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NOAA Technical Memorandum NOS OR&R 3



# Summary of Chemistry Results: Shoreline Monitoring Study in Prince William Sound, Alaska During the Summer of 1995

Chemistry Report

Seattle, Washington  
April 1999

**noaa**

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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National Ocean Service



**Office of Response and Restoration**  
**National Ocean Service**  
**National Oceanic and Atmospheric Administration**  
**U.S. Department of Commerce**

NOAA is responsible for protecting and restoring marine and coastal environments impacted by spills and hazardous substance releases. The Office of Response and Restoration (OR&R) is the focal point for NOAA's spill preparedness, emergency response, and restoration programs. OR&R's Hazardous Materials Response Division and its contingent of on-scene Scientific Support Coordinators have earned a wide reputation for delivering scientifically valid solutions to the Federal On-Scene Coordinator (the U.S. Coast Guard in the coastal zone, or EPA in inland areas).

OR&R's Coastal Protection and Restoration Division and Damage Assessment Center are critical components of NOAA's natural resource trusteeship responsibilities. The CPR Division works closely with the U.S. Environmental Protection Agency to redress the environmental effects of hazardous waste sites across the United States. Coastal Resource Coordinators provide site-specific technical expertise in ecological risk assessment and coastal remediation issues. This expertise ranges from physical science to ecology, marine biology, and oceanography. In their NOAA trusteeship role, CRCs assess the longer-term risks to coastal resources (including threatened and endangered species) from Superfund-site contamination, support decision-making for site remedies and habitat restoration, and negotiate protective remedies with the responsible parties to ensure that cleanup, restoration, and recovery are appropriate and fully monitored.

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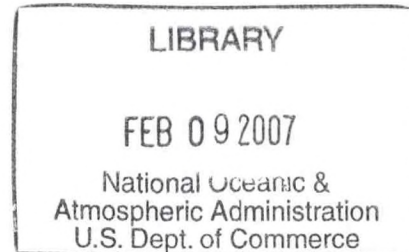


# Summary of Chemistry Results: Shoreline Monitoring Study in Prince William Sound, Alaska During the Summer of 1995

## Chemistry Report

Paulene O. Roberts,  
Charles B. Henry, Jr.,  
Ron LeBlanc,  
Keith Deroche,  
Rebecca East, and  
Edward B. Overton

Institute for Environmental Studies  
42 Atkinson Hall  
Louisiana State University  
Baton Rouge, Louisiana 70803



Edited By:

Gary Shigenaka  
NOAA Hazardous Materials Response and Assessment Division  
7600 Sand Point Way Northeast  
Seattle, Washington 98115

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Seattle, Washington

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William Daley, Secretary,  
U.S. Department of Commerce

D. James Baker, Ph.D.  
Under Secretary for  
Oceans and Atmosphere  
and Administrator, National  
Oceanic and Atmospheric  
Administration

Nancy Foster, Ph.D.  
Assistant Administrator  
for Ocean Services and  
Coastal Zone Management  
NOAA National Ocean  
Service

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Response and Restoration Division  
National Ocean Service  
National Oceanic and Atmospheric Administration  
U.S. Department of Commerce  
Silver Spring, Maryland

## NOTICE

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## Introduction

In 1989, the T/V *Exxon Valdez* ran aground and released roughly 11 million gallons of Exxon Valdez Oil (EVO) into Prince William Sound, Alaska. Since 1990 the Hazardous Materials Response and Assessment Division (HAZMAT) of the National Oceanic and Atmospheric Administration (NOAA), has sponsored an integrated biological, geomorphological, and chemical monitoring study to assess the effects of high-pressure, hot-water washing and the persistence of stranded oil on shoreline ecology and recovery. The annual monitoring results document the intertidal biological species and species abundance, the chemical state of the EVO and sediment concentration, and the uptake of EVO by bivalve species. The results are synoptic, representing June to July 1995, relative to the polynuclear aromatic hydrocarbon (PAH) concentration and PAH profiles alterations/weathering, but are part of a larger research agenda, therefore, only chemistry samples analyzed during 1995 are discussed. The 1995 Prince William Sound Chemistry Report provides the EVO quantitative values for sediments and biological samples, weathering trends, and source fingerprint results.

The 1995 NOAA Shoreline Monitoring Survey focused on biological sites and three additional special studies projects. A total of 91 samples of clams, mussels, surface, and subsurface sediments were collected for possible chemical analysis. All samples were sent to the Institute for Environmental Studies, Louisiana State University (LSU) for archival storage. Of these samples, 61 were selected for gas chromatography/ mass spectroscopy (GC/MS) detailed analysis. Most of the samples were *Mytilus* cf. *trossulus* (mussels). EVO was detected in many of these samples even 6 years after the T/V *Exxon Valdez* incident.



# Chapter 1

## Methodology

### Analytical Methodology

Chemistry methods are consistent with the methods used in previous shoreline monitoring studies and reported separately (Henry and Overton 1993, Roques et al. 1994). The analytical approach targeted specific compounds selected by the following criteria:

- hydrocarbon constituents common to crude oils,
- specific compounds generally associated with chronic oil toxicity, and
- oil constituents that have value in differentiating between petroleum and other sources of hydrocarbon pollution, both natural and anthropogenic (e.g., terrestrial plant waxes and combustion byproducts).

Selected target analytes for both qualitative and quantitative analytical analyses include:

- individual saturated hydrocarbons (the normal alkanes and isoprenoids between nC-9 and nC-35),
- PAH including the dominant alkylated homologues in oil,
- sulfur heterocyclic aromatic hydrocarbons and related alkylated homologues, and
- oil biomarkers.

Oil is a complex mixture of organic compounds; many thousand different compounds make up an individual oil's composition. For chemical characterization and source fingerprinting by GC/MS, specific compounds are selectively quantitated. The most useful group of target analytes in oil are the 2- to 6-ring aromatic and sulfur heterocyclic hydrocarbons and their respective alkyl-substituted homologues. Although these selected target PAH represent less than 2% of the bulk composition of EVO, they are essential to characterize petroleum sources, identify potential biological effects, determine exposure pathways, monitor weathering trends, and degradation of the oil (Sauer and Boehm 1991). The target analytes may be a single compound or isomers quantified as a single group.

The target PAH listed in Table 1 exceed the EPA priority pollutant list with many of the target analytes existing not as single compounds, but as isomer groups such as the C-2 naphthalene homologue series. Quantification of the nonalkylated PAH and the saturate alkanes is based on authentic standards while the alkylated homologues are quantified by response factors generated by the unalkylated parent, e.g., the response factor generated for naphthalene (C-0) is used to calculate the C-1 through C-4 naphthalene homologues. Oil biomarkers, such as the hopane series (191 ion), may not always be present in refined oil products and are of limited value in assessing levels of petroleum pollution. Surrogate standards injected with each sample are quantitated for extraction efficiency; the surrogates include acenaphthene-d10, phenanthrene-d10, and terphenyl-d14. Results for all analytical methods are reported as a function of wet weight, with dry weight values provided for tissue correction.

Since hydrocarbons are naturally present in the environment, detailed chemical analyses are required to confirm the presence of oil and differentiate the types of hydrocarbons detected in a monitoring study. PAH are extremely useful in differentiating petroleum from byproducts of combustion. Oil is generally characterized by PAH composed primarily of 1-, 2-, and 3- ring aromatic compounds with a preference for alkyl-substituted alkanes (e.g., 2-, 4-, 5-trimethylphenanthrene, one of many C-3 phenanthrene homologues). PAH resulting from incomplete combustion are characterized by 3-, 4-, and 5- ring aromatic compounds with few substituted alkyl homologues. Differences between background PAH derived from natural events such as forest fires and residual oil pollution are a key element of this study.

Standard EPA methodologies are inadequate to assess petroleum pollution since they lack key target compounds characteristic of oil. While no standardized methodology currently exists, there is fundamental acceptance by the research community and regulatory agencies for (GC/MS) petroleum analysis in oil spill response and monitoring studies. GC/MS provides a very powerful means of separating oil constituents and is a sensitive and highly selective tool for characterizing spilled oil samples. GC/MS procedures are widely accepted for oil spill response activities, oil fate and effects studies, and baseline pollution monitoring (Overton et al. 1981, Boehm and Farrington 1984, Michel et al. 1991; Sauer and Boehm 1991, Sauer et al. 1993). GC/MS provides highly selective source-fingerprinting information as well as compound-specific quantitative results for target aromatic and aliphatic hydrocarbons. Fingerprinting is a term used to describe the analytical process of analyzing a petroleum sample and comparing the results to a known crude oil or petroleum product to determine if the sample is characteristically the same and, therefore, possibly from the same source.



Table 1.. Target compounds assessed by GC/MS.

<u>Compound</u>	<u>ion mass</u>
alkanes* (nC-10 thru nC-31)	85
decalin*	138
C-1 decalin*	152
C-2 decalin*	166
C-3 decalin*	180
naphthalene	128
C-1 naphthalenes	142
C-2 naphthalenes	156
C-3 naphthalenes	170
C-4 naphthalenes	184
fluorene	166
C-1 fluorenes	180
C-2 fluorenes	194
C-3 fluorenes	208
dibenzothiophene	184
C-1 dibenzothiophenes	198
C-2 dibenzothiophenes	212
C-3 dibenzothiophenes	226
phenanthrene	178
C-1 phenanthrenes	192
C-2 phenanthrenes	206
C-3 phenanthrenes	220
naphthobenzothiophene	234
C-1 naphthobenzothiophenes	248
C-2 naphthobenzothiophenes	262
C-3 naphthobenzothiophenes	276
fluoranthrene/pyrene	202
C-1 pyrenes	216
C-2 pyrenes	230
chrysene	228
C-1 chrysenes	242
C-2 chrysenes	256
benzo(b)fluoranthene	252
benzo(k)fluoranthene	252
benzo(e)pyrene	252
benzo(a)pyrene	252
perylene	252
indeno(1,2,3-cd)pyrene	276
dibenzo(a,h)anthracene	278
benzo(g,h,i)perylene	276
hopanes (191 family)*	191
sterenes (217 family)*	217

The sum of these compounds excluding those identified with a \* is the TTAH value.

\* Used primarily for source fingerprinting and generally not quantified.

## Pyrogenic vs. Petrogenic Determination

The Fossil Fuel Pollution Index (FFPI) technique developed by Boehm and Farrington (1984) can aid to characterize the relative contribution between combustion related PAH and oil pollution. A modified FFPI technique (FFPI\*) was used in the 1993 and 1994 Prince William Sound Monitoring Study, Summary of Chemistry Results. The FFPI was slightly modified from that referenced to incorporate an expanded list of target aromatic compounds. Note, this index only provides differences between combustion and petroleum sources; further evaluation must be made to potentially identify other petroleum sources. The FFPI was calculated as follows:

$$\text{Modified FFPI} = \frac{\begin{aligned} &(\text{naphthalene} + \text{C-1 naphthalenes} + \text{C-2 naphthalenes} + \text{C-3 naphthalenes} \\ &+ \text{C-4 naphthalenes} + \text{fluorene} + \text{C-1 fluorenes} + \text{C-2 fluorenes} + \text{C-3} \\ &\text{fluorenes} + \text{dibenzothiophene} + \text{C-1 dibenzothiophenes} + \text{C-2} \\ &\text{dibenzothiophenes} + \text{C-3 dibenzothiophenes} + \text{C-2 phenanthrenes} + \text{C-3} \\ &\text{phenanthrenes} + \text{naphthobenzothiophene} + \text{C-1 naphthobenzothiophenes} \\ &+ \text{C-2 naphthobenzothiophenes} + \text{C-3 naphthobenzothiophenes} + \text{C-2} \\ &\text{pyrenes} + \text{C-2 chrysenes} + (0.5 * (\text{phenanthrene} + \text{C-1 phenanthrenes} + \text{C-1} \\ &\text{pyrenes} + \text{C-1 chrysenes}))) \end{aligned}}{\text{TTAH} - \text{perylene}}$$

## Source Fingerprinting Indices

The difference between monitoring weathering trends compared to source identification is the selection of isomers resistant to natural weathering processes. The selected peaks can be compared and plotted by a ratio technique referred to as Source Fingerprinting Index (SFI) plots. The defensibility of this source fingerprinting approach, also called double ratio plots, is directly related to the stability of the compounds used to derive the index. Through systematic use of numerous ratios for a variety of sources (Henry *et al.* 1993, Henry *et al.* 1995), certain discriminating components were found effective for "matching" petroleum sources despite natural weathering processes. The Source Fingerprinting Indices (SFI) approach is an alternative method for source screening that can confirm differences noted by chromatographic profiles or histogram plots.

The SFI plot for Prince William Sound samples is the combination of C-3 phenanthrene peaks a/b to the total C-3 dibenzothiophene/C-3 phenanthrene for all sediment samples of significant concentrations. The individual peak ratio within the C-3 phenanthrene group provides an internal comparison that removes any instrument variability and strengthens the preliminary fingerprinting assessment. SFIs, like chromatographic source fingerprinting are limited by analyte concentration. Highly weathered samples and/or trace concentrations have considerable ratio variance and possible interferences, reducing the value of the SFI plot as a tool. The SFI plot includes a target range, shown as a circled area indicating the 20% error margin allowed for instrumental variability; those samples within the circle are considered positive matches. The 20% analytical variability is more stringent than a 95% confidence interval obtained statistically from the TTAH concentrations due to environmental patchiness.



## Chapter 2

### Results

The samples analyzed were divided into two study populations. The first consisted of 27 samples and represented standard study site collections for the 1995 Prince William Sound Shoreline Monitoring Study. The second population consisted of 34 samples and represented special studies from selected locations. Tables 2 and 3 summarize the two populations listing the sites, field numbers, laboratory numbers, and sample type. The following results will present the PAH concentration, source correlation, source fingerprinting, and oil weathering.

**Table 2.. Summary of bivalves analyzed. Listed by NOAA identification number, LSU laboratory number, site, sample type, and collection type.**

NOAA ID	LSU Lab ID	Site	Type	Comments	Standard Collection	Special Study
95061504	N5171-19	Block Island	Clams	Excavation Plots 1		1
95061508	N5171-21	Block Island	Clams	Excavation Plots 2		1
	N5171-BO	Block Island	Clams	Orange		1
	N5171-BY	Block Island	Clams	Yellow		1
95061401	N5171-08	Outside Bay	Clams	Transplant Ref.		1
	N5171-OO	Outside Bay	Clams	Orange		1
	N5171-OY	Outside Bay	Clams	Yellow		1
95061311	N5171-40	Bay of Isles	Mussels	Death Marsh		1
95061505	N5171-20	Block Island	Mussels	Excavation Plot 1		1
95061509	N5171-22	Block Island	Mussels	Excavation Plot 2		1
95071242	N5208-01	Block Island	Mussels	Soft	1	
95071243	N5208-10	Block Island	Mussels	Rocky	1	
95071543	N5208-12	Chenega Dock	Mussels	Reference	1	
95071541	N5208-02	Crab Bay	Mussels	Soft	1	
95071542	N5208-05	Crab Bay	Mussels	Rocky	1	
95071541A	N5208-02A	Crab Bay A	Mussels	Soft	1	
95071465	N5208-04	Crafton Island	Mussels	Soft	1	
95061511	N5171-01	Disk Island	Mussels	Cleaning Site		1
95071464	N5208-14	Eshamy Bay	Mussels	Rocky	1	
95071244	N5208-15	Mussel Beach	Mussels	Mid	1	
95071358	N5208-13	NW Bay Islet	Mussels	Rocky	1	
95071359	N5208-11	NW Bay W Arm	Mussels	Soft	1	
95071456	N5208-09	Outside Bay	Mussels	Soft	1	
95071525	N5208-06	Shelter Bay	Mussels	Soft	1	
95071526	N5208-08	Sleepy Bay	Mussels	Soft	1	
95061312	N5171-03	Smith Island East	Mussels	Boulder/Cobble	1	
95061313	N5171-04	Smith Island	Mussels	Plot 1		1
95061314	N5171-05	Smith Island	Mussels	Plot 2		1
95061315	N5171-06	Smith Island	Mussels	Plot 3		1
95061316	N5171-07	Smith Island West	Mussels	Boulder/Cobble	1	
95071613	N5208-07	Snug Harbor	Mussels	Soft	1	
95071614	N5208-03	Snug Harbor	Mussels	Rocky	1	
95061101	N5171-02	Whittier Harbor	Mussels	Reference		1
<b>Totals</b>					<b>18</b>	<b>15</b>



Table 3. Listing of all sediment samples analyzed.

NOAA ID	LSU Lab ID	Site	Type	Comments	Standard Collection	Special Study
94062314	N4187-06 *	Block Island	Sediment	Clear Plot 1		1
94062315	N4187-11 *	Block Island	Sediment	Clear Plot 2		1
94062316	N4187-07 *	Block Island	Sediment	Clear Plot 3		1
94062317	N4187-03 *	Block Island	Sediment	Clear Plot 4		1
94062318	N4187-10 *	Block Island	Sediment	Clear Plot 5		1
94062319	N4187-09 *	Block Island	Sediment	Clear Plot 6		1
95061502	N5171-42	Block Island	Sediment	Excavation Plot 1		1
95061506	N5171-44	Block Island	Sediment	Excavation Plot 2		1
95071241	N5208-24	Block Island	Sediment	Soft Low	1	
95071255	N5208-28	Block Island	Sediment	Clear Plot 1		1
95071256	N5208-35	Block Island	Sediment	Clear Plot 2		1
95071257	N5208-38	Block Island	Sediment	Clear Plot 3		1
95071258	N5208-16	Block Island	Sediment	Clear Plot 4		1
95071259	N5208-39	Block Island	Sediment	Clear Plot 5		1
95071260	N5208-30	Block Island	Sediment	Clear Plot 6		1
95071540	N5208-23	Crab Bay	Sediment	Soft	1	
95071357	N5208-27	NW Bay Islet	Sediment	Rocky	1	
95071467	N5208-32	NW Bay W Arm	Sediment	Soft Low	1	
95071441	N5208-40	Outside Bay	Sediment	Soft	1	
95071512	N5208-26	Shelter Bay	Sediment	Low	1	
95071524	N5208-17	Sleepy Bay	Sediment	Low	1	
95061317	N5171-47	Smith Island	Sediment	Plot 1		1
95061318	N5171-48	Smith Island	Sediment	Plot 2		1
95061319	N5171-49	Smith Island	Sediment	Plot 3		1
95071612	N5208-34	Snug Harbor	Sediment	Soft	1	
95071615	N5208-41	Snug Harbor	Sediment	Rocky	1	
95061503	N5171-43	Block Island	Sub. Sed	Excavation Plot 1		1
95061507	N5171-45	Block Island	Sub. Sed	Excavation Plot 2		1
Totals					9	19

\* Note, samples collected in 1994 but analysis requested in 1995.

Overall, petroleum contamination was found in 54 of the 61 samples analyzed. The total range of total target aromatic hydrocarbons (TTAH) concentrations were from below detection (ND) to 71 ppm. As previously stated, the TTAH is the sum of the individual PAH compounds quantified by GC/MS. The remaining seven samples contained PAH contamination, but there was no indication of oil derived from the 1989 incident.

### TTAH Concentrations at Standard Site Collections

The standard biological collections for 1995 emphasized the mid to lower intertidal zones at 18 study locations. The GC/MS results, summarized in Table 4, summarizes the PAH concentration detected at these sites. As with previous years, the sediment TTAH concentration was greater than the bivalves. The composited sediment sample results range from 0.004 parts per million (ppm) to approximately 8 ppm TTAH, while the mussel results were below detection (ND, < 0.001 ppm) to 0.24 ppm TTAH. An order of magnitude difference exists between the highest sediment and the highest mussel TTAH concentration. Note that the highest sediment TTAH concentration was collected at Block Island, soft low,

while the greatest mussel TTAH was from Smith Island, West; therefore, the highest sediment TTAH concentrations do not correlate with the tissue TTAH for the 1995 collection.

Table 4. Listing of standard collection samples analyzed and TTAH concentrations.

Site	Comments	TTAH (ng/mg)	Standard Collections		
			Mussel	Clam	Sediment
Block Island	Soft	0.056	1		
Block Island	Rocky	ND	1		
Block Island	Soft Low	8.600			1
Chenega Dock	Reference	0.096	1		
Crab Bay	Soft	ND	1		
Crab Bay	Rocky	0.007	1		
Crab Bay	Soft	0.004			1
Crab Bay A	Soft	0.001	1		
Crafton Island	Soft	0.015	1		
Eshamy Bay	Rocky	0.055	1		
Mussel Beach	Mid	0.004	1		
NW Bay Islet	Rocky	0.033	1		
NW Bay Islet	Rocky	0.980			1
NW Bay W Arm	Soft Low	0.028			1
NW Bay W Arm	Soft	0.017	1		
Outside Bay	Soft	0.011	1		
Outside Bay	Soft	0.004			1
Shelter Bay	Soft	0.010	1		
Shelter Bay	Low	0.066			1
Sleepy Bay	Soft	0.028	1		
Sleepy Bay	Low	0.095			1
Smith Island East	Boulder/Cobb	0.100	1		
Smith Island West	Boulder/Cobb	0.240	1		
Snug Harbor	Soft	0.007	1		
Snug Harbor	Rocky	0.001	1		
Snug Harbor	Soft	0.020			1
Snug Harbor	Rocky	0.820			1
Totals			18	0	9

#### *Mytilus cf. trossulus*: Mussels

A total of 19 mussels was collected from the mid intertidal zone and analyzed. PAH contamination was detected at quantifiable levels in all but two of the samples (Block Island, Rocky and Crab Bay, soft). The remaining 17 samples contained TTAH concentrations from 0.001 to 8.6 ppm (Snug Harbor, Rocky or Crab Bay A, soft to Block Island, soft low) with an average of 0.038 ppm. Table 4 also lists the TTAH concentrations documented for the standard collections. Figure 1, in log scale, shows the concentrations of TTAH found within mussels contrasted with corresponding sediment TTAH for both the standard and special study collections.

*Protothaca staminea*: Clams

Clams were not included in the standard monitoring collections for 1995 due to the designated middle intertidal elevation priority. For standard collection sites within Prince William Sound, clams are located in the lower intertidal elevation. However, clams were collected for special studies (Section 3.2.3).

Sediments

Nine sediment samples were analyzed to correlate with the 1995 standard biological collection; each was an intertidal zone composite of the site and considered an integrated residual oil sample. In all cases, the sediment concentration was greater than the corresponding site tissue concentrations. The range of TTAH concentration was 0.004 to 8.6 ppm collected at Crab Bay, soft and Block Island, soft, respectively.



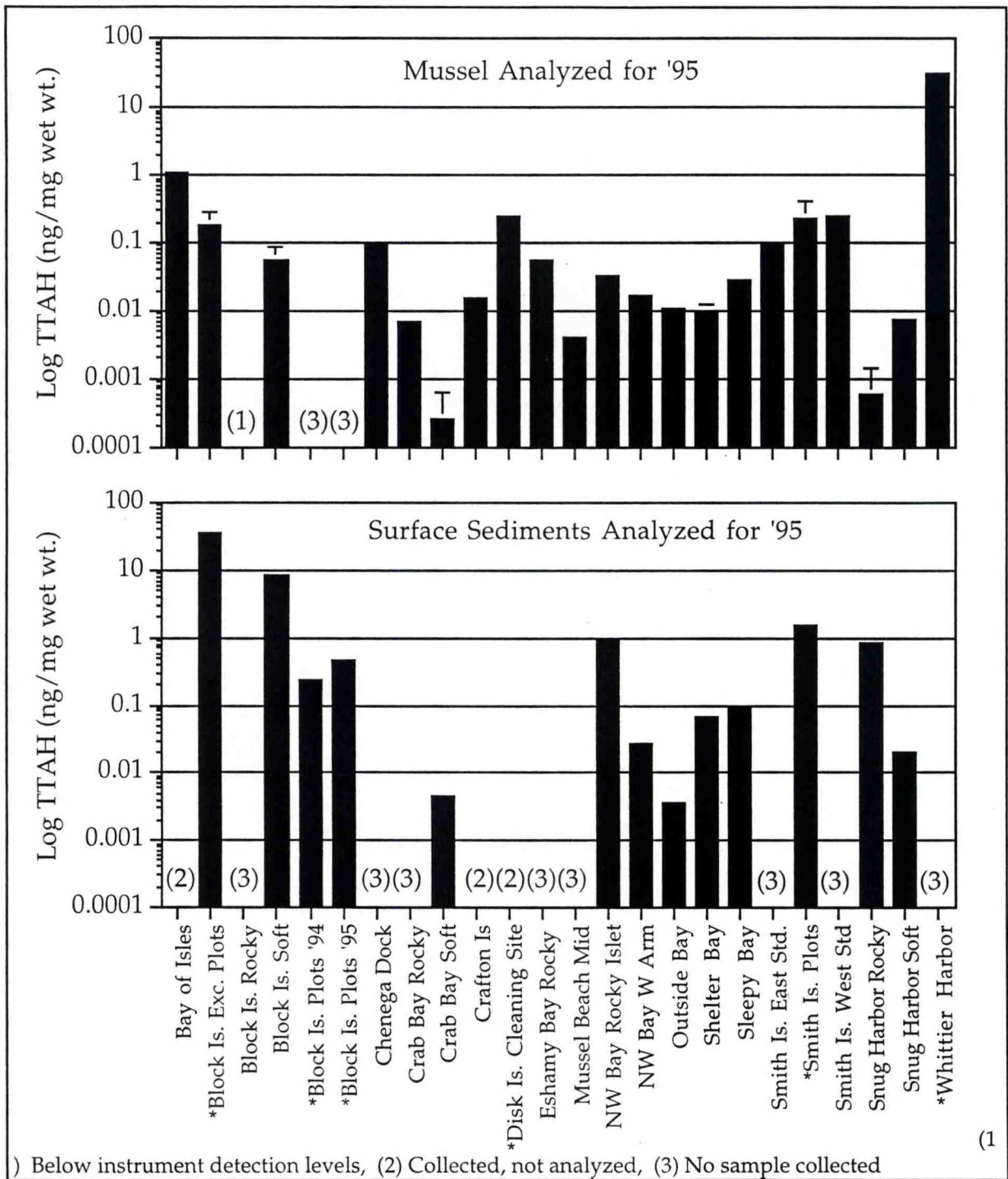


Figure 1.. The histogram plots of mussels (top) and surface sediments (bottom) by log TTAH concentration. The asterisk (\*) represents special study collections. The error bars represent analytical variability.

## TTAH Concentrations at Special Study Collections

Four special studies were conducted in 1995: Block Island Clear Plots, Block Island Excavation Plots, Clam Transplant Study, and Smith Island Transect. The principle topic of the special studies was correlation; TTAH in sediments to tissue, TTAH concentration and depuration, 8 mussels, 7 clams and 19 sediment samples were analyzed. The results presented here for the special studies are analytical only and may be only a portion of the required data to complete the study. The TTAH data from each study will be presented individually. Two additional mussel samples, collected from Bay of Isles, Death Marsh, and Disk Island cleaning site, were also analyzed. The average TTAH concentration and range are listed in Table 5.

Table 5.. Listing of all special collection samples analyzed, average, and range of TTAH concentrations in nanogram per milligram (ng/mg) wet weight.

Site	Comments	Mean TTAH*	High TTAH*	Low TTAH*	Special Studies		
					Mussel	Clam	Sediment
Bay of Isles	Death Marsh	1.100	NA	NA	1		
Block Island	Transplants	0.160	0.210	0.100		2	
Block Island	Excavation Plots	0.530	0.950	0.110		2	
Block Island	Excavation Plots	0.180	0.260	0.097	2		
Block Island	Clear Plots '94	0.270	0.590	0.018			6
Block Island	Clear Plots '95	0.450	2.200	0.030			6
Block Island	Excavation Plots Sur.	36.000	71.000	1.800			2
Block Island	Excavation Plots Sub.	6.100	7.100	5.000			2
Disk Island	Cleaning Site	0.240	NA	NA	1		
Outside Bay	Transplants	0.034	0.067	0.000		2	
Outside Bay	Reference	0.000	NA	NA		1	
Smith Island	Transect	0.230	0.450	0.095	3		
Smith Island	Transect	1.600	4.400	0.048			3
Whittier Harbor	Reference	32.000	NA	NA	1		
Totals					8	7	19

\* TTAH concentration in ng/mg wet weight.

### Block Island Clear Plots

Clear plots, or transplant plots, were established in 1992 at Block Island to evaluate the TTAH concentration within sediments to uptake within a selected species of transplanted clams, *Protothaca staminea*, in a 0.5 meter (m) stationary quadrat. The transplant clams and composited sediment samples were collected in 1993. Since 1994, a composite sediment sample has been collected at each of the five quadrats across the mid intertidal zone; sediment from the 1995 field survey and archived 1994 samples were analyzed during 1995. The sediment samples for 1994 and 1995 show a pattern of increasing TTAH concentration from plot 1 to plot 6. Comparing the TTAH concentrations by plot and year, there appears to be no decrease attributed to the passing of a year. Figure 2 shows the TTAH concentration for each plot by year. The field observations indicate plot 6 was protected by a large bedrock outcropping that shelters the area from wave action, while plot 1 was the most exposed. The results suggest distinct microenvironments within a limited study of



intertidal zone sediments. Plot 1 also contained influences of fuel oil to be discussed in the Source Fingerprinting section.

