-Raritan estuary found high incidences of toxicity around the Throg's Neck area. While amphipod toxicity and metal concentrations did not correlate, suggesting a poor likelihood of metal-induced toxicity, other chemical and physical factors may affect metal availability. Toxicity, correlated best with PAHs, however.

Ten-day amphipod sediment toxicity tests done by the EPA and ACOE (2003) comparing reference and alternative disposal sites found little difference in percent survival values (range: 84-100%). The NCA study determined sediment toxicity in LIS to be generally low, with the exception of some areas in WLIS (USEPA, 2004). To test for metal bioavailability, the ACOE study also analyzed for acid volatile sulfide (AVS) and simultaneously extracted metal (SEM) concentrations. AVS concentrations exceeded SEM concentrations, indicating low bioavailability (metals exist bound to insoluble sulfide complexes) at all of the sites except for the Bridgeport site. Copper and zinc were found in bioavailable forms in one sample at this site (USEPA – USACOE, 2003). Other studies have found toxicity incidences more often in nearshore areas rather than in offshore sites. Nearshore toxicity findings may be correlated with high metal concentrations found in pore water samples that are not found in offshore sites (USEPA – USACOE, 2003).

The National Coastal Assessment findings parallel those reported by Wolfe et al. (1991) with respect to WLIS toxicity. However, it is unclear if toxicity incidences continue to be the result of PAH concentrations, as noted by Wolfe et al., or metals, or a combination of other factors.

4.3 Biota

Exposure to contaminants found in the water column and in the sediments can result in bioaccumulation in biota, posing both human and ecological health risks. Contaminant levels measured in fin fish and shellfish sampled throughout LIS were compared to fish advisory levels and tolerance values set by the Food and Drug Administration (USFDA, 2005). Values that exceeded FDA levels in specific fish were considered to pose a human health risk. For mercury levels, EPA's fish tissue criterion for human health risk for methylmercury (0.3 μg/g wet weight) was used. A conversion factor of 1.0 was used to convert mercury concentrations to methylmercury, a factor that is appropriate for aquatic species in trophic levels 3 and above (USEPA – OW, 2001).

It should be noted that the FDA threshold concentrations are not directly applied to the State of Connecticut Department of Health (DPH) fish consumption advisories. The DPH reviews the species and develops a consumption rate to determine whether an advisory is warranted. The advisory may only apply to certain age or risk groups.

To determine the level of ecological risk resulting from contaminant bioaccumulation, tissue contaminant concentrations were compared to contaminant-specific ecological effects values (EEVs). Used by the EPA/ACOE in their Environmental Impact Statement for the Designation of Dredged Material (USEP - USACOE, 2003), the EEV is derived from the EPA Water Quality Criteria chronic value for aquatic life. Levels that exceed the EEV are considered to be unsafe for aquatic life.

4.3.1 Metals

Robertson et al.'s (1991) national comparative study of NS&T contaminant values for the blue mussel indicated that Long Island Sound pre-1990 values of As, Cr, Hg, Se, and Zn ranked low. Mussel concentrations of Cu, Pb and Sn, however, exceeded national mean values.
Analysis of mussel metal concentrations since 1994 (Table 4-10) shows median tissue concentrations of all metals analyzed below NOAA's national 85^{th} percentile throughout LIS. The only average concentration exceeding the 85^{th} percentile was of Mn in ELIS. Overall, median tissue concentrations of Sb, As, Cd, Cr, Cu, Mn, Hg, Ni, Se, Sn, and Zn were lowest in WLIS and highest in ELIS. The relationship for Ag and Pb, however, was the opposite.

The statistical values included in the analysis for the blue mussel, however, exclude certain 1998 values that were orders of magnitude higher or lower than other years (Table 4-11). Concentration values measured from mussels in Port Jefferson (CLIS) offered the most uncharacteristic results. In 1998, Zinc values were 1590 μg/g dry weight, higher than the 97 μg/g dry weight reported in 1996, but were 73 μg/g dry weight in 1999. Similar patterns were observed for Cu, Hg, and Ag in the specific LIS regions noted in Table 4-11. Because of these uncharacteristic findings, the values were excluded from the data presented in Table 4-10.

Table 4-10: NOAA Blue Mussel Metal Concentrations (1994-2005) - μg/g dry weight[1,2]

	N	Median	Average	Stdev	Max	Min	NOAA	FDA	Ecological
	Long Island Sound						85th	Mollusks[3]	Effects Value[4]
Sb	9	0.007	0.009	0.007	0.029	0.006	0.190		
As	39	6.44	6.89	1.91	13.6	4.37	12.7	602	88.2
Cd	39	1.84	1.91	0.71	3.86	1.00	3.61	28.0	21.0
Cr	39	1.41	1.65	0.80	4.35	0.57	3.51	91.0	82.6
Cu	37	9.02	10.5	3.36	21.1	6.54	13.0		67.2
Hg[5]	38	0.101	0.122	0.062	0.283	0.03	0.270	2.10	1.40
Mn	39	31.9	56.0	90.9	580	13.8	52.0		
Ni	39	1.81	2.09	1.14	6.36	0.80	3.50	560	26.6
Pb	39	2.63	2.86	1.31	6.72	1.07	5.00	11.9	83.3
Se	39	2.25	2.33	0.585	3.43	0.90	3.83		
Ag	37	0.134	0.269	0.410	2.02	0	0.750		10.5
Sn	39	0.089	0.160	0.280	1.69	0	0.460		
Zn	37	92.4	95.4	19.6	140	68.0	170		10619
	Western Long Island Sound						85th	FDA	EEV
Sb	3	0.007	0.008	0.002	0.010	0.006	0.190		
As	14	5.44	5.53	0.878	7.24	4.37	12.7	602	88.2
Cd	14	1.32	1.63	0.597	2.87	1.08	3.61	28.0	21.0
Cr	14	1.09	1.21	0.512	2.77	0.565	3.51	91.0	82.6
Cu	14	9.42	10.3	3.14	19.8	6.95	13.0		67.2
Hg[5]	13	0.091	0.100	0.052	0.197	0.033	0.270	2.10	1.40
Mn	14	24.6	35.4	23.6	94.1	13.8	52.0		
Ni	14	1.54	1.79	0.668	3.06	0.848	3.50	560	26.6
Pb	14	3.82	3.73	1.63	6.72	1.09	5.00	11.9	83.3
Se	14	2.11	2.02	0.541	2.80	0.900	3.83		
Ag	14	0.196	0.243	0.166	0.550	0	0.750		10.5
Sn	14	0.131	0.169	0.152	0.504	0	0.460		
Zn	14	91.6	96.1	19.0	135	70.9	170		10619

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS, ELIS=Eastern LIS
SHADED values exceed the NOAA National 85th Percentile value

Table 4-10 (continued): NOAA Blue Mussel Metal Concentrations (1994-2005) - μg/g dry weight[1,2]

	N	Median	Average	Stdev	Max	Min		FDA	Ecological
	Central Long Island Sound						85th	Mollusks[3]	Effects Value[4]
Sb	5	0.006	0.007	0.001	0.008	0.006	0.190		
As	21	6.88	7.12	1.38	9.13	4.70	12.7	602	88.2
Cd	21	1.87	2.03	0.775	3.86	1.00	3.61	28.0	21.0
Cr	21	1.59	1.77	0.777	4.35	0.62	3.51	91.0	82.6
Cu	19	8.69	10.2	3.49	21.1	6.54	13.0		67.2
Hg[5]	21	0.102	0.125	0.064	0.283	0.055	0.270	2.10	1.40
Mn	21	34.7	46.8	34.3	153	18.9	52.0		
Ni	21	1.78	2.08	1.19	6.36	0.800	3.50	560	26.6
Pb	21	2.63	2.47	0.794	4.01	1.07	5.00	11.9	83.3
Se	21	2.24	2.38	0.490	3.40	1.80	3.83		
Ag	19	0.060	0.253	0.478	2.02	0	0.750		10.5
Sn	21	0.085	0.143	0.359	1.69	0	0.460		
Zn	19	85.9	90.3	16.8	139	68.0	170		10619
	Eastern Long Island Sound						85th	FDA	EEV
Sb	1	0.029	0.029		0.029	0.029	0.190		
As	4	9.67	10.4	2.15	13.6	8.84	12.7	602	88.2
Cd	4	2.25	2.28	0.463	2.88	1.75	3.61	28.0	21.0
Cr	4	2.40	2.63	0.759	3.73	2.00	3.51	91.0	82.6
Cu	4	11.3	12.2	3.84	17.3	8.85	13.0		67.2
Hg[5]	4	0.163	0.180	0.059	0.265	0.129	0.270	2.10	1.40
Mn	4	47.6	176	269	580	30.2	52.0		
Ni	4	2.46	3.27	1.69	5.81	2.35	3.50	560	26.6
Pb	4	1.83	1.83	0.328	2.18	1.50	5.00	11.9	83.3
Se	4	3.24	3.13	0.372	3.43	2.63	3.83		
Ag	4	0.128	0.434	0.700	1.48	0	0.750		10.5
Sn	4	0.243	0.217	0.172	0.381	0	0.460		
Zn	4	118	117	23.0	140	93.3	170		10619

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS, ELIS=Eastern LIS
SHADED values exceed the NOAA National 85th Percentile value

[1]NOAA NS&T, 2005
[2]blue mussel (*Mytilus edulis*)
[3]U.S. Food and Drug Administration (FDA) Action Level for Crustacea and Mollusks (USFDA, 2003)
[4]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[5]EPA fish tissue (including shellfish) criterion for methylmercury is 0.3 μg/g wet weight = 2.1 μg/g dry weight. Hg concentrations were interpreted as 100% methylmercury for all species (all at trophic levels three and above) (USEPA-OW, 2001).

Table 4-11: Blue Mussel Tissue Metal Concentrations (1994-2005) - μg/g dry weight

Location		1994	1996	1998	1999	2002
Ag	Port Jefferson	0.04	0.00	1.18	0.00	0.60
	Housatonic River	0.07	0.00	1.72	2.02	
Cu	Port Jefferson	8.00	8.83	111	7.52	8.40
	Housatonic River	11.5	21.1	353	15.2	
Hg	Mamaroneck	0.07	0.09	0.24	0.08	
Zn	Port Jefferson	68.0	97.0	1590	73.0	84.9
	Housatonic River	97.7	100	3253	118	

SHADED boxes indicate unusually high values.
Source: NOAA NS&T, 2005

The EPA/ACOE study reported average metal concentrations in lobsters (with the exception of Cu), worms, and clams below FDA and ecological effects values (EEV). (Note that NOAA's 85th percentile level is available for comparison only for blue mussels.) Levels of As, Cu, and Ag were highest in the American lobster (Table 4-12). Concentrations of Cu exceeded the ecological effects value.

The concentrations of Cu in lobsters have been noted to be historically high. Mercaldo-Allen et al. (1994) measured Cu concentrations in embryos and offspring sampled in 1985-1986 from Bridgeport, Milford, and New Haven Connecticut. For embryos, Cu concentrations averaged between 172-227 μg/g dry weight. For first stage larvae and juvenile lobsters, concentrations averaged between 137-227 and 24.9-27.9 μg/g dry weight, respectively (Mercaldo-Allen et al., 1994). Adult lobsters sampled from the Housatonic River prior to 1991 were noted to contain concentrations that were 100 times higher than those found in the digestive glands of blue crabs during the pre-molting stage (Engel et al., 2001). Engel et al. (2001) also noted that lobsters sampled from areas exhibiting high levels of Cu in the sediments were found to have high levels of hemocyanin – a Cu rich protein that carries oxygen to the hemolymph. However, the authors found no correlation between Cu tissue and sediment concentrations. The authors concluded that other environmental stressors, such as hypoxia and low food availability caused by anthropogenic activities, might influence hemocyanin levels, thus affecting the lobster's metabolic functions (Engel et al., 2001). With respect to Zn, Engel et al. (2001) found that both blue crabs and lobsters tended to have effective Zn regulating mechanisms. The values measured between 2000 and 2002 support that, as average Zn levels in the American Lobster were measured well below the ecological effects value (Table 4-12).

Table 4-12: Average Benthic Tissue Metal Concentrations (1994-2005) - μg/g dry weight[1,2,3,4]

Analyte	Blue Crab		American Lobster				Worm		Clam		FDA Action Levels[5]		Ecological Effects Value[6]
	N	WLIS	N	WLIS	N	CLIS	N	CLIS	N	CLIS	Crustacea	Mollusks	
Sb	1	0.500											
As	1	1.30	5	21.4	5	40.0	3	25.5	3	7.35	532	602	88.2
Cd	1	0.160	5	0.140	5	0.210	3	0.980	3	1.19	21.0	28.0	21.0
Cr	1	0.650	5	0.280	5	0.280	3	1.12	3	2.80	84.0	91.0	82.6
Cu	1	21.5	5	**104**	5	**156**	3	20.9	3	18.2			67.2
Fe	1	148											
Hg[7]	1	0.05	5	0.42	5	0.56	3	0.07	3	0.07	2.10	2.10	1.40
Ni	1	1.66	5	0.42	5	0.42	3	3.64	3	8.40	490	560	26.6
Pb	1	0.72	5	0.42	5	0.07	3	3.71	3	5.46	10.5	11.9	83.3
Se	1	1.91											
Ag	1		5	2.24	5	3.78	3	0.35	3	1.12			10.5
Sn	1	3.73											
Zn	1	32.6	5	128	5	138	3	138	3	112			10619

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS
Bold values exceed the Ecological Effects Value
Underlined values exceed FDA Action Levels or EPA fish tissue criterion for the protection of human health for methylmercury: 2.1 μg/g dry weight.

[1]Sources: USEPA – USACOE, 2003; USEPA – NCA, 2005.
[2]All ACOE, FDA, and EEV values were multiplied by a wet to dry weight factor of 7 (estimate of 85% tissue moisture content).
[3]ACOE reported values are averages for composite samples.
[4]American Lobster (*Homarus americanus*), blue crab (*Callinectes sapidus*), worm (*Nephtys incisa*), clam (*Pitar morrhuana*)
[5]U.S. Food and Drug Administration (FDA) Action Level for Crustacea and Mollusks (USFDA, 2003);
[6]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003).
[7]EPA fish tissue (including shellfish) criterion for methylmercury is 0.3 μg/g wet weight = 2.1 μg/g dry weight. Hg concentrations were interpreted as 100% methylmercury for all species (all at trophic levels three and above) (USEPA-OW, 2001).

