NOAA NOS Technical Memorandum NCCOS 156

NS&T Program

National Status and Trends Program
for Marine Environmental Quality

CONTAMINANT TRENDS IN US NATIONAL ESTUARINE RESEARCH RESERVES

An aerial view of the jetties extending out from the entrance of Waquoit Bay, Massachusetts, Waquoit Bay NERR

National Oceanic and Atmospheric Administration
National Ocean Service
National Centers for Coastal Ocean Science
Center for Coastal Monitoring and Assessment

October 2002

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October 2002

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ACRONYMS

ACE	Ashepoo, Combahee and Edisto Basin NERR
CICEET	The Cooperative Institute for Coastal and Estuarine Environmental Technology
HCB	Hexachlorobenzene
NERR	National Estuarine Research Reserve
NOAA	National Oceanic and Atmospheric Administration
NS&T	National Status and Trends Program
YSI™ SITE	Location of Yellow Springs Instrument Co., data loggers that measure oxygen, conductivity, turbidity, temperature and pH at 30-min. intervals.
∑BTs	The sum of the concentrations of tributyltin and its breakdown products dibutyltin and monobutyltin (as tBT/g dry wt.).
∑Cdane	The sum of *cis*-chlordane, *trans*-nonachlor, heptachlor and heptachlorepoxide.
∑DDTs	The sum of concentrations of DDTs and its metabolites, DDEs and DDDs.
∑Diel	The sum of concentrations of aldrin and dieldrin.
∑PAHs	The sum of concentrations of the 18 PAH compounds.
∑PCBs	The sum of the concentrations of homologs, which is approximately twice the sum of the 18 congeners regularly quantified by the NS&T Program.

ABSTRACT

Inputs of toxic chemicals provide one of the major types of anthropogenic stress threatening our Nation's coastal and estuarine waters. To assess this threat, the National Oceanic and Atmospheric Administration's (NOAA's) National Status and Trends (NS&T) Program Mussel Watch Project monitors the concentrations of more than 70 toxic chemicals in sediments and on the whole soft-parts of mussels and oysters at over 300 sites around the U.S. Twenty of the 25 designated areas that comprise NOAA's National Estuarine Research Reserve System (NERRS) have one or more Mussel Watch monitoring sites. Trace elements and organic contaminants were quantified including As, Ag, Cd, Cu, Hg, Ni, Pb, Zn, ∑PCBs, ∑PAHs, DDT and its metabolites, and butyltins. The Mussel Watch sites located in or near the 20 Reserves provide for both status and trends. Generally the Reserves have trace element and organic contaminant concentrations that are at or below the median concentration determined for all NS&T Mussel Watch monitoring data. Trends were derived using the Spearman-rank correlation coefficient. It was possible to determine if trends exist for sites at which six or more years of data are available. Generally no trends were found for trace elements but when trends were found they were usually decreasing. The same general conclusion holds for organic contaminants but more decreasing trends were found than for trace elements. The greatest number of decreasing trends were found for tributyltin and its metabolites.

PART I

CONTAMINANT TRENDS IN US NATIONAL ESTUARINE RESEARCH RESERVES

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INTRODUCTION

Toxic chemicals are a major anthropogenic stress threatening the coastal and estuarine waters. To assess this threat, the National Oceanic and Atmospheric Administration's (NOAA) National Status and Trends (NS&T) Program Mussel Watch Project monitors more than 70 toxic chemicals in sediments and on whole soft-parts of mussels and oysters at over 300 sites around the U.S. (Table 1 and Figure 1). Twenty of the 25 designated areas comprising NOAA's National Estuarine Research Reserve System (NERRS) (Figure 2) have one or more Mussel Watch monitoring sites (Table 2). Regional maps showing the location of NERRS sites and NS&T Mussel Watch sites are in Part II. Data collected in these 20 Reserves are from 30 individual Mussel Watch Project sites at which measurements of bio-accumulation of toxic chemicals in bivalves (mussels and oysters) are used to assess ambient contaminant conditions.

This report presents a summary of these contaminants in bivalves at these 30 sites and compares these to levels found in bivalves at NS&T Mussel Watch sites nationwide. Temporal trends are discussed for sites for which there are six or more years of data. This work is an update of a document prepared by Gottholm and Robertson (1996).

In 1992 scientists from the NERRS proposed establishing a national coordinated monitoring program to identify and track short-term variability and long-term changes (Wenner and Giest, 2001). The resulting monitoring program measures pH, conductivity, temperature, dissolved oxygen, turbidity, and water level. With the addition of NS&T trace element and organic contaminants data, both the abiotic and chemical status and trends of the Reserves are documented.

This report provides both a national overview of chemical contaminants within NERRS, and a Reserve-by-Reserve status of contaminants and trends. Reserve information is found in Part III. Characterization within Reserves would be improved by incorporating bivalve mollusk monitoring sites in as many of the remaining Reserves as possible.

NATIONAL STATUS AND TRENDS PROGRAM

Species Collected – The primary species of mollusks monitored are the blue mussel, *Mytilus edulis*, at sites from Maine to Delaware Bay; the American oyster, *Crassostrea virginica*, from Delaware Bay south through the Gulf of Mexico; the mussels, *M. edulis* and *M. californianus*, on the West Coast; the zebra mussels, *Dreissena polymorpha* and *D. bugensis*,

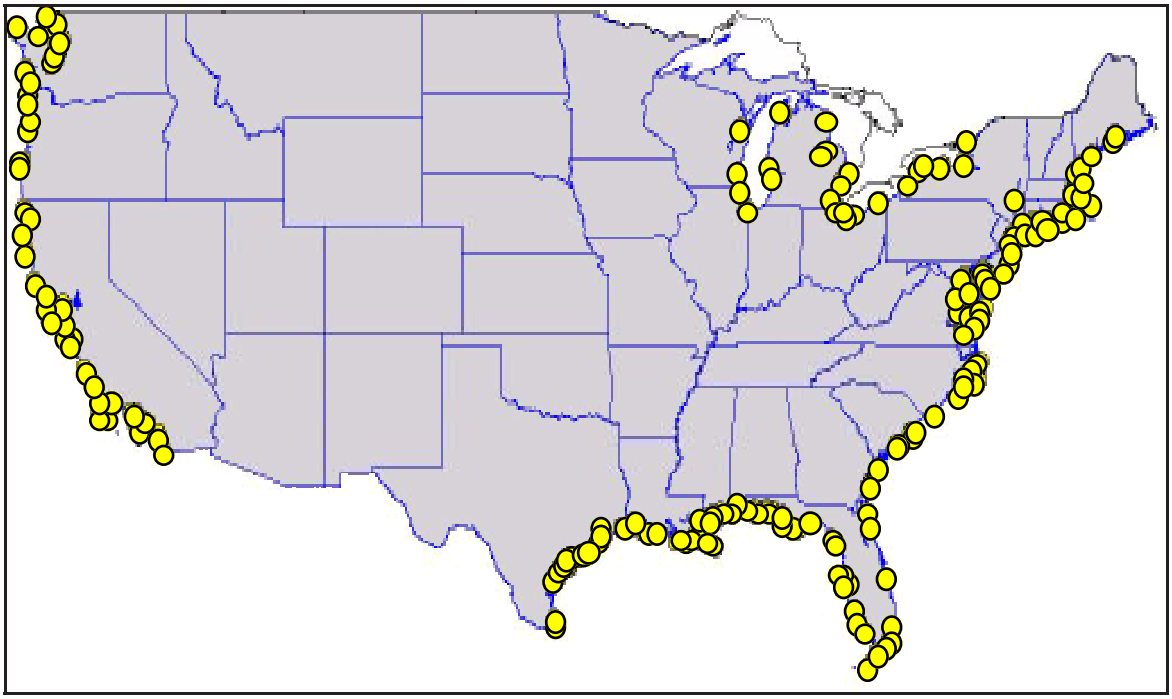


Figure 1. Location of NS&T Mussel Watch sites in continental US.

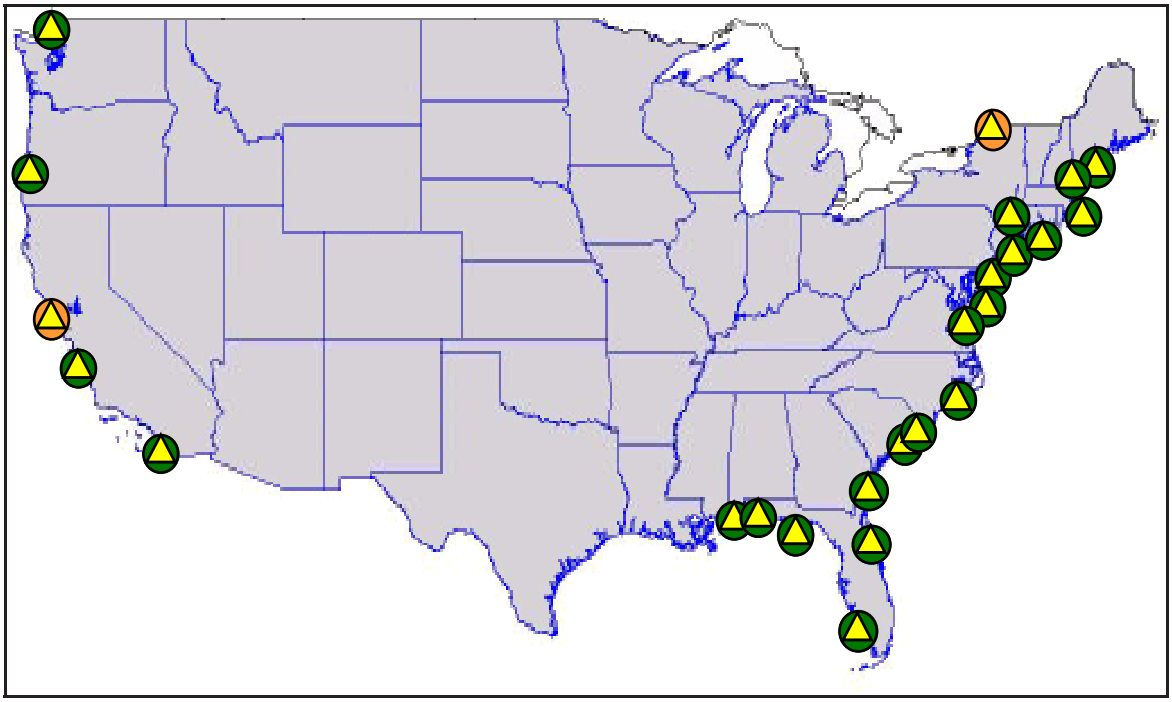


Figure 2. Location of NERRS sites in continental US (proposed NERRS in orange).

Table 1

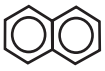
Organic Contaminants, and Major and Trace Elements Determined As Part of the NS&T Program

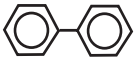
(Number below chemical structure is the Chemical Abstracts Service registry number.)

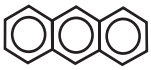
Polycyclic aromatic hydrocarbons

Low molecular weight PAHs
(2- and 3-ring structures)

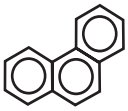
1-Methylnaphthalene
1-Methylphenanthrene
2-Methylnaphthalene
2,6-Dimethylnaphthalene
1,6,7-Trimethylnaphthalene*
Acenaphthene
Acenaphthylene*
Anthracene
Biphenyl
Fluorene
Naphthalene
Phenanthrene


Naphthalene
91-20-3

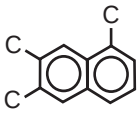

Biphenyl
92-52-4

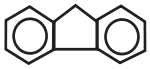

Anthracene
120-12-7

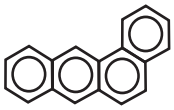

Acenaphthene
83-32-9

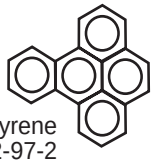

Phenanthrene
85-01-8

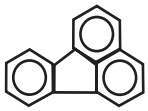

Acenaphthylene
208-96-8


1,6,7-Trimethylnaphthalene
2245-38-7

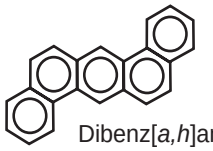

Fluorene
86-73-7


Benz[*a*]anthracene
56-55-3


Benzo[*e*]pyrene
192-97-2


Fluoranthene
206-44-0


Perylene
198-55-0


Dibenz[*a,h*]anthracene
53-70-3

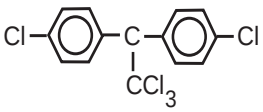

Benzo[*ghi*]perylene
191-24-2

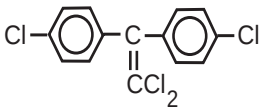
High molecular weight PAHs
(4-, 5-, and 6-rings)

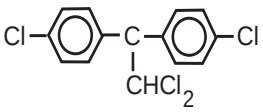
Benz[*a*]anthracene
Benzo[*a*]pyrene
Benzo[*b*]fluoranthene*
Benzo[*e*]pyrene
Benzo[*ghi*]perylene*
Benzo[*k*]fluoranthene*
Chrysene
Dibenz[*a,h*]anthracene
Fluoranthene
Indeno[1,2,3-*cd*]pyrene*
Perylene
Pyrene

Chlorinated pesticides

2,4'-DDD
4,4'-DDD
2,4'-DDE
4,4'-DDE
2,4'-DDT
4,4'-DDT


4,4'-DDT
50-29-3


4,4'-DDE
72-55-9


4,4'-DDD
72-54-8

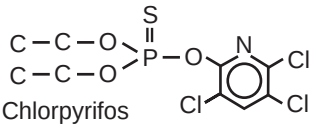
* PAHs added in 1988. Only the original 18 PAHs were used in this report.

Table 1 (cont.)

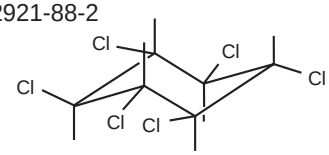
Organic Contaminants, and Major and Trace Elements Determined As Part of the NS&T Program

(Number below chemical structure is the Chemical Abstracts Service registry number.)

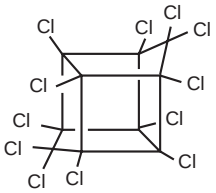
Aldrin
Chlorpyrifos
cis-Chlordane
Dieldrin
Endosulfan-II
delta-Hexachlorocyclohexane
gamma-Hexachlorocyclohexane
(Lindane)
Heptachlor
Heptachlor epoxide
Hexachlorobenzene
alpha-Hexachlorocyclohexane
beta-Hexachlorocyclohexane
Mirex
cis-Nonachlor
trans-Nonachlor
Oxychlordane



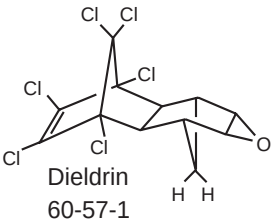
Chlorpyrifos
2921-88-2



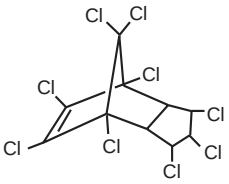
gamma-Hexachlorocyclohexane
58-89-9



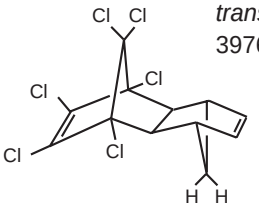
Mirex
2385-85-5



Dieldrin
60-57-1



trans-Nonachlor
39765-80-5

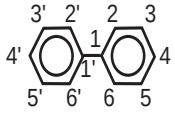


Aldrin
309-00-2

Polychlorinated biphenyl congeners (IUPAC numbering system)

PCB 8, PCB 18, PCB 28, PCB 44, PCB 52, PCB 66, PCB 101, PCB 105, PCB 118, PCB 128, PCB 138, PCB 153, PCB 170, PCB 180, PCB 187, PCB 195, PCB 206, PCB 209

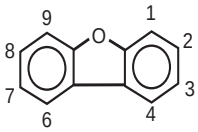
Planar PCBs (PCB 77, PCB 126, PCB 169)



PCB parent structure

Chlorinated dibenzofurans*

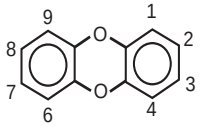
2,3,7,8-Tetrachlorodibenzofuran
1,2,3,7,8-Pentachlorodibenzofuran
2,3,4,7,8-Pentachlorodibenzofuran
1,2,3,4,7,8-Hexachlorodibenzofuran
1,2,3,6,7,8-Hexachlorodibenzofuran
2,3,4,6,7,8-Hexachlorodibenzofuran
1,2,3,7,8,9-Hexachlorodibenzofuran
1,2,3,4,6,7,8-Heptachlorodibenzofuran
1,2,3,4,7,8,9-Heptachlorodibenzofuran
Octachlorodibenzofuran



Dibenzofuran parent structure

Chlorinated dibenzodioxins*

2,3,7,8-Tetrachlorodibenzo-*p*-dioxin
1,2,3,7,8-Pentachlorodibenzo-*p*-dioxin
1,2,3,4,7,8-Hexachlorodibenzo-*p*-dioxin
1,2,3,6,7,8-Hexachlorodibenzo-*p*-dioxin
1,2,3,7,8,9-Hexachlorodibenzo-*p*-dioxin
1,2,3,4,6,7,8-Heptachlorodibenzo-*p*-dioxin
Octachlorodibenzo-*p*-dioxin



Dibenzo-*p*-dioxin parent structure

*Dioxins and furans are not discussed in this report.

Table 1 (cont.)

Organic Contaminants, and Major and Trace Elements Determined As Part of the NS&T Program

(Number below chemical structure is the Chemical Abstracts Service registry number.)

Major and trace elements

Al	-	aluminum	Cu	-	copper	Ag	-	silver
Si	-	silicon	Zn	-	zinc	Cd	-	cadmium
Cr	-	chromium	As	-	arsenic	Hg	-	mercury
Mn	-	manganese	Se	-	selenium	Tl	-	thallium
Fe	-	iron	Sn	-	tin	Pb	-	lead
Ni	-	nickel	Sb	-	antimony			

Organotins

Monobutyltin^{3+}, dibutyltin^{2+}, tributyltin^{+}, tetrabutyltin

at sites in the Great Lakes; the Hawaiian oyster, *Ostrea sandvicensis* in Hawaii; and the mangrove oyster *Crassostrea rhizophorae* in Puerto Rico.

Sample Size – During the first years of the NS&T Program (1986-1991), the objective for bivalve sampling was to obtain three discrete composite samples from each site. At each station, a bivalve sample generally consisted of 20 to 30 mollusks, depending on size and species. In 1992, the number of specimens collected at each site was reduced to what was necessary for one composite sample.

Sampling Methods – Field sampling along the East and West Coasts used a variety of techniques such as a bivalve dredge, tongs, and pitchfork. At some shoreline sites, intertidal bivalves were collected by hand. For Gulf Coast sampling, oysters were collected with tongs, dredge and, where possible, by hand. In some areas, collection methods were constrained by sampling permits and restrictions in use of certain equipment. After collection, bivalves were separated and scrubbed with a nylon or natural fiber brush to remove detritus. A complete overview and summary of the sampling and analytical methods of the NS&T Program are described in Lauenstein and Cantillo (1993 and 1998).

Site Selection – The criteria for the NS&T sites selected for this report were that they be nearby or within the boundaries of a National Estuarine Research Reserve (not more than 10 miles away). They also had to be affected by the same estuarine drainage. Table 2 lists the Reserves where NS&T sites meet these criteria. How well these corresponded to the Mussel Watch sites was rated according to the fit between the site and the associated NERR.

Contaminants Analyzed – The elements and compounds measured in the NS&T Mussel Watch Project are listed in Table 1. With the exceptions of manganese, aluminum, iron, and silicon, the elements in Table 1 are potential contaminants because their concentrations in the environment have been altered by human activity (Nriagu, 1989).

"The mere existence of chlorinated organic compounds and butlytins indicates human activity. Polycyclic aromatic hydrocarbons (PAHs), some of which are naturally occurring, are found in fossil fuels such as coal and oil, and are produced during the combustion of organic matter. Their environmental presence is also attributable to human activities because they are released in the use and transportation of petroleum products, and from a multitude of other human activities, such as burning coal and

Table 2

National Estuarine Research Reserve Locations and Their Associated NS&T Mussel Watch Project Sites

National Estuarine Research Reserve	*NS&T Code**	*General Location*	*Specific Location*	*Distance Apart*	*Site Match Quality*
Wells, ME	CAKP	Cape Arundel	Kennebunkport	3.2	fair
Great Bay, NH	GBDP	Great Bay	Dover Point	2.4	good
Waquoit Bay	BBNI	Buzzards Bay	Naushon Island	11	no match
Narragansett Bay, RI	NBPI	Narragansett Bay	Patience Island	0	excellent
	NBDI	Narragansett Bay	Dyer Island	0.8	good
Hudson River, Tivoli, NY	HRCI	Hudson River	Cruger Island	0	excellent
Jacques Costeau, NJ	BIBL	Barnegat Inlet	Barnegat Light	8.6	fair
	AIAC	Absecon Inlet	Atlantic City	1.6	good
Delaware,					
Blackbird, DE	DBHC	Delaware Bay	Hope Creek	6.0	fair
St. Jones	DBKI	Delaware Bay	Kelly Island	8.0	fair
Chesapeake Bay,					
Otter Point, MD	CBBO	Chesapeake Bay	Bodkin Point	20	no match
Chesapeake Bay,					
Godwin Island, VA	CBDP	Chesapeake Bay	Dandy Point	10	fair
North Carolina,					
Rachel Carson, NC	BIPI	Beaufort Inlet	Pivers Island	0.3	excellent
Zeke's Island	CFBI	Cape Fear	Battery Is.	3	fair
North Inlet-Winyah Bay, SC	WBLB	Winyah Bay	Lower Bay	1.6	good
	SRNB	North Bay	Santee River	6.3	fair
Ashepoo, Combahee and Edisto Basin	CHFJ	Charleston Harbor	Fort Johnson	30	no match
Sapelo Island, GA	SSSI	Sapelo Sound	Sapelo Island	0.2	excellent
	ARWI	Altamaha River	Wolfe Island	4.5	fair
Guana Tolomato Matanzas (GTM)	MRCB	Matanzas River	Crescent Beach	0	excellent
Jobos Bay, Puerto Rico	PRBJ	Puerto Rico	Bahia de Jobos	2	good
Rookery Bay, FL	RBHC	Rookery Bay	Henderson Creek	0	excellent
	NBNB	Naples Bay	Naples Bay	3	fair
Apalachicola Bay, FL	APDB	Apalachicola Bay	Dry Bar	0	excellent
	APCP	Apalachicola Bay	Cat Point Bar	0	excellent
Weeks Bay, AL	MBCP	Mobile Bay	Cedar Pt. Reef	17	no match
Grand Bay, MS	MSPB	Mississippi Sound	Pascagoula Bay	7.3	fair
Tijuana River, CA	IBNJ	Imperial Beach	North Jetty	1.0	good
Elkhorn Slough, CA	MBES	Monterey Bay	Moss Elkhorn Slough	0.7	good
	MBML	Monterey Bay	Moss Landing	1.25	fair
San Francisco Bay (proposed)[Δ]					
South Slough, OR	CBCH	Coos Bay	Coos Head	2.5	good
	CBRP	Coos Bay	Russell Point	9	fair
Padilla Bay, WA	BBSM	Squalicum Marina Jetty	Bellingham Bay	12	no match
Kachemak Bay, AK	CIHS	Cook Inlet	Homer Spit	0	excellent
Old Woman Creek, OH[◊]	LEOW	Lake Erie	Old Woman	0.4/0	fair/excellent
St. Lawrence River (proposed)					

* Mussel site coordinates and site descriptions can be found in Appendix 1.

[Δ] Five Mussel Watch Project monitoring sites exist in the Bay: San Pablo Bay-Point San Pedro (sediment only), San Pablo Bay Semple Point (sediment only), San Francisco Bay-Emeryville, San Francisco Bay-San Mateo Bridge, and San Francisco Bay-Dumbarton Bridge.

[◊] The bivalve site is outside the Reserve while the associated sediment site is inside the Reserve.

wood, and incinerating waste." (O'Connor, 1996)

RESULTS AND DISCUSSION

Part III shows how Mussel Watch data correspond to median and 'high' bivalve concentrations found at NS&T Mussel Watch Project sites in or near the Reserves in relation to concentrations found at NS&T sites nation-wide. 'High' is defined as the mean plus one standard deviation of the geometric concentrations for all Mussel Watch sites (O'Connor, 1996), and include the highest 15% values for each compound. They do not indicate problem levels of contamination. Rather, they serve as a basis for categorizing NS&T site data.

Median and 'high' (85th percentile values) are recalculated to include Mussel Watch data through 1999. On each graph, the dotted blue line indicates the NS&T national median concentration; the dashed red line indicates the calculated NS&T 85th percentile or 'high' concentration (Table 3).

Organisms Tested – Oysters and mussels do not equally concentrate chemicals (O'Connor, 1992). While there is no statistically significant difference in the rate each accumulates organic contaminants, oysters have an affinity for silver, copper, and zinc, while mussels have an affinity for chromium and lead. Because of this, mussel and oyster data for these trace elements were evaluated separately.

References made to bivalve data include combined mussel and oyster data. For mussels, three mussel species or species groups were used: *Mytilus edulis, M. californianus*, and *Dreissena* spp. Oyster data include *Crassostrea virginica, C. rhizophorae*, and *Ostrea sandvicensis*.

Compounds Tested – Total chlordane and total DDT are chlorinated pesticides. PCBs are chlorinated compounds developed for other uses.

∑Chlordane – The sum of the concentrations of alpha-chlordane, *trans*-nonachlor, heptachlor and heptachlor epoxide.

∑DDTs – The sum of the ortho and para forms of the parent DDT and its metabolites, i.e., 2,4'-DDE, 4,4'-DDE, 2,4'-DDD, 4,4'-DDD, 2,4'-DDT and 4,4'-DDT.

∑PAHs – The 18 PAH compounds listed in Table 1.

∑PCBs – All non-planar PCB congeners (18).
Table 4 presents a national overview of the contaminant status of the Reserves. It is based on the work of O'Connor (2002). Contaminant status and trends for each Reserve are provided in Part III. Table 4 notes those trace elements and organic contaminants where concentrations were in the NS&T 'high' category for at least half the years the site was sampled. Most of the Reserves have few or no analytes in the 'high' category. Further, most analytes in most of the Reserves are at or below the NS&T median concentration.

Exceptions to this general conclusion occur more frequently for trace elements than for organics. Reserves where trace elements are 'high' include: Great Bay, Jacques Costeau, South Slough, and both Old Woman Creek and the Hudson River sites where zebra mussels are collected (See Hudson River NERR discussion, Part III). Each of these special cases and the consistently 'high' arsenic concentrations associated with Reserves in the U.S. Southeast are also discussed in Part III.

Trends were derived using a two-tailed Spearman-rank correlation coefficient, as outlined in the SAS™ software. Correlation coefficients used to determine if a trend was significant were taken from Mendenhall, 1975. Trends were determined for sites where there are six or more years of data. The number of increasing and decreasing contaminant trends are shown in Table 5.

With a 0.05 probability of finding a trend where none existed, statistically five trends in 100 sites might be false positives. For 206 sites, that would mean 10 false positives. But Table 5 shows are approximately 10 increasing and decreasing trends for each trace element.

Cadmium is the exception. Twice that number of decreasing trends was found. All summed organics also had greater than the expected 10

Table 3

NS&T Mussel Watch Data Medians and 85th Percentile Values (1986-1999)

(Medians and percentiles were determined using the average at each site across all sampled years. Element data in µg/g dry wt. unless noted, and organic data in ng/g dry wt.).

Oyster data only

	Cu	Zn	Ag	Pb
n	135	128	134	128
Median	140	2200	2.3	0.50
85th percentile	310	4600	5.7	0.80

Mussel data only

	Cu	Zn	Ag	Pb
n	149	149	146	149
Median	9.9	130	0.17	1.8
85th percentile	16	170	0.54	4.6

Mussel and oyster data

	Ni	As	Se	Cd	Hg
n	285	285	285	285	284
Median	2.0	9.2	2.8	2.9	0.10
85th percentile	4.6	16	4.1	6.1	0.20

	∑DDTs	∑PCBs	∑PAHs	∑Cdane	∑Diel
n	285	285	285	285	285
Median	31	110	320	10	5.0
85th percentile	140	500	1100	32	15

	Mirex	Hexachloro-benzene	Lindane	∑BTs
n	285	285	285	277
Median	0.25	0.23	1.2	59
85th percentile	1.2	1.1	2.7	240

n: Number of data points (roughly equivalent to the number of sampling sites).
∑BTs: The sum of the concentrations of tributyltin and its breakdown products dibutyltin and monobutyltin (as ng Sn/g dry wt.).
∑Cdane: The sum of *cis*-chlordane, *trans*-nonachlor, heptachlor and heptachlorepoxide.
∑DDTs: The sum of concentrations of DDTs and its metabolites, DDEs and DDDs.
∑Dieldrin: The sum of dieldrin and aldrin.
∑PAHs: The sum of concentrations of the 18 PAH compounds.
∑PCBs: The sum of the concentrations of homologs, which is approximately twice the sum of the 18 congeners.

Table 4

Site/Chemical Combinations Where Concentrations in Mollusks Were 'High' in at Least Half the Years Sampled Since 1990◊ (O'Connor, 2002)

General Location	Specific Location	Yrs*	Ag	As	Cu	Cr	Hg	Ni	Pb	Se	Zn	∑Diel	∑DDT	∑PCB	∑PAH
Cape Arundel	Kennebunkport	6													
Great Bay	Dover Point	1			◆	◆	◆	◆	◆	◆					
Narragansett Bay	Dyer Is.	5										◆			
	Patience Is.	7										◆		◆	
Barnegat	Barnegat Inlet Light	6			◆		◆			◆					
Absecon Inlet	Atlantic City	6				◆	◆		◆	◆					
Delaware Bay	Hope Creek$^{\Delta}$														
	Kelly Island	1 0	◆					◆				◆			
Chesapeake Bay	Dandy Pt.	6													
Beaufort Inlet	Pivers Is.	7		◆											◆
Cape Fear	Battery Is.	8		◆											
Winyah Bay	Lower Bay	7		◆											
North Bay	Santee River	7		◆						◆					
Sapelo Sound	Sapelo Is.	6		◆											
Altamaha River	Wolfe Is.	6		◆						◆					
Matanzas R.	Crescent Beach	6		◆											
Puerto Rico	Bahia de Jobos	5													
Rookery Bay	Henderson Creek	7													
Naples Bay	Naples Bay	7			◆										
Apalachicola Bay	Dry Bar	6													
	Cat Point Bar	6													
Mississippi Snd.	Pascagoula Bay	7													
Imperial Beach	North Jetty	6	◆			◆							◆		
Monterey Bay	Moss Landing	8				◆		◆				◆	◆		
	Elkhorn Slough	4				◆						◆	◆		
Coos Bay	Coos Head	7													
	Russell Point	7				◆		◆			◆				
Cook Inlet	Homer Spit	2			◆										
Lake Erie	Old Woman Cr.^	3			◆			◆	◆			◆			
Hudson River	Cruger Island^	2			◆	◆		◆	◆					◆	

*Number of years for which concentration was considered 'high'.

◊No information is provided for ∑butyltin, ∑chlordane, or Cd because none of these analytes were found to be 'high' at NERRs sites since 1990.

$^{\Delta}$This site was only sampled in 1989.

^See discussion of zebra mussels versus other bivalves' ability to concentrate trace elements, Hudson River NERR (Part III).

Table 5

Temporal Trends in Chemical Concentrations Measured Nationally at 206 Mussel Watch Project Sites and at 30 Sites in the NERRS for Which Data Exist for Six Years During 1986-1999

	Trend				Trend		
Organics*	I	D	NT	Element	I	D	
∑Cdane	1	85 (8)	120	As	9	15 (3)	182
∑DDTs	1(1)	54 (5)	151	Cd	7(4)	20 (2)	179
∑Diel	4(2)	32 (4)	170	Cu	9	10 (1)	187
∑PCBs	5(1)	30	171	Hg	13(1)	14(2)	179
∑PAHs	18(3)	26 (1)	162	Ni	11(2)	6(1)	189
∑BTs	0	100(10)	106	Pb	11(2)	12(3)	183
HCB	16	7	183	Se	14(2)	4	188
Lindane	3	31	172	Zn	7(1)	15(4)	184
Mirex	17	6	183				

I - Increasing, D - Decreasing, NT - No trend. Increasing and decreasing trends for NERRs are given in parentheses.
* Individual organic compound concentrations have been aggregated into these groups:
∑BTs: The sum of the concentrations of tributyltin and its breakdown products dibutyltin and monobutyltin.
∑Cdane: The sum of *cis*-chlordane, *trans*-nonachlor, heptachlor and heptachlorepoxide.
∑DDTs: The sum of concentrations of DDTs and its metabolites, DDEs and DDDs.
∑Dield: the sum of concentrations of aldrin and dieldrin.
∑PAHs: The sum of concentrations of the 18 PAH compounds.
∑PCBs: The sum of the concentrations of homologs, which is approximately twice the sum of the 18 congeners.

Plate 1. A forested wetland area, Georgetown, South Carolina, ACE Basin NERR (NOAA National Estuarine Research Reserve Collection, nerr0017, NOAA Photo Collection, NOAA Central Library).

decreasing trends. In decreasing order these were ∑BTs, ∑Cdane, ∑DDTs, ∑Diel, Lindane, ∑PCBs, ∑PAHs. While there were few increasing trends for any organic, there were more increasing trends for ∑PAHs than would be expected from chance alone.

The slightly more apparent increasing trends for ∑PAHs may be associated with changes in the analytical methods. Early in the Mussel Watch Project, the analytical methodology was not as sensitive, and what are now low PAH concentrations were recorded as zero.

On a national basis, only Lindane had statistically significant decreasing trends for non-summed organics. Hexachlorobenzene and Mirex had a few more increasing than decreasing trends.

Results for both trace elements and organic contaminants are not unexpected. Trace elements are found in the earth's crust and are a natural part of the environment. However, many trace elements quantified by the Mussel Watch Project are also found in industrial effluents and municipal outfalls. Pollution controls and the ban on lead-based gasoline additives have reduced the input to coastal waters. Decreasing lead concentrations reported by Lauenstein *et al.* (1990) were attributed to phasing out leaded gasoline.

O'Connor (2002) provided information on when the use of various summed organic compounds quantified by the Project were phased out or banned.

DDT and Dieldrin – All uses were banned in the U.S. in the 1970s.

Chlordane – Its use on U.S. crops ended in 1983. Use for termite control effectively ended in 1988.

∑PCBs – Phasing out polychlorinated biphenyls in the U.S. began in 1971. A ban on new uses took effect in 1976.

∑BTs – The three butyltin compounds are found in mollusks because tributyltin (TBT) is an antifouling agent used in boat paint. In 1988, the U.S. Organotin Anti-Fouling Paint Act banned its use on vessels under 75 feet.

PAHs – Polycyclic aromatic hydrocarbons occur from natural seepage of oil and when fossil fuels and organic matter burns. Human activities add to this – burning coal and wood, waste incineration, and production, transport, and use of oil.

Hexachlorobenzene, Lindane, and Mirex are not presented as aggregate organic compounds. The following information is from the Registry of the Agency for Toxic Substances and Disease Registry (2002).

HCB - Hexachlorobenzene is a by-product of the manufacture of 1) chemicals used as solvents, 2) other chlorine-containing compounds, and 3) pesticides. Small amounts can be produced during combustion (burning of city wastes). It may also be produced as a by-product in waste streams of chlor-alkali and wood preserving plants. Widely used as a pesticide until 1965, it was also used to make fireworks, ammunition, and synthetic rubber. Currently, there are no commercial uses of the substance in the United States.

Lindane or g-HCH – Gamma-Hexachlorocyclo-hexane was used as an insecticide on fruit, vegetables, and forest crops. It is also used in the U.S. and in other countries as a topical treatment for head and body lice and scabies. Lindane has not been produced in the United States since 1976. However, imported g-HCH is available for insecticide use as a dust, powder, liquid, or concentrate, as well as a lotion, cream, or shampoo to control scabies and head lice. Technical-grade HCH has not been produced in the United States since 1983. In addition, isomers of HCH other than g-HCH may not be made or used commercially in the United States.

Mirex – This insecticide does not occur naturally. No longer made or used in the United States, Mirex was most commonly used as a pesticide to control fire ants in the southeastern U.S. in the 1960s and 1970s. Also, as a flame retardant, it was added to plastics, rubber, paint, paper, and electrical goods from 1959 to 1972. All registered products containing Mirex were canceled between 1977 and 1978.

Trends – There was not enough data (covering six or more years) at seven of the 30 Mussel Watch sites within the 25 Reserves to determine trends. They are: Great Bay-Dover

Point, Hudson River-Tivoli, Delaware Bay-Hope Creek, Puerto Rico-Bahia de Jobos, Elkhorn Slough-Elkhorn Slough, Kachemak Bay, Old Woman Creek.

Tables 6 and 7 present Reserve-specific trends for trace elements and organic contaminants. The sum of both decreasing and increasing contaminant trends are contrasted to the corresponding national trends in Table 4. Few trends were found, either increasing or decreasing. But when trace element trends were found (Table 6) they were primarily decreasing.

Locations with more than three trends are Dyer Island, a Mussel Watch site in the Narragansett Bay Reserve, and Barnegat Inlet, the Mussel Watch site in the Jacques Cousteau Reserve. At Dyer Island silver, copper, nickel, lead, and zinc are all decreasing. At Barnegat Inlet, silver, and chromium are decreasing while mercury, nickel and selenium are all increasing.

For most organic contaminants (Table 7) the same general conclusion applies: at most sites there were no trends, and when trends were found, they were primarily decreasing. Note, there were more decreasing trends found for organics than for trace elements.

The only site with more than three trends was Pascagoula Bay near the Grand Bay Reserve. All five trends there were decreasing (∑BTs, ∑Cdane, ∑DDT, ∑Diel and Mirex).

CONCLUSIONS

The levels for 11 trace elements and 9 categories of the most problematic organic chemicals were examined. In general, the levels in or near the Reserves were close to or below the national medians for all Mussel Watch sites. However, there were exceptions where 'high' values relative to the national means were found.

For bivalve tissues, arsenic concentrations were 'high' along the U.S. Southeast coast, and as a result, within those Reserves. These high concentrations were most likely from natural phenomena, not pollution. They are not a health concern because of the chemical form in which arsenic is found.

Few monitoring sites in or near the Reserves had consistently high trace element or organic contaminant concentrations. An exception to this was the Dover Point site near the Great Bay Reserve. Although this site had 'high' concentrations for six trace elements (copper, chromium, mercury, selenium, nickel, lead), only two years of data were used, and the site is not located within the Great Bay Reserve, but to the north of it.

Absecon Inlet for which there is a good site match with the Jacques Costeau Reserve had four trace elements in the 'high' category and this condition held for six of the years that this site was sampled. The Barnegat Inlet site, to the north of the Reserve, also had three 'high' trace elements (copper, mercury, selenium). The Moss Landing site in the vicinity of the Elkhorn Slough Reserve was high in two trace elements (chromium, nickel) and organics (∑Diel and ∑DDT). High levels for chromium and the two organics were also found at the Elkhorn Slough Mussel Watch site.

High trace elements were found at the two Reserves where zebra mussels were collected (Tivoli-Hudson River, NY and Old Woman Creek, OH). This seems to be an artifact because zebra mussels have a greater affinity for nickel, copper, selenium, chromium, and cadmium than other bivalves used in the Mussel Watch Project (O'Connor 2002).

In general, no trends were found for either trace elements or organics. But when trends were found they were generally decreasing. Decreasing trends were more prevalent for organics. The greatest number of decreasing trends found was for butyltins, for both the national monitoring sites and the Reserves. Summed-chlordane had nearly as many decreasing trends as summed butyltins.

With minor exceptions, the National Estuarine Research Reserves represent some of the least contaminated estuaries in the US.

Table 6

Trace Element Trends at National Estuarine Research Reserve Mussel Watch Project Sites

National Estuarine Research Reserve	NS&T Site	n	Trends: Ag	As	Cd	Cu	Cr	Hg	Ni	Pb	Se	Sn	Zn
Wells, ME	CAKP	8											
Narragansett Bay, RI	NBPI	9											●
	NBDI	10	●			●			●	●			●
Jacques Costeau, NJ	BIBL	8	●				●	◆	◆		◆		
	AIAC	8								◆	◆		
Delware Bay, DE St. Jones	DBKI	10											
Chesapeake Bay, VA Godwin Island,	CBDP	11				◆							
North Carolina, NC Rachel Carson	BIPI	7				◆							
Zeke's Island	CFBI	12											
North Inlet-Winyah Bay, SC	WBLB	8											
	SRNB	8											
Sapelo Island, GA Sapelo Island	SSSI	11											
Wolfe Island	ARWI	8											
Guana Tolomaro Matanzas, FL	MRCB	11				◆							
Jobos Bay, Puerto Rico	PRBJ	5								◆			◆
Rookery Bay, FL	RBHC	11		●									
	NBNB	11		●	●	◆							
Apalachicola Bay, FL	APDB	11			●								
	APCP	11											
Grand Bay, MS	MSPB	11						●					
Tijuana River, CA	IBNJ	11						●		●			●
Elkhorn Slough, CA	MBES	5		●					◆				●
	MBML	9								●			
South Slough, OR	CBCH	11											
	CBRP	11											

● Decreasing trends ◆ Increasing trends

Trends were derived using the Spearman-ranked correlation coefficient in SAS™. No contaminant trends were determined for those sites with less than 5 years of data. Reserves with less than 5 years of data include Great Bay, Hudson River, Delaware Bay-Hope Creek, Jobos Bay, Elkhorn Slough-Elkhorn Slough, Kachemak Bay, Old Woman Creek.

Table 7

Organic Contaminant Trends at National Estuarine Research Reserve Mussel Watch Project Sites

National Estuarine Research Reserve	NS&T Site	n	Trends								
			∑PAH	∑BT	∑Cdane	∑DDT	∑Diel	∑PCB	HCB	Lindane	Mirex
Wells, ME	CAKP	8	●	●		●					
Narragansett Bay, RI	NBPI	9		●			●				
	NBDI	10						◆	●		
Jacques Costeau, NJ	BIBL	8			●						
	AIAC	8									
Delaware Bay, DE St. Jones	DBKI	10			●						
Chesapeake Bay - VA Godwin Island	CBDP	11		●	●				●		
North Carolina, NC Rachel Carson, Zeke's Island	BIPI	7									
	CFBI	12									
North Inlet-Winyah Bay, SC	WBLB	8					◆			◆	
	SRNB	8	◆				◆				
Sapelo Island, GA	SSSI	11				●	●				
	ARWI	8									
Guana Tolomato Matanzas, FL	MRCB	7		●							◆
Rookery Bay, FL	RBHC	11	◆	●					●		
	NBNB	11		●	●						
Apalachicola Bay, FL	APDB	11				●			●	●	
	APCP	11			●		●			●	
Grand Bay, MS	MSPB	11		●	●	●	●				●
Tijuana River, CA	IBNJ	11	◆		●	●					
Elkhorn Slough, CA	MBML	9		●		◆			◆		
South Slough, OR	CBCH	11		●						●	
	CBRP	11		●	●					●	

● Decreasing trends ◆ Increasing trends

Trends were derived using the Spearman-ranked correlation coefficient in SAS™. Analyses of butyltins began in 1988-1989 so there are fewer years of data than for other analytes. No contaminant trends were determined for those sites with less than 5 years of data. Reserves with less than 5 years of data include Great Bay, Hudson River, Delaware Bay-Hope Creek, Jobos Bay, Elkhorn Slough-Elkhorn Slough, Kachemak Bay, Old Woman Creek.

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REFERENCES

Agency for Toxic Substances and Disease (2002) http://www.atsdr.cdc.gov/ToxProfiles.

Gottholm, B. W., and A. Robertson (1996) National Status and Trends Program, Marine Environmental Quality: Contaminant levels measured at NOAA's National Estuarine Research Reserves. Silver Spring, Maryland. http://ccma.nos.noaa.gov.

Lauenstein G. G., A. Robertson, and T. P. O'Connor (1990) Comparison of trace metal data in mussels and oyster from a Mussel Watch Programme of the 1970s with those from a 1980s Programme. Mar. Pollut. Bull., 21(9) 440-447.

Lauenstein G. G., and A. Y. Cantillo (eds.) (1993) Sampling and Analytical Methods of the NOAA National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-1992: Vol. I - IV. NOAA Tech. memo. NOS ORCA 71. NOAA/NOS/ORCA, Silver Spring, MD.

Lauenstein G. G., and A. Y. Cantillo (1998) Analytical Methods of the National Status and Trends Program Mussel Watch Project - 1993 -1997 Update. NOAA Technical Memorandum NOS ORCA 130. NOAA/NOS/ORCA, Silver Spring, MD.

Lauenstein G. G., A. Y. Cantillo and T. P. O'Connor (2002) The status and trends of trace element and organic contaminants in oysters, *Crassostrea virginica*, in the waters of the Carolinas, USA. Science of the Total Environment, 285: 79-87.

Mendenhall, W. (1975) Introduction to Probability and Statistics. Duxbury Press, North Scltuate, MA. 460 pp.

Nriagu, J. O. 1989. A global assessment of natural sources of atmospheric trace elements. Nature, 338, 47-9.

O'Connor, T. P. (1992) Mussel Watch: Recent Trends in Coastal Environmental Quality. NOAA Rockville, MD, 46 pp.

O'Connor, T. P. (1996) Trends in chemical concentrations in mussels and oysters collected along the US coast from 1986 to 1993. Mar. Environ. Res., 41:183-200.

O'Connor, T. P. (2002) National distribution of chemical concentrations in mussels and oyster in the USA. Mar. Environ. Res., 53:117-143.

Wenner, E. L. and M. Geist (2001) The National Estuarine Research Reserves Program to monitor and preserve estuarine waters. Coastal Management, 29:1-17.

Plate 2. Mussel Watch Program bivalve sampling on oyster reef in Chincoteague, Virginia (A. Cantillo).

Plate 3. Mussel Watch Program bivalve sampling for mussels on the West Coast (TAMU/GERG).

PART II

Locations of NERRS and NS&T Mussel Watch Sites

Plate 4. Mussel sampling from bridge supports, Coronado Bridge, San Diego, California (TAMU/GERG).

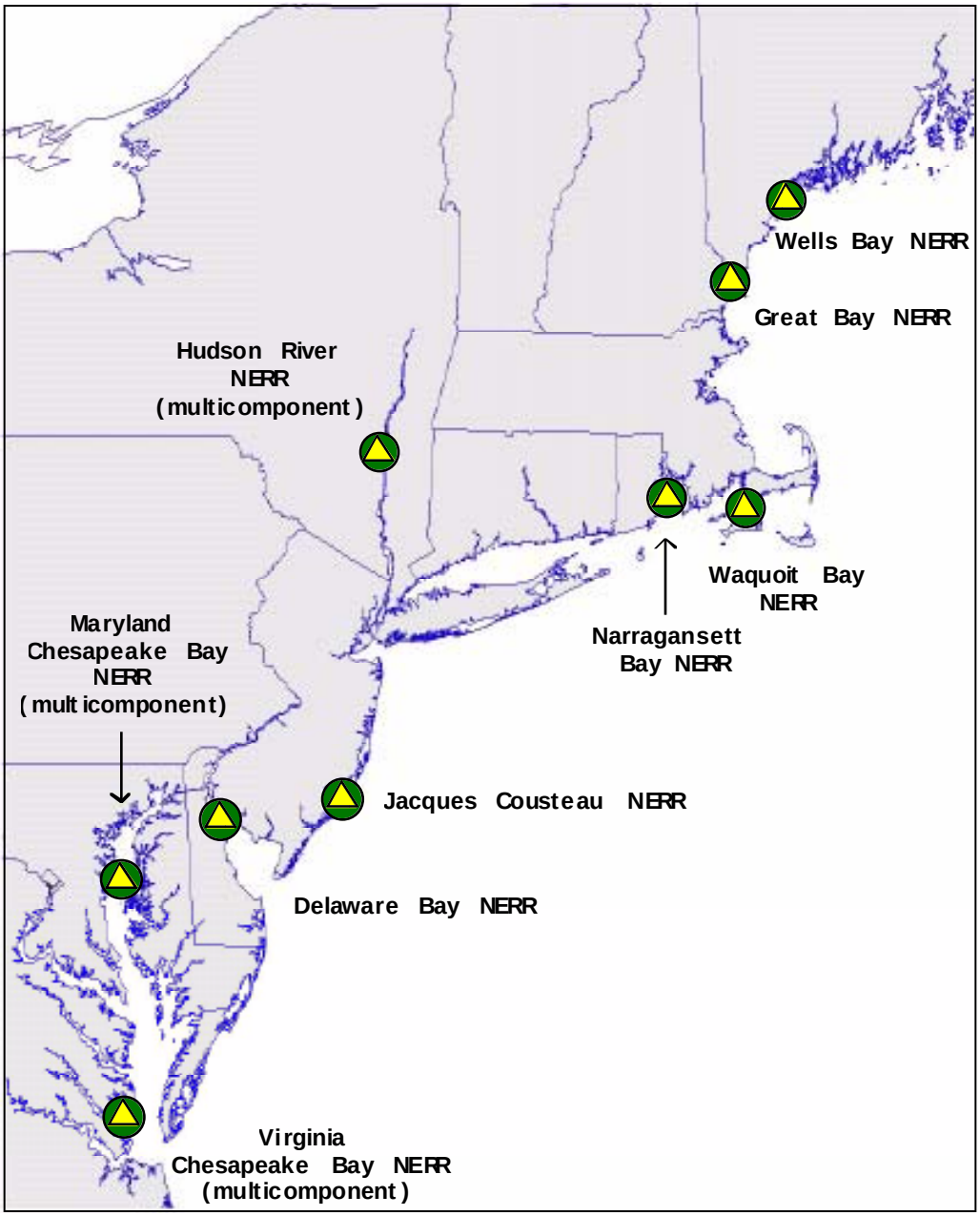


Figure 3. Location of National Estuarine Research Reserves along the northeast coast.