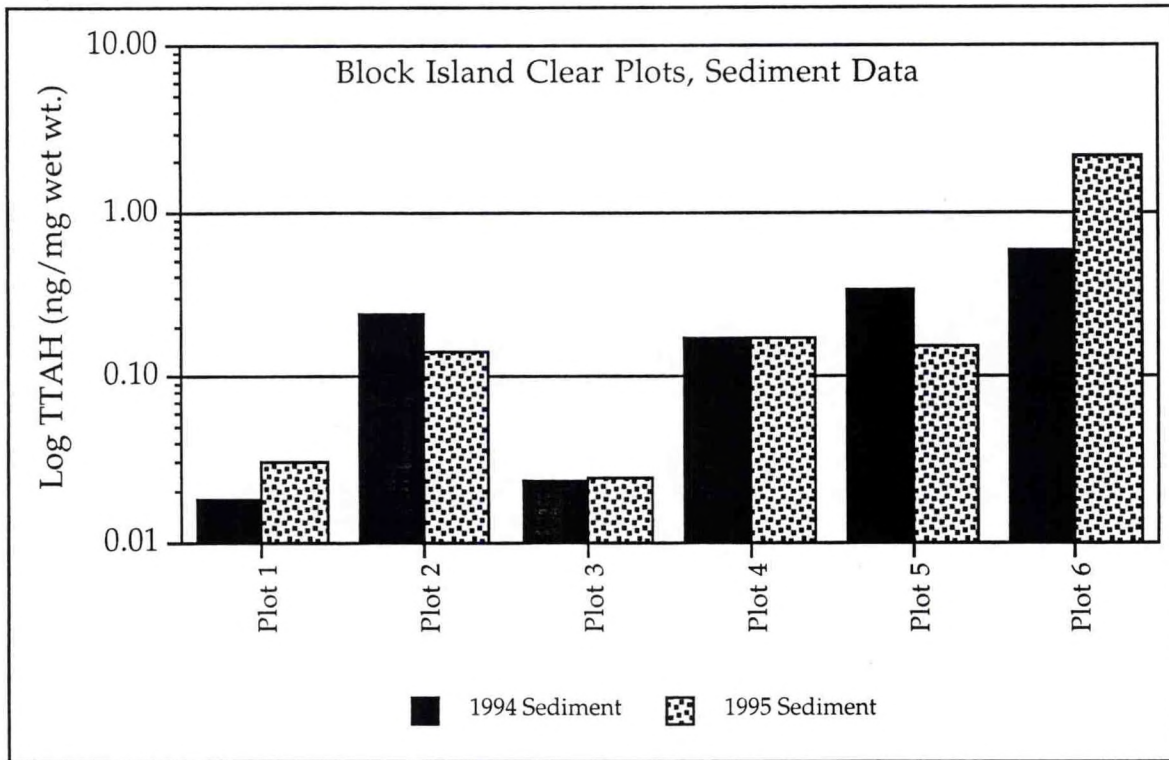


Figure 2. Clear plot data for the sediment collections during 1994 and 1995. Note the trend of increasing oil from plot 1 to plot 6 yet no distinctive difference can be seen between 1994 and 1995. This suggests little petroleum degradation, reducing TTAH concentration, has occurred.

### Block Island Excavation Plots

Excavation plots were designed to directly correlate sediment and bivalve TTAH concentrations within a 0.5 m defined area. A 0.5 m-square quadrat was placed and composite surface sediments and mussels were collected. A 2-inch layer of the surface was removed and composite subsurface sediments and clams were collected. The excavation plots were located above the clear plot study, on the beach platform, and generally covered by tidal action except during low tides. Excavation plot 1 was dug near a bedrock outcropping while excavation plot 2 was dug closer to the tree line and adjacent to the tide pool found at low tide. Figure 3 shows the TTAH concentration for excavation plot 2 was greater for the surface sediments, clams, and mussels, but statistical validity is lacking with only two samples.



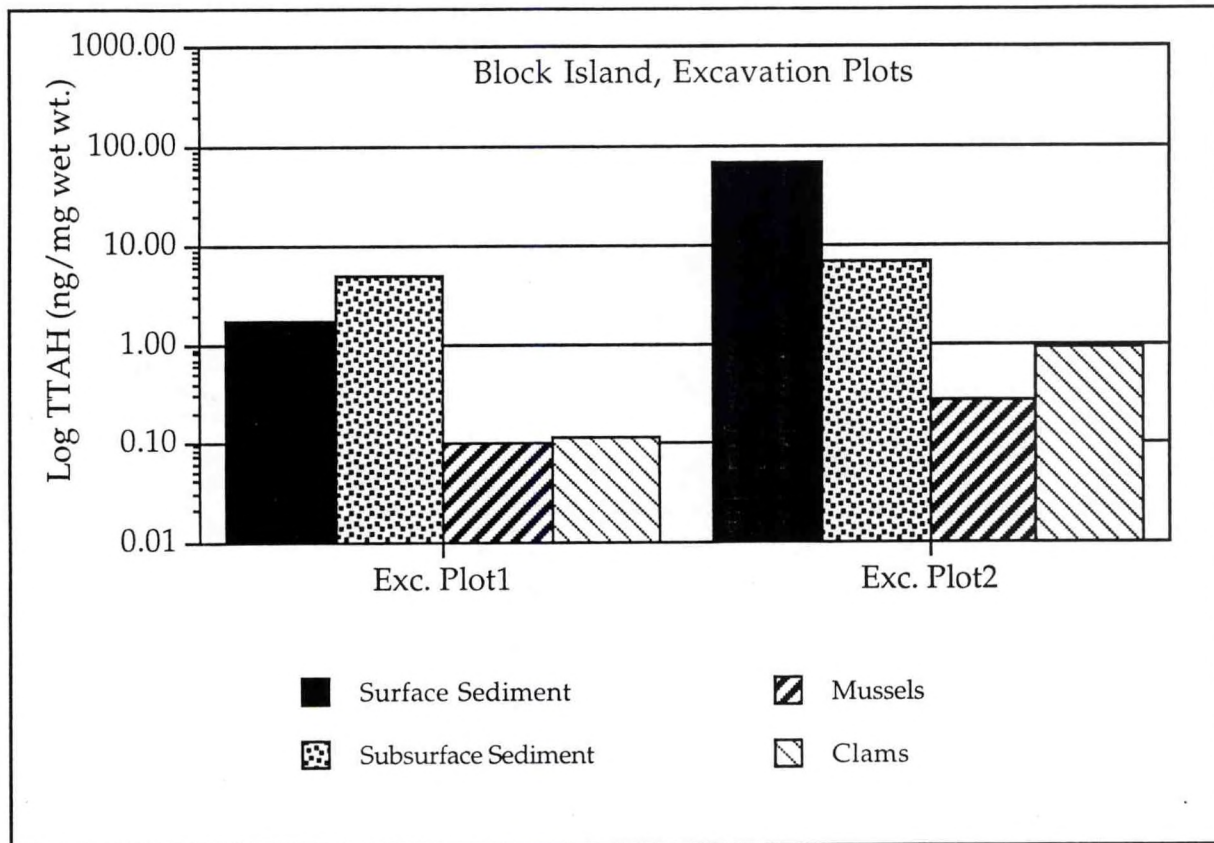


Figure 3. Excavation plot data for the sediment collections during 1994 and 1995. Note the trend of increasing oil from plot 1 to plot 6, though no

### Clam Transplant Study

The clam transplant study was designed to evaluate the oil bioavailability and depuration of EVO using Outside Bay and Block Island sites. The study was attributable to Allan Fukuyama at the University of Washington and only the chemistry results and basic design will be presented here. The study evaluated the oil uptake of "clean" clams from Outside Bay, transplanted to the oiled Block Island intertidal zone. Conversely the study also evaluated the depuration of oiled clams from Block Island, transplanted to the unoiled Outside Bay intertidal zone. The TTAH concentrations for the composite collection of clams are presented in Figure 4. The "orange" represents the clams originating from Outside Bay, the "yellow" clams are the clams taken from Block Island, and the Block Excavation plots represent the range of TTAH found within the native clams at Block Island.

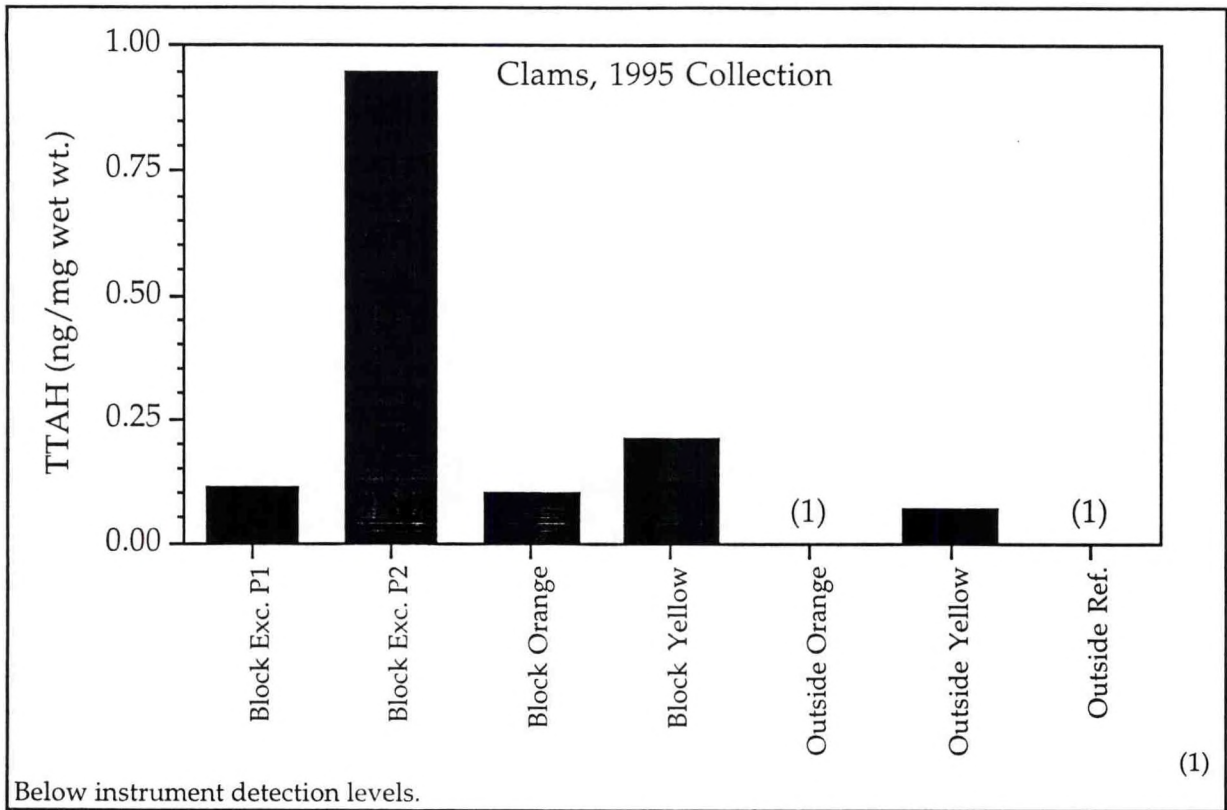


Figure 4. Concentrations of clam samples analyzed in 1995. Note the log scale. These samples are all part of the special study collection of clam transplants.

### Smith Island Transect

The transect study, across the Smith Island intertidal zone boulder/cobble armoring, assessed the mussel body burden relative to the protected oil concentration within the sediments. The transect included three collections of mussels and sediments beneath armoring between the east and west standard collection sites. The TTAH concentrations for the transect are presented in Figure 5 and show less variability for the tissue concentration compared to the sediments. The sediment TTAH concentration increased to the west; the sediment results were consistent with field observations for the past few years.

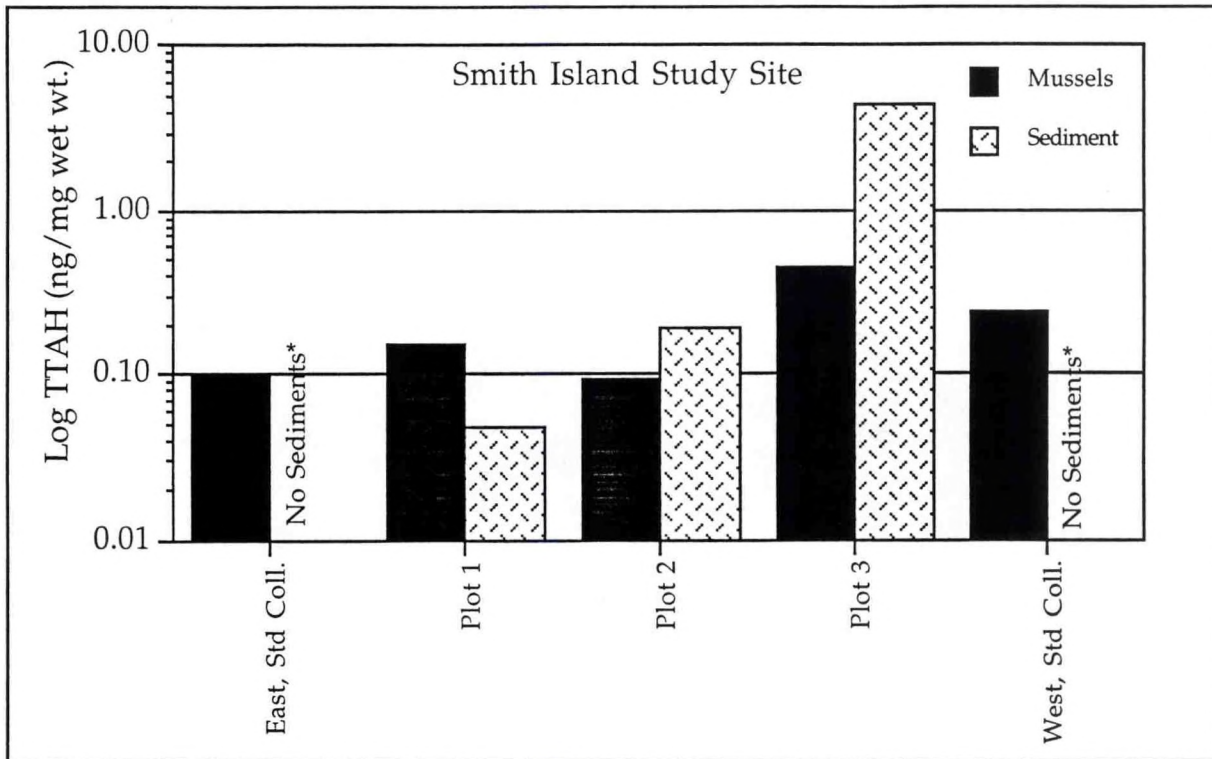


Figure 5. Smith Island transect samples, including the standard mussel collections off bedrock outcroppings. A subtle variation is observed for the mussel samples, but not significant. The sediment samples tend to imply a concentration increase westward across the beach face. \* No sediment samples were collected due to the bedrock substrate.

### Source Characterization

The source characterization for the 1995 population indicates few samples dominated by combustion influence, from tissues or sediments. Both clams and mussel data, when plotted by the FFPI, show limited scatter and TTAH concentrations generally less than 1.0 ppm. Figures 6 and 7 are the FFPI plotted data for the bivalves and sediments respectively. From all the samples analyzed in 1995, 55 out of 61 samples (90%) showed evidence of a strong petroleum derived PAH influence as defined by a FFPI greater than 0.75. Only three samples were 0.5 or less by the FFPI; these samples were from Crab Bay, soft sediments; Snug Harbor, soft low sediments; and Crab Bay, soft A tissues. Three samples fell between 0.5 and 0.75: Shelter Bay, low sediments; Block Island Clear Plot 4, 1994 sediments; and Crafton Island mussels. The overall evaluation indicates a higher domination of petroleum influence than combustion in the tissue and sediment samples. While combustion byproducts were generally less than the petroleum contribution, the 1994 data exhibited a stronger influence of pyrogenic pollutants. The latter may only be another example of environmental patchiness in the PWS study.



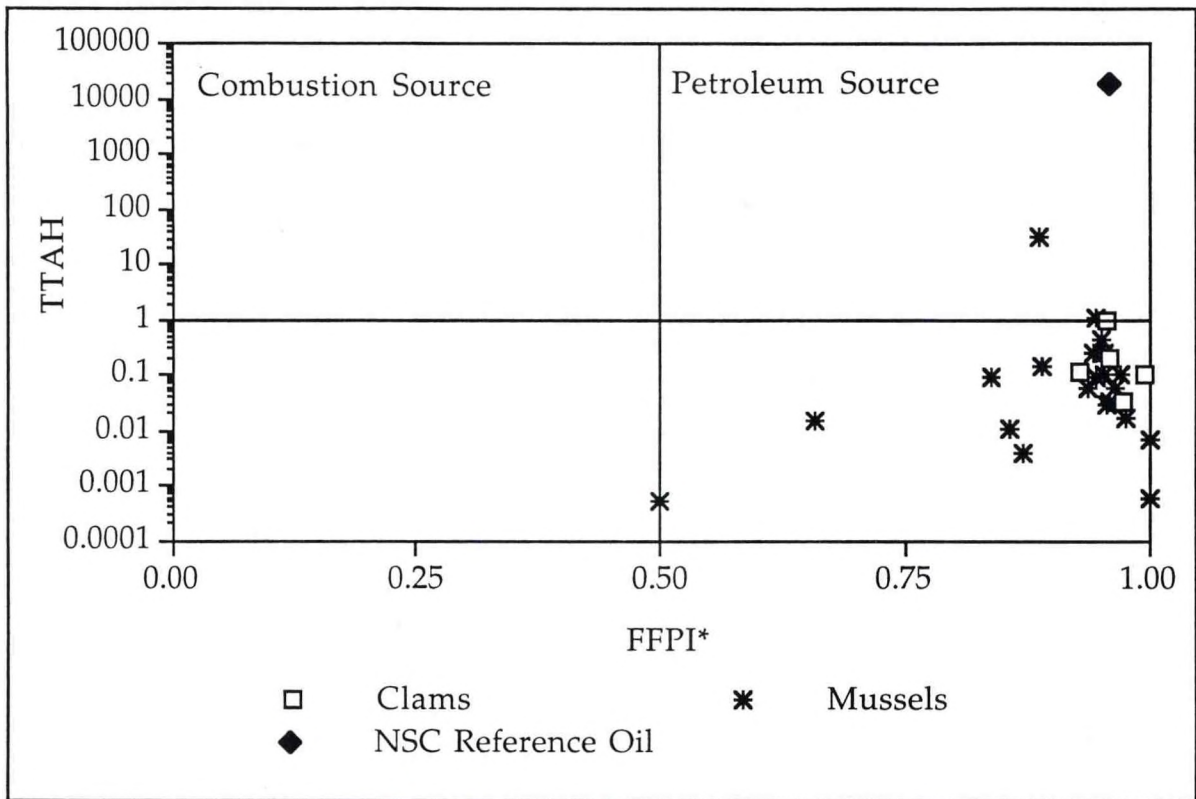


Figure 6. Pyrogenic influences noted by the FFPI plotted against TTAH for distinguishing combustion influence within the clam and mussel samples. Only Crab Bay, soft A and Crafton Island were below 0.75, or the petroleum-dominant threshold.

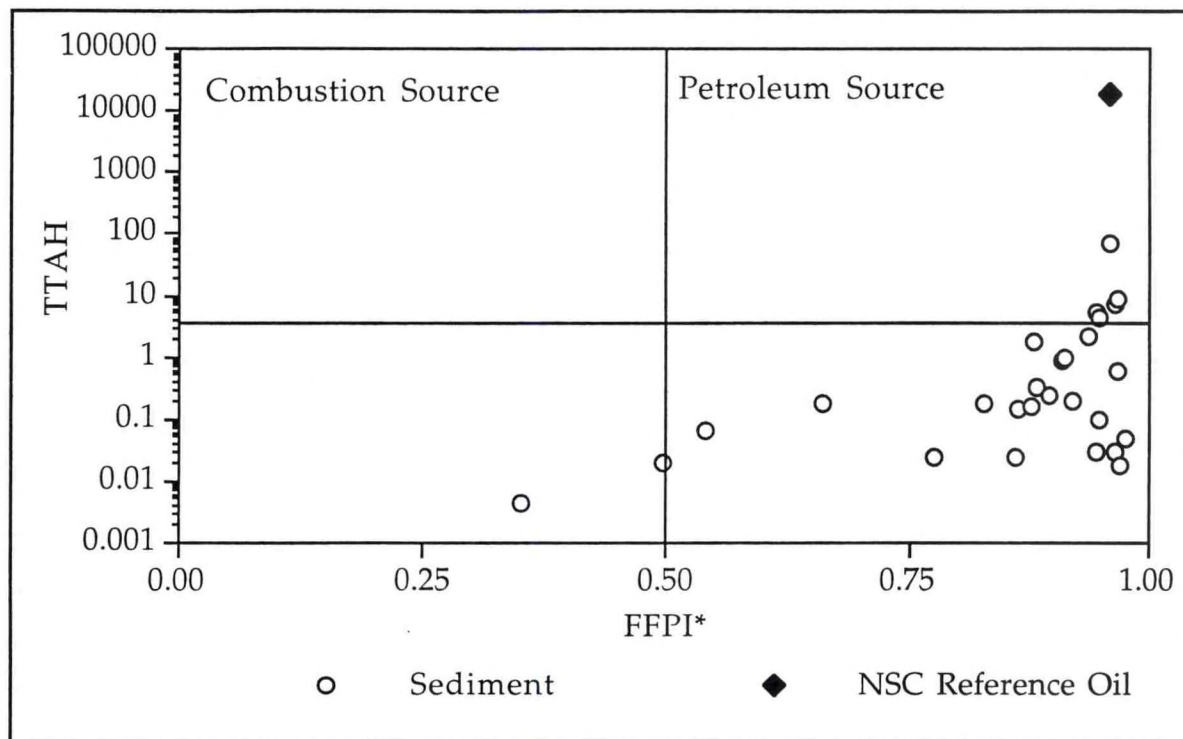


Figure 7. Pyrogenic influences noted by the FFPI plotted against TTAH for distinguishing combustion influence for the sediment samples. The four samples below 0.75 are Crab Bay, soft; Snug Harbor, soft low; Shelter Bay, low; and Block Island Clear Plot 4, 1994.

## Source Fingerprinting

All samples containing significant chromatographic traces were manually source fingerprinted to the EVO. For samples that did not meet the chromatographic criteria, containing several severely degraded profiles, histogram plots were used to determine if additional source influences existed. For sediment samples SFI were also employed as confirmation of source dominance. The results for the biological and sediment samples are described by site with additional sample-specific information for the sediments.

## Biological Samples

In the 1995 biological sample population, careful examination of the extracted ion profiles indicated a TTAH range above 0.5 ppm as acceptable for fingerprinting. As with previous years, there are certain biological samples that contain petroleum, but distinctly not EVO oil by chromatographic profiles and histogram plots. Examples of these are the Chenega Dock and Whittier Harbor mussels these biological samples contain a diesel or #2 fuel oil source. The other samples examined show altered and degraded chromatographic profiles and relatively low TTAH concentrations.

For the 1995 biological population, 26 of the 33 samples were below the levels of chromatographic fingerprinting. Therefore the fingerprinting for all 33 samples was accomplished through histogram profile comparison (Appendix 1A contains a histogram profile for each tissue sampling site, Table 6 describes sources found). EVO was the

dominant source of petroleum identified within ten sites, despite influences from other sources, while seven sites contained diesel or #2 fuel oil without EVO. Table 6 contains the sites and the sources found. Of the ten sites that contained distinguishable EVO patterns, five of these sites also contained a diesel or lighter fuel oil. Only two samples with EVO contained influences of combustion while four samples contained no influence of petroleum profiles.

### Sediment Samples

The sediment samples analyzed for 1995 were not complicated by the additional biological alterations and interferences commonly found in bivalves. All sites except Outside Bay contained remnants of EVO. Of the 28 sediment samples analyzed, only 14 contained sufficient ions that were not degraded or below the signal to noise threshold (0.1 ppm TTAH). These 14 were found to be positive EVO matches by chromatographic profiles, but additional sources were found in Shelter Bay, low (diesel/light fuel oil) Sleepy Bay, low (diesel/light fuel oil); and Snug Harbor, soft low (combustion). TTAH was below 0.1 ppm in 10 of the 28 samples ppm and below levels of accurate chromatographic source fingerprinting. There were four sediment samples above 0.1 ppm but they contained key profiles degraded beyond source fingerprinting.

Table 6. Sources detected through chromatographic profiles and histogram plots for biological samples selected for 1995 analysis. Note a significant influence of pyrogenic and diesel found within the sample set.

Location	EVO	D/L.O.	Pyro.	Ind.	N.S.
Bay of Isles, Death Marsh	X				
Block Island	X				
Chenega		X			
Crab Bay, Rocky		X	X		
Crab Bay, soft & A					X
Crafton					X
Disc Island	X				
Eshamy, rocky	X	X			
Mussel Beach			X	X	
NW Bay, rocky	X	X			
NW Bay, West Arm		X	X		
Outside Bay, Clam, Ref.					X
Outside Bay, Clam Orange					X
Outside Bay, Clam Yellow	X	X	X		
Outside Bay, Mussels		X	X		
Shelter Bay		X			
Sleepy Bay	X	X	X		
Snug Harbor, rocky					X
Snug Harbor, soft		X	X		
Smith Island, east	X	X			
Smith Island, west	X				
Smith Island Plots	X				
Whittier Harbor		X			

EVO: Exxon Valdez crude  
D/L.O: Diesel/ Light Oil  
Pryro: Pyrogenic

Ind: Indeterminate  
NS No Source



Histogram plots were compared for all sediment samples. These plots cannot match the accuracy of chromatographic source fingerprinting, but they can indicate influences and weathering trends. Appendix IB contains the histogram profiles for all the sediment samples analyzed. The site results (Table 7) show a greater influence of other sources as well as a pyrogenic contribution. Only Northwest Bay rocky west Arm and Snug Harbor rocky contained EVO alone, with the other seven sites containing mixed sources. For the nine sites with EVO, the EVO was still the dominant source.

Table 7. Influences found through chromatographic profiles and histogram plots for sediment samples selected for 1995 analysis.

Location	EVO	D/L.O.	Pyro.	Ind.	N.S.
Block Island*	X	X			
Crab Bay, Soft	X	X	X		
NW Bay, Rocky	X				
NW Bay, W. Arm	X				
Outside Bay, Soft		X	X		
Shelter Bay, Low	X	X	X		
Sleepy Bay, Low	X	X			
Snug Harbor, Rocky	X				
Snug Harbor, Soft, Low	X	X	X		
Smith Island Plots*	X	X			

EVO: Exxon Valdez crude  
 D/L.O: Diesel/ Light Oil  
 Pyro: Pyrogenic

Ind: Indeterminate  
 N.S: No Source

\* Of the 16 Block Island samples, 3 contained a light fuel oil, Block Island Clear Plot #1 for 1994 and 1995, and Clear Plot #4 for 1994. For the Smith Island Plots, 1 and 2 both contained a light fuel oil.

Examination of individual sediment samples resulted in additional sources found in 11 of the 28 sediments, but representing 7 sites. The source influence most noted was a diesel or light fuel oil with three samples found on Block and two on Smith Island. Detectable influences from combustion were found in 4 of the 11 samples, TTAH concentration less than 0.1 ppm. The highest concentration containing combustion was Shelter Bay at 0.06 ppm TTAH.

As additional confirmation, sediment samples containing chromatographic profiles resistant to degradation were compared by SFI as in the previous 1994 report. Twenty-four sediments, plus additional crude oils as reference points, were plotted by SFIs and presented in Figure 8. The plot indicates 20 samples within the 20% analytical error and a positive match to the EVO, while 4 samples lie on the edge of the circle or outside. The four samples outside and the four samples degraded beyond SFI application are listed in Table 8. The histogram profile differences for the samples within the SFI 20% error are found in Figure 9. All the samples outside the 20% error had TTAH concentrations below 0.1 ppm in common.

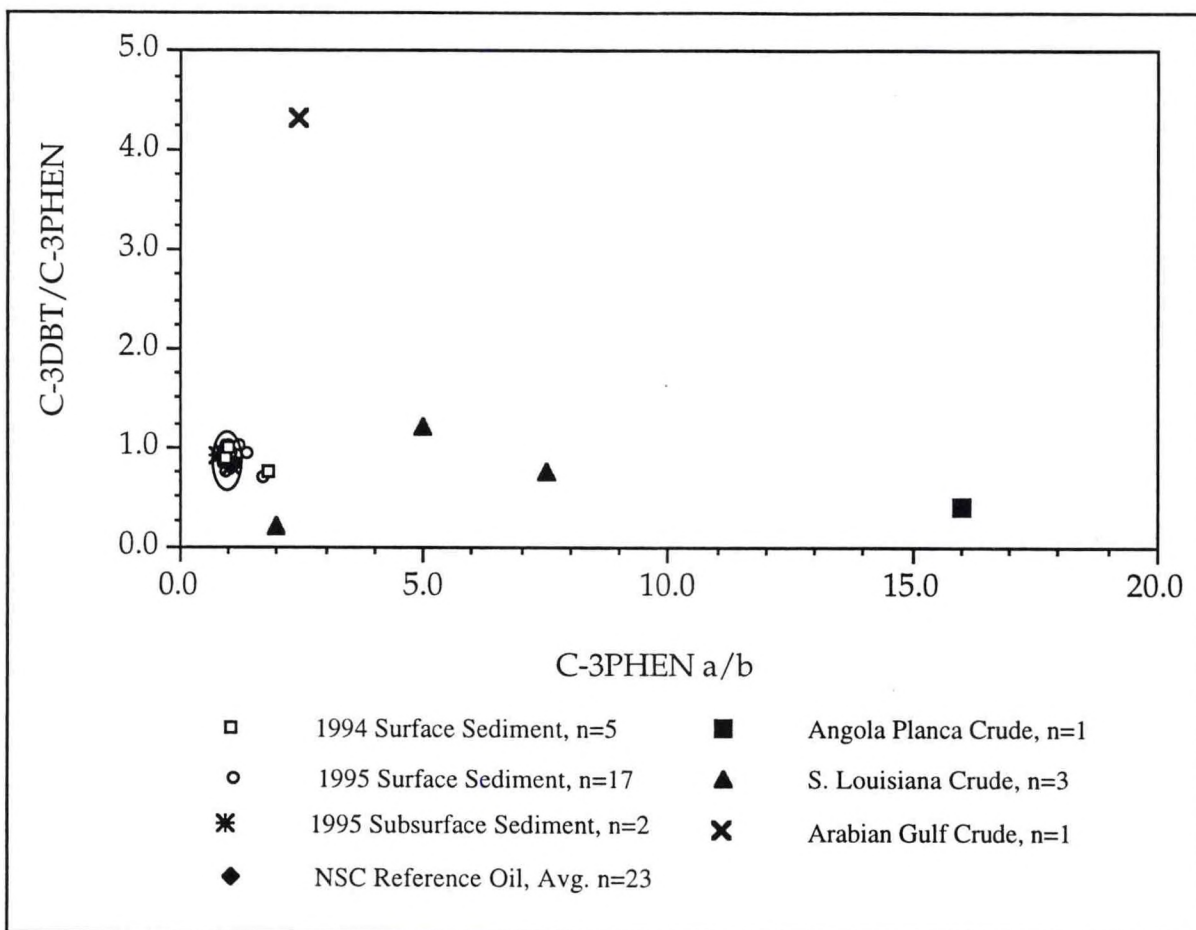


Figure 8. SFI plot for 24 sediment samples. Four samples were not plotted due to lack of values.