Metal concentration values reported for finfish (scup, summer flounder, winter flounder, and bluefish) fell below corresponding FDA action levels and the EEVs (Tables 4-13 to 4-16). There were large interspecific differences in concentrations, with winter and summer flounder, for example, being relatively low in Cu and high in As compared to other species. Mercury concentrations in the striped bass, however, exceeded the EEV in both western and central LIS, but exceeded EPA's fish tissue criterion for methylmercury only in CLIS.

Table 4-13: National Coastal Assessment Metal Concentrations in Summer Flounder (2001) μg/g dry weight[1]

	N	Median	Average	Stdev	Max	Min	Ecological Effects Value[2]
	Western Long Island Sound						
As	2	0.500	0.500	0.000	0.500	0.500	63.0
Cd	2	0.050	0.050	0.000	0.050	0.050	15.0
Cr	2	0.320	0.320	0.240	0.490	0.150	59.0
Cu	2	0.500	0.500	0.000	0.500	0.500	240
Fe	2	163	163	223	321	5.00	
Hg[3]	2	0.065	0.065	0.007	0.070	0.060	1.00
Ni	2	0.150	0.150	0.000	0.150	0.150	19.0
Pb	2	0.300	0.300	0.283	0.500	0.100	59.5
Se	2	0.500	0.500	0.000	0.500	0.500	
Ag	2	0.100	0.100	0.000	0.100	0.100	7.50
Sn	2	2.40	2.40	0.049	2.43	2.36	
Zn	2	9.54	9.54	0.792	10.1	8.98	7585
	Central Long Island Sound						
As	5	0.500	0.730	0.315	1.08	0.500	63.0
Cd	5	0.050	0.064	0.031	0.120	0.050	15.0
Cr	5	0.310	0.308	0.087	0.430	0.190	59.0
Cu	5	3.73	3.06	2.24	5.79	0.500	240
Fe	5	13.2	14.6	8.20	27.3	5.00	
Hg[3]	5	0.050	0.056	0.015	0.080	0.040	1.00
Ni	5	0.330	0.396	0.202	0.690	0.150	19.0
Pb	5	0.100	0.198	0.219	0.590	0.100	59.5
Se	5	0.500	0.500	0.000	0.500	0.500	
Ag	5	0.100	0.158	0.079	0.250	0.100	7.50
Sn	5	3.11	3.16	0.627	3.96	2.52	
Zn	5	22.8	23.4	2.31	26.9	21.0	7585

[1]USEPA – NCA, 2005
[2]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[3]EPA fish tissue (including shellfish) criterion for methylmercury is 0.3 μg/g wet weight = 2.1 μg/g dry weight. Hg concentrations were interpreted as 100% methylmercury for all species (all at trophic levels three and above) (USEPA-OW, 2001).

Table 4-14: Winter Flounder Metal Concentrations (1994-2005) - μg/g dry weight[1,2,3,4]

	WLIS		CLIS		CLIS[5]		CLIS[6]		CLIS[7]		CLIS – National Coastal Assessment						Ecological Effects Value[8]
	N	ACOE	N	ACOE	N	ACOE	N	ACOE	N	ACOE	N	Median	Average	Stdev	Max	Min	
As	2	9.00	2	17.0	2	34.5	3	21.0	3	26.5	4	0.500	0.500	0	0.500	0.500	63.0
Cd	2	0.010	2	0.020	2	0.010	3	0.010	3	0.010	4	0.050	0.050	0	0.050	0.050	15.0
Cr	2	0.800	2	0.800	2	0.750	3	0.250	3	0.250	4	0.310	0.303	0.074	0.380	0.210	59.0
Cu	2	0.900	2	0.900	2	0.500	3	0.500	3	0.700	4	0.500	0.690	0.380	1.26	0.500	240
Fe											4	11.8	10.5	3.77	13.5	5.00	
Hg[9]	2	0.100	2	0.080	2	0.130	3	0.080	3	0.100	4	0.015	0.0175	0.010	0.03	0.010	1.00
Ni	2	0.120	2	0.130	2	0.170	3	0.130	3	0.130	4	0.435	0.635	0.610	1.52	0.150	19.0
Pb	2	0.030	2	0.060	2	0.850	3	0.070	3	0.340	4	0.100	0.148	0.095	0.290	0.100	59.5
Se											4	0.500	0.500	0	0.500	0.500	
Ag	2	0.010	2	0.010	2	0.010	3	0.020	3	0.010	4	0.100	0.100	0	0.100	0.100	7.50
Sn											4	2.71	2.62	0.261	2.82	2.24	
Zn	2	34.5	2	40.0	2	34.0	3	33.5	3	38.0	4	19.9	19.1	4.42	23.4	13.2	7585

WLIS = Western Long Island Sound (LIS), CLIS = Central LIS

Bold values exceed the Ecological Effects Value

Underlined values exceed FDA Action Levels or EPA fish tissue criterion for the protection of human health for methylmercury: 2.1 μg/g dry weight.

[1]Sources: ACOE = Army Corps of Engineers (USEPA – USACOE, 2003); NCA - National Coastal Assessment (USEPA – NCA, 2005).
[2] Winter flounder (*Pleuronectes americanus*)
[3]ACOE reported values are averages for composite samples.
[4]All ACOE, FDA, and EEV values were multiplied by a wet to dry weight factor of 7 (estimate of 85% tissue moisture content).
[5]CLIS - Mud, water depth 60-90 ft, [6]CLIS - Mud, water depth >90 ft, [7]CLIS - Mud to sand, water depth 60-90 ft.
[8]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[9]U.S. Food and Drug Administration (FDA) Action Level for Crustacea and Mollusks (USFDA, 2003); EPA fish tissue (including shelfish) criterion for methylmercury is 0.3 μg/g wet weight = 2.1 μg/g dry weight. Hg concentrations were interpreted as 100% methylmercury for all species (all at trophic levels three and above) (USEPA-OW, 2001).

Table 4-15: Scup Average Metal Concentrations (2000 - 2002) - μg/g dry weight[1,2,3]

	WLIS		WLIS		CLIS		CLIS		CLIS[4]		CLIS[5]		CLIS[6]		Ecological Effects Value[7]
	N	NCA	N	ACOE	N	NCA	N	ACOE	N	ACOE	N	ACOE	N	ACOE	
As	1	1.63	2	5.00	1	1.05	2	8.00	2	5.50	3	9.00	3	12.0	63.0
Cd	1	0.050	2	0.010	1	0.050	2	0.010	2	0.010	3	0.010	3	0.010	15.0
Cr	1	0.250	2	0.950	1	0.340	2	0.260	2	0.470	3	0.260	3	0.380	59.0
Cu	1	1.93	2	1.90	1	0.500	2	1.60	2	2.20	3	2.55	3	1.75	240
Fe	1	13.6			1	35.5									
Hg[8]	1	0.040	2	0.300	1	0.040	2	0.320	2	0.440	3	0.280	3	0.210	1.00
Ni	1	0.530	2	0.140	1	0.790	2	0.130	2	0.130	3	0.450	3	0.110	19.0
Pb	1	0.100	2	0.020	1	0.100	2	0.030	2	0.380	3	0.210	3	0.020	59.5
Se	1	0.500			1	0.500									
Ag	1	0.100	2	0.010	1	0.100	2	0.010	2	0.010	3	0.010	3	0.010	7.50
Sn	1	2.90			1	2.60									
Zn	1	9.64	2	26.5	1	12.9	2	28.5	2	29.5	3	30.5	3	25.0	7585

WLIS = Western Long Island Sound (LIS), CLIS = Central LIS

[1]Sources: ACOE = Army Corps of Engineers (USEPA – USACOE, 2003); NCA - National Coastal Assessment (USEPA – NCA, 2005).
[2]Scup (*Stenotomus chrysops*)
[3]ACOE reported values are averages for composite samples.
[4]CLIS - Mud, water depth 60-90 ft, [5]CLIS - Mud, water depth >90 ft, [6]CLIS - Mud to sand, water depth 60-90 ft
[7]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[8]EPA fish tissue (including shellfish) criterion for methylmercury is 0.3 μg/g wet weight = 2.1 μg/g dry weight. Hg concentrations were interpreted as 100% methylmercury for all species (all at trophic levels three and above) (USEPA-OW, 2001).

Table 4-16: ACOE Striped Bass and Bluefish Average Metal Concentrations (2000-2002) – μg/g dry weight[1,2,3]

Analyte	Striped bass				Bluefish				Ecological Effects Value[5]
	N	WLIS	N	CLIS	N	CLIS	N	CLIS[4]	
As	1	6.35	1	7.65	1	2.60	1	1.20	63.0
Cd	1	0.010	1	0.030	1	0.010	1	0.010	15.0
Cr	1	0.980	1	0.260	1	1.060	1	0.260	59.0
Cu	1	2.30	1	2.50	1	2.15	1	1.90	240
Hg[6]	1	**1.05**	1	**<u>1.65</u>**	1	0.490	1	0.460	1.00
Ni	1	0.080	1	0.130	1	0.160	1	0.150	19.0
Pb	1	0.020	1	0.020	1	0.020	1	0.020	59.5
Ag	1	0.020	1	0.010	1	0.010	1	0.020	7.50
Zn	1	33.5	1	32.5	1	38.0	1	71.0	7585

WLIS = Western Long Island Sound (LIS), CLIS = Central LIS

Bold values exceed the Ecological Effects Value
<u>Underlined</u> values exceed EPA fish tissue criterion for the protection of human health for methylmercury: 1.5 μg/g dry weight.

[1]Sources: ACOE = Army Corps of Engineers (USEPA – USACOE, 2003); NCA - National Coastal Assessment (USEPA – NCA, 2005).
[2]Striped bass (*Morone saxatilis*), Bluefish (*Pomatus saltatrix*)
[3]ACOE reported values are averages for composite samples.
[4]CLIS - Mud, water depth 60-90 ft
[5]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[6]EPA fish tissue (including shellfish) criterion for methylmercury is 0.3 μg/g wet weight = 2.1 μg/g dry weight. Hg concentrations were interpreted as 100% methylmercury for all species (all at trophic levels three and above) (USEPA-OW, 2001).

In sum, based on simple threshold analyses, metals that might pose an ecological risk include Cu in lobster and Hg in striped bass. Hg exceeded the CT advisory level for fish consumption. Despite the very high metal concentrations in the sediments (see Section 4.2.1), metal levels in biota do not generally seem to pose an ecological risk, nor do they rank among the worst nationally. Given the low sediment toxicity and metal bioavailability found by the EPA/ACOE and NCA studies, these findings are not surprising (see section 4.2.3).

It is interesting to note, however, that the EPA/ACOE study did find evidence of Cu and Zn bioavailability in the samples taken at the Bridgeport site (USEPA – ACOE, 2003). While Engel et al. (2001) failed to establish a correlation between copper sediment concentrations and tissue levels in the American lobster, the high tissue concentrations reported in the EPA/ACOE study can be due to a combination of factors. Hypoxia, for example, would reduce the bioavailability of Cu. Because hypoxia is most severe in WLIS during the summer months, Cu bioavailability would be low. In CLIS, where there is more Cu and where hypoxia is not as severe as in WLIS, Cu would become more bioavailable. Hence, given the right conditions, lobsters sampled from CLIS are likely to have higher Cu tissue levels than those sampled from WLIS. Fish and lobsters move, as do their prey. Also, the metabolic use of Cu may result in non-linear uptake of that metal.

The trends observed for Hg concentrations in the striped bass follow the distribution patterns observed in the water column. While concentrations of sediment HgT follow a west to east decreasing trend (Table 4-16), Rolfhus and Fitzgerald (2000) noted opposite trends for unfiltered HgR concentrations in the water column. The authors indicated that unfiltered HgR increased from 14% to 71% from west to east (Rolfhus and Fitzgerald, 2000). Higher concentrations of reactive Hg in CLIS and ELIS would therefore account for higher levels in fish tissue. While Hg levels in other fish species did not exceed EEV or EPA fish criteria values, the general west to east increasing trend in Hg concentrations was apparent for these species as well. Hg median concentrations in blue mussels, for example, were higher in CLIS and highest in ELIS (Table 4-10).

It is difficult to determine, however, if post-1994 values show an improving trend from Robertson et al.'s 1991 assessment, because this study did not provide concentration units. However, all of the 1994-2005 median metal concentrations fell below the NOAA 85th percentile. The values presented in Table 4-11, however, do show a constant trend in blue mussel tissue metal concentrations (excluding 1998). It is therefore unlikely that tissue levels have changed significantly since 1991. Cu and Hg may continue to pose both human and ecological health risks based on available data.

4.3.2 Organic Pollutants

Median contaminant levels measured in blue mussels sampled from WLIS exceeded the 85th national percentile value of total endosulfans and dioxin-like PCBs (Table 4-17). Levels of dioxin-like PCBs also exceeded the 85th percentile in CLIS and ELIS. While the maximum values indicate that other organic pollutants pose problems in some sample sites throughout LIS, the median concentrations indicate that these pollutants have generally been measured at levels that do not exceed the NOAA 85th percentile or FDA and EEV values. Total dieldrin concentrations measured in blue mussels sampled from Throgs Neck and Hempstead Harbor exceeded the EEV in 1994. The 1997, 1998, and 2000 data indicate concentrations below the EEV, however.

It is important to note that while the FDA Action Level for PCBs is 10,000 ng/g (dry weight – 80% moisture content), LIS-specific PCB threshold guidelines used by the Connecticut Department of Public Health (CT DPH) to develop fish consumption advisories place this threshold at 500 ng/g dry weight for fin fish (80% moisture content) and 700 ng/g dry weight (85% moisture content) for mollusks and crustaceans (0.1 mg/kg PCB wet weight) (USEPA – USACOE, 2003). Concentrations of total PCBs exceeded the CT Department of Health guideline in blue mussels sampled from Throgs Neck and the Housatonic River in 1997, 1998, and 2000.

Roberston et al.'s 1991 study reported LIS blue mussel concentrations of low and high molecular weight PAHs, total PCBs, total DDT, total dieldrin, and total chlordane at levels above the national mean for all the categories. Values of total chlordane and total dieldrin were noticeably higher (Robertson et al., 1991). Peven et al.'s (1996) overview of 1989 NS&T blue mussel data showed total DDT (222 ng/g dry weight), total PCB (730 ng/g dry weight), and total PAH (2160 ng/g dry weight) concentrations highest at Throgs Neck (WLIS), while tributyltin (TBT) concentrations were highest in Port Jefferson (CLIS, 1130 ng/g dry weight or 458 ng Sn/g dry weight).

