INTERAGENCY ENVIRONMENTAL ASSESSMENT OF HURRICANE KATRINA

Preliminary Results from the NOAA National Status and Trends (NS&T) Mussel Watch Survey: Post-storm Assessment and 20 Year Retrospective Analysis

Background

The National Oceanic and Atmospheric Administration (NOAA), U.S. Environmental Protection Agency (EPA), US Geological Survey (USGS), US Food and Drug Administration (FDA), and coastal States of northern Gulf of Mexico are engaged in a comprehensive interagency effort to assess human-health and environmental impacts of Hurricanes Katrina and Rita in affected coastal waters. This combined effort has been designed to characterize the magnitude and extent of coastal contamination and associated human-health and ecological effects resulting from this unprecedented storm. This report provides a summary of preliminary results from samples collected as part of NOAA's National Status and Trends (NS&T) Mussel Watch field surveys conducted as a part of this coordinated effort.

NOAA's NS&T Program supports ecosystem-based management through an integrated program of environmental monitoring, assessment, and research to detect changes in the environmental quality of our Nation's estuarine and coastal waters. The NS&T Mussel Watch Project has a 20-year time series for over 100 contaminants in mussels from 300 sites Nationwide. A complete list of analytes quantified is provided in appendix 1. Twenty of these sites in the northern Gulf of Mexico were sampled by NOAA staff and partners between September 29 and October 10 as part of the integrated Katrina survey (figure 1). The extensive Mussel Watch time series provides a critical long-term baseline for contaminant levels in the affected region, including sites sampled for this assessment. Coupled with the nationwide coverage of the NS&T monitoring program, this report provides quantitative information required to assess whether contaminant signatures resulting from the passage of Katrina are significantly different from historic levels, and from neighboring regions.

Figure 1. *NOAA National Status and Trends Program post Katrina Mussel Watch sample locations. Blue line indicates the storm path, and locations shown in red indicate no oyster sample was collected due to restricted access or otherwise compromised oyster reefs.*

In this portion of the interagency assessment, sediment, water, and soft tissues from American oysters (*Crassostrea virginica*) were collected for analysis. Sediments were analyzed for chemical contamination, microbial and pathogen indicators, condition of benthic fauna, and sediment toxicity as measures of contaminant exposure and biological effect. Water samples were collected to quantify microbial/pathogen indicators and chemical contaminants. Additional samples were collected to analyze emerging contaminants of concern, including flame retardants (PBDEs), and the pesticides fipronil and atrazine. Oysters were collected to measure chemical and biological contaminant levels in this commercially important shellfish species. The incidence of oyster disease and parasites also was documented.

This report provides results of contaminant concentrations of PAHs (*e.g.*, petroleum and burned fossil fuels), organochlorines (*e.g.*, pesticides), and metals in oyster tissues. In addition, we provide concentrations of atrazine (herbicide) and indicators of fecal pollution in the water column near the oyster reefs. A short description of these contaminants and their potential human health impacts are provided in appendix 2. A more complete analysis of all NS&T analytes quantified will follow this preliminary report. In addition, a companion report describing results of the joint NOAA/EPA/USGS surveys in Lake Pontchartrain and in the open waters of Mississippi Sound will be forthcoming. The objectives of this survey were to:

- Measure contaminant levels in oysters (*Crassostrea virginica*) and sediment collected from shallow coastal environments impacted by the storm;
- Perform toxicity bioassays on sediments to assess potential biological effects of contaminant exposure;
- Measure human pathogen indicators

Results

Chemical Contamination in Oysters

The range of analytical procedures used to quantify PAHs, organochlorines, and metals in this assessment can be found in Lauenstein and Cantillo 1998 (http://www.ccma.nos.noaa.gov/publications/tm130.pdf).