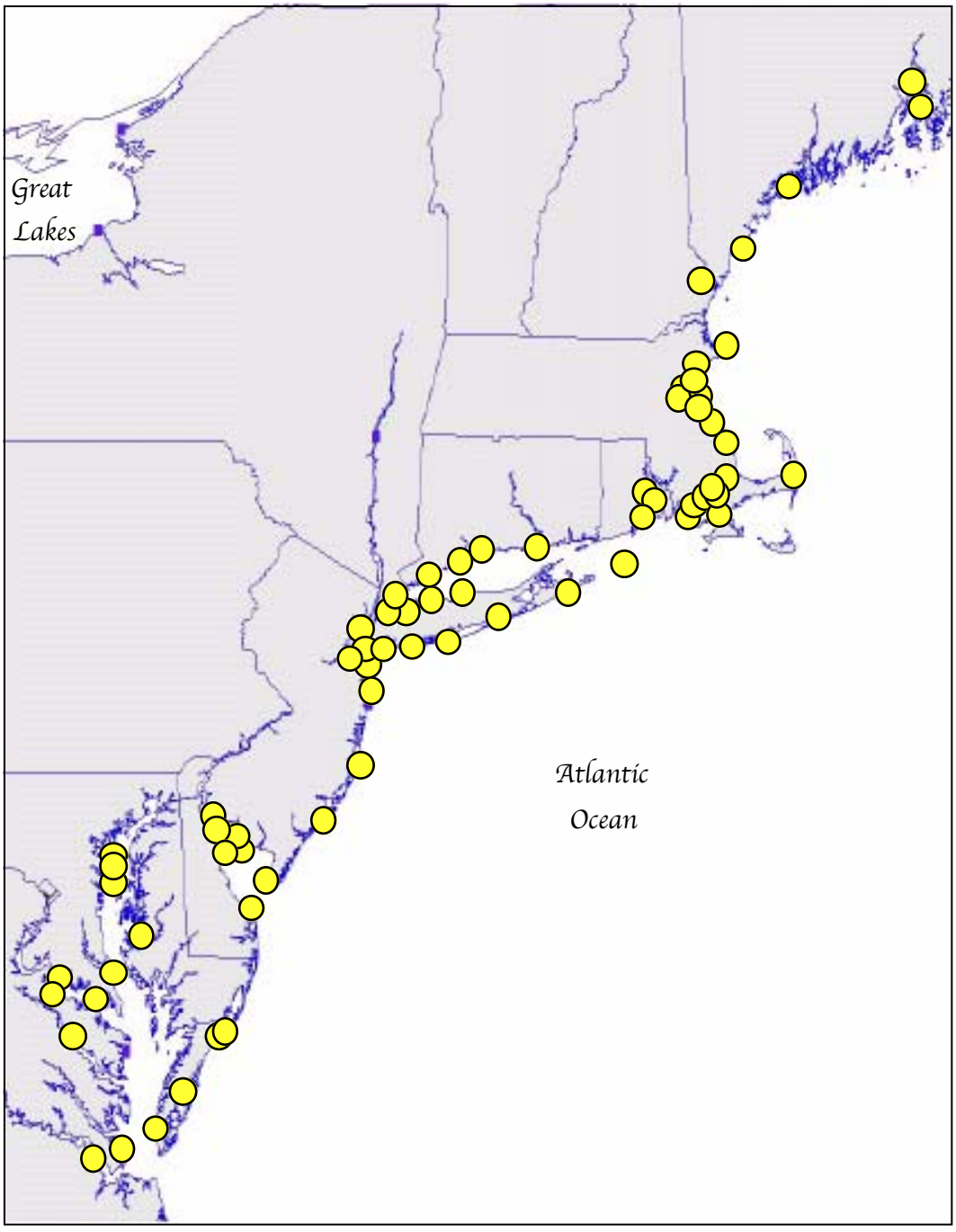


Figure 4. Location of NS&T Mussel Watch sites along the northeast coast.

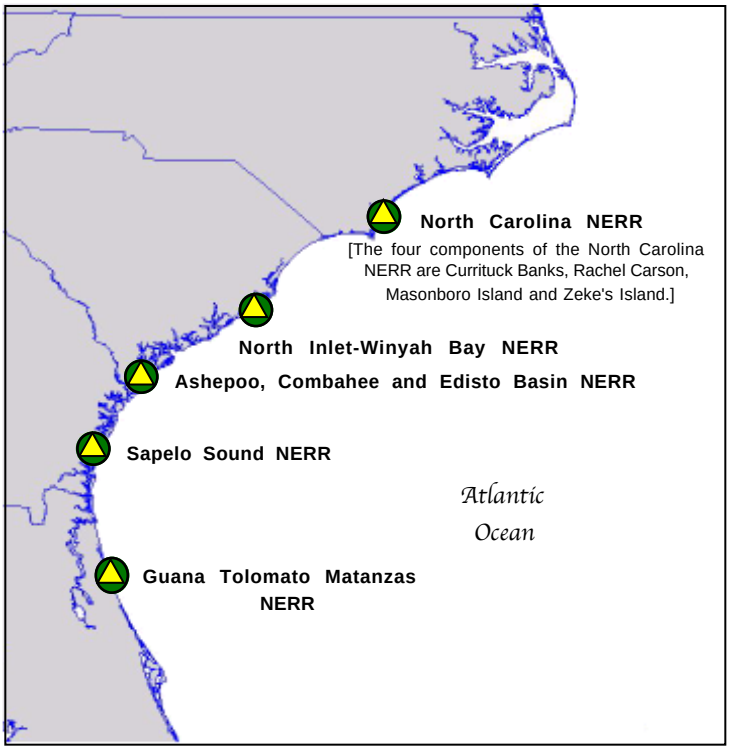


Figure 5. Location of National Estuarine Research Reserves along the southeast coast.

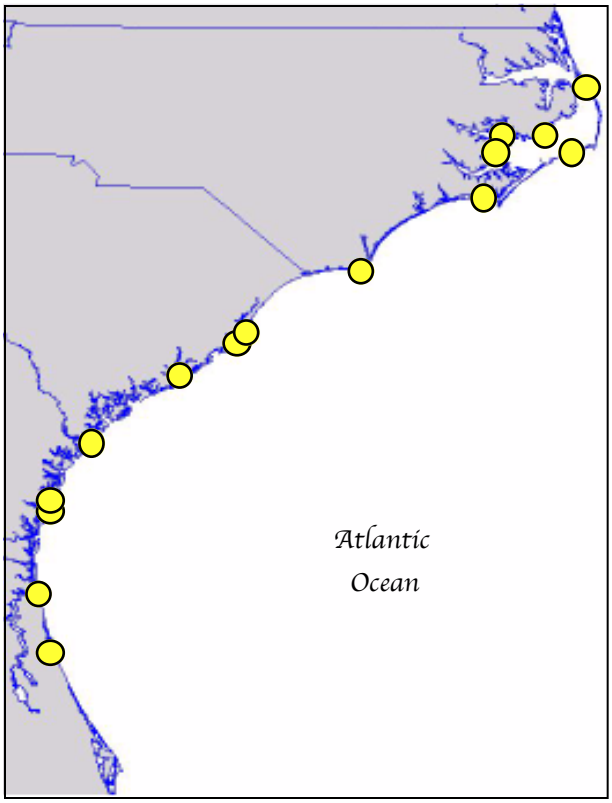


Figure 6. Location of NS&T Mussel Watch sites along the southeast coast.

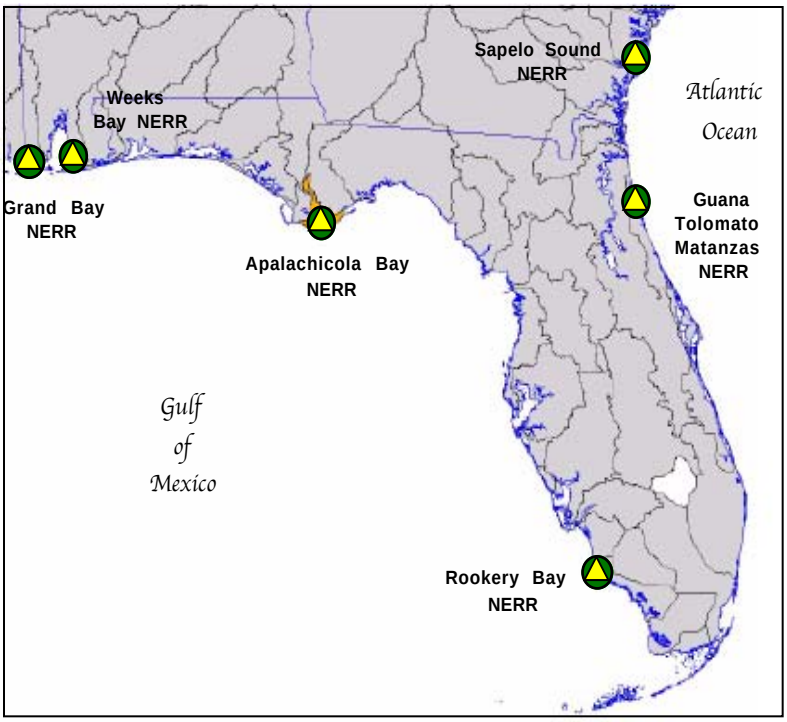


Figure 7. Location of National Estuarine Research Reserves along the south and Gulf coasts.

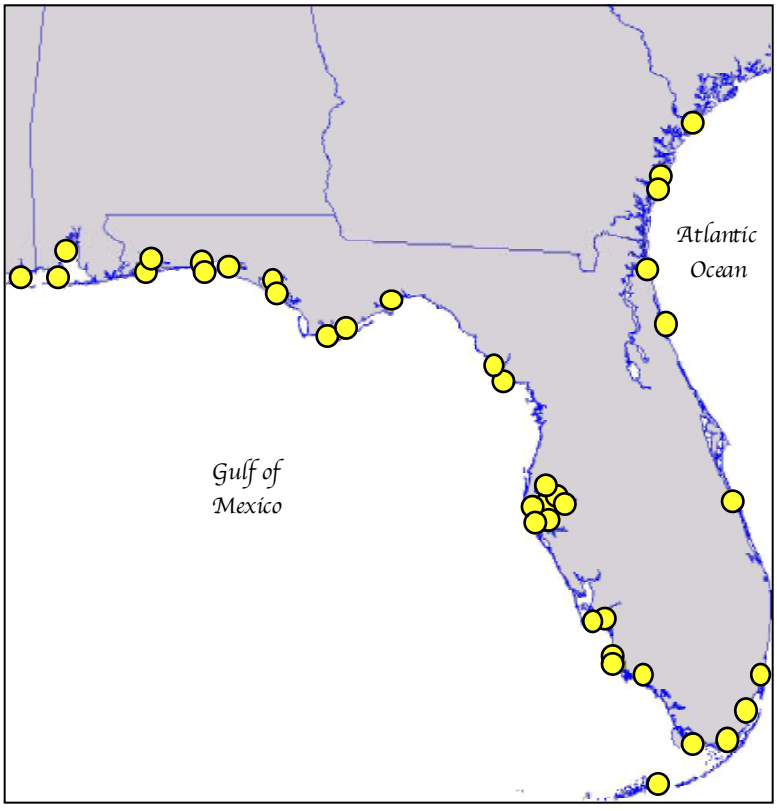


Figure 8. Location of NS&T Mussel Watch sites along the south and Gulf coasts.

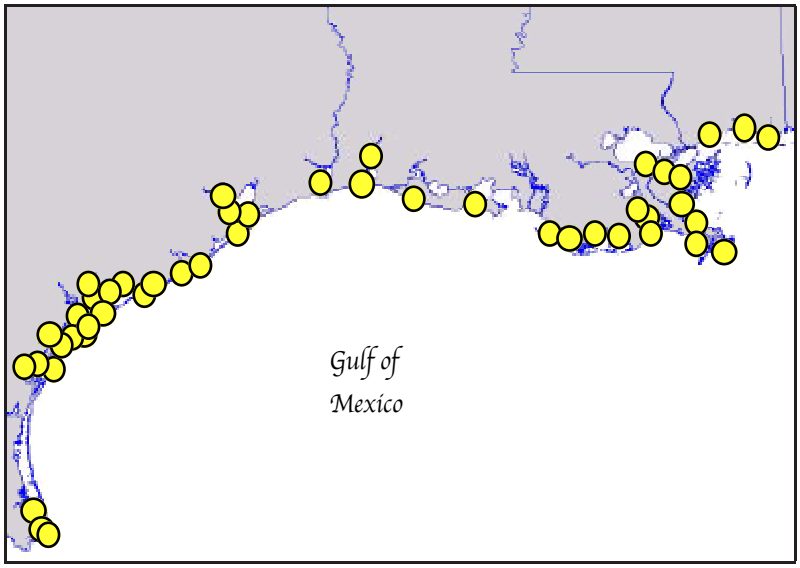


Figure 9. Location of NS&T Mussel Watch sites along the western Gulf coast. There are no NERRS along the western Gulf of Mexico coast.

Plate 5. Sampling at Joseph Harbor Bayou Mussel Watch site (TAMU/GERG).

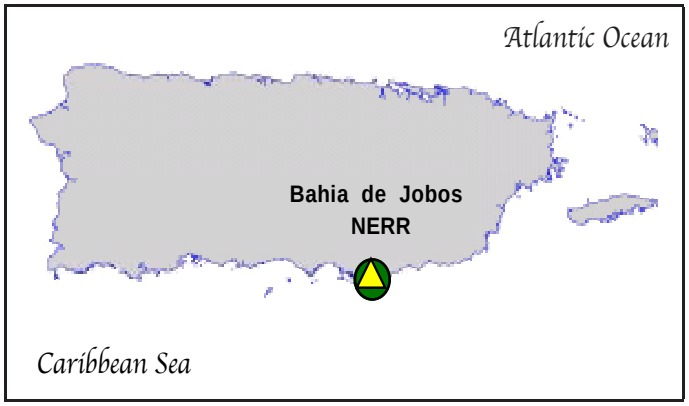


Figure 10. Location of National Estuarine Research Reserve along the coast of Puerto Rico.

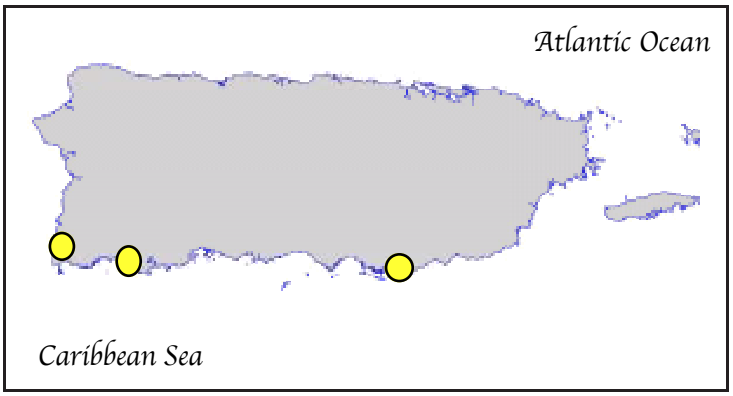


Figure 11. Location of NS&T Mussel Watch sites in Puerto Rico.

Plate 6. Aerial view, Bahia de Jobos, Puerto Rico, Jobos Bay NERR (NOAA National Estuarine Research Reserve Collection, nerr0076, NOAA Photo Collection, NOAA Central Library).

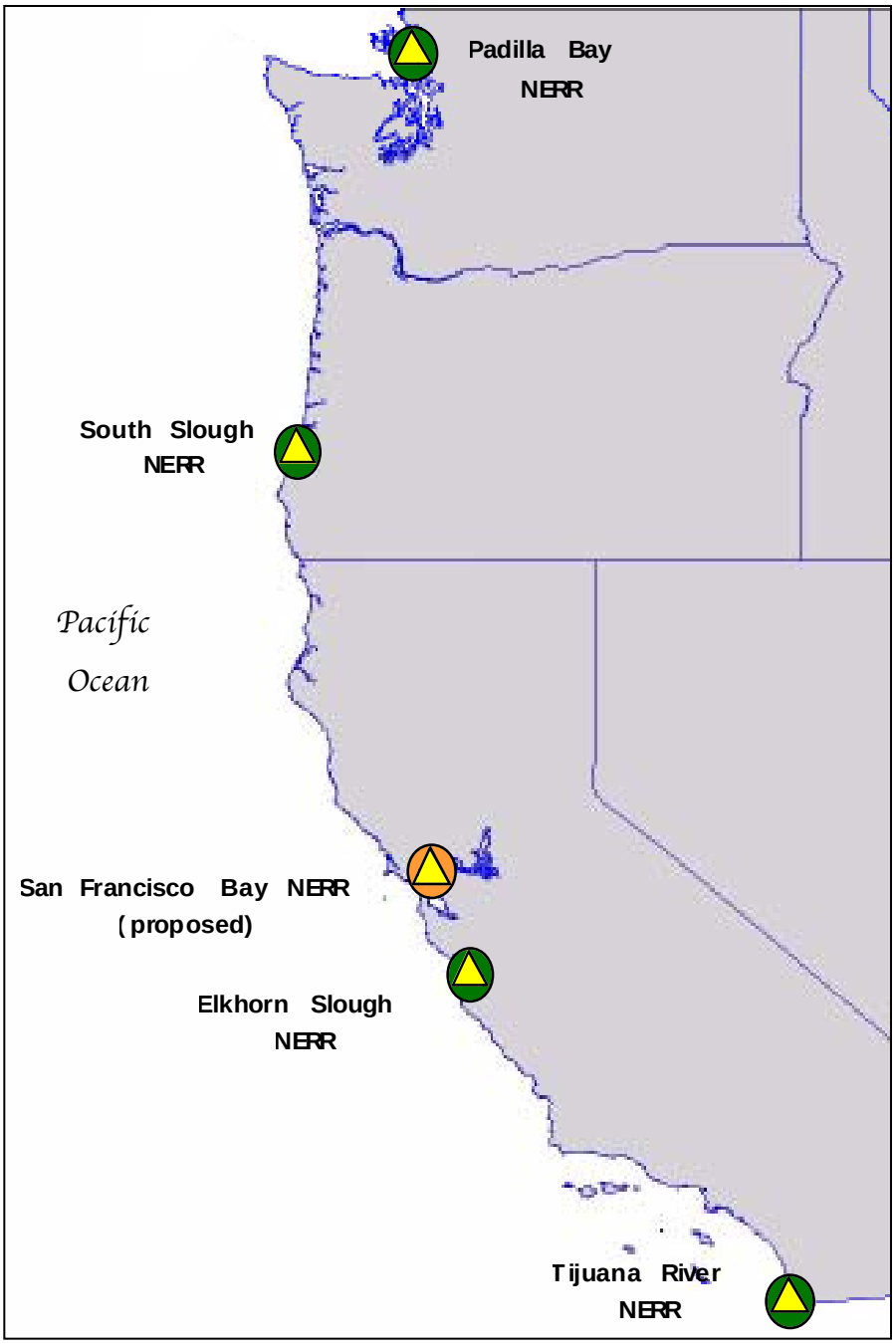


Figure 12. Location of National Estuarine Research Reserves along the Pacific coast.

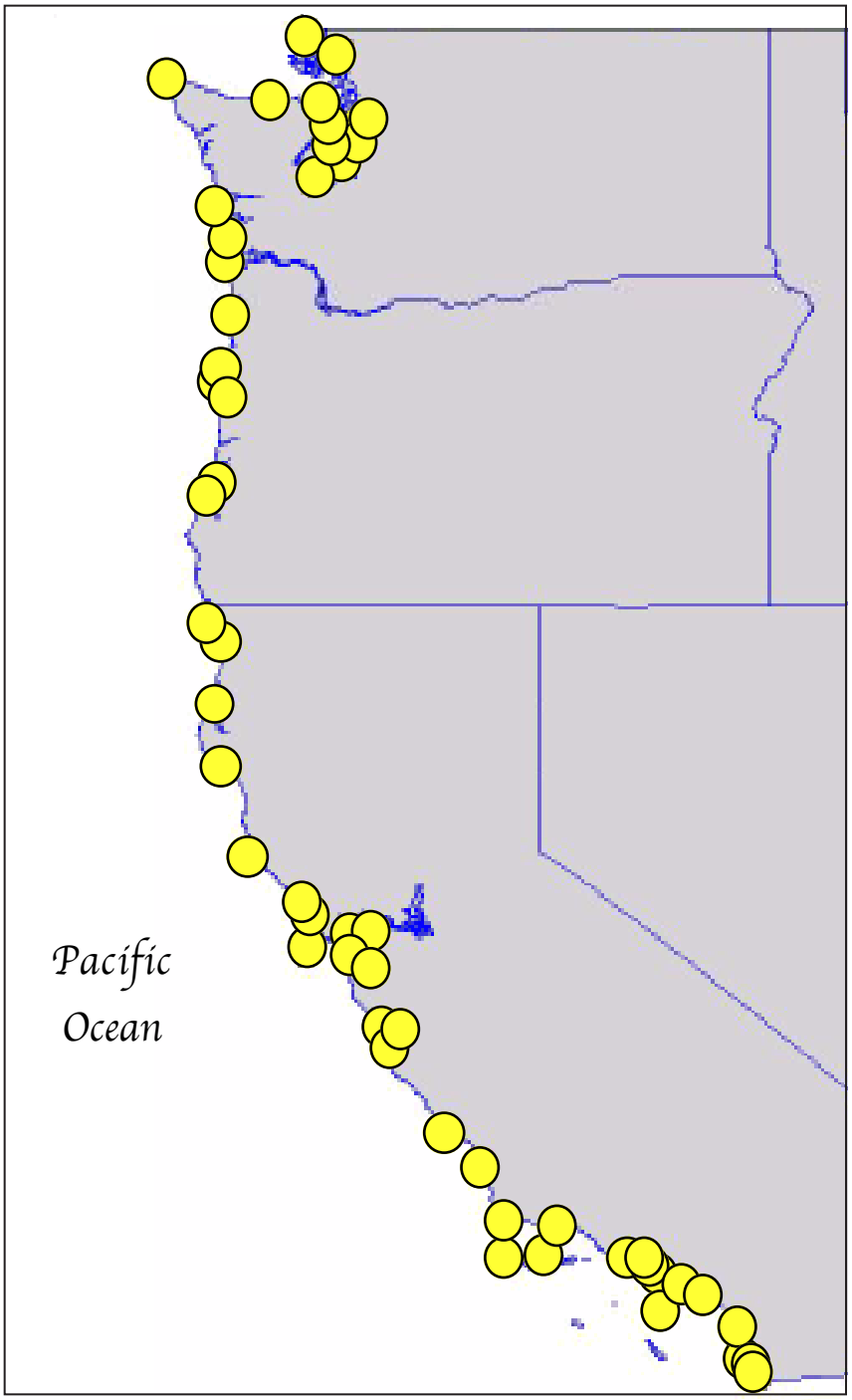


Figure 13. Location of NS&T Mussel Watch sites along the Pacific coast.

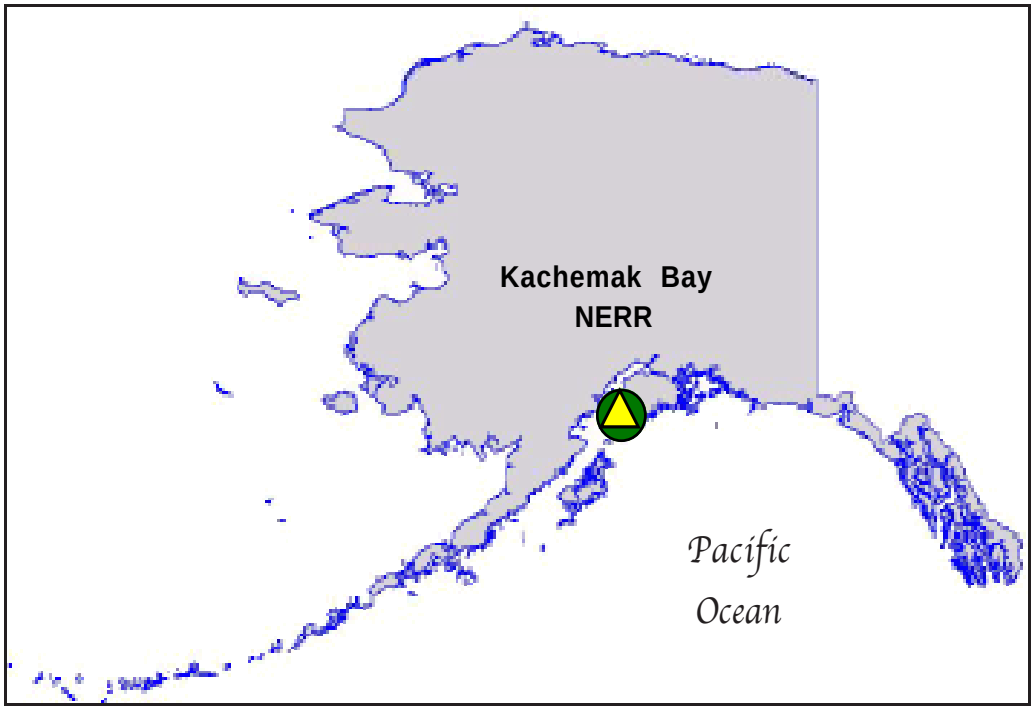


Figure 14. Location of National Estuarine Research Reserve in Alaska.

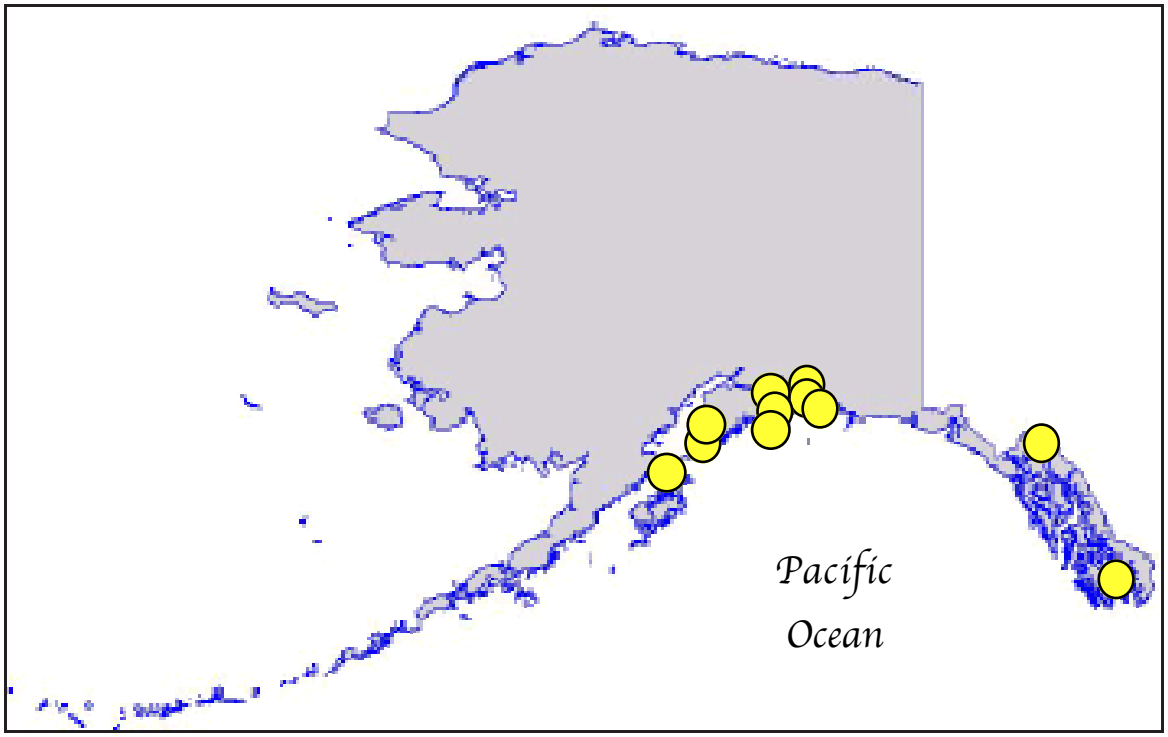


Figure 15. Location of NS&T Mussel Watch sites in Alaska.

Figure 16. Location of National Estuarine Research Reserves in Lake Erie and the St. Lawrence Seaway. The St. Lawrence Reserve is proposed at this time.

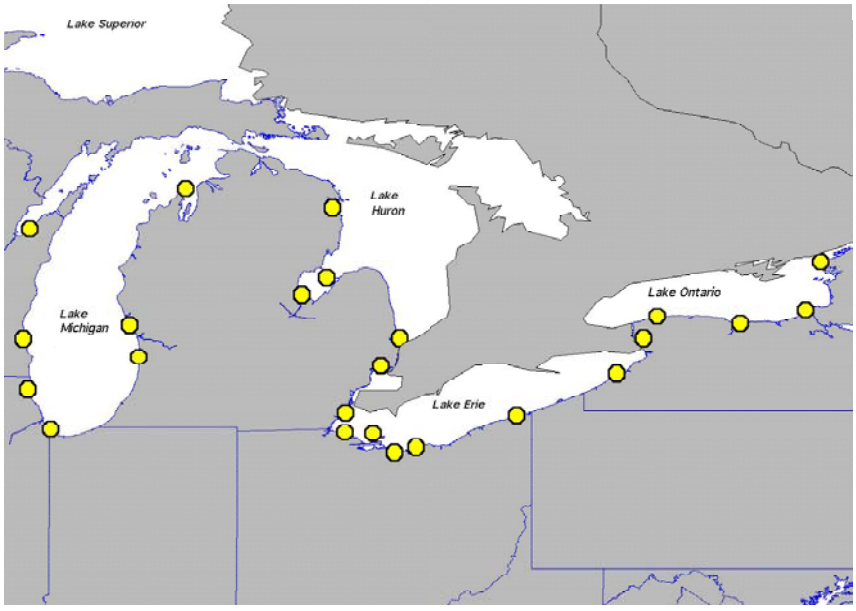


Figure 17. Location of NS&T Mussel Watch sites in the Great Lakes

Plate 7. Zebra Mussels on a unionid clam, Anchor Bay, Lake St. Clair, Michigan (Photo: NOAA).

Plate 8. Zebra mussels collected using a dredge, Anchor Bay, Lake St. Clair, Michigan (Photo: NOAA).

PART III

Contaminant Trends by Location

Plate 9. Sampling at the Spring Creek, Apalachee Bay, Mussel Watch site (TAMU/GERG).

Plate 10. Coniferous and deciduous trees in the Oregon coastal lowlands, Charleston, Oregon, South Slough NERR (NOAA National Estuarine Research Reserve Collection, nerr0438, NOAA Photo Collection, NOAA Central Library).

WEL

Wells NERR

Maine

The Mussel Watch site at Kennebunkport was established in 1989 at the mouth of the Kennebunk River. While development in Kennebunkport and around the Reserve is approximately the same, different rivers drain into the ocean near these sites, so the site match is only fair (Table 1).

Concentrations of trace elements and organic contaminants at the Mussel Watch site are generally at or below NS&T median concentrations (Table 3). In 1997, mercury levels reached the NS&T 85th percentile or 'high' concentration, as did the ∑Diel concentration in 1989.

With eight years of data available, no statistically-significant trends were found for trace elements. Some statistically-significant decreasing trends were found for ∑PAHs, ∑DDTs, and ∑BTs.

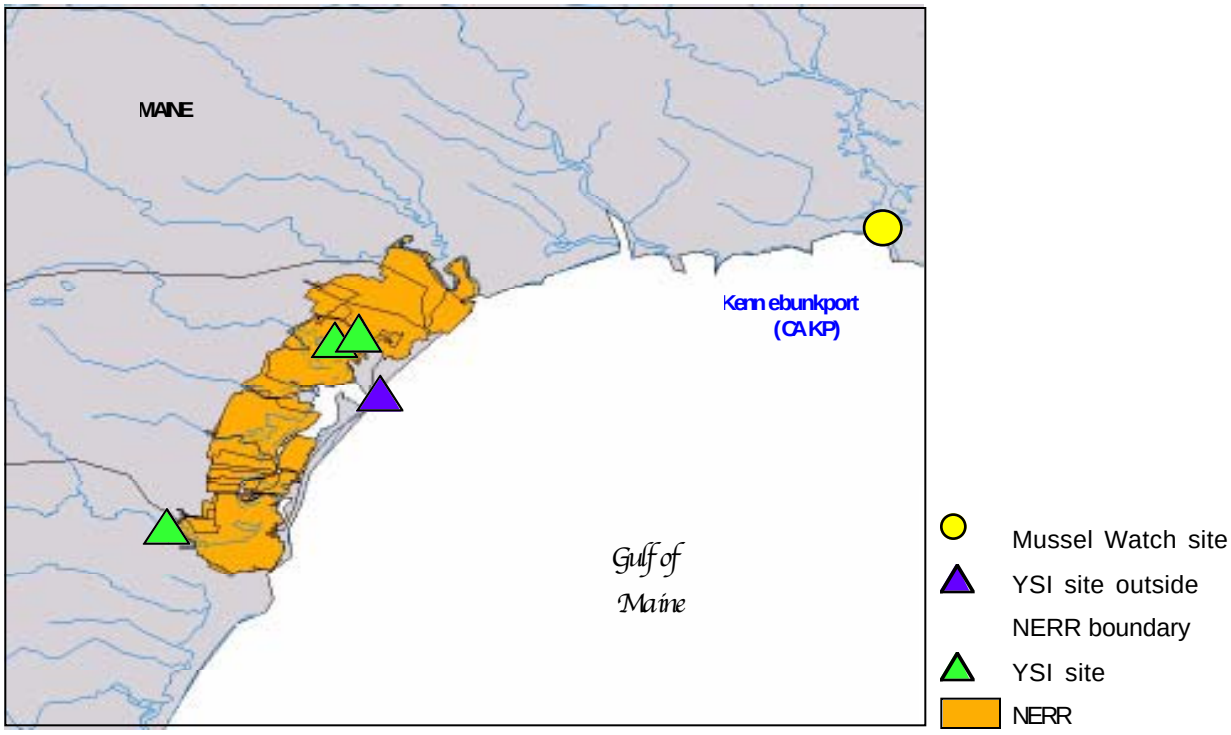


Figure 18. Wells NERR and adjacent areas.

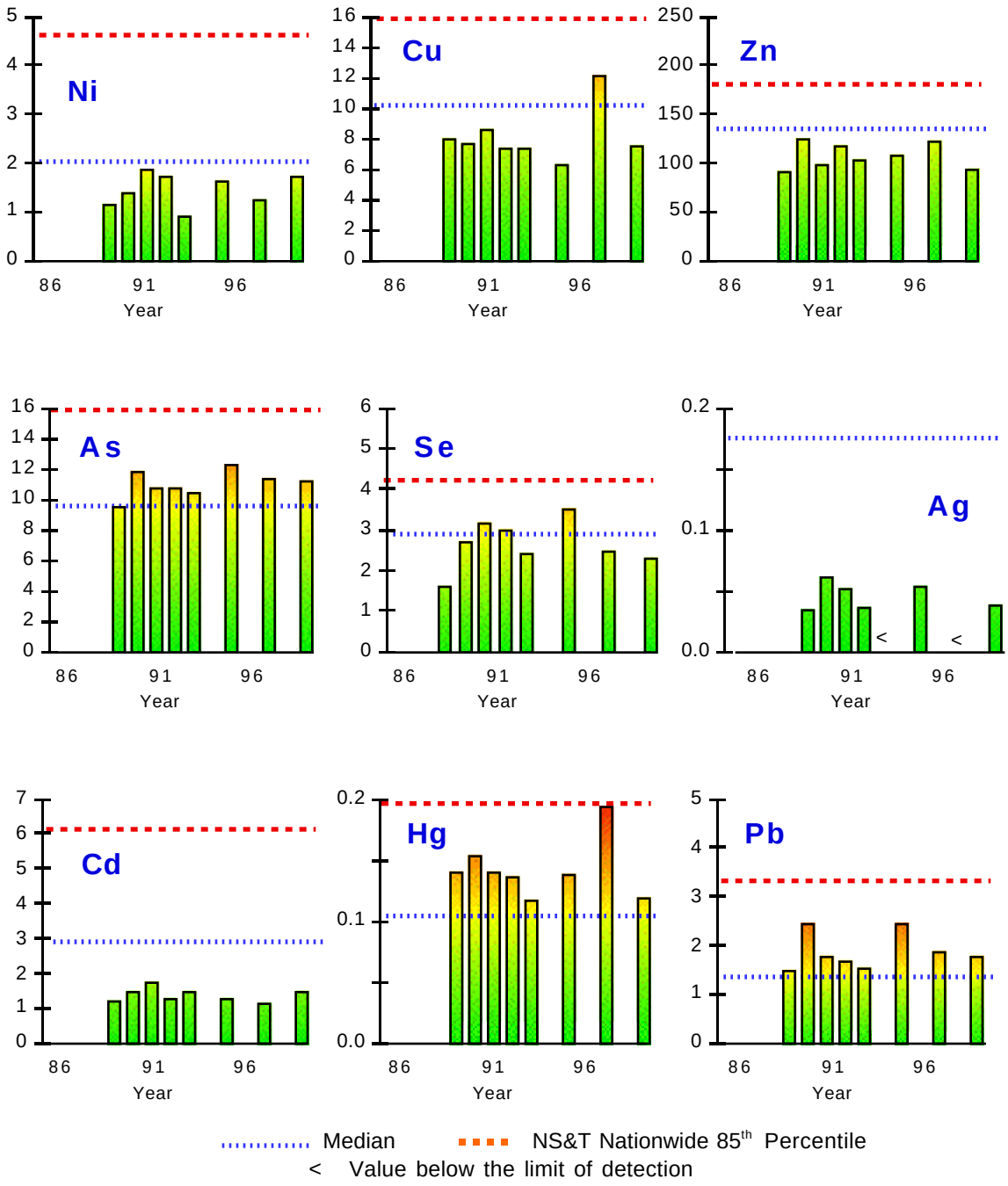


Figure 19. Trace element trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Kennebunkport (Cape Arundel) (CAKP) (µg/g dry wt).

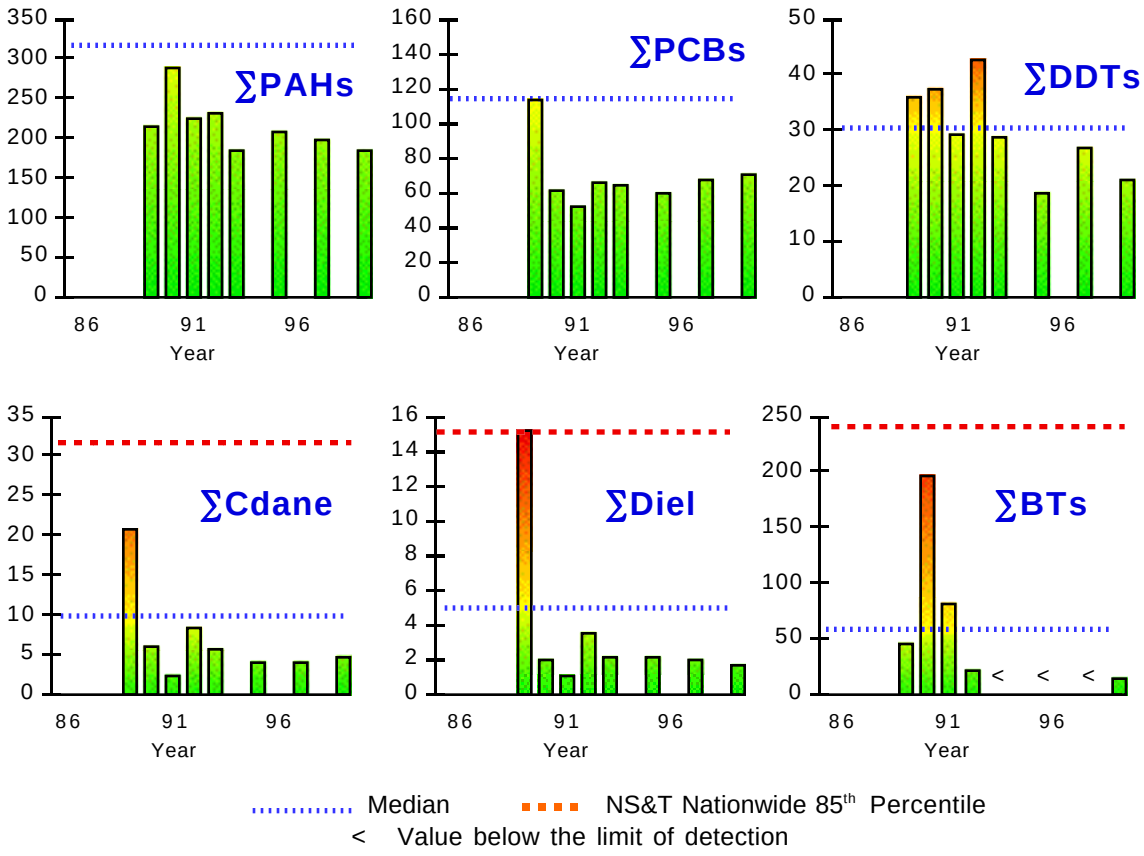


Figure 20. Trace organic contaminant and total butyltin trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Kennebunkport (Cape Arundel) (CAKP) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 11. Mussel Watch site at Cape Arundel (CAKP), Kennebunkport, in the Wells NERR (TAMU/GERG).

Table 8. Trace element and trace organic contaminant concentrations in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Kennebunkport (Cape Arundel) (CAKP) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1989		0.99	7.6	83	9.1	1.43	0.03
1990	13.3	1.22	7.2	117	11.4	2.53	0.06
1991	32.7	1.73	8.1	91	10.3	3.00	0.05
1992	14.0	1.56	6.8	110	10.3	2.82	0.03
1993	39.0	0.77	6.9	96	10.0	2.24	<
1995	20.2	1.46	5.8	101	11.8	3.33	0.05
1997	7.4	1.10	11.6	115	10.9	2.28	<
1999	17.6	1.55	7.1	87	10.7	2.12	0.03
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1989	0.98	0.07	0.133	1.33	37.1
1990	1.24	0.58	0.147	2.30	190
1991	1.53	0.06	0.133	1.63	73.6
1992	1.07	0.09	0.130	1.52	14.6
1993	1.27	<	0.110	1.40	<
1995	1.03	0.07	0.133	2.27	<
1997	0.95	0.19	0.188	1.70	<
1999	1.28		0.112	1.64	6.4
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1989	204	109	34.2	19.9	14.7	5.70	11.7	<
1990	279	56	35.7	5.05	1.52	<	2.93	<
1991	214	48	27.6	1.29	0.63	<	0.89	<
1992	221	60	41.1	7.17	3.09	<	0.00	<
1993	175	60	27.1	4.76	1.70	0.48	0.52	0.30
1995	198	55	17.0	3.01	1.69	0.26	0.98	<
1997	187	62	25.6	2.96	1.55	0.69	0.37	<
1999	174	66	19.5	3.74	1.23	0.50	0.34	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

GRB

Great Bay NERR

New Hampshire

The Dover Point Mussel Watch site was established in 1997 specifically to represent the NERR in Great Bay. Richard Langan, Co-director CICEET informed the NOAA field team where the nearest viable mussel population could be found. This site is categorized as good in Table 1 because the site is influenced by Piscataqua River as well as the waters of Great Bay. Only two years of data are currently available, so there are no bar charts.

Organic contaminant concentrations are mostly near median NS&T concentrations and no contaminant exceeds the 85th percentile NS&T value. Copper, arsenic, mercury, and lead either approach or exceed the 85th percentile for at least one of the two years for which data are available.

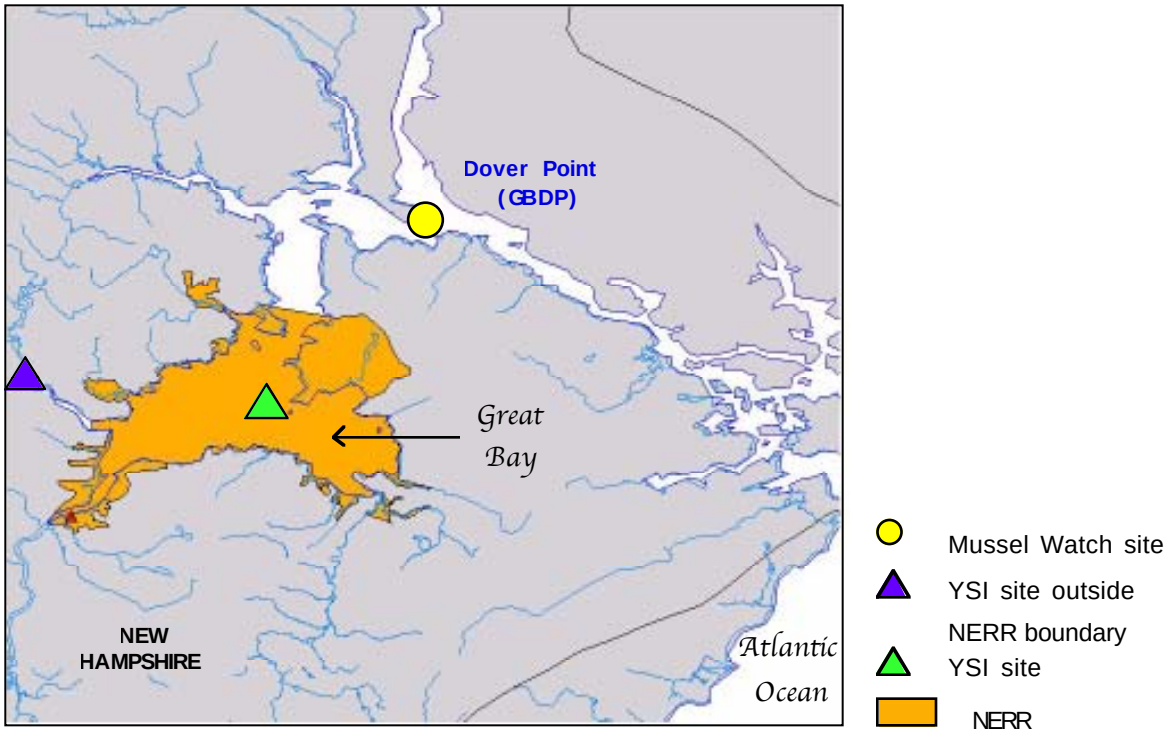


Figure 21. Great Bay NERR and adjacent areas.

Table 9. Trace element and trace organic contaminant concentrations in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Dover Point (Great Bay) (GBDP) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1997	34.0	3.17	16.2	136	15.2	3.48	<
1999	23.2	2.21	8.8	104	11.6	2.18	0.08
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1997	2.08	0.45	0.583	6.03	47.0
1999	1.62		0.353	2.95	89.9
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1997	450	148	18.1	3.11	1.17	0.37	0.39	0.35
1999	499	206	20.2	5.66	1.21	0.72	0.32	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 12. Mussel Watch site at Dover Point (GBDP) near the Great Bay NERR(TAMU/GERG).

WQB

Waquoit Bay NERR

Massachusetts

There are no Mussel Watch sites representative of the Waquoit Bay NERR. The nearest Mussel Watch site, which is Naushon Island, 11 miles away. It is more representative of environmental conditions in eastern Buzzards Bay than Waquoit Bay.

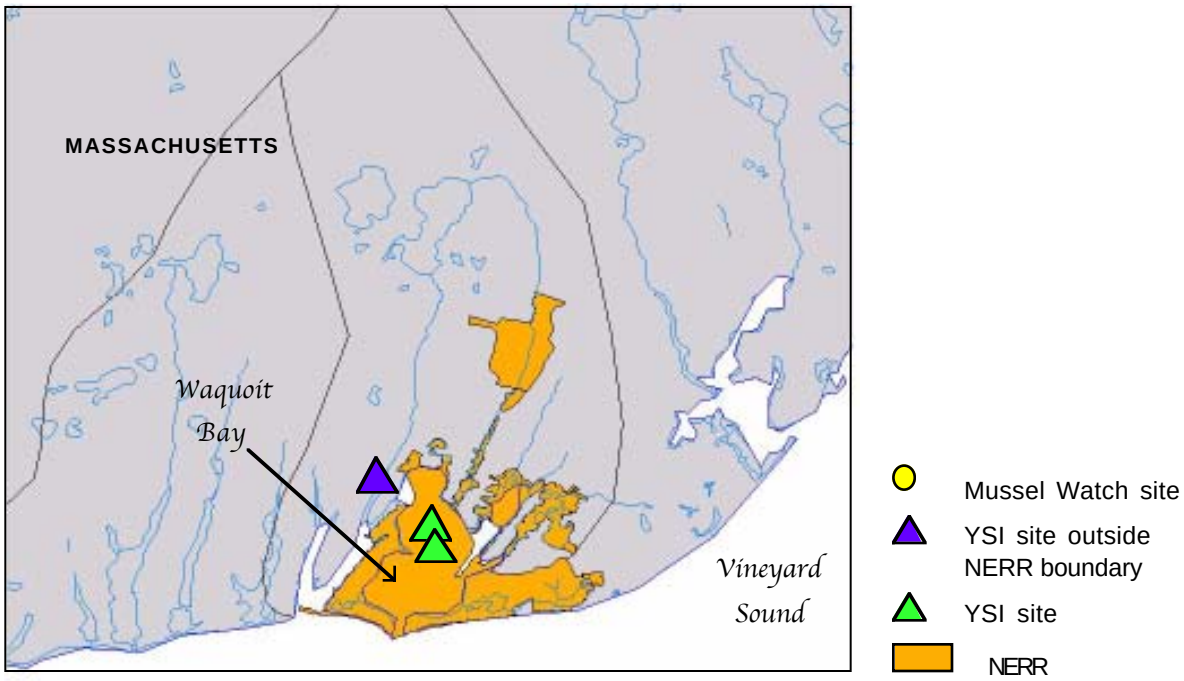


Figure 22. Waquoit Bay NERR and adjacent areas.