Comparison to Peven et al.'s data (1996) indicates that levels of total DDT and total PAH in blue mussels sampled at Throgs Neck have decreased since 1989, while TBT concentrations in Port Jefferson have also dropped. Tributyltin levels measured in mussels from Port Jefferson, for example, ranged between 11.8 and 28.0 ng Sn/g dry weight in 1994, 1998, and 2000. PCB levels measured since 1989, however, have remained relatively high and were highest in blue mussels sampled from Throgs Neck and the Housatonic River. Sample PCB data from 1997 through 2000 ranged between 785 to 927 ng/g dry weight at the Throgs Neck site. PCB levels from blue mussels sampled in the Housatonic River were also relatively high, ranging between 702 and 772 ng/g dry weight.

Table 4-18 summarizes organic pollutant levels in other benthic organisms. While lobster muscle tissue concentrations did not exceed the CT DPH advisory threshold for PCB, high total PCB concentrations were measured in the hepatopancreas of lobsters. The EPA/ACOE study reported average values ranging between 10,024 and 14,432 ng/g dry weight in WLIS and CLIS (USEPA - USACOE, 2003). These values exceed both the FDA Action Level and CT DPH fish advisory for PCBs, although the consumption rate of lobster organs is lower than claw and tail meats.

PCB levels measured in winter flounder did not exceed the CT DPH advisory threshold for PCBs (Table 4-19). High PCB concentrations were, however, measured in some fin fish samples. Average total PCB levels reported in the EPA/ACOE study striped bass, bluefish, and scup were found to exceed the fish advisory level (Tables 4-20 and 4-21). NCA reported levels of PCB concentrations in scup samples and channel catfish, however, did not exceed the fish advisory level (Tables 4-20 and 4-22). Similarly, NCA PCB concentrations measured in summer flounder also did not exceed the fish advisory level (Table 4-23).

The EPA/ACOE study also reported average winter flounder liver PCB concentrations ranging between 2,870 and 12,590 ng/g dry weight in WLIS and CLIS, values that also exceed the PCB advisories. Winter flounder livers are not generally eaten, however, so exposure to PCBs from their consumption would be relatively small. Although the EPA/ACOE data are limited, the findings do suggest that fin fish PCB levels pose a problem. These findings warrant further studies to evaluate potential health and ecological risks.

Table 4-17: Organic Pollutant Concentrations in Blue Mussel Tissue (1994-2005) - ng/g dry weight[1,2,3]

Analyte	Long Island Sound						85th[4]	FDA Action Level[5]	Ecological Effects Value[6]
Pesticides	**N**	**Median**	**Average**	**Stdev**	**Max**	**Min**			
Total Chlordanes[7]	39	14.3	18.0	11.3	47.9	2.60	27.7	2100	448
Alpha-Chlordane	9	10.5	13.4	8.15	25.8	3.19	13.7		
Heptachlor	9	0	0.160	0.321	0.820	0	0.930		
Trans-nonachlor	9	8.61	10.4	5.90	19.3	3.10	13.7		
Total Chlorobenzenes[8]	39	0.704	1.34	1.78	9.96	0	5.20		
Chlorpyrifos	30	0.502	0.776	0.860	3.11	0	1.70		
Total DDT[9]	39	43.5	47.6	22.4	93.4	12.1	123	35000	21000
Dieldrin	39	5.42	8.20	8.86	**40.0**	0.948	11.6	2100	30.6
Total Endosulfans[10]	30	3.73	4.32	4.14	16.4	0	4.00		20.0
Endrin	39	0	0.079	0.112	0.401	0	0.120		
Total HCHs[11]	39	0.650	0.937	0.651	2.48	0	5.90		
Mirex	39	0.385	0.628	0.643	2.98	0	1.10		
Pentachloroanisole	30	1.06	1.07	0.472	2.02	0.292	2.05		
PAHs									
Total PAH[12]	39	435	598	439	1764	126	2076		70000
Total HPAH[13]	39	323	486	381	1441	85.0	1703		
Total LPAH[14]	39	89.0	112	76	323	29.5	514		
PCBs/Other									
Total PCBs[15,16]	39	323	388	201	<u>927</u>	154	<u>727</u>	<u>1400</u>	28000
PCB110/77 (dioxin like)	18	258	628	1083	4401	0	0		
PCB126 (dioxin like)	18	33.3	119	308	1331	0	0		
PCB169 (dioxin like)	9	12.1	51.4	117	361	0	13.0		
Dibenzofuran (pg/g dry weight)	9	4.25	5.23	4.00	15.5	1.82	15.7		
Total butyltins (ng Sn/g dry weight)[17]	30	19.9	21.9	16.4	90.4	0	340		

Bold values exceed the Ecological Effects Value
<u>UNDERLINED</u> values exceed FDA Action Levels or CT Department of Public Health guidelines for PCBs (100 ppb wet, 700 ppb dry)
SHADED values exceed the NOAA National 85th Percentile – only for blue mussel values

Table 4-17 (continued): Organic Pollutant Concentrations in Blue Mussel Tissue (1994-2005) - ng/g dry weight[1,2,3]

	Western Long Island Sound								
Pesticides	**N**	**Median**	**Average**	**Stdev**	**Max**	**Min**	**85^{th}[4]**	**FDA[5]**	**EEV[6]**
Total Chlordanes[7]	14	27.2	28.6	11.0	47.9	12.0	27.7	2100	448
Alpha-Chlordane	3	25.1	23.1	4.08	25.8	18.4	13.7		
Heptachlor	3	0	0.273	0.473	0.820	0	0.930		
Trans-nonachlor	3	18.9	17.0	3.74	19.3	12.7	13.7		
Total Chlorobenzenes[8]	14	0.647	1.72	2.68	9.96	0	5.20		
Chlorpyrifos	11	0.833	1.26	1.16	3.11	0.126	1.70		
Total DDT[9]	14	69.8	65.4	22.3	93.4	22.7	123	35000	21000
Dieldrin	14	6.38	12.1	12.2	**40.0**	3.49	11.6	2100	30.6
Total Endosulfans[10]	11	5.88	6.18	5.03	16.4	0	4.00		20.0
Endrin	14	0	0.061	0.090	0.224	0	0.120		
Total HCHs[11]	14	0.653	1.01	0.634	2.08	0.326	5.90		
Mirex	14	0.887	1.13	0.835	2.98	0.337	1.10		
Pentachloroanisole	11	1.09	1.25	0.518	2.02	0.476	2.05		
PAHs									
Total PAH[12]	14	615	736	481	1764	158	2076		70000
Total HPAH[13]	14	520	631	436	1441	121	1703		
Total LPAH[14]	14	95.0	105	67.1	323	36.1	514		
PCBs/Other									
Total PCBs[15,16]	14	459	475	240	927	183	727	1400	28000
PCB110/77 (dioxin like)	6	358	619	796	1977	0	0		
PCB126 (dioxin like)	6	46.2	60.6	70.2	162	0	0		
PCB169 (dioxin like)	3	13.0	12.5	1.04	13.2	11.3	13.0		
Dibenzofuran (pg/g dry weight)	3	4.25	4.48	1.45	6.03	3.16	15.7		
Total butyltins (ng Sn/g dry weight)[17]	11	21.5	25.0	23.3	90.4	0	340		

Bold values exceed the Ecological Effects Value

UNDERLINED values exceed FDA Action Levels or CT Department of Public Health guidelines for PCBs (100 ppb wet, 700 ppb dry)

SHADED values exceed the NOAA National 85^{th} Percentile – only for blue mussel values

Table 4-17 (continued): Organic Pollutant Concentrations in Blue Mussel Tissue (1994-2005) - ng/g dry weight[1,2,3]

Pesticides	Central Long Island Sound						85th[4]	FDA[5]	EEV[6]
	N	Median	Average	Stdev	Max	Min			
Total Chlordanes[7]	21	13.3	13.5	5.66	29.5	5.19	27.7	2100	448
Alpha-Chlordane	5	9.44	9.70	3.38	15.0	6.49	13.7		
Heptachlor	5	0	0.124	0.277	0.620	0	0.930		
Trans-nonachlor	5	7.14	7.86	2.98	12.7	5.33	13.7		
Total Chlorobenzenes[8]	21	0.861	1.13	1.06	3.84	0	5.20		
Chlorpyrifos	16	0.361	0.545	0.493	1.49	0	1.70		
Total DDT[9]	21	38.2	40.8	14.5	76.9	16.7	123	35000	21000
Dieldrin	21	4.55	6.54	5.72	26.0	1.92	11.6	2100	30.6
Total Endosulfans[10]	16	3.20	3.43	3.38	11.2	0	4.00		20.0
Endrin	21	0	0.078	0.109	0.309	0	0.120		
Total HCHs[11]	21	0.840	0.946	0.680	2.48	0.097	5.90		
Mirex	21	0.350	0.370	0.210	1.06	0.098	1.10		
Pentachloroanisole	16	1.08	1.03	0.421	1.91	0.449	2.05		
PAHs									
Total PAH[12]	21	333	506	427	1506	126.3	2076		70000
Total HPAH[13]	21	235	387	344	1206	85.0	1703		
Total LPAH[14]	21	86.2	119	87.8	313	29.5	514		
PCBs/Other									
Total PCBs[15,16]	21	311	348	166	773	154	727	1400	28000
PCB110/77 (dioxin like)	10	258	698	1346	4401	0	0		
PCB126 (dioxin like)	10	34.1	171	411	1331	0	0		
PCB169 (dioxin like)	5	12.1	85.0	155	361	0	13.0		
Dibenzofuran (pg/g dry weight)	5	4.39	6.02	5.40	15.5	1.82	15.7		
Total butyltins (ng Sn/g dry weight)[17]	16	19.0	21.3	10.6	42.6	4.08	340		

Bold values exceed the Ecological Effects Value
UNDERLINED values exceed FDA Action Levels or CT Department of Public Health guidelines for PCBs (100 ppb wet, 700 ppb dry)
SHADED values exceed the NOAA National 85th Percentile – only for blue mussel values

Table 4-17 (continued): Organic Pollutant Concentrations in Blue Mussel Tissue (1994-2005) - ng/g dry weight[1,2,3]

Pesticides	Eastern Long Island Sound						85th[4]	FDA[5]	EEV[6]
	N	Median	Average	Stdev	Max	Min			
Total Chlordanes[7]	4	5.40	5.01	1.86	6.65	2.60	27.7	2100	448
Alpha-Chlordane	1	3.19	3.19		3.19	3.19	13.7		
Heptachlor	1	0	0		0	0	0.930		
Trans-nonachlor	1	3.1	3.1		3.1	3.1	13.7		
Total Chlorobenzenes[8]	4	0.923	1.07	0.751	2.12	0.334	5.20		
Chlorpyrifos	3	0.203	0.246	0.112	0.373	0.163	1.70		
Total DDT[9]	4	21.3	21.4	7.93	30.8	12.1	123	35000	21000
Dieldrin	4	2.91	3.23	2.60	6.13	0.948	11.6	2100	30.6
Total Endosulfans[10]	3	2.55	2.25	2.12	4.20	0	4.00		20.0
Endrin	4	0.095	0.148	0.191	0.401	0	0.120		
Total HCHs[11]	4	0.531	0.646	0.642	1.52	0	5.90		
Mirex	4	0.188	0.221	0.219	0.508	0	1.10		
Pentachloroanisole	3	0.688	0.676	0.379	1.05	0.292	2.05		
PAHs									
Total PAH[12]	4	575	593	276	940	282	2076		70000
Total HPAH[13]	4	478	496	251	800	227	1703		
Total LPAH[14]	4	96.7	97.1	45.5	141	54.7	514		
PCBs/Other									
Total PCBs[15,16]	4	253	289	134	481	169	<u>727</u>	<u>1400</u>	28000
PCB110/77 (dioxin like)	2	305	305	431	610	0	0		
PCB126 (dioxin like)	2	33.3	33.3	47.0	66.5	0	0		
PCB169 (dioxin like)	1	0	0		0	0	13.0		
Dibenzofuran (pg/g dry weight)	1	3.58	3.58		3.58	3.58	15.7		
Total butyltins (ng Sn/g dry weight)[17]	3	13.9	13.7	13.6	27.1	0	340		

Bold values exceed the Ecological Effects Value
<u>UNDERLINED</u> values exceed FDA Action Levels or CT Department of Public Health guidelines for PCBs (100 ppb wet, 700 ppb dry)
SHADED values exceed the NOAA National 85th Percentile – only for blue mussel values

[1]NOAA NS&T, 2005
[2]blue mussel (*Mytilus edulis*)
[3]All FDA and EEV values were multiplied by a wet to dry weight factor of 7 (estimate of 85% tissue moisture content).
[4]NOAA 85th National Percentile (NOAA – NS&T, 2005)
[5]U.S. Food and Drug Administration (FDA) Action Level for Crustacea and Mollusks (USFDA, 2003)
[6]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[7]Total chlordanes (sum of 4)= alpha chlordane + heptachlor + heptachlor epoxide + trans-nonachlor
[8]Total chlorobenzenes (sum of 4) = 1,2,3,4-Tetrachlorobenzene + 1,2,4,5-Tetrachlorobenzene + Hexachlorobenzene + Pentachlorobenzene
[9]Total DDT (sum of 6) =2,4'-DDD (o,p'-DDD) + 2,4'-DDE (o,p'-DDE) + 2,4'-DDT (o,p'-DDT) + 4,4'-DDD (p,p' DDD) + 4,4'-DDE (p,p' DDE) + 4,4'-DDT (p,p' DDT)
[10]Endosulfans(sum of 4) = Endosulfan + Endosulfan I (alpha-endosulfan) + Endosulfan II (beta-endosulfan) + Endosulfan Sulfate
[11] Total HCH = Hexachlorocyclohexane = alpha-HCH + beta-HCH, delta-HCH, gamma-HCH, Lindane,
[12] Total polycyclic aromatic hydrocarbon (PAHs) ➔ NCA, NOAA, and SQUID = low molecular weight PAH + high molecular weight PAH; ACOE = sum of 16 PAHs
[13] Total high molecular weight PAH (HPAH) (12) = Benz(a)anthracene +Benzo(a)pyrene +Benzo(b)fluoranthene +Benzo(e)pyrene+Benzo(g,h,i)perylene +Benzo(k)fluoranthene +Chrysene +Dibenz(a,h)anthracene +Fluoranthene +Indeno(1,2,3-c,d)pyrene +Perylene +Pyrene
[14]Total low molecular weight PAH (LPAH) (12) = 1,6,7-Trimethylnaphthalene +1-methylphenanthrene +2,6-dimethylnaphthalene +2-methylnaphthalene +Acenaphthylene +Acenaphthene +Anthracene +Biphenyl +Dibenzothiophene +Fluorene +Naphthalene +Phenanthrene
[15] Total Polychlorinated biphenyls (PCB) =sum of 18 congeners x 2, ACOE Total PCB = sum of 22 congeners [NOAA: PCBs 8,8/5,18,28,44,52,66,87,101,101/90,105,118,128,138,153,153/132,168,170,170/190,180,187,195,195/208,206,209. ACOEs: 49.87.183.184]
[16] CT Department of Public Health guidelines for PCBs ➔ fish advisory of 700 ppb (100 ppb wet) (USEPA – USACOE, 2003)
[17] Total butylins (sum of 3) = Dibutyltin + Monobutyltin + Tributyltin