Table 8. Description of samples outside the 20% analytical criteria, or samples with insufficient data to plot by SFIs.

Sample Location and (Lab ID.)	Conc. (ppm)
Block Island Clear Plot 1, 1994 (N4187-06) <sup>1</sup>	0.018
Block Island Clear Plot 1, 1995 (N5208-28) <sup>2</sup>	0.030
Shelter Bay, Low (N5208-26) <sup>1</sup>	0.066
Sleepy Bay, Low (N5208-17) <sup>2</sup>	0.095
Block Island Clear Plot 3, 1994 (N4187-07) <sup>3</sup>	0.023
Crab Bay, Soft (N5208-23) <sup>3</sup>	0.0044
Outside Bay, Soft (N5208-40) <sup>3</sup>	0.0035
Snug Harbor, Soft (N5208-34) <sup>3</sup>	0.020

<sup>1</sup> These samples fell together, lower right of the 20% range.

<sup>2</sup> These samples fell together, upper right of the 20% range.

<sup>3</sup> Samples not plotted using SFI.

For the samples to the right and outside the 20% error circle an alteration in the peaks within the C-3 phenanthrene profile existed primarily due to an additional source. Block Island, Clear Plot 1 for 1994 and 1995 contained an additional light fuel source confirmed by the histogram plots (Figure 10). Shelter Bay fell out due to the mixture of sources from light fuel oil and pyrogenic influences. Sleepy Bay was also identified by the histogram plots as a mix of light fuel oil and EVO, also at concentrations sufficient to fall beyond the 20% error margin. The influence of the additional sources is sufficient in the selected SFI to alter the sample's position in the plot.

The samples not plotted contained severely degraded sulfur constituents. The values for Outside Bay and Crab Bay fall outside this SFI plot, while Block Island Plot 3, 1994 has the sulfur (DBT) significantly degraded and Snug Harbor contains a significant mixture of pyrogenic and other fuel oil influences. Histogram plots of these samples are found in Figure 11.



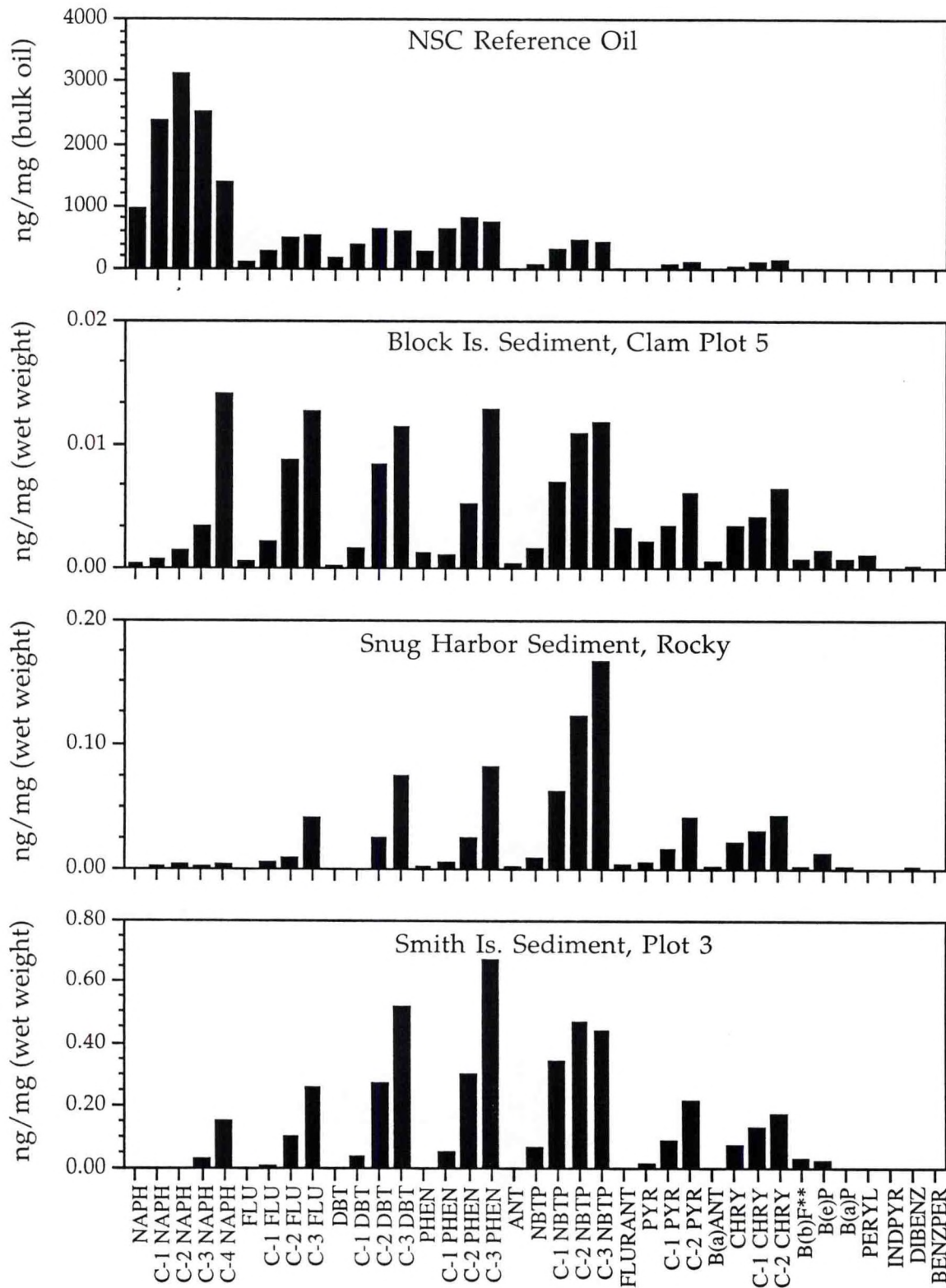


Figure 9. Histogram plots from within the SFI 20% analytical error circle. Changes in the plots are present, yet the SFI still distinguishes as EVO.

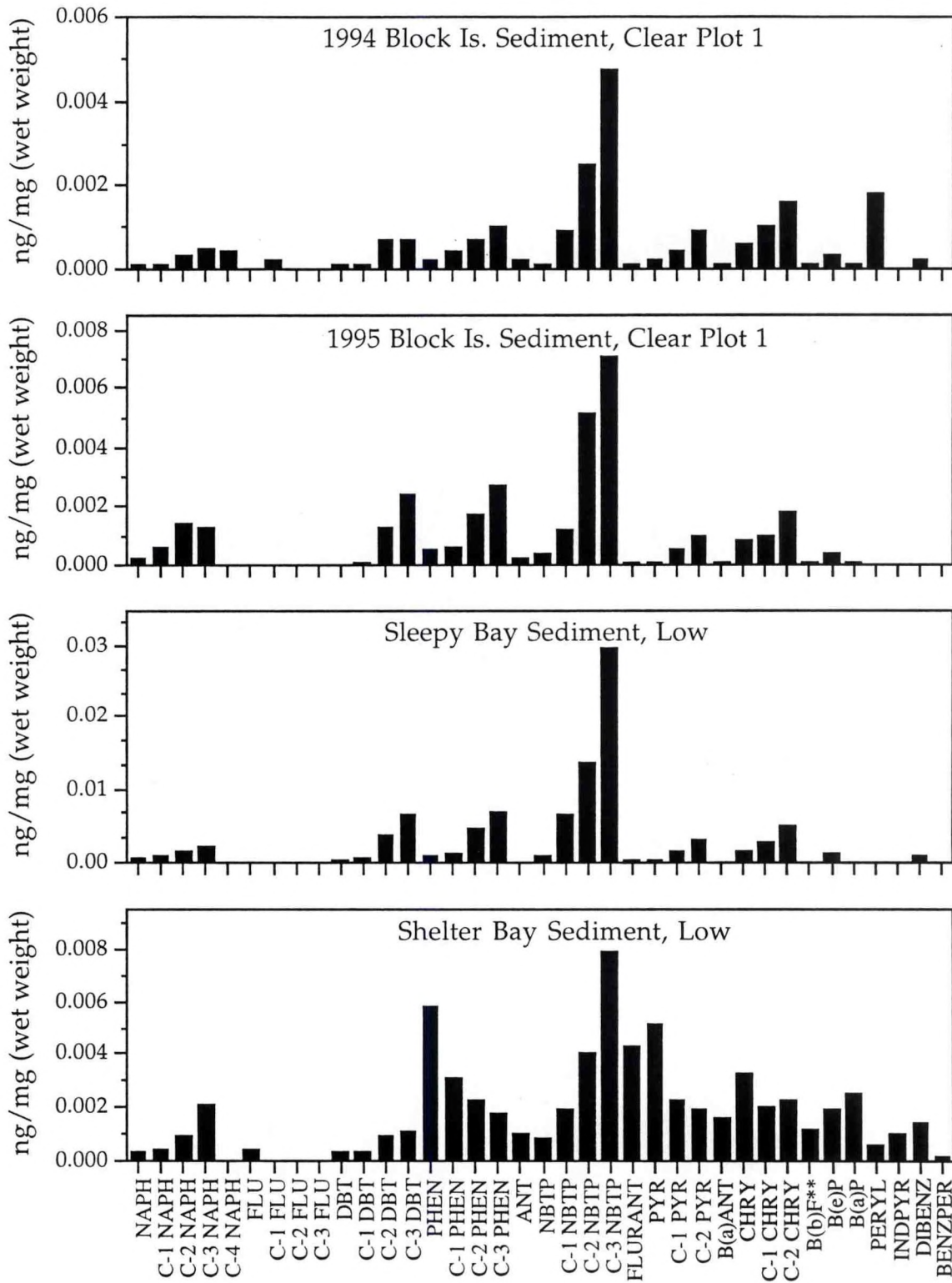


Figure 10. Histogram plots of samples outside the 20% analytical criteria. Note the heavily weathered profiles and the low concentrations.

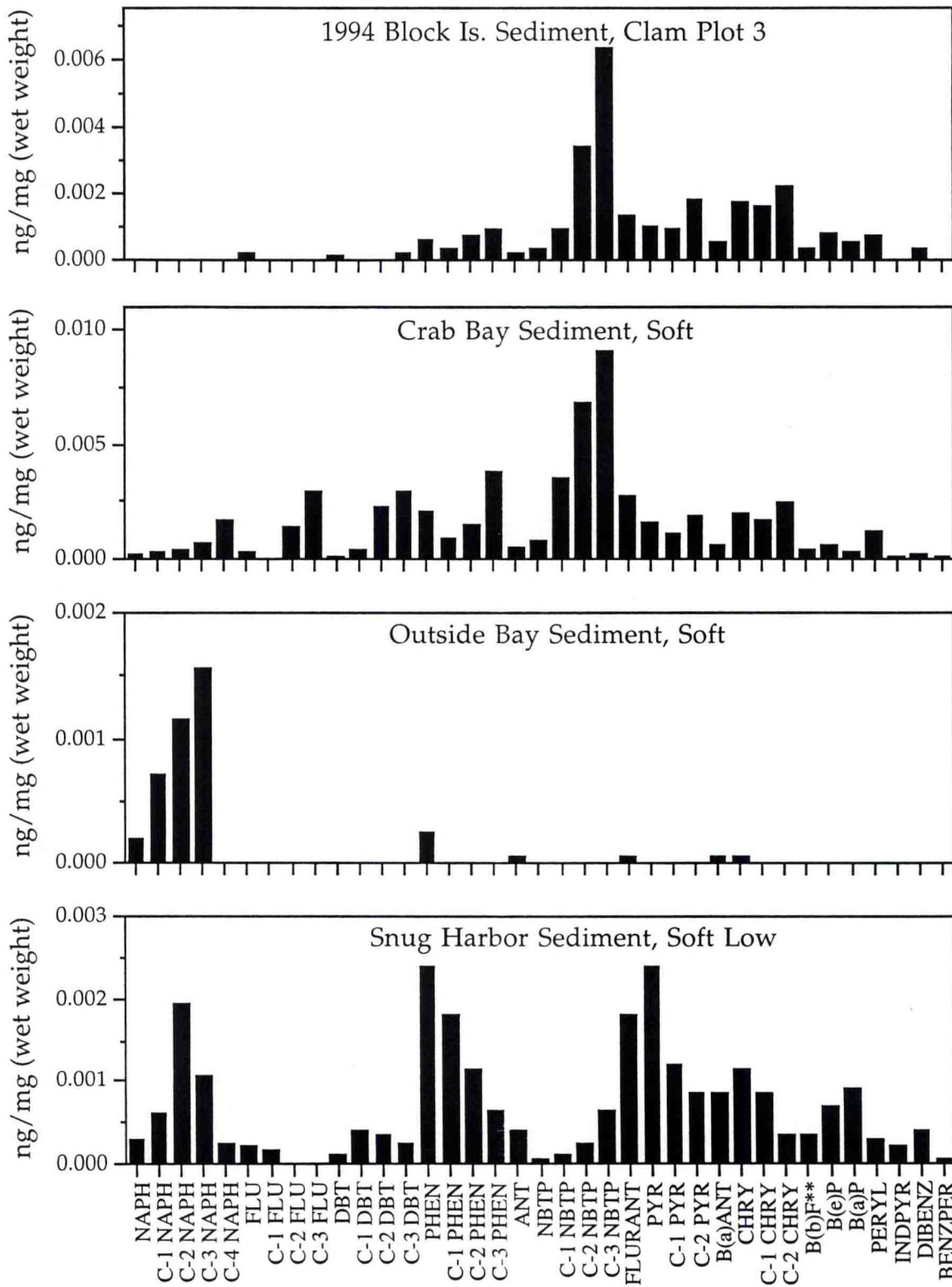


Figure 11. Histogram plots of sites with insufficient isomers to plot by SFIs. Note samples are highly degraded, Block Island (top) and Crab Bay or contain additional sources, i.e., Outside Bay and Snug Harbor, Soft/Low.





## Chapter 3

### Discussion

Because the overall sampling strategy in 1995 emphasized middle intertidal stations, fewer sites were sampled in 1995 than in previous years (16 sites sampled compared to 35 sites in 1994). Additional samples were collected at selected sites to address special biological questions. Several interesting trends were observed in the data set. We must note that the observations could be skewed due to the reduction in site population, with fewer sites represented; but the basic changes noted are more likely indicative of alterations occurring to EVO within the intertidal zone. The 1995 chemistry data suggest a static TTAH concentration, but an increased petrogenic versus pyrogenic contamination. An increase in other petrogenic sources was observed at numerous sites, yet EVO was still the dominant feature. These observations are reflected in the source characterization, source fingerprinting, and oil weathering alterations that directly relate EVO bioavailability to intertidal zone animals.

#### Source Characterization

PAH are ubiquitous in the environment, originating from both natural causes and anthropogenic sources. In the marine environment, PAH are generally characterized as two types: petroleum-derived from diesel, crude oil, and petroleum seeps; and pyrogenic-derived or byproducts from incomplete combustion of burning wood and fossil fuels (note, creosote leachates are similar to the latter). PAH derived from crude oil are primarily composed of 2- and 3- ring structures that are highly alkylated. Pyrogenic or incomplete combustion PAH are highly ubiquitous environmental contaminants and frequently found at low or "background" concentrations. Combustion derived PAH is commonly composed of 3-, 4-, and 5- ring PAH with parent compounds dominant and relatively low concentration of alkylated homologue groups. By using GC/MS distinctive chromatographic profiles or TTAH patterns often indicate the PAH dominance and provide characterization of the source or type of pollution detected in the field sample.

As the concentration of EVO residues is reduced and altered by physical and biological removal processes, chronic background sources that were masked by the dominance of EVO now represent a greater fraction of the total PAH in sediments and organism in PWS. From the results presented in the previous two chemistry reports (Henry et al. 1994 and Roberts et al. 1995) we would have expected a higher influence of combustion within the 1995 samples. This was not observed in the data. Instead a higher influence of petrogenic PAH was indicated by higher FFPI values, although the TTAH concentrations were generally no greater than the previous years. The calculated FFPI for each sample analyzed is incorporated into the GC/MS data summary (Appendix II). Unweathered North Slope crude oil analyzed during this study gave a FFPI between 0.940 and 0.957 (n=40), with an average value of 0.948. Weathered oils tend to have a slightly lower FFPI, but values generally greater than 0.750. A high pyrogenic-derived PAH has a FFPI less than 0.250. Creosote oils, which are derived from coal tar and commonly used to preserve dock pilings and telephone poles, also have low FFPI values and include a similar suite of PAH, though generally detected at significantly higher TTAH concentrations. Clearly, petroleum dominates the PAH profiles, but what was the petroleum source or sources?

The increased petroleum dominance in the samples appears to be the result of an increase in light fuel oil/diesel in sample contaminants at low TTAH concentrations. The lighter fuel



oils contain sufficient amounts of lighter alkylated PAH to sway the FFPI to a more "petrogenic" source, explaining the lack of combustion influence. Whether this observation was an anomaly of the 1995 data, a function of increased background petroleum PAH concentrations in PWS, or a function of lower EVO concentrations and sample handling was uncertain. Since diesel and gasoline powered engines are principle modes of sampling transportation around PWS, sample handling can not be ignored. As concentrations of petroleum within the samples become less, small amounts of background petroleum or pyrogenic sources could easily be picked up by the samples during collection and transportation. To document sample handling is not a possible source. Field blanks should be considered for future collections.

## Fingerprinting Results

Forensic source fingerprinting is the process of qualitatively and quantitatively comparing an environmental sample to a known reference oil; the objective is to determine if the unknown sample is derived from the source oil and compositionally a match. The standard techniques employed are manual comparisons of the extracted ion chromatographic profiles from a sample to a potential source. Ratios of compounds obtained from GC/MS analytical data have been documented in studies to indicate weathering trends (Boehm et al. 1981, Sauer and Uhler 1994) and positive identification of sources (Overton et al. 1981, Henry 1995). Accurate source fingerprinting depends the ion pattern uniqueness, abundance and extent of oil degradation. Petroleum altered by environmental processes presents technical obstacles in establishing legally defensible links between residual oil and the original source. These alterations result in changes in chromatographic profiles, reduction of selected analytes, and PAH concentration; all reduce the accuracy of source fingerprinting.

With the many inputs of pyrogenic and petrogenic pollutants into the marine environment, the ability to distinguish sources has become a focus of many researchers. Work from Page et al. (1996, 1993), Burns et al. (1997), and Sporstol et al. (1983) use various techniques from ratio plots to multivariate analysis to assess source correlation. All of these techniques can provide general characterization, but have limitations for source fingerprinting. The SFI, based on selected chromatographic measurements, provide a less "non biased" confirmation (Henry et al. 1993, 1995) that can encompass analytical variability and strengthen the source fingerprinting results.

Determining other dominant sources or petroleum mixtures is the PWS monitoring chemistry challenge. Studies conducted by Page et al. (1996), Burns et al. (1997), Kvenvolden et al. (1993) indicate EVO is not the dominant petroleum source within PWS, but for the sampling sites selected EVO dominates. Environmental variability and oil degradation were easily observed in the 1995 data, adding to potential variability in defining sources. The sediment samples include those 'able to be fingerprinted' and those degraded beyond source fingerprinting. Less than 50% of the sediments were manually source fingerprinted, while all but four contained oil concentrations too low to compute SFI values. The SFI values selected to plot (Figure 12) used a sulfur and nonsulfur ratio to distinguish the diesel derived from EVO and the EVO. For the sites sampled, EVO remains the dominant petroleum source, though other sources may be present.



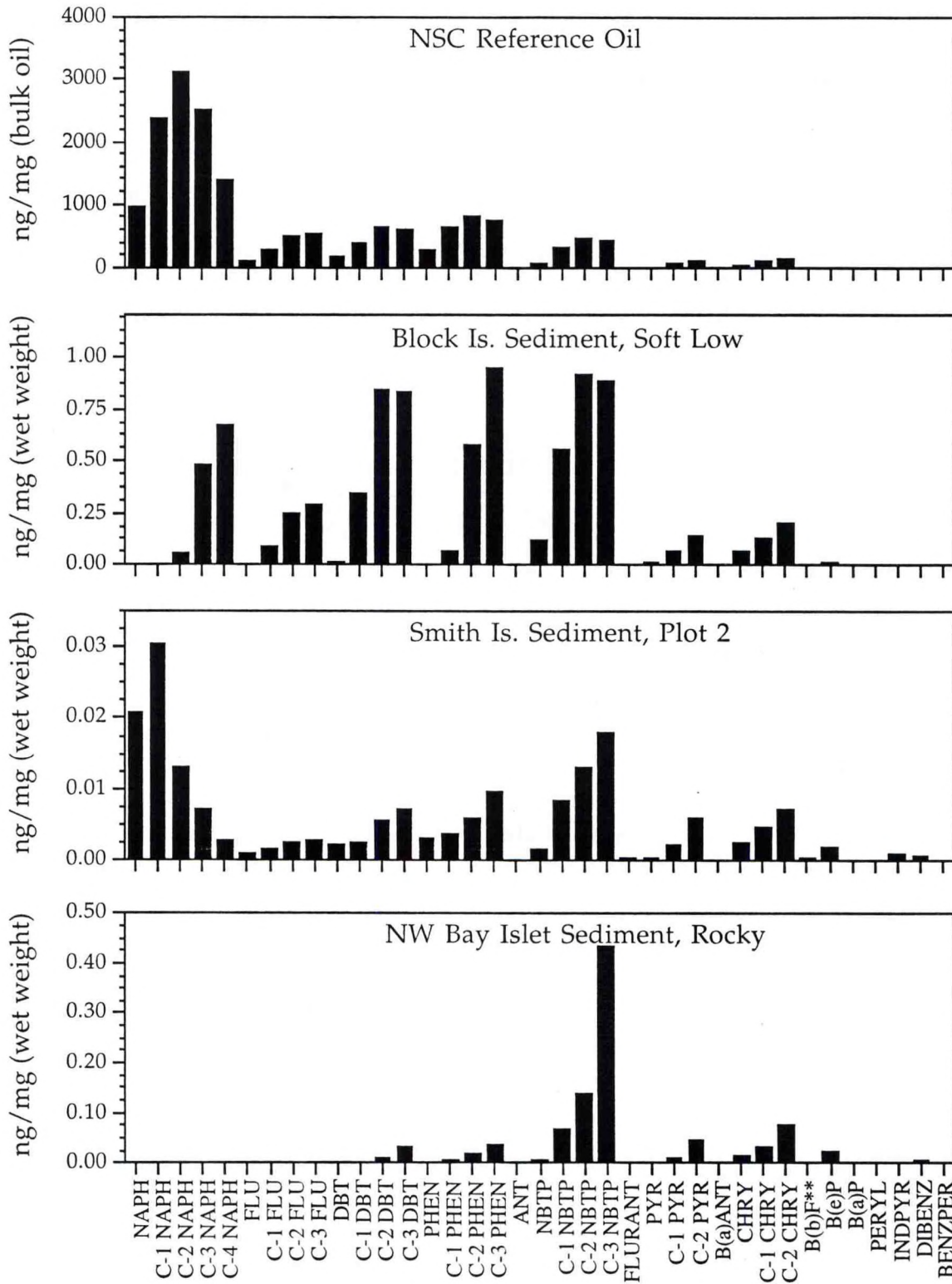


Figure 12. Histogram profiles of "weathered" samples. Block Island represents a moderately weathered site, Smith Island heavy to moderate with a diesel influence, and Northwest Bay heavily weathered.

## Weathering of Stranded Oil

Environmental weathering is commonly known to reduce oil bioavailability. As alterations in the bulk oil composition are monitored at various sites, patterns can be compared across temporal and spatial scales. Numerous environmental studies have examined the patterns of oil weathering trends such as Hostetler and Kvenvolden (1994), Whittaker and Pollard (1997), Butler et al. (1991) and Page et al. (1988). Hostetler and Kvenvolden reported the chromatographic profile alterations for selected EVO PAH observed for many sites within PWS by this study and during other monitored incidents. Common definitions derived for describing "oil weathering" have been used since 1990; these simple definitions are:

*Slightly Weathered:* No major change occurs in the relative order or abundance of aromatic homologues. The alkylated naphthalenes are the most abundant constituents, but may be slightly reduced. Alkanes are generally still present.

*Moderately Weathered:* The total naphthalenes are significantly depleted from the bulk oil and the total alkylated dibenzothiophenes and phenanthrenes dominate the histogram plot. The alkane fraction is highly degraded.

*Heavily Weathered:* The dibenzothiophenes and phenanthrenes are significantly depleted from the bulk oil and the dominant constituents are the alkylated naphthobenzothiophenes, pyrenes and chrysenes.

Initial weathering trends can be considered to follow the physical laws pertaining to volatility, water solubility along with the slower process of photooxidation. Once a majority of the volatile and water soluble components are lost to the environment, oil degradation becomes based principally upon the microbial community activity and physical forces present. The latter is the current state of all sediment samples analyzed from 1995. The detected residual oil represents moderate to heavily weathered oil. The most weathered EVO was found at NW Bay Rocky Islet while the freshest oil (classified as moderately weathered) observed was at Block Island soft, low.

This study continues to document that weathering trends are not consistent within site. Despite 6 years of environmental exposure, sites like Block and Smith islands show considerable differences in the chromatographic profiles. Note in the following sediment sample classification (Table 9) that Smith Island and Block Island contain both heavily and moderately weathered EVO within the sediments. Figure 12 histogram profiles represent samples of the three weathered states found within PWS for the 1995 monitoring.

Table 9. Weathering descriptions of sediment samples found by site location.

<i>Moderately Weathered</i>	
	Block Island, Soft Low
	Block Island, 1994. Plots 2, 5 and 6
	Block Island, 1995. Plots 5 and 6
	Block Island Clear Plots 1 and 2 (surface and subsurface)
	Smith Island, Plot 3
<i>Heavily to Moderately Weathered</i>	
	North West Bay, West Arm
	Smith Island, Plot 2
<i>Heavily Weathered</i>	
	Block Island, 1994. Plots 1 and 3
	Block Island, 1995. Plots 1, 2, 3, and 4
	Crab Bay, Soft
	North West Bay, Rocky
	Shelter Bay, Low
	Sleepy Bay, Low
	Snug Harbor, Soft Low
	Snug Harbor, Rocky
	Smith Island Plot 1

Phenanthrenes and dibenzothiophenes were plotted to indicate stages of weathering (Page et al. 1996) and potentially indicate persistence. Figure 13 shows the alteration changes from the reference EVO oil compared to 1995 sediments by tracking the relative ratios of an alkylated sulfur (C-2 and C-3 DBT) to alkylated nonsulfur (C-2 and C-3 Phen) components within oil. Figure 13 also indicates no significant clustering within the sample population and only a single outlier of Shelter Bay. The wide scatter of data eliminates detailed comparisons except for the extreme outliers. Recall that Shelter Bay, an oiled and treated site, was an outlier in the SFI plot and contained a combination of fuel oil and pyrogenic sources. The interesting point revealed by the weathering plot is that multiple samples collected at one site do not indicate the same weathering, despite being collected approximately 2 m apart as in the Block Island Clear Plots. Note that this ratio plot presents only four selected components in the oil, not the "whole oil."

Profile differences can be due to additional sources, or alterations occurring to the bulk oil by evaporation, photolytic, and biological degradation. As documented in previous reports the alterations, or weathering depends significantly on the microenvironment around the oil. Broad generalization of beach profiles and exposure indices provide general classifications, but do not clearly predict the extent of weathering and persistence of the oil present. Instead, the localized effects from oxygen and nutrient availability, mixing energy, and ultimately the microbial community, play the most significant roles. The stranded oil in the lower intertidal zone, 6 years after the T/V *Exxon Valdez* incident, was moderately to heavily degraded. The extent of degradation continues to be controlled by the microhabitat abiotic factors.