Plate 13. An aerial view of the jetties extending out from the entrance of Waquoit Bay, Massachusetts, Waquoit Bay NERR (1995) (Photographer: R. Crawford. NOAA National Estuarine Research Reserve Collection, nerr0791, NOAA Photo Collection, NOAA Central Library).

Plate 14. American oyster (*Crassostrea virginica*), Waquoit Bay, Massachusetts, Waquoit Bay NERR (1996) (Photographer J. Muller. NOAA National Estuarine Research Reserve Collection, nerr0312, NOAA Photo Collection, NOAA Central Library).

NAR

Narragansett Bay NERR

Rhode Island

Both Mussel Watch sites represent conditions present at the NERR. The Patience Island site is within the boundaries of the Reserve, while the Dyer Island site is 0.8 miles south. Therefore the associations are considered excellent and good, respectively. The Dyer Island site is an original Mussel Watch site, dating back to 1986. The Patience Island site was established three years later.

Copper, arsenic and lead exceeded the NS&T 85th percentile at the Dyer Island Mussel Watch site. Copper, silver, mercury, and lead also exceeded the 85th percentile at the Patience Island site.

The summed organics ∑PCBs, ∑DDTs, and ∑Diel exceeded the 85th percentile at Dyer Island. For Patience Island, ∑PCBs values are near the 85th percentile, while ∑Cdane and ∑Diel exceeded the 85th percentile. The ∑Diel values at Patience Island are as much as twice as high as those from Dyer Island.

Statistically-significant decreasing trace element concentrations were found at both Mussel Watch sites. Zinc decreased at Patience Island, while nickel, copper, zinc, silver and lead all decreased at Dyer Island. The organics ∑Diel and ∑BTs have both decreased at Patience Island. However, at Dyer Island there is a statistically significant increase of ∑PCBs and a significant decrease of hexachlorobenzene.

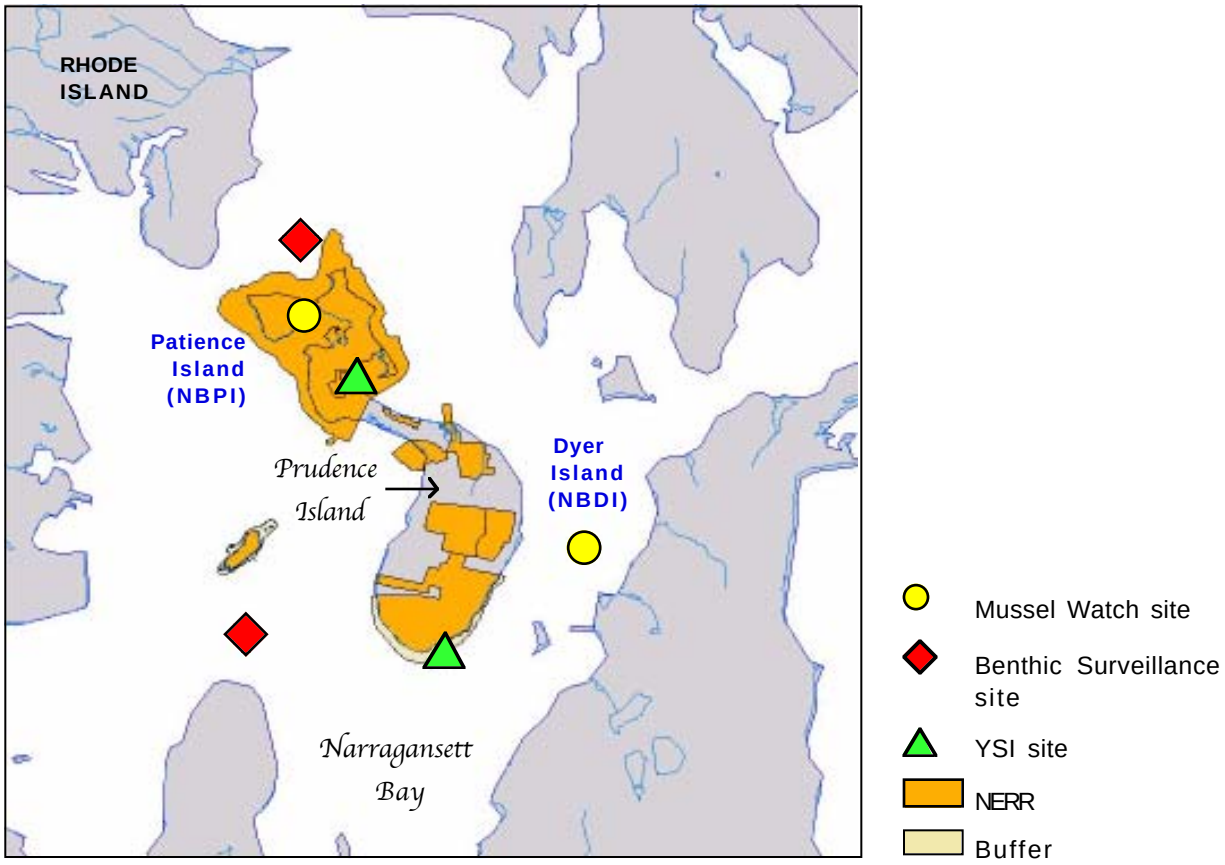


Figure 23. Narragansett Bay NERR and adjacent areas.

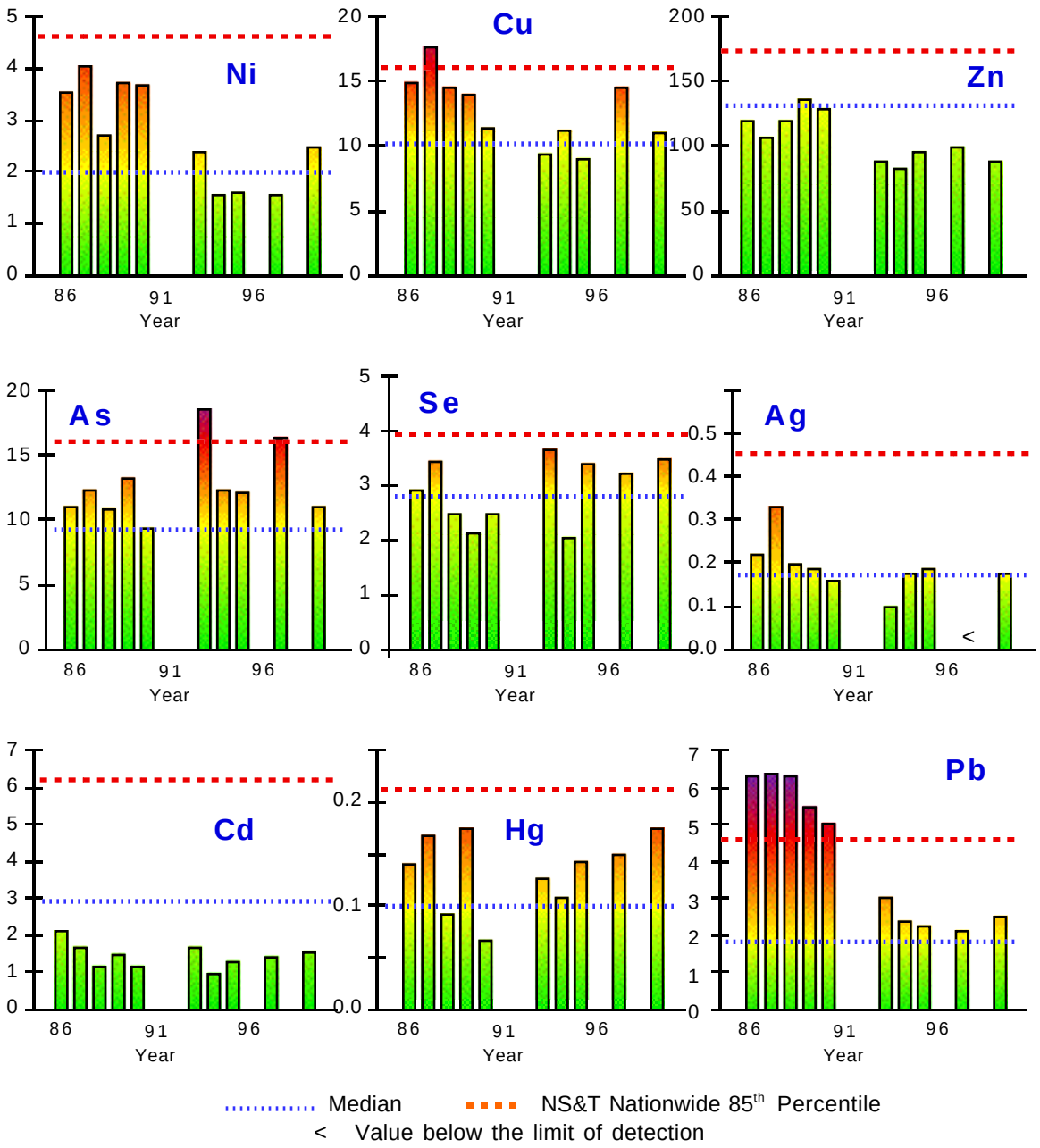


Figure 24. Trace element trends in blue mussels (*Mytilus edulis*) collected at the NS&T Mussel Watch site of Dyer Island (Narragansett Bay) (NBDI) (µg/g dry wt.).

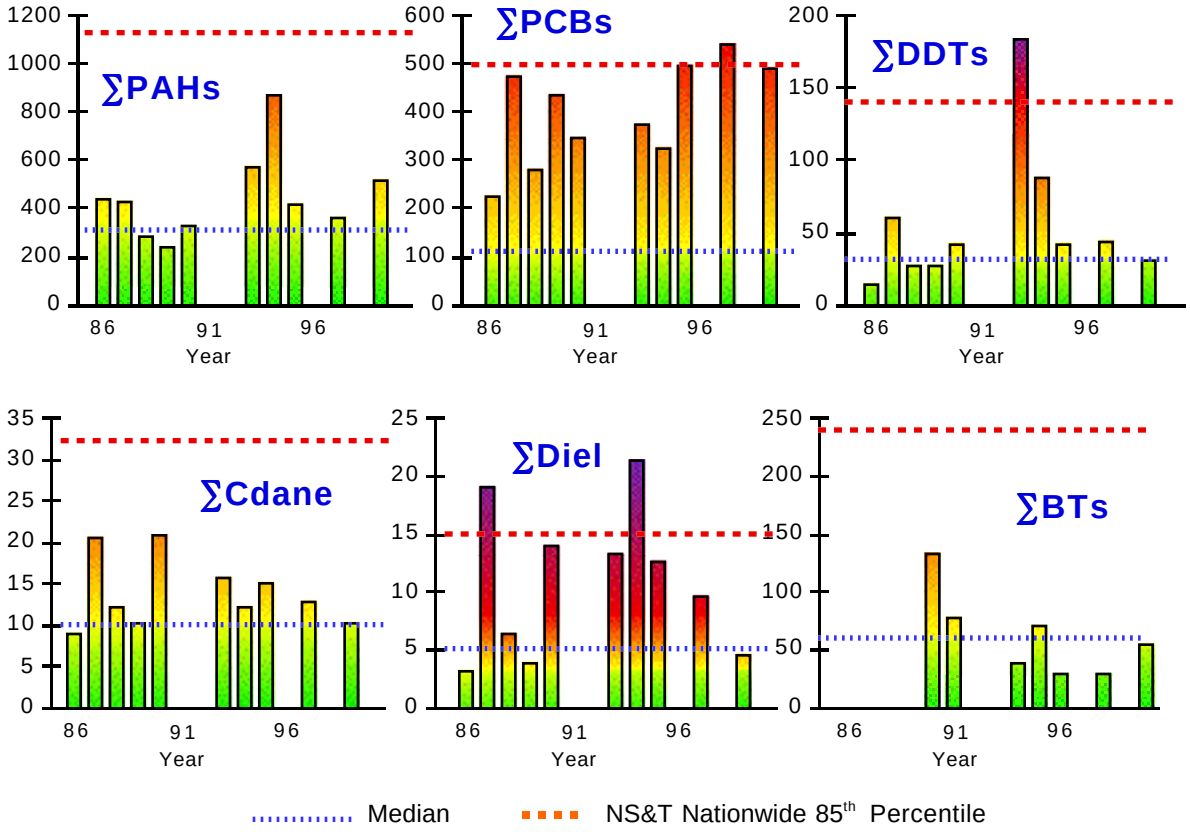


Figure 25. Trace organic contaminants and ∑BTs trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site at Dyer Island (Narragansett Bay) (NBDI) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 15. Dislodged *Spartina* at Providence Point, Prudence Island, Narragansett Bay NERR (1977) (Photographer J. Bruno. NOAA National Estuarine Research Reserve Collection, nerr0423, NOAA Photo Collection, NOAA Central Library).

Table 10. Trace element and trace organic contaminant concentrations in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Dyer Island (Narragansett Bay) (NBDI) (Trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	60.3	3.40	14.3	113	10.5	2.77	0.20
1987	99.7	3.90	17.0	101	11.7	3.30	0.31
1988		2.57	14.0	113	10.3	2.37	0.18
1989		3.60	13.3	130	12.7	2.00	0.17
1990	26.3	3.52	10.9	123	8.7	2.37	0.14
1993	8.7	2.26	8.7	83	18.0	3.53	0.08
1994	16.8	1.43	10.5	78	11.8	1.93	0.16
1995	17.2	1.47	8.4	89	11.5	3.27	0.17
1997	7.4	1.40	13.9	94	15.8	3.09	<
1999	22.8	2.32	10.5	83	10.5	3.33	0.16
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1986	1.90	0.17	0.133	6.13	
1987	1.43	0.17	0.160	6.20	
1988	0.93	0.15	0.083	6.10	
1989	1.27	0.33	0.167	5.27	126.0
1990	0.96	0.38	0.060	4.79	71.3
1993	1.47	<	0.120	2.80	31.4
1994	0.75	0.11	0.100	2.18	64.8
1995	1.05	0.20	0.134	2.07	21.8
1997	1.18	0.01	0.141	1.90	21.2
1999	1.35		0.168	2.26	46.9
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	405	210	9.0	7.84	2.40	0.77	0.63	<
1987	391	455	53.8	19.67	18.30	0.86	0.67	0.61
1988	248	264	22.3	11.13	5.63	1.15	2.40	1.40
1989	210	417	20.9	9.30	3.23	4.93	<	<
1990	294	329	35.6	19.78	13.30	0.40	3.17	0.05
1993	544	359	177.7	14.84	12.56	0.20	0.63	0.53
1994	831	306	82.5	11.05	20.65	0.51	0.98	<
1995	383	480	37.2	14.03	11.95	0.23	1.37	<
1997	328	523	38.5	11.69	8.93	0.63	0.52	<
1999	483	476	25.3	9.27	3.84	0.35	<	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 16. Mussel Watch site at Dyer Island (NBDI), Narragansett Bay, Narragansett Bay NERR (TAMU/GERG).

Plate 17. Mussel Watch site at Patience Island (NBPI), Narragansett Bay, Narragansett Bay NERR (TAMU/GERG).

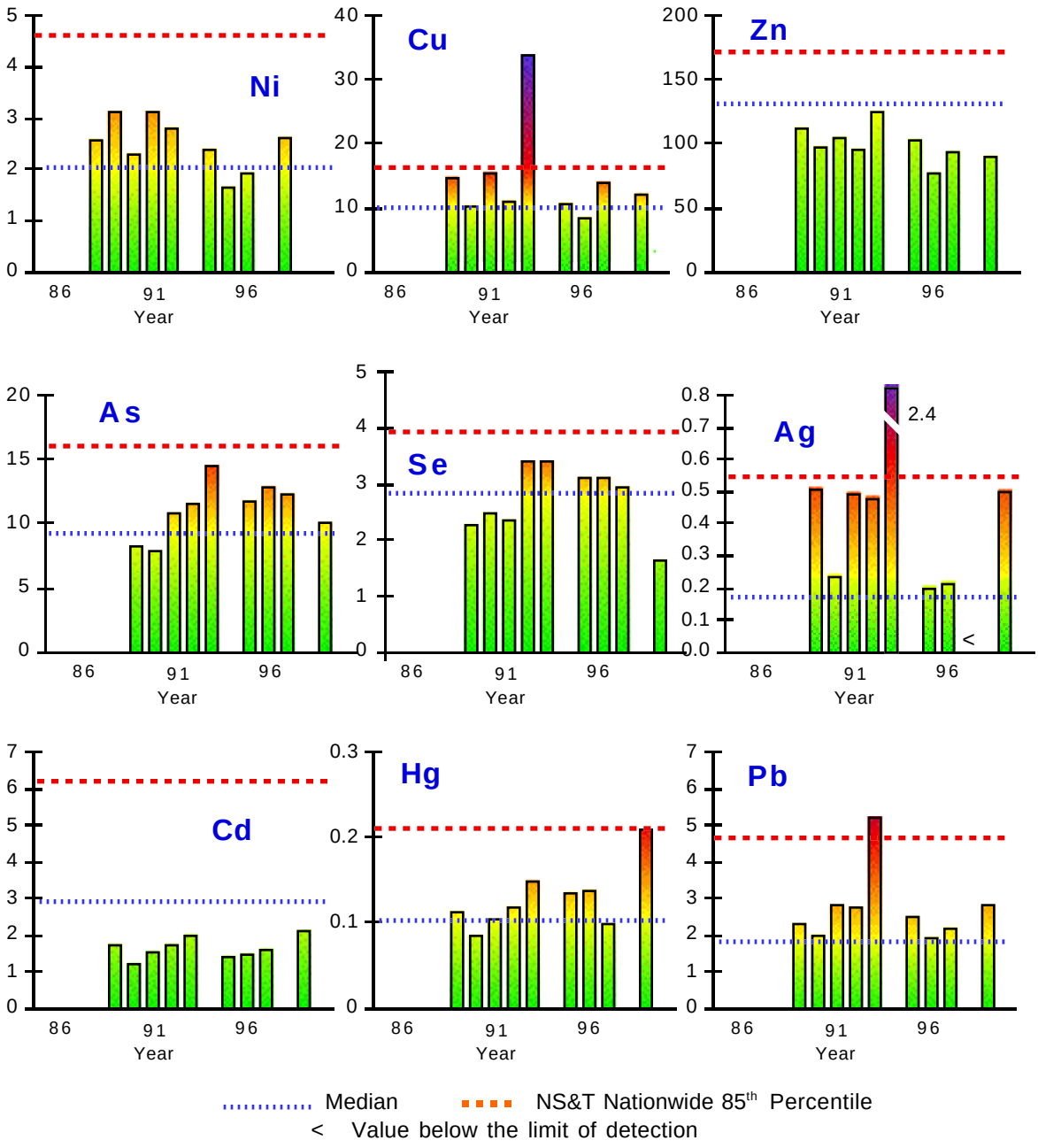


Figure 26. Trace element trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Patience Island (Narragansett Bay) (NBPI) (µg/g dry wt.).

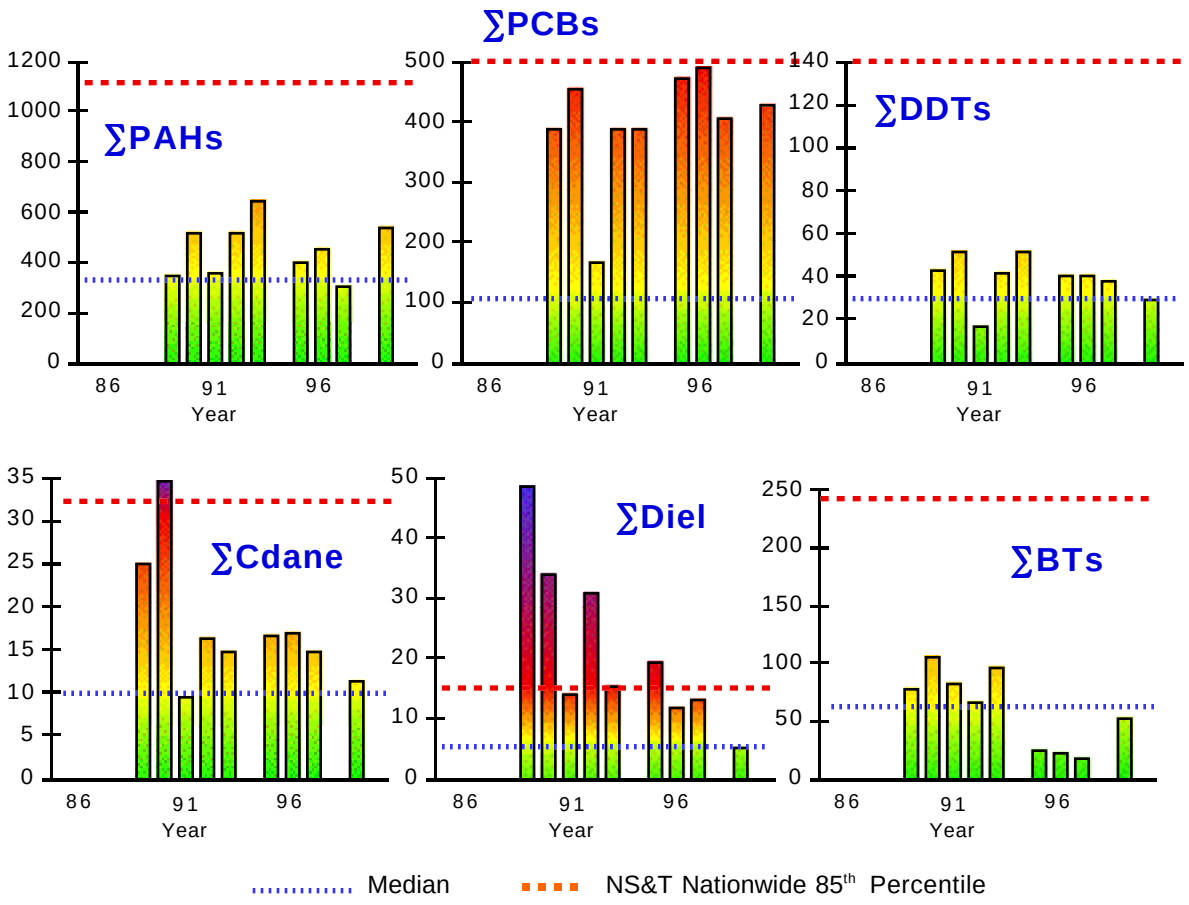


Figure 27. Trace organic contaminants and ∑BTs trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Patience Island (Narragansett Bay) (NBPI) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.)

Plate 18. Aerial view of the Mussel Watch site at Dyer Island (NBDI), Narragansett Bay, Narragansett Bay NERR (TAMU/GERG).

Table 11. Trace element and trace organic contaminant concentrations in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Patience Island (Narragansett Bay) (NBPI) (Trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1989		2.43	13.7	107	7.7	2.13	0.48
1990	12.4	3.00	9.1	92	7.3	2.36	0.21
1991	11.7	2.13	14.3	99	10.2	2.23	0.47
1992	12.0	2.99	9.9	90	11.0	3.27	0.46
1993	9.4	2.66	32.6	120	14.0	3.27	2.39
1995	50.9	2.23	9.5	97	11.1	2.99	0.17
1996	23.9	1.50	7.1	72	12.2	3.00	0.19
1997	8.0	1.80	12.9	87	11.7	2.81	<
1999	12.1	2.48	10.8	84	9.5	1.50	0.48
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1989	1.53	0.16	0.103	2.10	71.1
1990	1.04	0.75	0.077	1.77	98.9
1991	1.33	0.15	0.097	2.60	74.8
1992	1.54	0.15	0.110	2.53	59.1
1993	1.77	0.20	0.140	5.00	89.0
1995	1.20	0.33	0.127	2.31	17.5
1996	1.30	0.32	0.130	1.70	14.4
1997	1.40	0.04	0.090	2.00	9.9
1999	1.89		0.202	2.62	45.4
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1989	309	376	39.2	24.13	47.00	1.90	<	<
1990	484	440	48.2	33.75	32.43	0.48	2.77	<
1991	323	151	13.3	8.46	12.60	0.21	1.40	<
1992	485	373	38.5	15.41	29.62	<	0.00	<
1993	608	375	47.9	13.81	13.88	0.32	0.77	0.55
1995	366	457	36.9	15.64	17.92	0.19	1.33	<
1996	417	478	36.8	15.93	10.35	0.39	2.03	0.49
1997	269	394	33.8	13.66	11.62	0.74	0.58	<
1999	501	415	25.2	10.32	3.63	0.45	0.35	0.15
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

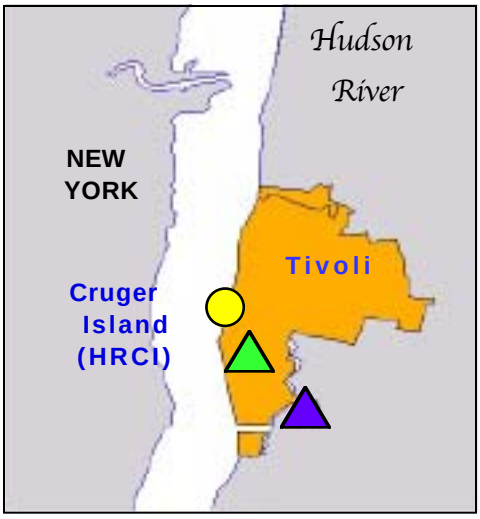
HUD

Hudson River NERR

New York

There are four components to this NERR: Stockport Flats, Tivoli, Iona Island and Piermont Marsh. Only the Tivoli NERR has a Mussel Watch site. The Cruger Island Mussel Watch site was established within the Hudson River-Tivoli Component NERR in 1995.

Zebra mussels are collected at this and 24 Great Lakes Mussel Watch sites.



Mussel Watch site

YSI site

YSI site outside NERR boundary

NERR

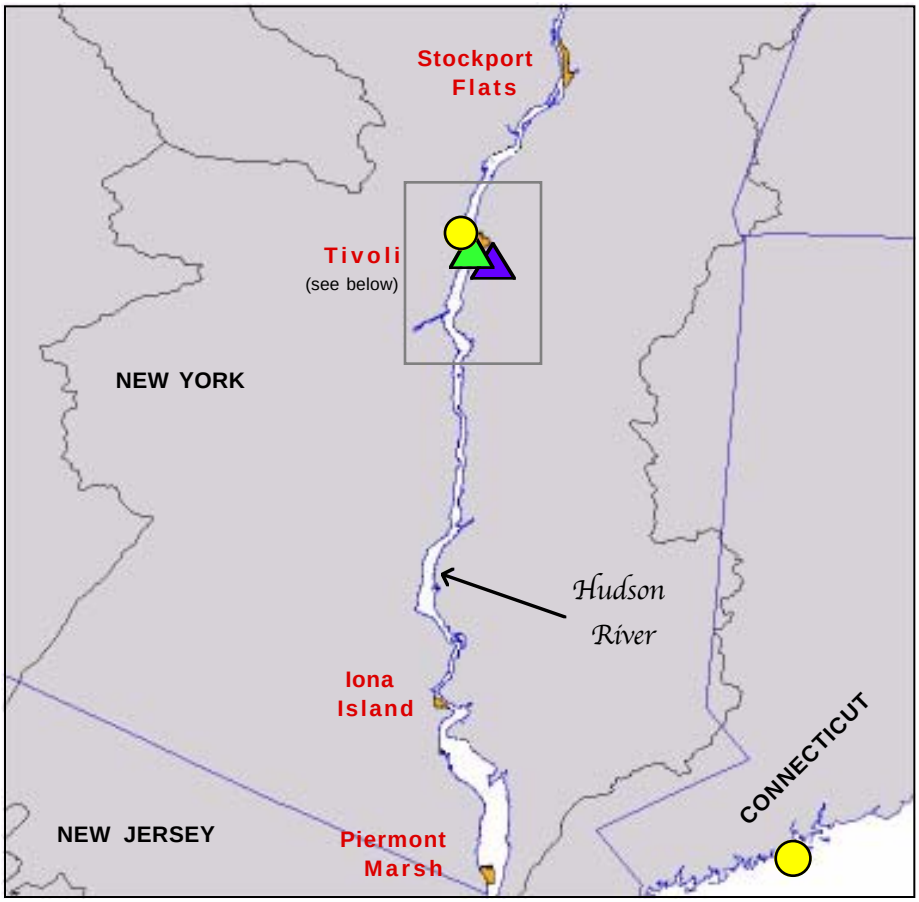


Figure 28. Hudson River NERR and adjacent areas.

Trace element concentrations were 'high' for nickel and copper in all years. Zinc and Lead also exceeded the 85th percentile in 1995.

O'Connor (2002) found that of the 25 Mussel sites at which zebra mussels are collected, all 25 were 'high' (above the 85th percentile) in nickel; copper was 'high' at 22, selenium at 21, chromium at 17, and cadmium at 11. He concludes this probably reflects the species, not the environment. Trace elements from Cruger Island should only be compared to sites where zebra mussels were used.

Of the summed organic contaminants, ∑BTs approached the 85th percentile in 1999. ∑PCBs were at or above the 85th percentile in all years. The high ∑PCBs are not unexpected because of the history of PCB discharges in the upper Hudson River. There are not enough years of data to perform statistical trend analyses for this site.

Plate 19. Mussel Watch site at Cruger Island (Hudson River) (HRCI) in the Hudson River NERR (C. Nieder, Research coordinator, Hudson River NERR).

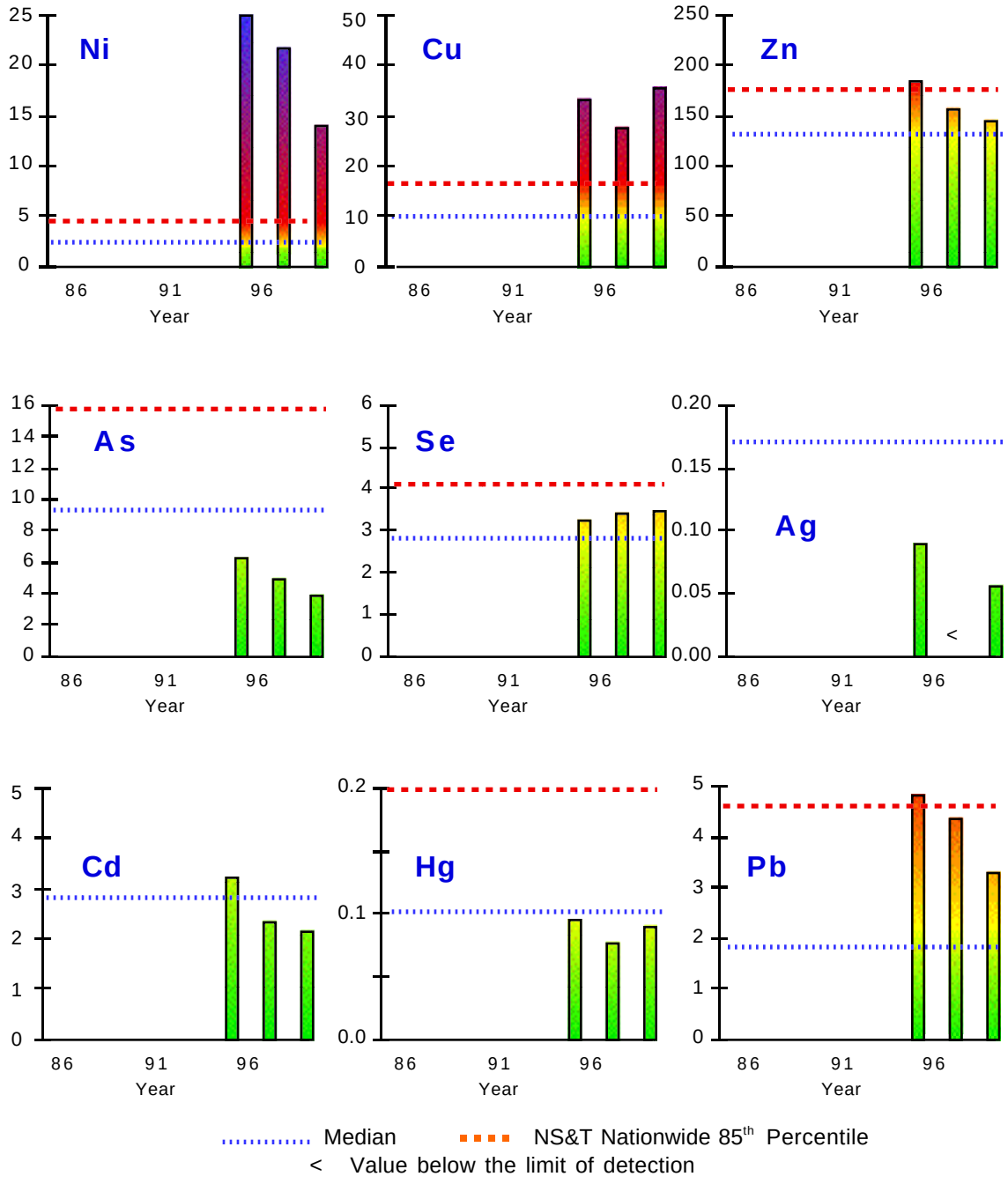


Figure 29. Trace element trends in zebra mussels (*Dreissena polymorpha* and *D. bugensis*) collected at NS&T Mussel Watch site Cruger Island (Hudson River) (HRCI) (µg/g dry wt.).

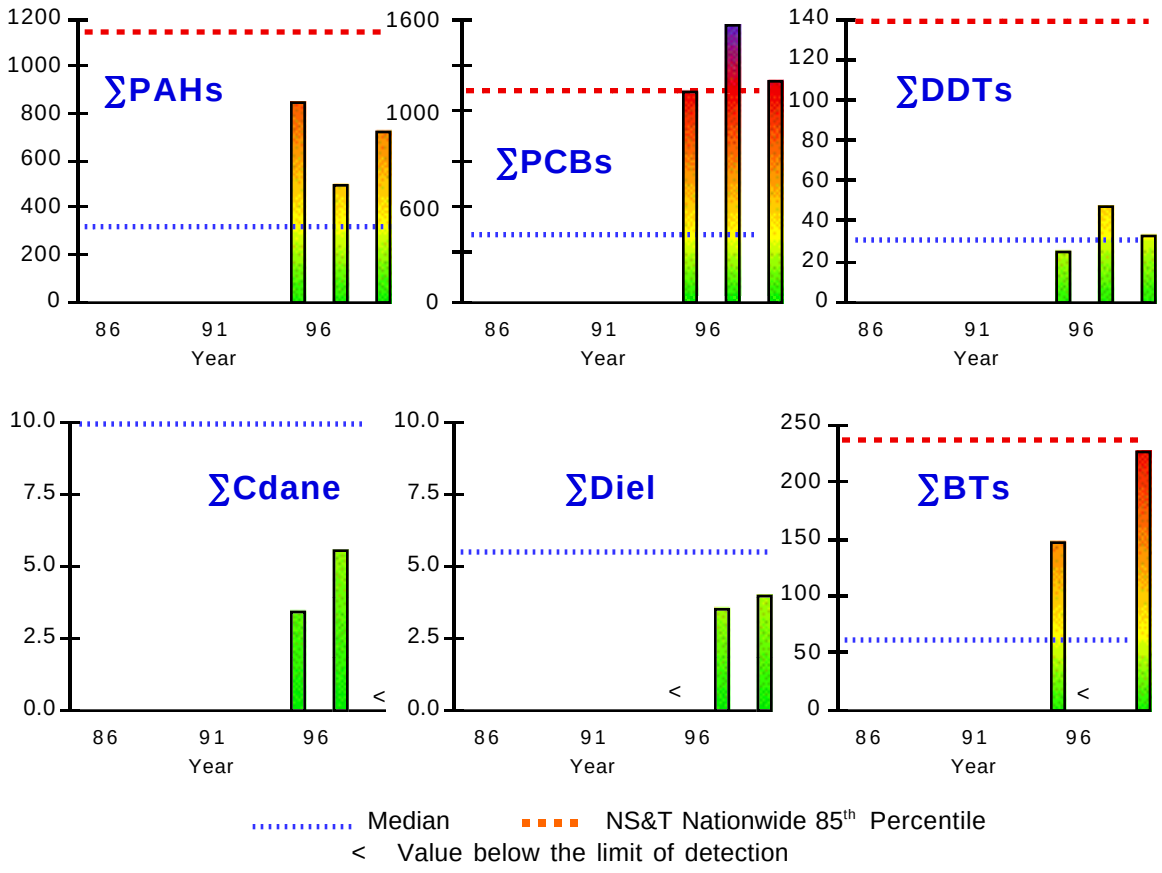


Figure 30. Trace organic contaminants and total butyltins trends in zebra mussels (*Dreissena polymorpha* and *D. bugensis*) collected at NS&T Mussel Watch site Cruger Island (Hudson River) (HRCI) (ng/g dry wt.; ∑Bts, ng Sn/g dry wt.).

Plate 20. Waterway, Hudson River NERR (NOAA National Estuarine Research Reserve Collection, nerr0071, NOAA Photo Collection, NOAA Central Library).

Table 12. Trace element and trace organic contaminant concentrations in zebra mussels (*Dreissena polymorpha* and *D. bugensis*) collected at NS&T Mussel Watch site Cruger Island (Hudson River) (HRCI) (Trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1995	716.9	25.56	32.0	183	6.2	3.10	0.08
1997	321.0	21.50	26.6	150	4.7	3.20	<
1999	181.0	13.10	33.9	140	3.7	3.23	0.05
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1995	3.09	0.63	0.087	4.86	153.8
1997	2.17	0.27	0.070	4.28	0.0
1999	2.14	1.44	0.082	3.16	223.4
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1995	866	1085	26.2	3.42	<	0.80	<	<
1997	503	1393	43.8	5.08	2.83	1.07	0.28	0.34
1999	729	1176	31.4	<	3.25	1.31	<	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 21. Bird nest, Hudson River NERR (NOAA National Estuarine Research Reserve Collection, nerr0074, NOAA Photo Collection, NOAA Central Library).

Plate 22. Marsh, Hudson River NERR (NOAA National Estuarine Research Reserve Collection, nerr0069, NOAA Photo Collection, NOAA Central Library).

Plate 23. Second view of a marsh, Hudson River NERR (NOAA National Estuarine Research Reserve Collection, nerr0075, NOAA Photo Collection, NOAA Central Library).

JAC

Jacques Costeau NERR (Mullica River)

New Jersey

Two sites were established in the vicinity of the Jacques Costeau NERR. The Absecon Inlet site (AIAC), which is 1.6 miles from the boundary of the Reserve, was established in 1989. The Barnegat Inlet site, 8.6 miles from the Reserve, was established in 1988.

Selenium at Absecon Inlet exceeded the 85th percentile for the three most recent sampling years. Lead exceeded the 85th percentile in 1996. Mercury exceeded the 85th percentile every year.

At Barnegat, nickel exceeded the 85th percentile; copper, selenium, silver, and lead approached the 85th percentile in 1998. Like the Absecon site, mercury was high at Barnegat Inlet for all sampling years. Table 7 indicates that Barnegat Inlet and Absecon Inlet had three and four trace elements, respectively, that were 'high' for at least half of the years for which data exist.

Organics for both sites approached and occasionally exceeded their 85th percentiles. But these concentrations are not unusually high for urban environments.

Three statistically-significant increasing trace element trends (nickel, selenium, mercury) and a decreasing trend (silver) were found for the Barnegat Inlet site. Both selenium and lead were increasing at the Absecon Inlet site. The only statistically-significant trend found for organic contaminants was for decreasing ∑Cdane concentrations at Barnegat Inlet.

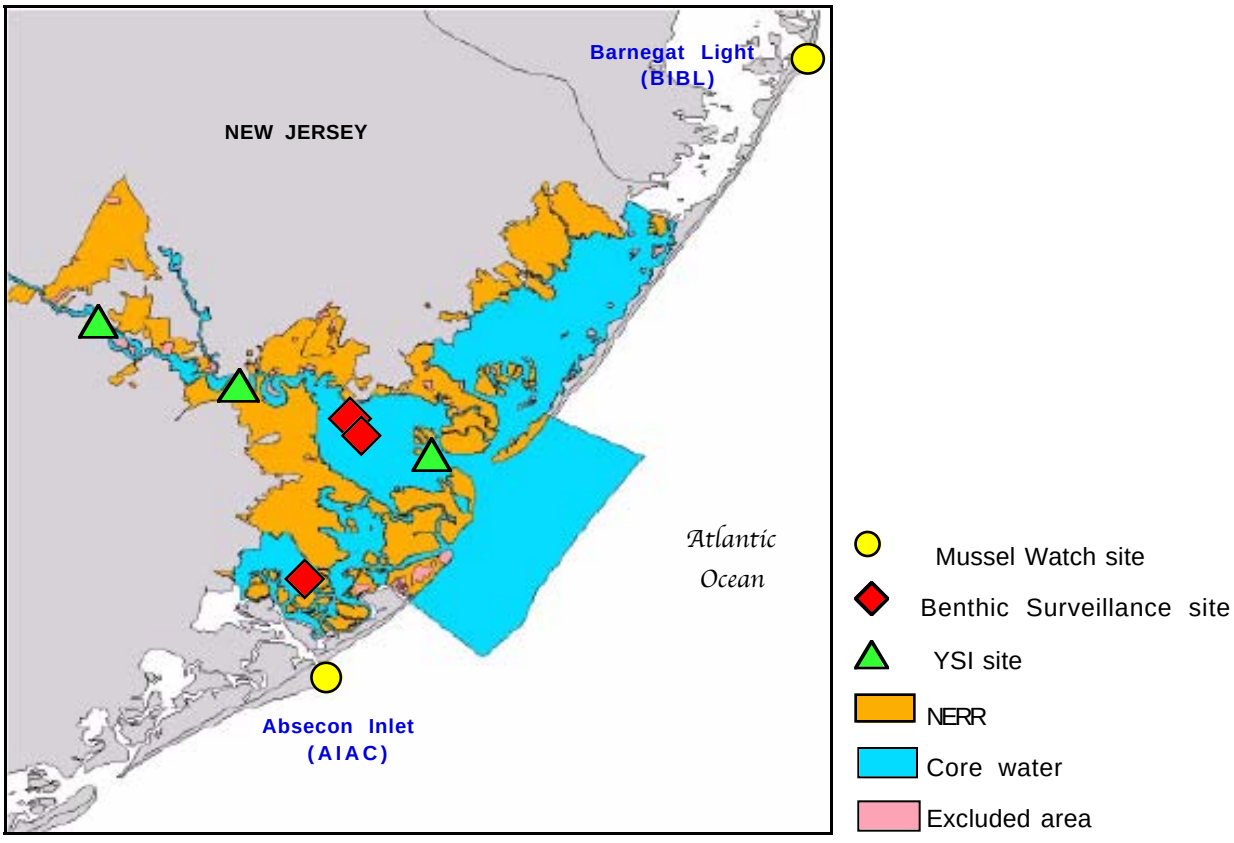


Figure 31. Jacques Cousteau NERR and adjacent areas.

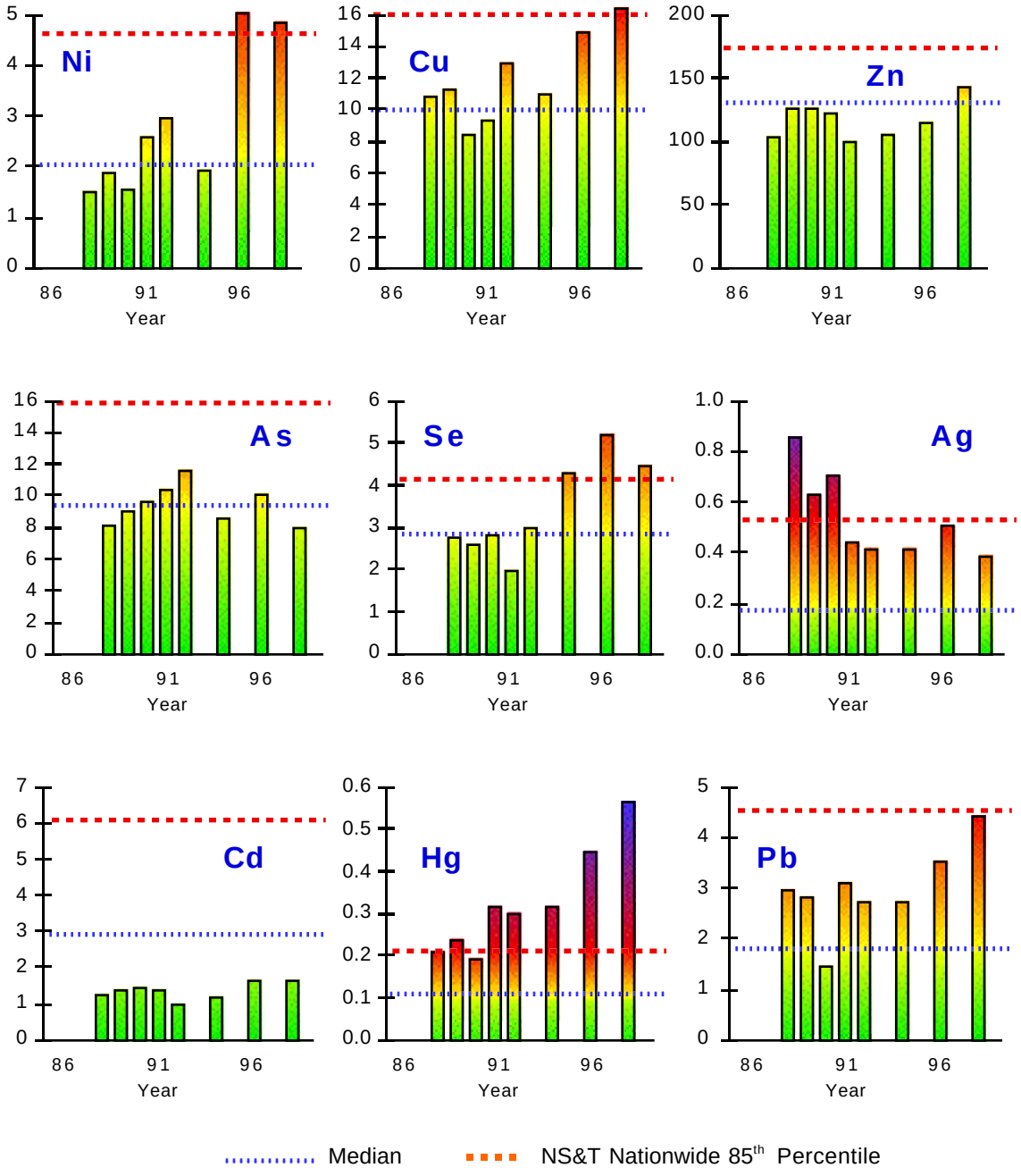


Figure 32. Trace element trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Barnegat Light (Barnegat Inlet) (BIBL) (µg/g dry wt.).

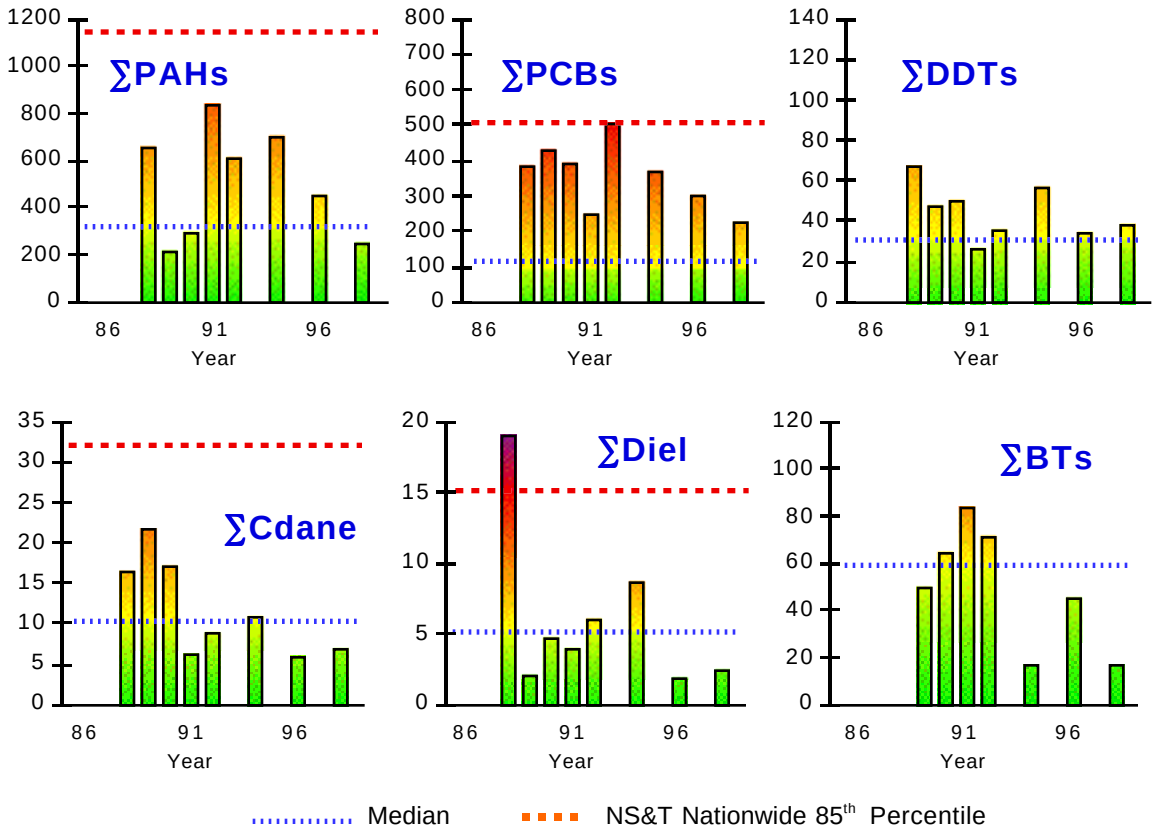


Figure 33. Trace organic contaminants and ∑BTs trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Barnegat Light (Barnegat Inlet) (BIBL) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 24. Winter sampling at the Mussel Watch site at Absecon Inlet (AIAC), Atlantic City, in the Jacques Costeau, Mullica River, NJ, NERR (TAMU/GERG).