Organochlorines (Pesticides and PCBs)

Contamination levels of organochlorine compounds after the storm were low when compared to the 20 year historical record for each site (table 1). When considered collectively, 87% of the sites had organochlorine (total chlordane, total dieldrin, DDTs, and PCBs) concentrations below the 25th percentile of the preceding 20 year record, and 67% of measured concentrations for this group of contaminants were record lows. Post storm PCB (polychlorinated biphenyls) concentrations were the lowest recorded at all sites, with the exception of Mississippi Sound – Biloxi Bay (MSBB), which was the second lowest on record (figure 2). Similarly, DDT exhibited record low concentrations at all but two sites, both of which were in Mississippi Sound (table1, figure 3). Concentrations of total dieldrin and total chlordane also were generally low; however, levels of these two contaminants showed a sharp spike in Mississippi Sound (MSBB). In each of these cases, contamination levels exceeded the upper 75th percentile of the preceding 20 year record, and were much higher than expected based on significant decreasing trends for these chemicals since 1986.

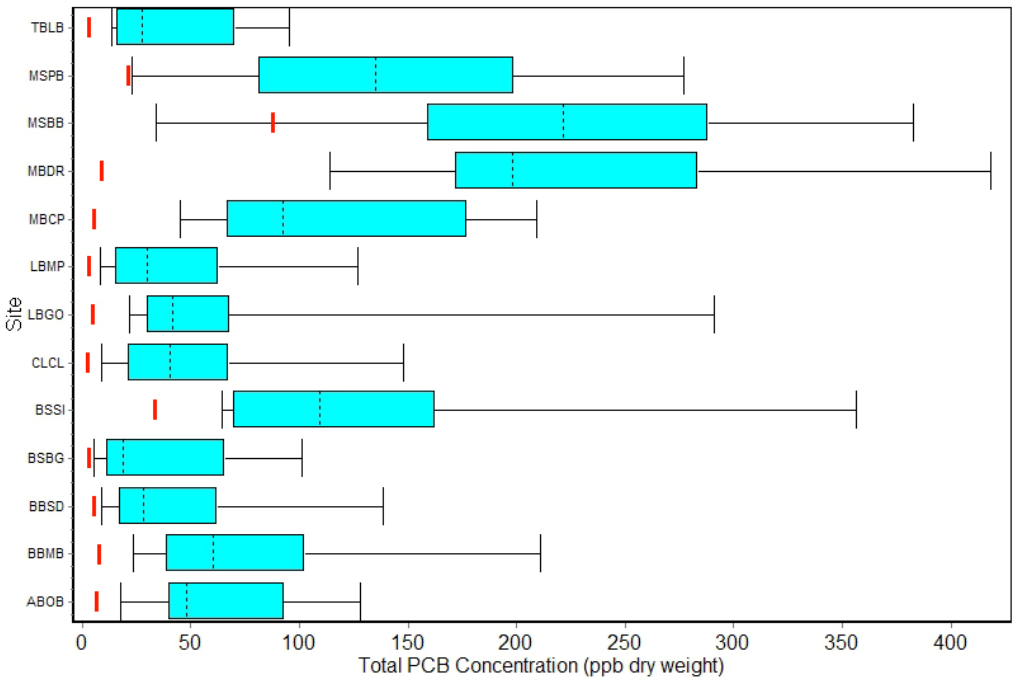

Figure 2. *Total PCB concentrations measured at sites impacted by Hurricane Katrina. Red markers indicate post storm measurements. Blue boxes show the 20 year inter-quartile range (25-75th percentile) for this contaminant at each site, while black bars indicate the upper and lower range. Nearly all sites had record low measurements for this group of contamination. Site locations designations refer to sites shown in figure 1.*