Table 4-18: Organic Pollutant Concentrations in Benthic Tissue (1994-2005) - ng/g dry weight[1,2,3,4]

Analyte	Blue Crab				Worm		Clam		American Lobster								FDA Action Level[5]	Ecological Effects Value[6]
		WLIS		ELIS		CLIS		CLIS	Western LIS				Central LIS					
	N	NCA	N	NCA	N	ACOE	N	ACOE	N	NCA	N	ACOE	N	NCA	N	ACOE		
Pesticides																		
Total Chlordanes[7]	1	3.00	1	4.40	3	4.00	3	2.00	1	2.03	5	0.700	2	4.81	5	0.700	2100	448
Total Chlorobenzenes[8]	1	1.00	1	1.30					1	0.507			2	1.20				
Total DDT[9]	1	27.9	1	7.40	3	35.9	3	12.0	1	6.30	5	8.80	2	7.07	5	8.10	35000	21000
Dieldrin	1	2.00	1	1.30	3	3.10	3	1.50	1	0.348	5	7.80	2	1.20	5	6.40	2100	30.59
Total Endosulfans[10]	1	9.30	1	3.80	3	2.20	3	2.30	1	1.52	5	0.800	2	2.47	5	0.800		19.95
Endrin	1	1.00	1	1.30					1	0.507			2	1.20				
Total HCHs[11]	1	1.00	1	6.30					1	1.52			2	3.67				
Mirex	1	1.00	1	1.30					1	0.507			2	1.20				
PAHs																		
Total PAH[12]	1	7.00	1	580	3	547	3	378	1	329	5	102	2	313	5	83.0		70000
Total HPAH[13]	1	2.70	1	252					1	96.3			2	235				
Benzo(a)pyrene	1	0.240	1	25.2	3	32.3	3	27.6			5	9.70			5	6.10		56000
Total LPAH[14]	1	4.10	1	278					1	132			2	313				
Anthracene	1	0.100	1	25.2	3	10.1	3	8.1			5	0.600			5	0.400		26250
PCBs/Other																		
Total PCB[15,16]	1	91.4	1	46.7	3	464	3	199	1	10.3	5	110	2	24.5	5	114	1400	28000
PCB 77 (dioxin like)	1	1.00	1	1.26					1	0.507			2	1.20				
PCB126 (dioxin like)	1	1.00	1	1.26					1	0.507			2	1.20				
2,3,7,8-TCDD					3	ND-0.005	3	ND-0.005										

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS, ELIS = Eastern LIS

[1]Sources: USEPA – USACOE, 2003; USEPA – NCA, 2005.
[2]American Lobster (*Homarus americanus*), blue crab (*Callinectes sapidus*), worm (*Nephtys incisa*), clam (*Pitar morrhuana*)
[3]All FDA and EEV values were multiplied by a wet to dry weight factor of 7 (estimate of 85% tissue moisture content).
[4]ACOE reported values are averages for composite samples.
[5]U.S. Food and Drug Administration (FDA) Action Level for Crustacea and Mollusks (USFDA, 2003)
[6]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[7]Total chlordanes (sum of 4)= alpha chlordane + heptachlor + heptachlor epoxide + trans-nonachlor
[8]Total chlorobenzenes (sum of 4) = 1,2,3,4-Tetrachlorobenzene + 1,2,4,5-Tetrachlorobenzene + Hexachlorobenzene + Pentachlorobenzene
[9]Total DDT (sum of 6) =2,4'-DDD (o,p'-DDD) + 2,4'-DDE (o,p'-DDE) + 2,4'-DDT (o,p'-DDT) + 4,4'-DDD (p,p' DDD) + 4,4'-DDE (p,p' DDE) + 4,4'-DDT (p,p' DDT)
[10]Endosulfans(sum of 4) = Endosulfan + Endosulfan I (alpha-endosulfan) + Endosulfan II (beta-endosulfan) + Endosulfan Sulfate
[11] Total HCH = Hexachlorocyclohexane = alpha-HCH + beta-HCH, delta-HCH, gamma-HCH, Lindane,
[12] Total polycyclic aromatic hydrocarbon (PAHs) ➔ NCA, NOAA, and SQUID = low molecular weight PAH + high molecular weight PAH; ACOE = sum of 16 PAHs
[13] Total high molecular weight PAH (HPAH) (12) = Benz(a)anthracene +Benzo(a)pyrene +Benzo(b)fluoranthene +Benzo(e)pyrene+Benzo(g,h,i)perylene +Benzo(k)fluoranthene +Chrysene +Dibenz(a,h)anthracene +Fluoranthene +Indeno(1,2,3-c,d)pyrene +Perylene +Pyrene
[14]Total low molecular weight PAH (LPAH) (12) = 1,6,7-Trimethylnaphthalene +1-methylphenanthrene +2,6-dimethylnaphthalene +2-methylnaphthalene +Acenaphthylene +Acenaphthene +Anthracene +Biphenyl +Dibenzothiophene +Fluorene +Naphthalene +Phenanthrene
[15] Total Polychlorinated biphenyls (PCB) =sum of 18 congeners x 2, ACOE Total PCB = sum of 22 congeners [NOAA: PCBs 8,8/5,18,28,44,52,66,87,101,101/90,105,118,128,138,153,153/132,168,170,170/190,180,187,195,195/208,206,209. ACOEs: 49.87.183.184]
[16] CT Department of Public Health guidelines for PCBs ➔ fish advisory of 700 ppb (100 ppb wet) (USEPA – USACOE, 2003)

Table 4-19: Organic Pollutant Concentrations in Winter Flounder (1994-2005) - ng/g dry weight[1,2,3,4]

Analyte	Army Corps of Engineers										National Coastal Assessment						FDA Action Level[8]	Ecological Effects Value[9]
	WLIS		CLIS		CLIS[5]		CLIS[6]		CLIS[7]		Central Long Island Sound							
	N	Average	N	Average	N	Average	N	Average	N	Average	N	Median	Average	Stdev	Max	Min		
Pesticides																		
Total chlordanes[10]	2	6.50	2	6.10	2	6.80	3	3.80	2	4.80	4	19.0	15.7	8.55	21.7	3.00	1500	320
Total chlorobenzenes[11]											4	1.00	1.00	0	1.00	1.00		
Total DDT[12]	2	26.0	2	36.0	2	36.0	3	20.0	2	31.0	4	13.3	13.6	1.45	15.6	12.2	25000	15000
Dieldrin	2	4.20	2	4.50	2	4.20	3	2.10	2	3.90	4	1.00	0.750	0.500	1.00	0	1500	21.9
Endosulfans[13]											4	14.2	13.8	10.8	23.2	3.50		
Endrin											4	1.00	1.00	0	1.00	1.00		
Total HCHs[14]											4	1.00	1.00	0	1.00	1.00		
Mirex											4	1.00	1.00	0	1.00	1.00		
PAHs																		
Total PAH[15]	2	10.0	2	8.00	2	26.5	3	6.00	2	9.00	4	2.03	2.23	0.928	3.51	1.37		50000
Total HPAH[16]											4	0.215	0.243	0.135	0.430	0.110		
Total LPAH[17]											4	1.81	1.99	0.800	3.08	1.26		
PCBs/Other																		
Total PCBs[18,19]	2	321	2	476	2	492	3	269	2	387	4	32.5	31.8	1.79	33.2	29.2	10000	20000
PCB 77 (dioxin like)											4	1.00	1.00	0	1.00	1.00		
PCB110/77 (dioxin like)											4	2.45	2.38	0.287	2.60	2.00		
PCB126 (dioxin like)											4	1.00	1.00	0	1.00	1.00		
2,3,7,8-TCDD	2	ND-0.004	2	ND-0.006	2	ND-0.003	3	ND-0.006	2	ND-0.003								

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS

[1]Sources: USEPA – USACOE, 2003; USEPA – NCA, 2005.
[2] Winter flounder (*Pleuronectes americanus*)
[3]All FDA and EEV values were multiplied by a wet to dry weight factor of 5 (estimate of 80% tissue moisture content).
[4]ACOE reported values are averages for composite samples.
[5]CLIS - Mud, water depth 60-90 ft, [6]CLIS - Mud, water depth >90 ft, [7]CLIS - Mud to sand, water depth 60-90 ft.
[8]U.S. Food and Drug Administration (FDA) Action Level (USFDA, 2003)
[9]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[10]Total chlordanes (sum of 4)= alpha chlordane + heptachlor + heptachlor epoxide + trans-nonachlor
[11]Total chlorobenzenes (sum of 4) = 1,2,3,4-Tetrachlorobenzene + 1,2,4,5-Tetrachlorobenzene + Hexachlorobenzene + Pentachlorobenzene
[12]Total DDT (sum of 6) =2,4'-DDD (o,p'-DDD) + 2,4'-DDE (o,p'-DDE) + 2,4'-DDT (o,p'-DDT) + 4,4'-DDD (p,p' DDD) + 4,4'-DDE (p,p' DDE) + 4,4'-DDT (p,p' DDT)
[13]Endosulfans(sum of 4) = Endosulfan + Endosulfan I (alpha-endosulfan) + Endosulfan II (beta-endosulfan) + Endosulfan Sulfate
[14] Total HCH = Hexachlorocyclohexane = alpha-HCH + beta-HCH, delta-HCH, gamma-HCH, Lindane,
[15] Total polycyclic aromatic hydrocarbon (PAHs) ➔ NCA = low molecular weight PAH + high molecular weight PAH; ACOE = sum of 16 PAHs
[16]Total high molecular weight PAH (HPAH) (12) = Benz(a)anthracene +Benzo(a)pyrene +Benzo(b)fluoranthene +Benzo(e)pyrene+Benzo(g,h,i)perylene +Benzo(k)fluoranthene +Chrysene +Dibenz(a,h)anthracene +Fluoranthene +Indeno(1,2,3-c,d)pyrene +Perylene +Pyrene
[17]Total low molecular weight PAH (LPAH) (12) = 1,6,7-Trimethylnaphthalene +1-methylphenanthrene +2,6-dimethylnaphthalene +2-methylnaphthalene +Acenaphthylene +Acenaphthene +Anthracene +Biphenyl +Dibenzothiophene +Fluorene +Naphthalene +Phenanthrene
[18] Total Polychlorinated biphenyls (PCB) =sum of 18 congeners x 2, ACOE Total PCB = sum of 22 congeners [NOAA: PCBs 8,8/5,18,28,44,52,66,87,101,101/90,105,118,128,138,153,153/132,168,170,170/190,180,187,195,195/208,206,209. ACOEs: 49.87.183.184]
[19] CT Department of Public Health guidelines for PCBs ➔ fish advisory of 500 ppb (100 ppb wet) (USEPA – USACOE, 2003)

Table 4-20: Organic Pollutant Concentrations in Striped Bass, Bluefish, and Channel Catfish (2000 - 2001) - ng/g dry weight[1,2,3,4]

Analyte	Striped bass				Bluefish				Channel Catfish		FDA Action Level[6]	Ecological Effects Value[7]
	WLIS		CLIS		CLIS		CLIS[5]		ELIS			
	N	Avg	N	Avg	N	Avg	N	Avg	N	Avg		
Pesticides												
Total chlordanes[8]	1	7.5	1	9.5	1	20.5	1	16	1	1.8	1500	320
Total chlorobenzenes[9]									1	0.3		
Total DDT[10]	1	143	1	187	1	152	1	120	1	5.5	25000	15000
Dieldrin	1	6	1	17.5	1	35.5	1	37.5	1	0.3	1500	21.9
Endosulfans[11]									1	1		
Endrin									1	0.3		
Total HCHs[12]									1	1.7		
Mirex									1	0.3		
PAHs												
Total PAH[13]	1	52	1	17	1	31.5	1	22	1	152		50000
Total HPAH[14]									1	66.1		
Benzo(a)pyrene									1	6.6		
Total LPAH[15]									1	72.7		
Anthracene									1	6.6		
PCBs/Other												
Total PCBs[16,17]	1	1550	1	1840	1	1500	1	4270	1	45.9	10000	20000
PCB 77 (dioxin like)									1	0.33		
PCB110/77 (dioxin like)												
PCB126 (dioxin like)									1	0.33		
2,3,7,8-TCDD	1	ND-0.008	1	ND-0.004	1	ND-0.008	1	ND-0.005				