Table 13. Trace element and trace organic contaminant concentrations in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Barnegat Light (Barnegat Inlet) (BIBL) (Trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1988		1.37	10.3	97	7.6	2.57	0.83
1989		1.73	10.9	120	8.6	2.43	0.60
1990	10.9	1.41	7.9	120	9.1	2.66	0.68
1991	31.7	2.43	8.8	117	9.9	1.80	0.41
1992	29.0	2.84	12.5	94	11.2	2.79	0.38
1994	14.1	1.77	10.6	100	8.1	4.14	0.38
1996	88.0	4.90	14.4	109	9.6	5.00	0.48
1998	82.2	4.72	16.0	138	7.5	4.30	0.35
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1988	1.06	0.14	0.190	2.83	
1989	1.17	0.07	0.217	2.67	46.5
1990	1.23	0.85	0.173	1.29	60.7
1991	1.17	0.26	0.300	2.97	79.7
1992	0.79	0.36	0.280	2.56	67.5
1994	0.98	0.14	0.300	2.59	13.8
1996	1.44	0.16	0.430	3.40	41.2
1998	1.42	<	0.547	4.29	13.0
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1988	624	362	63.0	15.60	18.37	0.33	1.27	1.60
1989	182	408	43.9	20.83	1.50	1.93	<	<
1990	258	368	46.1	16.11	4.05	<	2.40	<
1991	804	227	22.4	5.22	3.42	<	0.61	1.30
1992	572	478	31.0	7.94	5.38	2.57	2.79	<
1994	662	346	52.5	9.78	8.08	<	1.04	1.57
1996	416	278	30.1	5.01	1.29	0.31	0.52	1.20
1998	213	204	34.2	5.84	1.88	2.12	<	0.50
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection.

Plate 25. Mussel Watch site at Barnegat Inlet (BIBL) in the Jacques Cousteau NERR (TAMU/GERG).

Plate 26. Barnegat Lighthouse at Barnegat Inlet, Jacques Cousteau NERR (TAMU/GERG).

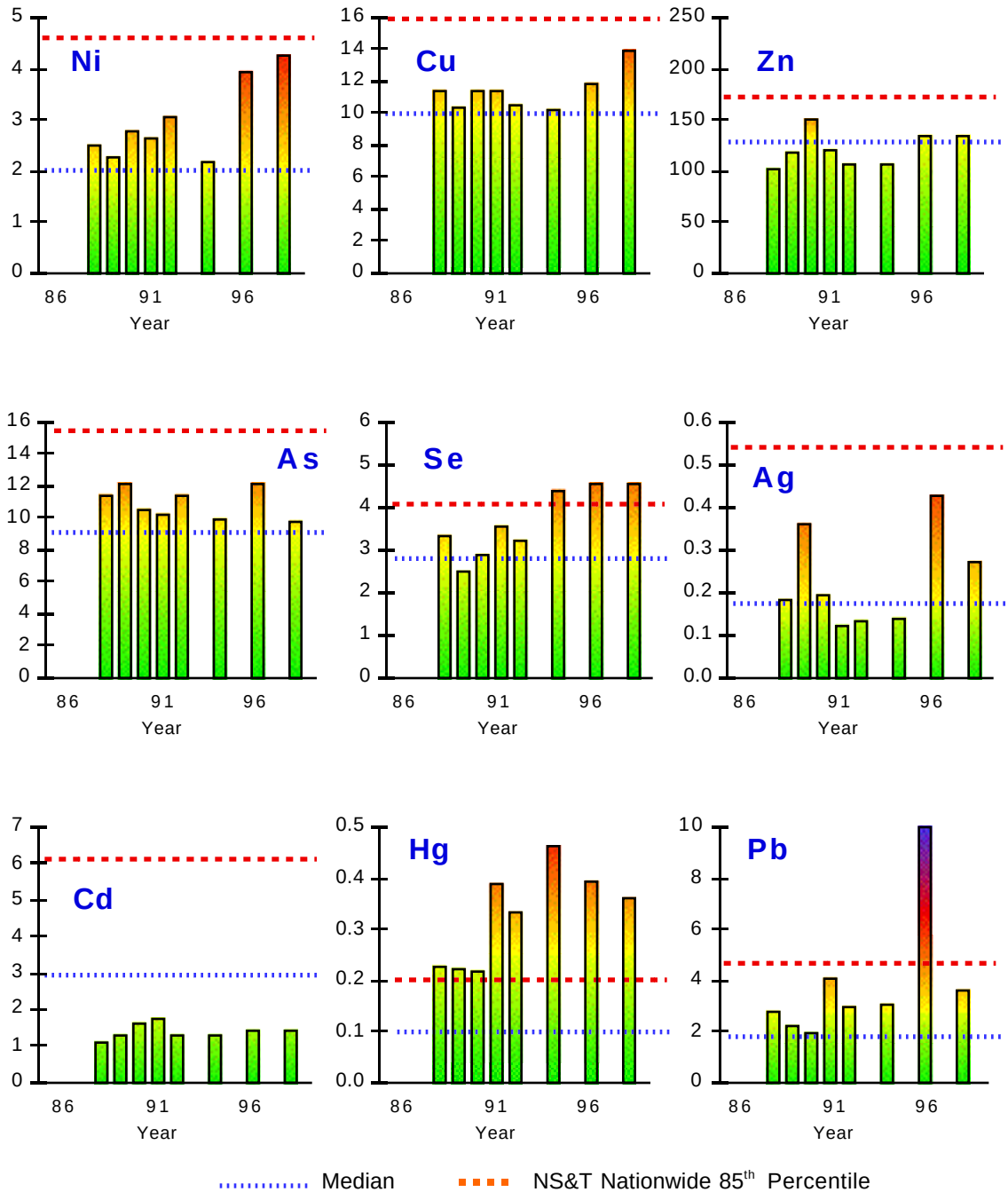


Figure 34. Trace element trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Atlantic City (Absecon Inlet) (AIAC) (µg/g dry wt.).

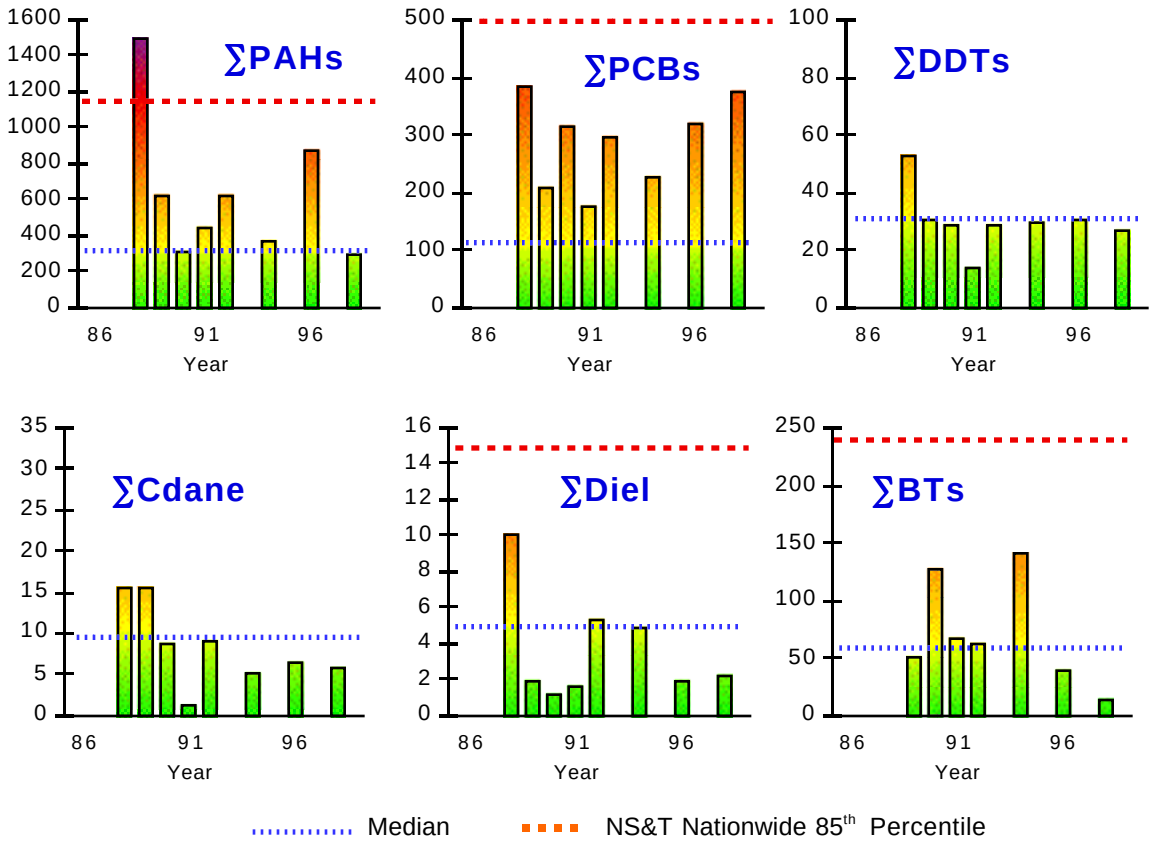


Figure 35. Trace organic contaminants and ∑BTs trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Atlantic City (Absecon Inlet) (AIAC) (ng/g dry wt.; ∑Bts, ng Sn/g dry wt.).

Plate 27. Mussel Watch site at Absecon Inlet (AIAC), Atlantic City, in the Jacques Costeau, Mullica River, NJ, NERR (TAMU/GERG).

Table 14. Trace element and trace organic contaminant concentrations in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Atlantic City (Absecon Inlet) (AIAC) (Trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1988		2.37	11.00	95	11.0	3.17	0.16
1989		2.13	9.93	110	11.7	2.33	0.34
1990	28.3	2.61	10.95	143	10.0	2.73	0.17
1991	67.0	2.50	11.00	113	9.8	3.40	0.10
1992	27.0	2.91	10.11	100	11.0	3.02	0.12
1994	11.0	2.01	9.70	100	9.4	4.20	0.12
1996	59.0	3.80	11.40	127	11.7	4.40	0.41
1998	80.2	4.10	13.50	127	9.3	4.41	0.25
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1988	0.91	0.09	0.210	2.50	
1989	1.08	0.13	0.207	1.97	43.7
1990	1.42	0.57	0.203	1.63	119.9
1991	1.57	0.25	0.373	3.80	59.6
1992	1.11	0.25	0.320	2.63	54.5
1994	1.10	0.14	0.450	2.73	133.6
1996	1.21	0.04	0.380	9.70	32.6
1998	1.20	0.00	0.346	3.36	5.9
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1988	1459	372	49.77	14.67	9.67	0.47	<	0.67
1989	568	191	27.60	14.37	1.43	0.50	<	<
1990	268	298	25.75	7.57	0.66	<	<	0.15
1991	392	159	11.08	0.38	1.08	<	<	<
1992	574	282	26.08	7.95	4.80	3.13	4.26	<
1994	317	213	27.11	4.14	4.39	<	0.66	0.70
1996	827	305	28.02	5.48	1.48	0.62	0.68	1.72
1998	247	363	23.69	4.70	1.80	0.38	<	0.44
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection.

DEL

Delaware NERR

Delaware

The closest Mussel Watch sites to the two-component Delaware Bay NERR (Blackbird and St Jones) are the Hope Creek site, 6 miles away from Blackbird, and Kelly Island, 8 miles away from St. Jones. Both components were rated as fair in Table 1, although Kelly Island probably better represents the estuarine conditions of St. Jones than Hope Creek represents a marsh environment like Blackbird.

The Hope Creek site was only sampled once in 1989. When new Mussel Watch sites were established, three samples are taken within that site to determine sample variance.

Nickel, copper, zinc, sliver, cadmium, and lead all are above the NS&T 85th percentile. In contrast, only two organics (∑Diel and Lindane) were above the 85th percentile.

Both Hope Creek and Kelly Island exceeded the same trace element 85th percentiles. The difference between the two sites is that while only two organic contaminants or grouped contaminants exceeded the 85th percentile at Hope Island, all the organic contaminants reported exceeded the 85th percentile sometime during monitoring at Kelly Island.

While it appears organic contaminant levels were higher in the early years, the only statistically-significant trend was for the ∑Cdane at Kelly Island. It was decreasing. No trends were found for trace element concentrations.

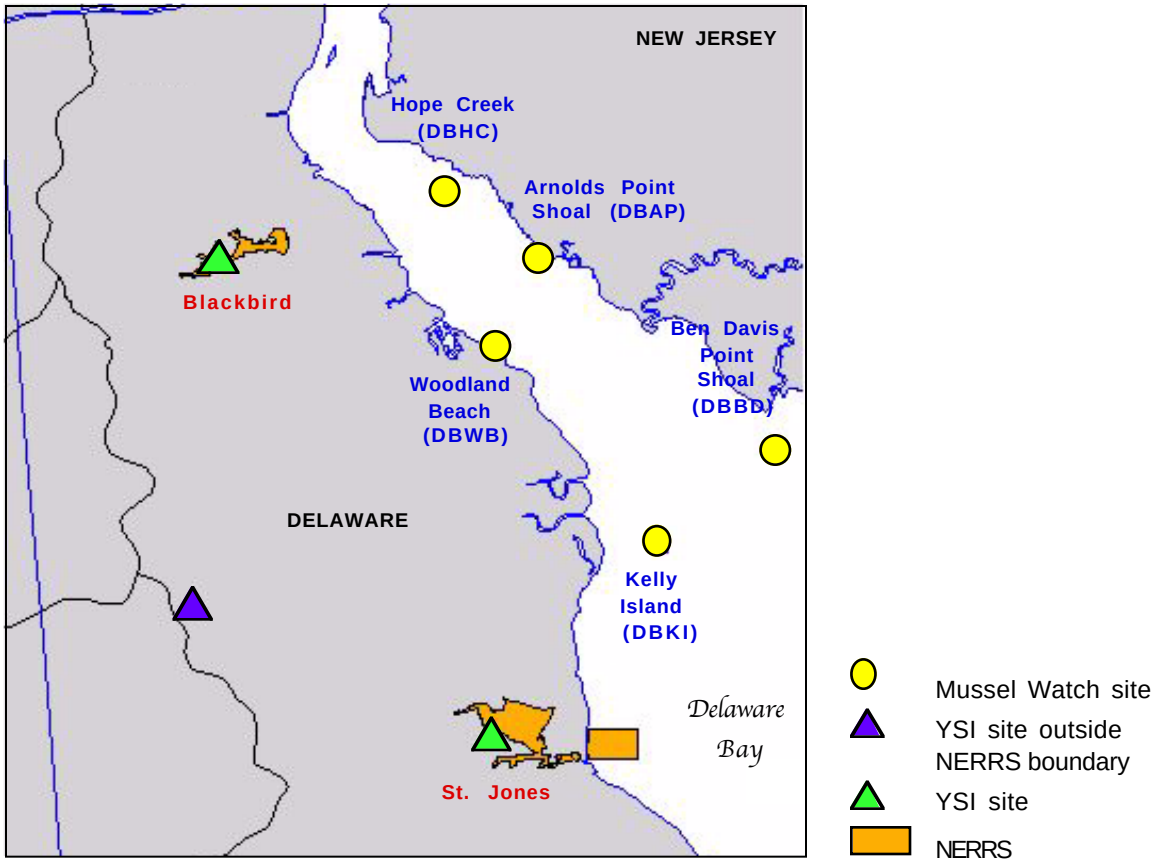


Figure 36. The two components of the Delaware NERRS and adjacent areas.

Table 15. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Hope Creek (Delaware Bay) (DBHC) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1989		8.23	1030.0	18333	5.2	3.30	21.78
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high'		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1989	14.67	0.18	0.123	1.06	267.2
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high'	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1989	14	157	121.7	28.03	15.33	<	15.33	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 28: Oyster Sampling, Delaware Bay, using an oyster dredge (TDI-Brook International, Inc.).

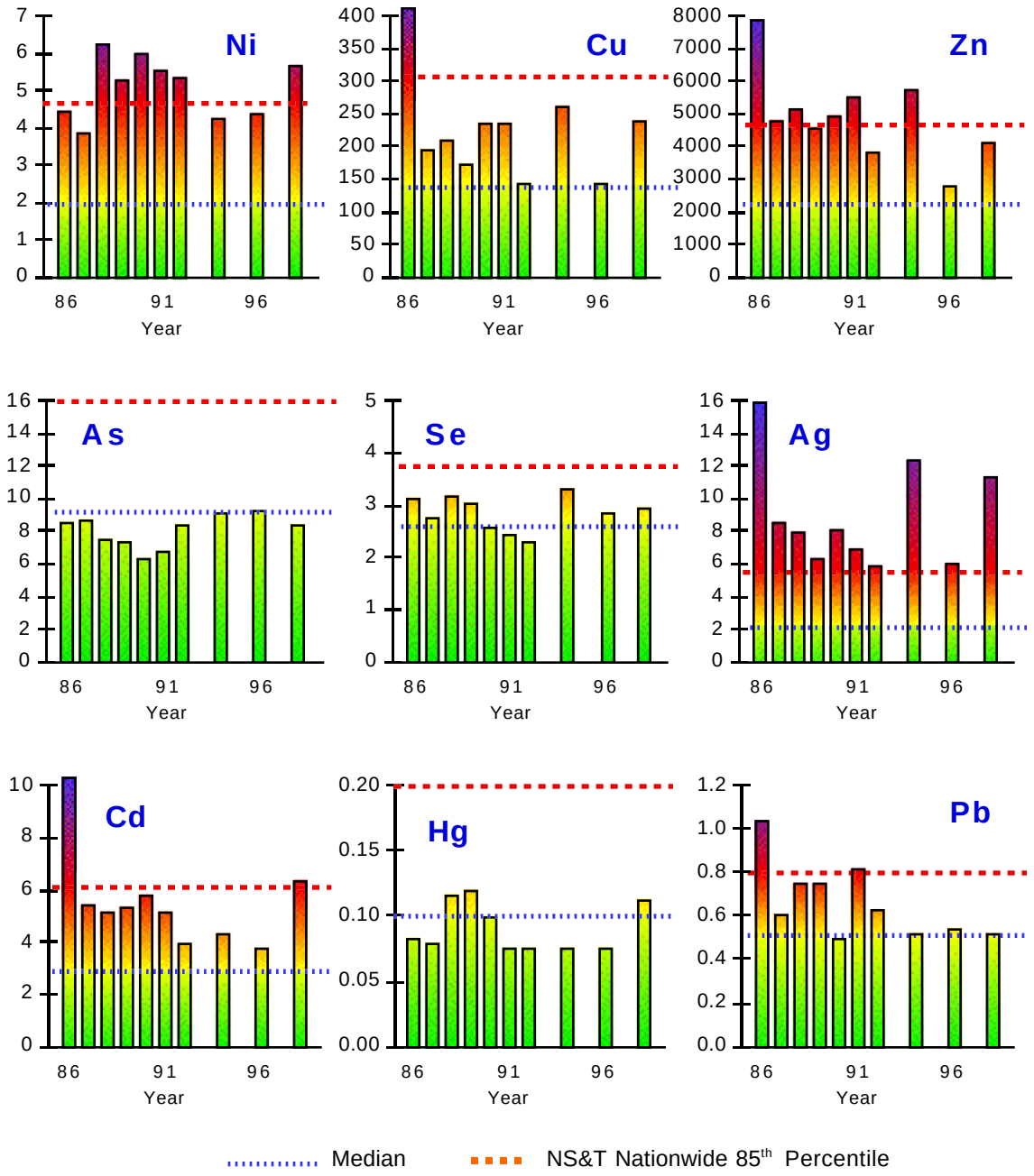


Figure 37. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Kelly Island (Delaware Bay) (DBKI) (µg/g dry wt.).

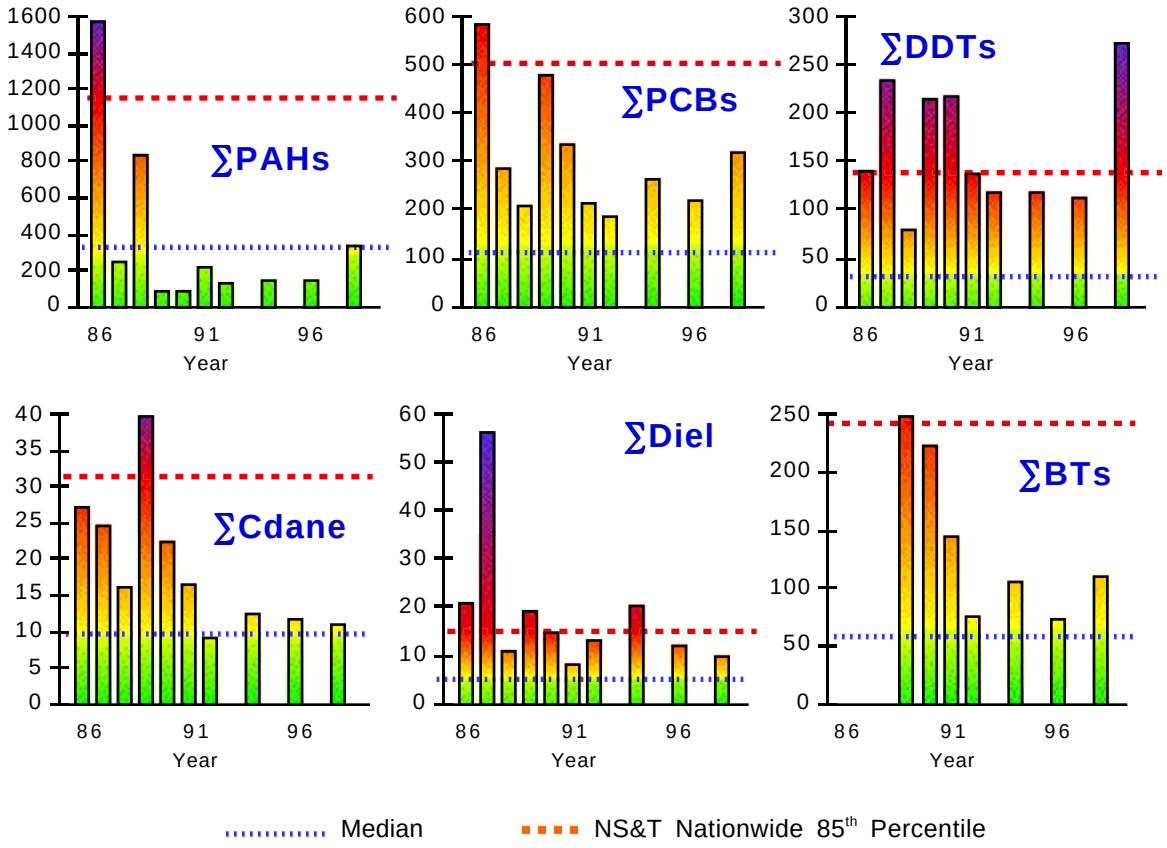


Figure 38. Trace organic contaminants and ∑BTs trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Kelly Island (Delaware Bay) (DBKI) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 29. Delaware NERR (NOAA National Estuarine Research Reserve Collection, nerr00051, NOAA Photo Collection, NOAA Central Library).

Table 16. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Kelly Island (Delaware Bay) (DBKI) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	22.7	4.23	400	7667	8.00	3.00	15.44
1987	13.6	3.67	183	4533	8.20	2.63	8.03
1988		6.03	197	4900	7.03	3.03	7.51
1989		5.07	160	4333	6.87	2.87	5.92
1990	11.0	5.81	223	4700	5.89	2.44	7.64
1991	16.3	5.33	223	5300	6.33	2.27	6.49
1992	21.0	5.12	130	3600	7.85	2.17	5.48
1994	8.2	4.06	250	5500	8.63	3.18	11.88
1996	8.4	4.20	131	2542	8.80	2.70	5.50
1998	28.0	5.48	227	3900	7.96	2.78	10.80
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high'		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1986	9.97	0.07	0.08	1.00	
1987	5.13	0.08	0.07	0.58	
1988	4.87	0.09	0.11	0.71	
1989	5.00	0.13	0.11	0.71	215
1990	5.53	0.07	0.09	0.46	240
1991	4.83	0.13	0.07	0.78	138
1992	3.62	0.17	0.07	0.59	67
1994	4.05	0.10	0.07	0.48	98
1996	3.51	0.40	0.07	0.50	66
1998	6.06	0.00	0.11	0.48	103
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high'	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	1526	565	131	26.0	19.0	<	3.50	1.08
1987	203	271	225	23.6	54.4	0.86	2.87	7.61
1988	798	194	70	15.1	9.3	0.23	3.17	2.70
1989	43	462	205	38.6	17.7	<	16.67	5.87
1990	35	316	209	21.2	13.0	<	5.93	0.04
1991	166	200	129	15.3	6.6	0.24	7.11	<
1992	89	170	109	8.1	11.3	<	2.92	<
1994	105	250	110	11.2	18.4	<	2.45	0.73
1996	97	203	103	10.4	10.2	0.34	1.57	0.63
1998	294	304	264	10.0	8.3	<	1.12	0.76
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 30. Aerial view of the Mussel Watch site at Kelly Island (DBKI), Delaware Bay, Delaware Bay NERR (TAMU/GERG).

Plate 31. Mussel Watch site at Kelly Island (DBKI), Delaware Bay, Delaware Bay NERR (TAMU/GERG).

CBM

Chesapeake Bay – Maryland NERR

Maryland

No Mussel Watch sites are representative of any of the three components of the Maryland Chesapeake Bay NERR (Otter Point, Jug Bay, and Monie Bay). The closest site to any of these is Bodkin Point, 20 miles from the Otter Point NERR.

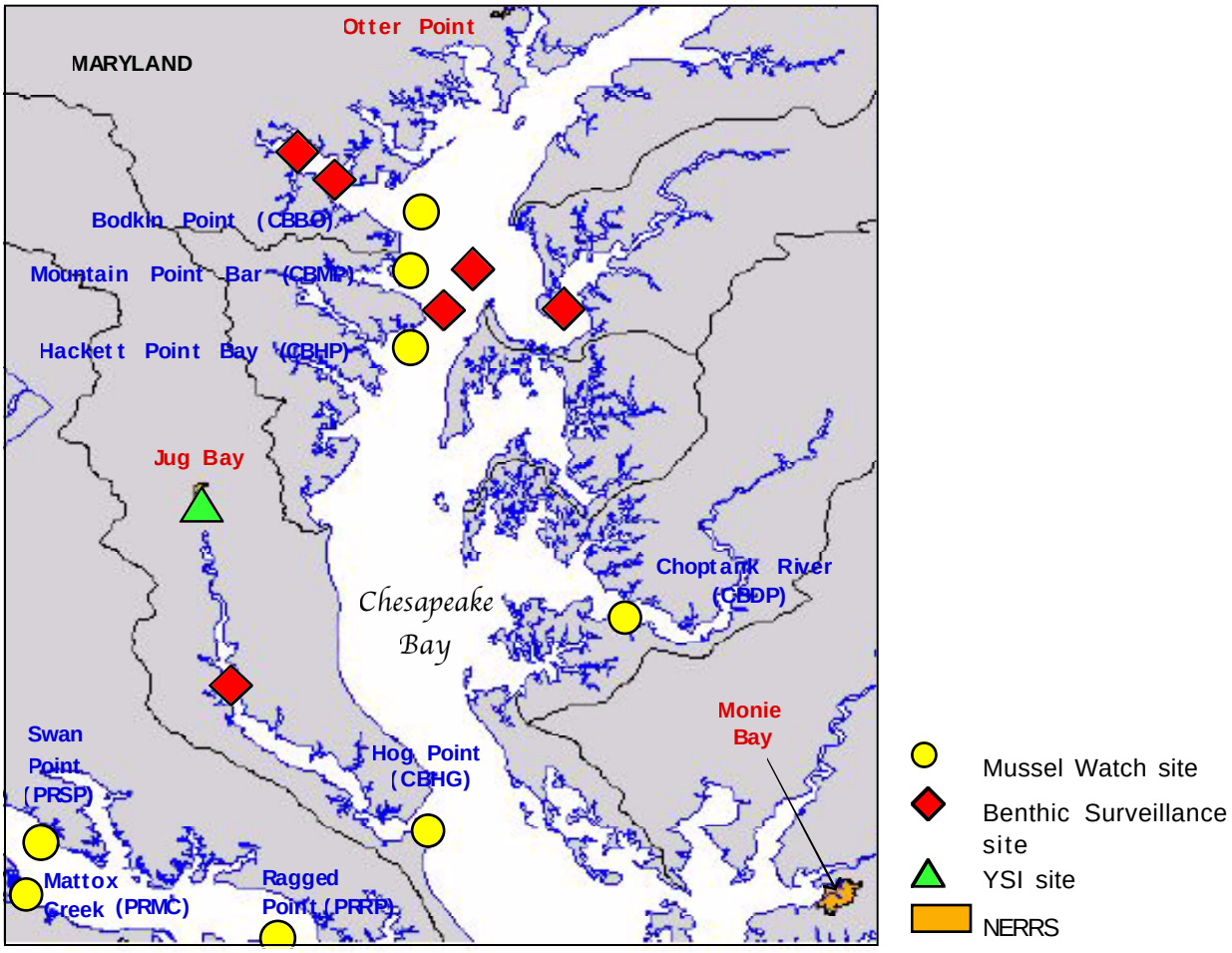


Figure 39. Chesapeake Bay – Maryland NERR and adjacent areas.

Plate 32. View into the shoreline of the Mussel Watch site at Dandy Point (CBDP), Chesapeake Bay, Chesapeake Bay NERR (TAMU/GERG).

Plate 33. View from shoreline of the Mussel Watch site at Dandy Point (CBDP), Chesapeake Bay, Chesapeake Bay NERR (TAMU/GERG).

CBV

Godwin Island Component
Chesapeake Bay – Virginia NERR

Virginia

There are four components associated with the Virginia Chesapeake Bay NERR: Sweet Hall Marsh, Taskinas Creek Catlett Islands and Godwin Island. Of these, Godwin Island is the closest to the Dandy Point Mussel Watch site. Being 10 miles away, the association is rated as fair (Table 1).

Zinc, silver, mercury, and lead all approached or exceed the 85th percentile. Some grouped and individual organics – ∑Cdane, ∑BTs, hexachlorobenzene, Lindane, and Mirex – exceeded the 85th percentiles at some point. An increasing trend was found for copper, while ∑Cdane, ∑BTs, and hexachlorobenzene were all decreasing.

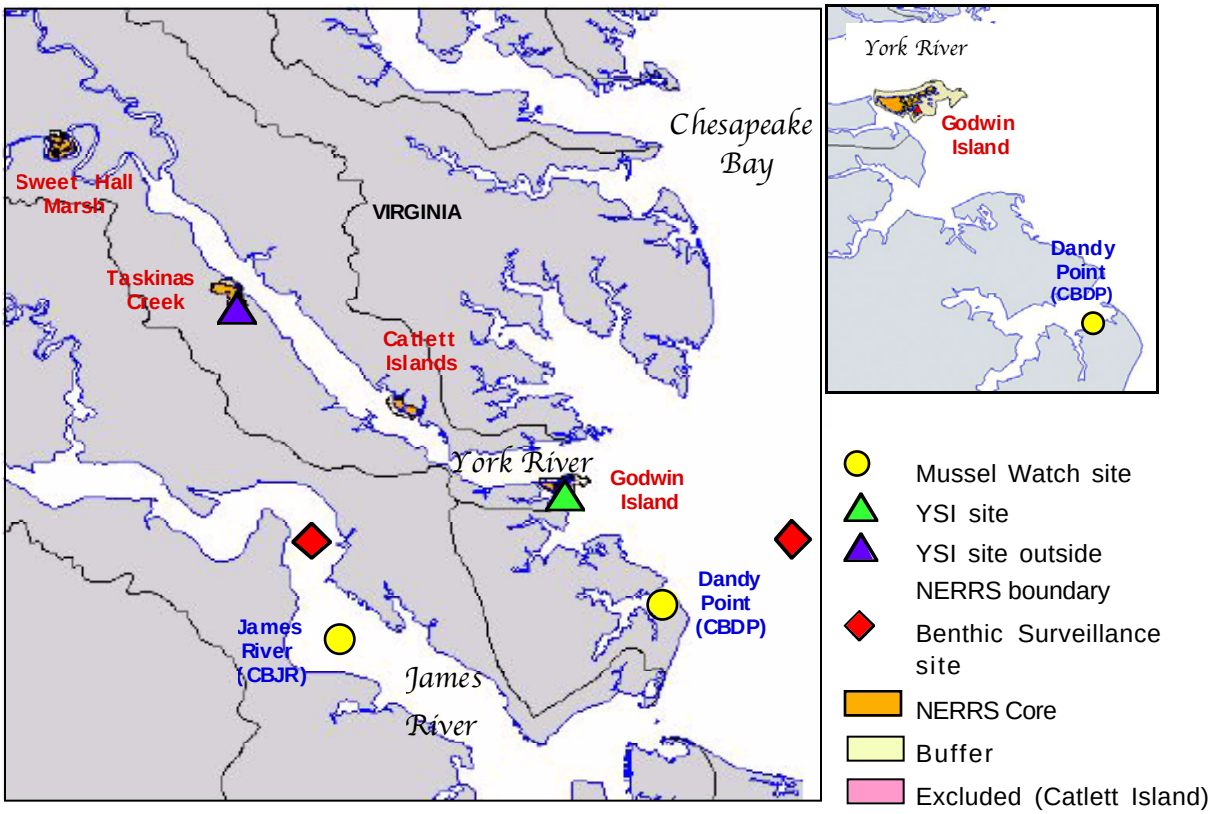


Figure 40. Chesapeake Bay – Virginia NERR and adjacent areas.

Plate 34. *Phragmites*, or common reed, although scenic can be invasive nuisance species, Patuxent River, MD (1997) (Photo: Mary Hollinger. America's Coastlines, line0620, NOAA Photo Collection, NOAA Central Library).

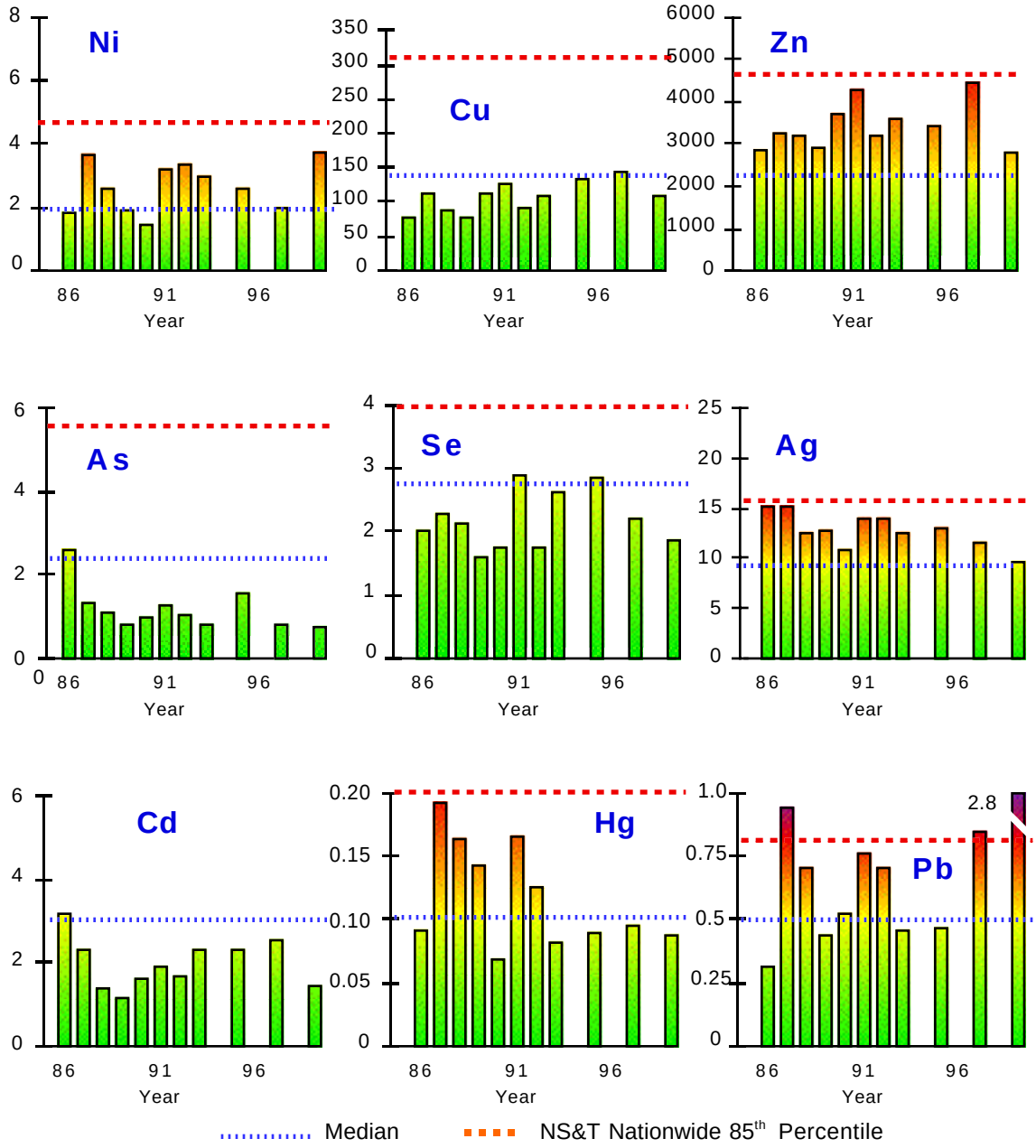


Figure 41. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Dandy Point (Chesapeake Bay) (CBDP) (µg/g dry wt.).

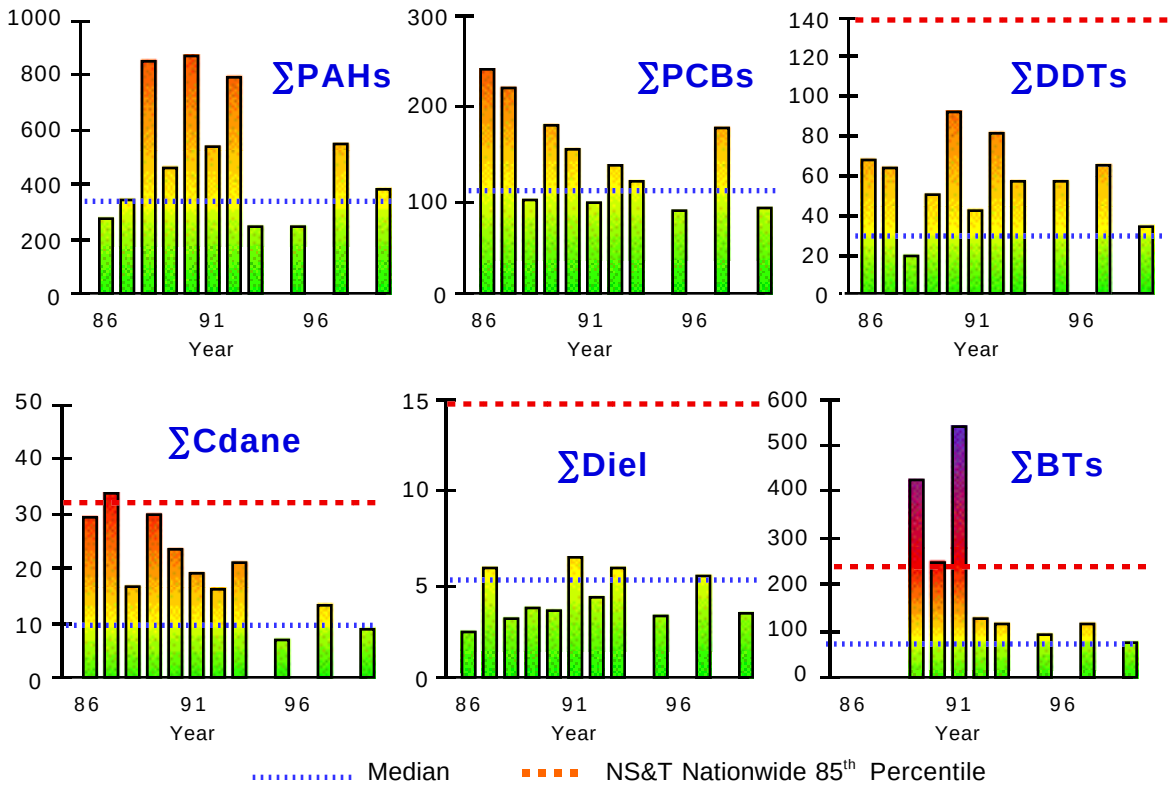


Figure 42. Trace organic contaminants and ∑BTs trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Dandy Point (Chesapeake Bay) (CBDP) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 35. The Goodwin Islands as seen from the air, York River, Virginia, Chesapeake Bay NERR (Photographer A. Bahen. NOAA National Estuarine Research Reserve Collection, nerr0188, NOAA Photo Collection, NOAA Central Library).

Table 17. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Dandy Point (Chesapeake Bay) (CBDP) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	15.3	1.60	67	2700	14.7	2.03	2.43
1987	17.0	3.40	102	3067	14.7	2.30	1.08
1988		2.37	78	3000	12.0	2.07	0.87
1989		1.67	66	2733	12.3	1.67	0.55
1990	12.2	1.20	100	3567	10.4	1.79	0.68
1991	15.0	2.97	117	4100	13.3	2.90	0.96
1992	13.0	3.13	80	3000	13.4	1.77	0.79
1993	9.3	2.76	98	3400	12.0	2.53	0.58
1995	11.1	2.38	128	3274	12.6	2.89	1.32
1997	12.0	2.00	140	4521	11.2	2.32	0.62
1999	24.3	3.73	115	2690	9.4	1.83	0.55
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high'		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1986	2.93	0.06	0.090	0.30	
1987	2.13	0.21	0.190	0.86	
1988	1.17	0.20	0.170	0.72	
1989	0.96	0.12	0.147	0.44	424
1990	1.42	0.32	0.067	0.52	259
1991	1.73	0.15	0.173	0.75	543
1992	1.52	0.16	0.130	0.71	130
1993	2.07	0.00	0.070	0.45	109
1995	2.08	0.26	0.081	0.45	97
1997	2.39	0.22	0.092	0.87	113
1999	1.34		0.086	2.77	86
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high'	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	280	235	66	28	2.83	1.33	<	15.77
1987	355	211	61	32	7.60	1.87	0.13	<
1988	838	92	16	15	3.80	0.57	2.40	0.57
1989	437	176	47	29	4.60	<	<	2.50
1990	891	147	90	22	4.37	0.27	3.70	<
1991	560	87	39	17	8.47	0.35	4.51	<
1992	775	129	78	15	5.43	<	3.85	<
1993	341	108	54	19	7.74	<	0.68	<
1995	341	68	54	5	3.91	0.10	0.75	<
1997	537	183	64	14	5.15	0.34	0.60	0.59
1999	382	95	36	10	2.86	<	<	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 36. Mussel Watch site at Dandy Point (CBDP), Chesapeake Bay, in the Chesapeake Bay NERR (TAMU/GERG).

Plate 37. Muddy shoreline next to an abandoned shack, Patuxent River, MD (1994) (Photographer: Mary Hollinger. America's Coastlines, line0631, NOAA Photo Collection, NOAA Central Library).

NOC

North Carolina NERR

North Carolina

The four components of the North Carolina NERR are Carrituck Banks, Rachel Carson, Masonboro Island and Zeke's Island. There are Mussel Watch sites at or near Rachel Carson and Zeke's Island. These are discussed separately in the next two sections.

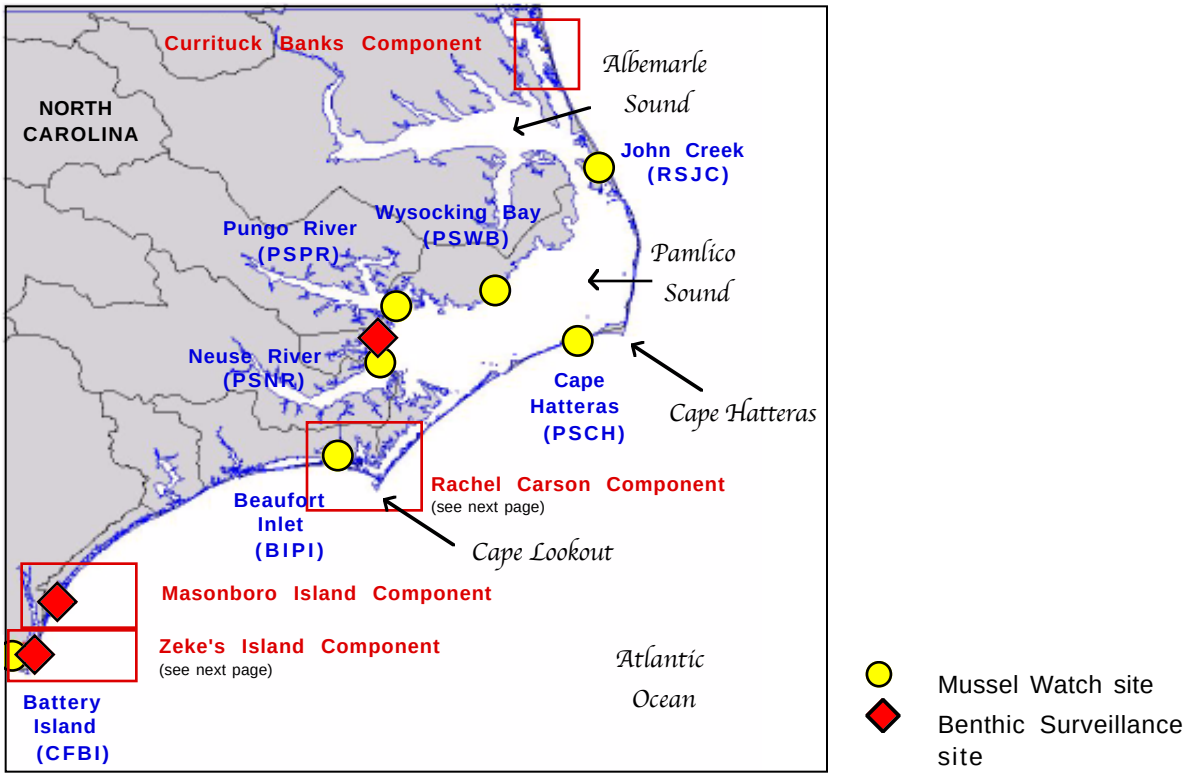


Figure 43. North Carolina NERR and adjacent areas.

Plate 38. North Inlet, Winyah Bay National Estuarine Research Reserve. Aerial view of North Inlet (foreground) and Winyah Bay (upper left and top), Winyah Bay NERR, Georgetown, South Carolina (NOAA National Estuarine Research Reserve Collection, nerr0313, NOAA Photo Collection, NOAA Central Library).

Plate 39. A flight of Black Skimmers, North Carolina NERR, Masonboro Island, North Carolina (NOAA National Estuarine Research Reserve Collection, nerr0090, NOAA Photo Collection, NOAA Central Library).

NOC
Rachel Carson Component
North Carolina NERR
North Carolina

The Beaufort Inlet (Pivers Island) Mussel Watch site is 0.3 miles from the Rachel Carson component and is considered an excellent match (Table 1).

Trace elements are generally at or below the median NS&T value. Oysters had lead concentrations at or above the NS&T 85th percentile. Arsenic levels are among the highest found anywhere in the nation.

The arsenic appears to be primarily from natural sources and is in a chemical form that does not lead to adverse biological effects. These high levels are common along the U.S. Southeast coast (Lauenstein *et al.*, 2002).

Of the summed organics, both ∑PAHs and ∑BTs at Pivers Island exceeded the NS&T 85th percentile. This seems to be related to the site location and nearby boating activity, respectively (Lauenstein *et al.*, 2002). Mirex exceeded the 85th percentile.

The only trend found was increasing copper.

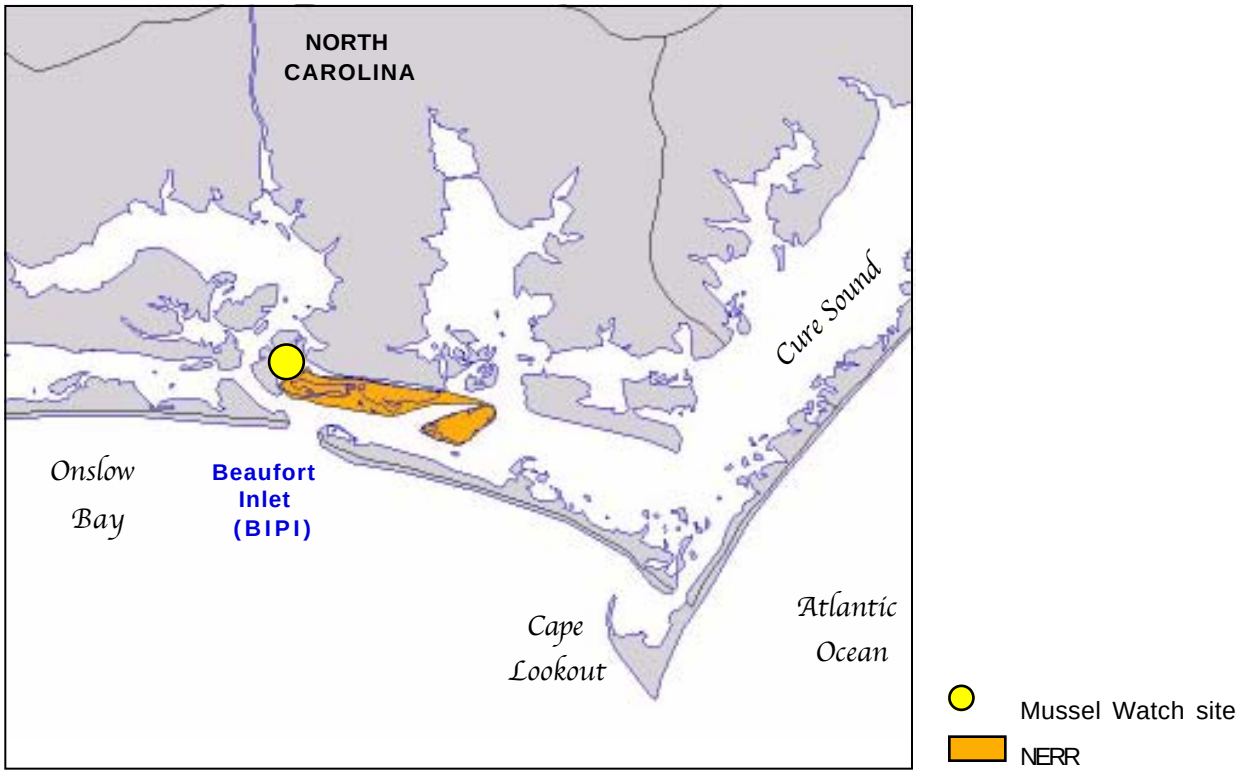


Figure 44. Rachel Carson component, North Carolina NERR, and adjacent areas.