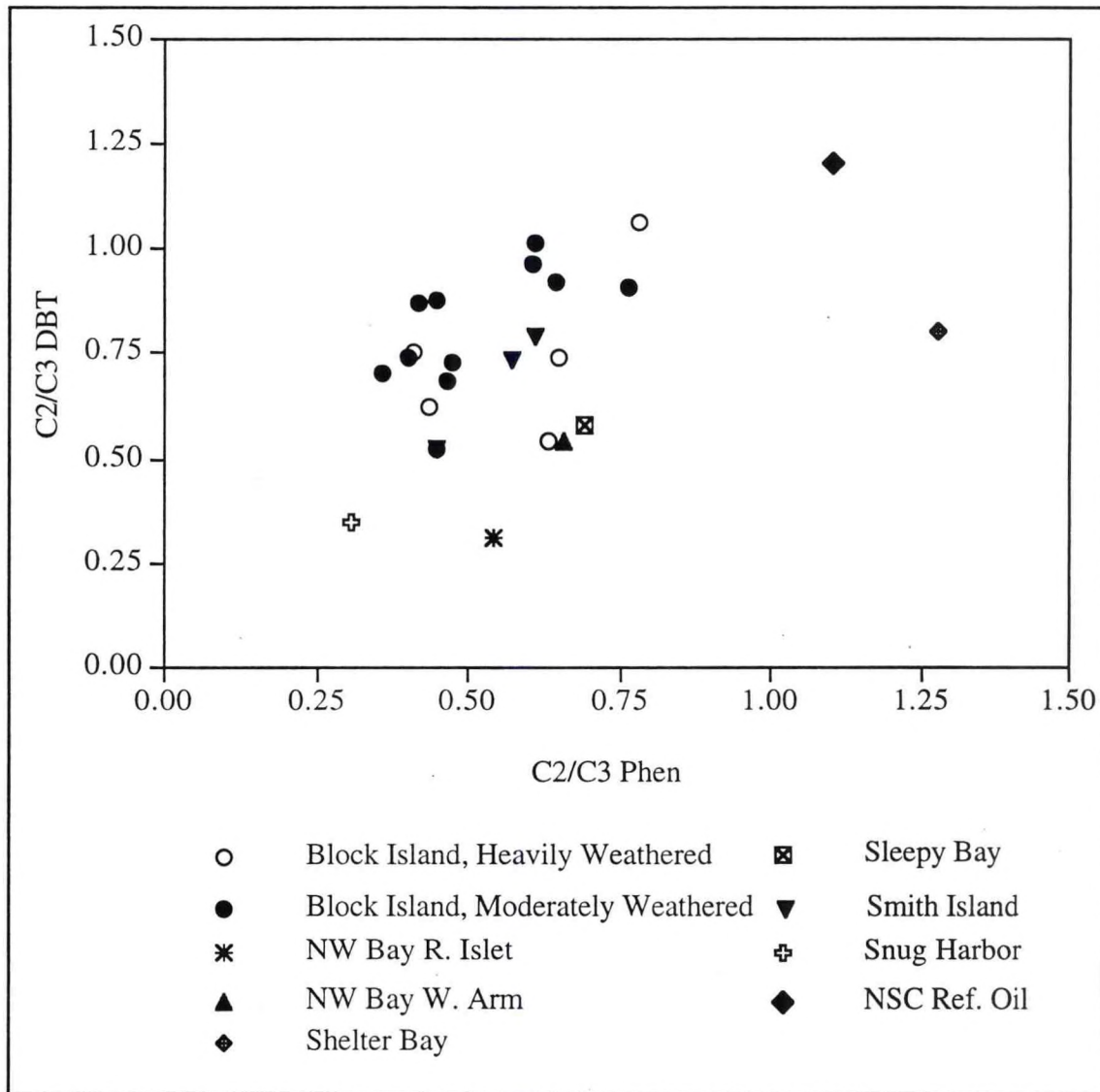


Figure 13. Weathering plot of 23 of the 28 samples and EVO reference oil. The remaining five contained insufficient data to quantitate. Only Shelter Bay appears as an outlier in the trend and no significant grouping by site is apparent.

## Bioavailability

Despite the extent of weathering, petroleum hydrocarbons were still biologically available 6 years after the release. The EVO bioavailability correlated with the oil "uptake" was indicated by the bivalve tissue TTAH concentrations. Whether the uptake and body burden were due to water soluble components or whole oil adsorbed to particles has been a significant debate and being investigated. A study by Neff and Burns (1996) evaluated PAH concentrations within mussels and salmon to petroleum on water. The findings documented a higher PAH concentration found in the mussels compared to the juvenile salmon. Neff and Burns indicated that the results were possibly due to either seasonal variation in mussel lipid content, differences in uptake and depuration, or differences between mussels and fish interactions with particulate oil.

From the 1995 bivalve population, the analytical data indicate a dominance of whole oil. The histogram plots show a pattern more similar to "weathered whole oil" rather than water soluble fraction. If more water soluble components were present, then the tissue histogram profiles may appear as a combination or dominated by the water soluble fraction, but, the implications from the 1995 data indicated that whole oil bioavailability was significant.

Weathering does affect the bioavailability as indicated by the PAH histogram profiles between sediments and tissues. The TTAH profiles within the tissues at heavily weathered locations, such as Smith Island Plot 1, appear weathered and lower in TTAH concentration. Due to data from the Block/Outside transplant study and information documented from Narbonne et al. (1992) and Tanacredl and Cardenas (1991), the oil was apparently from recent/chronic exposure rather than a persistent concentration from past years. Narbonne evaluated the *Mytilus galloprovincialis* for uptake and depuration of benzo(a)pyrene and determined purging time of roughly 1 week. Tanacredl and Cardenas (1991) determined a depuration rate for nine parent-PAH to be greater than 45 days while Boehm and Quinn (1976) determined petroleum depuration to be greater than 120 days. From the transplant study initiated by Fukuyama (personal communication 1998), petroleum depuration and correlated uptake were occurring between 17 and 29 days though complete depuration was not observed, the uptake appeared relatively quickly.

As with the sediment results, environmental variability was evident within the tissue results, yet tissue concentrations were always less than sediments. The Excavation Plots 1 and 2, from Block Island, suggest that the oil body burden found in bivalves (clams and mussels) represents "whole oil." Differences in composition were noted when compared to the surrounding sediments (Figure 14 and 15) and may suggest metabolic transport mechanism to include dissolution. An increase in the C-3 fluorenes was also observed for the Block Island bivalves. Full evaluation of this is best completed as an overview with several years of data available. Similar tissues and sediment comparisons are noted for the Smith Island transect samples (Figure 16, 17 and 18). For the most weathered oil in plot 1 (Figure 16) the mussels appear to contain more pronounced alterations than the less weathered oil in plot 3 (Figure 18), due to the DBTP homologue series. Fewer alterations are noted for the body burden of the mussels in plot 3. The less weathered the EVO, the more bioavailable even after 6 years.

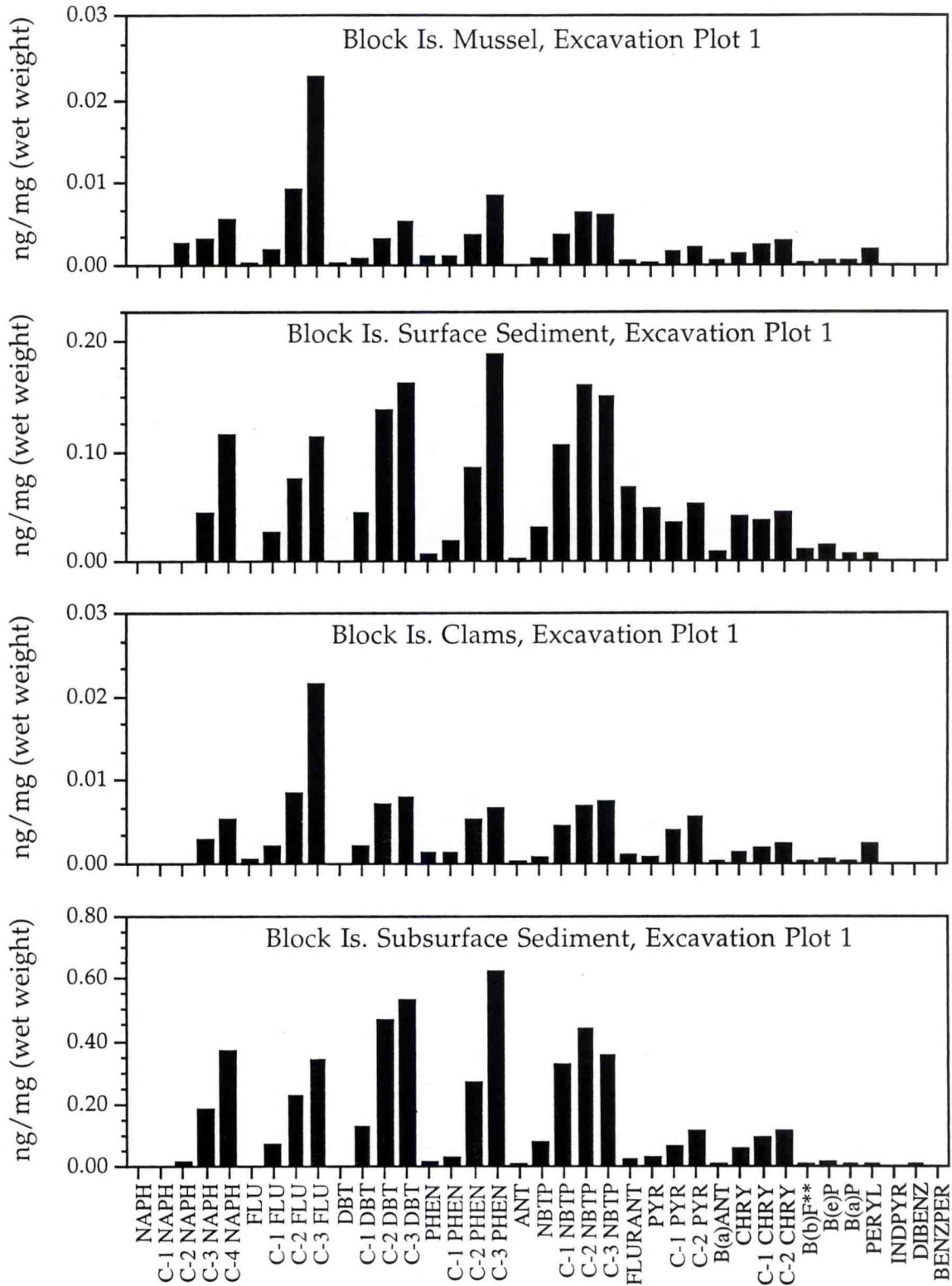


Figure 14. Bioavailability comparison for surface and subsurface sediments to mussels and clams. Note the whole oil body burden within the tissues, but a profile different from the surrounding sediments.



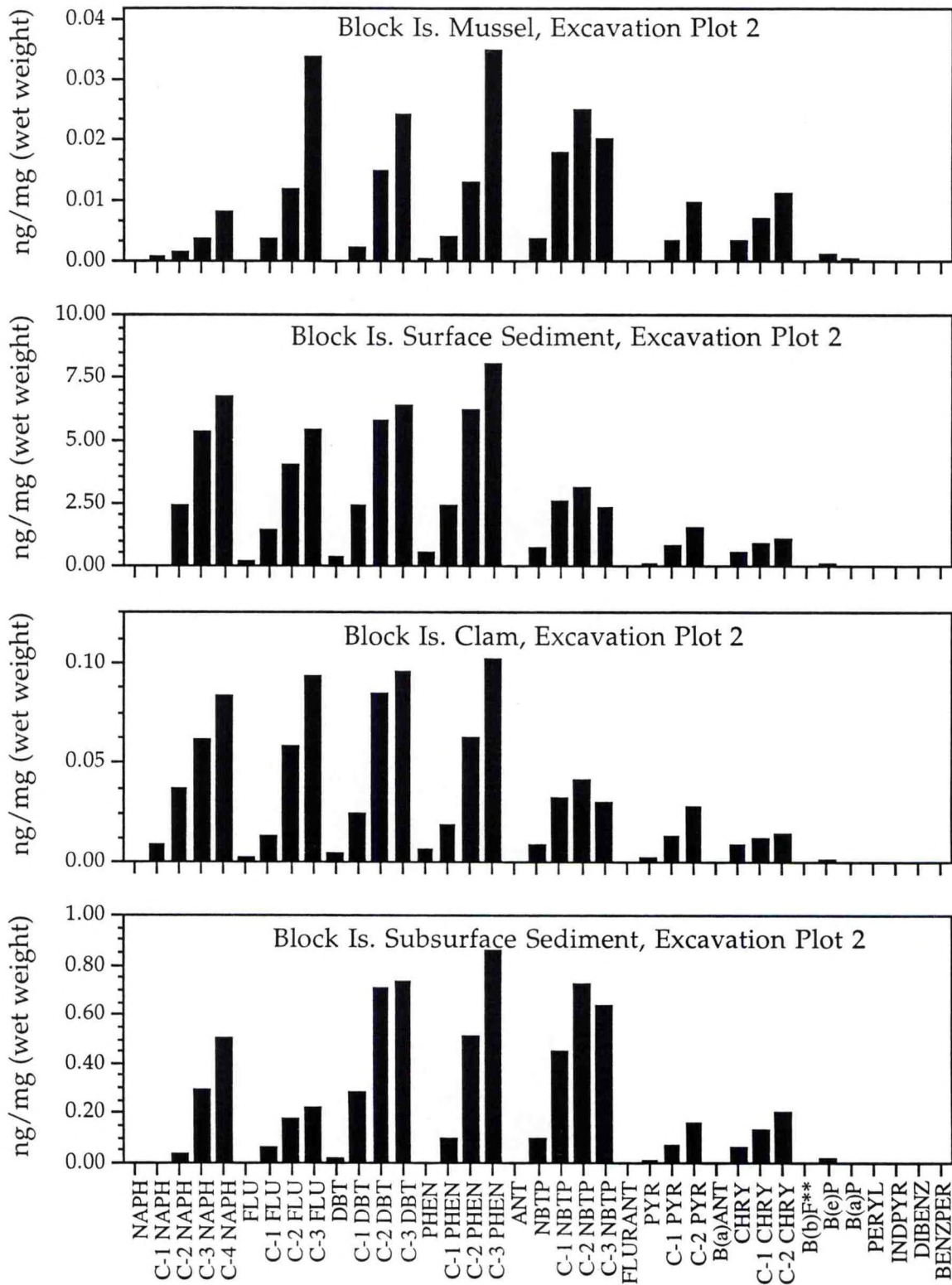


Figure 15. Bioavailability comparison for surface and subsurface sediments to mussels and clams. Note the whole oil body burden within the tissues, but a profile different from the surrounding sediments.

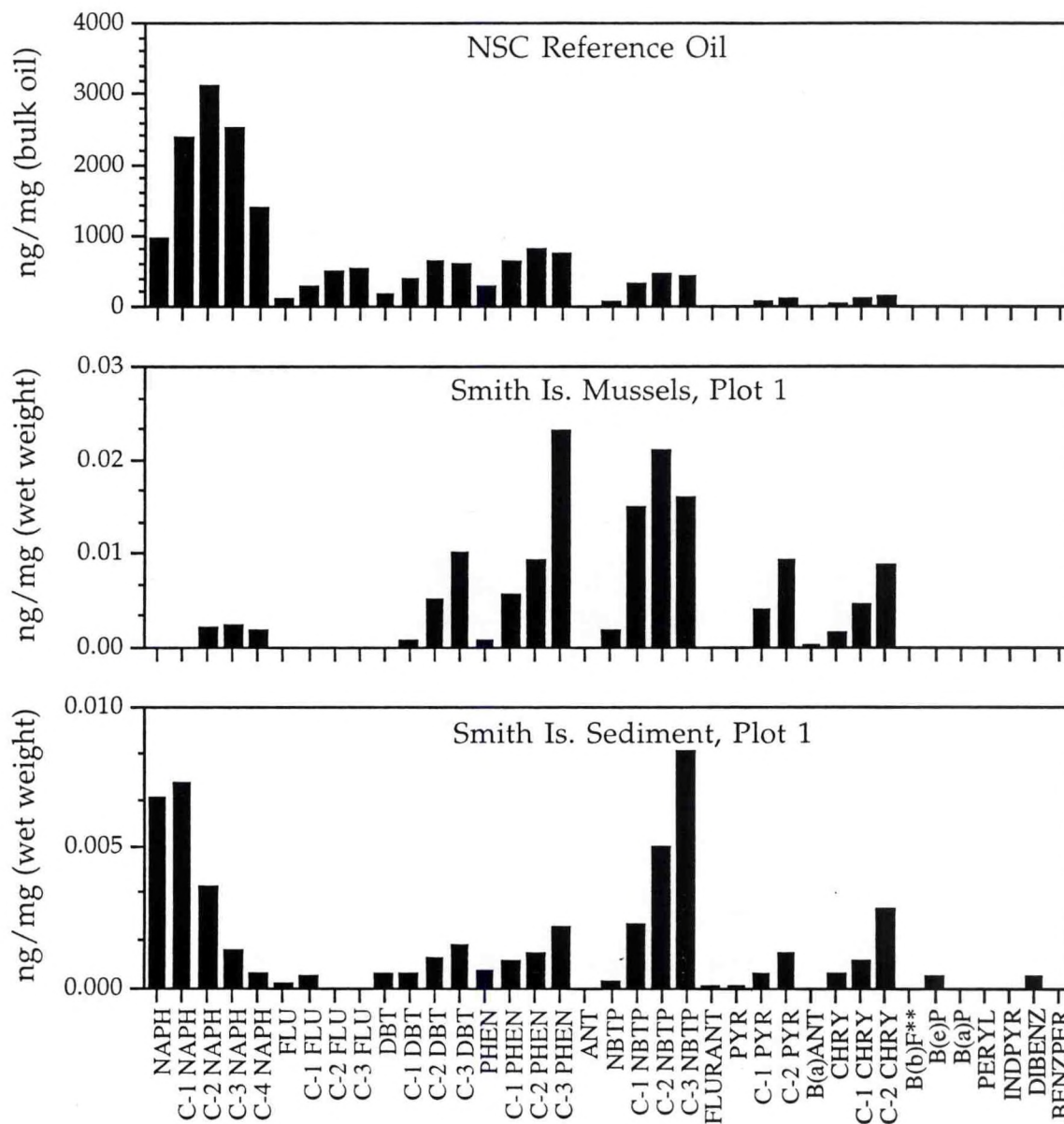


Figure 16. Histogram profiles of the mussels and sediments at Smith Island transect, Plot 1. Note the TTAH abundance and differences in the PAH profiles. Plot 1 sediments contained heavily weathered EVO with a distinctive presence of a light fuel oil. The tissues contained an altered pattern, appearing heavily weathered with the exception of the NBTP homologues.

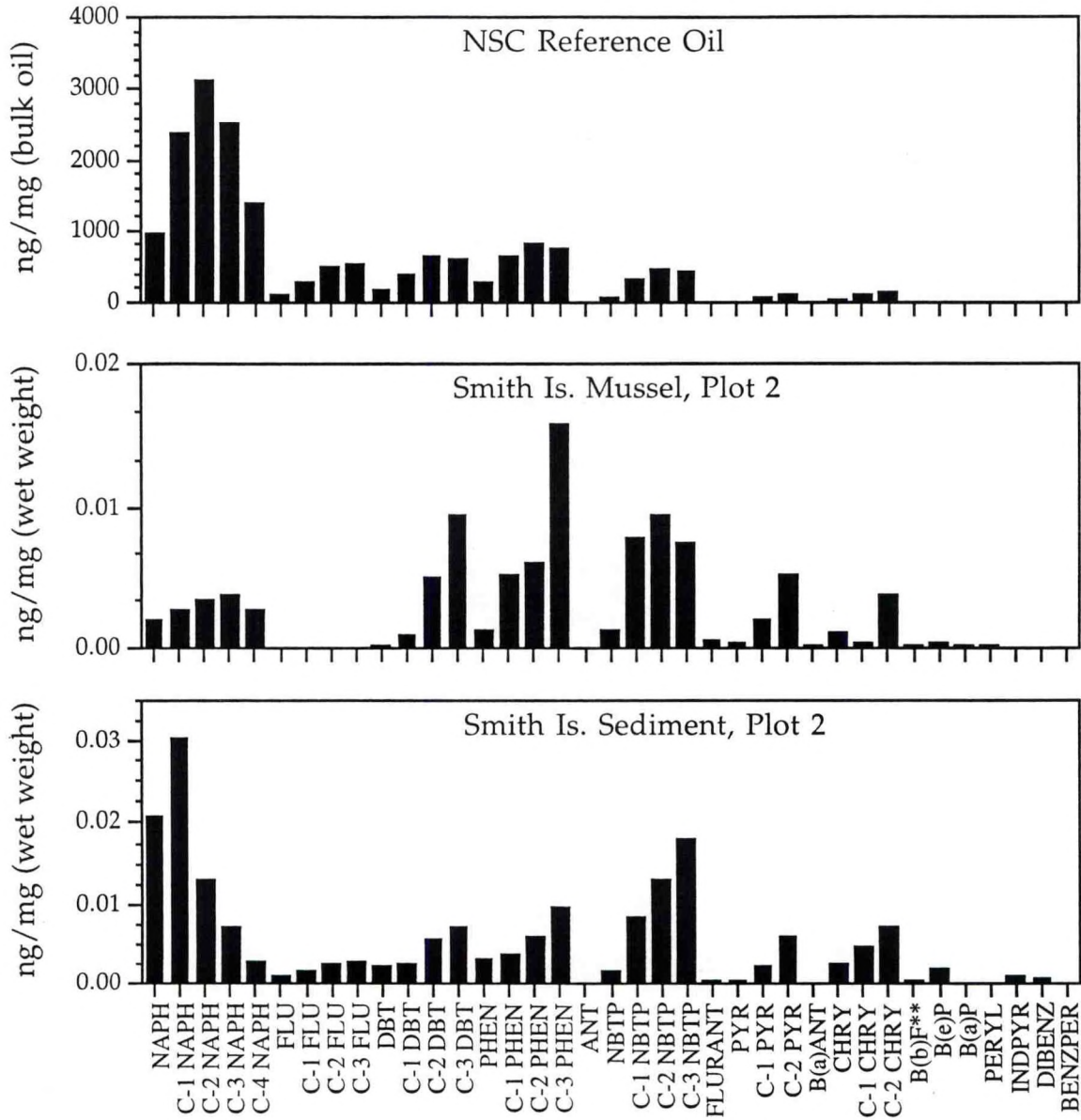


Figure 17 Histogram profiles of the mussels and sediments at Smith Island transect, Plot 2. Note the TTAH abundance and differences in the PAH profiles. Plot 2 sediments contained moderately to heavily weathered EVO with a distinctive presence of a light fuel oil. The tissues contained an altered pattern, appearing heavily weathered with the exception of the NBTP homologues similar to Plot 1.



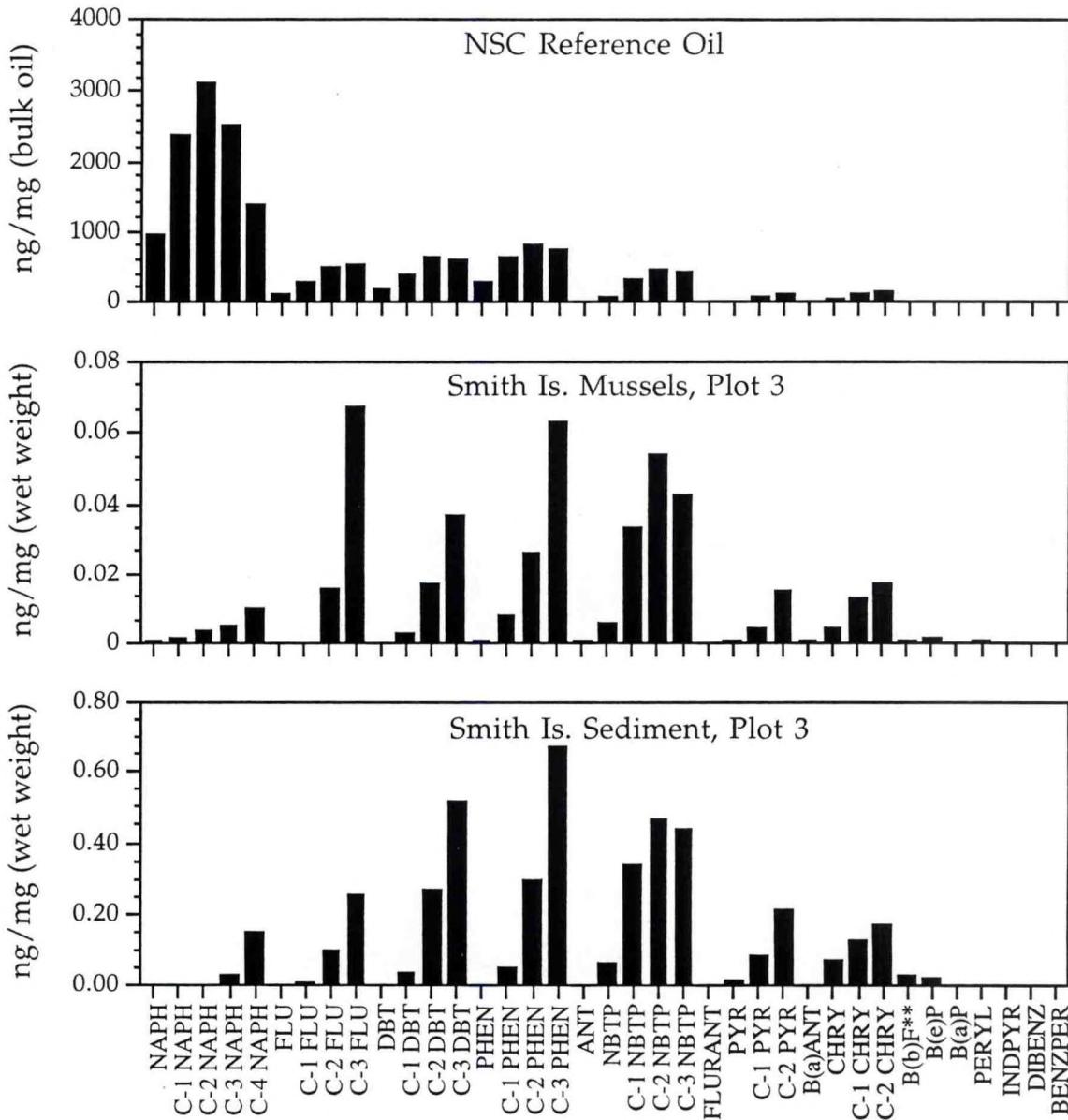


Figure 18. Histogram profiles of the mussels and sediments at Smith Island transect, Plot 3. Note the TTAH abundance and the similarity in the PAH profiles. Plot 3 sediments contained the least weathered, or moderately weathered, and highest concentration of EVO. The tissues contained a similar pattern with the exception of the increased C-3 flourene; this is due to either biological alterations and/or interferences within the same range and unable to identify.

## Recovery Present

Environmental patchiness may play a role, but the apparent sediment TTAH concentration for the 1995 sample population appears little altered from 1994, as presented by the Block Island Clear Plots. Further examination of other 1994 and 1995 sites is required to confirm this observation, but the concept of "recovery" from biological and chemical perspective is required to fully address PWS and apply "EVO status" to sites. The presence of EVO was

detected in many of the bivalves, but whether the concentrations actually cause biological stress cannot be determined by analytical chemistry. From the biological matrix evaluated by biologists, recovery is occurring (Shigenaka 1997). From the chemistry perspective a temporal chemical "equilibrium" has been reached by the EVO and it appears that EVO biological uptake is still occurring, though not significantly 'affecting' the biological community.

The observations of chemical weathering and biological recovery should be put into perspective. From the state of the oil analyzed in 1995, we would predict the future degradation of persistent EVO to be severely slow unless intense physical movement of the oil occurs. Are further manual manipulations required? Despite intensive manual cleanup operations within PWS, oil still persists as a function of microenvironment protection from the weathering processes. The current key removal processes, if not physical, are through microbial activity.

The threshold concentration for enhanced microbial degradation of petroleum was a conceptual idea addressed in the 1994 PWS Report. The concentration of petroleum found in the environment where clear indications of petroleum degradation present can provide guidance criteria for cleanup issues or "How clean is clean?" by chemical standards. No clear reference or criteria have been given or documented to provide values where cleanup operations should cease. The values obtained from the 1994 report indicate a notable degradation at approximately 1 ppm TTAH. The same indices (nC-18 to TTAH) examined for the 1995 data indicate other influences of nC-18 were present. Whether the reduced number of samples, sampling sites, and reduced overall concentrations (due to no geomorphological samples) play a role in this observation is unknown. Samples greater than 0.75 ppm TTAH with a higher nC-18 were found at Block Island excavation site 1 (surface and subsurface greater than 1 ppm), Snug Harbor and Northwest Bay Rocky Islet. The source of the nC-18 has not been identified. Future and historical PWS data should be further evaluated for selected biodegradative changes that may provide insight to threshold values for cleanup operations.





## Chapter 4

### Summary

The most notable fact 6 years after the T/V *Exxon Valdez* incident was that EVO was still present at select study sites within PWS. According to studies conducted by Page *et al.*, (1996), Burns *et al.* (1997), and Kvenvolden *et al.* (1993), EVO is not the dominant petroleum source within PWS, but for the intertidal beaches studied, EVO remains the dominant petroleum source. The chemistry approach to the NOAA Shoreline Monitoring Study emphasizes tracking the fate, alteration, biological uptake, and tissue concentrations of the persistent EVO. Although, the target compounds represent less than 2% of the EVO, these compounds are of great interest since they represent specific compounds linked with long-term oil persistence and oil toxicity. Many of the target-PAH compounds are classified as either known or possible mammalian carcinogens (Kauss and Hamdy 1991). By documenting the presence, concentration, and alterations of residual or stranded oil at selected study sites that represent different intertidal habitats and prescribed cleanup treatments, we hope to refine our understanding of oil transport and fate. Further, this information will be highly useful in planning cleanup strategies for future spills.

The chemistry data for the 1995 Prince William Sound Monitoring Study represents 14 biological standard collection sites and 3 special studies. There were 91 samples collected, clams, mussels, surface sediments and subsurface sediments. Of these, 61 were extracted, analyzed, and quantitated. The results show a wide range of TTAH concentration values from 71 ppm (sediment from Block Island) to below detection limits (clams from Outside Bay, mussels from Block Island, Rocky site, to sediment from Crab Bay, soft site). The oil contamination detected in many of the bivalve samples was highly similar to 'whole oil' though differences were observed. The relative PAH distribution patterns provide insight to the mechanism of exposure. It appears that both dissolution and bulk oil transport are involved. Food web affects require further investigations.