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS, ELIS = Eastern LIS

[1]Sources: USEPA – USACOE, 2003; USEPA – NCA, 2005.
[2]Striped bass (*Morone saxatilis*), Bluefish (*Pomatus saltatrix*), Channel catfish (*Ictalurus punctatus*)
[3]All FDA and EEV values were multiplied by a wet to dry weight factor of 5 (estimate of 80% tissue moisture content).
[4]ACOE reported values are averages for composite samples.
[5]CLIS - Mud, water depth 60-90 ft
[6]U.S. Food and Drug Administration (FDA) Action Level (USFDA, 2003)
[7]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[8]Total chlordanes (sum of 4)= alpha chlordane + heptachlor + heptachlor epoxide + trans-nonachlor
[9]Total chlorobenzenes (sum of 4) = 1,2,3,4-Tetrachlorobenzene + 1,2,4,5-Tetrachlorobenzene + Hexachlorobenzene + Pentachlorobenzene
[10]Total DDT (sum of 6) =2,4'-DDD (o,p'-DDD) + 2,4'-DDE (o,p'-DDE) + 2,4'-DDT (o,p'-DDT) + 4,4'-DDD (p,p' DDD) + 4,4'-DDE (p,p' DDE) + 4,4'-DDT (p,p' DDT)
[11]Endosulfans(sum of 4) = Endosulfan + Endosulfan I (alpha-endosulfan) + Endosulfan II (beta-endosulfan) + Endosulfan Sulfate
[12] Total HCH = Hexachlorocyclohexane = alpha-HCH + beta-HCH, delta-HCH, gamma-HCH, Lindane,
[13] Total polycyclic aromatic hydrocarbon (PAHs) ➔ NCA = low molecular weight PAH + high molecular weight PAH; ACOE = sum of 16 PAHs
[14] Total high molecular weight PAH (HPAH) (12) = Benz(a)anthracene +Benzo(a)pyrene +Benzo(b)fluoranthene +Benzo(e)pyrene+Benzo(g,h,i)perylene +Benzo(k)fluoranthene +Chrysene +Dibenz(a,h)anthracene +Fluoranthene +Indeno(1,2,3-c,d)pyrene +Perylene +Pyrene
[15]Total low molecular weight PAH (LPAH) (12) = 1,6,7-Trimethylnaphthalene +1-methylphenanthrene +2,6-dimethylnaphthalene +2-methylnaphthalene +Acenaphthylene +Acenaphthene +Anthracene +Biphenyl +Dibenzothiophene +Fluorene +Naphthalene +Phenanthrene
[16] Total Polychlorinated biphenyls (PCB) =sum of 18 congeners x 2, ACOE Total PCB = sum of 22 congeners [NOAA: PCBs 8,8/5,18,28,44,52,66,87,101,101/90,105,118,128,138,153,153/132,168,170,170/190,180,187,195,195/208,206,209. ACOEs: 49.87.183.184]
[17] CT Department of Public Health guidelines for PCBs ➔ fish advisory of 500 ppb (100 ppb wet) (USEPA – USACOE, 2003)

Table 4-21: ACOE Organic Pollutant Concentrations in Scup (2000 - 2001) - ng/g dry weight[1,2,3,4]

Analyte	Scup										FDA Action Level[8]	Ecological Effects Value[9]
		WLIS		CLIS		CLIS[5]		CLIS[6]		CLIS[7]		
	N	Average	N	Average	N	Average	N	Average	N	Average		
Pesticides												
Total Chlordanes[10]	2	4.2	2	2.9	2	3.8	3	4.7	2	2.3	1500	320
Total Chlorobenzenes[11]	2											
Total DDT[12]	2	35	2	41.5	2	63.5	3	62.5	2	24.5	25000	15000
Dieldrin	2	5	2	10.5	2	14.6	3	14.3	2	2.9	1500	21.9
Total Endosulfans[13]												
Endrin												
Total HCHs[14]												
Mirex												
PAHs												
Total PAH[15]	2	9	2	11.5	2	14	3	19	2	9		50000
Total HPAH[16]												
Benzo(a)pyrene												
Total LPAH[17]												
Anthracene												
PCBs/Other												
Total PCBs[18,19]	2	372	2	601	2	832	3	778	2	343	10000	20000
PCB 77 (dioxin like)												
PCB110/77 (dioxin like)												
PCB126 (dioxin like)												
2,3,7,8-TCDD		ND-0.004		ND-0.006		ND-0.004		ND-0.004		ND-0.005		

WLIS=Western Long Island Sound (LIS), CLIS=Central LIS, ELIS = Eastern LIS

[1]Source: USEPA – USACOE, 2003.
[2]Scup (*Stenotomus chrysops*)
[3]All FDA and EEV values were multiplied by a wet to dry weight factor of 5 (estimate of 80% tissue moisture content).
[4]ACOE reported values are averages for composite samples.
[5]CLIS - Mud, water depth 60-90 ft, [6]CLIS - Mud, water depth >90 ft, [7]CLIS - Mud to sand, water depth 60-90 ft.
[8]U.S. Food and Drug Administration (FDA) Action Level (USFDA, 2003)
[9]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[10]Total chlordanes (sum of 4)= alpha chlordane + heptachlor + heptachlor epoxide + trans-nonachlor
[11]Total chlorobenzenes (sum of 4) = 1,2,3,4-Tetrachlorobenzene + 1,2,4,5-Tetrachlorobenzene + Hexachlorobenzene + Pentachlorobenzene
[12]Total DDT (sum of 6) =2,4'-DDD (o,p'-DDD) + 2,4'-DDE (o,p'-DDE) + 2,4'-DDT (o,p'-DDT) + 4,4'-DDD (p,p' DDD) + 4,4'-DDE (p,p' DDE) + 4,4'-DDT (p,p' DDT)
[13]Endosulfans(sum of 4) = Endosulfan + Endosulfan I (alpha-endosulfan) + Endosulfan II (beta-endosulfan) + Endosulfan Sulfate
[14] Total HCH = Hexachlorocyclohexane = alpha-HCH + beta-HCH, delta-HCH, gamma-HCH, Lindane,
[15] Total polycyclic aromatic hydrocarbon (PAHs) ➔ NCA = low molecular weight PAH + high molecular weight PAH; ACOE = sum of 16 PAHs
[16]Total high molecular weight PAH (HPAH) (12) = Benz(a)anthracene +Benzo(a)pyrene +Benzo(b)fluoranthene +Benzo(e)pyrene+Benzo(g,h,i)perylene +Benzo(k)fluoranthene +Chrysene +Dibenz(a,h)anthracene +Fluoranthene +Indeno(1,2,3-c,d)pyrene +Perylene +Pyrene
[17]Total low molecular weight PAH (LPAH) (12) = 1,6,7-Trimethylnaphthalene +1-methylphenanthrene +2,6-dimethylnaphthalene +2-methylnaphthalene +Acenaphthylene +Acenaphthene +Anthracene +Biphenyl +Dibenzothiophene +Fluorene +Naphthalene +Phenanthrene
[18] Total Polychlorinated biphenyls (PCB) =sum of 18 congeners x 2, ACOE Total PCB = sum of 22 congeners [NOAA: PCBs 8,8/5,18,28,44,52,66,87,101,101/90,105,118,128,138,153,153/132,168,170,170/190,180,187,195,195/208,206,209. ACOEs: 49.87.183.184]
[19] CT Department of Public Health guidelines for PCBs ➔ fish advisory of 500 ppb (100 ppb wet) (USEPA – USACOE, 2003) [5]U.S. Food and Drug Administration (FDA) Action Level for Crustacea and Mollusks (USFDA, 2003)

Table 4-22: National Coastal Assessment Organic Pollutant Concentrations in Scup (2001) - ng/g dry weight[1,2,3]

Pesticides	Long Island Sound						FDA Action Level[4]	Ecological Effects Value[5]
	N	Median	Average	Stdev	Max	Min		
Total Chlordanes[6]	18	4.98	4.84	3.83	19.0	1.69	1500	320
Total Chlorobenzenes[7]	18	1.13	0.988	0.394	1.38	0.249		
Total DDT[8]	17	7.61	8.62	6.50	23.9	3.29	25000	15000
Dieldrin	18	1.18	1.34	1.56	7.40	0.249	1500	21.9
Total Endosulfans[9]	18	3.74	4.86	5.59	25.7	1.32		
Endrin	18	1.13	0.988	0.394	1.38	0.249		
Total HCHs[10]	18	4.36	3.58	1.67	5.31	1.00		
Mirex	18	1.13	0.988	0.394	1.38	0.249		
PAHs								
Total PAH[11]	18	330	441	401	1444	2.06		50000
Total HPAH[12]	18	249	300	324	1160	0.150		
Total LPAH[13]	19	284	233	127	341	1.21		
Other								
Total PCBs[14,15]	19	23.7	26.4	17.4	68.6	9.50	10000	20000
PCB 77 (dioxin like)	18	1.13	0.988	0.394	1.38	0.249		
PCB110/77 (dioxin like)	2	3.00	3.00	1.41	4.00	2.00		
PCB126 (dioxin like)	18	1.13	0.988	0.394	1.38	0.249		
Pesticides	**Western Long Island Sound**						**FDA[4]**	**EEV[5]**
	N	**Median**	**Average**	**Stdev**	**Max**	**Min**		
Total Chlordanes[6]	3	1.69	2.89	2.08	5.30	1.69	1500	320
Total Chlorobenzenes[7]	3	0.627	0.636	0.359	1.00	0.282		
Total DDT[8]	2	3.65	3.65	0.002	3.65	3.65	25000	15000
Dieldrin	3	0.627	2.77	4.01	7.40	0.282	1500	21.9
Total Endosulfans[9]	3	1.36	9.48	14.1	25.7	1.36		
Endrin	3	0.627	0.636	0.359	1.00	0.282		
Total HCHs[10]	3	1.82	1.55	0.472	1.82	1.00		
Mirex	3	0.627	0.636	0.359	1.00	0.282		
PAHs								
Total PAH[11]	3	1444	964	833	1444	2.06		50000
Total HPAH[12]	3	1160	774	669	1160	0.850		
Total LPAH[13]	4	143	143	163	284	1.21		
Other								
Total PCBs[14,15]	4	40.9	40.9	32.0	68.6	13.2	10000	20000
PCB 77 (dioxin like)	3	0.627	0.636	0.359	1.00	0.282		
PCB110/77 (dioxin like)	1	4.00	4.00		4.00	4.00		
PCB126 (dioxin like)	3	0.627	0.636	0.359	1.00	0.282		

Table 4-22 (continued): National Coastal Assessment Organic Pollutant Concentrations in Scup (2001) - ng/g dry weight[1,2,3]

Pesticides	Central Long Island Sound						FDA[4]	EEV[5]
	N	Median	Average	Stdev	Max	Min		
Total Chlordanes[6]	9	4.98	5.98	4.97	19.0	2.87	1500	320
Total Chlorobenzenes[7]	9	1.15	1.08	0.320	1.38	0.282		
Total DDT[8]	9	7.61	7.64	3.39	15.8	4.27	25000	15000
Dieldrin	9	1.15	1.08	0.320	1.38	0.282	1500	21.9
Total Endosulfans[9]	9	3.74	3.64	1.31	6.60	2.15		
Endrin	9	1.15	1.08	0.320	1.38	0.282		
Total HCHs[10]	9	4.36	3.92	1.38	4.98	1.00		
Mirex	9	1.15	1.08	0.320	1.38	0.282		
PAHs								
Total PAH[11]	9	330	315	148	501	3.32		50000
Total HPAH[12]	9	218	194	85.8	261	0.15		
Total LPAH[13]	9	283	252	111	340	3.17		
Other								
Total PCBs[14,15]	9	24.2	24.7	10.6	47.2	12.9	10000	20000
PCB 77 (dioxin like)	9	1.15	1.08	0.320	1.38	0.282		
PCB110/77 (dioxin like)	1	2.00	2.00		2.00	2.00		
PCB126 (dioxin like)	9	1.15	1.08	0.320	1.38	0.282		
Pesticides	**Eastern Long Island Sound**						**FDA[4]**	**EEV[5]**
	N	**Median**	**Average**	**Stdev**	**Max**	**Min**		
Total Chlordanes[6]	6	5.24	4.10	1.82	5.31	1.76	1500	320
Total Chlorobenzenes[7]	6	1.28	1.03	0.472	1.37	0.25		
Total DDT[8]	6	7.96	11.7	9.68	23.9	3.29	25000	15000
Dieldrin	6	1.28	1.03	0.472	1.37	0.249	1500	21.9
Total Endosulfans[9]	6	3.98	4.39	2.94	7.87	1.32		
Endrin	6	1.28	1.03	0.47	1.37	0.249		
Total HCHs[10]	6	5.24	4.10	1.82	5.31	1.76		
Mirex	6	1.28	1.03	0.47	1.37	0.249		
PAHs								
Total PAH[11]	6	302	369	193	605	144		50000
Total HPAH[12]	6	262	224	61.8	265	144		
Total LPAH[13]	6	340	265	117	341	113		
Other								
Total PCBs[14,15]	6	23.7	19.4	7.72	25.1	9.50	10000	20000
PCB 77 (dioxin like)	6	1.28	1.03	0.472	1.37	0.249		
PCB126 (dioxin like)	6	1.28	1.03	0.472	1.37	0.249		

[1]USEPA – NCA, 2005
[2]Scup (*Stenotomus chrysops*)
[3]All FDA and EEV values were multiplied by a wet to dry weight factor of 5 (estimate of 80% tissue moisture content).
[4]U.S. Food and Drug Administration (FDA) Action Level (USFDA, 2003)
[5]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[6]Total chlordanes (sum of 4)= alpha chlordane + heptachlor + heptachlor epoxide + trans-nonachlor
[7]Total chlorobenzenes (sum of 4) = 1,2,3,4-Tetrachlorobenzene + 1,2,4,5-Tetrachlorobenzene + Hexachlorobenzene + Pentachlorobenzene
[8]Total DDT (sum of 6) =2,4'-DDD (o,p'-DDD) + 2,4'-DDE (o,p'-DDE) + 2,4'-DDT (o,p'-DDT) + 4,4'-DDD (p,p' DDD) + 4,4'-DDE (p,p' DDE) + 4,4'-DDT (p,p' DDT)
[9]Endosulfans(sum of 4) = Endosulfan + Endosulfan I (alpha-endosulfan) + Endosulfan II (beta-endosulfan) + Endosulfan Sulfate
[10] Total HCH = Hexachlorocyclohexane = alpha-HCH + beta-HCH, delta-HCH, gamma-HCH, Lindane,
[11] Total polycyclic aromatic hydrocarbon (PAHs) ➔ NCA = low molecular weight PAH + high molecular weight PAH; ACOE = sum of 16 PAHs
[12] Total high molecular weight PAH (HPAH) (12) = Benz(a)anthracene +Benzo(a)pyrene +Benzo(b)fluoranthene +Benzo(e)pyrene+Benzo(g,h,i)perylene +Benzo(k)fluoranthene +Chrysene +Dibenz(a,h)anthracene +Fluoranthene +Indeno(1,2,3-c,d)pyrene +Perylene +Pyrene
[13]Total low molecular weight PAH (LPAH) (12) = 1,6,7-Trimethylnaphthalene +1-methylphenanthrene +2,6-dimethylnaphthalene +2-methylnaphthalene +Acenaphthylene +Acenaphthene +Anthracene +Biphenyl +Dibenzothiophene +Fluorene +Naphthalene +Phenanthrene
[14] Total Polychlorinated biphenyls (PCB) =sum of 18 congeners x 2, ACOE Total PCB = sum of 22 congeners [NOAA: PCBs 8,8/5,18,28,44,52,66,87,101,101/90,105,118,128,138,153,153/132,168,170,170/190,180,187,195,195/208,206,209. ACOEs: 49.87.183.184]
[15] CT Department of Public Health guidelines for PCBs ➔ fish advisory of 500 ppb (100 ppb wet) (USEPA – USACOE, 2003)