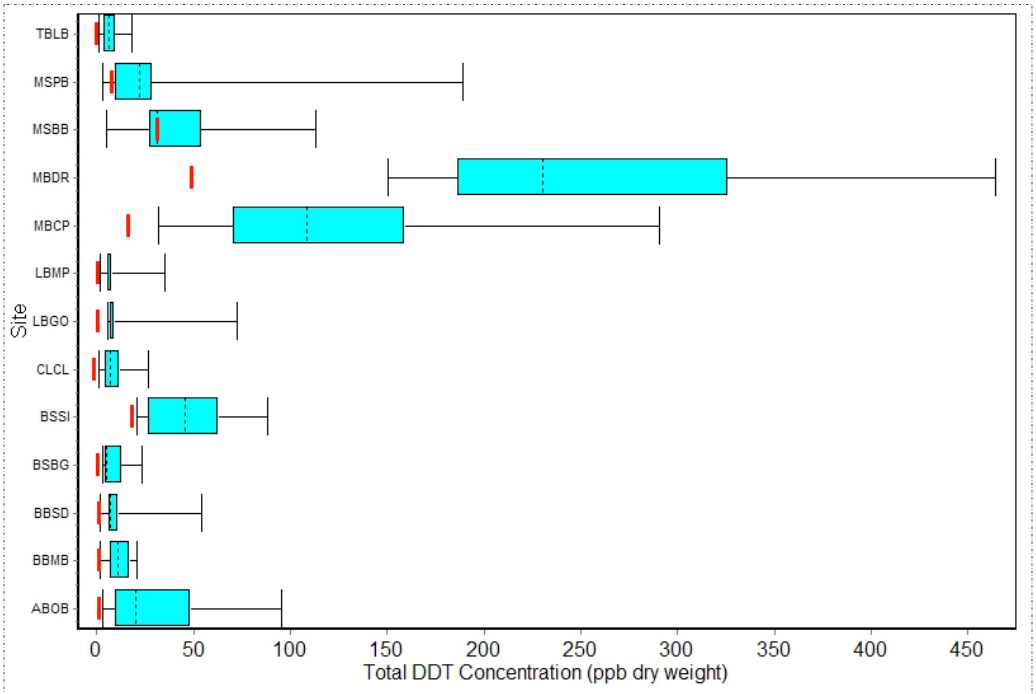

Figure 3. *Total DDT concentrations measured at sites impacted by Hurricane Katrina. Red markers indicate post storm measurements. Blue boxes show the 20 year inter-quartile range (25-75th percentile) for this contaminant at each site, while black bars indicate the upper and lower range. Site locations designations refer to sites shown in figure 1.*