The increasing influence from other petrogenic sources was observed in the 1995 results and may reflect increased activities in the study area or possibly an artifact of the 1995 sampling. The overall sample population analyzed was less in 1995 than in 1994, although the number of surface sediments increased. The increased number of sediment samples were from a few selected sites and are not representative of all PWS intertidal zones affected by EVO.

#### Key Observations for 1995 data:

- The residual oil was classified as moderately to heavily weathered
- Sediment sample population in 1995 (14 sites) contained detectable EVO in all but Outside Bay locations
- EVO can be found 6 years after the incident as body burden within intertidal bivalves. The average TTAH tissue concentration is 0.038 ppm
- Compared to the 1994 data, the 1995 data contains a stronger influence of petroleum, despite the low TTAH concentrations for both the tissues and the sediments
- Other petroleum sources were detected within sediment and tissues was characterized as a light fuel oil or diesel

- Sediment TTAH concentrations for the 1995 sample population was greater than TTAH concentrations found in tissues from the same locations
- Many samples contained highly degraded petroleum. The chromatographic results were significantly altered, therefore, legally defensive source fingerprinting was not possible.
- The profiles of PAH contaminants in bivalves suggest that both dissolution and bulk physical transport are mechanisms of exposure.

## Chapter 5

# References and Acronyms

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## ACRONYMS

EVO	T/V Exxon Valdez Oil
FFPI	Fossil Fuel Petroleum Index
GC/MS	gas chromatography/mass spectroscopy
HAZMAT	Hazardous Materials Response and Assessment Division
LSU	Louisiana State University
nC	normal hydrocarbon
nd	nondetected
NOAA	National Oceanic and Atmospheric Administration
ng/mg	nanogram per milligram
PAH	polynuclear aromatic hydrocarbons
ppm	parts per million
SFI	Source Fingerprinting Indices
TTAH	total target aromatic hydrocarbons





# Appendix A

This appendix comprises histogram plots of all tissue samples analyzed; the samples are sorted alphabetically by site with duplicates and replicates averaged into a single plot. The following observations were made on the tissue data from these plots.

1. As oil traces weather and alter, more interferences were noted in the profiles. Most samples interferences were easily removed, in others, such as Northwest Bay, West Arm, the interferences were extreme in the range of C-1 phenanthrene and C-3 Phenanthrene therefore the ions could not be quantitated.
2. Numerous samples do not show a suite of analytes indicative of petroleum. Generally these are found in samples of low concentrations. Examples are:

Block Island mussel, Rocky  
 Crab Bay mussel, soft and soft A  
 Crafton mussel  
 Mussel Beach, mid  
 Northwest Bay, West Arm  
 Northwest Bay, Rocky  
 Outside Bay, clams and mussels

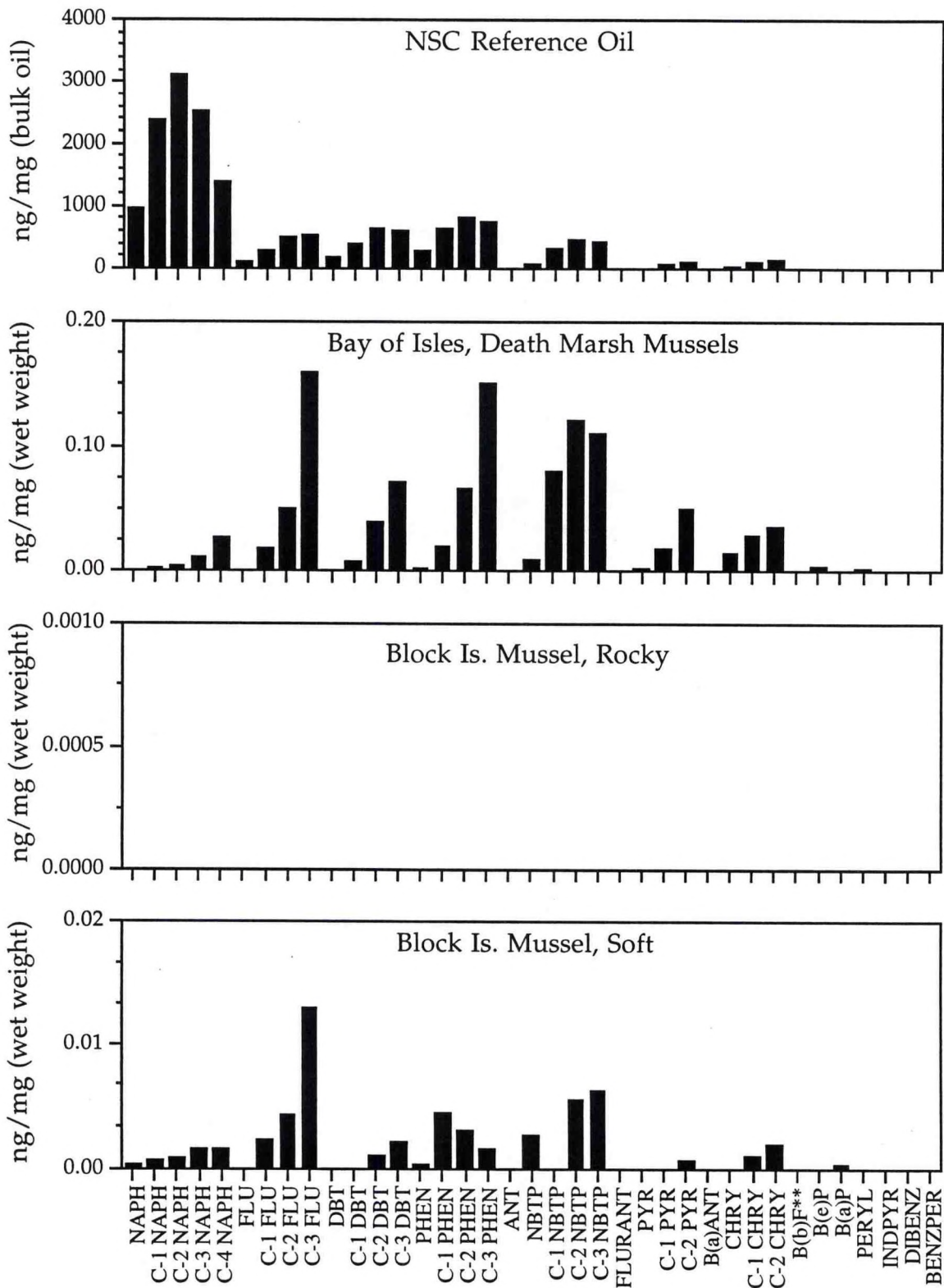
3. Samples indicating other influences due to increased naphthalene components are:

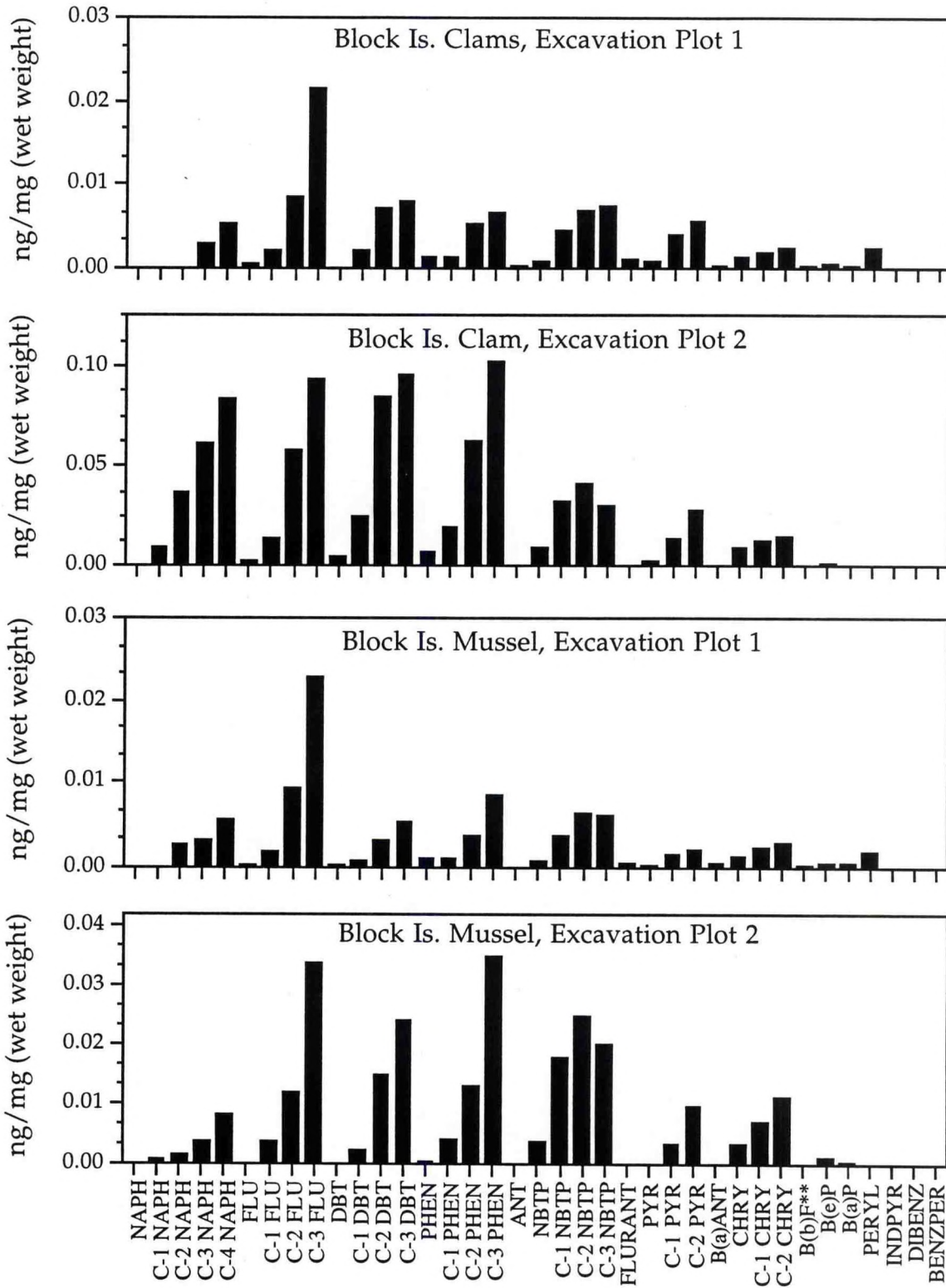
Shelter Bay, soft  
 Sleepy Bay  
 Snug Harbor, soft

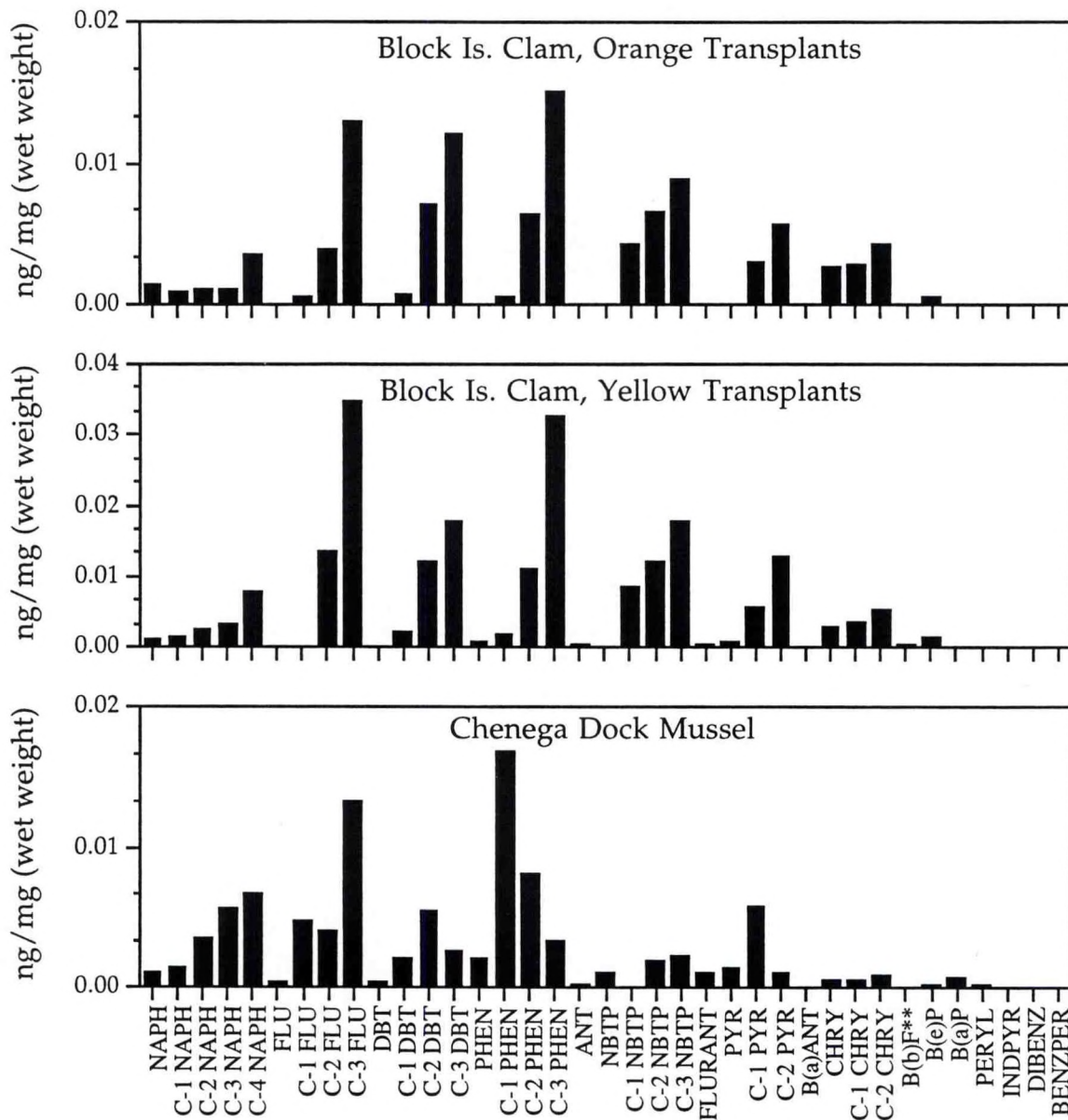
4. Weathered data was noted in all the tissues.
5. A noted influence of C-3 flourene was noted in several tissue samples with oil. Whether this is from alteration of the oil or from an interference that cannot be removed is yet to be determined.



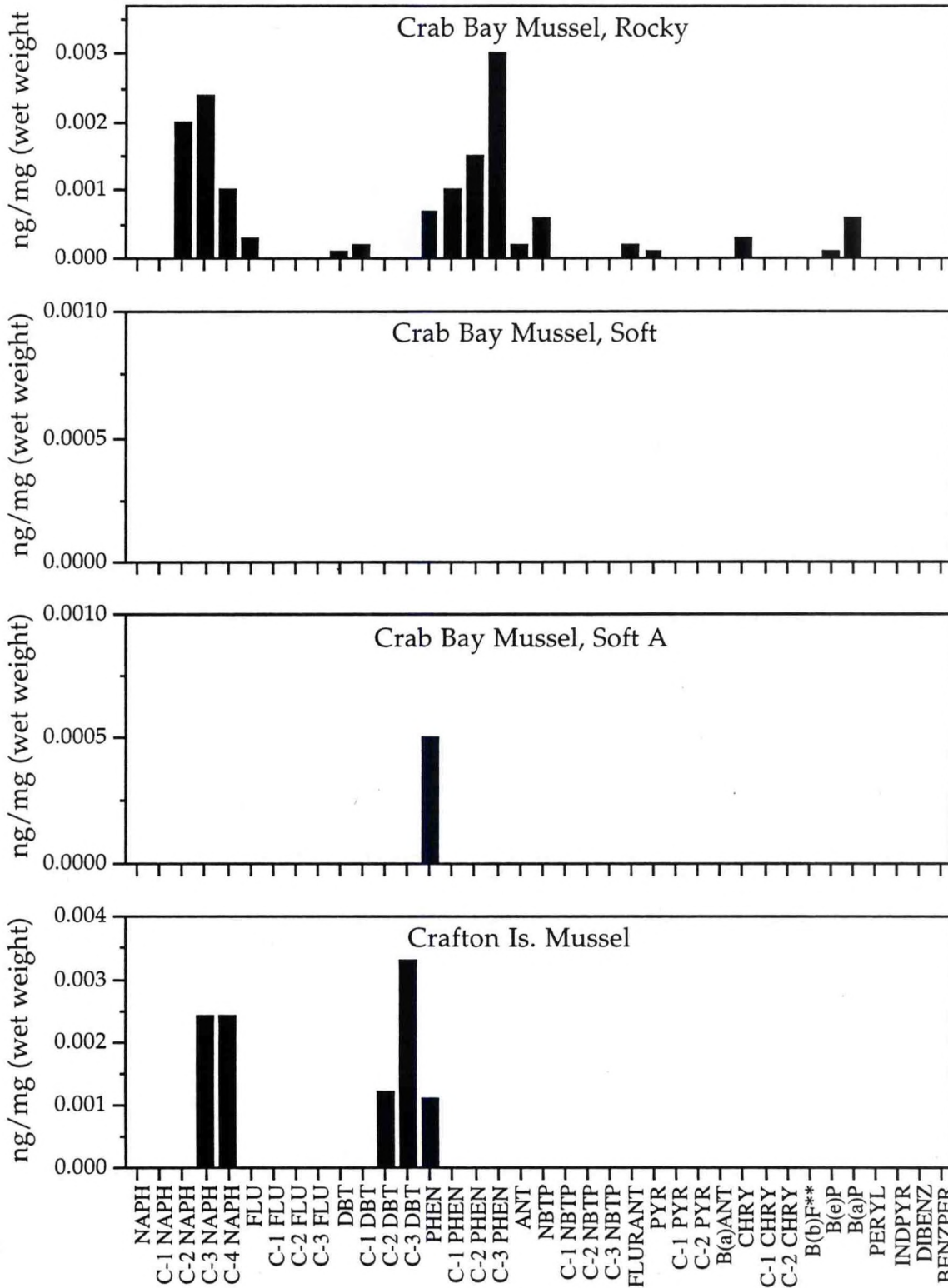


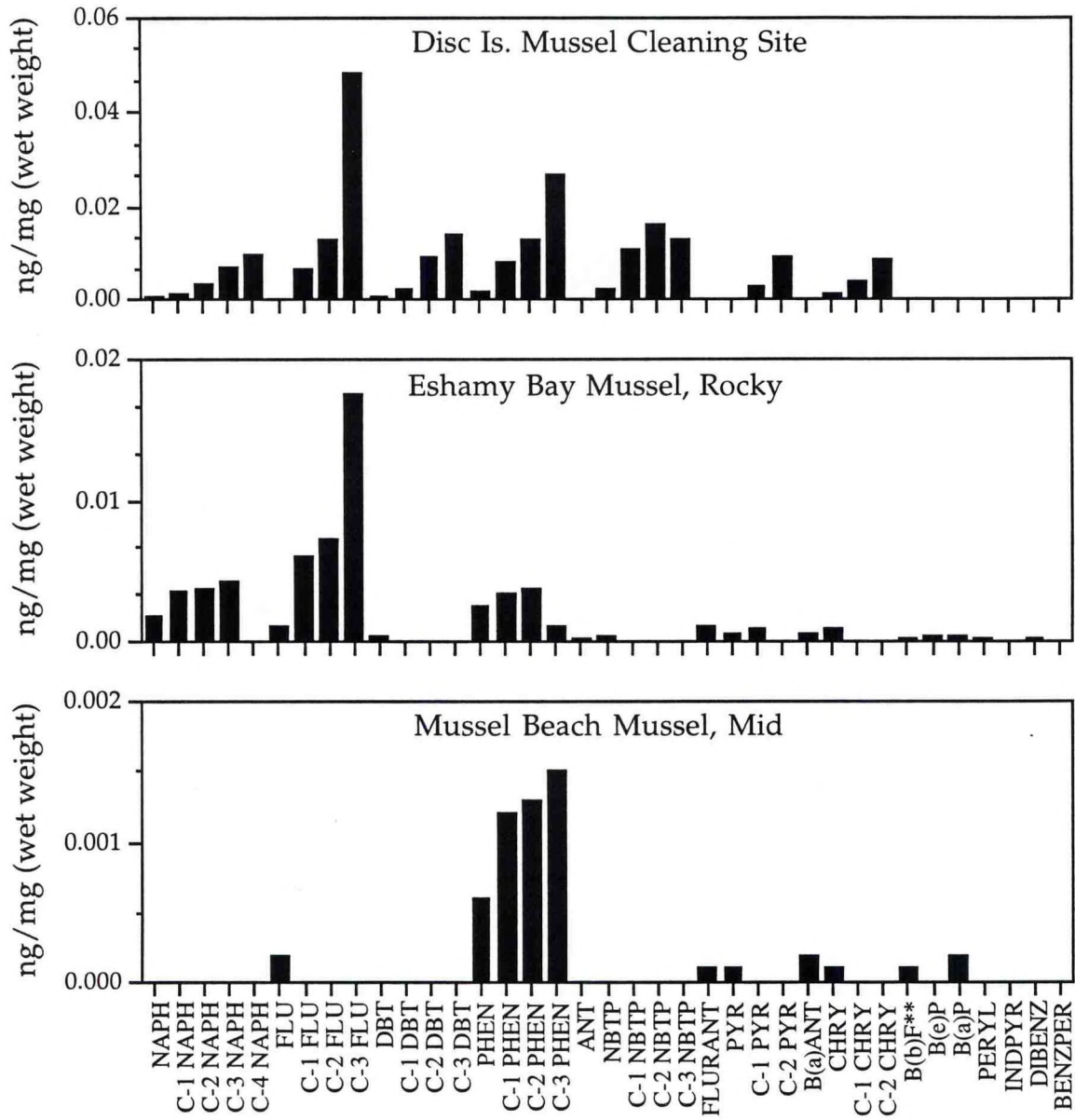


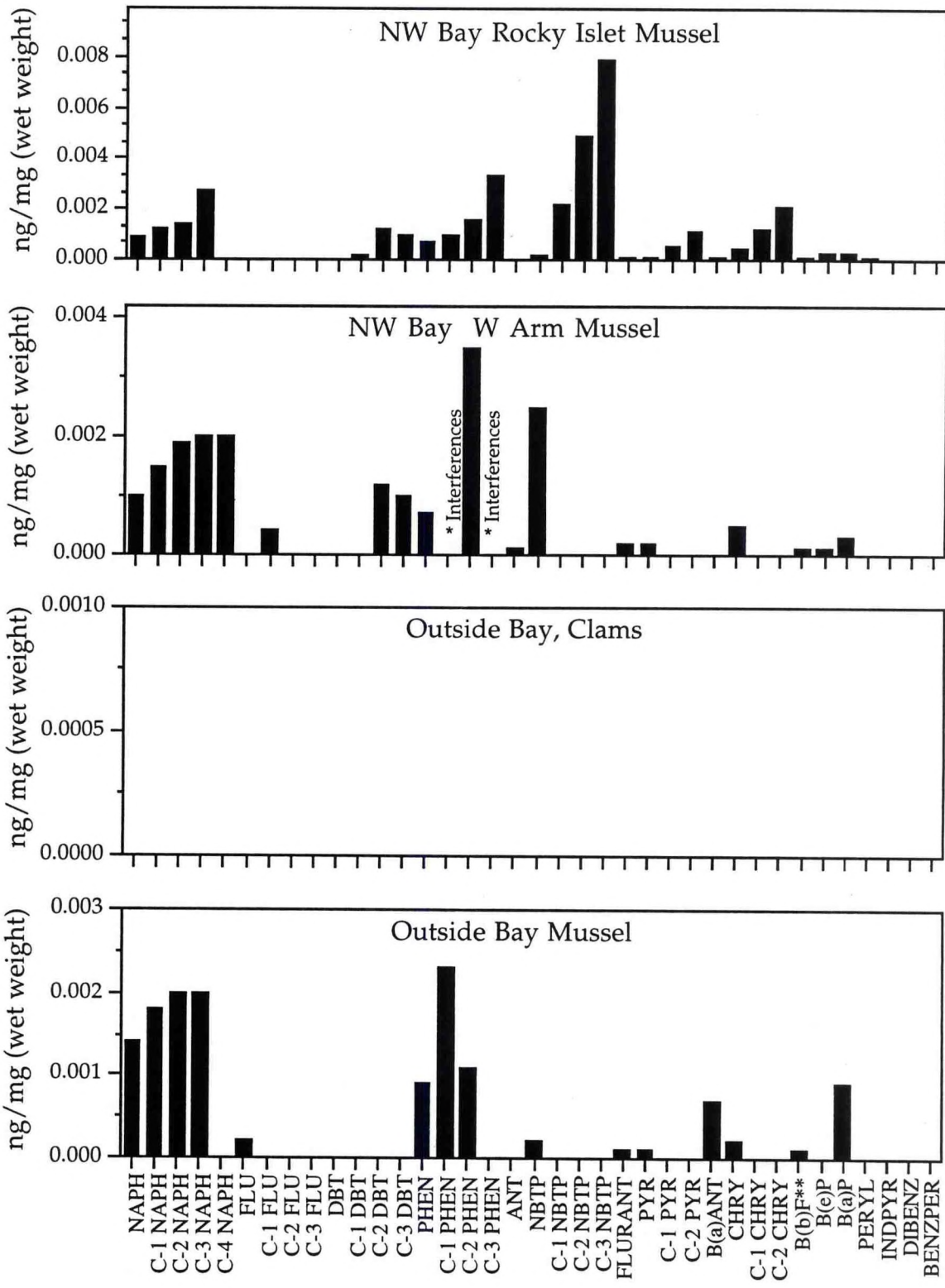




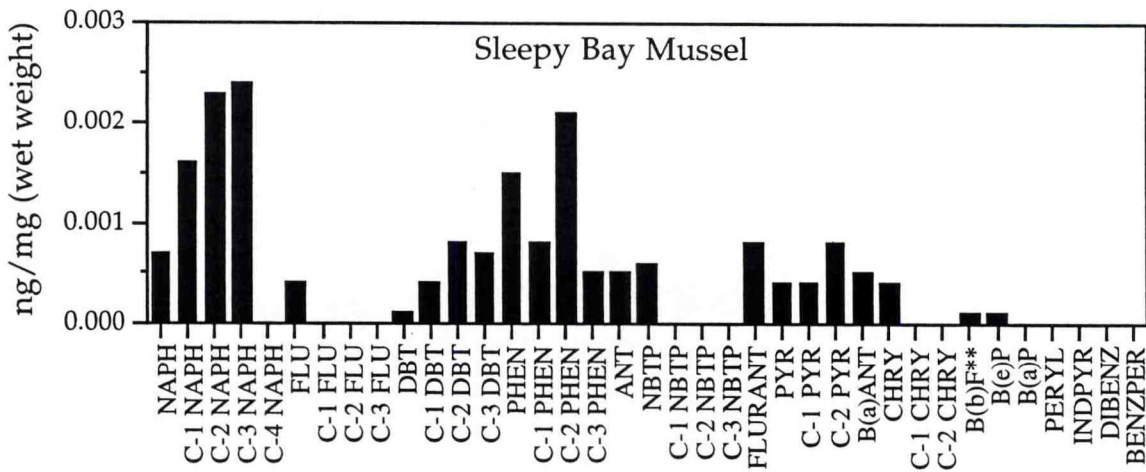
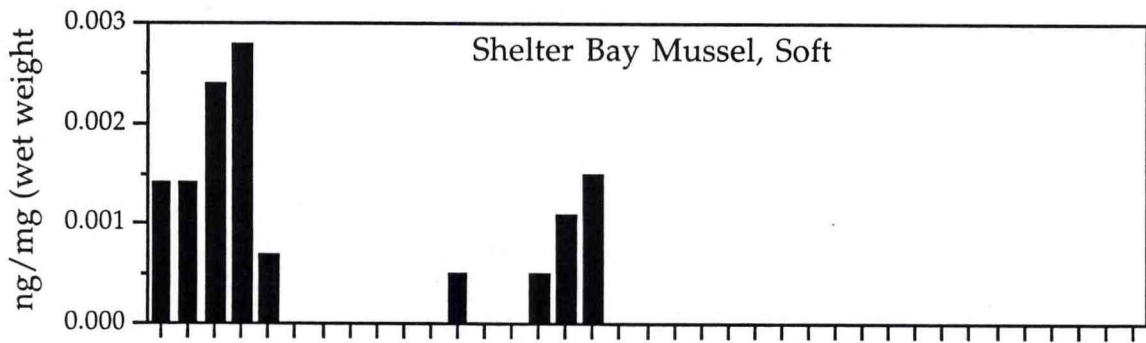
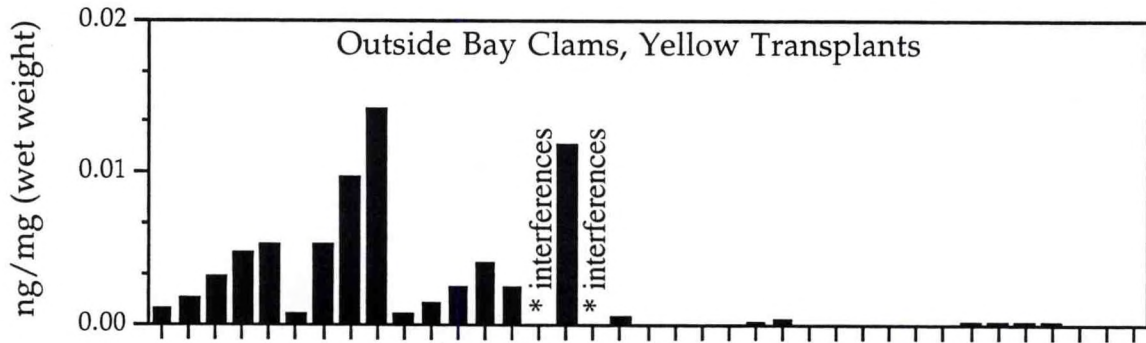
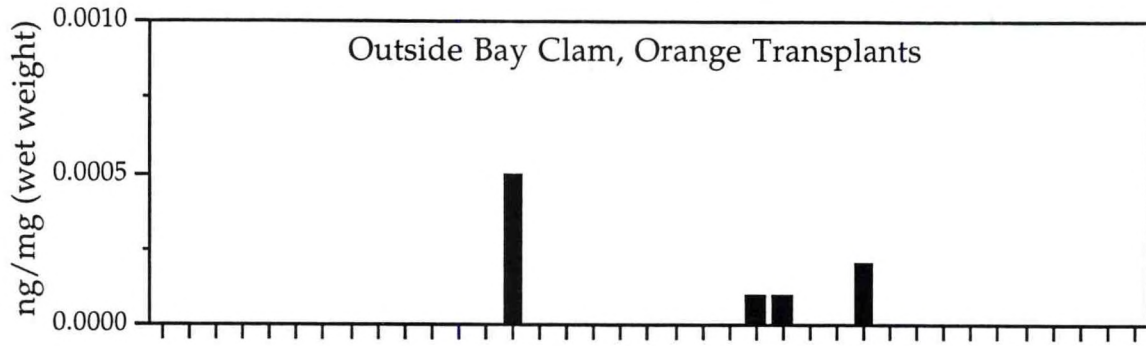