Plate 40. Core Sound, North Carolina (1998) (Photographer M. Beaver. America's Coastline Collection, line0540, NOAA Photo Collection, NOAA Central Library).

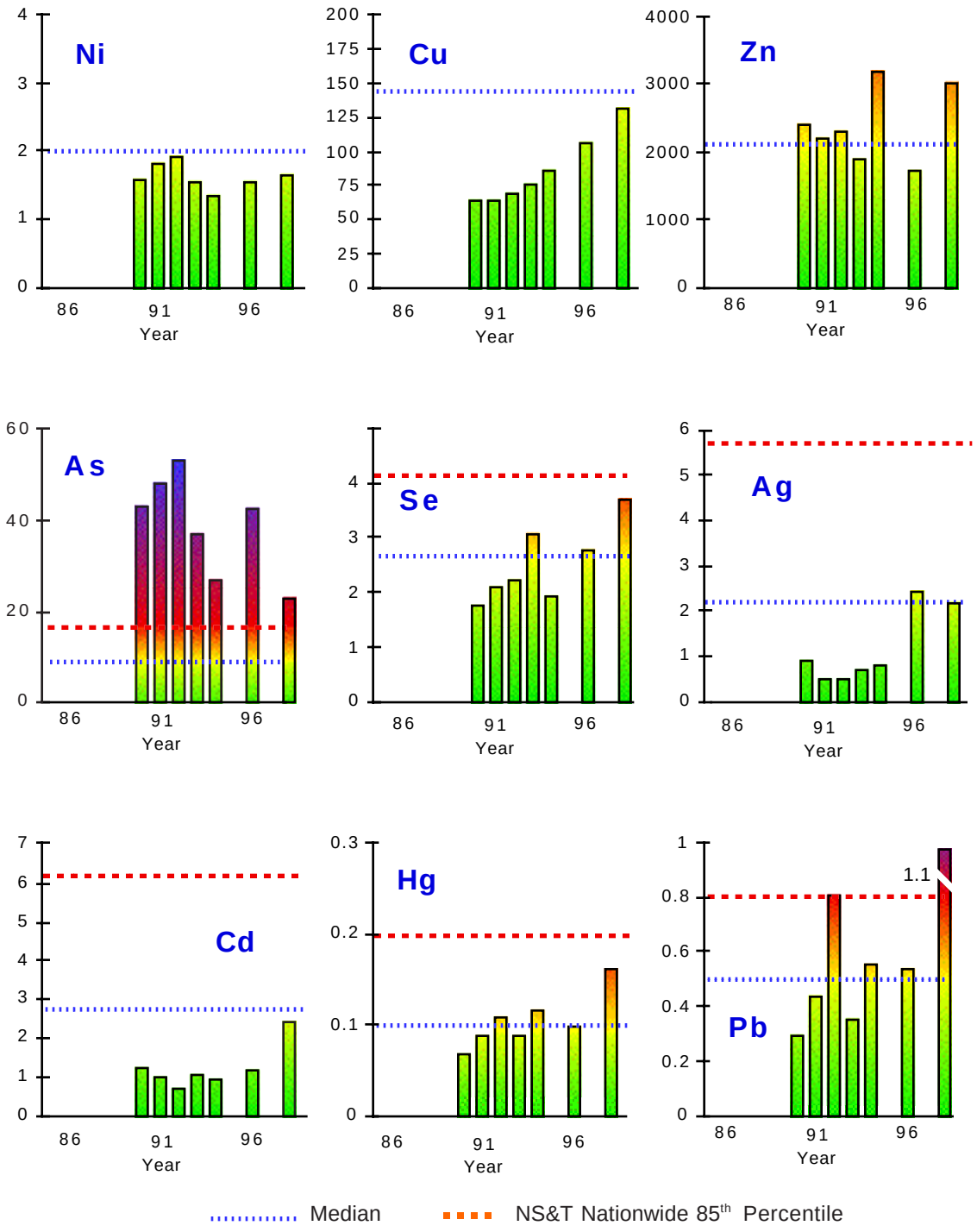


Figure 45. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Pivers Island (Beaufort Inlet) (BIPI) (µg/g dry wt.).

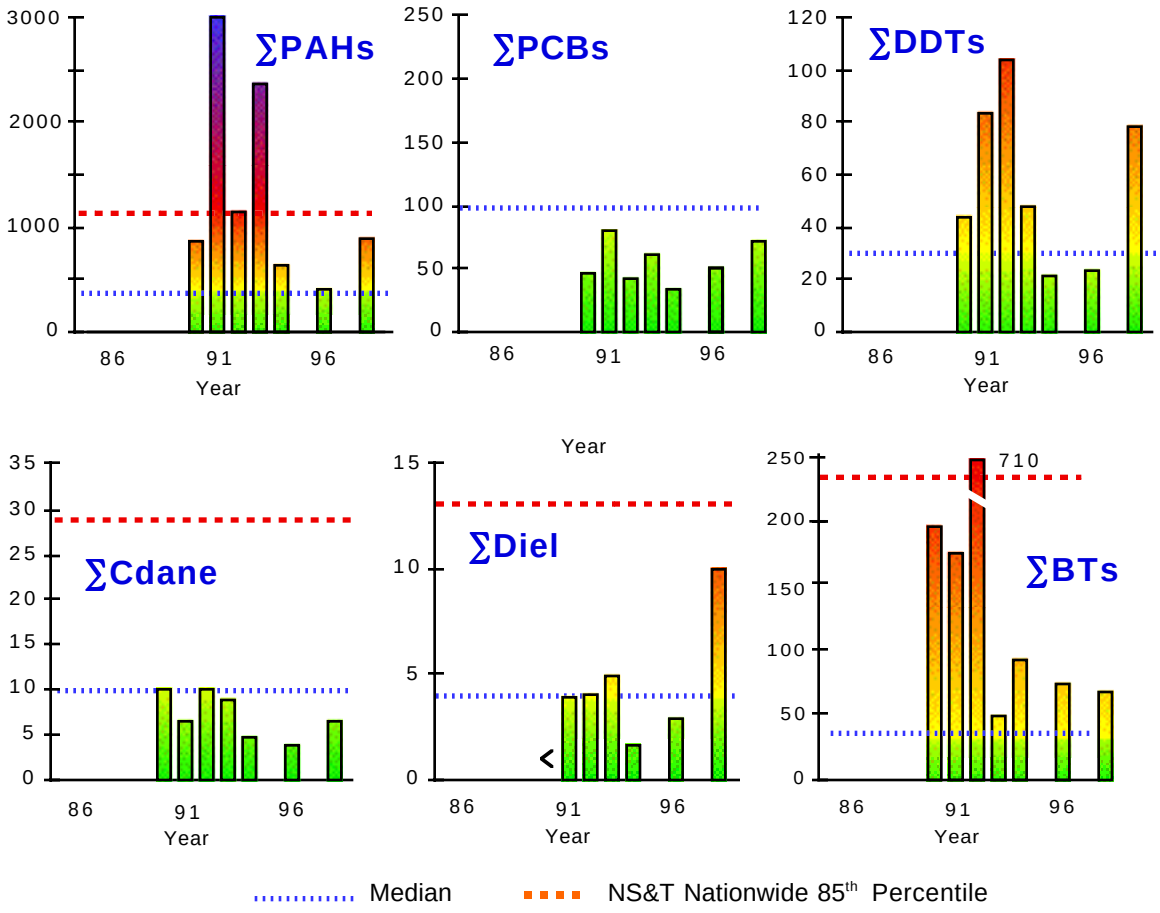


Figure 46. Trace organic contaminants and total butyltins trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Pivers Island (Beaufort Inlet) (BIPI) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 41. Panoramic view of a *Spartina alterniflora* salt marsh in North Inlet Estuary, Georgetown, South Carolina, Winyah Bay NERR (NOAA NERR Collection, nerr0320, NOAA Photo Collection, NOAA Central Library).

Table 18. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Pivers Island (Beaufort Inlet) (BIPI) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1990	10.7	1.51	59.9	2300	41.8	1.67	0.83
1991	11.6	1.73	60.0	2100	47.0	2.00	0.43
1992	8.8	1.86	65.6	2200	52.5	2.12	0.41
1993	8.8	1.46	71.3	1800	36.0	2.95	0.62
1994	9.1	1.27	82.4	3100	25.5	1.87	0.67
1996	9.7	1.50	102.0	1652	41.5	2.70	2.30
1998	17.9	1.60	128.0	2930	22.1	3.49	2.10
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high'		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1990	1.11	0.16	0.063	0.28	194.8
1991	0.86	0.13	0.083	0.42	173.2
1992	0.60	0.42	0.100	0.79	707.8
1993	0.94	<	0.080	0.34	43.8
1994	0.82	0.13	0.110	0.53	87.6
1996	1.03	0.32	0.090	0.50	68.5
1998	2.34	0.40	0.154	1.13	64.2
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high'	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1990	1304	41	42.4	9.19	<	0.00	2.43	1.46
1991	3241	74	82.0	5.98	3.63	0.48	0.43	<
1992	1129	36	102.0	9.29	3.72	<	0.00	1.74
1993	2314	57	45.6	7.99	4.67	<	0.00	3.08
1994	623	29	19.6	4.09	1.34	<	0.28	1.94
1996	440	46	22.0	3.09	2.55	0.29	0.05	1.24
1998	800	55	78.6	5.43	9.96	<	0.63	2.62
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 42. Mussel Watch site at Battery Island (CFBI), Cape Fear, in the Zeke's Island component of the NERR (TAMU/GERG).

Plate 43. Second view of the Mussel Watch site at Battery Island (CFBI), Cape Fear, in the Zeke's Island component of the NERR (TAMU/GERG).

NOC

Zeke's Island
North Carolina NERR

North Carolina

Even though the Cape Fear-Battery Island Mussel Watch site is only three miles away from the Zeke's Island component, the match is only fair (Table 1). The site is closer to a population center than the Reserve.

Like the Pivers Island site, trace elements at Battery Island are generally at or below the median NS&T value, and at least one lead concentration was at or above the NS&T 85th percentile. Like other sites along the south-east coast, arsenic levels are high.

In 1986, ∑PAHs exceeded the 85th percentile. Hexachlorobenzene also exceeded the 85th percentile in 1988 and 1991.

There were no trends.

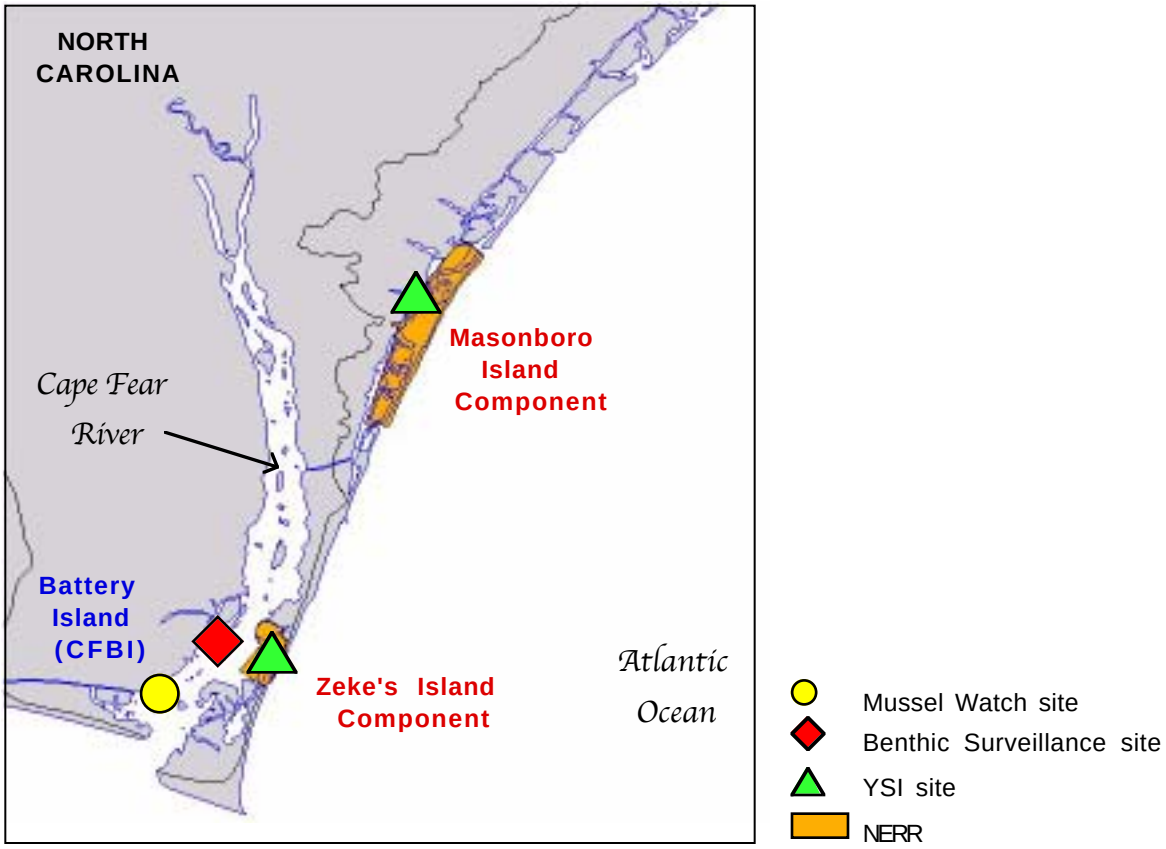


Figure 47. Zeke's Island component, North Carolina NERR, and adjacent areas.

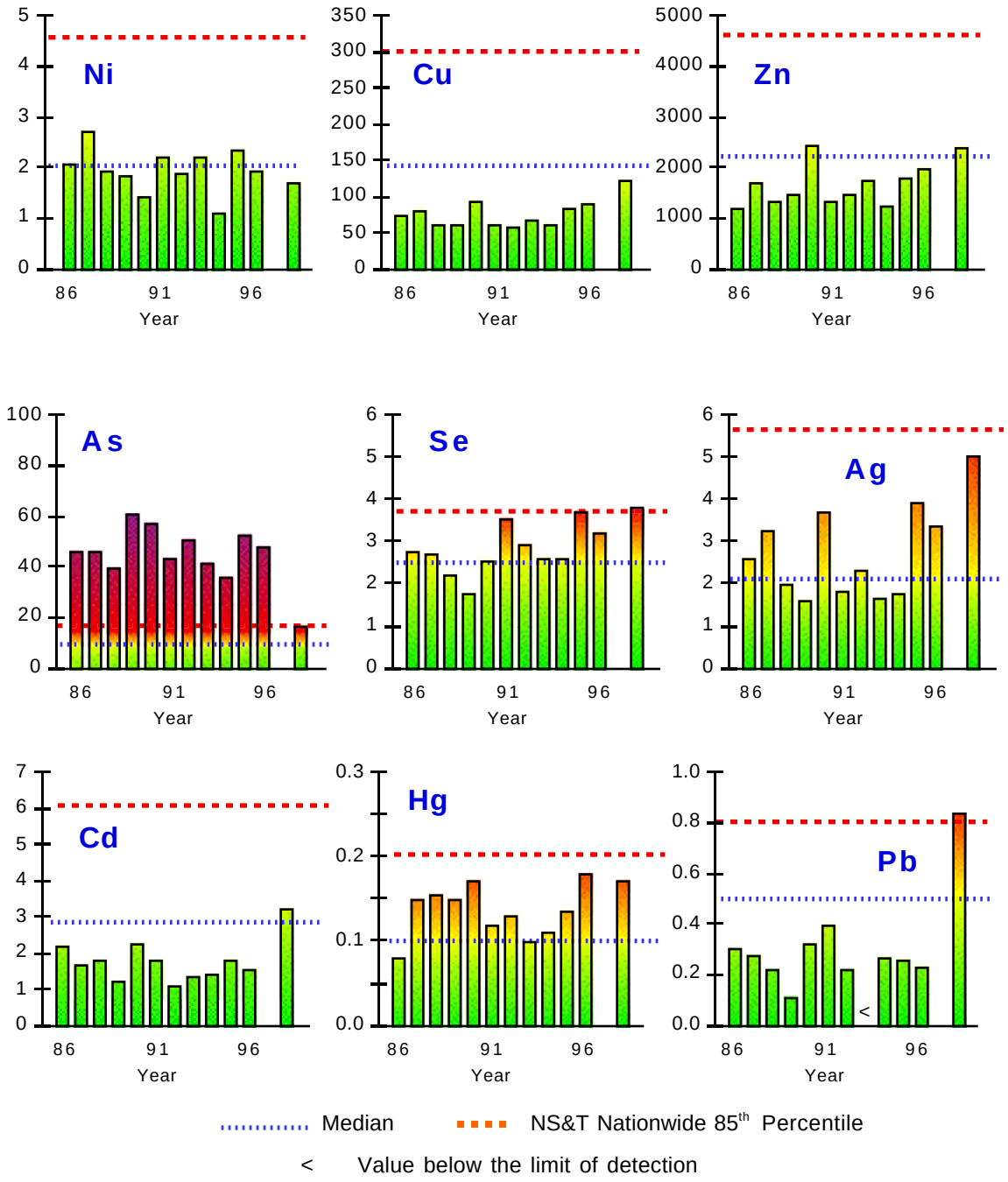


Figure 48. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Battery Island (Cape Fear) (CFBI) (µg/g dry wt.).

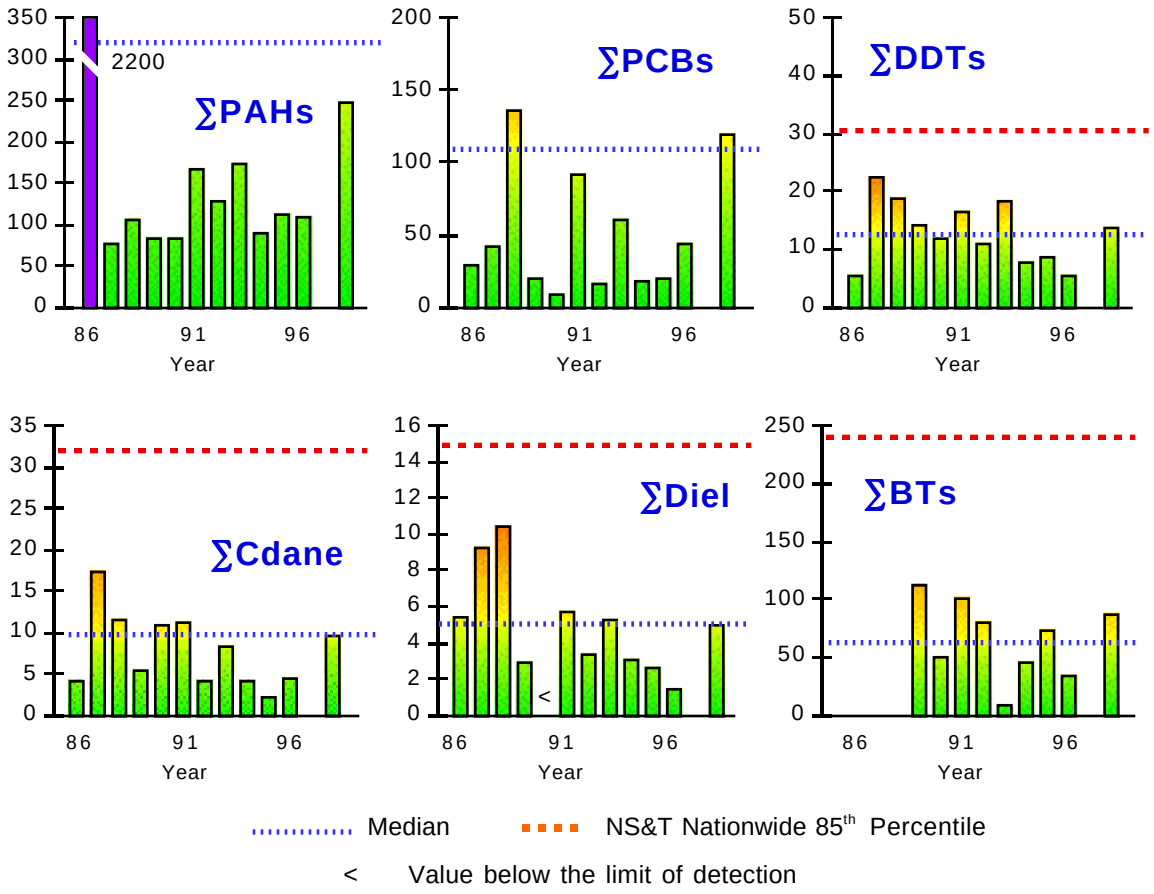


Figure 49. Trace organic contaminant and total butyltin trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Battery Island (Cape Fear) (CFBI) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 44. Aerial view, Mussel Watch site at Battery Island (CFBI), Cape Fear, in the Zeke's Island NERR (TAMU/GERG).

Table 19. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Battery Island (Cape Fear) (CFBI) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	13.3	1.90	62.7	1027	42.7	2.57	2.40
1987	10.3	2.57	70.3	1533	43.3	2.50	3.08
1988		1.77	49.0	1200	36.7	2.03	1.83
1989		1.70	51.7	1333	57.7	1.60	1.39
1990	13.3	1.29	81.8	2267	53.9	2.39	3.51
1991	12.7	2.07	51.0	1167	40.3	3.37	1.63
1992	8.3	1.75	47.4	1300	47.6	2.73	2.14
1993	6.7	2.06	58.0	1600	38.0	2.41	1.46
1994	12.7	0.94	49.4	1100	32.6	2.39	1.60
1995	10.9	2.18	74.4	1663	49.1	3.51	3.75
1996	14.1	1.80	79.0	1814	45.0	3.00	3.20
1998	25.7	1.56	111.0	2260	13.2	3.64	4.84
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high'		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1986	1.97	0.07	0.070	0.27	
1987	1.47	0.05	0.140	0.24	
1988	1.60	0.09	0.147	0.19	
1989	1.01	0.09	0.140	0.08	106.1
1990	2.07	0.29	0.163	0.29	42.9
1991	1.60	0.12	0.110	0.36	93.9
1992	0.89	0.20	0.120	0.19	72.2
1993	1.17	<	0.090	<	0.9
1994	1.20	0.06	0.100	0.24	38.8
1995	1.57	0.23	0.126	0.23	64.9
1996	1.32	<	0.170	0.20	27.9
1998	3.03	0.59	0.163	0.81	80.4
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high'	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	2200	24	4.0	3.21	5.03	0.23	<	<
1987	65	36	21.0	16.20	8.83	<	0.62	<
1988	96	131	17.5	10.47	10.03	5.37	1.47	0.70
1989	74	14	12.9	4.57	2.40	0.89	0.96	<
1990	74	3	10.3	9.94	<	0.00	<	<
1991	156	86	15.2	10.12	5.27	1.69	4.40	<
1992	119	11	9.6	2.97	2.84	<	0.00	<
1993	163	55	16.7	7.41	4.82	<	0.00	<
1994	81	11	6.5	3.28	2.68	<	0.71	<
1995	102	15	7.3	1.25	2.20	0.08	0.47	0.27
1996	99	38	4.2	3.52	0.98	0.16	0.33	0.38
1998	236	113	12.9	8.71	4.50	0.16	1.65	<
NS&T 'median'	320	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'1130	450	140	32	15	1.1	2.8	1.2	

< Value below the limit of detection

NIW
North Inlet-Winyah Bay NERR
South Carolina

Even though the Mussel Watch site at Lower Bay is 1.6 miles away from the Reserve boundaries, there is a good match because both locations are influenced by the same waters (Table 1). This site was established in 1989. The Mussel Watch site in the Santee River-North Bay is considered only a fair match. Being 6.3 miles away, it lies in a somewhat different estuarine area.

Trace element concentrations at both sites are generally low with the exception of a few instances of high silver and lead concentrations at the Lower Bay site, and selenium at North Bay site. Arsenic levels for both sites are some of the highest reported. High arsenic concentrations for the U.S. Southeast are discussed in the section on the North Carolina NERR. Organic concentrations are uniformly low at both locations, with the exception of Mirex, which was high at the North Bay site.

No increasing or decreasing trends were found for trace elements. Apparent increasing trends were found for ∑Dieldrin and Lindane at the Lower Bay site. While statistically significant, this is most likely the result of low contaminant concentrations and using zeros to indicate values below the detection limit.

An increasing ∑PAHs trend was found for the North Bay, a result that was not overly influenced by detection limit issues.

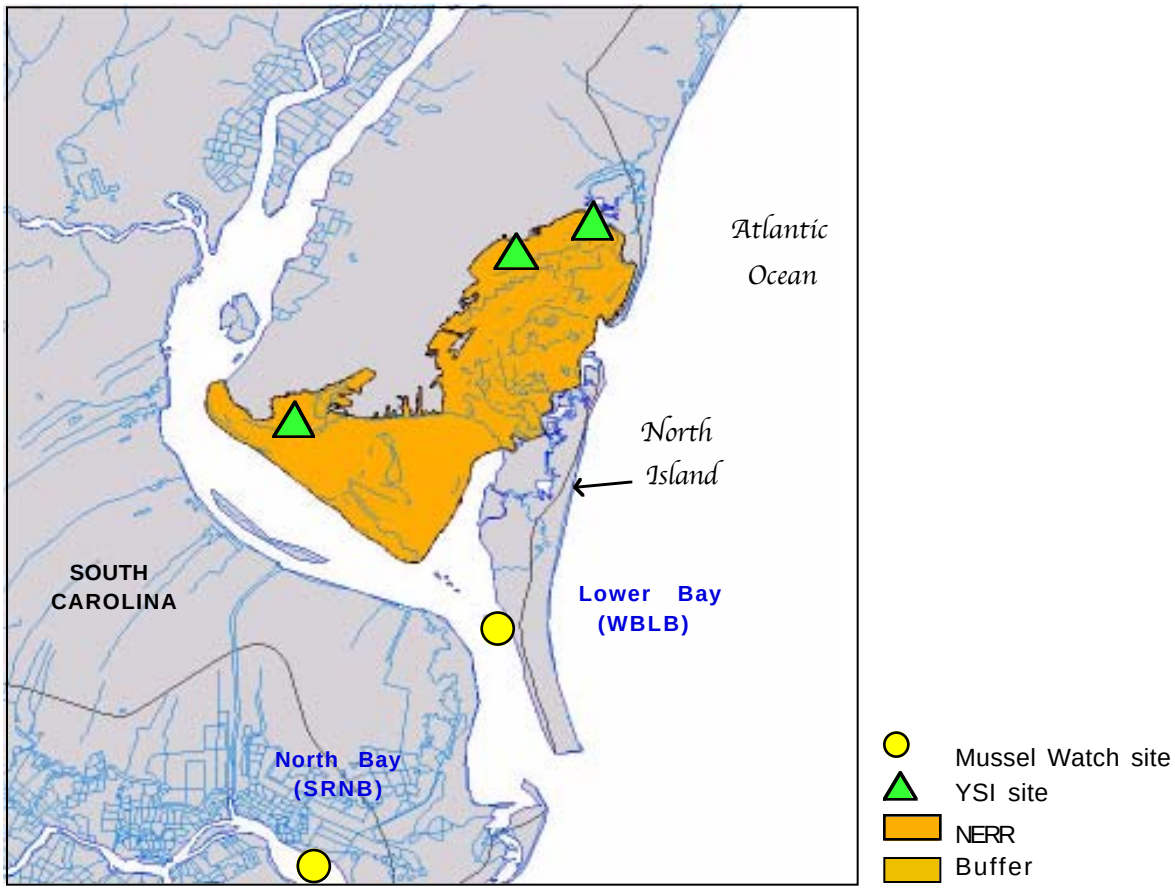


Figure 50. North Inlet-Winyah Bay NERR and adjacent areas.

Plate 45. Aerial view, Mussel Watch site at Lower Bay (WBLB), Winyah Bay, in the North Inlet-Winyah Bay NERR (TAMU/GERG).

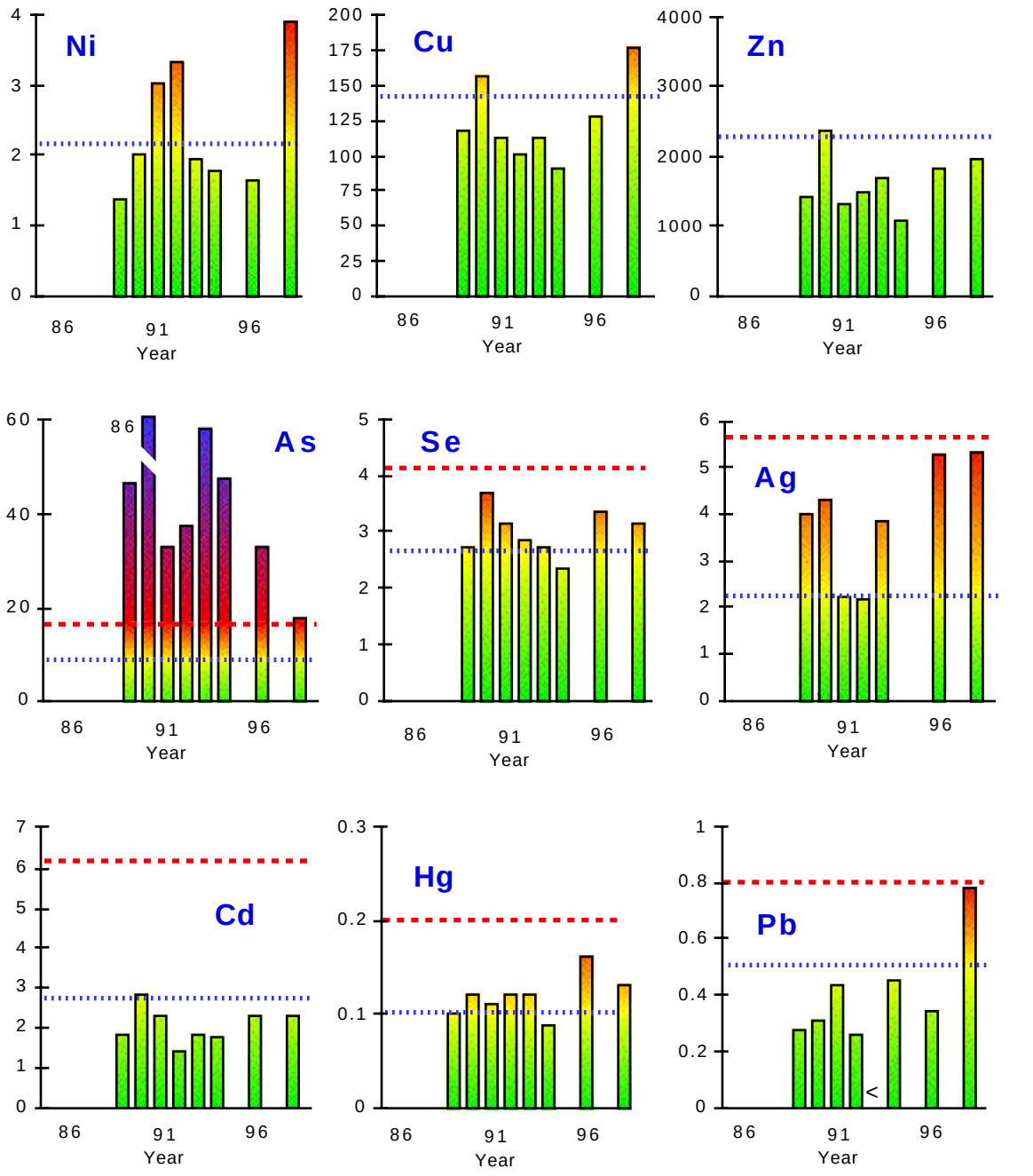


Figure 51. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Lower Bay (Winyah Bay) (WBLB) (µg/g dry wt.).

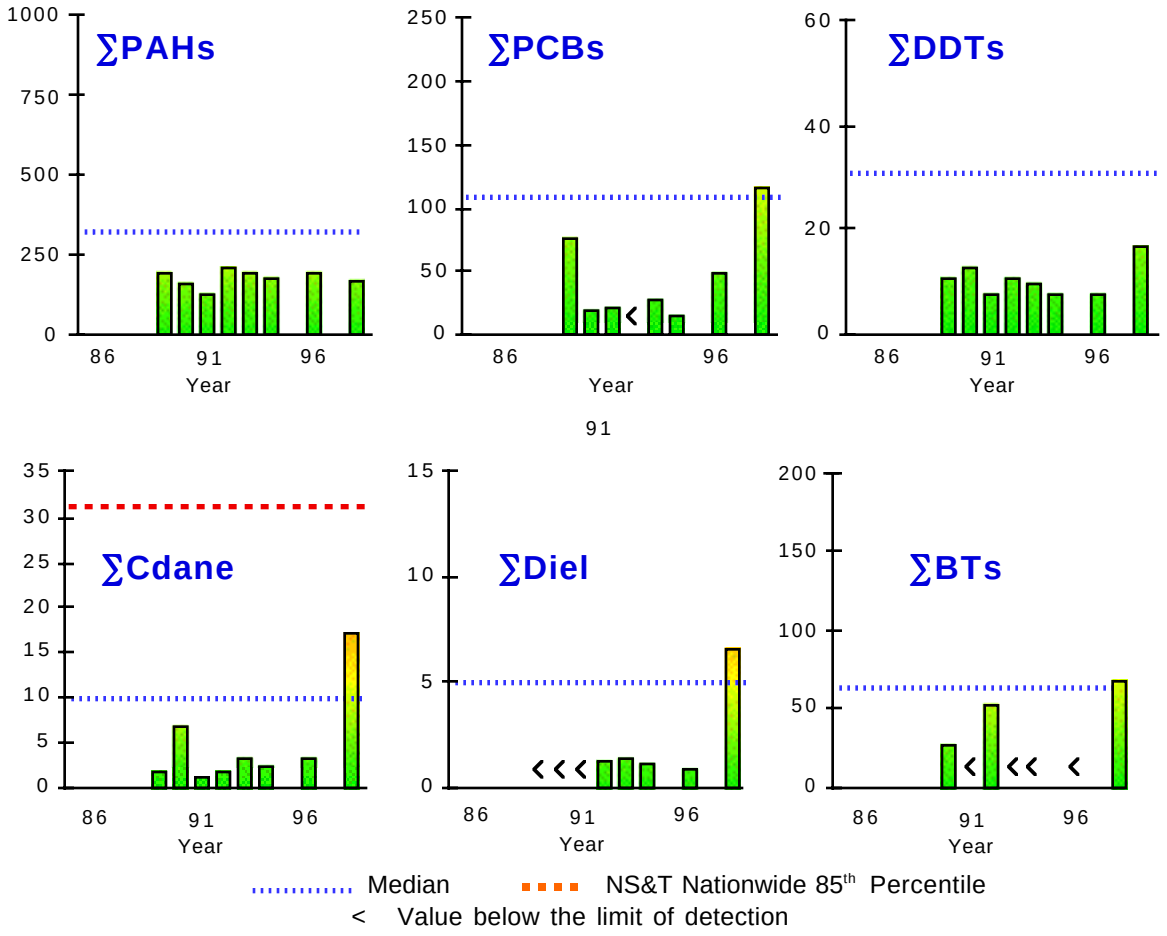


Figure 52. Trace organic contaminant and total butyltin trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Lower Bay (Winyah Bay) (WBLB) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 46. Mussel Watch site at Lower Bay (WBLB), Winyah Bay, in the North Inlet-Winyah Bay NERR (TAMU/GERG).

Table 20. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Lower Bay (Winyah Bay) (WBLB) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1989		1.30	113.3	1333	45.3	2.63	3.87
1990	25.0	1.94	153.3	2267	86.8	3.62	4.18
1991	32.3	2.97	110.0	1233	31.7	3.03	2.08
1992	22.0	3.25	97.5	1400	36.1	2.76	2.04
1993	12.0	1.86	110.0	1600	57.0	2.64	3.75
1994	11.3	1.70	86.4	1000	46.3	2.22	2.80
1996	20.8	1.60	125.0	1734	31.5	3.30	5.10
1998	30.0	3.89	170.0	1860	18.2	2.99	5.25
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1989	1.67	<	0.093	0.25	<
1990	2.63	0.21	0.113	0.29	22.9
1991	2.13	0.04	0.107	0.41	<
1992	1.27	0.05	0.120	0.23	47.1
1993	1.67	<	0.120	<	<
1994	1.60	0.05	0.080	0.43	<
1996	2.15	0.02	0.160	0.30	<
1998	3.58	0.42	0.125	0.78	65.7
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1989	60	70	6.8	0.87	<	<	<	<
1990	64	14	9.8	5.83	<	<	<	0.26
1991	59	15	4.9	0.33	<	<	<	<
1992	150	<	7.3	0.91	0.92	<	<	<
1993	120	21	6.3	2.20	1.07	0.31	0.60	<
1994	94	9	4.3	1.52	0.74	<	0.50	0.37
1996	128	44	4.9	2.52	0.54	0.24	0.74	0.56
1998	116	113	10.9	17.62	6.34	0.55	0.09	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high	1200	450	140	32	15	1.1	2.8	1.2

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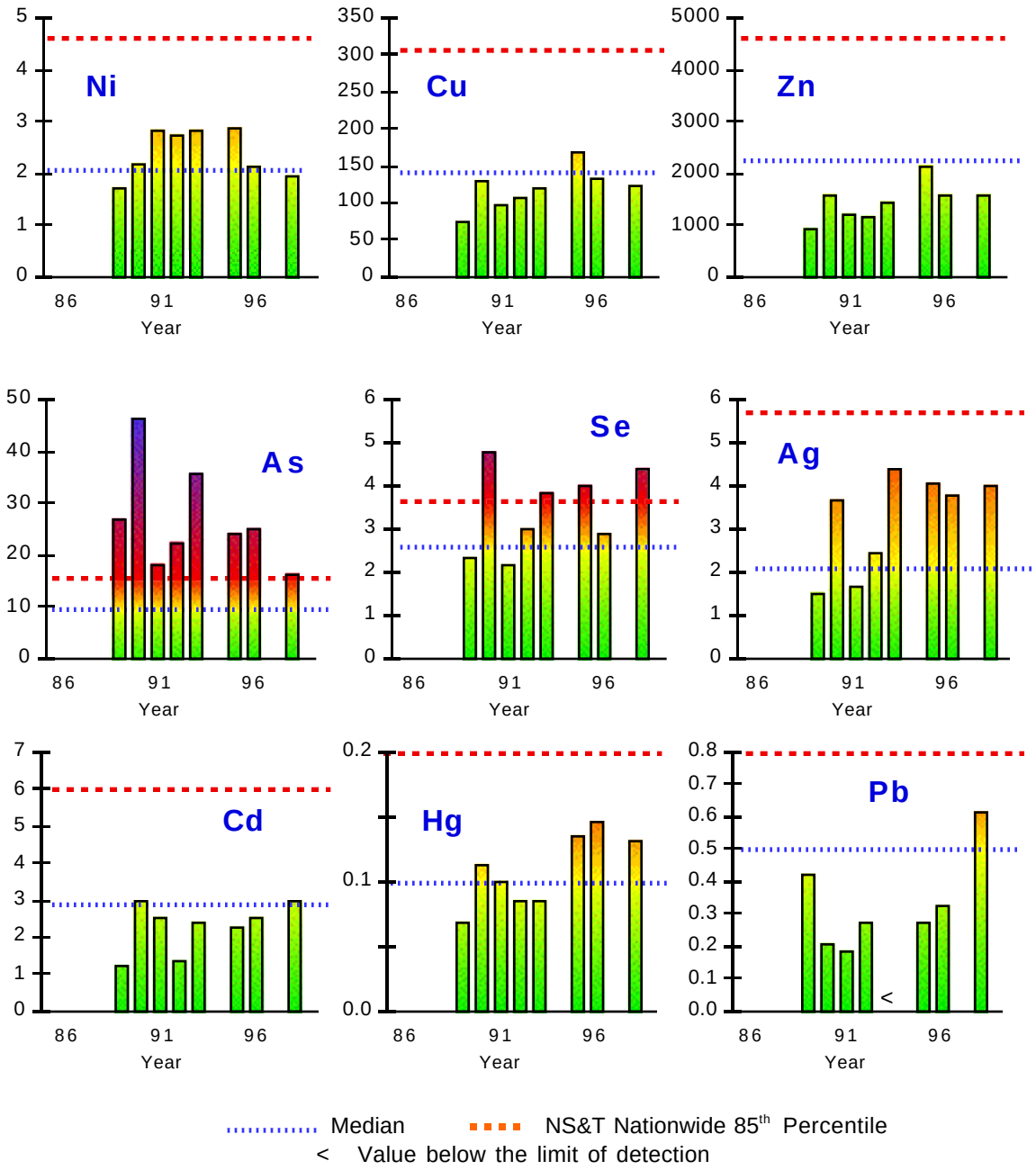

Figure 53. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site North Bay (Santee River) (SRNB) (µg/g dry wt.).

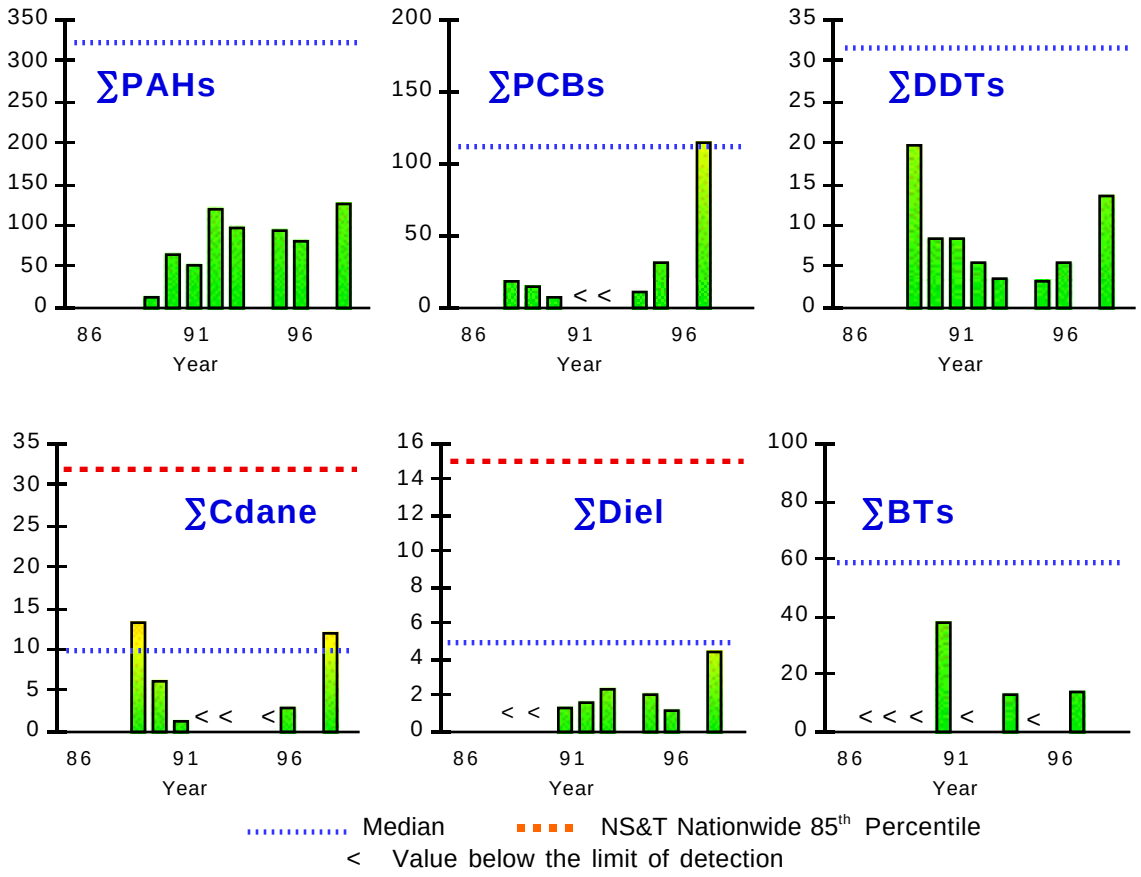

Figure 54. Trace organic contaminant and total butyltin trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site North Bay (Santee River) (SRNB) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 47. Aerial view of a thousand-acre Rice field on the Belle W. Baruch Foundation's property, Hobcaw Barony, George-town, South Carolina (Winyah Bay in foreground, North Inlet and Atlantic Ocean in background), Winyah Bay NERR (NOAA National Estuarine Research Reserve Collection, nerr0314, NOAA Photo Collection, NOAA Central Library).

Table 21. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site North Bay (Santee River) (SRNB) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1989		1.57	63.7	783	25.3	2.13	1.32
1990	27.0	2.02	120.0	1433	45.1	4.59	3.47
1991	12.2	2.70	87.3	1067	16.7	2.00	1.49
1992	10.0	2.59	95.0	1000	20.9	2.85	2.24
1993	16.0	2.66	110.0	1300	34.0	3.68	4.21
1995	19.8	2.73	159.4	1964	22.8	3.83	3.87
1996	19.9	2.00	123.0	1415	23.6	2.70	3.60
1998	43.5	1.78	112.0	1440	14.7	4.19	3.81
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1989	1.00	<	0.063	0.40	<
1990	2.78	0.07	0.107	0.18	<
1991	2.33	0.03	0.093	0.16	<
1992	1.15	0.05	0.080	0.25	35.1
1993	2.17	<	0.080	<	<
1995	2.04	0.32	0.129	0.25	9.8
1996	2.30	0.27	0.140	0.30	<
1998	2.77	<	0.125	0.60	10.5
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1989	3	12	18.9	12.20	<	<	<	<
1990	53	8	7.3	5.10	<	<	0.39	1.02
1991	40	1	7.3	0.21	0.82	<	<	<
1992	110	<	4.6	<	1.17	<	<	<
1993	87	<	2.5	<	1.86	0.40	<	<
1995	84	5	2.2	<	1.57	<	0.67	1.10
1996	71	26	4.6	1.95	0.72	0.30	0.64	1.16
1998	116	109	12.4	11.05	3.97	0.63	1.35	2.00
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

ACE
Ashepoo, Combahee and Edisto Basin NERR
South Carolina

The nearest Mussel Watch sites to this Reserve are in Charleston Harbor, SC, 30 miles away. The Mussels Watch sites are in different estuarine drainage areas, and the Charleston area is much more populated than the ACE Basin, so the two locations would have distinctly different characteristics.

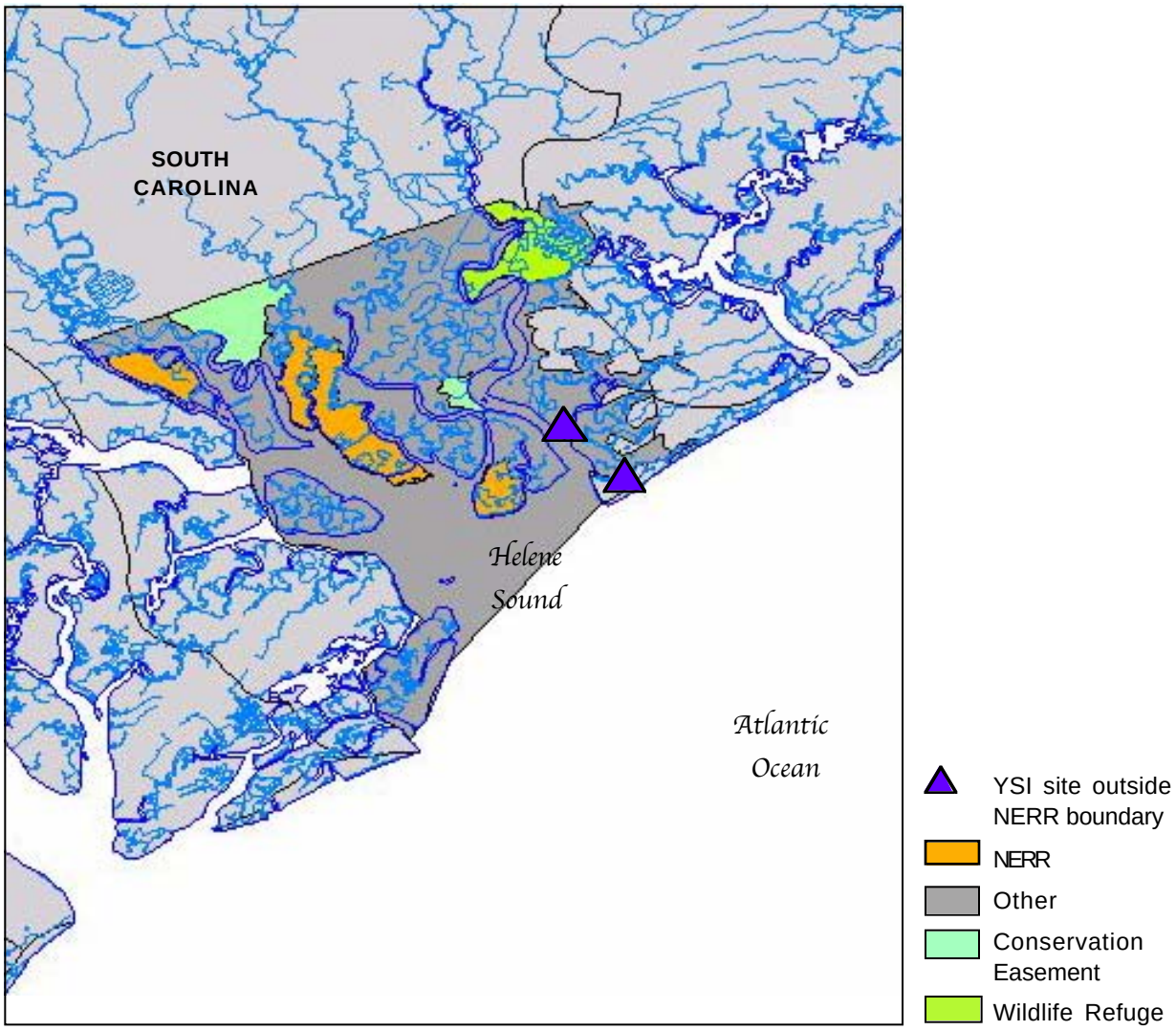

Figure 55. Ashepoo, Combahee and Edisto Basin NERR and adjacent areas.