Table 4-23: National Coastal Assessment Organic Pollutant Concentrations in Summer Flounder (2001) - ng/g dry weight[1,2,3]

Pesticides	Long Island Sound						FDA Action Level[26]	Ecological Effects Value[5]
	N	Median	Average	Stdev	Max	Min		
Total Chlordanes[6]	19	5.10	6.80	4.77	19.6	4.00		
Total Chlorobenzenes[7]	19	1.15	1.14	0.13	1.41	1.00	1500	320
Total DDT[8]	19	7.83	15.2	16.2	74.6	6.85		
Dieldrin	19	1.20	1.27	0.60	3.70	1.00	25000	15000
Total Endosulfans[9]	19	3.94	8.45	8.00	24.0	3.30	1500	21.9
Endrin	19	1.15	1.14	0.13	1.41	1.00		
Total HCHs[10]	19	4.57	3.44	1.93	5.25	1.00		
Mirex	18	1.17	1.14	0.13	1.41	1.00		
PAHs								
Total PAH[11]	18	257	261	222	580	2.13		
Total HPAH[12]	19	228	153	120	258	0.140		50000
Total LPAH[13]	18	297	211	153	340	1.96		
Other								
Total PCBs[14,15]	18	25.8	39.4	29.7	134	20.4	10000	20000
PCB 77 (dioxin like)	19	1.15	1.14	0.13	1.41	1.00		
PCB110/77 (dioxin like)	7	3.70	5.04	2.44	9.20	3.00		
PCB126 (dioxin like)	19	1.15	1.14	0.13	1.41	1.00		
Pesticides	**Western Long Island Sound**						**EEV**	**FDA**
	N	**Median**	**Average**	**Stdev**	**Max**	**Min**		
Total Chlordanes[6]	2	7.65	7.65	5.16	11.30	4.00		
Total Chlorobenzenes[7]	2	1.00	1.00	0.00	1.00	1.00	1500	320
Total DDT[8]	2	43.1	43.1	44.6	74.6	11.5		
Dieldrin	2	2.35	2.35	1.91	3.70	1.00	25000	15000
Total Endosulfans[9]	2	18.8	18.8	7.42	24.0	13.5	1500	21.9
Endrin	2	1.00	1.00	0.00	1.00	1.00		
Total HCHs[10]	2	1.00	1.00	0.00	1.00	1.00		
Mirex	2	1.00	1.00	0.00	1.00	1.00		
PAHs								
Total PAH[11]	1	3.37	3.37		3.37	3.37		
Total HPAH[12]	2	0.235	0.235	0.092	0.300	0.170		50000
Total LPAH[13]	1	3.07	3.07		3.07	3.07		
Other								
Total PCBs[14,15]	1	134	134		134	134	10000	20000
PCB 77 (dioxin like)	2	1.00	1.00	0.00	1.00	1.00		
PCB110/77 (dioxin like)	2	6.10	6.10	4.38	9.20	3.00		
PCB126 (dioxin like)	2	1.00	1.00	0.00	1.00	1.00		

Table 4-23 (continued): National Coastal Assessment Organic Pollutant Concentrations in Summer Flounder (2001) - ng/g dry weight[1,2,3]

Pesticides	Central Long Island Sound						EEV	FDA
	N	Median	Average	Stdev	Max	Min		
Total Chlordanes[6]	13	5.10	7.28	5.49	19.6	4.19		
Total Chlorobenzenes[7]	13	1.15	1.14	0.14	1.41	1.00	1500	320
Total DDT[8]	13	8.00	13.4	8.62	34.0	7.55		
Dieldrin	13	1.06	1.13	0.14	1.41	1.00	25000	15000
Total Endosulfans[9]	13	3.94	8.36	8.12	23.2	3.30	1500	21.9
Endrin	13	1.15	1.14	0.14	1.41	1.00		
Total HCHs[10]	13	4.41	3.39	1.99	5.25	1.00		
Mirex	13	1.15	1.14	0.14	1.41	1.00		
PAHs								
Total PAH[11]	13	239	192	175	552	2.13		
Total HPAH[12]	13	215	149	123	258	0.14		50000
Total LPAH[13]	13	286	196	160	340	1.96		
Other								
Total PCBs[14,15]	13	26.7	37.6	19.8	88.5	22.3	10000	20000
PCB 77 (dioxin like)	13	1.15	1.14	0.14	1.41	1.00		
PCB110/77 (dioxin like)	5	3.70	4.62	1.83	7.70	3.30		
PCB126 (dioxin like)	13	1.15	1.14	0.138	1.41	1		
Pesticides	**Eastern Long Island Sound**						**EEV**	**FDA**
	N	**Median**	**Average**	**Stdev**	**Max**	**Min**		
Total Chlordanes[6]	4	4.80	4.80	0.273	5.04	4.57		
Total Chlorobenzenes[7]	4	1.20	1.20	0.093	1.31	1.08	1500	320
Total DDT[8]	4	7.21	7.21	0.410	7.56	6.85		
Dieldrin	4	1.20	1.20	0.093	1.31	1.08	25000	15000
Total Endosulfans[9]	4	3.60	3.60	0.205	3.78	3.43	1500	21.9
Endrin	4	1.20	1.20	0.093	1.31	1.08		
Total HCHs[10]	4	4.80	4.80	0.273	5.04	4.57		
Mirex	4	1.20	1.20	0.093	1.31	1.08		
PAHs								
Total PAH[11]	4	552	552	31	580	525		
Total HPAH[12]	4	240	240	14	252	228		50000
Total LPAH[13]	4	312	312	17.7	328	297		
Other								
Total PCBs[14,15]	4	21.6	21.6	1.29	22.7	20.4	10000	20000
PCB 77 (dioxin like)	3	1.21	1.24	0.062	1.31	1.20		
PCB110/77 (dioxin like)								
PCB126 (dioxin like)	4	1.20	1.20	0.093	1.31	1.08		

[1]USEPA – NCA, 2005
[2]Summer Flounder (*Paralichthys dentatus)*
[3]All FDA and EEV values were multiplied by a wet to dry weight factor of 5 (estimate of 80% tissue moisture content).
[4]U.S. Food and Drug Administration (FDA) Action Level (USFDA, 2003)
[5]Ecological Effects Value (EEVs) (USEPA – USACOE, 2003)
[6]Total chlordanes (sum of 4)= alpha chlordane + heptachlor + heptachlor epoxide + trans-nonachlor
[7]Total chlorobenzenes (sum of 4) = 1,2,3,4-Tetrachlorobenzene + 1,2,4,5-Tetrachlorobenzene + Hexachlorobenzene + Pentachlorobenzene
[8]Total DDT (sum of 6) =2,4'-DDD (o,p'-DDD) + 2,4'-DDE (o,p'-DDE) + 2,4'-DDT (o,p'-DDT) + 4,4'-DDD (p,p' DDD) + 4,4'-DDE (p,p' DDE) + 4,4'-DDT (p,p' DDT)
[9]Endosulfans(sum of 4) = Endosulfan + Endosulfan I (alpha-endosulfan) + Endosulfan II (beta-endosulfan) + Endosulfan Sulfate
[10] Total HCH = Hexachlorocyclohexane = alpha-HCH + beta-HCH, delta-HCH, gamma-HCH, Lindane,
[11] Total polycyclic aromatic hydrocarbon (PAHs) ➔ NCA = low molecular weight PAH + high molecular weight PAH; ACOE = sum of 16 PAHs
[12] Total high molecular weight PAH (HPAH) (12) = Benz(a)anthracene +Benzo(a)pyrene +Benzo(b)fluoranthene +Benzo(e)pyrene+Benzo(g,h,i)perylene +Benzo(k)fluoranthene +Chrysene +Dibenz(a,h)anthracene +Fluoranthene +Indeno(1,2,3-c,d)pyrene +Perylene +Pyrene
[13]Total low molecular weight PAH (LPAH) (12) = 1,6,7-Trimethylnaphthalene +1-methylphenanthrene +2,6-dimethylnaphthalene +2-methylnaphthalene +Acenaphthylene +Acenaphthene +Anthracene +Biphenyl +Dibenzothiophene +Fluorene +Naphthalene +Phenanthrene
[14] Total Polychlorinated biphenyls (PCB) =sum of 18 congeners x 2, ACOE Total PCB = sum of 22 congeners [NOAA: PCBs 8,8/5,18,28,44,52,66,87,101,101/90,105,118,128,138,153,153/132,168,170,170/190,180,187,195,195/208,206,209. ACOEs: 49.87.183.184]
[15] CT Department of Public Health guidelines for PCBs ➔ fish advisory of 500 ppb (100 ppb wet) (USEPA – USACOE, 2003)

Overall, the blue mussel data indicate that total endosulfans, dioxin-like PCBs, and PCBs exceed levels typically measured in other estuarine systems throughout the U.S. Levels of DDT, PAHs, and tributyltin, however, may have fallen since 1989. Concentrations of most pollutants in blue mussel samples were also generally measured in higher concentrations in WLIS, while lowest in ELIS. These findings likely correspond to the trend from finer-grained, higher-carbon content sediments in the west to coarser-grained, lower-carbon sediments in the east.

Concentrations of most organic pollutants reviewed were generally found at higher levels in bluefish and striped bass, specifically those samples collected from WLIS. Because these fish are more migratory than the other fish used in the EPA/ACOE study, they may be exposed to contaminants in areas other than LIS (USEPA - USACOE, 2003). However, with the exception of PCBs, organic pollutant values did not exceed any FDA action levels or EEVs.

4.3.2.1 Lobster Die-Off

In 1999, LIS experienced a massive lobster die-off that reduced landings by 90-99.99% in WLIS and 60-80% in CLIS and ELIS (De Guise et al., 2004). Since 1999, significant research has been focused on understanding the causes of the lobster die-off. While recent findings indicate that temperature, storm events, and hypoxia may have contributed to the lobster die-off (Sea Grant, 2005), several studies have looked into the effects of organic pollutants on lobster health. Of key interest are the pesticides malathion, methoprene, resmethrin and sumithrin, chemicals that have been used in an effort to control mosquitoes carrying the West Nile virus. Because the application of these pesticides coincided with the 1999 lobster die-off, they were first implicated as one of the possible causes for the decline in lobster landings (De Guise et al., 2004 and Walker et al., 2005).

No detectable concentrations of malathion were measured in lobsters that were sampled during the 1999 event. However, experimental findings indicate that adult lobsters are highly sensitive to the pesticide. Single-dose static toxicity tests done by De Guise et al. (2004) determined a 96-h 50% lethal concentration (LC50) of 38 μg/L, a level that is half of the LC50 for walleye (60 μg/L). Lobster immunotoxicity was also observed at levels 5-7 times lower than the LC50. Tests done by Zulkosky et al. (2005) on stage I-II larval lobsters reported a 48-h LC50 of 3.7 μg/L for malathion based on flow-through tests.

While lobsters are highly susceptible to the acute toxicity of malathion, bioconcentration of the chemical is not likely because its half-life in lobsters is only 12 hours. De Guise et al.'s (2004) study measured no detectable levels in lobster tissue after 5 days of exposure. However, other experiments have reported concentrations of malathion in brown shrimp at levels 800 times higher than those found in the water column (De Guise et al., 2004).

Experimental testing of methoprene toxicity on stage I-II larval lobsters indicated no toxicity at 10 μg/L (Zulkosky et al., 2005). Other studies, however, have noted adverse effects on lobster stage II survival and an increase in molt frequency in stage IV larvae at concentrations of 1 and 5 μg/L, respectively (based on static tests). The pesticide was also noted to bioconcentrate up to 125-fold in the adult lobster (Walker et al., 2005).

Zulkosky et al. (2005) found stage I-II larval lobsters to be significantly more susceptible to resmethrin than to malathion or methoprene. Flow-through tests demonstrated LC50 values of 0.26 μg/L at 48-h and 0.095 μg/L at 96-h upon exposure to resmethrin at 16°C. At a dose of 10 μg/L, however, tests on resmethrin exposure on juvenile lobsters did not result in mortality, demonstrating that juvenile lobsters are less sensitive to the pesticide than larval lobsters (Zulkosky et al., 2005). Similarly, De Guise et al. (2005) noted a 96-h LC50 greater than 1 μg/L upon a single exposure of adult lobsters to resmethrin. Additional tests done by De Guise et al. (2005), noted a 14-day LC50 of 0.75 μg/L and indicated that prolonged exposure to low concentrations of resmethrin can result in adverse effects. Immunotoxicity was observed at resmethrin concentrations 10 to 100 times lower than the 96-h LC50 (De Guise et al., 2005).

While malathion, methoprene, and resmethrin pose a level of toxicity risk to the aquatic life of LIS, researchers believe that very high levels of these pesticides would have been needed to cause such a massive lobster kill. Water column samples taken off Staten Island an hour after pesticide spray events in 2002 and 2003 indicated resmethrin levels ranging from 0.0017 to 0.980 μg/L at 5 out of the 10 locations sampled (only one sample measured above 0.150 μg/L). Methoprene was measured at concentrations ranging from 0.0074 to 0.631 μg/L. Malathion was not used during the spray events and was not detected in the water column (Zulkosky et al., 2005).

Numeric water quality models have also been used in an attempt to determine the concentration of pesticides in Long Island Sound (Landeck Miller et al., 2005). Results based on conservative model assumptions indicated maximum methoprene, malathion, resmethrin, and sumithrin concentrations of 0.0005 μg/L, 10.3 μg/L, 0.225 μg/L, and 0.151 μg/L, respectively. However, these results were based on a 24 hour, entire mass approach that did not include pesticide loss mechanisms. Model runs using less conservative assumptions resulted in a 24-hour average malathion concentration of 5.4 μg/L in the near surface waters in Flushing Bay and < 1.0 μg/L in the bottom waters of the rest of Long Island Sound. Resmethrin and sumithrin concentrations in near surface waters were noted at 0.034 μg/L and 0.099 μg/L in Flushing and Eastchester Bays, respectively. Concentrations of resmethrin in near bottom waters were noted at < 0.01 μg/L throughout LIS (Landeck Miller et al., 2005). Based on these findings, the study concluded that methoprene and malathion concentrations did not cause the lobster die-off and that levels of resmethrin and sumithrin were not likely to have caused the lobster die-off (Landeck Miller et al., 2005).