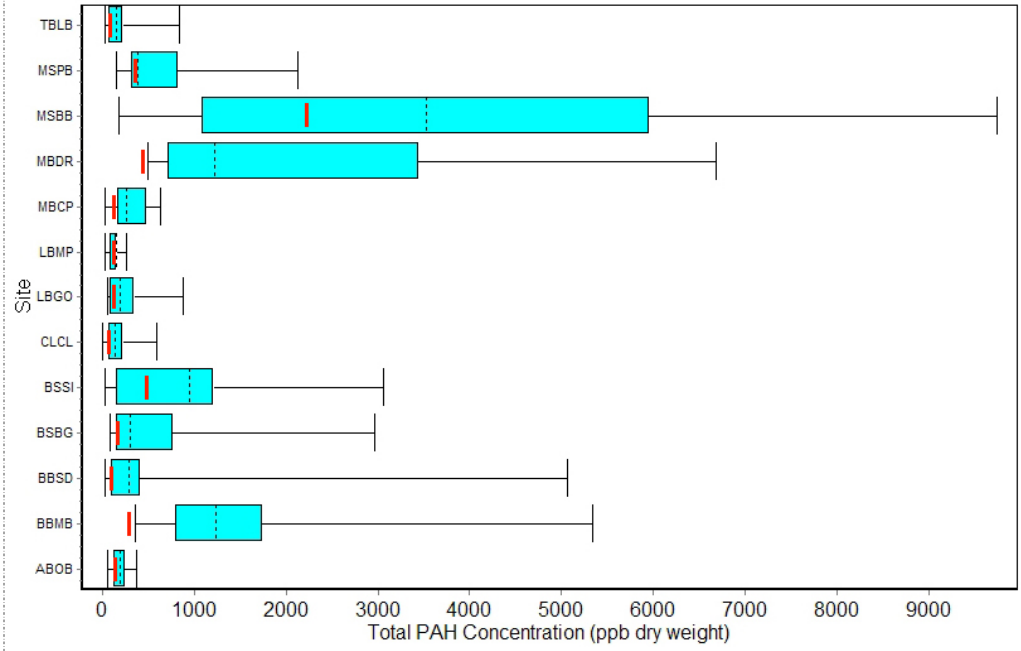

Figure 4. *Total PAH concentrations measured at sites impacted by Hurricane Katrina. Red markers indicate post storm measurements Blue boxes show the 20 year inter-quartile range (25-75th percentile) for this contaminant at each site, while black bars indicate the upper and lower range. Site locations designations refer to sites shown in figure 1.*

Polycyclic Aromatic Hydrocarbons

PAHs have been divided into 2 groups based on molecular structure and size. The division of PAHs between the low-molecular weight and high-molecular weight compounds can help to discriminate among compounds entering the environment from petroleum and those from a combustion source.

Contamination levels of all forms of polycyclic aromatic hydrocarbons (PAHs) were relatively low after the passage of Katrina when compared to the 20 year historical record for each site (table 1, figure 4). Collectively, 58% of the sites exhibited PAH concentrations below the 25th percentile of the preceding 20 year record, and 18% of measured concentrations for this group of contaminants were record lows. Overall, low molecular weight PAHs exhibited greatest declines in concentration levels. Mississippi Sound – Biloxi Bay (MSBB) was again the only site that exhibited a

PAH concentration (high molecular weight) that was considered to be elevated (*i.e.*, above the 75th percentile) relative to the historical record (table1).

Metals and Major Trace Elements

Contamination levels of metals after the storm were elevated when compared to the 20 year historical record for each site. When considered collectively, 45% of the sites had concentrations above the 75th percentile of the preceding 20 year record, and 23% of measured concentrations for this group of contaminants were record highs. Selenium exhibited elevated concentrations at all but one site (MSBB), and record highs at all but 5 sites (figure 5). Inspection of Table 1 indicates that similarly elevated concentrations were evident for chromium (CR), copper (Cu), iron (Fe), manganese (Mn), and nickel (Ni) when compared to the 20 year record.