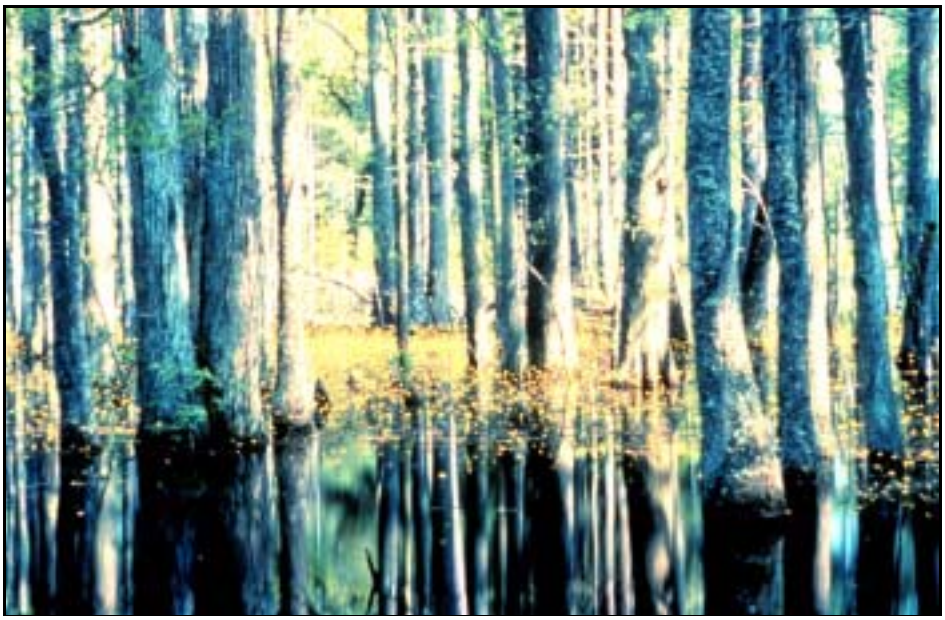

Plate 48. Forested wetland, ACE Basin National Estuarine Research Reserve, Charleston, South Carolina (NOAA National Estuarine Research Reserve Collection, nerr0001, NOAA Photo Collection, NOAA Central Library).

Plate 49. Egrets at the Bear Island impoundments, ACE Basin National Estuarine Research Reserve, Charleston, South Carolina (NOAA National Estuarine Research Reserve Collection, nerr0023, NOAA Photo Collection, NOAA Central Library).

SAP
Sapelo Island NERR
Georgia

Two Mussel Watch sites are located near this NERR. The Mussel Watch site at Sapelo Island is only 0.2 miles away. It is influenced by the same waters as the Reserve and has been sampled since the beginning of the Mussel Watch Project. Therefore, this site has an excellent correlation with the Reserve.

The site at Wolfe Island is 4.5 miles from the Reserve and is more directly influenced by the Altamaha River than the Sapelo Island site.

In spite of the differences between the sites, their contaminant characteristics are very similar. Both have elevated arsenic, expected for U.S. Southeast estuaries, and both sites have at least some elevated selenium. Neither site has any elevated summed organics, although both have high Mirex concentrations and Sapelo Island had a high Lindane one year.

The only trend found at either site was for decreasing ∑Diel at the Sapelo Island site.

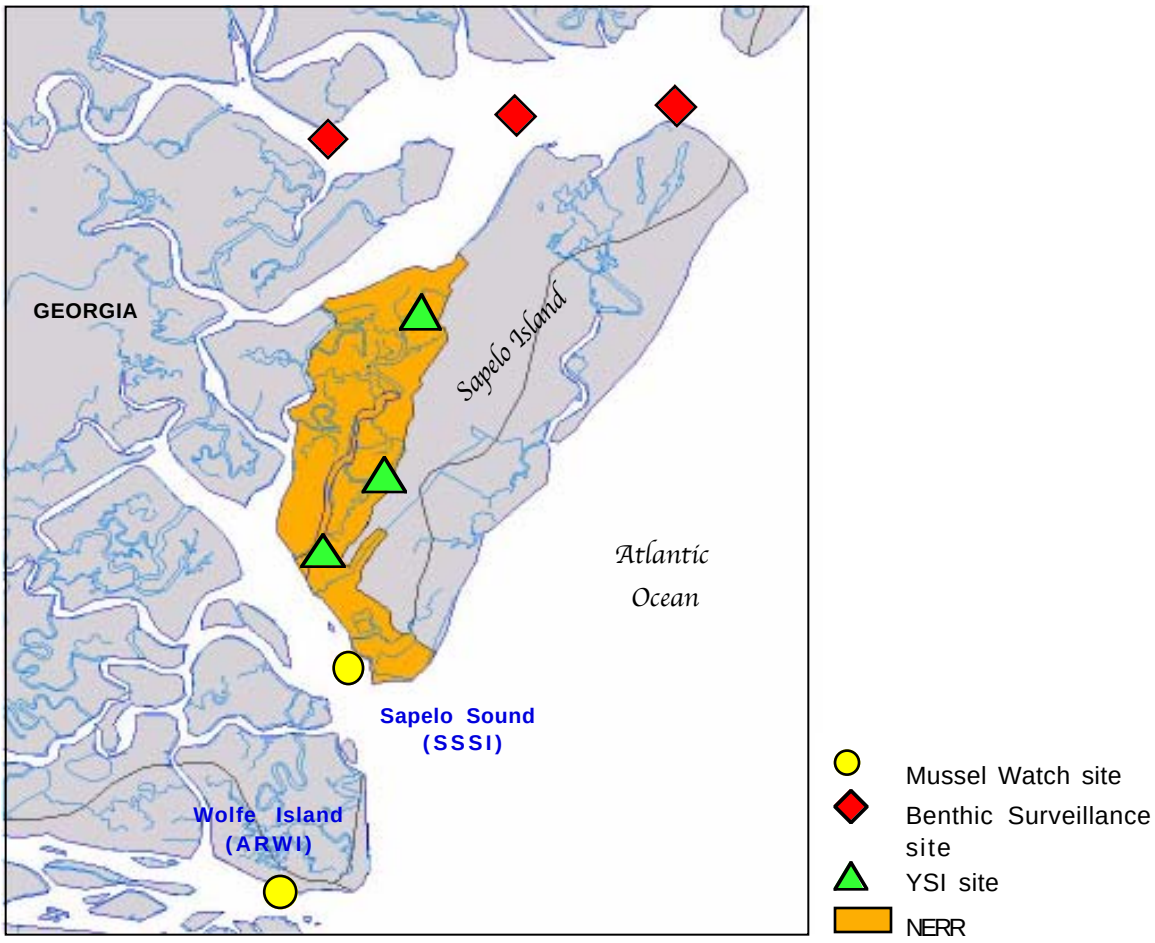

Figure 56. Sapelo Island NERR and adjacent areas.

Plate 50. Mussel Watch site at Wolfe Island (ARWI), Altamaha River, in the Sapelo Island NERR (TAMU/GERG).

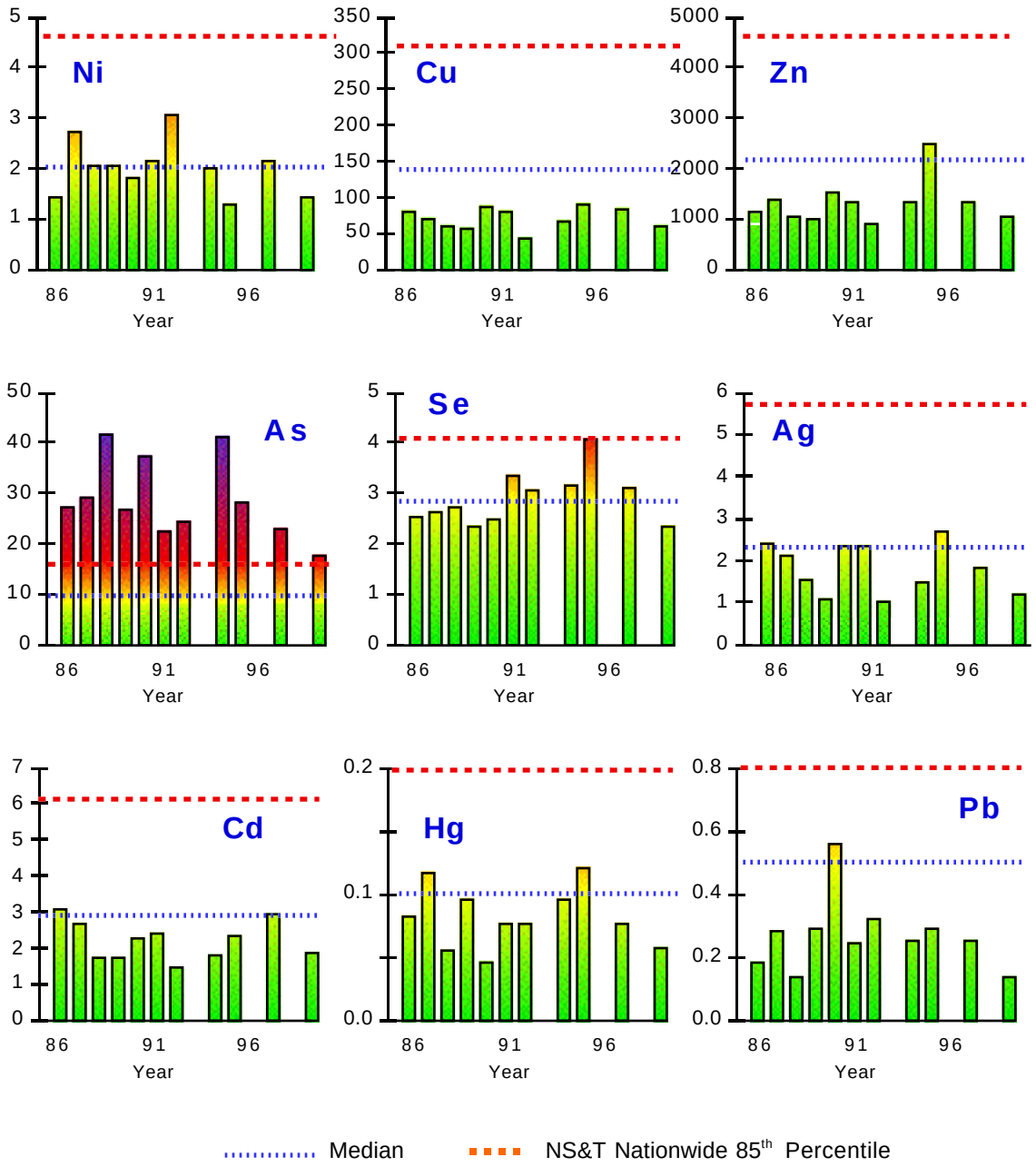

Figure 57. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Sapelo Island (Sapelo Sound) (SSSI) (µg/g dry wt.).

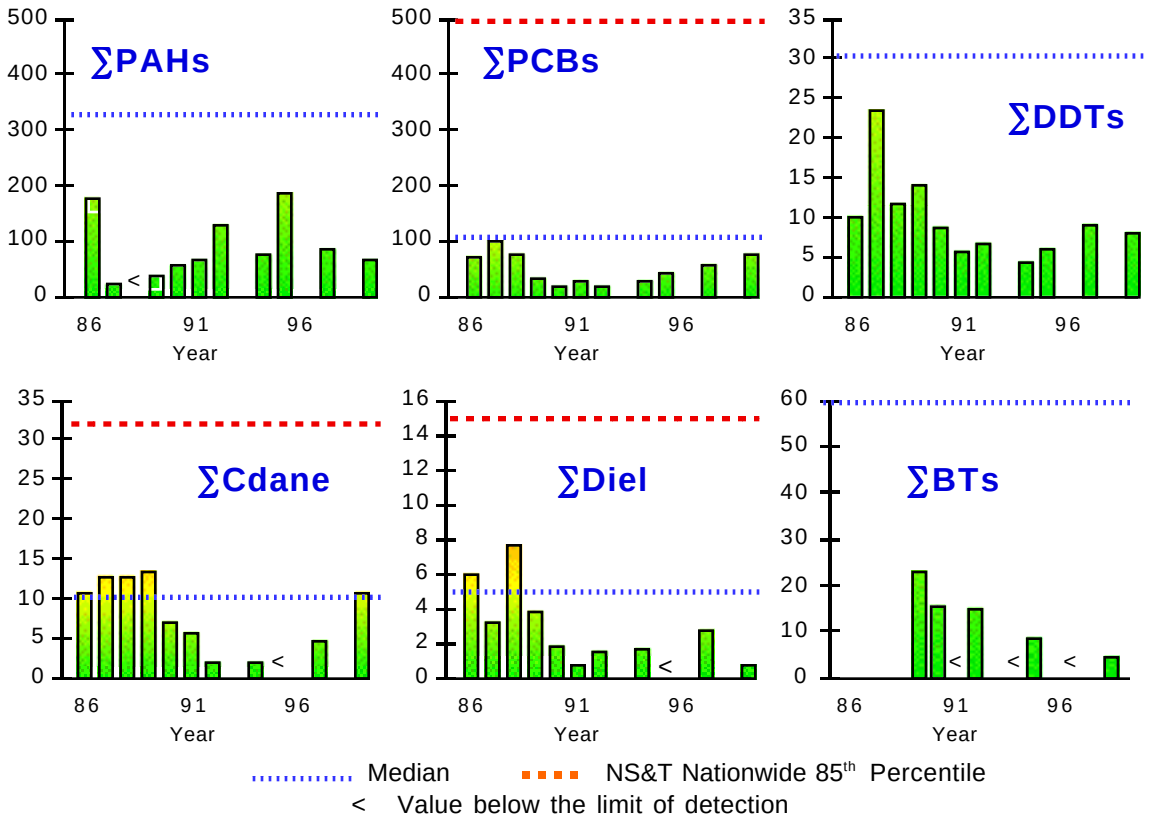

Figure 58. Trace organic contaminant and total butyltin trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Sapelo Island (Sapelo Sound) (SSSI) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 51. Ghost crab tracks (lower left to the right center of the image) through sea oats and railroad vines, Sapelo Island, Georgia, Sapelo Island NERR (1999) (Photographer: J. Couch. NOAA National Estuarine Research Reserve Collection, nerr0854, NOAA Photo Collection, NOAA Central Library).

Table 22. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Sapelo Island (Sapelo Sound) (SSSI) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	16.3	1.27	69.3	1000	25.7	2.37	2.25
1987	13.3	2.57	60.3	1233	27.7	2.47	1.94
1988		1.93	49.0	890	40.3	2.57	1.36
1989		1.93	47.0	847	25.3	2.20	0.93
1990	14.6	1.66	77.0	1400	36.1	2.35	2.20
1991	18.7	2.00	71.3	1200	21.0	3.20	2.19
1992	14.0	2.91	33.2	740	23.0	2.93	0.84
1994	12.2	1.88	55.9	1200	39.7	3.00	1.30
1995	15.8	1.16	80.7	2341	27.0	3.91	2.54
1997	11.0	2.00	72.0	1183	21.7	2.96	1.67
1999	9.2	1.28	50.1	897	16.0	2.22	1.03
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1986	2.90	0.01	0.077	0.16	
1987	2.47	0.01	0.110	0.26	
1988	1.50	0.07	0.050	0.11	
1989	1.53	<	0.090	0.27	21.2
1990	2.06	0.10	0.040	0.54	13.6
1991	2.20	0.03	0.070	0.22	<
1992	1.26	0.07	0.070	0.30	13.1
1994	1.60	<	0.090	0.23	<
1995	2.13	6.40	0.115	0.27	6.9
1997	2.74	0.33	0.070	0.23	<
1999	1.64		0.051	0.11	2.8
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	162	58	9.0	9.56	5.47	<	<	2.27
1987	9	85	22.5	11.83	2.77	<	0.76	<
1988	<	62	10.7	11.63	7.13	<	<	1.96
1989	25	20	12.9	12.20	3.33	<	<	<
1990	43	2	7.7	6.12	1.41	<	3.40	<
1991	51	12	4.7	4.66	0.35	<	<	<
1992	114	3	5.7	1.03	1.12	<	1.41	<
1994	60	11	3.4	1.07	1.15	<	0.37	0.61
1995	170	26	5.1	<	<	<	<	1.53
1997	72	41	7.9	3.78	2.31	<	0.26	0.65
1999	53	61	7.0	9.61	0.33	<	0.08	1.20
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 52. Mussel Watch site at Pivers Island (BIPI), Beaufort Inlet, in the Sapelo Island NERR (TAMU/GERG).

Plate 53. Bridge at the Mussel Watch site at Pivers Island (BIPI), Beaufort Inlet, in the Sapelo Island NERR (TAMU/GERG).

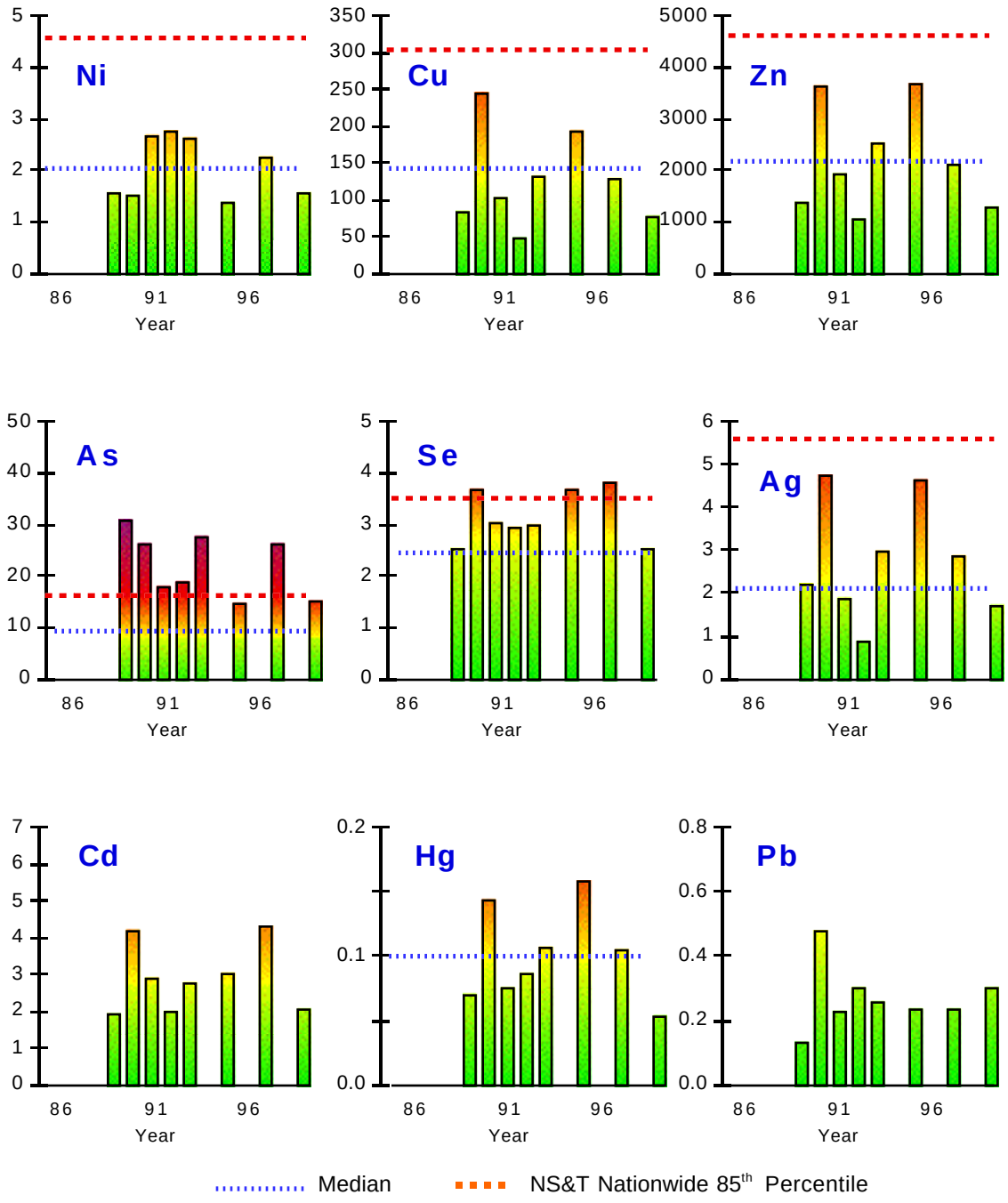

Figure 59. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Wolfe Island (Altamaha River) (ARWI) (µg/g dry wt.).

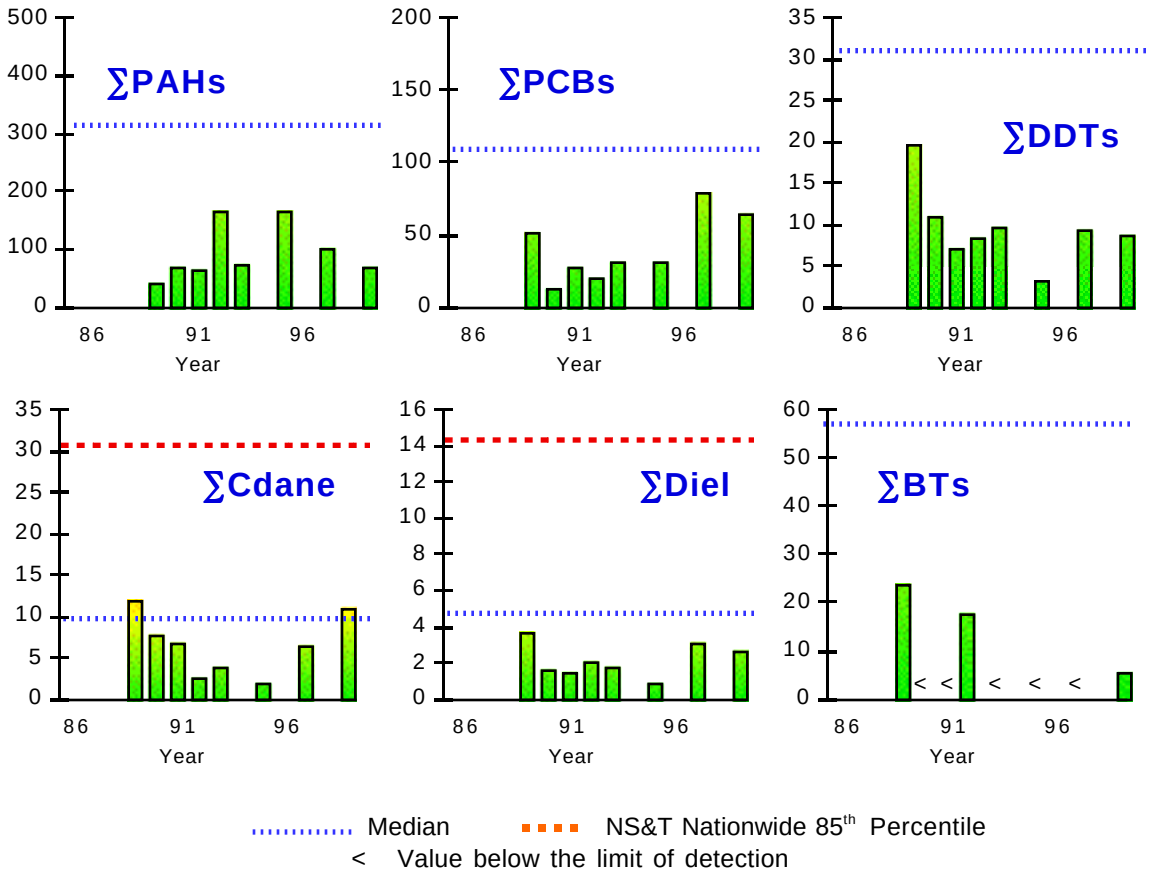

Figure 60. Trace organic contaminant and total butyltin trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Wolfe Island (Altamaha River) (ARWI) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 54. Sea oats and railroad vines, Sapelo Island, Georgia, Sapelo Island NERR (1999) (Photographer: J. Couch. NOAA National Estuarine Research Reserve Collection, nerr0853, NOAA Photo Collection, NOAA Central Library).

Table 23. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Wolfe Island (Altamaha River) (ARWI) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1989		1.43	74.3	1233	29.3	2.40	2.03
1990	21.8	1.38	233.3	3500	24.7	3.51	4.56
1991	12.5	2.53	93.0	1800	16.3	2.87	1.69
1992	9.4	2.63	38.2	910	17.4	2.79	0.69
1993	12.0	2.46	120.0	2400	26.0	2.83	2.80
1995	14.9	1.25	183.7	3515	13.3	3.53	4.46
1997	13.0	2.10	117.0	1969	24.8	3.65	2.71
1999	12.5	1.42	66.1	1120	13.6	2.38	1.51
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1989	1.73	0.02	0.063	0.11	22.0
1990	3.95	0.01	0.137	0.45	0.0
1991	2.70	0.03	0.070	0.21	0.0
1992	1.76	0.06	0.080	0.28	15.7
1993	2.57	<	0.100	0.23	<
1995	2.81	0.04	0.153	0.21	<
1997	4.08	0.07	0.098	0.21	<
1999	1.82		0.047	0.28	3.7
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1989	28	45	18.6	10.83	3.20	<	<	<
1990	56	6	9.9	6.59	1.20	<	<	0.55
1991	48	22	6.0	5.66	0.97	<	<	<
1992	150	14	7.4	1.40	1.56	<	<	<
1993	58	25	8.6	2.68	1.23	0.65	0.72	2.54
1995	152	25	2.3	0.90	0.44	0.17	0.19	1.92
1997	85	74	8.2	5.45	2.55	0.20	0.16	1.72
1999	56	59	7.7	9.85	2.15	<	0.13	1.31
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 55. Fishing on the marsh, Sapelo Island NERR (1989) (NOAA National Estuarine Research Reserve Collection, nerr0103, NOAA Photo Collection, NOAA Central Library).

Plate 56. Aerial view of the south end of Sapelo Island looking toward Doboy Sound, Sapelo Island NERR (1989) (America's Coastlines Collection, line0939, NOAA Photo Collection, NOAA Central Library).

GTM
Guana Tolomato Matanzas NERR
Florida

The Crescent Beach Mussel Watch site within the Reserve was established in 1986 during the first year of the monitoring project.

One time each, selenium and mercury exceeded the NS&T 'high' value. Arsenic has been near or above the NS&T high values for all years. The 'high' arsenic concentrations are most likely the result of the U.S. Southeast geology. Discussion of this can be found in the section on the North Carolina NERR. Organic contaminants within the Reserve are consistently low with the exception of Lindane, which exceeded the NS&T 'high' value in 1987.

No trends were found for either trace elements or organic contaminants.

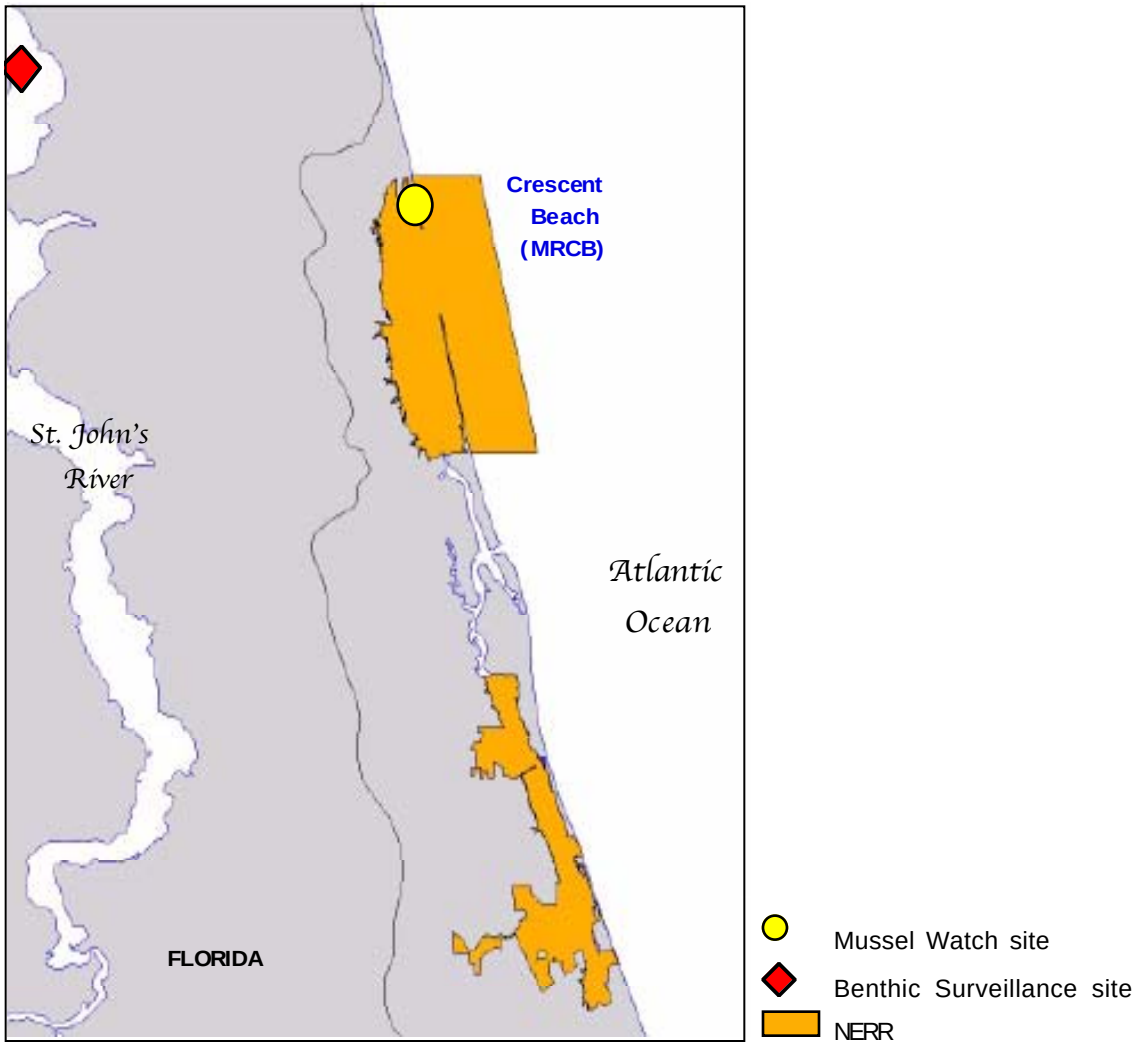

Figure 61. Guana Tolomato Matanzas NERR and adjacent areas.

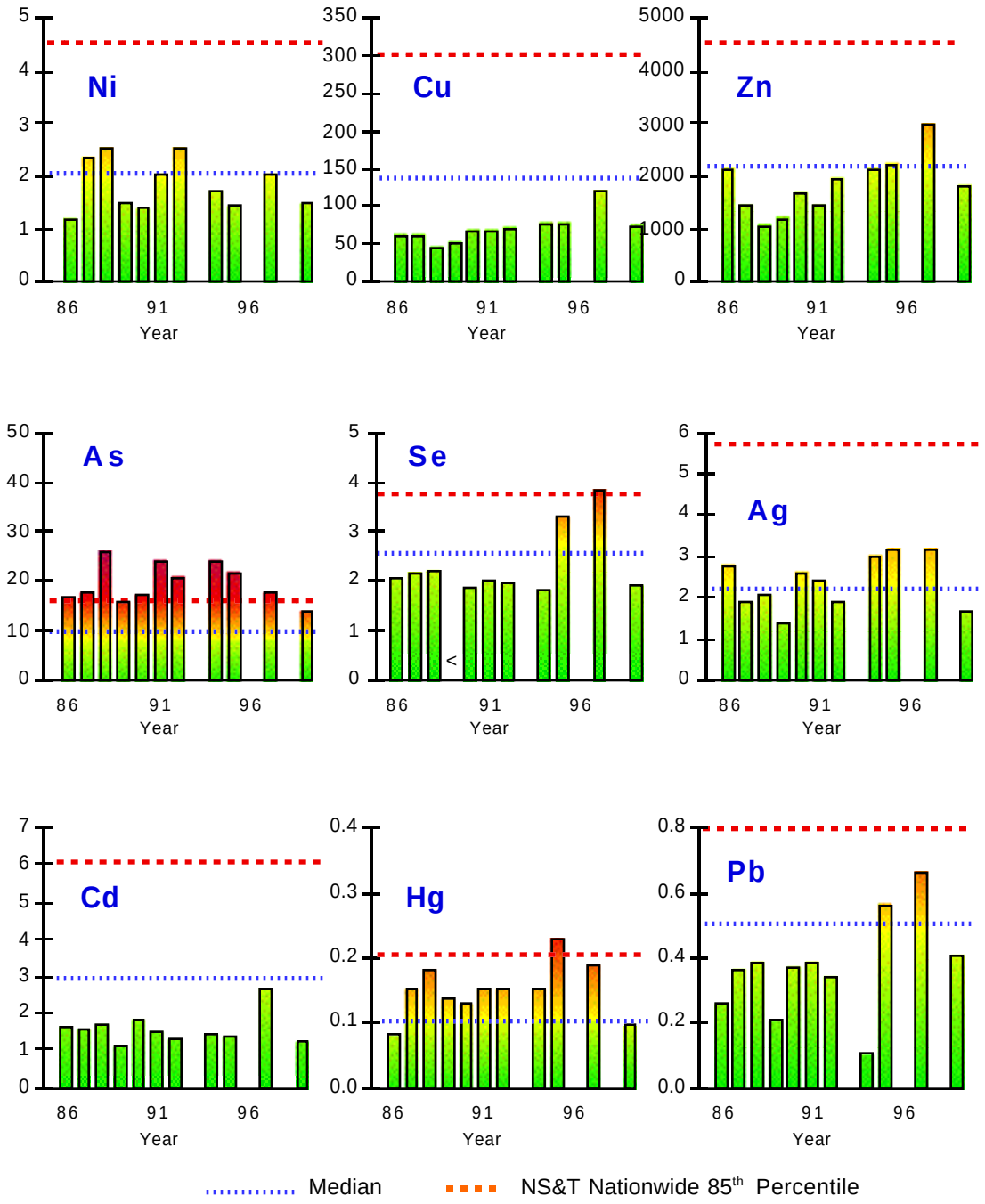

Figure 62. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Crescent Beach (Matanzas River) (MRCB) (µg/g dry wt.).

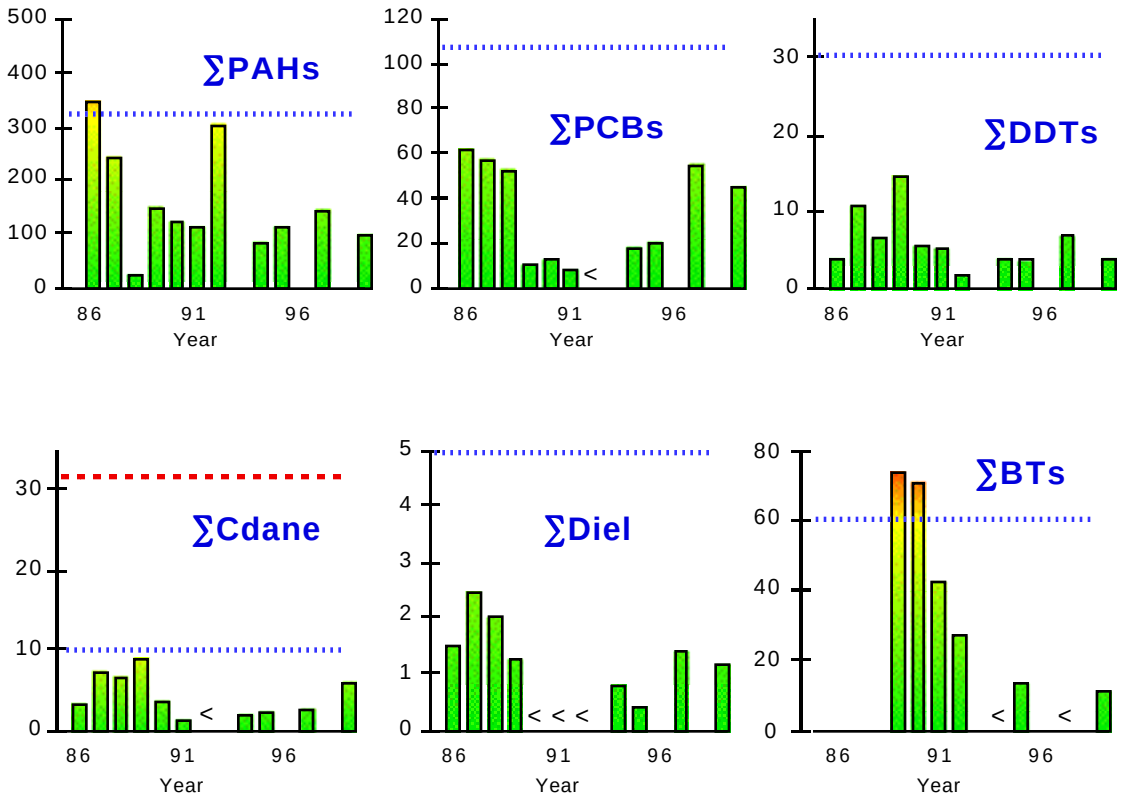

Figure 63. Trace organic contaminant and total butyltin trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Crescent Beach (Matanzas River) (MRCB) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 57. Guana Tolomato Matanzas NERR (NOAA National Estuarine Research Reserve Collection, nerr0155, NOAA Photo Collection, NOAA Central Library).

Table 24. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Crescent Beach (Matanzas River) (MRCB) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.)

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	13.0	1.06	50.0	2000	15.3	1.90	2.58
1987	11.0	2.23	51.7	1267	16.0	2.03	1.73
1988		2.40	33.7	903	24.3	2.07	1.90
1989		1.33	40.0	1067	14.3	<	1.20
1990	24.7	1.23	57.1	1533	15.7	1.69	2.46
1991	13.7	1.87	57.0	1300	22.7	1.83	2.21
1992	9.7	2.40	59.4	1800	19.5	1.78	1.71
1994	8.6	1.58	67.2	2000	22.4	1.64	2.80
1995	12.2	1.29	67.7	2094	20.4	3.15	2.99
1997	13.0	1.90	109.0	2835	16.0	3.69	3.01
1999	10.3	1.31	65.1	1670	12.3	1.77	1.47
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1986	1.40	0.05	0.070	0.23	
1987	1.37	0.05	0.140	0.34	
1988	1.47	0.15	0.170	0.36	
1989	0.88	0.12	0.123	0.19	72.3
1990	1.59	0.29	0.117	0.35	69.5
1991	1.30	0.06	0.140	0.36	40.7
1992	1.07	0.12	0.140	0.32	24.9
1994	1.20	0.03	0.140	0.08	0.0
1995	1.16	0.07	0.218	0.54	11.5
1997	2.51	0.08	0.176	0.64	0.0
1999	1.05		0.085	0.39	9.3
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	332	58	2.8	2.26	1.35	<	0.00	<
1987	229	54	9.7	6.28	2.33	<	3.90	<
1988	10	49	5.4	5.52	1.87	<	0.38	<
1989	133	6	13.6	7.87	1.10	<	0.00	<
1990	106	9	4.4	2.68	<	0.00	<	<
1991	98	4	4.0	0.12	<	0.00	<	<
1992	290	0	0.5	<	0.00	<	0.00	<
1994	70	14	2.7	0.93	0.62	<	0.44	<
1995	99	17	2.6	1.20	0.49	0.10	0.37	0.09
1997	131	51	5.7	1.51	1.24	<	0.46	0.67
1999	81	42	2.8	4.94	1.01	<	0.00	0.24
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

JOB
Jobos Bay NERR
Puerto Rico

There are three Mussel Watch sites in Puerto Rico, all established in 1992. The Mussel Watch site in Bahia de Jobos is 2 miles from the Reserve and within Puerto Rico's larger environmental protected area (Dr. P. Robles, Puerto Rico Department of Natural and Environmental Resources, personal communication, 2000).

Both arsenic and selenium met or exceeded the NS&T 'high' concentration in one year. None of the organics approached the NS&T 'high' concentrations; they were below the respective NS&T median concentrations. The only exception was ∑BTs, which exceeded the median in 1994. No trend analyses were possible because there are only five years of data.

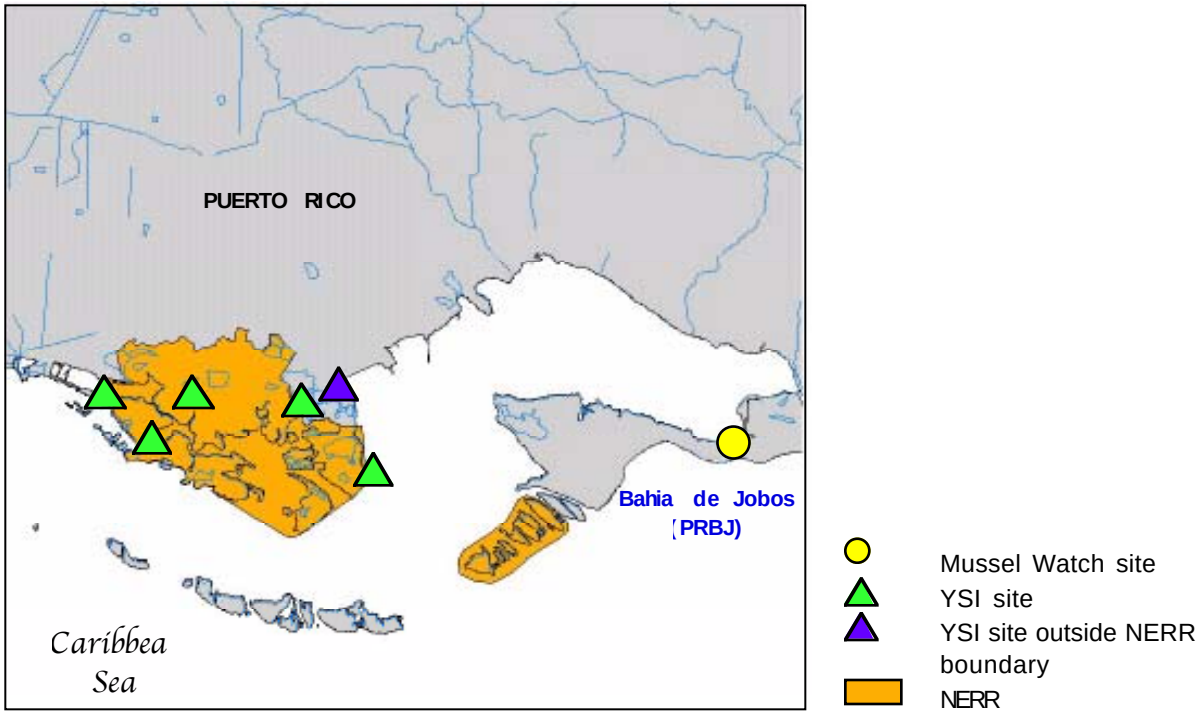

Figure 64. Bahia de Jobos NERR and adjacent areas.

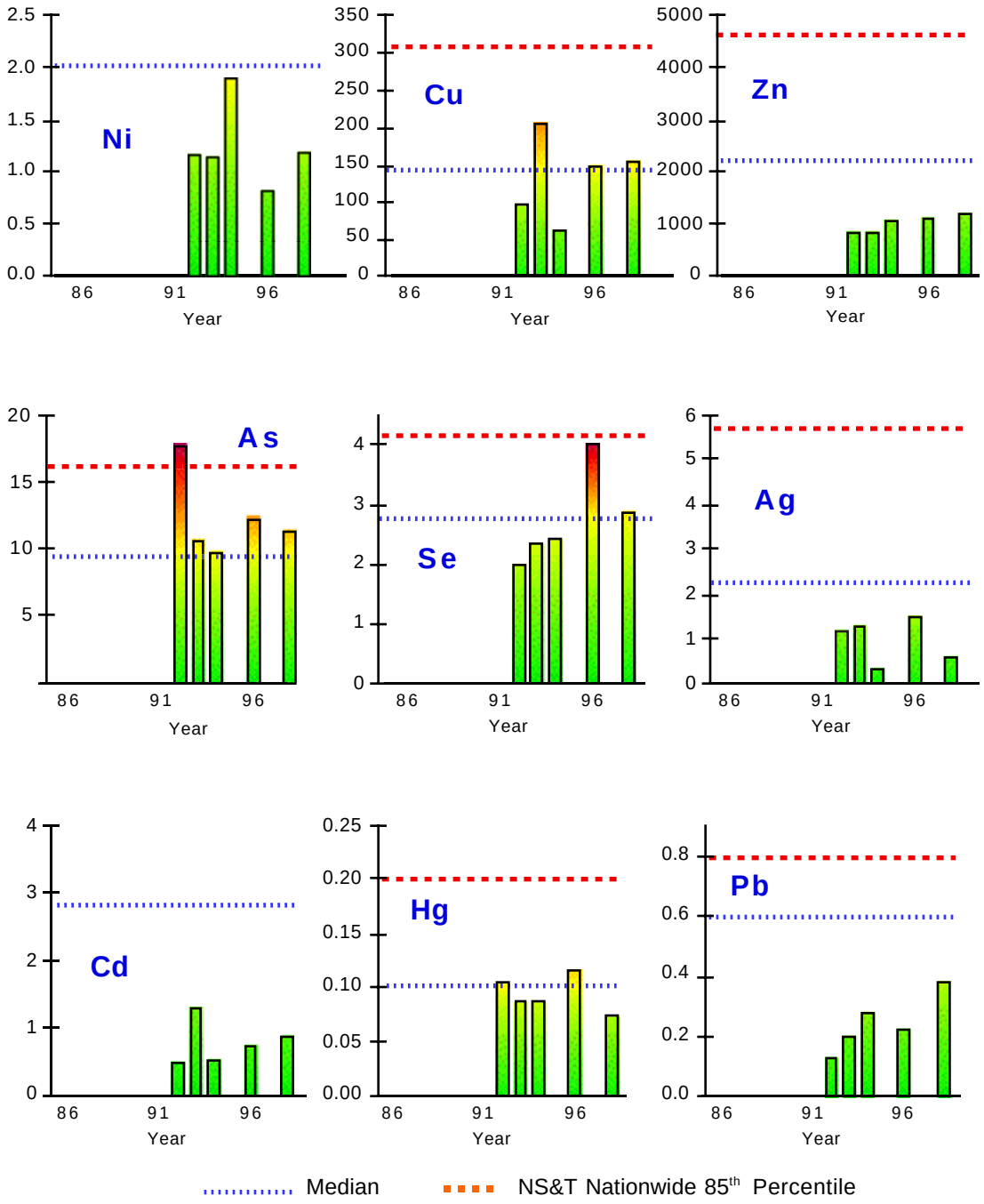

Figure 65. Trace element trends in mangrove oysters (*Crassostrea rhizophorae*) collected at NS&T Mussel Watch site Bahia de Jobos (Puerto Rico) (PRBJ) (µg/g dry wt.).

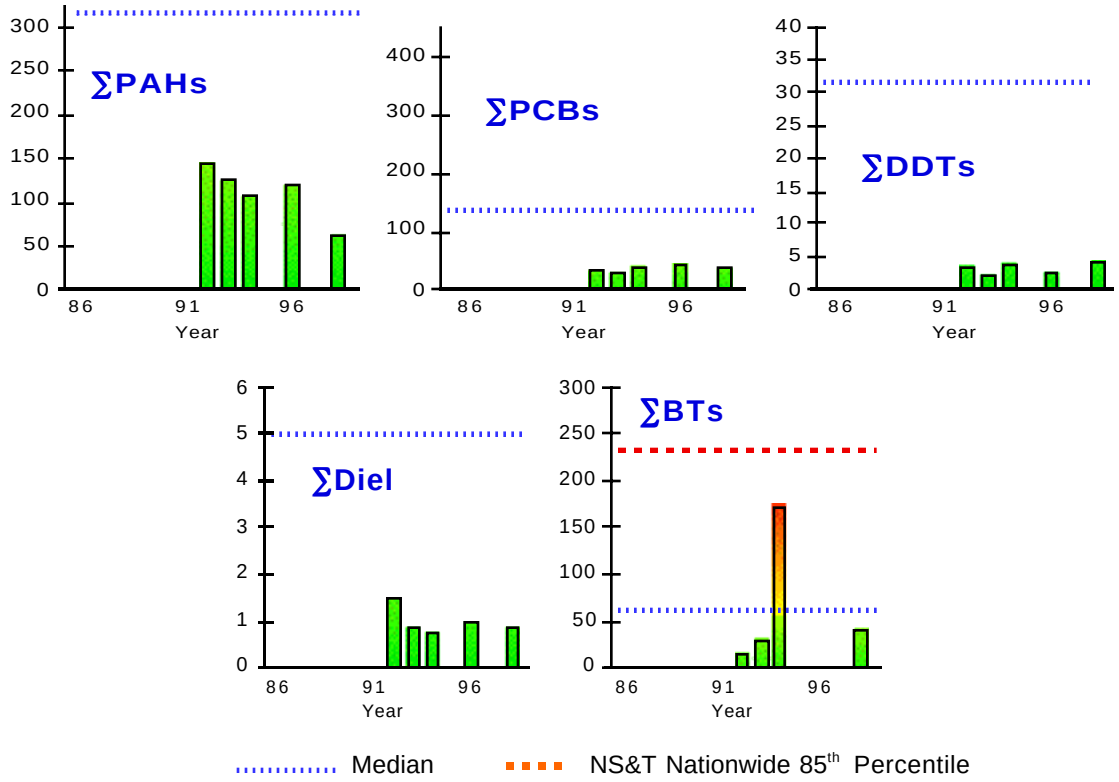

Figure 66. Trace organic contaminant and total butyltin trends in mangrove oysters (*Crassostrea rhizophorae*) collected at NS&T Mussel Watch site Bahia de Jobos (Puerto Rico) (PRBJ) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 58. Manatee, Jobos Bay, Puerto Rico, Jobos Bay NERR (NOAA National Estuarine Research Reserve Collection, nerr0508, NOAA Photo Collection, NOAA Central Library).