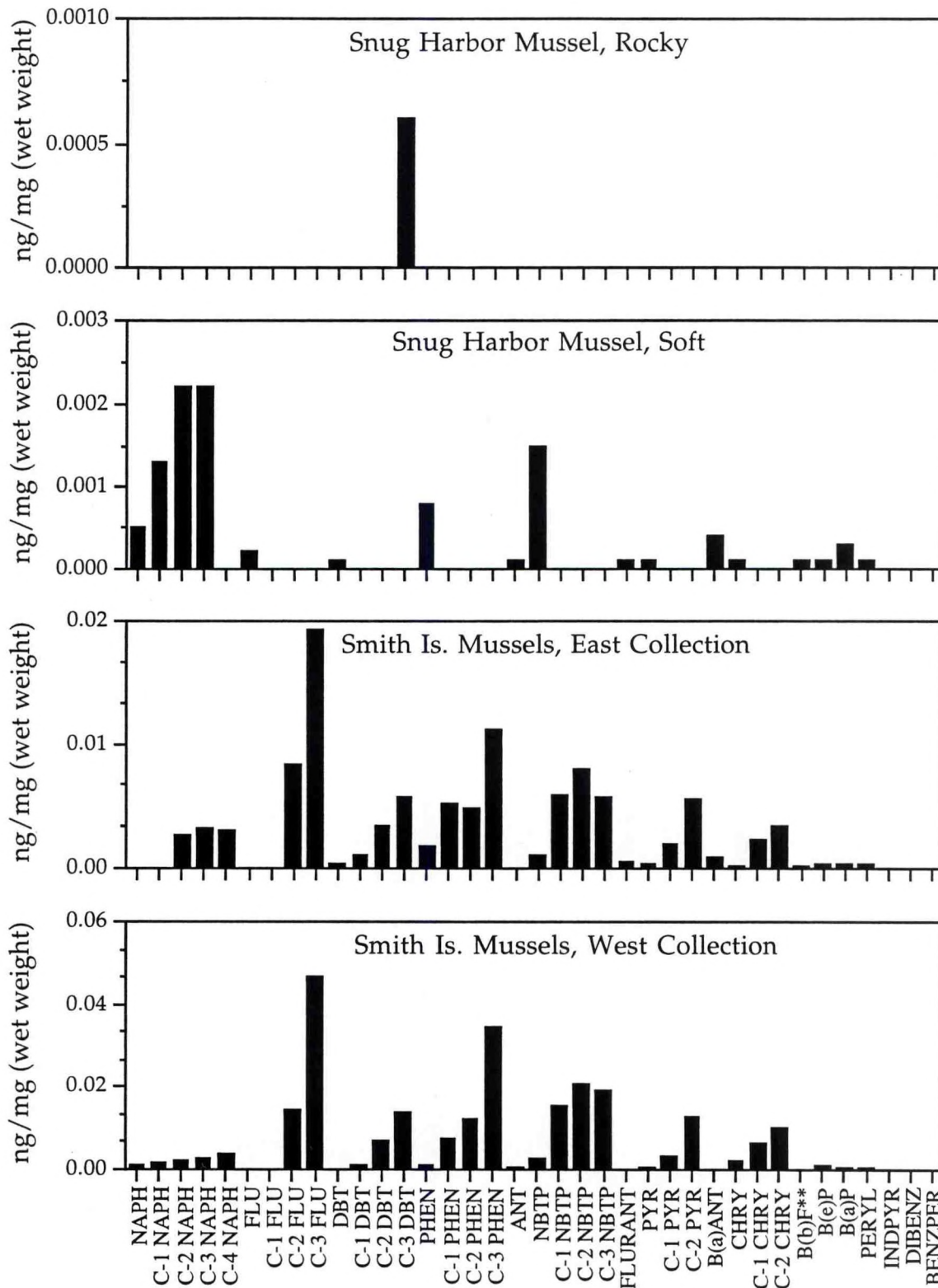


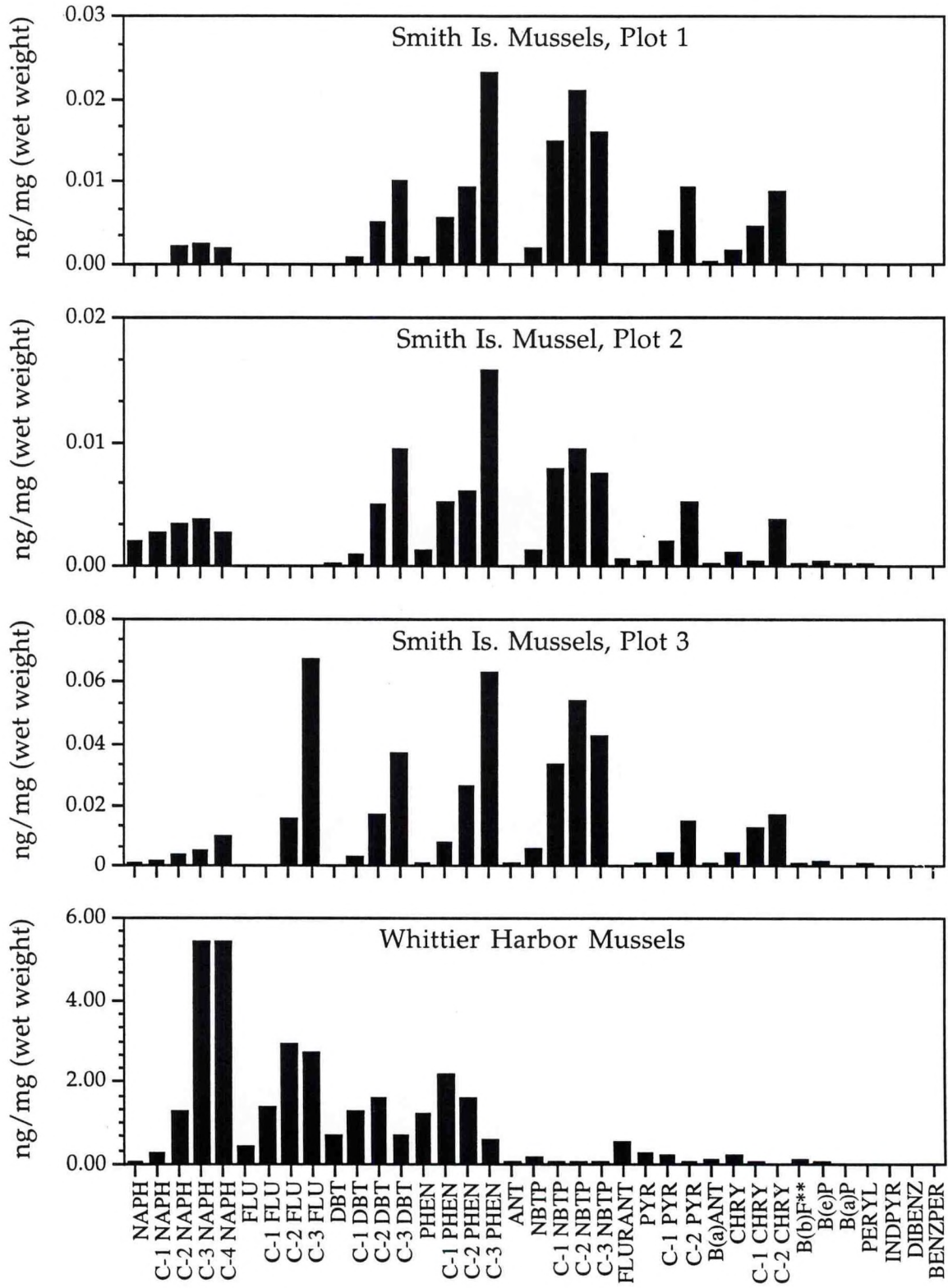














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NOAA ID:	95061311	95061504	95061508			95061505	95061509	95071242	95071243	95071543
SAMPLE SITE:	Bay of Isles	Block Is	Block Is	Block Is	Block Is	Block Is	Block Is	Block Is	Block Is	Chenega Dock
MATRIX:	Mussel	Clam	Clam	Clam	Clam	Mussel	Mussel	Mussel	Mussel	Mussel
DESCRIPTION:	Death Marsh	Excav. Plot 1	Excav. Plot 2	Orange, Comp.	Yellow, Comp.	Excav. Plot 1	Excav. Plot 2	Soft	Rocky	
# ANIMALS	70	60	15	43	38	39	42	30	39	32
COMPOUND	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)
NAPHTHALENE(128),a, f	0.0008	nd (T)	nd (T)	0.0014	nd (T)	nd (T)	nd (T)	0.0004	nd (T)	0.0011
C-1 NAPHTHALENE(142)	0.0015	nd (T)	0.0094	0.0008	0.0015	nd (T)	0.0008	0.0007	nd (T)	0.0015
C-2 NAPHTHALENE(156)	0.0040	nd (T)	0.0360	0.0010	0.0025	0.0026	0.0015	0.0008	nd (T)	0.0035
C-3 NAPHTHALENE(170)	0.0110	0.0029	0.0610	0.0010	0.0033	0.0032	0.0037	0.0016	nd (T)	0.0057
C-4 NAPHTHALENE(184)	0.0260	0.0053	0.0830	0.0036	0.0077	0.0057	0.0083	0.0016	nd (T)	0.0067
FLUORENE, a, f(166)	nd (T)	nd (T)	0.0028	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-1 FLUORENE(180)	0.0180	0.0020	0.0140	0.0006	nd (T)	0.0018	0.0036	0.0023	nd (T)	0.0047
C-2 FLUORENE(194)	0.0500	0.0086	0.0580	0.0039	0.0140	0.0092	0.0120	0.0043	nd (T)	0.0041
C-3 FLUORENE(208)	0.1600	0.0210	0.0930	0.0130	0.0350	0.0230	0.0340	0.0130	nd (T)	0.0130
DIBENZOTHIO., b, f(184)	nd (T)	nd (T)	0.0045	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-1 DIBENZOTHIO.(198)	0.0065	0.0021	0.0250	0.0007	0.0022	nd (T)	0.0023	nd (T)	nd (T)	0.0021
C-2 DIBENZOTHIO.(212)	0.0390	0.0072	0.0840	0.0070	0.0120	0.0032	0.0150	0.0010	nd (T)	0.0055
C-3 DIBENZOTHIO.(226)	0.0710	0.0080	0.0960	0.0120	0.0180	0.0053	0.0240	0.0022	nd (T)	0.0026
PHENANTHRENE, b, f(178)	0.0015	0.0012	0.0070	nd (T)	nd (T)	0.0011	0.0005	0.0004	nd (T)	0.0021
C-1 PHENANTHRENE(192)	0.0190	0.0012	0.0190	0.0006	0.0016	0.0011	0.0041	0.0044	nd (T)	0.0170
C-2 PHENANTHRENE(206)	0.0650	0.0052	0.0620	0.0064	0.0110	0.0037	0.0130	0.0030	nd (T)	0.0081
C-3 PHENANTHRENE(220)	0.1500	0.0067	0.1000	0.0150	0.0320	0.0084	0.0350	0.0016	nd (T)	0.0034
ANTHRACENE, b, f(178)	0.0006	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
NAPHTHOBENZTHIO., b(234)	0.0082	nd (T)	0.0088	nd (T)	nd (T)	nd (T)	0.0036	0.0027	nd (T)	0.0010
C-1 NBTP(248)	0.0800	0.0045	0.0320	0.0043	0.0086	0.0038	0.0180	0*	nd (T)	nd (T)
C-2 NBTP(262)	0.1200	0.0069	0.0410	0.0066	0.0120	0.0064	0.0250	0.0055	nd (T)	0.0019
C-3 NBTP(276)	0.1100	0.0074	0.0300	0.0089	0.0180	0.0061	0.0200	0.0062	nd (T)	0.0023
FLUORANTHRENE, b, f(202)	nd (T)	0.0010	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0011
PYRENE, b, f(202)	0.0017	nd (T)	0.0022	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0015
C-1 PYRENE(216)	0.0170	0.0039	0.0140	0.0030	0.0057	0.0015	0.0035	nd (T)	nd (T)	0.0058
C-2 PYRENE(230)	0.0500	0.0057	0.0280	0.0057	0.0130	0.0022	0.0097	0.0007	nd (T)	0.0010
BENZO(a)ANT.(228)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
CHRYSENE, c, g(228)	0.0140	0.0014	0.0096	0.0026	0.0029	0.0014	0.0033	nd (T)	nd (T)	nd (T)
C-1 CHRYSENE(242)	0.0280	0.0018	0.0130	0.0029	0.0036	0.0025	0.0072	0.0010	nd (T)	nd (T)
C-2 CHRYSENE(256)	0.0350	0.0025	0.0150	0.0043	0.0053	0.0030	0.0110	0.0020	nd (T)	nd (T)
BENZO(b,k)FLU., d, g(252)	0.0006	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
BENZO(e)PYRENE, d, g(252)	0.0038	nd (T)	0.0018	0.0005	0.0013	nd (T)	0.0012	nd (T)	nd (T)	nd (T)
BENZO(a)PYRENE, d, g(252)	0.0006	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0004	0.0004	nd (T)	nd (T)
PERYLENE, d, g(252)	0.0024	0.0023	nd (T)	nd (T)	nd (T)	0.0018	nd (T)	nd (T)	nd (T)	nd (T)
IND.(1,2,3-cd)PYR., d, g(276)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
BENZ.(g,h,i)PER., d, g(276)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
DIBENZ.(a,h)ANT., d, g(278)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
<b>TOTAL TARGET AH:</b>	<b>1.1000</b>	<b>0.1100</b>	<b>0.9500</b>	<b>0.1000</b>	<b>0.2100</b>	<b>0.0970</b>	<b>0.2600</b>	<b>0.0560</b>	<b>0.0000</b>	<b>0.0960</b>
% Dry Weight	9.90	10.00	16.00	15.00	16.00	11.00	14.00	11.00	11.00	11.00



MS FILE NAME:	AVG (2)	ED6163F	AVG (2)	AVG (2)	AVG (4)	ED6164C	ED6164D	ED6164F	ED6163I	ED6157C
LABORATORY ID:	N5208-02M	N5208-05	N5208-02AM	N5208-04M	N5171-01M	N5208-14	N5208-15	N5208-13	N5208-11	N5171-00
NOAA ID:	95071541	95071542	95071541A	95071465	95061511	95071464	95071244	95071358	95071359	
SAMPLE SITE:	Crab Bay Mussel	Crab Bay Mussel	Crab Bay Mussel	Crafton Is Mussel	Disk Island Mussel	Eshamy Bay Mussel	Mussel Beach Mussel	NW Bay Mussel	NW Bay Mussel	Outside Bay Clam
DESCRIPTION:	Soft	Rocky	Soft		Cleaning Site	Rocky	Mid	Rocky Islet		Orange, Comp.
# ANIMALS	26	35	31	28	38	45	36	33	48	44
COMPOUND	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)
NAPHTHALENE(128),a, f	nd (T)	nd (T)	nd (T)	nd (T)	0.0009	0.0017	nd (T)	nd (T)	0.0010	nd (T)
C-1 NAPHTHALENE(142)	nd (T)	nd (T)	nd (T)	nd (T)	0.0015	0.0036	nd (T)	0.0012	0.0015	nd (T)
C-2 NAPHTHALENE(156)	nd (T)	0.0020	nd (T)	nd (T)	0.0037	0.0036	nd (T)	0.0014	0.0019	nd (T)
C-3 NAPHTHALENE(170)	nd (T)	0.0024	nd (T)	0.0024	0.0073	0.0042	nd (T)	0.0027	0.0020	nd (T)
C-4 NAPHTHALENE(184)	nd (T)	0.0010	nd (T)	0.0024	0.0100	nd (T)	nd (T)	nd (T)	0.0020	nd (T)
FLUORENE, a, f(166)	nd (T)	nd (T)	nd (T)	nd (T)	0.0005	0.0010	nd (T)	nd (T)	nd (T)	nd (T)
C-1 FLUORENE(180)	nd (T)	nd (T)	nd (T)	nd (T)	0.0065	0.0061	nd (T)	nd (T)	nd (T)	nd (T)
C-2 FLUORENE(194)	nd (T)	nd (T)	nd (T)	nd (T)	0.0130	0.0072	nd (T)	nd (T)	nd (T)	nd (T)
C-3 FLUORENE(208)	nd (T)	nd (T)	nd (T)	nd (T)	0.0480	0.0180	nd (T)	nd (T)	nd (T)	nd (T)
DIBENZOTHIO., b, f(184)	nd (T)	nd (T)	nd (T)	nd (T)	0.0006	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-1 DIBENZOTHIO.(198)	nd (T)	nd (T)	nd (T)	nd (T)	0.0025	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-2 DIBENZOTHIO.(212)	nd (T)	nd (T)	nd (T)	nd (T)	0.0094	nd (T)	nd (T)	0.0012	0.0012	nd (T)
C-3 DIBENZOTHIO.(226)	nd (T)	nd (T)	nd (T)	0.0033	0.0140	nd (T)	nd (T)	0.0010	0.0010	nd (T)
PHENANTHRENE, b, f(178)	nd (T)	nd (T)	0.0005	0.0011	0.0017	0.0024	nd (T)	nd (T)	nd (T)	nd (T)
C-1 PHENANTHRENE(192)	nd (T)	0.0010*	nd (T)	nd (T)	0.0080	0.0034	0.0012	0.0010	0.0035	nd (T)
C-2 PHENANTHRENE(206)	nd (T)	0.0015	nd (T)	nd (T)	0.0130	0.0038	0.0013	0.0016	0.0035	nd (T)
C-3 PHENANTHRENE(220)	nd (T)	0.0030*	nd (T)	nd (T)	0.0270	0.0010	0.0015	0.0033	*	nd (T)
ANTHRACENE, b, f(178)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
NAPHTHOBENZTHIO., b(234)	nd (T)	nd (T)	nd (T)	nd (T)	0.0022	nd (T)	nd (T)	nd (T)	0.0025	nd (T)
C-1 NBTP(248)	nd (T)	nd (T)	nd (T)	nd (T)	0.0110	nd (T)	nd (T)	0.0022	nd (T)	nd (T)
C-2 NBTP(262)	nd (T)	nd (T)	nd (T)	nd (T)	0.0160	nd (T)	nd (T)	0.0049	nd (T)	nd (T)
C-3 NBTP(276)	nd (T)	nd (T)	nd (T)	nd (T)	0.0130	nd (T)	nd (T)	0.0079	nd (T)	nd (T)
FLUORANTHENE, b, f(202)	nd (T)	nd (T)	nd (T)	nd (T)	0.0004	0.0011	nd (T)	nd (T)	nd (T)	nd (T)
PYRENE, b, f(202)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-1 PYRENE(216)	nd (T)	nd (T)	nd (T)	nd (T)	0.0029	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-2 PYRENE(230)	nd (T)	nd (T)	nd (T)	nd (T)	0.0092	nd (T)	nd (T)	0.0011	nd (T)	nd (T)
BENZO(a)ANT.(228)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
CHRYSENE, c, g(228)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-1 CHRYSENE(242)	nd (T)	nd (T)	nd (T)	nd (T)	0.0042	nd (T)	nd (T)	0.0012	nd (T)	nd (T)
C-2 CHRYSENE(256)	nd (T)	nd (T)	nd (T)	nd (T)	0.0087	nd (T)	nd (T)	0.0021	nd (T)	nd (T)
BENZO(b,k)FLU., d, g(252)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
BENZO(e)PYRENE, d, g(252)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
BENZO(a)PYRENE, d, g(252)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
PERYLENE, d, g(252)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
IND.(1,2,3-cd)PYR., d, g(276)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
BENZ.(g,h,i)PER., d, g(276)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
DIBENZ.(a,h)ANT., d, g(278)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
<b>TOTAL TARGET AH:</b>	<b>0.0000</b>	<b>0.0069</b>	<b>0.0005</b>	<b>0.0150</b>	<b>0.2400</b>	<b>0.0550</b>	<b>0.0039</b>	<b>0.0330</b>	<b>0.0170</b>	<b>0.0000</b>
% Dry Weight	11.00	11.00	11.00	13.00	--	10.00	9.60	9.90	11.00	18.00



MS FILE NAME:	ED6171H	AVG (2)	ED6163H	AVG (2)	ED6159E	ED6155E	AVG (2)	ED6155G	ED6156C	ED6156D
LABORATORY ID:	N5171-OYR	N5171-08M	N5208-09	N5208-06M	N5208-08	N5171-03R	N5171-04M	N5171-05R	N5171-06R	N5171-07R
NOAA ID:	95061401	95071456	95071456	95071525	95071526	95061312	95061313	95061314	95061315	95061316
SAMPLE SITE:	Outside Bay Clam	Outside Bay Clam	Outside Bay Mussel	Shelter Bay Mussel	Sleepy Bay Mussel	Smith Is Mussel	Smith Is Mussel	Smith Is Mussel	Smith Is Mussel	Smith Is Mussel
MATRIX:	Clam	Clam	Mussel	Mussel	Mussel	Mussel	Mussel	Mussel	Mussel	Mussel
DESCRIPTION:	Yellow, Comp.	Reference				East, Std Coll.	Plot 1	Plot 2	Plot 3	West, Std Coll.
# ANIMALS	40	25	42	41	47	78	105	80	70	70
COMPOUND	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)
NAPHTHALENE(128), a, f	0.0010	nd (T)	0.0014	0.0014	nd (T)	nd (T)	nd (T)	0.0019	0.0010	nd (T)
C-1 NAPHTHALENE(142)	0.0017	nd (T)	0.0018	0.0014	0.0016	nd (T)	nd (T)	0.0027	0.0016	0.0018
C-2 NAPHTHALENE(156)	0.0032	nd (T)	0.0020	0.0024	0.0023	0.0027	0.0022	0.0033	0.0033	0.0020
C-3 NAPHTHALENE(170)	0.0047	nd (T)	0.0020	0.0028	0.0024	0.0032	0.0024	0.0038	0.0051	0.0025
C-4 NAPHTHALENE(184)	0.0054	nd (T)	nd (T)	0.0007	nd (T)	0.0030	0.0019	0.0026	0.0096	0.0035
FLUORENE, a, f(166)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-1 FLUORENE(180)	0.0052	nd (T)	nd (T)	nd (T)	0.0042	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-2 FLUORENE(194)	0.0097	nd (T)	nd (T)	nd (T)	0.0042	0.0084	nd (T)	nd (T)	0.0150	0.0140
C-3 FLUORENE(208)	0.0140	nd (T)	nd (T)	nd (T)	0.0092	0.0190	nd (T)	nd (T)	0.0670	0.0460
DIBENZOTHIO, b, f(184)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-1 DIBENZOTHIO,(198)	0.0014	nd (T)	nd (T)	nd (T)	nd (T)	0.0010	0.0007	nd (T)	0.0025	0.0011
C-2 DIBENZOTHIO,(212)	0.0024	nd (T)	nd (T)	0.0005	nd (T)	0.0034	0.0050	0.0050	0.0170	0.0070
C-3 DIBENZOTHIO,(226)	0.0040	nd (T)	nd (T)	nd (T)	nd (T)	0.0057	0.0100	0.0094	0.0370	0.0140
PHENANTHRENE, b, f(178)	0.0024	nd (T)	nd (T)	nd (T)	0.0015	0.0017	0.0007	0.0013	0.0010	0.0010
C-1 PHENANTHRENE(192)	0*	nd (T)	0.0023	0.0005*	nd (T)	0.0052	0.0056	0.0052	0.0079	0.0072
C-2 PHENANTHRENE(206)	0.0120	nd (T)	0.0011	0.0011	0.0021	0.0048	0.0092	0.0060	0.0260	0.0120
C-3 PHENANTHRENE(220)	0*	nd (T)	nd (T)	0.0015*	nd (T)	0.0110	0.0230	0.0160	0.0630	0.0340
ANTHRACENE, b, f(178)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
NAPHTHOBENZTHIO, b(234)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0011	0.0019	0.0013	0.0054	0.0027
C-1 NBTP(248)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0058	0.0150	0.0078	0.0330	0.0150
C-2 NBTP(262)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0080	0.0210	0.0094	0.0540	0.0210
C-3 NBTP(276)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0056	0.0160	0.0075	0.0430	0.0190
FLUORANTHENE, b, f(202)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
PYRENE, b, f(202)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-1 PYRENE(216)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0019	0.0039	0.0019	0.0042	0.0033
C-2 PYRENE(230)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0054	0.0092	0.0052	0.0150	0.0120
BENZO(a)ANT,(228)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0002	nd (T)	nd (T)	nd (T)
CHRYSENE, c, g(228)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0015	0.0011	0.0046	0.0019
C-1 CHRYSENE(242)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0023	0.0045	nd (T)	0.0130	0.0064
C-2 CHRYSENE(256)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0034	0.0087	0.0037	0.0170	0.0100
BENZO(b,k)FLU,*, d, g(252)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
BENZO(e)PYRENE, d, g(252)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0016	nd (T)
BENZO(a)PYRENE, d, g(252)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
PERYLENE, d, g(252)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
IND.(1,2,3-cd)PYR., d, g(276)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
BENZ.(g,h,i)PER., d, g(276)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
DIBENZ.(a,h)ANT., d, g(278)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
<b>TOTAL TARGET AH:</b>	<b>0.0670</b>	<b>0.0000</b>	<b>0.0110</b>	<b>0.0100</b>	<b>0.0280</b>	<b>0.1000</b>	<b>0.1500</b>	<b>0.0950</b>	<b>0.4500</b>	<b>0.2400</b>
% Dry Weight	19.00	14.00	13.00	12.00	13.00	11.00	13.00	11.00	13.00	12.00



MS FILE NAME:	ED6162C	AVG (2)	AVG (3)	TB AVG	NSC REF AVC
LABORATORY ID:	N5208-07	N5208-03M	N5171-02M	TB	NSC REF
NOAA ID:	95071613	95071614	95061101		
SAMPLE SITE:	Snug Harbor Mussel	Snug Harbor Mussel	Whittier Harbor Mussel	Tissue Blank	NSC REF
DESCRIPTION:	Soft	Rocky	Reference	n=6	n=15
# ANIMALS	30	32	29		
COMPOUND	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)
NAPHTHALENE(128),a, f	nd (T)	nd (T)	0.0280	0.0730	950.0000
C-1 NAPHTHALENE(142)	0.0013	nd (T)	0.2600	0.0470	2400.0000
C-2 NAPHTHALENE(156)	0.0022	nd (T)	1.3000	0.0013	3100.0000
C-3 NAPHTHALENE(170)	0.0022	nd (T)	5.4000	nd (T)	2500.0000
C-4 NAPHTHALENE(184)	nd (T)	nd (T)	5.4000	nd (T)	1400.0000
FLUORENE, a, f(166)	nd (T)	nd (T)	0.4100	nd (T)	110.0000
C-1 FLUORENE(180)	nd (T)	nd (T)	1.4000	nd (T)	300.0000
C-2 FLUORENE(194)	nd (T)	nd (T)	2.9000	nd (T)	510.0000
C-3 FLUORENE(208)	nd (T)	nd (T)	2.7000	nd (T)	510.0000
DIBENZOTHIO., b, f(184)	nd (T)	nd (T)	0.6800	nd (T)	190.0000
C-1 DIBENZOTHIO.(198)	nd (T)	nd (T)	1.3000	nd (T)	380.0000
C-2 DIBENZOTHIO.(212)	nd (T)	nd (T)	1.6000	nd (T)	640.0000
C-3 DIBENZOTHIO.(226)	nd (T)	0.0006	0.6800	nd (T)	580.0000
PHENANTHRENE, b, f(178)	nd (T)	nd (T)	1.2000	nd (T)	270.0000
C-1 PHENANTHRENE(192)	nd (T)	nd (T)	2.2000	nd (T)	640.0000
C-2 PHENANTHRENE(206)	nd (T)	nd (T)	1.6000	nd (T)	830.0000
C-3 PHENANTHRENE(220)	nd (T)	nd (T)	0.5600	nd (T)	750.0000
ANTHRACENE, b, f(178)	nd (T)	nd (T)	0.0370	nd (T)	nd (T)
NAPHTHOBENZTHIO.,b(234)	0.0015	nd (T)	0.1400	nd (T)	74.0000
C-1 NBTP(248)	nd (T)	nd (T)	0.0640	nd (T)	330.0000
C-2 NBTP(262)	nd (T)	nd (T)	0.0280	nd (T)	470.0000
C-3 NBTP(276)	nd (T)	nd (T)	0.0290	nd (T)	410.0000
FLUORANTHENE, b, f(202)	nd (T)	nd (T)	0.5100	nd (T)	1.7000
PYRENE, b, f(202)	nd (T)	nd (T)	0.2700	nd (T)	9.1000
C-1 PYRENE(216)	nd (T)	nd (T)	0.1900	nd (T)	62.0000
C-2 PYRENE(230)	nd (T)	nd (T)	0.0580	nd (T)	120.0000
BENZO(a)ANT.(228)	nd (T)	nd (T)	0.1200	nd (T)	0.6900
CHRYSENE, c, g(228)	nd (T)	nd (T)	0.2100	nd (T)	48.0000
C-1 CHRYSENE(242)	nd (T)	nd (T)	0.0700	nd (T)	98.0000
C-2 CHRYSENE(256)	nd (T)	nd (T)	0.0230	nd (T)	160.0000
BENZO(b,k)FLU., d, g(252)	nd (T)	nd (T)	0.1100	nd (T)	4.0000
BENZO(e)PYRENE, d, g(252)	nd (T)	nd (T)	0.0720	nd (T)	12.0000
BENZO(a)PYRENE, d, g(252)	nd (T)	nd (T)	0.0091	nd (T)	1.4000
PERYLENE, d, g(252)	nd (T)	nd (T)	0.0029	nd (T)	0.6900
IND.(1,2,3-cd)PYR., d, g(276)	nd (T)	nd (T)	0.0060	nd (T)	nd (T)
BENZ.(g,h,i)PER., d, g(276)	nd (T)	nd (T)	0.0043	nd (T)	1.8000
DIBENZ.(a,h)ANT., d, g(278)	nd (T)	nd (T)	0.0015	nd (T)	0.0520
<b>TOTAL TARGET AH:</b>	<b>0.0072</b>	<b>0.0006</b>	<b>32.0000</b>	<b>0.1200</b>	<b>18000.0000</b>
% Dry Weight	14.00	13.00	11.00		

## Appendix B

This appendix comprises histogram plots of all sediment samples analyzed; the samples are sorted alphabetically by site with duplicates and replicates averaged into a single plot. The following observations were made on the tissue data from these plots.