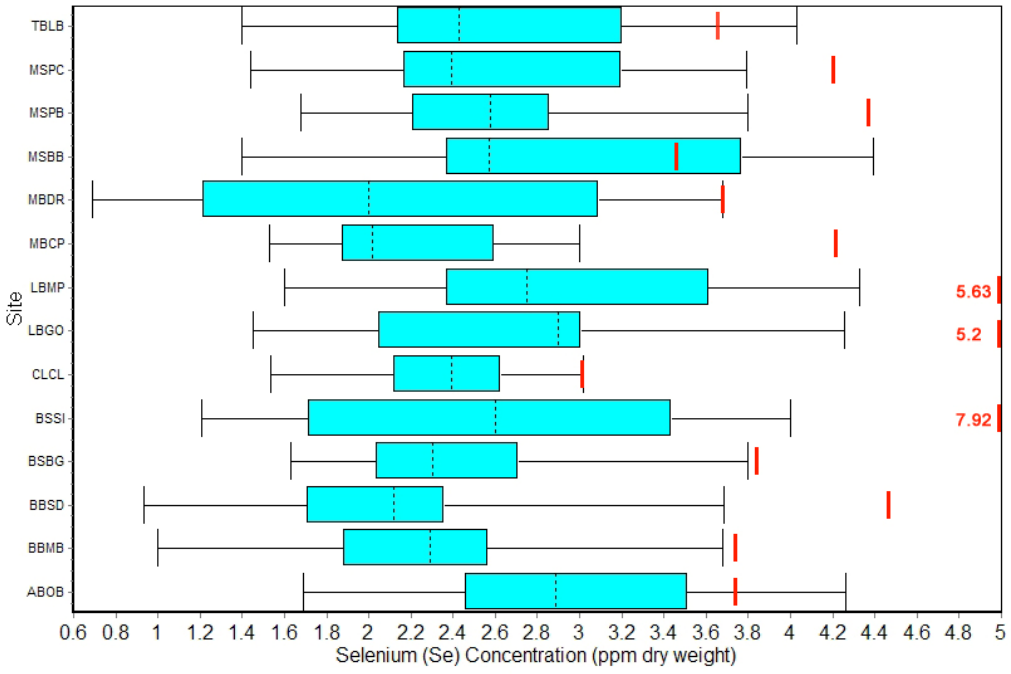

***Figure 5**. Selenium (Se) concentrations measured at sites impacted by Hurricane Katrina. Red markers indicate post storm measurements Blue boxes show the 20 year inter-quartile range (25-75th percentile) for this contaminant at each site, while black bars indicate the upper and lower range. Site locations designations refer to sites shown in figure 1.*

<u>Chemical & Biological Contamination in Water</u>

Atrazine (Herbicide)

A commercially available magnetic particle immunoassay test kit was used to estimate atrazine concentrations in water. Results are provided in Table 1 and indicate that 8 of the 20 sampling sites had detectable concentrations of atrazine. Concentrations ranged from 0.11-0.22 µg/L and fell within the concentration range typically measured in nearshore estuarine waters. Concentrations at all sites were well below the currently proposed EPA saltwater chronic criterion of 17 µg/L. Atrazine is frequently measured in surface waters throughout the United States at concentrations ranging from 0.1-30 µg/L. It is the most commonly detected herbicide in surface and groundwater and is often transported to fresh and saltwater systems by nonpoint source runoff following rainfall.

Fecal Contamination Indicators

Fecal pollution indicator organisms-enterococci and fecal coliform bacteria- were enumerated to assess potential human health risk of pathogen exposure in the Gulf of Mexico. Fourteen samples (70%) from the NS&T Mussel Watch sites tested positive for fecal coliforms, and all 20 (100%) samples were positive for enterococcus (Table 1). Fecal coliform concentrations in positive samples ranged from 1-37 cfu/100 ml. Enterococci concentrations ranged from 6-673 cfu/100 ml. Fecal coliform concentrations in water samples were compared to two criteria for shellfish harvesting waters (EPA 841-R-00-002). The first criterion (14 cfu/100 ml) is the 30-day median concentration, while the second (43 cfu/100 ml) is the criterion that should not be exceeded by >10% of samples collected during a 30-day period. Three of the samples from the NS&T/Mussel

Watch cruise exceeded the first criterion and none of the samples from that cruise exceeded the second, higher number. Enterococci concentrations in water samples were compared to EPA criteria for recreational water uses (EPA440/5-84-002). Concentrations in samples were compared to single sample maximum (SSM) criteria based on the frequency of exposure. Results were compared to both the SSM for a designated bathing beach area (104 cfu/100 ml) and the SSM for infrequent use (501 cfu/100 ml). Ten samples exceeded the criterion for a designated beach area and one sample (MRPL) exceeded the less-stringent criterion for infrequent use.

Both fecal-pollution indicator organisms were detected at a higher frequency and at higher concentrations in samples from the NS&T Mussel Watch cruise when compared to similar assessments conducted by NOAA's National Marine Fisheries Service (NMFS) and EPA in offshore areas of the region. In general, the NS&T Mussel Watch sampling sites represented more in-shore stations in closer proximity to land-based sources of fecal pollution. These preliminary results should be used carefully since they reflect conditions at the sites at a single point in time and should be compared as needed with other data and criteria that are most appropriate for a given designated use within each watershed sampled. Also, final judgments as to the state of environmental conditions in these areas should be based on a weight-of-evidence from the multiple indicators.