Table 25. Trace element and trace organic contaminant concentrations in mangrove oysters (*Crassostrea rhizophorae*) collected at NS&T Mussel Watch site Bahia de Jobos (Puerto Rico) (PRBJ) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1992		1.11	84.3	701	17.1	1.88	0.99
1993		1.08	196.8	707	10.0	2.24	1.09
1994	27.3	1.83	53.3	907	9.1	2.31	0.20
1996	24.8	0.77	141.0	960	11.7	3.90	1.33
1998	29.7	1.19	155.0	971	10.7	2.83	0.47
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1992	0.38	<	0.097	0.10	7.1
1993	1.17	<	0.080	0.17	22.4
1994	0.44	1.25	0.080	0.25	164.6
1996	0.65	0.18	0.110	0.20	
1998	0.74	<	0.072	0.35	27.9
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1992	130	18	2.5	1.57	1.31	0.01	1.02	0.07
1993	100	16	1.1	0.24	0.69	<	0.00	<
1994	91	19	3.0	0.69	0.61	0.08	0.15	<
1996	98	28	1.4	0.89	0.77	0.15	0.27	<
1998	49	16	2.6	0.61	0.91	0.12	0.08	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 59. Mussel Watch site at Bahia De Jobos (PRBJ), Puerto Rico, in the Jobos Bay NERR (TAMU/GERG).

Plate 60. Mussel Watch site at Bahia De Jobos (PRBJ), Puerto Rico, in the Jobos Bay NERR (TAMU/GERG).

Plate 61. Narrow channels, fringed by red mangrove, are connected to open waters along the keys, Bahia de Jobos, Puerto Rico, Jobos Bay NERR (NOAA National Estuarine Research Reserve Collection, nerr0491, NOAA Photo Collection, NOAA Central Library).

RKB
Rookery Bay NERR
Florida

The Mussel Watch sites at Henderson Creek and Naples Bay were established at the beginning of the Project in 1986. While the site at Henderson Creek corresponds well with the Reserve, Naples Bay has less correspondence. It is farther away (3 miles) and in a non-NERR urban environment, while the Henderson Creek site is completely surrounded by the primarily undeveloped Reserve.

Three trace elements at Henderson Creek exceeded the NS&T 'high' values: arsenic, silver, and mercury. In the more urban estuary, copper, zinc, and arsenic exceeded the NS&T 'high' value. In Henderson Creek, only one organic exceeded the NS&T 'high' value (hexachlorobenzene), in 1987. At Naples Bay, ∑Cdane and ∑BTs have exceeded the NS&T 'high.'

At Henderson Creek there are decreasing trends for arsenic, and ∑BTs, while ∑PAHs are increasing. Naples Bay had decreasing arsenic, cadmium, ∑Cdane and ∑BTs. Only copper at Naples Bay was both above the NS&T 'high' value and showed an increasing trend.

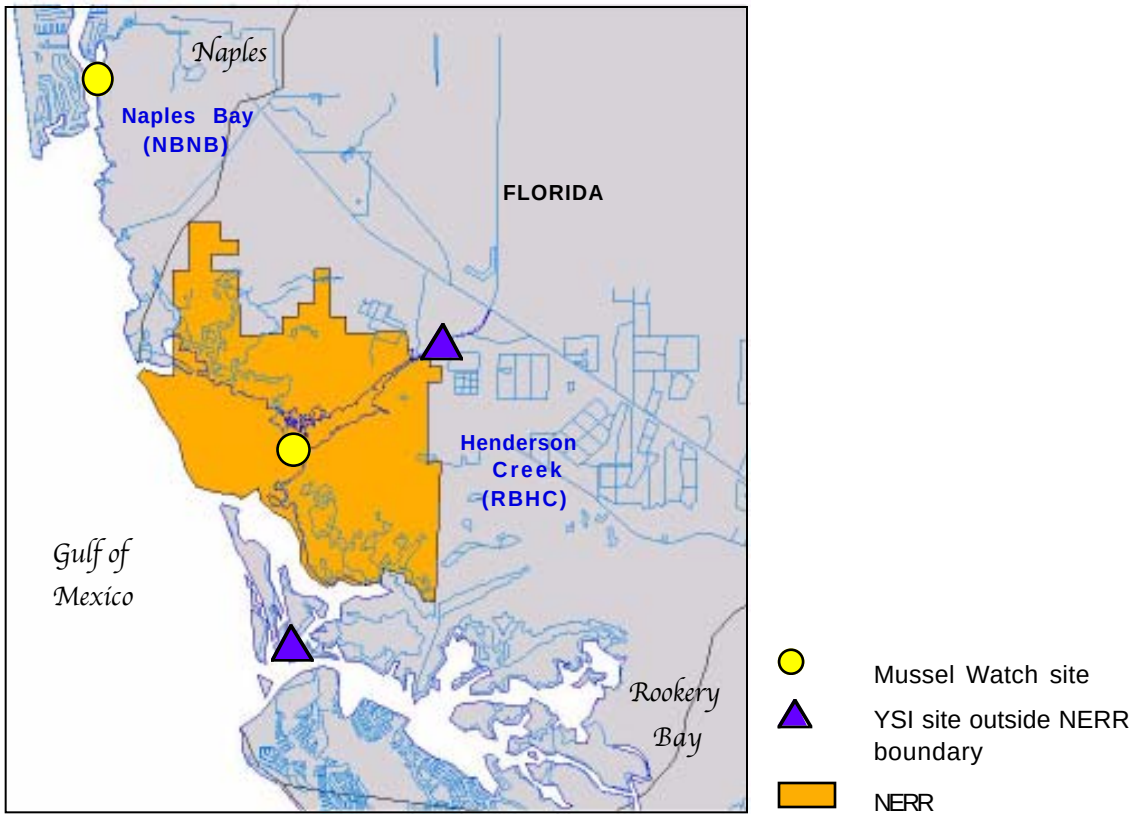

Figure 67. Rookery Bay NERR and adjacent areas.

Plate 62. Mussel Watch site at Henderson Creek (RBHC) in the Rookery Bay NERR. Arrow marks location of sampling site (TAMU/GERG).

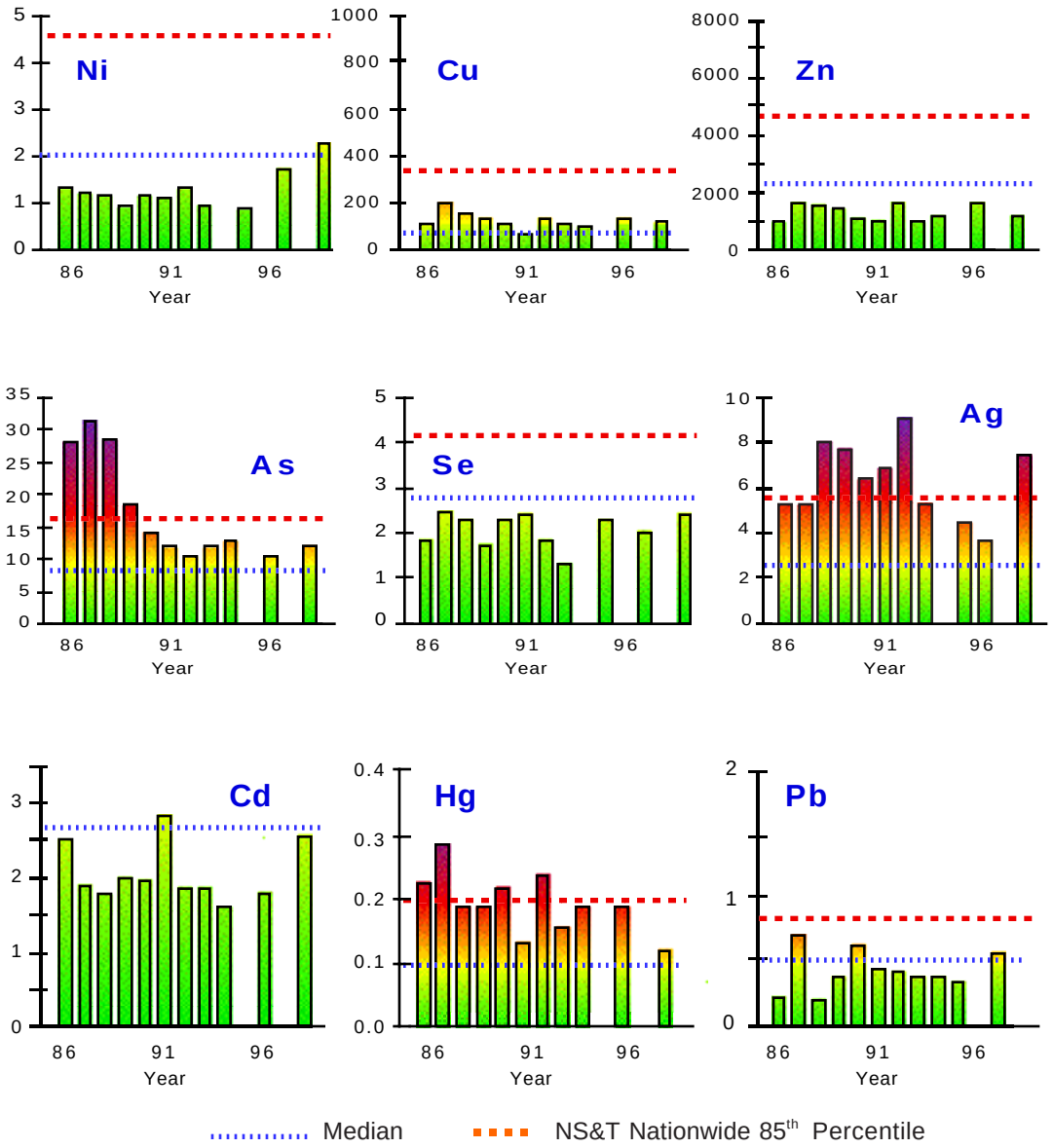

Figure 68. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Henderson Creek (Rookery Bay) (RBHC) (µg/g dry wt.).

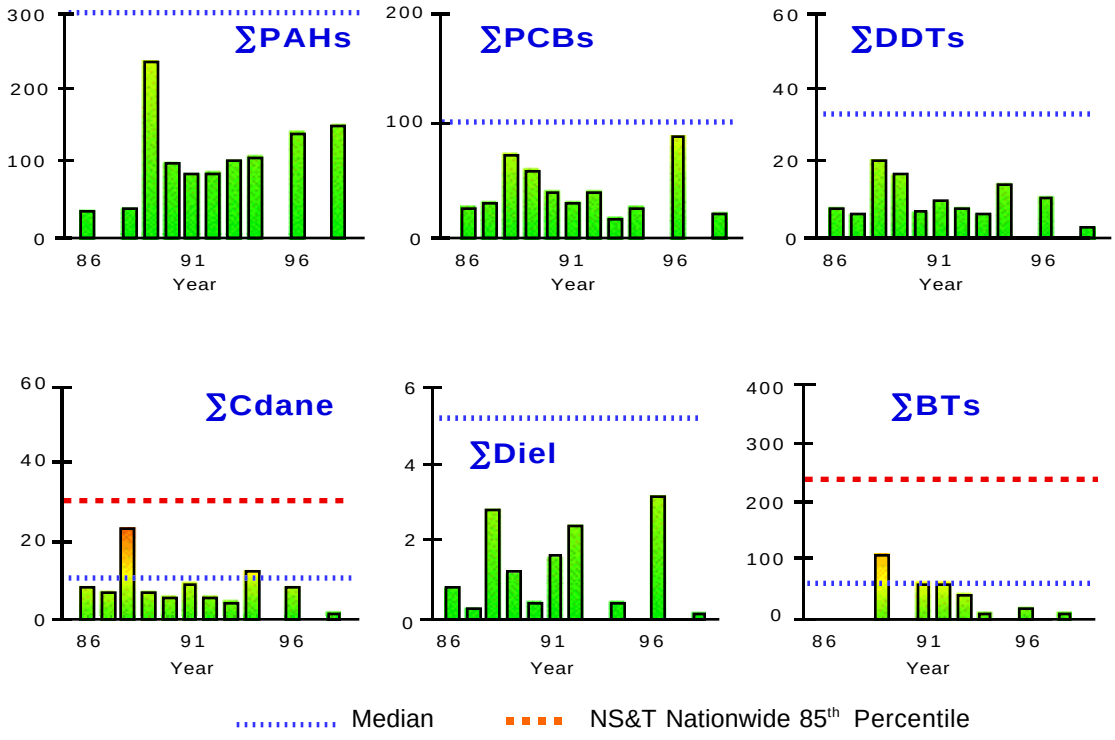

Figure 69. Trace organic contaminant and total butyltin trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Henderson Creek (Rookery Bay) (RBHC) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 63. Aerial view of the Mussel Watch site at Naples Bay (NBNB), in the Rookery Bay NERR. Arrow marks the sampling site. (TAMU/GERG).

Table 26. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Henderson Creek (Rookery Bay) (RBHC) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	5.8	1.22	68.3	717	27.3	1.77	2.09
1987	9.2	1.19	172.3	1422	30.2	2.41	2.73
1988	10.7	1.07	126.3	1288	27.5	2.22	2.66
1989	6.9	0.89	97.1	1201	17.2	1.60	3.31
1990	8.2	0.98	78.7	851	13.0	2.13	1.91
1991	6.6	0.93	35.0	809	10.8	2.37	1.28
1992		1.26	115.2	1373	9.5	1.77	2.46
1993		0.87	67.4	743	10.8	1.06	1.37
1994	5.7	0.74	65.5	967	11.9	2.35	1.94
1996	13.2	1.80	115.0	1414	9.5	2.00	1.50
1998	12.4	2.27	109.0	998	11.0	2.30	2.88
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1986	2.40	<	0.233	0.17	
1987	1.83	<	0.280	0.66	
1988	1.64	0.08	0.183	0.14	
1989	1.90	<	0.190	0.33	99.0
1990	1.88	0.19	0.213	0.58	
1991	2.75	<	0.127	0.39	67.4
1992	1.77	<	0.260	0.36	66.2
1993	1.76	<	0.140	0.33	41.9
1994	1.49	<	0.200	0.34	16.1
1996	1.69	0.05	0.200	0.30	28.0
1998	2.52	<	0.129	0.51	13.0
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	32	26	5.6	3.92	0.96	0.18	<	<
1987	0	27	3.6	3.62	0.08	1.44	<	<
1988	36	63	18.5	19.19	2.70	<	0.95	0.97
1989	227	47	15.2	3.32	1.20	0.11	0.31	<
1990	98	33	4.7	2.78	0.64	<	0.43	0.27
1991	84	19	7.9	5.48	1.77	0.14	0.57	0.30
1992	88	31	5.3	2.39	2.24	<	0.81	<
1993	100	1	3.2	1.87	<	0.00	<	<
1994	106	10	11.7	9.31	0.46	<	<	<
1996	141	89	8.1	4.23	2.87	<	0.88	<
1998	148	9	1.8	1.54	0.20	<	0.13	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high	1200	450	140	32	15	1.1	2.8	1.2

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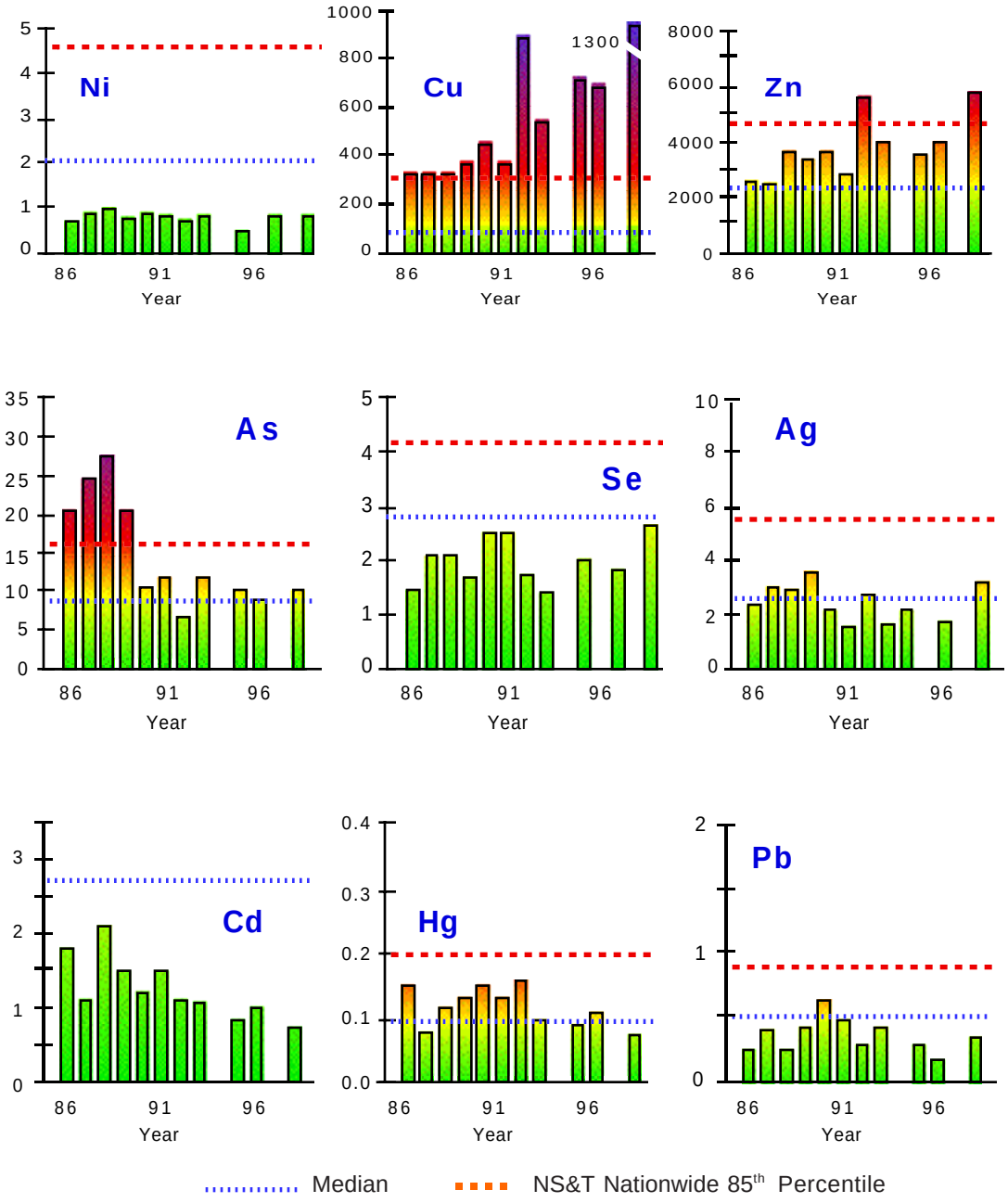

Figure 70. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Naples Bay (Naples Bay) (NBNB) (µg/g dry wt.).

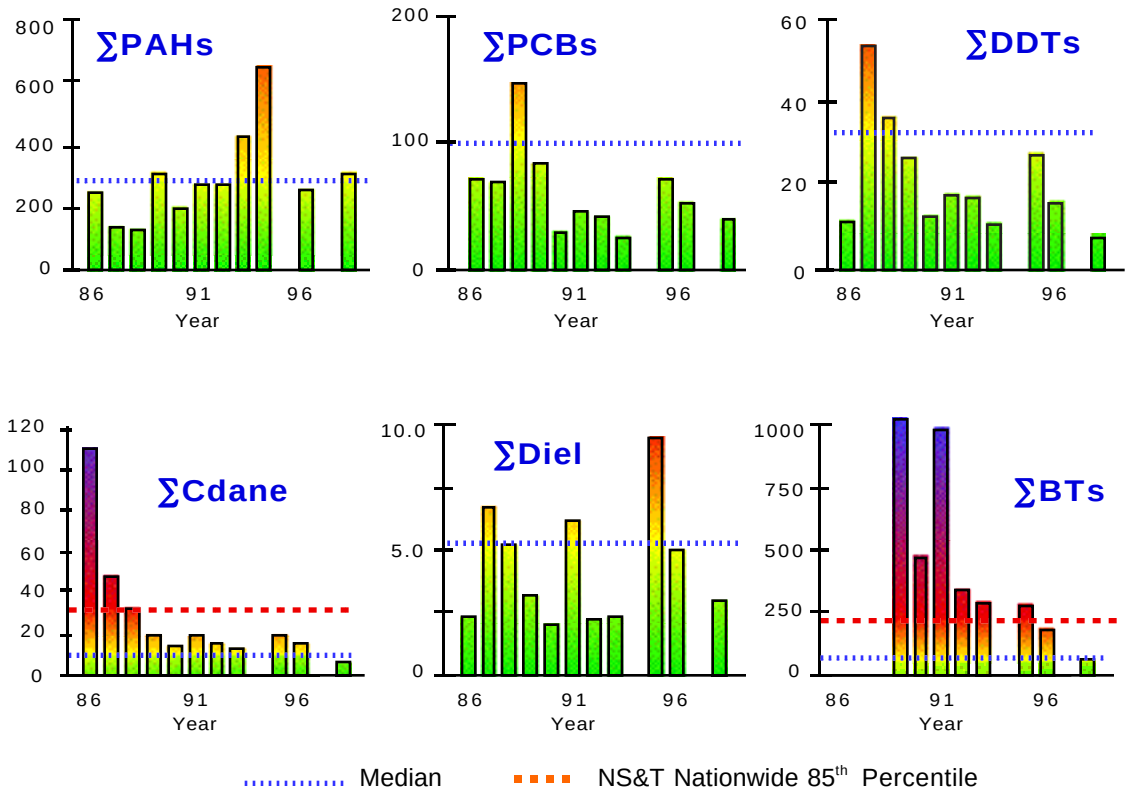

Figure 71. Trace organic contaminant and total butyltin trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Naples Bay (Naples Bay) (NBNB) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 64. Mussel Watch site at Naples Bay (NBNB), in the Rookery Bay NERR (TAMU/GERG).

Table 27. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Naples Bay (Naples Bay) (NBNB) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	8.7	0.63	326.7	2367	22.0	1.23	4.98
1987	8.4	0.86	326.0	2348	25.9	2.00	4.92
1988	10.5	0.93	324.7	3390	28.8	1.96	7.79
1989	7.9	0.71	371.6	3209	21.6	1.62	7.51
1990	7.5	0.89	456.5	3434	11.6	2.29	6.19
1991	7.4	0.80	369.0	2600	12.8	2.27	6.61
1992		0.74	930.5	5334	7.8	1.68	8.91
1993		0.80	556.1	3705	12.9	1.27	5.05
1995	12.5	0.47	742.7	3296	11.4	1.99	4.20
1996	9.0	0.88	715.0	3770	9.7	1.80	3.40
1998	13.2	0.90	1290.0	5670	11.4	2.62	7.84
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1986	1.70	0.58	0.150	0.20	
1987	1.03	0.80	0.097	0.34	
1988	2.00	0.69	0.107	0.16	
1989	1.37	0.35	0.117	0.35	1040.0
1990	1.14	0.88	0.133	0.58	478.0
1991	1.37		0.120	0.42	996.4
1992	0.99	0.43	0.150	0.24	375.7
1993	0.96	0.13	0.100	0.37	270.1
1995	0.74	0.46	0.088	0.24	263.1
1996	0.92	0.11	0.110	0.10	175.4
1998	0.88	<	0.084	0.33	99.3
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	258	77	10.0	114.42	2.24	0.45	0.34	<
1987	127	75	51.2	45.21	6.86	<	0.81	0.67
1988	124	142	33.9	31.09	5.05	<	1.56	0.82
1989	310	81	24.1	16.96	3.01	0.75	0.35	0.06
1990	192	26	9.5	11.28	2.01	<	0.77	0.14
1991	288	39	15.8	16.38	6.38	<	0.51	0.03
1992	280	36	14.6	12.03	2.45	0.05	1.37	0.48
1993	411	23	8.1	10.01	2.49	<	0.53	<
1995	683	69	25.7	17.96	9.19	0.18	0.50	0.23
1996	227	54	13.5	11.67	4.95	<	0.46	<
1998	311	38	6.5	6.78	2.89	<	0.21	0.10
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

APA
Apalachicola Bay NERR
Florida

The two Mussel Watch sites (Dry Bar and Cat Point Bar) found within the NERR boundaries were established at the beginning of the Mussel Watch Project in 1986. Consequently, the site match is excellent (Table 1).

Concentrations of most trace elements and organic contaminants at the two sites were generally at or below the NS&T median concentrations (Table 3). In 1987, arsenic exceeded the 85th percentile at the Dry Bar site, while arsenic exceeded the 85th percentile in 1995 at the Cat Point Bar site. Lead and mercury concentrations approached the 85th percentile at both sites, with lead exceeded the limit in 1987 at Cat Point Bar.

Cadmium at the Dry Bar site was the only trace element that had a statistically-significantly trend; it was decreasing. For organic contaminants, Cat Point Bar had the lower concentrations of the two sites, reaching the 85th percentile only once for ∑PAHs in 1989. While Dry Bar exceeded the 85th percentile more often, these occurred only once for any organic contaminant group.

Decreasing contaminant trends were found for ∑DDTs, hexachlorobenzene, and Lindane at the Dry Bar site, while decreasing trends were found for ∑Cdane, ∑Diel, and Lindane and Cat Point Bar. No increasing trends were found.

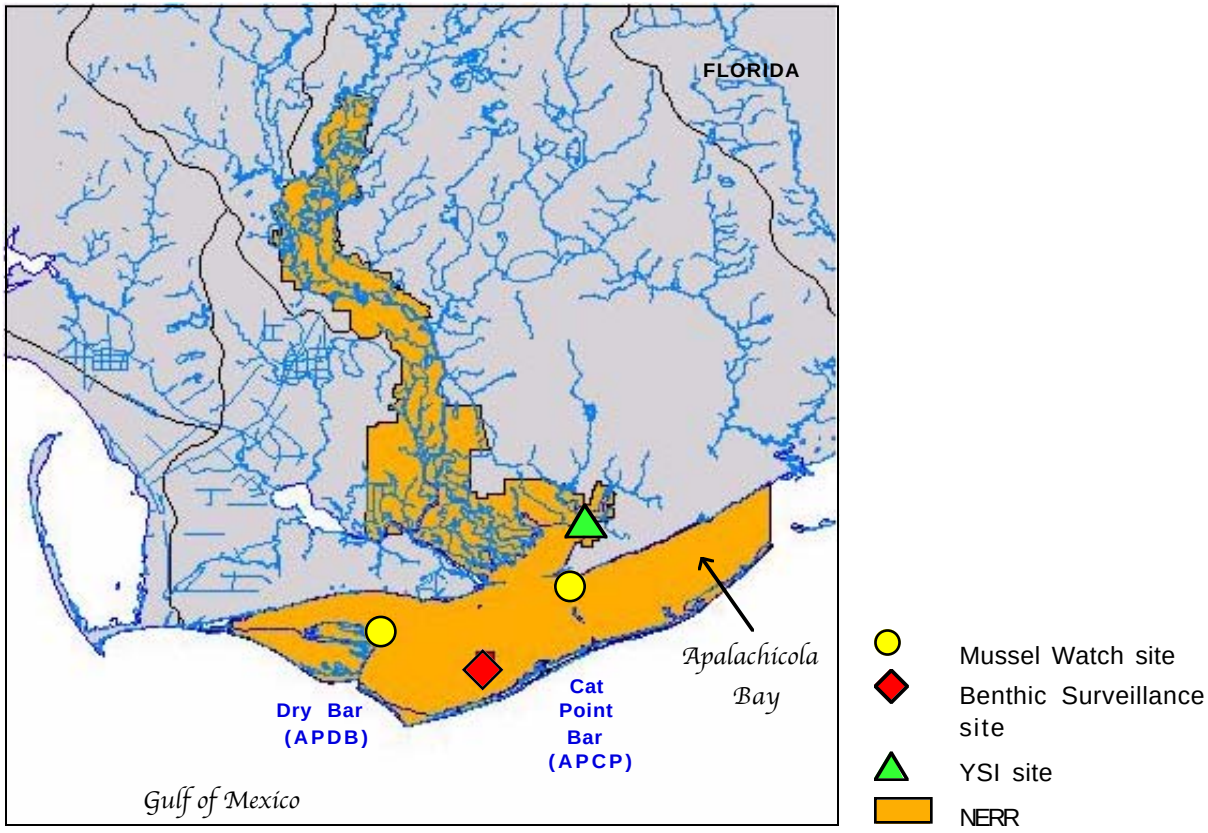

Figure 72. Apalachicola Bay NERR and adjacent areas.

Plate 65. Mussel Watch site at Cat Point Bar (APCP), Apalachicola Bay, in the Apalachicola Bay NERR (TAMU/GERG).

Plate 66. Mussel Watch site at Dry Bar (APDB), Apalachicola Bay, in the Apalachicola Bay NERR. Arrow marks sampling location (TAMU/GERG).

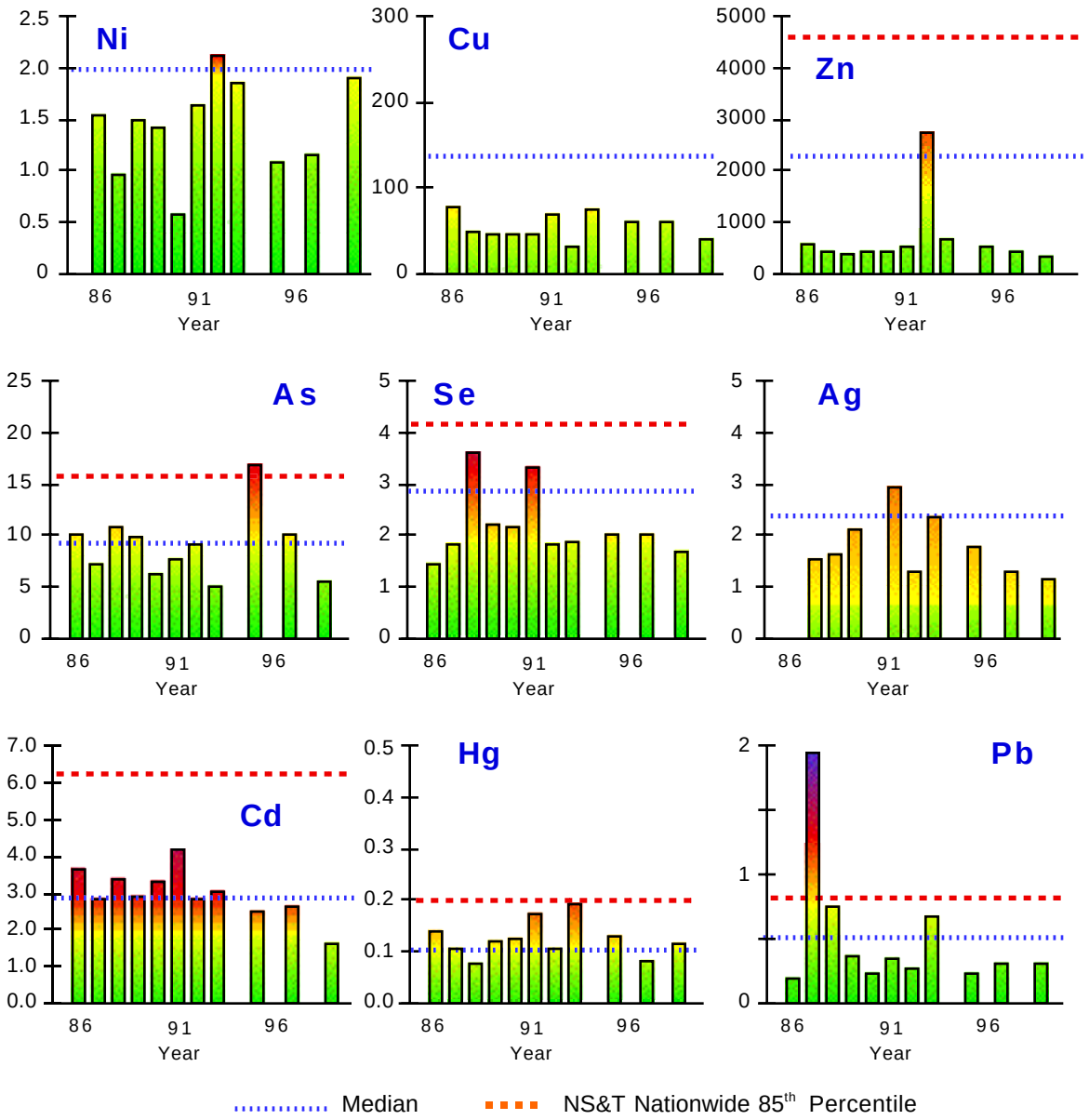

Figure 73. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Cat Point Bar (Apalachicola Bay) (APCP) (µg/g dry wt.).

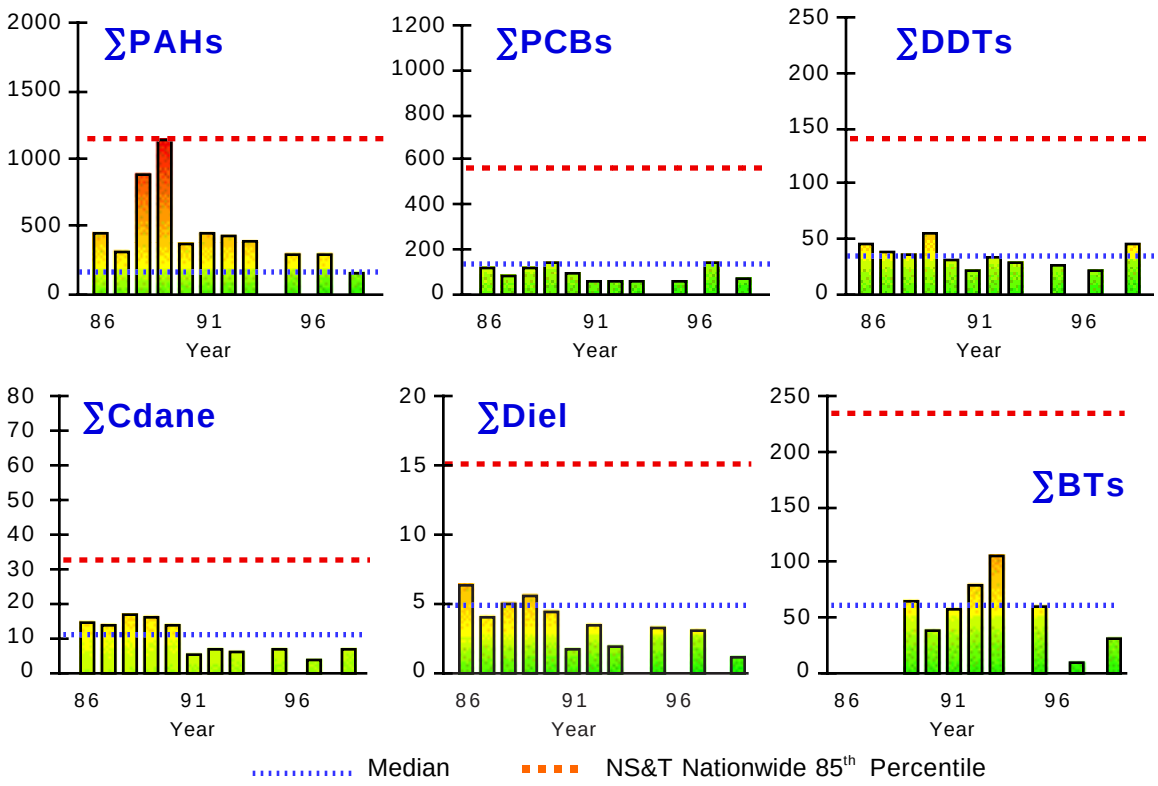

Figure 74. Trace organic contaminant and total butyltin trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Cat Point Bar (Apalachicola Bay) (APCP) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 67. Mussel Watch site at Cat Point Bar (APCP), Apalachicola Bay, in the Apalachicola Bay NERR (TAMU/GERG).

Table 28. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Cat Point Bar (Apalachicola Bay) (APCP) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	9.8	0.87	43.0	650	10.8	2.00	
1987	17.8	1.67	42.0	410	21.9	2.34	2.76
1988	10.1	0.93	66.7	630	13.2	3.09	1.05
1989	19.0	1.39	137.2	934	10.7	2.01	1.66
1990	10.6	0.81	102.1	622	7.5	2.12	0.98
1991	16.3	1.33	209.0	919	15.5	2.80	2.52
1992		1.75	135.1	774	11.2	2.01	1.69
1993		1.56	193.2	832	6.0	1.53	1.48
1995	19.5	1.27	136.4	1151	12.6	2.56	1.93
1997	30.0	2.00	133.0	783	9.3	2.38	1.07
1999	10.9	1.53	70.5	710	6.6	1.68	0.72
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high'		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1986	2.40	<	0.110	0.24	
1987	2.56	<	0.113	0.42	
1988	1.96	<	0.083	0.25	
1989	1.66	<	0.123	0.41	58.0
1990	1.90	<	0.093	0.30	30.0
1991	2.04	<	0.183	0.70	51.0
1992	2.24	<	0.110	0.26	73.2
1993	1.68	0.08	0.110	0.62	98.5
1995	3.01	0.19	0.158	0.32	51.9
1997	2.62	<	0.086	0.56	5.5
1999	1.62		0.094		21.5
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high'	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	136	73	37.9	11.97	5.79	<	1.53	0.51
1987	9	51	32.0	11.51	3.51	0.09	0.45	2.72
1988	829	77	28.7	14.62	4.33	<	3.79	1.81
1989	1087	106	47.1	13.43	5.01	0.28	1.02	0.65
1990	306	53	24.8	11.36	3.83	0.09	0.96	2.23
1991	386	27	14.0	2.91	1.16	0.02	0.24	0.08
1992	362	25	25.7	4.46	2.95	<	0.39	<
1993	340	26	20.9	3.92	1.31	<	0.31	<
1995	237	27	19.2	4.72	2.70	0.12	0.66	0.39
1997	232	108	15.6	2.69	2.43	<	0.17	0.59
1999	130	42	43.4	4.24	1.44	<	0.28	0.04
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

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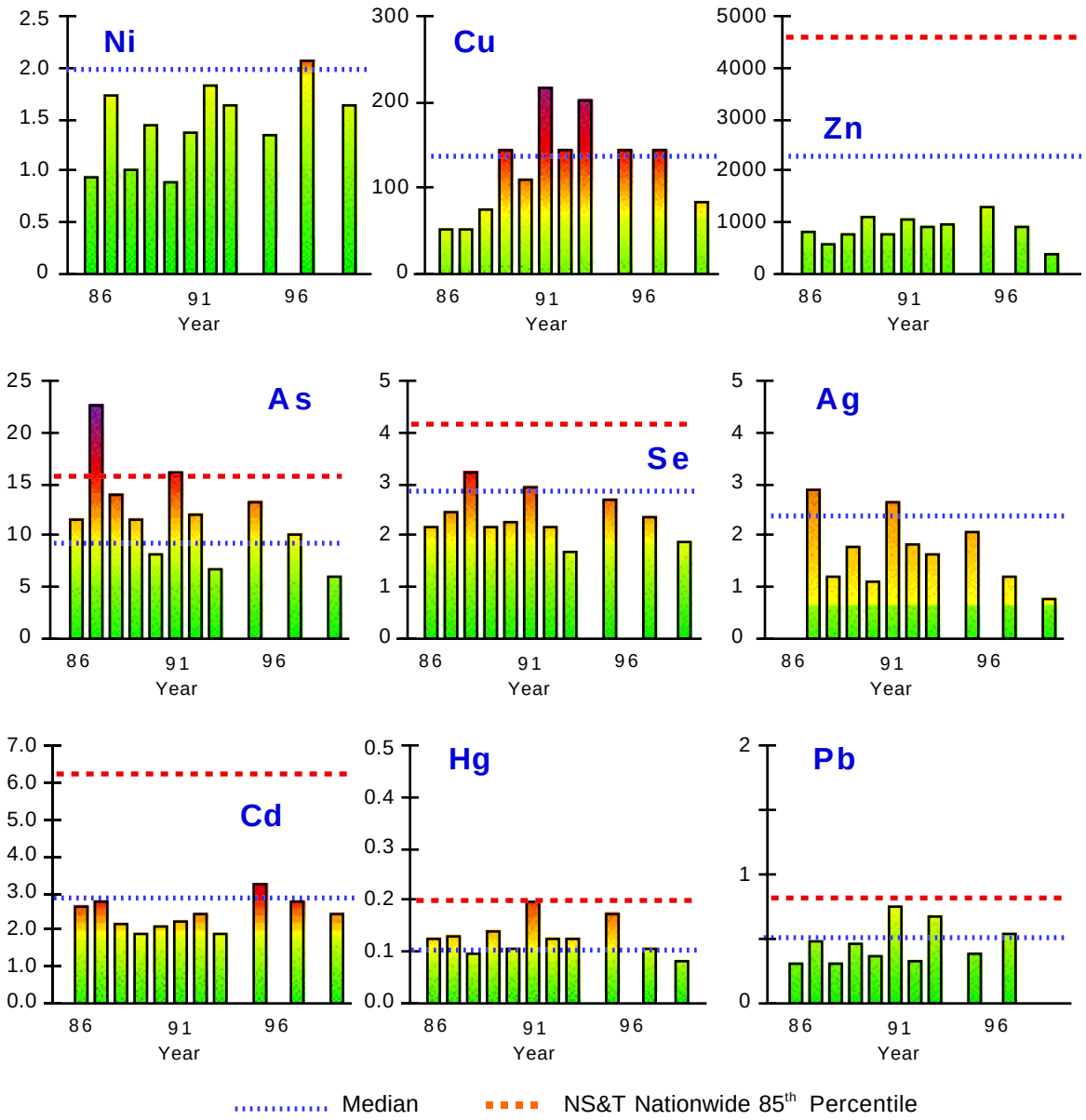

Figure 75. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Dry Bar (Apalachicola Bay) (APDB) (µg/g dry wt.).

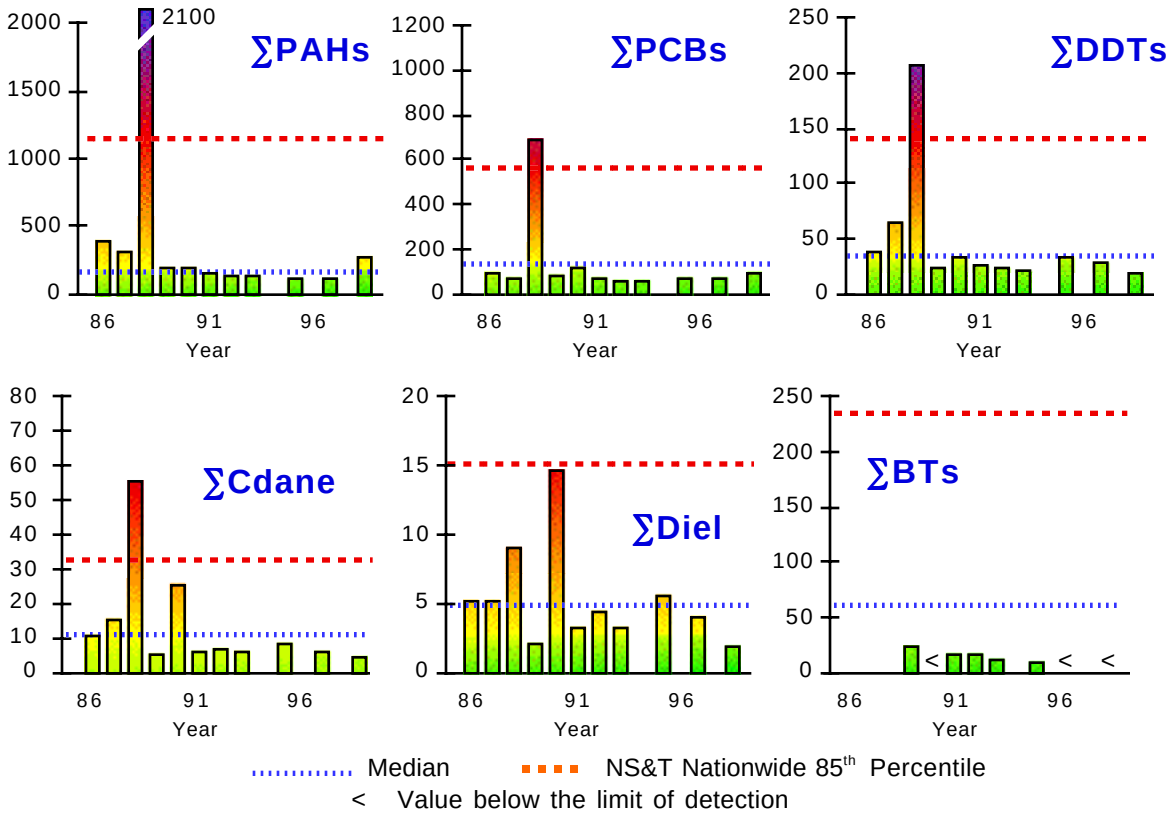

Figure 76. Trace organic contaminant and total butyltin trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Dry Bar (Apalachicola Bay) (APDB) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 68. A waterway within the reserve, Apalachicola, Florida, Apalachicola NERR (NOAA National Estuarine Research Reserve Collection, nerr0434, NOAA Photo Collection, NOAA Central Library).

Table 29. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Dry Bar (Apalachicola Bay) (APDB) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	22.3	1.47	68.3	433	9.3	1.30	
1987	8.0	0.89	40.3	271	6.5	1.70	1.40
1988	26.2	1.43	37.0	212	10.1	3.46	1.48
1989	21.4	1.35	37.1	300	9.1	2.06	1.96
1990	6.0	0.50	38.3	267	5.6	2.01	
1991	10.8	1.57	60.0	364	7.0	3.17	2.78
1992		2.05	24.1	2616	8.4	1.68	1.13
1993		1.78	72.7	522	4.3	1.75	2.22
1995	9.8	1.02	52.0	399	16.1	1.86	1.64
1997	10.0	1.10	52.0	310	9.3	1.91	1.10
1999	13.1	1.81	47.3	368	5.2	2.00	1.01
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high'		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1986	3.43	<	0.123	0.14	
1987	2.64	<	0.093	1.89	
1988	3.20	0.18	0.063	0.69	
1989	2.72	<	0.107	0.31	16.0
1990	3.13	<	0.110	0.17	<
1991	3.97	<	0.160	0.29	8.4
1992	2.61	<	0.090	0.21	8.3
1993	2.85	0.06	0.180	0.62	4.0
1995	2.27	0.09	0.114	0.16	3.1
1997	2.31	0.01	0.065	0.24	<
1999	2.40		0.106	0.25	<
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high'	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	0	63	32.2	8.00	4.66	0.39	0.82	0.72
1987	12	38	58.3	13.06	4.60	0.24	2.05	0.28
1988	2147	647	201.2	53.48	8.40	<	1.54	2.15
1989	139	45	15.5	2.62	1.46	0.10	0.56	0.23
1990	137	84	26.3	22.70	14.14	0.19	1.54	4.07
1991	104	30	18.6	3.67	2.70	0.07	0.82	0.20
1992	83	24	17.3	4.16	3.79	<	0.60	0.44
1993	75	17	13.0	3.91	2.70	0.07	0.27	0.44
1995	54	29	27.0	6.05	4.92	0.13	0.71	0.64
1997	51	37	21.3	5.68	3.34	<	0.41	0.57
1999	284	53	14.7	5.13	2.45	<	0.22	0.35
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

WKB
Weeks Bay NERR
Alabama

The Mussel Watch Project has three sites in Mobile Bay along the western shore of the Bay where oysters could be found. The sites are, from north to south, Dog River (MBDR), Hollingers Island (MBHI), and Cedar Point Reef (MBCP). The Cedar Point Reef site, which is across the mouth of Mobile Bay from the Reserve is closest to the Reserve, over 17 miles away. These Mussel Watch sites do not integrate contaminants from the same estuarine environment as that of the Reserve.