The links between pesticide exposure, climate change, and the 1999 lobster die-off are the subject of on-going research. The effects are complicated, and the interplay of stressors and chemicals or disease that could ultimately impact aquatic populations will require much additional research. Recent findings by Zulkosky et al. (2005) indicate that pesticide levels in the water column were measured below levels that have been determined to be acutely toxic to lobsters. Findings by De Guise et al. (2005), however, indicate that lobsters may be susceptible to prolonged sublethal concentrations of resmethrin, conditions that may result in increased susceptibility to infectious diseases. It is also important to note, however, that malathion has not been used since 1999 and that the use of resmethrin and sumithrin is limited. These two pesticides are no longer used in areas on the north shore of Long Island.

4.4 Emerging Contaminants

The existing List of Contaminants of Concern for LIS focused on compounds that could pose a threat to aquatic and human health, many derived primarily from industrial sources. While some of these priority pollutants continue to pose a problem due to their persistence and bioaccumulative characteristics, there is also increasing attention and research on the health effects of emerging contaminants. With the development of new analytical methods capable of measuring trace concentrations of hydrophilic compounds, researchers are detecting hydrophilic compounds derived from consumer products that are poorly degraded in municipal wastewater treatment plants. Household chemicals, pharmaceuticals and personal care products (PPCPs), biogenic hormones, and other organic compounds fall into this category (Kolpin et al., 2002).

The presence of numerous types of endocrine disrupting compounds (EDCs), in particular, has raised concern. Hermaphrodism in fish, for example, was first reported by U.K. scientists in the 1990s (Snyder et al., 2003). In the last decade, numerous scientific findings have linked high levels of estrogen in aquatic organisms to the presence of EDCs in wastewater.

Given that LIS is heavily impacted by wastewater treatment facilities servicing the dense populations that surround the Sound, emerging contaminants may become a concern. It is important to keep in mind, however, that these contaminants may behave differently than the organic pollutants discussed previously; because these compounds are hydrophilic, they likely will not bioaccumulate. However, their ongoing usage results in a continuous input that may result in the occurrence of steady-state concentrations exhibiting an ecological risk. The following sections provide an overview of specific categories of emerging contaminants. However, because the literature pertaining to LIS is not extensive, this overview summarizes the findings from a national reconnaissance study and ecological toxicity findings pertaining to some of these emerging contaminants.

In 1999 and 2000, the United States Geological Survey (USGS) embarked on a national reconnaissance of 95 emerging organic contaminants in wastewater-impacted streams (Kolpin et al., 2002). The study detected an array of domestic, agricultural, and industrial compounds in 80% of the 139 streams sampled. The highest concentrations (above 1 µg/L) were measured for cholesterol and detergent metabolites (nonylphenols). Most frequently detected were the following compounds: the fecal steroid coprostanol, the plant and animal steroid cholesterol, the insect repellant N,N-diethyltoluamide (DEET), caffeine, the antimicrobial disinfectant triclosan, the flame retardant tri(2-chloroethyl) phosphate, and the nonionic detergent metabolite 4-nonylphenol (Table 4-24). While the concentrations for these compounds were low (at the nano and microgram per liter level), the maximum total concentration of endocrine disrupting agents that the study reported was of 57.7 µg/L – a level that has been shown to cause adverse effects in aquatic organisms (Kolpin et al., 2002).

4.4.1 Wastewater Pollution Indicators – Coprostanol and Caffeine

Coprostanol is a fecal steroid and a metabolite of cholesterol. It was the most frequently detected compound in the USGS study as it is readily found in wastewater effluent. Because of its widespread distribution, studies have used it as a tracer for wastewater pollution. Little is known about the environmental health effects of coprostanol. Canadian studies found high levels (30 µg/g dry weight) of coprostanol is the tissue of freshwater mussels (*Elliptio complanata*) located downstream of a wastewater plant (Gagne et al., 2001). Mussels from the same experimental site also showed high levels of vitellin-like proteins. Vitellin is an egg yolk protein precursor, that can be tracked to indicate if organisms have been exposed to estrogenic contamination. A rise in vitellin levels, as observed in the freshwater mussels, indicated estrogenic contamination. Further studies assessing the extent of coprostanol-induced vitellin production indicated that cropostanol is an endocrine disruptor to freshwater mussels (Gagne et al., 2001).

Caffeine is a heavily used stimulant that is detected in wastewater and has been measured in groundwater and surface water at concentrations in the ng/L and µg/L range (Weigel et al., 2002). The USGS national reconnaissance found levels of caffeine in 60% of the samples taken, reporting a median concentration of 0.1 µg/L (Kolpin et al., 2002). Due to its widespread presence in streams and water bodies subject to wastewater discharges, it is commonly used as an indicator for wastewater. However, there are presently no studies highlighting the fate of caffeine in estuaries and its possible effects on aquatic organisms (Weigel et al., 2002).

4.4.2 Alkylphenols

Alkylphenol ethoxylates (APEOs) and their metabolites have become of increasing concern due to their widespread use and high production. APEOs are non-ionic surfactants present in detergents, spermicides, cosmetics, and other industrial products (Petrovic et al., 2004; ES&T, 2003). Shorter chained APEOs and APEO metabolites, such as nonylphenols (NPs), are readily formed in the biological and disinfection treatment processes at wastewater plants. APEO metabolites are of environmental significance due to their weak endocrine disrupting characteristics. Nonylphenols are structurally similar to both natural and synthetic hormones and hence are thought to compete with the natural hormone 17β-estradiol and the synthetic hormone diethylstilbestrol. Studies have shown octyphenol to be the most potent of APEO metabolites, causing adverse effects in fish at concentrations of 3 µg/L, while NPs have been noted to have adverse effects at 8.3 µg/L (Montgomery-Brown and Reinhard, 2003). U.K. scientists, however, observed developmental problems, sexual deformities, and increased death rates in the embryos and larvae of Pacific Oysters at nonylphenol concentrations of 0.1 µg/L (Nice et al., 2003). Moreover, some APEO metabolites have been found to bioaccumulate in aquatic organisms (Montgomery-Brown and Reinhard, 2003).

Analyses done on wastewater treatment effluent concentrations taken from the Yonkers wastewater treatment revealed total nonyphenol ethoxylate (NPEOs) concentrations of 100.9 µg/L (Ferguson et al. 2001a). Surface water concentrations of NPEOs and its metabolites were found at concentrations ranging between 0.22 and 1.05 µg/L throughout Jamaica Bay, New York (Ferguson et al., 2001b). The difference in concentration levels between wastewater effluent and surface water was attributed to sediment burial and dispersal (Ferguson et al., 2001b). Because APEO metabolites are hydrophobic, they have a high affinity for sediments. Ferguson et al. (2003) measured total nonylphenol ethoxylate concentrations in the sediments within Jamaica Bay, New York. Concentrations in the surface sediments exceeded 50 µg/g dry weight while deeper cores (50 cm deep) revealed concentrations less than 0.1 µg/g dry weight. The changes in

APEO concentrations within the sediment profile are indicative of the increased demand for these surfactants since the 1950s (Ferguson et al., 2003). Sediment toxicity studies have noted the possibility of adverse effects on benthic organisms at levels above 20 µg/g dry weight (Ferguson et al., 2001a). The levels found in the surface sediments of Jamaica Bay were above this range.

With respect to water column concentrations, levels measured in Jamaica Bay and in the USGS study exceeded the levels noted in the oyster toxicity studies to have endocrine-disrupting effects. While there are currently no regulatory levels for APEOs in the U.S., European nations have been at the forefront in establishing regulatory parameters for APEOs. A safe fresh and marine water level of 1.0 µg/L was established in the U.K. for nonyphenol (ES&T, 2003), while nonylphenol ethoxylate surfactants have been banned from household chemical products in Europe (Ferguson et al., 2001a).

4.4.3 Estradiols

The chemicals with the most endocrine disrupting potency, however, are 17β-estradiol (E2) and 17α-ethinyl estradiol (EE2) (Snyder et al., 2003). E2 is a natural female hormone that is used for replacement therapy and as a menopausal drug. The main metabolite excreted in urine is estriol, which is a less potent estrogen. Danish studies have found that therapeutic use of E2 contributes to less than 5% of the natural E2 that gets excreted naturally into the environment. Primarily used as an oral contraceptive, the synthetic pharmaceutical EE2 is significantly more potent than E2 (Christensen, 1998). Routledge et al. (1998), for example, found E2 concentrations ranging between 1 to 10 ng/L to increase levels of vitellogenin (a female egg protein) in rainbow trout. The study done by the USGS indicates the levels found in the environment are high. Kolpin et al. (2002) found 17α-ethinyl estradiol at a frequency of 15.7% at a median concentration of 73 ng/L and a maximum concentration of 831 ng/L while 17β-estradiol was detected at a median level of 9 and a maximum level of 93 ng/L. Estriol was found at median and maximum concentrations of 19 and 51 ng/L, respectively (Kolpin et al., 2002). The endocrine-disrupting potency of estradiol complexes and their abundance in wastewater effluents make these compounds of primary concern.

4.4.4 PBDEs and Organophosphorus Flame Retardants

Polybrominated diphenyl ethers (PBDEs) consist of chemical mixtures of penta-BDE, octa-BDE, and deca-BDE that are used as flame retardants in foam padding, plastic products, electronics, building materials, and a mixture of polymers and resins (Oros et al., 2005). Structurally similar to PCBs, these compounds are extremely fat soluble, and may be expected to bioaccumulate. These mixtures are ubiquitous and have been found in the tissue of animals, plants, and in sediments (Hites, 2004). PBDEs are persistent and bioaccumulate in organisms. Their toxicity seems to be congener specific and poorly understood. However, mice studies have identified PBDEs as neurotoxins (D'Silva et al., 2004).

In the San Francisco (SF) Estuary, sediment concentrations were measured at levels higher than those reported by European and Japanese studies (Oros et al., 2005). These levels ranged from not detectable to concentrations of 212 ng/g dry weight in some parts of the San Francisco Bay. Total PBDEs were also measured in the tissue of mussels in SF Bay at levels that ranged between 13 to 47 ng/g dry weight. These were noted to be 11 to 34 times higher than PBDE concentrations measured in the tissue of blue mussels collected from a rural part of Greenland. The SF study also reported accumulation levels in bivalves similar to those of PCBs, particularly in bivalves sampled from rivers (Oros et al., 2005). Moreover, concentrations of total PBDEs have increased by a factor of about 100 in human blood, milk, and tissues just over the past 30 years. Concentrations found in the average American are about 35 ng/g lipid, a value that is higher than the 2 ng/g lipid found in Europeans (Hites, 2004).

Because of their tendencies to accumulate in lipids, concentrations of PBDEs in the water column are generally very low (pg/L). In SF Bay, concentrations ranged between 3 and 513 pg/L. While low, these levels are significantly higher than those detected in estuaries throughout Europe. Major sources of PBDEs include wastewater effluent, stormwater flow, and atmospheric deposition (Oros et al., 2005).

The use of penta and octa-BDEs has been banned in Europe. In the U.S., the state of California will be the first to ban the use of the two congeners in consumer products. The phase out, however, will take effect in 2008 (Hites, 2004). While concentrations of PBDEs are expected to decline in the future, their ubiquity and persistence in the environment, much like PCBs, make them an important emerging contaminant.

Tris (2-chloroethyl) phosphate (TCEP) belongs to a class of organophosphorus flame retardants that, much like PBDEs, are mass produced. Used in polyurethane foam, rat and mice studies have identified TCEP as a carcinogen. Its production was phased out in Europe in the late 1990s due to concerns over its toxicity (Andresen et al., 2004). The USGS reported detecting TCEP 60% of the time at a median concentration of 0.1 µg/L in the water column (Kolpin et al., 2002). Concentrations of another type of organophosphorus flame retardant, tris(1,3-dichloro-2-propyl)phosphate (TDCPP), was found at values ranging between 0.005 and 0.076 µg/L in San Francisco Bay. Other studies have also correlated TDCPP to PBDEs concentrations (Oros et al., 2005). Like PBDEs, the major source of organophosphorus flame retardants is wastewater effluent (Andresen et al., 2004). While no information on concentrations of TCEP in sediments and in aquatic organisms could be found, given their low biodegradability in conventional wastewater treatment processes (Andresen et al., 2004) and their similarity to PBDEs, TCEP is likely to persist in the environment.

4.4.5 Musks

First introduced in the 1950s, musks are chemical compounds that make cosmetics, detergents, soaps, and countless types of cosmetics smell pleasant and refreshing (Daughton and Ternes, 1999). The two most widely produced polycyclic musks are 6-acetyl-1,1,2,44,7-hexamethyltetraline (AHTN) and 1,2,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-γ-2-benzopyran (HHCB) with production reaching approximately 6,000 tons per year. AHTN and HHCB are ubiquitous compounds that have a tendency to bioaccumulate in aquatic organisms (Schreurs et al., 2004). Concentrations in the water column have been measured at 6 µg/L (HHCB) and 4.4 µg/ (AHTN) while sewage sludge concentrations have been reported at 63 mg/kg (HHCB) and 34 mg/kg (AHTN) (Petrovic et al., 2004). Like many emerging contaminants, the major source of these polycyclic musks is wastewater effluent.

Unlike many endocrine disrupting compounds that mimic the functions of the female hormone estrogen 17β-estradiol, recent findings show that AHTN and HHCB have antiestrogenic properties. Instead of mimicking estrogen, these chemicals disrupt and suppress the natural functions of estrogen in organisms. The antiestrogenic properties were detected in zebrafish in which concentrations of AHTN and HHCB were also found to bioaccumulate by 600 times that of the concentrations used in the tests (Schreurs et al., 2004).