Table1. *Measured PAHs, organochlorines, and metals concentrations from oyster tissues; and atrazine, fecal coliform bacteria, and* <u>*Enterococcus*</u> *bacteria collected in waters from sites in Louisiana, Mississippi, and Alabama after the passage of Hurricanes Katrina and Rita. Green shading indicates a record low measurement since 1986. Red shading indicates a concentration in excess of the 75th percentile for this contaminant since 1986. National percentile thresholds for oyster tissue contamination (75th, 50th median, and 25th) are provided for reference. For fecal indicators, red shading indicates an EPA threshold exceedance. "NS" indicates no sample taken due to compromised oyster reefs or restricted access. "ND" indicates no detection. "NA" indicates not applicable.*

Site Locations	Oyster Tissue Samples: Polycyclic Aromatic Hydrocarbons (parts/billion dry wt.)			Organochlorines (parts/billion dry wt.)				Metals (parts/million dry wt.)														Water Samples: Herbi-cide (µg/l)	Fecal Indicators (cfu/100ml)	
	Total PAH	High Molecular Weight	Low Molecular Weight	Total Chlordane	Total Dieldrin	DDTs	PCBs	Silver (Ag)	Aluminum (Al)	Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Iron (Fe)	Mercury (Hg)	Manganese (Mg)	Nickel (Ni)	Lead (Pb)	Selenium (Se)	Zinc (Zn)	Atrazine	Fecal Coliforms	Enterococcus
ABOB	93	33	60	0.0	0.3	2.0	6.0	0.74	298.0	5.99	4.31	1.13	101.0	752.0	0.06	26.70	3.56	0.77	3.75	1830.0	*nd*	1	213
BBMB	198	90	108	2.6	0.4	1.9	7.3	0.46	404.0	6.89	1.53	1.17	57.5	830.0	0.09	42.20	2.86	0.85	3.74	1660.0	*nd*	<1	163
BBSD	53	13	40	0.9	0.2	1.8	5.3	1.37	360.0	7.26	3.10	1.76	255.0	754.0	0.04	32.90	2.20	0.90	4.44	4150.0	0.11	1	180
BSBG	80	15	65	0.0	0.4	1.3	3.3	0.71	289.0	8.51	1.86	0.83	119.0	547.0	0.06	32.20	2.80	0.62	3.81	1690.0	*nd*	<1	17
BSSI	187	93	94	2.4	2.5	14.2	33.1	1.99	493.0	6.93	9.96	1.69	291.0	902.0	0.05	42.50	2.44	0.90	7.92	3550.0	0.22	<1	38
CLCL	48	9	39	3.6	0.0	0.8	3.9	0.84	155.0	5.75	3.12	-	111.0	400.0	0.04	21.50	3.55	0.46	2.99	1740.0	0.14	<1	218
LBGO	66	12	54	3.0	2.4	1.5	7.8	4.32	362.0	5.57	7.42	0.87	526.0	637.0	0.06	60.20	3.16	0.61	5.20	7180.0	*nd*	2	8
LBMP	75	25	50	0.0	0.6	1.4	4.5	2.57	247.0	5.87	9.68	14.80	451.0	1330.0	0.06	63.10	7.81	1.51	5.63	6710.0	0.12	<1	14
MBCP	76	17	58	3.1	2.0	22.3	9.9	2.50	294.0	6.82	3.88	1.20	148.0	484.0	0.10	25.30	3.03	0.36	4.43	1800.0	*nd*	<1	6
MBDR	163	107	56	3.4	1.8	52.4	16.2	8.15	324.0	4.45	5.19	2.51	929.0	828.0	0.16	86.40	3.78	0.57	3.64	9590.0	*nd*	1	7
MSBB	1184	978	207	86.4	29.6	26.5	87.5	0.81	81.7	7.11	2.34	-	246.0	295.0	0.13	33.70	1.47	0.74	3.32	6820.0	0.11	23	11
MSPB	153	81	72	9.4	2.7	7.4	18.0	0.82	184.0	5.69	2.44	0.53	69.9	495.0	0.18	62.10	2.48	0.47	4.53	2040.0	*nd*	1	9
MSPC	-	-	-	-	-	-	-	1.40	136.0	6.67	5.41	0.76	273.0	327.0	0.11	44.90	2.07	0.58	4.12	4800.0	*nd*	37	350
TBLB	48	17	31	0.9	0.0	0.7	3.8	0.48	339.0	6.06	2.13	1.29	77.4	636.0	0.05	30.10	4.37	0.78	3.56	1250.0	*nd*	1	158
MRTP	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*nd*	2	136
MRPL	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	0.22	1	673
LPNO	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	0.17	4	20
TBLF	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	0.21	1	347
BBTB	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	0.11	1	467
MBHI	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*nd*	20	21
National 75th	*192*	*248*	*171*	*3.5*	*2.9*	*5.3*	*129.9*	*3.6*	*377*	*12.8*	*4.73*	*0.96*	*203*	*424*	*0.14*	*20.7*	*2.63*	*0.7*	*3.3*	*3478*	*na*	*na*	*na*
National Median	*89*	*81*	*94*	*1.1*	*0.7*	*1.4*	*60.3*	*2.1*	*194*	*7.9*	*3.02*	*0.6*	*120*	*283.3*	*0.09*	*13.8*	*1.83*	*0.49*	*2.59*	*2109*	*na*	*na*	*na*
National 25th	*42*	*31*	*50*	*0.2*	*0.0*	*0.2*	*29.6*	*1.23*	*95.8*	*5.8*	*1.89*	*0.32*	*71*	*206.8*	*0.06*	*10.3*	*1.27*	*0.34*	*2.05*	*1274*	*na*	*na*	*na*