1. The sediment samples indicate a range of weathering from heavily weathered to moderate. The weathering classification for the samples are:

Heavily Weathered

Block Island, 1994. Plots 1 and 3  
Block Island, 1995. Plots 1, 2, 3, and 4  
Crab Bay, soft  
North West Bay, rocky  
Shelter Bay, low (potential contamination)  
Sleepy Bay, low (potential contamination)  
Snug Harbor, soft low (combustion and contamination influence)  
Snug Harbor, rocky  
Smith Island Plot 1

Heavily to Moderately Weathered

North West Bay, West Arm  
Smith Island, Plot 2

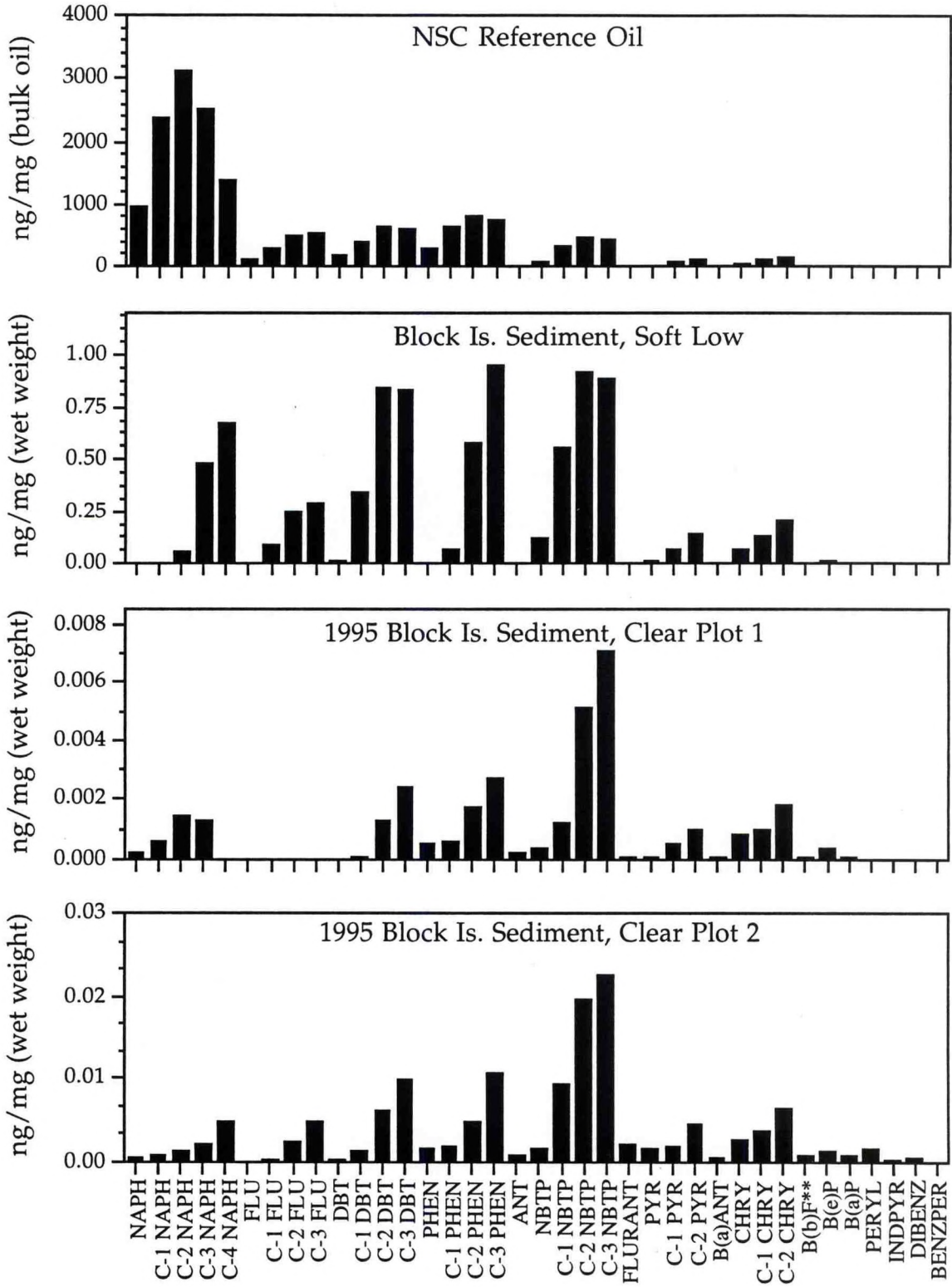
Moderately Weathered

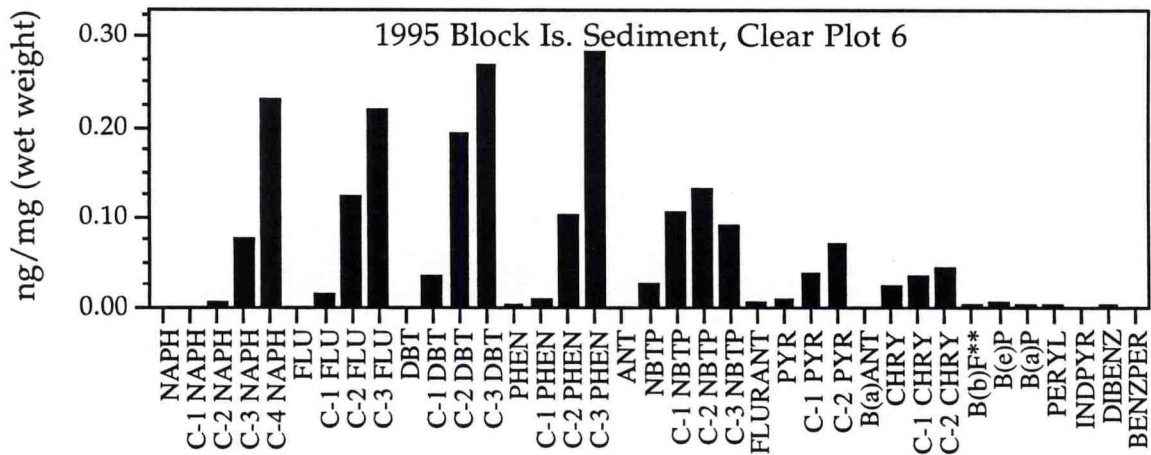
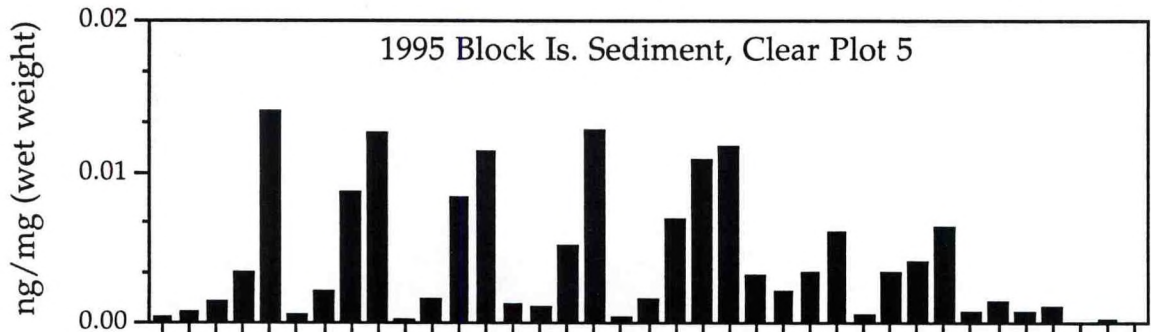
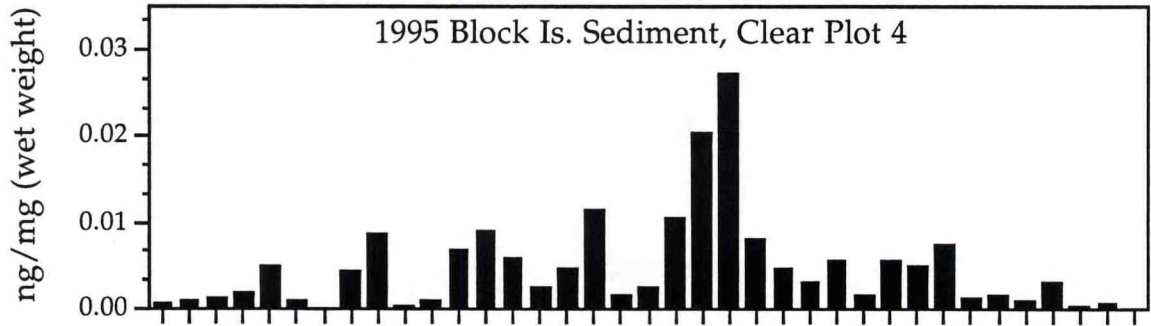
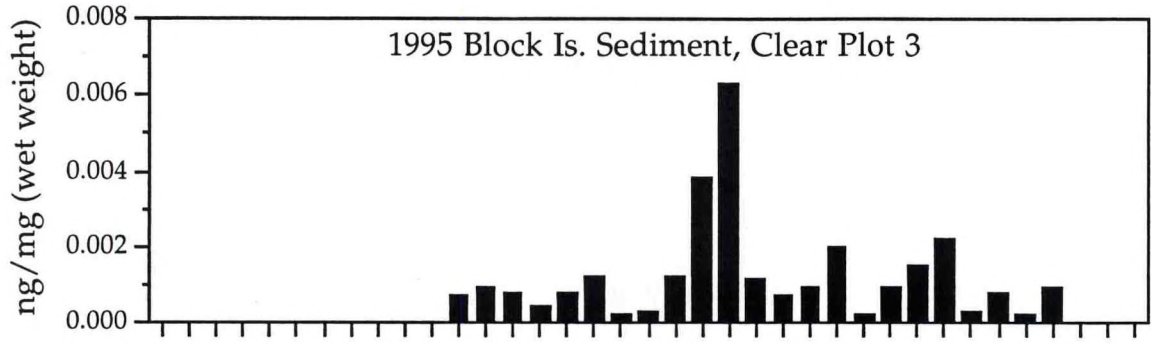
Block Island, Soft Low  
Block Island, 1994. Plots 2, 5 and 6  
Block Island, 1995. Plots 5 and 6  
Block Island Clear Plots 1 and 2  
Smith Island, Plot 3

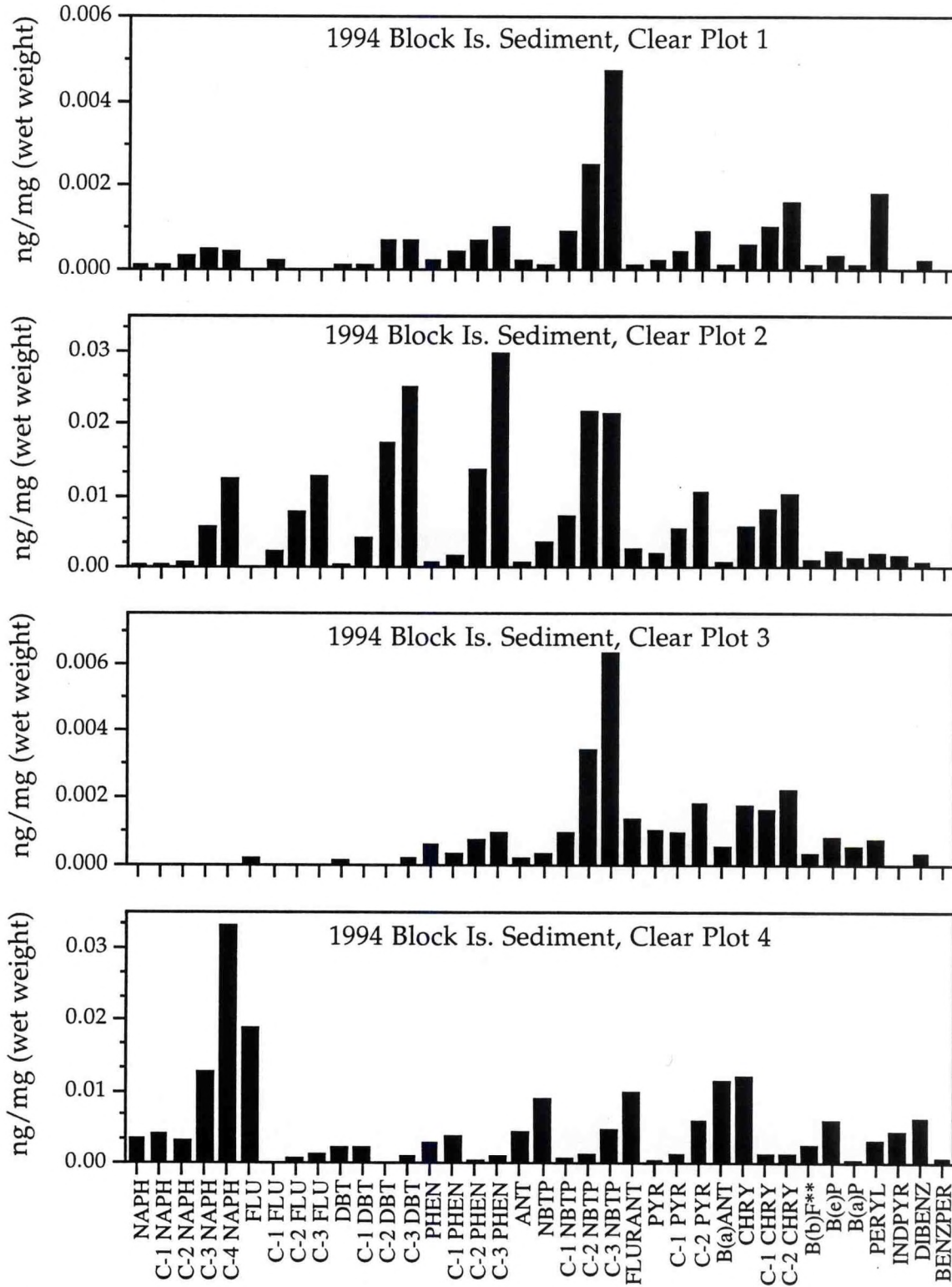
2. Other influences are noted in the oil profiles, generally the profiles of lowest concentration. Examples are:

1994 Block Island Clam Plot 4  
Outside Bay, soft  
Snug Harbor  
Smith Island Plots 1 and 2

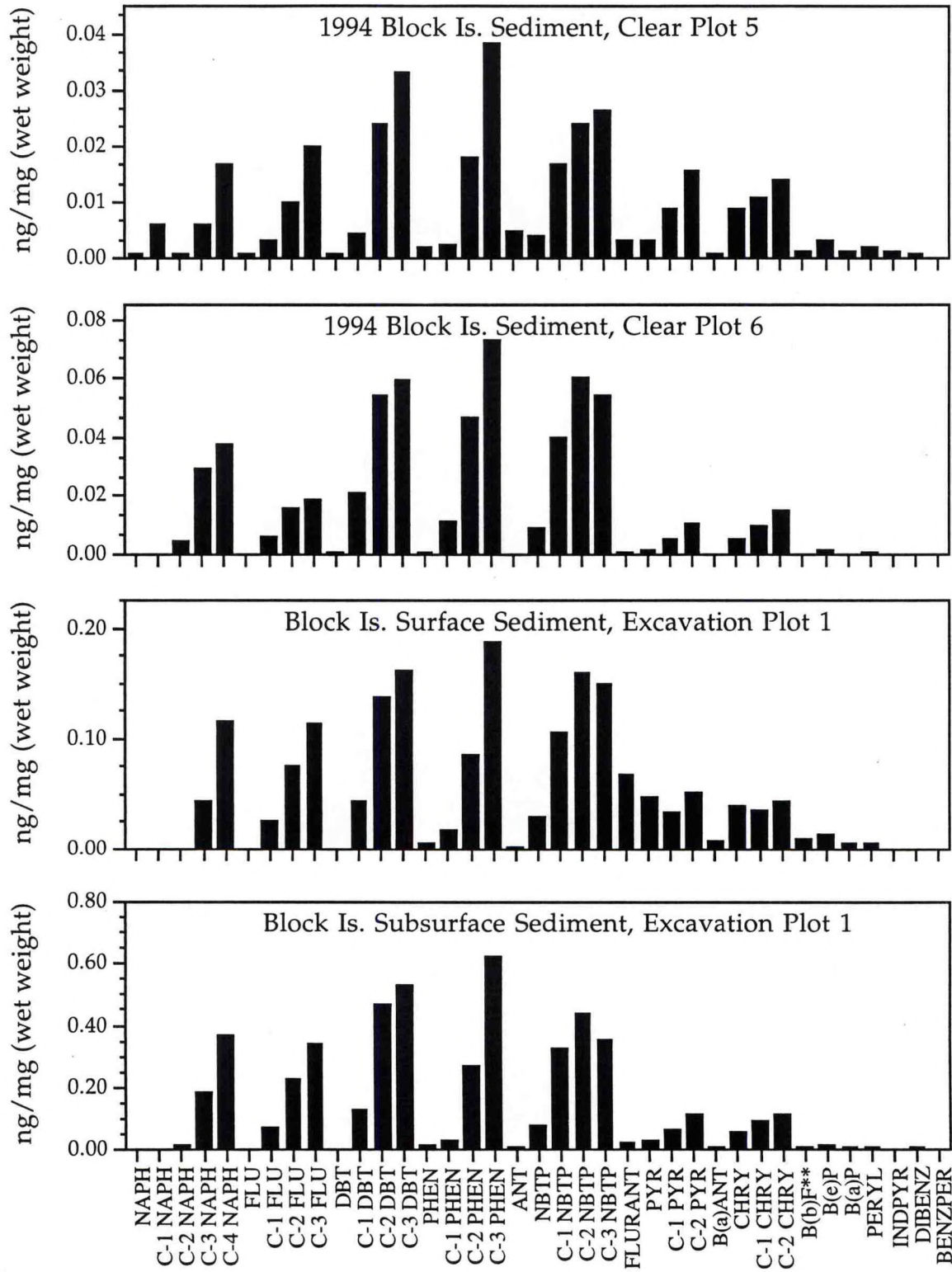


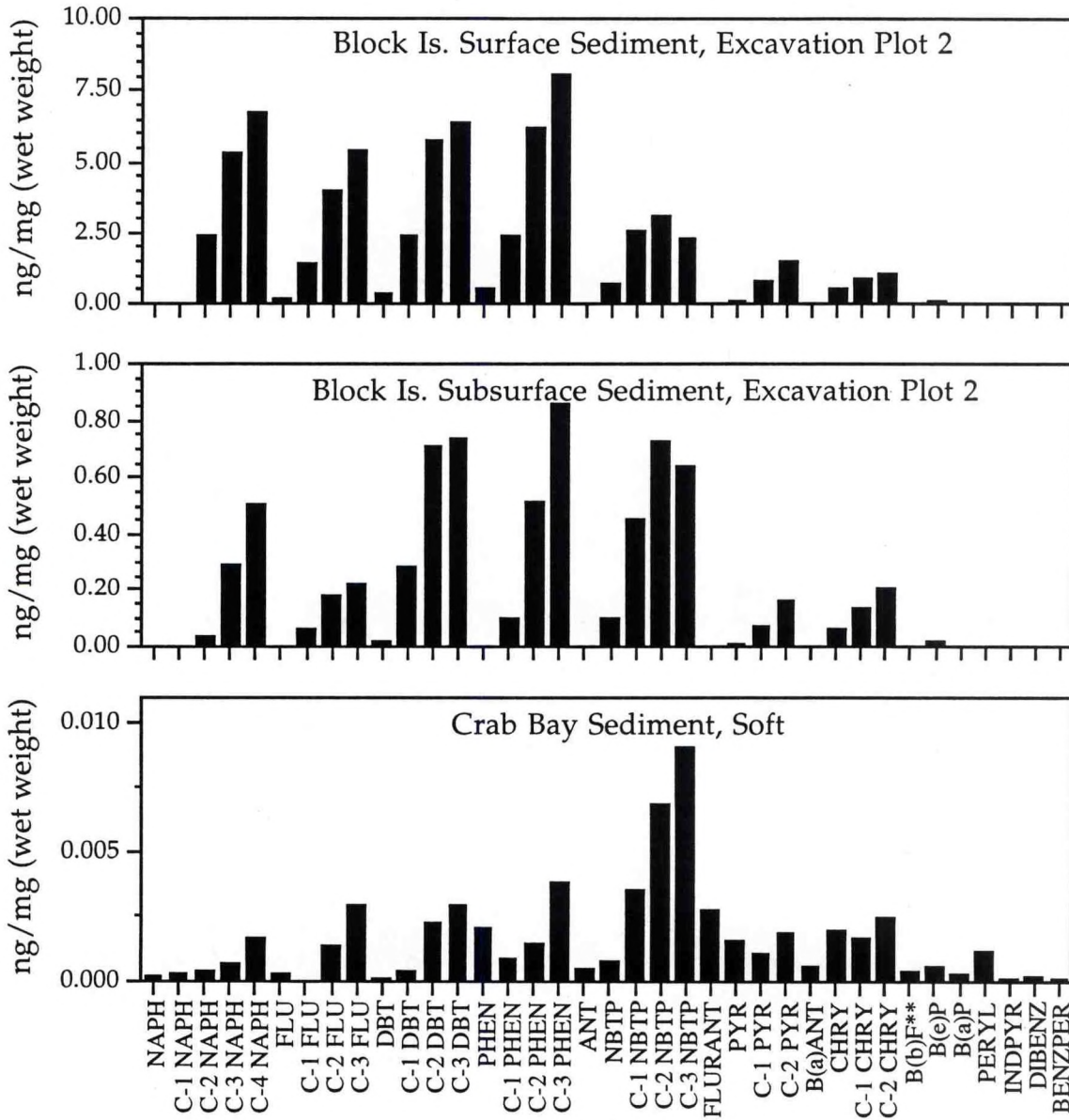


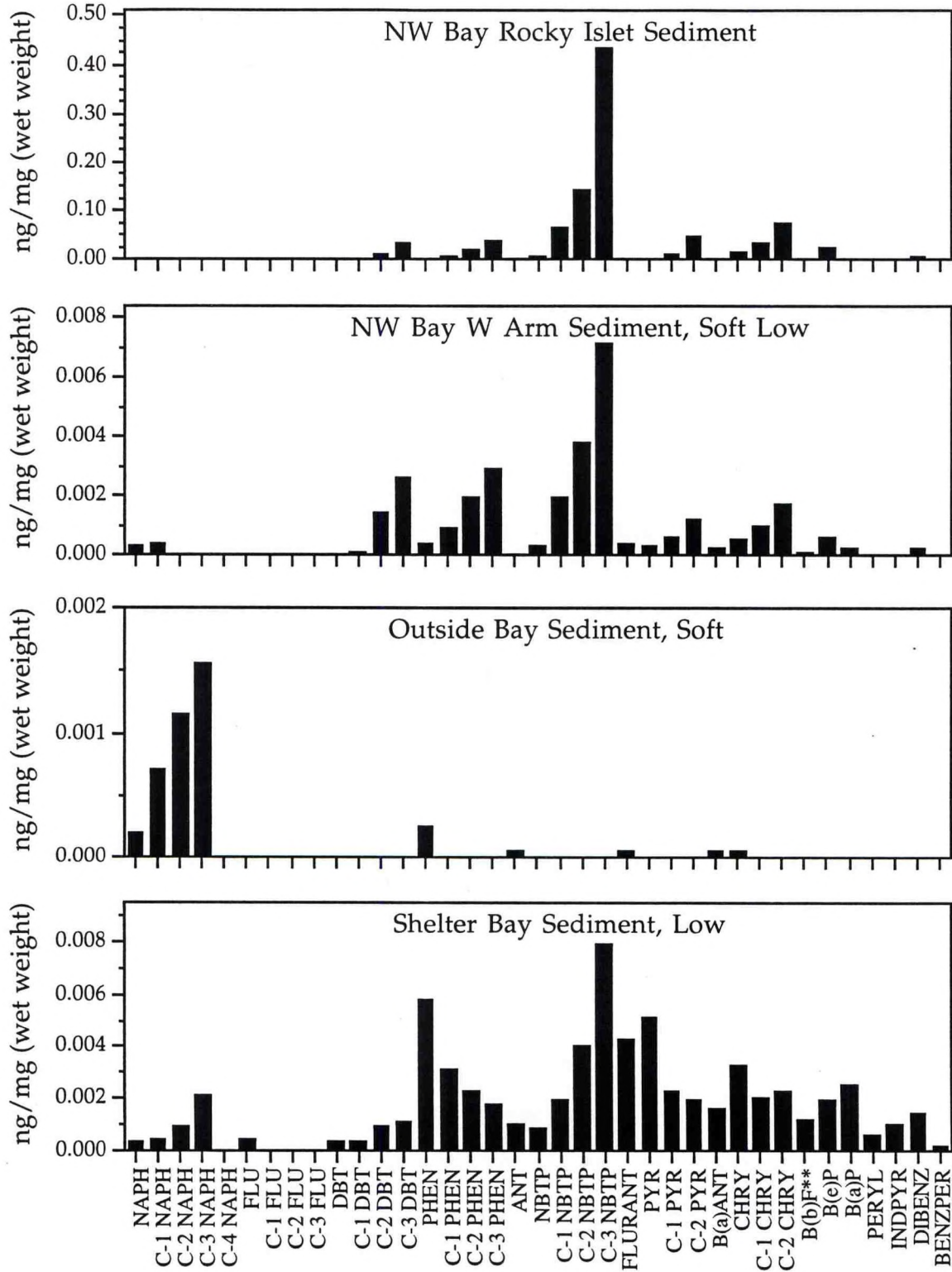




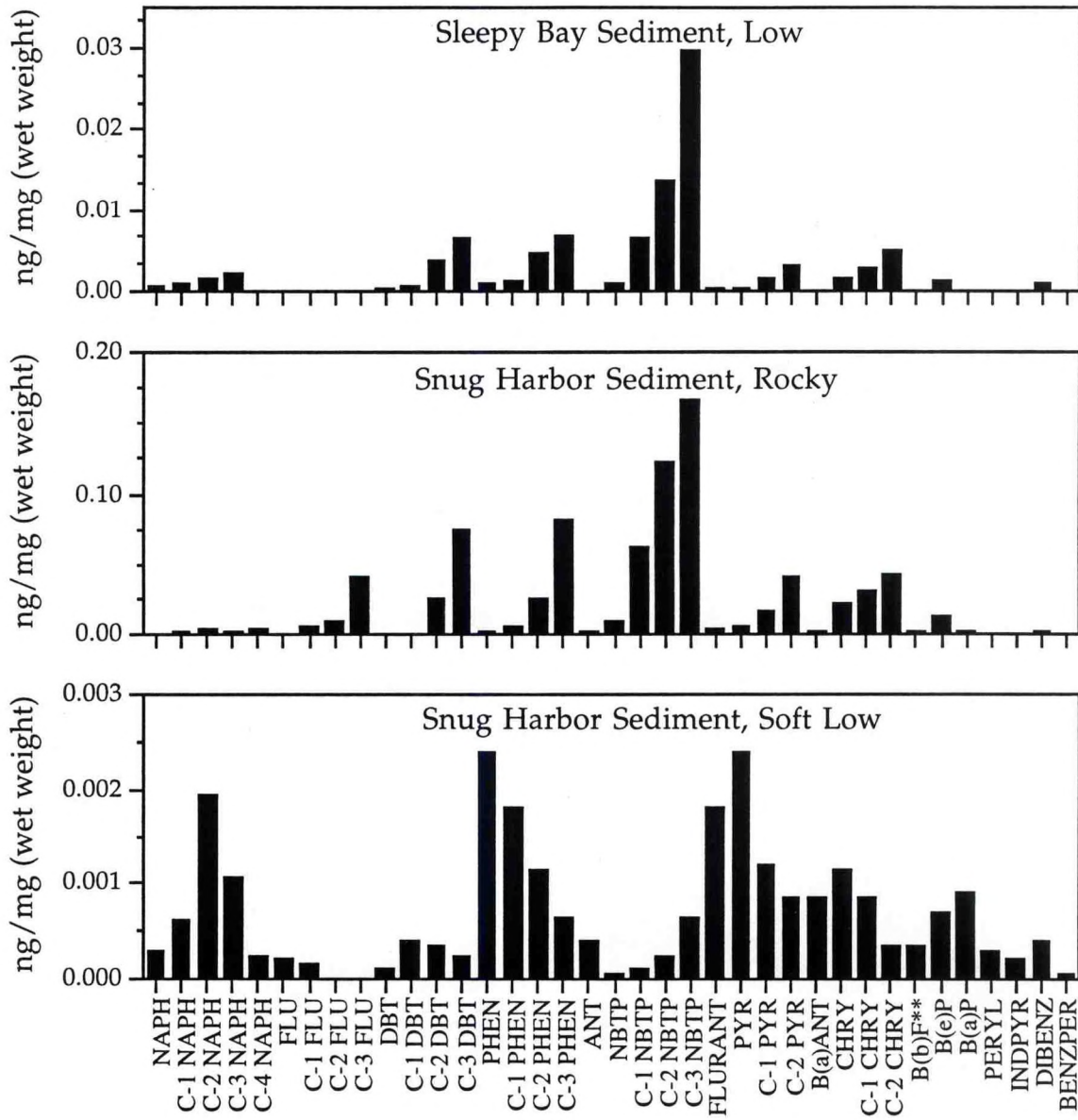


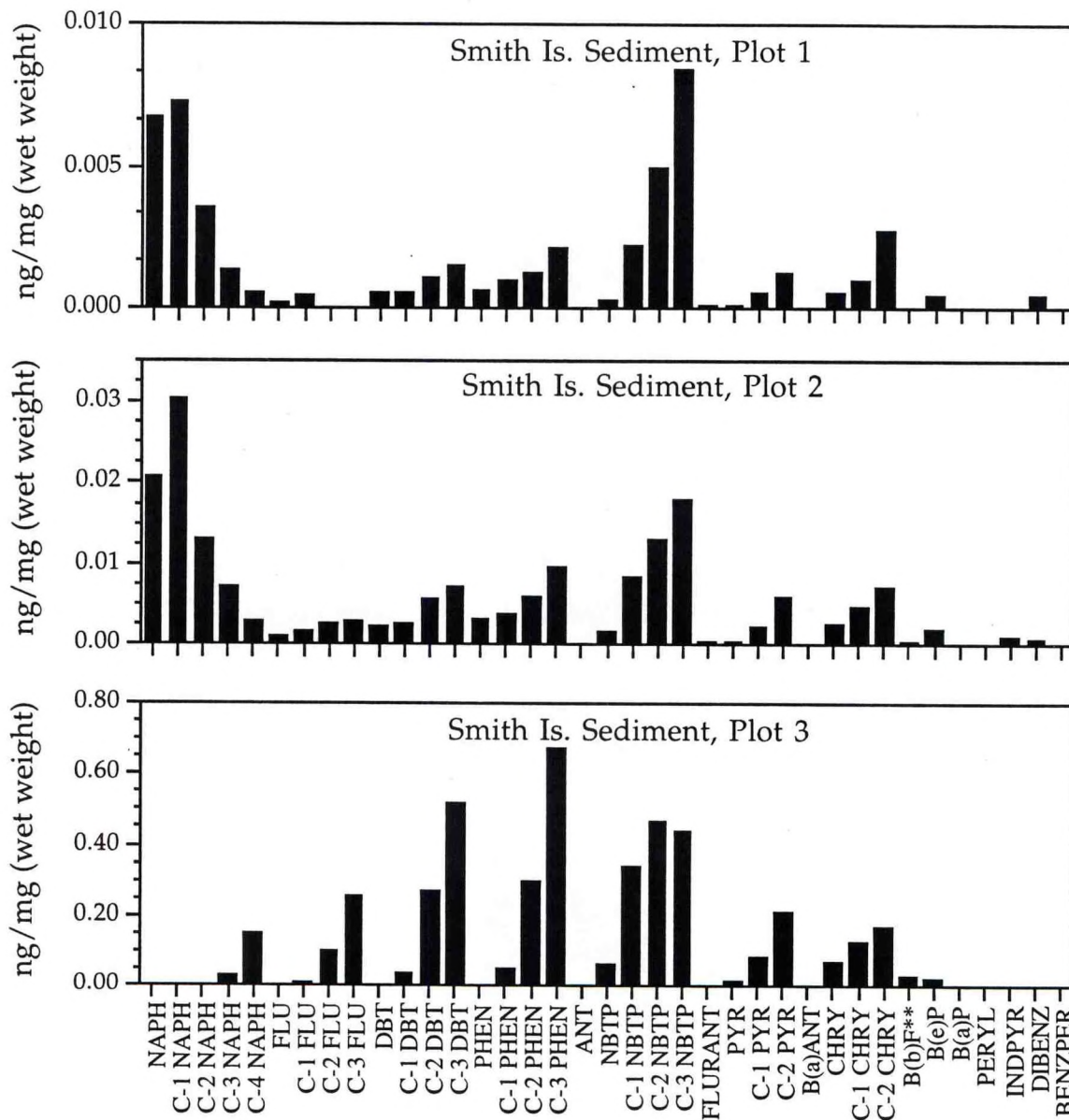












MS FILE NAME:	ED6137C	ED6138E	ED6138C	ED6138F	ED6138D	ED6143E	AVG (3)	AVG (3)
LABORATORY ID:	N4187-06	N4187-11	N4187-07	N4187-03	N4187-10	N4187-09	N5171-42M	N5171-43M
NOAA ID:	94062314	94062315	94062316	94062317	94062318	94062319	95061502	95061503
SAMPLE NAME:	Block Is.	Block Is.	Block Is.	Block Is.	Block Is.	Block Is.	Block Is.	Block Is.
MATRIX:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Surf. Sediment	Subsurf. Sed
DESCRIPTION:	Clear Plot1	Clear Plot2	Clear Plot3	Clear Plot4	Clear Plot5	Clear Plot6	Excav. Plot 1	Excav. Plot 1
COMPOUND	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)
NAPHTHALENE(128),a,f	nd (T)	0.0002	nd (T)	0.0035	0.0007	nd (T)	nd (T)	0.0002
C-1 NAPHTHALENE(142)	0.0001	0.0004	nd (T)	0.0040	0.0006	0.0003	nd (T)	0.0006
C-2 NAPHTHALENE(156)	0.0003	0.0005	nd (T)	0.0032	0.0007	0.0044	nd (T)	0.0120
C-3 NAPHTHALENE(170)	0.0005	0.0055	nd (T)	0.0130	0.0058	0.0290	0.0440	0.1800
C-4 NAPHTHALENE(184)	0.0004	0.0120	nd (T)	0.0330	0.0170	0.0370	0.1100	0.3700
FLUORENE, a, f(166)	nd (T)	nd (T)	0.0002	0.0190	0.0009	0.0002	nd (T)	0.0012
C-1 FLUORENE(180)	0.0002	0.0022	nd (T)	nd (T)	0.0033	0.0058	0.0250	0.0740
C-2 FLUORENE(194)	nd (T)	0.0076	nd (T)	0.0005	0.0100	0.0150	0.0750	0.2300
C-3 FLUORENE(208)	nd (T)	0.0130	nd (T)	0.0013	0.0200	0.0190	0.1200	0.3400
DIBENZOTHIO., b, f(184)	nd (T)	nd (T)	nd (T)	0.0022	0.0007	0.0010	0.0009	0.0035
C-1 DIBENZOTHIO.(198)	nd (T)	0.0040	nd (T)	0.0023	0.0045	0.0210	0.0450	0.1300
C-2 DIBENZOTHIO.(212)	0.0007	0.0170	nd (T)	nd (T)	0.0240	0.0550	0.1400	0.4600
C-3 DIBENZOTHIO.(226)	0.0007	0.0250	nd (T)	0.0008	0.0330	0.0600	0.1600	0.5300
PHENANTHRENE, b, f(178)	nd (T)	0.0006	0.0006	0.0027	0.0018	0.0009	0.0056	0.0140
C-1 PHENANTHRENE(192)	nd (T)	0.0016	nd (T)	0.0036	0.0023	0.0110	0.0180	0.0260
C-2 PHENANTHRENE(206)	0.0007	0.0140	0.0007	nd (T)	0.0180	0.0470	0.0850	0.2600
C-3 PHENANTHRENE(220)	0.0010	0.0300	0.0009	0.0008	0.0380	0.0730	0.1900	0.6200
ANTHRACENE, b, f(178)	nd (T)	0.0007	nd (T)	0.0042	0.0047	nd (T)	0.0036	0.0037
NAPHTHOBENZTHIO., b(234)	nd (T)	0.0033	nd (T)	0.0091	0.0038	0.0088	0.0310	0.0750
C-1 NBTP(248)	0.0009	0.0070	0.0009	0.0005	0.0170	0.0400	0.1000	0.3200
C-2 NBTP(262)	0.0025	0.0220	0.0034	0.0012	0.0240	0.0600	0.1600	0.4400
C-3 NBTP(276)	0.0047	0.0210	0.0063	0.0045	0.0260	0.0550	0.1500	0.3500
FLUORANTHENE, b, f(202)	nd (T)	0.0024	0.0013	0.0100	0.032	0.010	0.0670	0.0240
PYRENE, b, f(202)	nd (T)	0.0020	0.0010	nd (T)	0.0030	0.0015	0.0460	0.0260
C-1 PYRENE(216)	nd (T)	0.0053	0.0009	0.0012	0.0087	0.0051	0.0340	0.0620
C-2 PYRENE(230)	0.0009	0.0110	0.0018	0.0059	0.0160	0.0110	0.0510	0.1100
BENZO(a)ANT.(228)	nd (T)	nd (T)	nd (T)	0.0120	nd (T)	nd (T)	0.0086	0.0080
CHRYSENE, c, g(228)	nd (T)	0.0055	0.0017	0.0120	0.0086	0.0049	0.0390	0.0580
C-1 CHRYSENE(242)	0.0010	0.0079	0.0016	0.0013	0.0110	0.0098	0.0350	0.0920
C-2 CHRYSENE(256)	0.0016	0.0100	0.0022	0.0011	0.0140	0.0150	0.0430	0.1200
BENZO(b,k)FLU., d, g(252)	nd (T)	0.0010	nd (T)	0.0025	0.0013	nd (T)	0.0097	0.0081
BENZO(e)PYRENE, d, g(252)	nd (T)	0.0021	nd (T)	0.0059	0.0030	0.0012	0.0140	0.0170
BENZO(a)PYRENE, d, g(252)	nd (T)	0.0011	nd (T)	nd (T)	0.0010	nd (T)	0.0055	0.0080
PERYLENE, d, g(252)	0.0018	0.0019	nd (T)	0.0032	0.0020	nd (T)	0.0069	0.0100
IND.(1,2,3-cd)PYR., d, g(276)	nd (T)	0.0014	nd (T)	0.0043	0.0013	nd (T)	0.0008	nd (T)
BENZ.(g,h,i)PER., d,g(276)	nd (T)	nd (T)	nd (T)	0.0062	nd (T)	nd (T)	0.0007	0.0048
DIBENZ.(a,h)ANT., d, g(278)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
<b>TOTAL TARGET AH:</b>	<b>0.0180</b>	<b>0.2400</b>	<b>0.0230</b>	<b>0.1700</b>	<b>0.3300</b>	<b>0.5900</b>	<b>1.8000</b>	<b>5.0000</b>
TPH (ng/mg)	Trace, no TPH	Trace, no TPH	Trace, no TPH	Trace, no TPH	Trace, no TPH	1.70	0.45	1.00



MS FILE NAME:	ED6144E	ED6143F	AVG.(2)	ED6142E	ED6141C	AVG.(2)	ED6143G	ED6141F
LABORATORY ID:	N5171-44	N5171-45	N5208-35M	N5208-38	N5208-16	N5208-39M	N5208-24	N5208-28
NOAA ID:	95061506	95061507	95071256	95071257	95071258	95071259	95071241	95071255
SAMPLE NAME:	Block Is.	Block Is.	Block Is.	Block Is.	Block Is.	Block Is.	Block Is.	Block Is.
MATRIX:	Surf Sediment	Subsurf Sed	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
DESCRIPTION:	Excav. Plot 2	Excav. Plot 2	Lot 8, Plot 2	Lot 3, Plot 3	Lot 5, Plot 4	Lot 9, Plot 5	Soft Low	Lot 6, Plot 1
COMPOUND	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)
NAPHTHALENE(128).a.f	0.0210	nd (T)	0.0006	nd (T)	0.0007	0.0003	nd (T)	0.0002
C-1 NAPHTHALENE(142)	0.0370	0.0033	0.0008	nd (T)	0.0009	0.0007	nd (T)	0.0006
C-2 NAPHTHALENE(156)	2.4000	0.0340	0.0013	nd (T)	0.0013	0.0014	0.0600	0.0014
C-3 NAPHTHALENE(170)	5.3000	0.2900	0.0022	nd (T)	0.0019	0.0034	0.4800	0.0013
C-4 NAPHTHALENE(184)	6.7000	0.5000	0.0047	nd (T)	0.0050	0.0140	0.6700	nd (T)
FLUORENE, a.f(166)	0.1400	0.0037	nd (T)	nd (T)	0.0008	0.0005	nd (T)	nd (T)
C-1 FLUORENE(180)	1.4000	0.0640	0.0002	nd (T)	nd (T)	0.0022	0.0840	nd (T)
C-2 FLUORENE(194)	4.0000	0.1800	0.0025	nd (T)	0.0042	0.0089	0.2500	nd (T)
C-3 FLUORENE(208)	5.4000	0.2200	0.0047	nd (T)	0.0088	0.0120	0.2900	nd (T)
DIBENZOTHIO, b.f(184)	0.3800	0.0170	nd (T)	nd (T)	nd (T)	nd (T)	0.0110	nd (T)
C-1 DIBENZOTHIO.(198)	2.4000	0.2800	0.0012	nd (T)	0.0010	0.0015	0.3400	nd (T)
C-2 DIBENZOTHIO.(212)	5.8000	0.7100	0.0062	0.0007	0.0067	0.0081	0.8400	0.0013
C-3 DIBENZOTHIO.(226)	6.4000	0.7400	0.0100	0.0009	0.0089	0.0110	0.8300	0.0024
PHENANTHRENE, b.f(178)	0.5400	nd (T)	0.0017	0.0008	0.0060	0.0012	nd (T)	0.0005
C-1 PHENANTHRENE(192)	2.4000	0.0930	0.0019	nd (T)	0.0026	0.0010	0.0710	0.0007
C-2 PHENANTHRENE(206)	6.2000	0.5200	0.0048	0.0008	0.0045	0.0052	0.5800	0.0017
C-3 PHENANTHRENE(220)	8.1000	0.8600	0.0110	0.0012	0.0110	0.0130	0.9500	0.0027
ANTHRACENE, b.f(178)	nd (T)	nd (T)	0.0007	nd (T)	0.0015	0.0003	nd (T)	nd (T)
NAPHTHOBENZTHIO..b(234)	0.6900	0.1000	0.0015	nd (T)	0.0024	0.0015	0.1200	nd (T)
C-1 NBTP(248)	2.5000	0.4500	0.0092	0.0012	0.0110	0.0069	0.5500	0.0012
C-2 NBTP(262)	3.1000	0.7300	0.0200	0.0038	0.0210	0.0110	0.9200	0.0051
C-3 NBTP(276)	2.3000	0.6400	0.0230	0.0063	0.0270	0.0120	0.8800	0.0071
FLUORANTHRENE, b.f(202)	nd (T)	0.0035	0.0021	0.0011	0.0079	0.0030	0.0025	nd (T)
PYRENE, b.f(202)	0.1300	0.0120	0.0017	0.0007	0.0046	0.0020	0.0100	nd (T)
C-1 PYRENE(216)	0.8200	0.0740	0.0019	0.0009	0.0031	0.0034	0.0650	nd (T)
C-2 PYRENE(230)	1.5000	0.1600	0.0045	0.0020	0.0056	0.0060	0.1400	0.0010
BENZO(a)ANT.(228)	nd (T)	nd (T)	nd (T)	nd (T)	0.0016	0.0005	0.0013	nd (T)
CHRYSENE, c.g(228)	0.5100	0.0580	0.0027	nd (T)	0.0056	0.0034	0.0650	nd (T)
C-1 CHRYSENE(242)	0.8400	0.1300	0.0038	0.0015	0.0050	0.0040	0.1300	0.0010
C-2 CHRYSENE(256)	1.0000	0.2000	0.0065	0.0022	0.0073	0.0064	0.2000	0.0018
BENZO(b,k)FLU * .d.g(252)	nd (T)	0.0032	nd (T)	nd (T)	0.0011	0.0006	0.0030	nd (T)
BENZO(e)PYRENE, d.g(252)	0.1300	0.0150	0.0014	nd (T)	0.0017	0.0012	0.0150	nd (T)
BENZO(a)PYRENE, d.g(252)	nd (T)	nd (T)	0.0006	nd (T)	0.0006	0.0006	nd (T)	nd (T)
PERYLENE, d.g(252)	nd (T)	0.0016	0.0016	nd (T)	0.0031	0.0009	nd (T)	nd (T)
IND.(1,2,3-cd)PYR., d.g(276)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
BENZ.(g,h,i)PER., d.g(276)	nd (T)	0.0039	nd (T)	nd (T)	nd (T)	nd (T)	0.0034	nd (T)
DIBENZ.(a,h)ANT., d.g(278)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
<b>TOTAL TARGET AH:</b>	<b>71.0000</b>	<b>7.1000</b>	<b>0.1400</b>	<b>0.0240</b>	<b>0.1700</b>	<b>0.1500</b>	<b>8.6000</b>	<b>0.0300</b>
TPH (ng/mg)	4.50	0.70	Trace, No TPH	Trace, No TPH	Trace, No TPH	Trace, No TPH	0.76	Trace, No TPH



MS FILE NAME:	ED6141G	AVG(3)	ED6143H	ED6141H	AVG.(2)	ED6141E	ED6141D	ED6137G
LABORATORY ID:	N5208-30	N5208-23M	N5208-27	N5208-32	N5208-40M	N5208-26	N5208-17	N5171-47
NOAA ID:	95071260	95071540	95071357	95071467	95071441	95071512	95071524	95061317
SAMPLE NAME:	Block Is.	Crab Bay	NW Bay Islet	NW Bay W Arm	Outside Bay	Shelter Bay	Sleepy Bay	Smith Is.
MATRIX:	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
DESCRIPTION:	Lot 4, Plot 6	Soft	Rocky	Soft Low	Soft	Low	Low	Plot 1
COMPOUND	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)
NAPHTHALENE(128).a, f	0.0012	nd (T)	0.0017	0.0003	0.0002	0.0003	0.0006	0.0067
C-1 NAPHTHALENE(142)	0.0014	0.0001	0.0033	0.0004	0.0007	0.0004	0.0009	0.0073
C-2 NAPHTHALENE(156)	0.0050	0.0002	nd (T)	nd (T)	0.0011	0.0009	0.0016	0.0035
C-3 NAPHTHALENE(170)	0.0750	0.0002	nd (T)	nd (T)	0.0016	0.0021	0.0022	0.0013
C-4 NAPHTHALENE(184)	0.2300	0.0002	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0005
FLUORENE, a, f(166)	0.0012	0.0001	nd (T)	nd (T)	nd (T)	0.0004	nd (T)	0.0002
C-1 FLUORENE(180)	0.0140	0.0001	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0005
C-2 FLUORENE(194)	0.1200	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0002
C-3 FLUORENE(208)	0.2200	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0005
DIBENZOTHIO, b, f(184)	0.0011	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
C-1 DIBENZOTHIO.(198)	0.0340	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0007	nd (T)
C-2 DIBENZOTHIO.(212)	0.1900	nd (T)	0.0100	0.0014	nd (T)	0.0009	0.0037	0.0011
C-3 DIBENZOTHIO.(226)	0.2700	nd (T)	0.0320	0.0026	nd (T)	0.0011	0.0064	0.0015
PHENANTHRENE, b, f(178)	0.0039	0.0004	0.0018	nd (T)	nd (T)	0.0058	0.0008	0.0007
C-1 PHENANTHRENE(192)	0.0093	0.0006	0.0074	0.0009	nd (T)	0.0031	0.0012	0.0010
C-2 PHENANTHRENE(206)	0.1000	0.0002	0.0200	0.0019	nd (T)	0.0023	0.0047	0.0012
C-3 PHENANTHRENE(220)	0.2800	nd (T)	0.0370	0.0029	nd (T)	0.0018	0.0068	0.0021
ANTHRACENE, b, f(178)	0.0011	nd (T)	0.0018	nd (T)	nd (T)	0.0010	0.0009	nd (T)
NAPHTHOBENZTHIO..b(234)	0.0260	nd (T)	0.0046	nd (T)	nd (T)	0.0008	0.0009	nd (T)
C-1 NBTP(248)	0.1100	nd (T)	0.0670	0.0019	nd (T)	0.0019	0.0064	0.0022
C-2 NBTP(262)	0.1300	nd (T)	0.1400	0.0038	nd (T)	0.0040	0.0140	0.0050
C-3 NBTP(276)	0.0910	nd (T)	0.4300	0.0071	nd (T)	0.0079	0.0300	0.0084
FLUORANTHRENE, b, f(202)	0.0060	0.0009	0.0012	nd (T)	nd (T)	0.0043	nd (T)	nd (T)
PYRENE, b, f(202)	0.0084	0.0008	0.0007	nd (T)	nd (T)	0.0051	nd (T)	nd (T)
C-1 PYRENE(216)	0.0380	0.0003	0.0120	0.0006	nd (T)	0.0023	0.0014	0.0005
C-2 PYRENE(230)	0.0700	nd (T)	0.0460	0.0012	nd (T)	0.0019	0.0031	0.0012
BENZO(a)ANT.(228)	0.0010	nd (T)	nd (T)	nd (T)	nd (T)	0.0016	nd (T)	nd (T)
CHRYSENE, c, g(228)	0.0220	0.0004	0.0160	nd (T)	nd (T)	0.0033	0.0014	nd (T)
C-1 CHRYSENE(242)	0.0360	nd (T)	0.0340	0.0010	nd (T)	0.0020	0.0027	0.0010
C-2 CHRYSENE(256)	0.0450	nd (T)	0.0740	0.0017	nd (T)	0.0023	0.0050	0.0027
BENZO(b,k)FLU..*, d, g(252)	0.0022	nd (T)	0.0011	nd (T)	nd (T)	0.0012	nd (T)	nd (T)
BENZO(c)PYRENE, d, g(252)	0.0064	nd (T)	0.0250	nd (T)	nd (T)	0.0019	0.0013	nd (T)
BENZO(a)PYRENE, d, g(252)	0.0023	0.0003	nd (T)	nd (T)	nd (T)	0.0025	nd (T)	nd (T)
PERYLENE, d, g(252)	0.0043	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
IND.(1,2,3-cd)PYR., d, g(276)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	0.0010	nd (T)	nd (T)
BENZ.(g,h,i)PER., d, g(276)	0.0020	nd (T)	0.0072	nd (T)	nd (T)	0.0014	nd (T)	nd (T)
DIBENZ.(a,h)ANT., d, g(278)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)	nd (T)
<b>TOTAL TARGET AH:</b>	<b>2.2000</b>	<b>0.0044</b>	<b>0.9800</b>	<b>0.0280</b>	<b>0.0035</b>	<b>0.0660</b>	<b>0.0950</b>	<b>0.0480</b>
TPH (ng/mg)	No TPH	Trace, No TPH	1.30	Trace, No TPH	Trace, No TPH	Trace, No TPH	Trace, No TPH	Trace, No TPH



MS FILE NAME:	ED6138G	AVG.(2)	AVG.(2)	AVG.(2)	AVG.(2)	NSC REF AVG	Ext. Blank Avg
LABORATORY ID:	N5171-48	N5171-49M	N5208-34M	N5208-41M	N5208-41M	n=8	Blank 1-4
NOAA ID:	95061318	95061319	95071612	95071615	95071615	n=8	
SAMPLE NAME:	Smith Is.	Smith Is.	Snug Harbor	Snug Harbor	Snug Harbor	NSC REF	
MATRIX:	Sediment	Sediment	Sediment	Sediment	Sediment	1	
DESCRIPTION:	Plot 2	Plot 3	Soft Low	Rocky	Rocky		n=4
COMPOUND	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)	ng/mg (wet)
NAPHTHALENE(128),a,f	0.0210	0.0008	0.0003	0.0006	0.0006	1200.0000	nd (T)
C-1 NAPHTHALENE(142)	0.0300	0.0015	0.0006	0.0014	0.0014	2800.0000	0.0001
C-2 NAPHTHALENE(156)	0.0130	nd (T)	0.0008	0.0030	0.0030	3600.0000	nd (T)
C-3 NAPHTHALENE(170)	0.0072	0.0260	0.0011	0.0016	0.0016	2800.0000	nd (T)
C-4 NAPHTHALENE(184)	0.0028	0.1500	0.0003	0.0039	0.0039	1600.0000	nd (T)
FLUORENE, a, f(166)	0.0009	nd (T)	0.0002	nd (T)	nd (T)	120.0000	nd (T)
C-1 FLUORENE(180)	0.0014	0.0048	0.0002	0.0048	0.0048	320.0000	nd (T)
C-2 FLUORENE(194)	0.0025	0.0990	nd (T)	0.0085	0.0085	560.0000	nd (T)
C-3 FLUORENE(208)	0.0029	0.2600	nd (T)	0.0420	0.0420	610.0000	nd (T)
DIBENZOTHIO., b, f(184)	0.0022	0.0005	nd (T)	nd (T)	nd (T)	230.0000	nd (T)
C-1 DIBENZOTHIO(198)	0.0026	0.0340	0.0003	0.0007	0.0007	470.0000	nd (T)
C-2 DIBENZOTHIO.(212)	0.0055	0.2700	nd (T)	0.0260	0.0260	800.0000	nd (T)
C-3 DIBENZOTHIO.(226)	0.0070	0.5200	nd (T)	0.0740	0.0740	160.0000	nd (T)
PHENANTHRENE, b, f(178)	0.0030	nd (T)	0.0024	0.0019	0.0019	350.0000	nd (T)
C-1 PHENANTHRENE(192)	0.0036	0.0470	0.0018	0.0060	0.0060	850.0000	nd (T)
C-2 PHENANTHRENE(206)	0.0059	0.3000	0.0012	0.0250	0.0250	1100.0000	nd (T)
C-3 PHENANTHRENE(220)	0.0097	0.6700	0.0007	0.0810	0.0810	1000.0000	nd (T)
ANTHRACENE, b, f(178)	nd (T)	nd (T)	nd (T)	0.0017	0.0017	nd (T)	nd (T)
NAPHTHOBENZTHIO.,b(234)	0.0014	0.0630	nd (T)	0.0097	0.0097	100.0000	nd (T)
C-1 NBTP(248)	0.0085	0.3400	nd (T)	0.0610	0.0610	410.0000	nd (T)
C-2 NBTP(262)	0.0130	0.4700	0.0003	0.1200	0.1200	540.0000	nd (T)
C-3 NBTP(276)	0.0180	0.4400	0.0007	0.1700	0.1700	440.0000	nd (T)
FLUORANTHENE, b, f(202)	nd (T)	0.0012	0.0018	0.0044	0.0044	nd (T)	nd (T)
PYRENE, b, f(202)	nd (T)	0.0110	0.0024	0.0049	0.0049	13.0000	nd (T)
C-1 PYRENE(216)	0.0021	0.0830	0.0012	0.0170	0.0170	86.0000	nd (T)
C-2 PYRENE(230)	0.0059	0.2200	0.0008	0.0410	0.0410	160.0000	nd (T)
BENZO(a)ANT.(228)	nd (T)	0.0007	nd (T)	0.0010	0.0010	nd (T)	nd (T)
CHRYSENE, c, g(228)	0.0025	0.0680	0.0012	0.0220	0.0220	66.0000	nd (T)
C-1 CHRYSENE(242)	0.0045	0.1300	nd (T)	0.0310	0.0310	110.0000	nd (T)
C-2 CHRYSENE(256)	0.0071	0.1700	nd (T)	0.0430	0.0430	170.0000	nd (T)
BENZO(b,k)FLU., d, g(252)	nd (T)	0.0310	nd (T)	0.0025	0.0025	nd (T)	nd (T)
BENZO(c)PYRENE, d, g(252)	0.0019	0.0240	nd (T)	0.0120	0.0120	14.0000	nd (T)
BENZO(a)PYRENE, d, g(252)	nd (T)	nd (T)	0.0005	0.0015	0.0015	nd (T)	nd (T)
PERYLENE, d, g(252)	nd (T)	nd (T)	nd (T)	0.0009	0.0009	nd (T)	nd (T)
IND.(1,2,3-cd)PYR., d, g(276)	nd (T)	nd (T)	nd (T)	0.0007	0.0007	nd (T)	nd (T)
BENZ.(g,h,i)PER., d, g(276)	nd (T)	nd (T)	nd (T)	0.0021	0.0021	36.0000	nd (T)
DIBENZ.(a,h)ANT., d, g(278)	nd (T)	nd (T)	nd (T)	0.0007	0.0007	nd (T)	nd (T)
<b>TOTAL TARGET AH:</b>	<b>0.1900</b>	<b>4.4000</b>	<b>0.0200</b>	<b>0.8200</b>	<b>0.8200</b>	<b>21000.0000</b>	<b>0.0001</b>
TPH (ng/mg)	Trace, No TPH	1.10	Trace, No TPH	0.65	0.65		