Table 4-24: Summary of Most Detected Emerging Contaminants – USGS National Reconnaissance (Kolpin et al., 2002)

Compounds	Use/Origin	Med[1] (µg/L)	LC 50[2]	Frequency[3]
Coprostanol	Fecal steroid, EDC[4], Estrogen, cholesterol metabolite	0.088		~85%
Cholesterol	Plant/animal steroid	0.83		~80%
N-N-diethyltoluamide (DEET)	PPCP[5], mosquito repellant	0.06	71250	~80%
Caffeine	Nonprescription drug, stimulant	0.1	40000	~70%
Tris (2-chloroethyl)phosphate	Fire retardant	0.1	66000	~60%
Triclosan	PPCP, EDC, antimicrobial disinfectant - used in footware and hospital soap	0.14	180	~60%
4-Nonylphenol	Surfactant, EDC, AP[6], nonionic detergent metabolite	0.8	130	~50%
4-Nonylphenol monoethoxylate	Surfactant, EDC, APEO[7], nonionic detergent metabolite	1	14450	~45%
Ethanol, 2-butoxy-phosphate	Plasticizer	0.51	10400	~45%
4-Octylphenol monoethoxylate	Surfactant, EDC, APEO, nonionic detergent metabolite	0.2		~40%
Bisphenol A	Plasticizer, EDC	0.14	3600	~40%
Cotinine	Nonprescription drug, nicotine metabolite	0.024		~40%
4-Nonylphenol diethoxylate	Surfactant, EDC, APEO, nonionic detergent metabolite	1	5500	~35%
5-Methyl-1H-benzotriazole	Anticorrosive	0.39	155000	~30%
Fluoranthene	PAH[8]	0.04	74	~30%
1,7-Dimethylxanthine	Nonprescription drug, caffeine metabolite	0.11		~30%
Pyrene	PAH	0.05	90.9	~30%
Trimethoprim	PPCP, antibiotic	0.013	3000	~25%
1,4-Dichlorobenzene	Deodorizer	0.09	1100	~25%
Acetaminophen (Tylenol)	PPCP, nonprescription drug, antipyretic	0.11	6000	~25%
Tetrachloroethylene	Solvent, degreaser	0.07	4680	~20%
4-Octylphenol diethoxylate	Surfactant, EDC, APEO, nonionic detergent metabolite	0.1		~20%
Erythromycin-H20	PPCP, antibiotic, erythromycin metabolite	0.1	665000	~20%
Estriol	PPCP, EDC, natural female hormone	0.019		~20%
Lincomycin	PPCP, Antibiotic	0.06		~20%
Sulfamethoxazole	PPCP, Antibiotic	0.066		~20%
Phthalic anhydride	Plasticizer	0.7	40400	~15%
Carbaryl	Insecticide, EDC	0.04	0.4	~15%

BOLD = Endocrine disrupting compound

[1] Med = Median Concentration, [2] LC50=50% Lethal Concentration, [3] Frequency = frequency of detection
[4] EDC=endocrine disrupting compounds, [5] PPCP=Pharmaceutical and Personal Care Product, [6] AP=alkylphenols, [7]APEO=alkylphenol polyethoxylates, [8] PAH=Polycyclic Aromatic Hydrocarbons

5.0 Conclusions and Recommendations

Over the past few decades, significant effort has been made to improve the health of Long Island Sound. Despite great reductions in pollutant loadings, however, available LIS contaminant studies report concentrations that exceed regulatory guidelines for some contaminants (key findings summarized in Tables 5-1 and 5-2, below). Metal concentrations were elevated in some areas of Cd, Cr, Cu, Pb, Hg, and Zn, metals currently on the LIS List of Contaminants of Concern. Sediment concentrations of these metals generally exceeded the LEL and the NOAA NS&T 85th national percentile values. Concentrations of Mn, Ni, Ag, and Sn also showed similar patterns.

Spatial distribution of Cu, Cr, Mn, Hg, Ni, Ag, Sn, and Zn sediment concentrations generally followed a west to east decreasing concentration pattern, while Cd concentrations were highest in ELIS and WLIS. Median levels of Pb were highest in WLIS and ELIS. With the exception of Cd and Pb, the patterns noted for all the other metals did not differ from those noted in the 1994 CCMP, which showed a west to east decreasing gradient (LISS, 1994). While these patterns do not suggest differences in spatial distribution for most metals, it is difficult to determine if the 1994-2005 findings necessarily show an improvement from 1994 values because only the averages are available for comparison. The findings do suggest, however, that sediment quality continues to be poor with respect to certain metals.

Sediment median concentrations of total chlordanes, total DDT, dieldrin, and endrin measured throughout LIS generally exceeded the ERL and the NOAA NS&T 85th national percentile values. Median levels of total chlordanes in CLIS and ELIS exceeded the ERM value. Although banned decades ago (ASTDR, 2005), endrin was measured at high levels throughout the Sound, while chlorpyrifos and endosulfans, pesticides currently in use in the U.S. (ASTDR, 2005), were also reported at levels that exceeded NOAA's 85th percentile. Concentrations of dioxin-like PCBs were also elevated in samples from WLIS and CLIS.

Spatial trends indicated levels of total chlordanes, chlorpfyros, total DDT, endosulfans, and total HCH highest in CLIS, while levels of endrin were highest in ELIS. Due to the incomparability with CCMP data, however, it is unclear if organic pollutant concentrations in the sediments have decreased over the last decade. Again, more carefully designed monitoring programs are required with specific objectives of defining change in time and space.

Organic pollutant concentrations measured in the water column fell below detectable limits for the majority of contaminants included in this analysis. While metal concentrations measured in the water column did not exceed Connecticut's water quality standards, concentrations were reported at levels typically measured in highly urbanized estuaries. Levels of Ag measured in the East River, in particular, ranked among the highest ever recorded in the nation. Pb and Ag followed a west to east decreasing gradient, while concentrations of HgR, however, were noted to increase from west to east.

Despite the high levels of organic pollutants and metals found in LIS sediments, sediment toxicity in LIS is low. PCBs, Hg, and Cu were the only contaminants measured at levels that pose a human or an ecological health risk. Cu concentrations measured in the American lobster exceeded the ecological effects value (though this value is not specific to lobsters that use Cu metabolically), while Hg levels in striped bass exceeded the EEV and EPA fish tissue criterion. PCB tissue levels measured in striped bass, bluefish, scup, and in the hepatopancreas of the American lobster exceeded Connecticut's fish advisory level, though specific health risk evaluations need to be conducted for each relevant species and the tissues of concern before an advisory is determined to be necessary. Presently, only striped bass and bluefish have consumption advisories for PCBs in CT LIS waters. Blue mussel concentrations of endosulfans and dioxin-like PCBs also exceeded the NOAA 85th national percentile.

Table 5-1: Summary of Review Findings – Median Metal Concentrations

Contaminant	1994-2005 Review Findings
Sb	Sediment: Below LEL[1].
As	Sediment: Below LEL.
Cd	Water: Uniform concentrations measured throughout LIS. Sediment: Above LEL in WLIS and ELIS.
Cr	Sediment: Above LEL in WLIS, CLIS, and ELIS.
Cu	Water: Measured at levels similar to other urban estuaries. Elevated values in WLIS and CLIS. Sediment: Above LEL in WLIS, CLIS, and ELIS and the NOAA 85^{th} percentile[2] in WLIS and CLIS. Biota: Average American Lobster values above EEV in WLIS and CLIS.
Mn	Sediment: Above LEL WLIS and ELIS.
Hg	Water: West to east increasing concentrations of HgR. Elevated levels of HgR at mouth of CT river. Sediment: Above LEL in WLIS and CLIS. Biota: Striped bass values above EEV in WLIS and CLIS. CLIS values above EPA fish tissue criterion[3].
Ni	Water: Measured at levels similar to other urban estuaries. Elevated values in WLIS and CLIS. Sediment: Above LEL in WLIS and CLIS.
Pb	Water: High values detected in the East River and narrows. Below detection limit throughout the rest of LIS. Sediment: Above LEL in WLIS, CLIS, and ELIS. Above NOAA's 85^{th} percentile in WLIS and ELIS.
Se	Sediment: Below the NOAA percentile.
Ag	Water: East River concentrations highest in the U.S. West to east concentration gradient. Sediment: Above LEL in WLIS.
Sn	Sediment: Above the NOAA 85^{th} national percentile in WLIS and CLIS.
Zn	Water: Measured at levels similar to other urban estuaries. Elevated values in WLIS and CLIS. Sediment: Above LEL in WLIS and CLIS. Above the NOAA 85^{th} percentile in WLIS.

BOLD = Currently on LIS List of Contaminants of Concern
WLIS = Western Long Island Sound, CLIS = Central LIS, ELIS = Eastern LIS

[1]LEL = NYSDEC Lowest Effects Level (NYSDEC, 1999)
[2]NOAA's 85^{th} national percentile (NOAA NS&T, 2005)
[3]EPA fish tissue criterion for the protection of human health for methylmercury (USEPA-OW, 2001)

Table 5-2: Summary of Review Findings – Median Organic Pollutant Concentrations

Contaminant	1994-2005 Review Findings
Total chlordanes	Sediment: Median levels above the ERM[1] in CLIS and ELIS. Above the ELR in WLIS. Median level above the NOAA 85th percentile in CLIS and ELIS[2].
-Alpha-Chlordane	Sediment: Median level below the NOAA 85th percentile. Biota: Blue mussel medina concentration level above the NOAA 85th percentile in WLIS.
-Heptachlor	Sediment: Median level above the NOAA 85th percentile in WLIS, CLIS, and ELIS.
-Trans-nonachlor	Sediment: Median level below the NOAA 85th percentile. Biota: Median level above the NOAA 85th percentile in WLIS.
Chlorpyrifos	Sediment: Above the NOAA 85th percentile in WLIS and CLIS.
Total DDT	Sediment: Above ERL[3] in WLIS, CLIS, and ELIS. Above the NOAA 85th percentile in CLIS.
Dieldrin	Sediment: Above ERL in WLIS and ELIS. Above ERM in CLIS. Above the NOAA 85th percentile in CLIS and ELIS.
Total edosulfans	Sediment: Above the NOAA 85th percentile in WLIS, CLIS, and ELIS. Biota: Blue mussel median level above the NOAA 85th percentile in WLIS.
Endrin	Sediment: Above the ERL and the NOAA 85th percentile in WLIS, CLIS, and ELIS.
Total HCH	Sediment: Above the NOAA 85th percentile in WLIS, CLIS, and ELIS.
Total PAH[5]	Sediment: Median values below the ERL.
Total PCB	Sediment: Median levels below ERL and the NOAA 85th percentile. Biota: CLIS scup and bluefish, WLIS and CLIS striped bass, and American lobster hepatopancreas average concentrations above CT Department of Public Health guidelines[4].
PCB Dioxin-like congeners	Sediment: Above the NOAA 85th percentile in WLIS. Biota: Blue mussel median concentration level above the NOAA 85th percentile in WLIS, CLIS, and ELIS.

Bold = Currently on LIS List of Contaminants of Concern
WLIS = Western Long Island Sound, CLIS = Central LIS, ELIS = Eastern LIS

[1]ERM = NOAA's Effects range Median (NOAA, 1999)
[2]NOAA's 85th national percentile (NOAA NS&T, 2005)
[3]ERL = NOAA's Effects Range Low (NOAA, 1999)
[4]CT Department of Public Health (USEPA – USACOE, 2003)

While concentrations of some priority pollutants measured in the sediments, water column, and biota of LIS generally exceeded regulatory guidelines and thus may pose ecological and human health risks and warrant additional study, there is very little known on the types of emerging contaminants present in LIS. Recent studies, both riverine and of similar estuarine systems, however, have measured concentrations of coprostanol, caffeine, alkylphenols, estradiols, flame retardants such as PBDEs and TCEP, and musks at levels that pose an ecological risk to aquatic life. Because many of these compounds are found in household chemicals, biogenic hormones, and pharmaceuticals and personal care products, levels are likely to be highest in highly urbanized estuaries, such as LIS.

While there are currently no regulatory standards for emerging pollutants, their increasing detection will most likely result in increased management efforts. The first step, however, includes developing a monitoring program for compounds that are most likely to be present in LIS. Adequate monitoring information can then provide the basis for the development of sound management strategies.

Key findings indicate that the current List of Contaminants of Concern no longer completely identifies all the environmental stressors that may be impacting LIS. Over ten years of monitoring information, although somewhat scattered in time and space, indicates that concentrations of some contaminants in certain media still merit attention and concern. While there is no substitute for detailed studies focusing on toxic contaminants of LIS, available reports are adequate to support recommended changes to the List of Contaminants of Concern as follows:

- **Metals**
  - Currently on LIS List of Contaminants of Concern: Cd, Cr, Cu, Hg, Pb, Zn
  - Recommendations:
    - Addition of Ni, Ag, and Sn to list.
    - Further monitoring of Mn.
- **Organic Pollutants**
  - Currently on LIS List of Contaminants of Concern: PCBs, chlordane, dieldrin, DDT, DDD, DDE, heptachlor, lindane, trans-nonachlor, PAHs
  - Recommendations:
    - Addition of endosulfans, endrin, and chlorpyrifos to list.
    - Further research and monitoring of dioxin-like PCBs (77, 126, and 169) concentrations.
- **Emerging Contaminants**
  - Recommendation: Development of a research and monitoring program for coprostanol, alkylphenols, estradiols, PBDEs, TCEP, and musks.

Acknowledgements

We would like to thank Jane MacLellan and Mark Tedesco of the Long Island Sound Study for their support of this project and the Long Island Sound Office for the Long Island Sound Fellowship. Acknowledgement is made to the 2003-2004 Long Island Sound Fellows for their initial attempts at conducting this review. Many thanks go to Dr. William Mitch for his advice and patience.

6.0 Abbreviations

ACOE	Army Corps of Engineers
CCMP	Comprehensive Conservation Management Plan
CLIS	Central Long Island Sound
DEP	State of Connecticut Department of Environmental Protection
DPH	State of Connecticut Department of Health
EDC	Endocrine disrupting compound
EEV	Ecological Effects Value
ELIS	Eastern Long Island Sound
EPA	Environmental Protection Agency
ERL	Effects Range-Low
ERM	Effects Range-Median
FDA	U.S. Food and Drug Administration
HCH	Hexachlorocyclohexane
HgT	Total mercury
HgR	Reactive mercury
LEL	Lowest Effect Level
LIS	Long Island Sound
LISS	Long Island Sound Study
NCA	National Coastal Assessment
NOAA	National Oceanic and Atmospheric Administration
NS&T	National Status & Trends
NYSDEC	New York State Department of Environmental Conservation, Division of Fish and Wildlife and Marine Resources
PAH	polycyclic aromatic hydrocarbon
PCBs	Polychlorinated biphenyls
SEL	Severe Effect Level
SQUID	State of Connecticut Sediment Quality Information Database
WLIS	Western Long Island Sound
WQS	Water Quality Standard

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Endosulfans: http://www.atsdr.cdc.gov/tfacts41.html
Endrin: http://www.atsdr.cdc.gov/tfacts89.html
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