Appendix 1: *List of standard NS&T Mussel Watch analytes.*

Polycyclic Aromatic Hydrocarbons (PAHs)	**Organochlorine Contaminants**
Low molecular weight-PAHs	**total-DDT**
Biphenyl	2,4'-DDD
Naphthalene	4,4'-DDD
1-Methylnaphthalene	2,4'-DDE
2-Methylnaphthalene	4,4'-DDE
2,6-Dimethylnaphthalene	2,4'-DDT
1,6,7-Trimethylnaphthalene	4,4'-DDT
Acenaphthene	**total-Polychlorinated Biphenyls**
Acenaphthylene	PCB8
Fluorene	PCB18
Phenanthrene	PCB28
1-Methylphenanthrene	PCB44
Anthracene	PCB52
High molecular weight-PAHs	PCB66
Fluoranthene	PCB101
Pyrene	PCB105
Benz[*a*]anthracene	PCB118
Chrysene	PCB128
Benzo[*b*]fluoranthene	PCB138
Benzo[*k*]fluoranthene	PCB153
Benzo[*a*]pyrene	PCB170
Benzo[*e*]pyrene	PCB180
Perylene	PCB187
Dibenzo[*a,h]*anthracene	PCB195
Indeno[1,2,3-*c,d*)pyrene	PCB206
Benzo(*g,h,i*]perylene	PCB209
Alkylated PAHs	**total-Chlordane**
C1-naphthalenes	Alpha-Chlordane
C2-naphthalenes	Trans-Nonachlor
C3-naphthalenes	Heptachlor
C4-naphthalenes	Heptachlor-Epoxide
C1-fluorenes	**total-Dieldrin**
C2-fluorenes	Aldrin
C3-fluorenes	Dieldrin
C1-phenanthrenes/anthracenes	**Butyltins**
C2-phenanthrenes/anthracenes	mono-butyltin
C3-phenanthrenes/anthracenes	di-butyltin
C4-phenanthrenes/anthracenes	tri-butyltin
Dibenzothiophene	**Other organic contaminants**
C1-dibenzothiophenes	Alpha-Hexachlorohexane
C2-dibenzothiophenes	Beta-Hexachlorohexane
C3-dibenzothiophenes	Delta-Hexachlorohexane
Naphthobenzothiophene	Gamma-Hexachlorohexane
C1-naphthobenzothiophenes	Chlorpyrifos
C2-naphthobenzothiophenes	Cis-Nonachlor
C3-naphthobenzothiophenes	Endosulfan I
C1-pyrenes	Endosulfan II
C2-pyrenes	EndosulfanSulfate
C1-chrysenes	Endrin

Alkylated PAHs Continued

C2-chrysenes
C3-chrysenes
C4-chrysenes
C1-Fluoranthenes/Pyrenes

Trace and Major Elements

Aluminum
Arsenic
Cadmium
Chromium
Copper
Iron
Lead
Manganese
Mercury
Nickel
Selenium
Silver
Tin
Zinc

Other organic contaminants Continued

Gamma-Chlordane
Hexachlorobenzene
Mirex
Oxychlordane
Pentachloroanisole
Pentachlorobenzene
1,2,3,4-Tetrachlorobenzene
1,2,4,5-Tetrachlorobenzene
Tetrabutyltin

Appendix 2: *Description of reported contaminants and their potential human health impacts (source: Agency for Toxic Substances and Disease Registry – ATSDR and USEPA)*

PAHs:
Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 different chemicals that can occur naturally or are formed during the incomplete burning of coal, oil and gas, or other organic substances. PAHs are usually found as a mixture containing two or more of these compounds, such as soot. Animal studies have also shown that PAHs can cause harmful effects on the skin, body fluids, and ability to fight disease after both short- and long-term exposure. But these effects have not been seen in people, though the Department of Health and Human Services (DHHS) has determined that some PAHs may reasonably be expected to be carcinogens.

Chlordane:
Chlordane is a manufactured chemical that was used as a pesticide in the United States from 1948 to 1988. Exposure to chlordane occurs mostly from eating contaminated foods, such as root crops, meats, fish, and shellfish, or from touching contaminated soil. High levels of chlordane can cause damage to the nervous system or liver.

Dieldrin:
From the 1950s until 1970, dieldrin was a widely used pesticide for crops like corn and cotton. Because of concerns about damage to the environment and potentially to human health, EPA banned all uses of dieldrin in 1974, except to control termites. In 1987, EPA banned all uses. Exposure to aldrin and dieldrin happens mostly from eating contaminated foods, such as root crops, fish, or seafood. Aldrin and dieldrin build up in the body after years of exposure and can affect the nervous system.

DDTs:
DDT (dichlorodiphenyltrichloroethane) is a pesticide once widely used to control insects in agriculture and insects that carry diseases such as malaria. Exposure to DDT, DDE, and DDD occurs mostly from eating foods containing small amounts of these compounds, particularly meat, fish and poultry. High levels of DDT can affect the nervous system causing excitability, tremors and seizures. In women, DDE can cause a reduction in the duration of lactation and an increased chance of having a premature baby.

PCBs:
PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they don't burn easily and are good insulators. The manufacture of PCBs was stopped in the U.S. in 1977. Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils. Health effects that have been associated with exposure to PCBs include acne-like skin conditions in adults and neurobehavioral and immunological changes in children. PCBs are known to cause cancer in animals.

Atrazine:
Atrazine is a herbicide that is used to kill weeds, primarily on farms, but has also been used on highway and railroad rights-of-way as well as residential lawn and golf courses. Birth defects and liver, kidney, and heart damage has been seen in animals exposed to high levels of atrazine. The EPA's proposed saltwater chronic water quality criteria is 17 μg/L.

Enterococcus:
Infections caused by bacteria of the genus Enterococcus (most notably Enterococcus faecalis, which accounts for ~80% of all infections) include urinary tract infections, bacteremia, intra-abdominal infections, and endocarditis. The problem of nosocomial enterococcal infection is compounded by multiple antibiotic resistance.

E. Coli:
Escherichia coli is responsible for three types of infections in humans: urinary tract infections (UTI), neonatal meningitis, and intestinal diseases (gastroenteritis). These three diseases depend on a specific array of pathogenic (virulence) determinants.