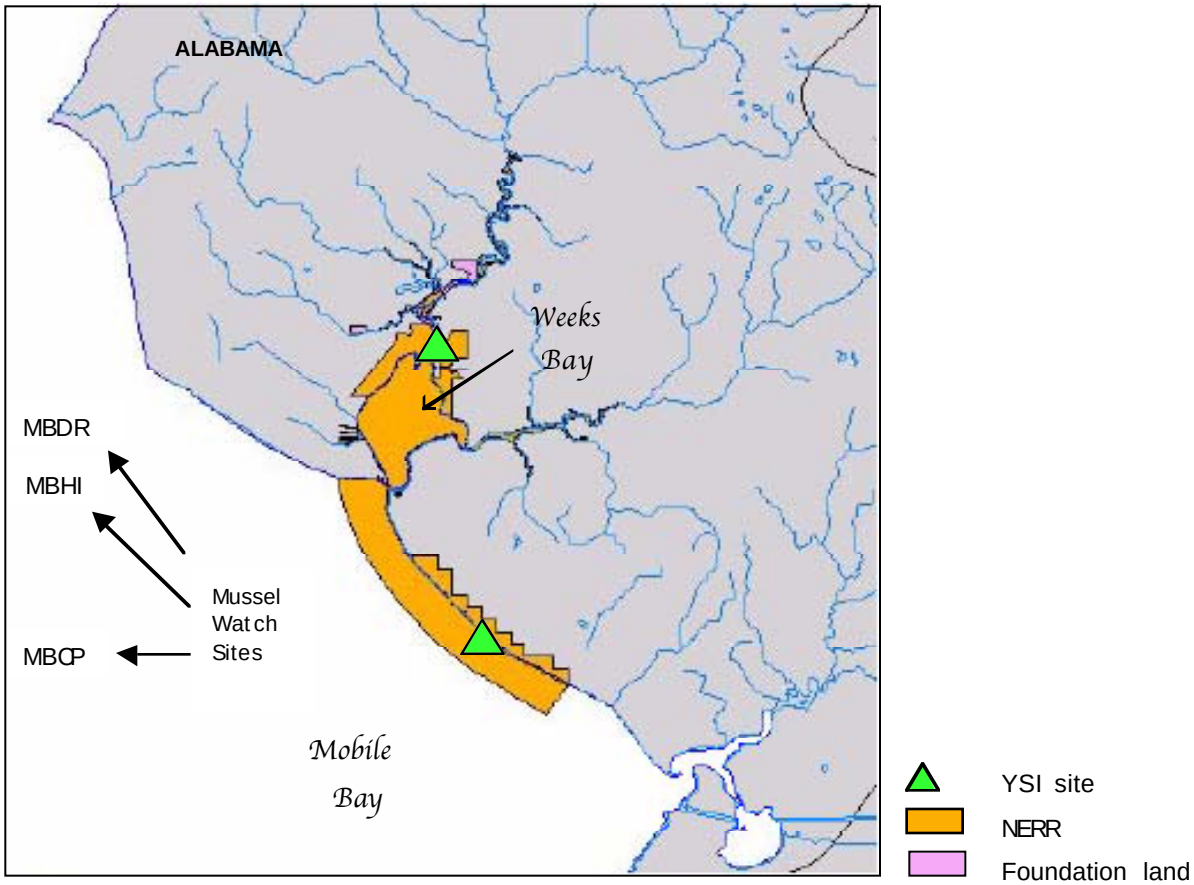

Figure 77. Weeks Bay NERR and adjacent areas.

Plate 69. Mussel Watch site at Cedar Pt. Reef (MBCP), Mobile Bay, in the Weeks Bay NERR (TAMU/GERG).

Plate 70. Bridge near the Mussel Watch site at Cedar Pt. Reef (MBCP), Mobile Bay, in the Weeks Bay NERR (TAMU/GERG).

GRD
Grand Bay NERR
Mississippi

The Mussel Watch site established in 1986 to the southwest of Pascagoula is only a fair match to the Grand Bay NERR. In addition to being 7.3 miles away, the monitoring site is influenced more by Pascagoula than the Reserve is. Therefore, contaminant concentrations would be expected to be generally higher at the Mussel Watch site than in the Reserve. Because of this, the rating is fair.

Many the trace elements exceeded the NS&T 'high,' including zinc, arsenic, selenium, mercury, and once, lead. For organics, ∑DDTs exceeded the NS&T 'high' once in 1988, ∑Cdane approached the NS&T 'high' concentration, and ∑BTs, hexachlorobenzene and Mirex exceeded their NS&T 'high' value.

By 1998, mercury had decreased to nearly the NS&T median concentration. For organics, there were decreasing contaminant trends, moving to or below the NS&T median concentrations for ∑DDTs, ∑Cdane, ∑Diel, ∑BTs and Mirex.

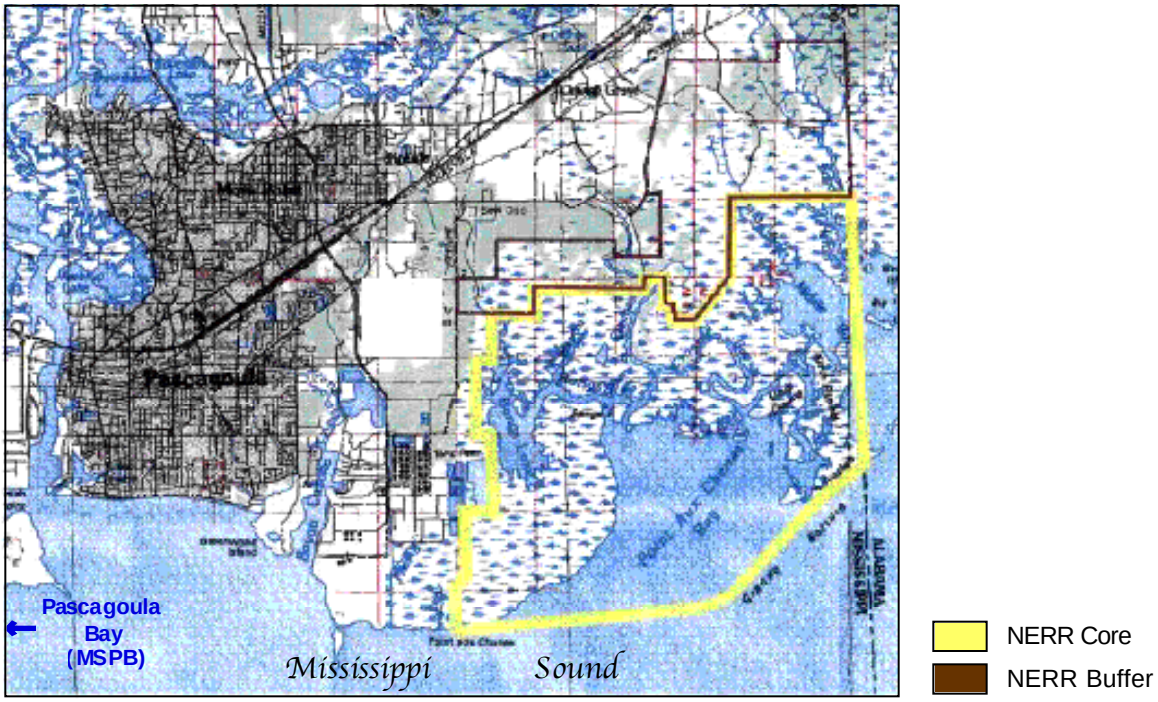

Figure 78. Grand Bay NERR and adjacent areas (Pascagoula Bay Mussel Watch site located to the west, off chart). Map taken from Grand Bay National Estuarine Research Reserve Final Environmental Impact Statement/Reserve Management Plan, Mississippi Department of Marine Resources, November, 1998.

Plate 71. Egret, Grand Bay, Mississippi, Grand Bay NERR (NOAA National Estuarine Research Reserve Collection, nerr0704, NOAA Photo Collection, NOAA Central Library).

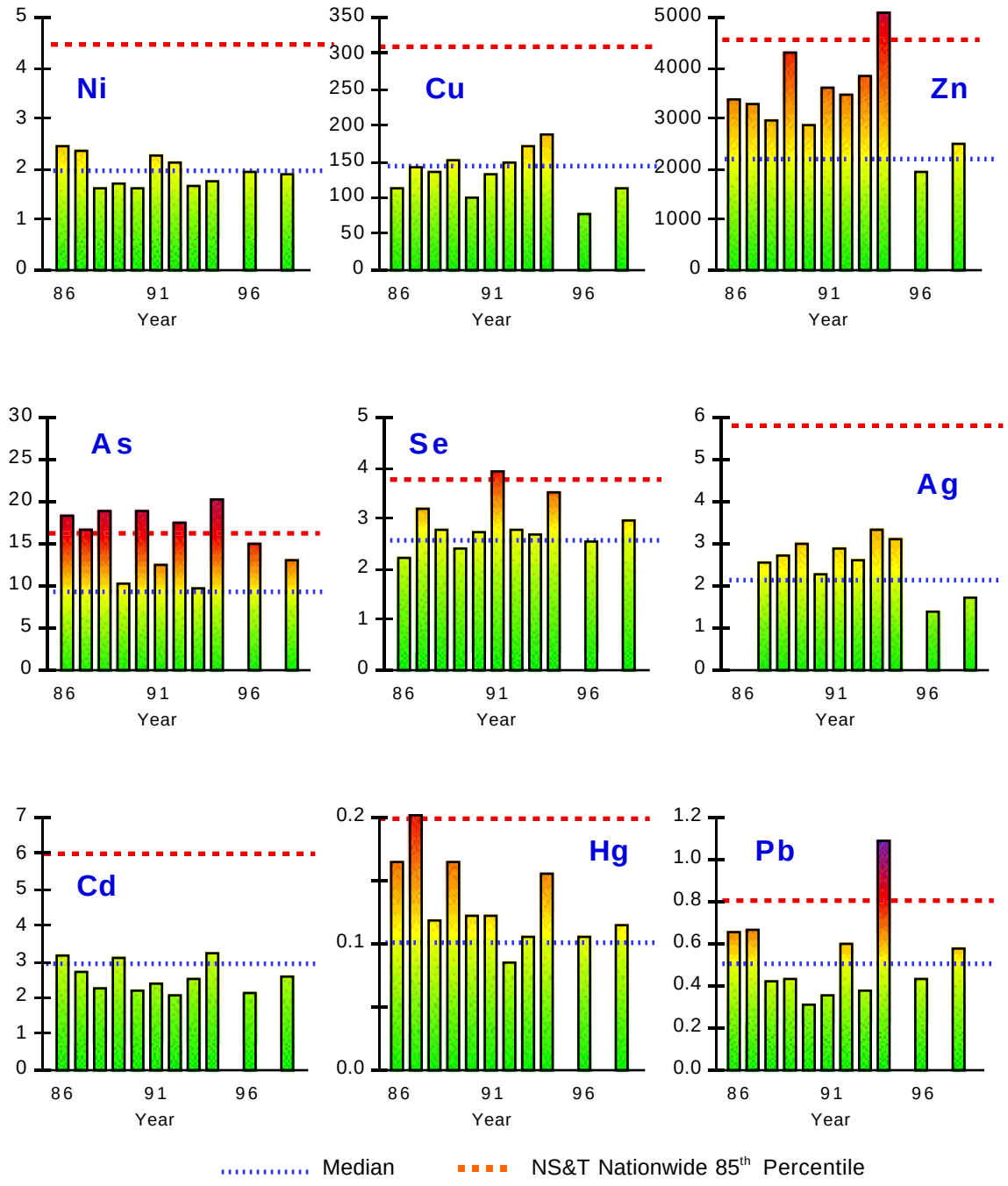

Figure 79. Trace element trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Pascagoula Bay (Mississippi Sound) (MSPB) (µg/g dry wt.).

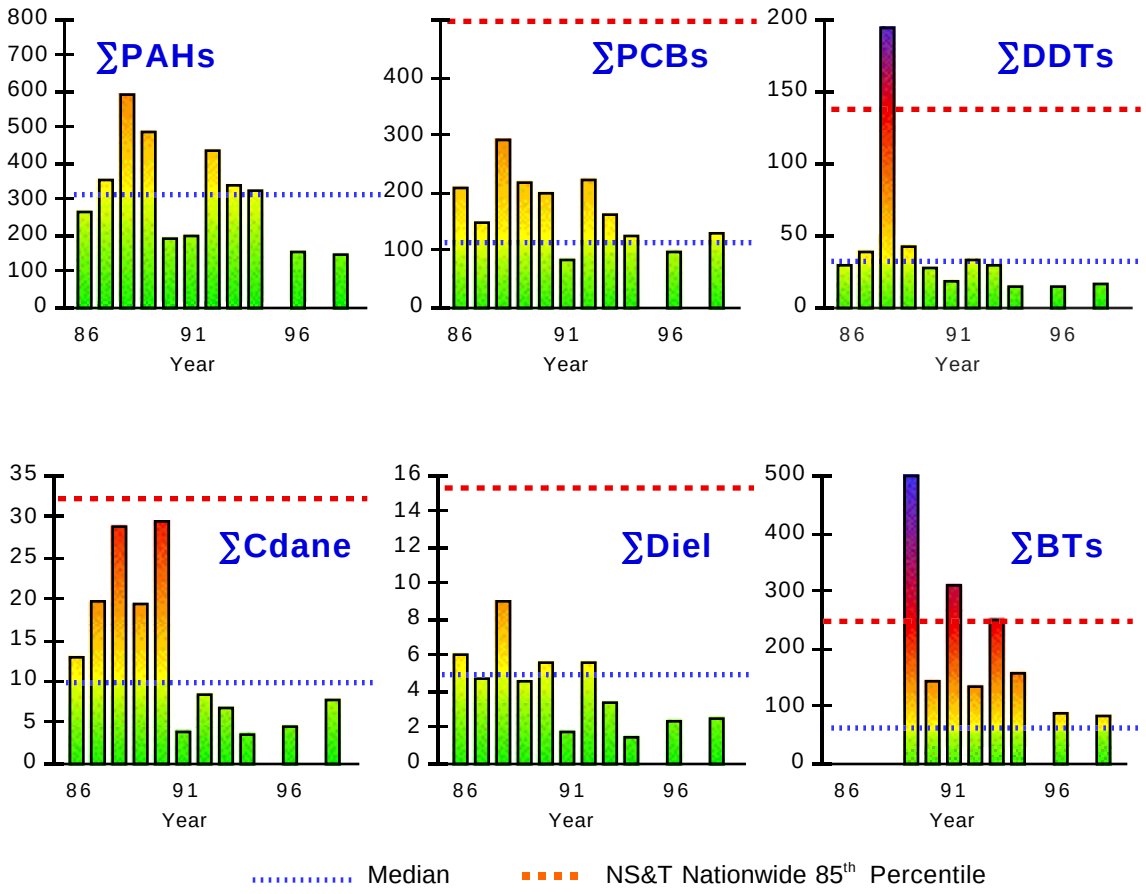

Figure 80. Trace organic contaminant and total butyltin trends in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Pascagoula Bay (Mississippi Sound) (MSPB) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 72. Grand Bay NERR, Grand Bay, Mississippi (NOAA National Estuarine Research Reserve Collection, nerr0679, NOAA Photo Collection, NOAA Central Library).

Table 30. Trace element and trace organic contaminant concentrations in American oysters (*Crassostrea virginica*) collected at NS&T Mussel Watch site Pascagoula Bay (Mississippi Sound) (MSPB) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	27.7	2.30	103.3	3233	17.3	2.07	
1987	14.4	2.22	130.7	3127	15.8	3.03	2.36
1988	13.2	1.49	126.3	2831	18.0	2.62	2.57
1989	15.3	1.56	141.4	4170	9.5	2.24	2.83
1990	14.6	1.49	89.0	2718	18.1	2.58	2.09
1991	10.9	2.10	121.3	3487	11.7	3.80	2.71
1992		1.98	139.2	3324	16.7	2.65	2.46
1993		1.53	160.7	3713	8.9	2.56	3.18
1994	28.4	1.59	176.3	4949	19.4	3.39	2.95
1996	37.0	1.80	68.0	1802	14.1	2.40	1.20
1998	84.7	1.75	102.0	2370	12.1	2.80	1.54
NS&T 'median'		2.0	140	2200	9.2	2.8	2.3
NS&T 'high'		4.6	310	4600	16	4.1	5.7

Year	Cd	Sn	Hg	Pb	∑BTs
1986	3.00	<	0.160	0.62	
1987	2.50	0.17	0.197	0.63	
1988	2.07	<	0.113	0.38	
1989	2.87	<	0.160	0.39	485.0
1990	1.97	0.11	0.117	0.27	130.0
1991	2.17	<	0.117	0.32	297.8
1992	1.85	0.41	0.080	0.56	120.8
1993	2.33	0.19	0.100	0.34	233.3
1994	3.01	0.22	0.149	1.06	140.8
1996	1.91	<	0.100	0.40	73.8
1998	2.40	<	0.109	0.55	70.1
NS&T 'median'	2.6		0.100	0.50	59
NS&T 'high'	6.1		0.200	0.80	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	242	195	23.3	12.01	5.62	0.06	0.47	4.84
1987	330	135	32.5	18.66	4.21	<	0.15	3.10
1988	571	277	188.8	27.93	8.62	<	1.85	10.51
1989	469	203	36.5	18.52	4.18	0.86	1.58	6.37
1990	167	186	21.9	28.45	5.15	2.10	<	4.06
1991	178	70	12.1	2.86	1.36	<	0.36	0.17
1992	416	208	27.1	7.52	5.21	<	0.47	0.42
1993	318	146	23.2	5.82	2.99	<	0.52	0.66
1994	300	110	9.0	2.65	0.98	0.06	0.36	1.68
1996	133	84	8.6	3.44	1.87	<	0.00	0.19
1998	122	115	11.0	6.63	2.07	<	0.35	1.11
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 73. Marsh, Grand Bay, Mississippi, Grand Bay NERR (NOAA National Estuarine Research Reserve Collection, nerr0667, NOAA Photo Collection, NOAA Central Library).

Plate 74. Aerial view, Grand Bay, Mississippi, Grand Bay NERR (NOAA National Estuarine Research Reserve Collection, nerr0613, NOAA Photo Collection, NOAA Central Library).

TJR
Tijuana River NERR
California

The Mussel Watch site at the North Jetty of Imperial Beach is about one mile north of the northernmost boundary of the Tijuana River NERR. Even though the Mussel Watch site is a distance away, there is a good match between the two locations because both are affected by same waters.

Of the trace elements, arsenic, selenium, silver, and zinc all approach or exceed their respective NS&T 'high' values. Those organics exhibiting NS&T 'high' concentrations were ∑Diel, ∑DDTs, and Lindane.

There were a number of trends, including both trace elements and organics. Mercury, lead, zinc, ∑Cdane, and ∑Diel were all decreasing, while an increasing trend was found for ∑PAHs.

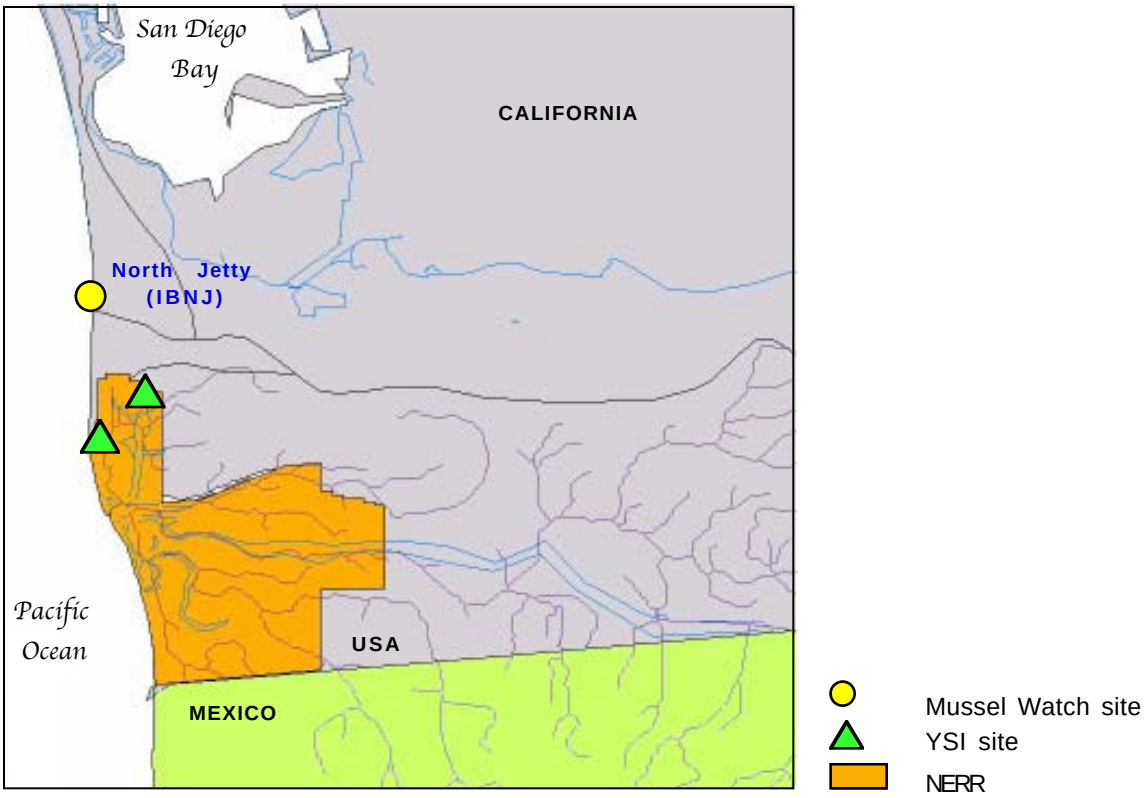

Figure 81. Tijuana River NERR and adjacent areas.

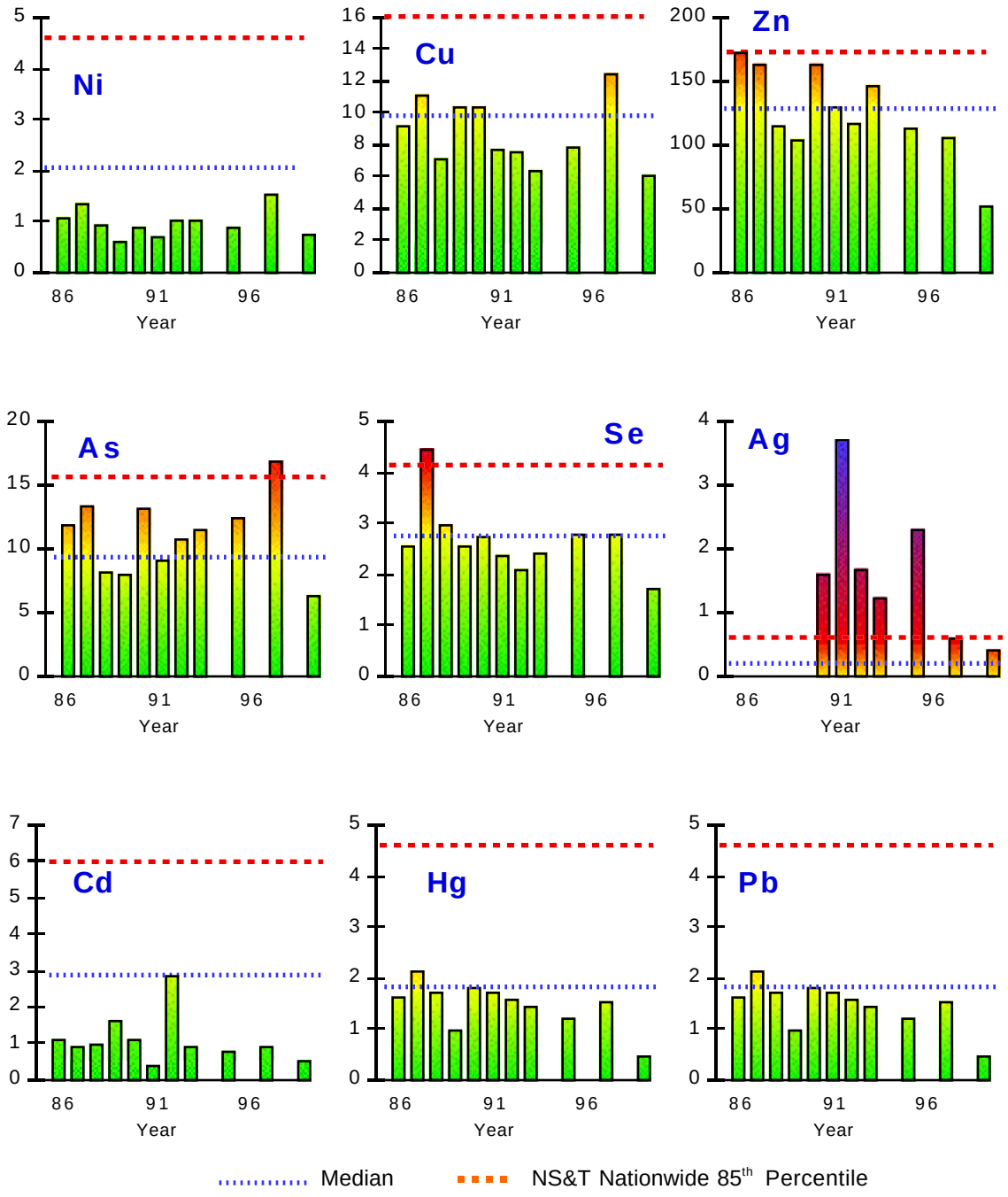

Figure 82. Trace element trends in California mussels (*Mytilus californianus*) collected at NS&T Mussel Watch site North Jetty (Imperial Beach) (IBNJ) (µg/g dry wt.).

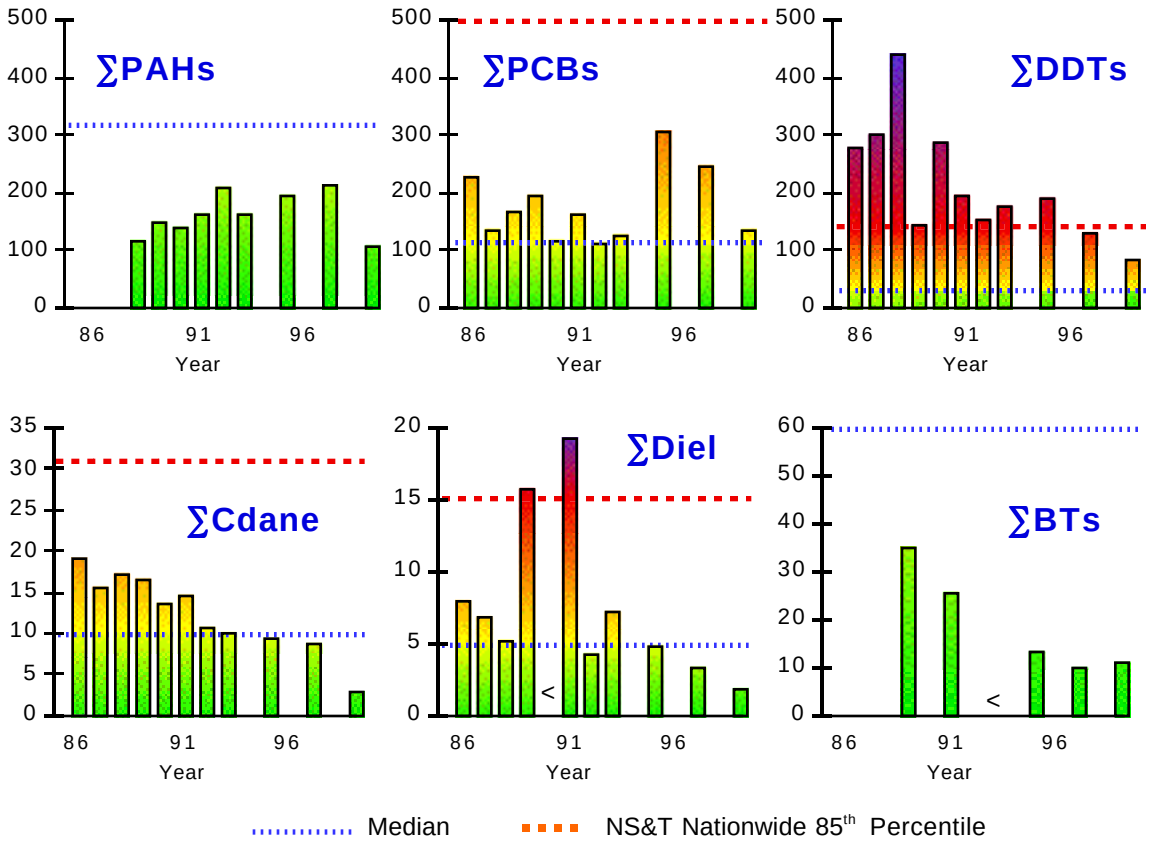

Figure 83. Trace organic contaminant and total butyltin trends in California mussels (*Mytilus californianus*) collected at NS&T Mussel Watch site North Jetty (Imperial Beach) (IBNJ) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 75. Tijuana River NERR (NOAA National Estuarine Research Reserve Collection, nerr0112, NOAA Photo Collection, NOAA Central Library).

Table 31. Trace element and trace organic contaminant concentrations in California mussels (*Mytilus californianus*) collected at NS&T Mussel Watch site North Jetty (Imperial Beach) (IBNJ) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	6.8	0.93	8.7	167	11.3	2.41	
1987	9.7	1.20	10.7	157	12.7	4.30	
1988		0.76	6.6	109	7.6	2.83	
1989		0.44	9.9	98	7.3	2.40	
1990	6.3	0.71	9.9	157	12.6	2.56	1.47
1991	8.8	0.56	7.3	123	8.5	2.20	3.61
1992	8.1	0.86	7.1	110	10.1	1.95	1.56
1993	<	0.89	6.0	140	10.9	2.24	1.09
1995	12.2	0.74	7.4	107	11.8	2.64	2.19
1997	12.0	1.40	12.0	100	16.3	2.61	0.49
1999	3.9	0.58	5.6	47	5.7	1.56	0.29
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1986	0.86	<	0.093	1.49	
1987	0.72	<	0.097	2.00	
1988	0.77	<	0.090	1.57	
1989	1.43	0.06	0.087	0.81	33.2
1990	0.87	0.07	0.040	1.65	
1991	0.18	0.03	0.090	1.57	23.8
1992	2.65	0.20	0.080	1.41	
1993	0.67	<	0.080	1.30	0.0
1995	0.56	0.21	0.060	1.04	11.5
1997	0.71	0.14	0.057	1.40	8.2
1999	0.28		0.045	0.32	9.1
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	0	212	264.9	18.23	7.37	0.27	1.73	<
1987	0	121	287.1	14.67	6.33	<	0.00	<
1988	102	152	426.6	16.13	4.50	<	0.00	<
1989	133	180	130.3	15.47	15.10	<	1.47	<
1990	124	102	273.6	12.64	<	<	1.93	<
1991	147	149	179.2	13.51	18.76	0.51	2.91	0.70
1992	194	95	136.8	9.70	3.65	<	2.87	<
1993	149	112	162.5	8.91	6.55	<	0.85	0.64
1995	180	290	174.1	8.28	4.16	0.11	0.67	0.11
1997	198	229	112.5	7.65	2.78	0.84	0.84	0.39
1999	90	119	66.0	2.00	1.18	<	0.09	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

ELK
Elkhorn Slough NERR
California

Two Mussel Watch sites are near the Reserve: the Elkhorn Slough and the Moss Landing sites. There is a good association between the Reserve and the Elkhorn Slough site, even though they are 0.7 miles apart. While the Moss Landing Mussel Watch site is 1.3 miles from the Reserve, the association is less because this Mussel Watch site is more oceanic than estuarine.

At Elkhorn Slough, trace elements exceeding the NS&T 'high' value were nickel and cadmium. While ∑Cdane, Lindane and Mirex exceeded their NS&T 'high' values on one occasion each, ∑PAHs and ∑Diel concentrations substantially exceeded the NS&T 'high' for most years.

At Moss Landing, nickel, zinc, selenium, cadmium, and lead were all elevated. The NS&T 'high' values were met or exceeded for ∑DDTs, ∑Cdane (once), ∑Diel, ∑BTs and Mirex.

No trend analyses were possible for Elkhorn Slough because data were only available for five years of monitoring. For Moss Landing, decreasing trends were determined for lead and ∑BTs. An increasing ∑DDTs trend was found, and an apparent increasing trend was found for hexachlorobenzene.

The increasing trend found for hexachlorobenzene may be an artifact of lower detection limits. During the first four years of the project, The values were reported as below the MDL, while for the next four years the values were still low but were reported as real numbers.

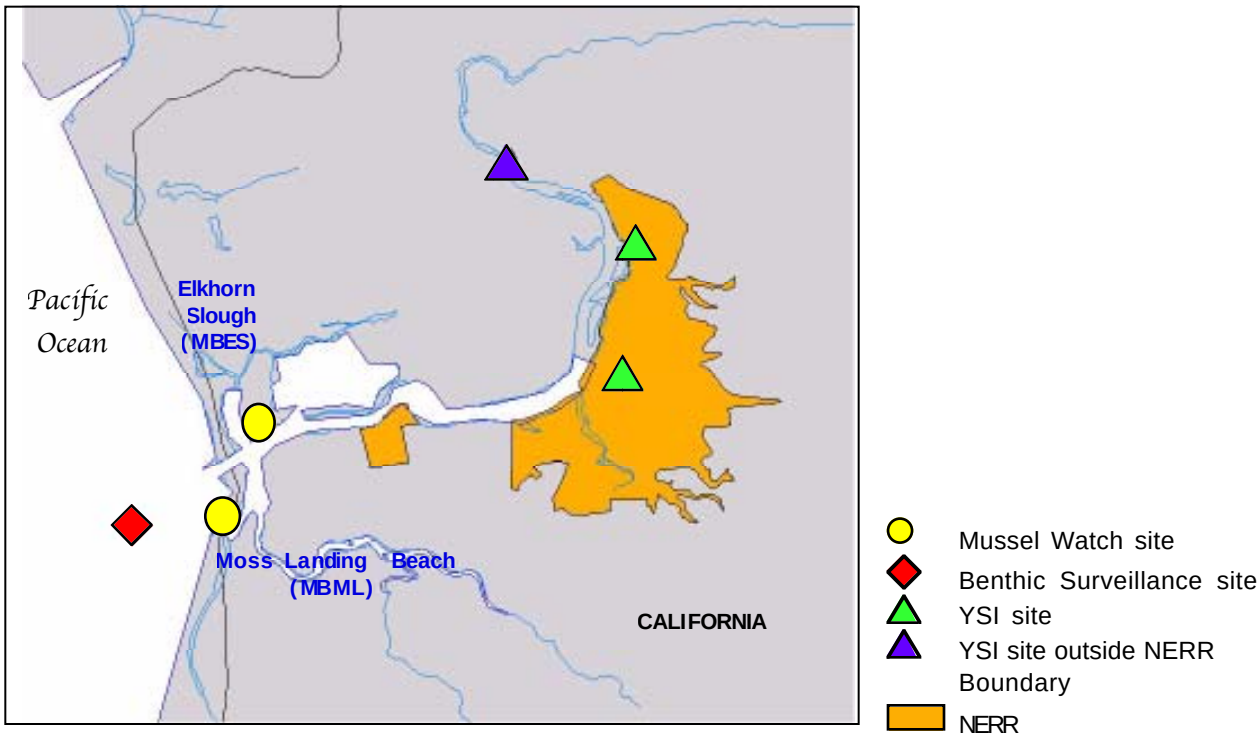

Figure 84. Elkhorn Slough NERR and adjacent areas.

Plate 76. Mussel Watch site at Moss Landing (MBML), Monterey Bay, near the Elkhorn Slough NERR (TAMU/GERG).

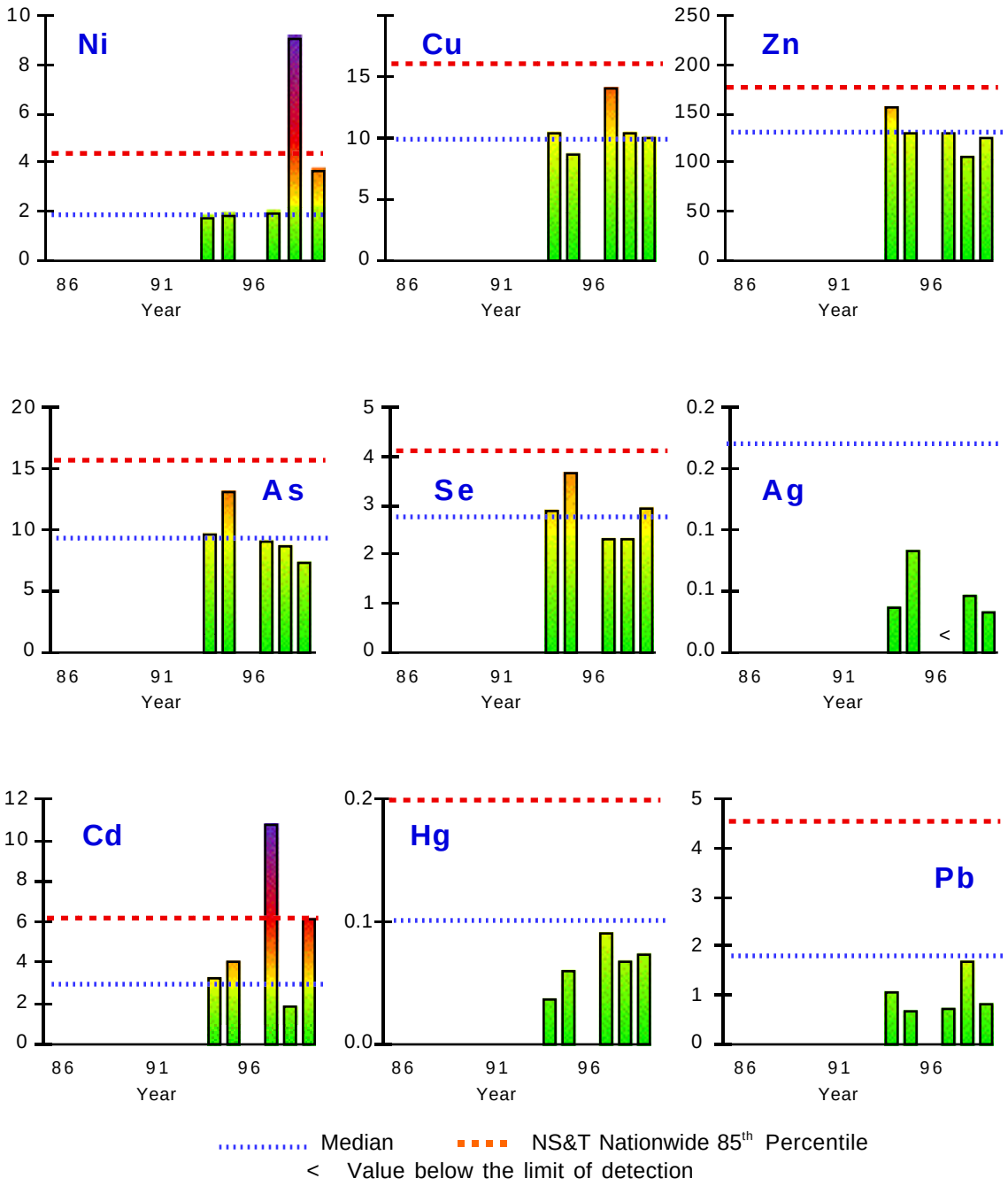

Figure 85. Trace element trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Elkhorn Slough (Monterey Bay) (MBES) (µg/g dry wt.).

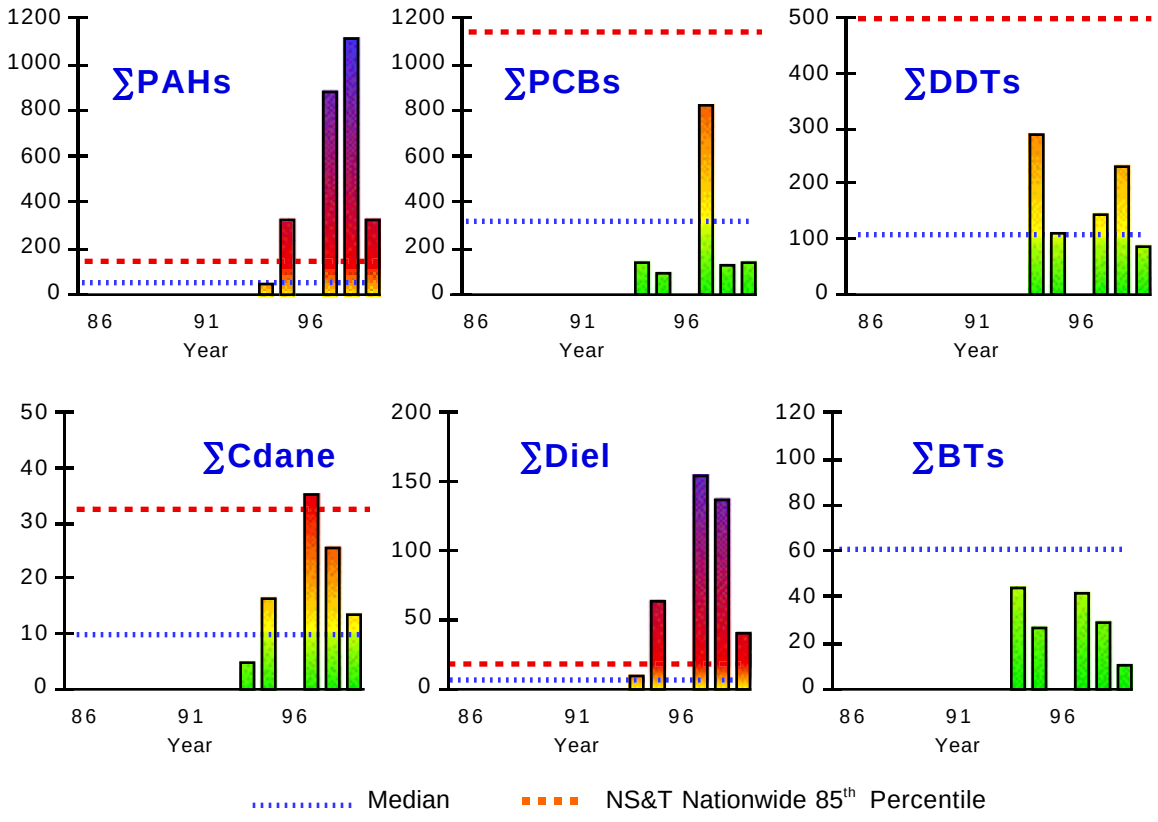

Figure 86. Trace organic contaminant and total butyltin trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Elkhorn Slough (Monterey Bay) (MBES) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.)

Plate 77. Salt marsh, Moss Landing, California, Elkhorn Slough NERR (NOAA National Estuarine Research Reserve Collection, nerr0058, NOAA Photo Collection, NOAA Central Library).

Table 32. Trace element and trace organic contaminant concentrations in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Elkhorn Slough (Monterey Bay) (MBES) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1994	9.6	1.48	9.8	150	9.0	2.76	0.03
1995	24.6	1.54	8.2	123	12.5	3.51	0.08
1997	10.0	1.60	13.6	122	8.4	2.17	<
1998	190.0	8.81	9.9	98	8.2	2.19	0.04
1999	18.9	3.33	9.5	119	6.8	2.79	0.03
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1994	2.86	0.03	0.030	0.93	40.0
1995	3.65	0.11	0.054	0.50	22.9
1997	10.40	0.15	0.085	0.55	37.8
1998	1.49	<	0.062	1.55	24.8
1999	5.77		0.068	0.69	7.3
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1994	102	274	13.6	3.25	2.98	<	0.33	<
1995	52	95	285.7	15.01	56.95	0.15	1.00	<
1997	783	132	846.8	33.73	149.17	0.22	0.53	1.52
1998	85	215	1074.7	24.34	130.60	0.44	0.60	<
1999	100	72	284.2	11.82	35.05	0.75	3.44	0.46
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 78. Spray in the sunset at Soquel Point, Monterey Bay, CA (1963) (Photographer Capt. A. E. Theberge. Historic C&GS Collection, theb1438, NOAA Photo Collection, NOAA Central Library).

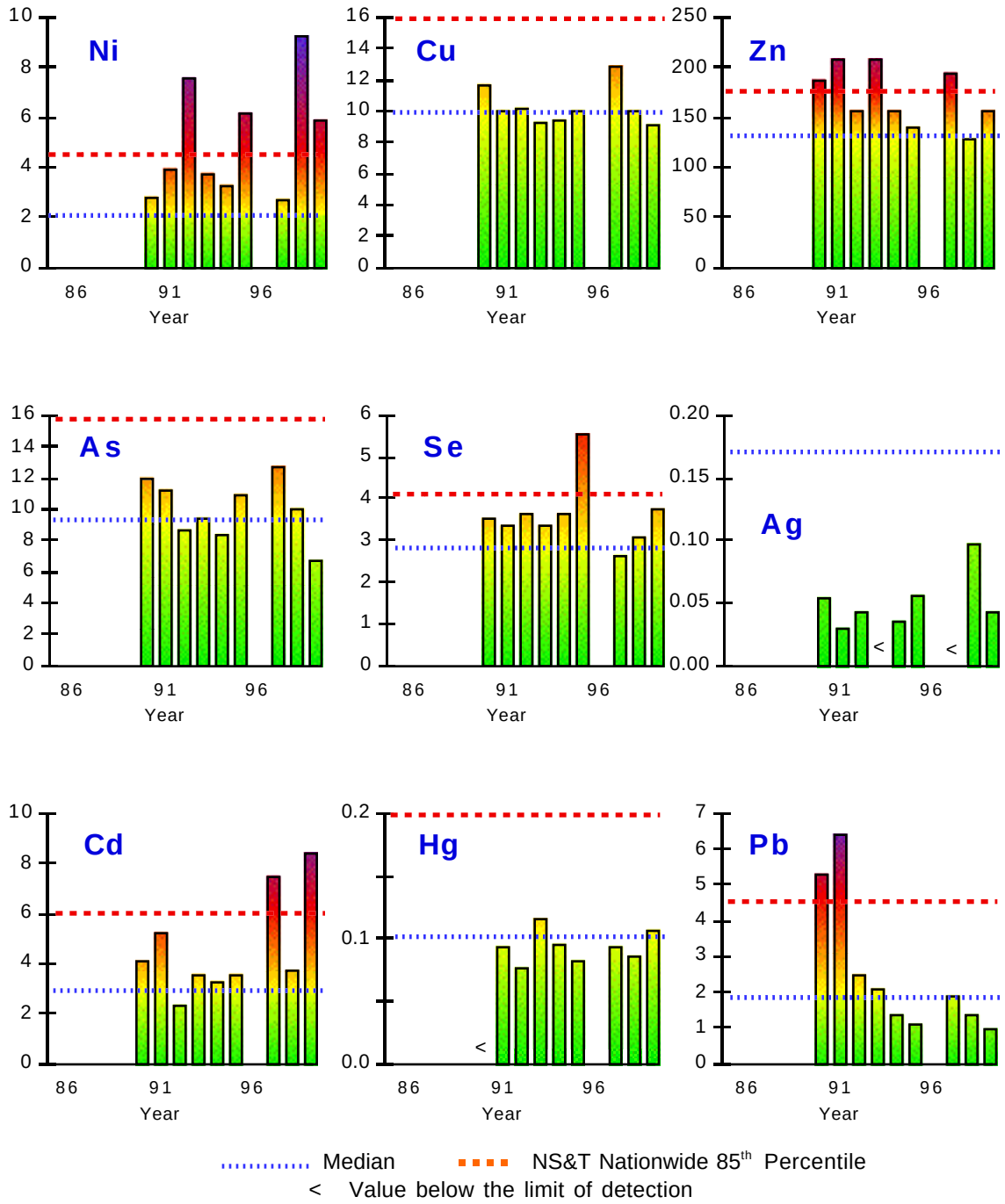

Figure 87. Trace element trends in California mussels (*Mytilus californianus*) collected at NS&T Mussel Watch site Moss Landing (Monterey Bay) (MBML) (µg/g dry wt.).

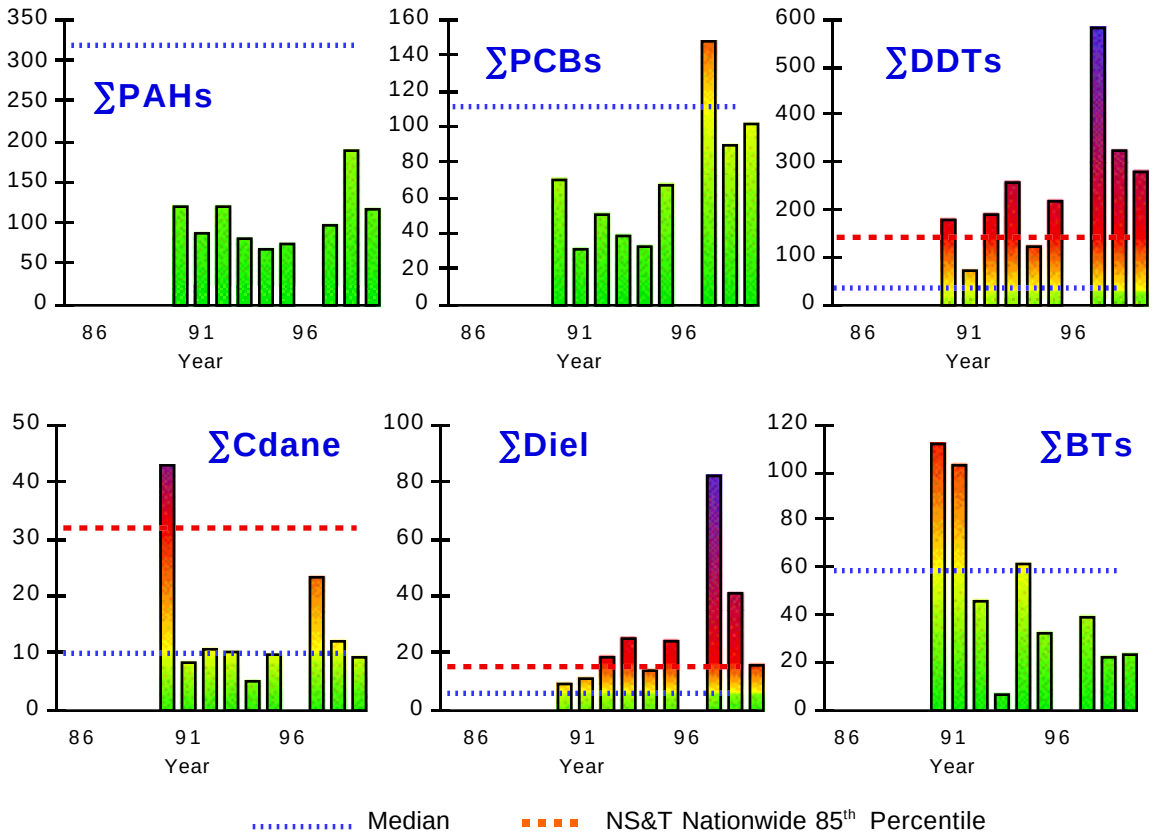

Figure 88. Trace organic contaminant and total butyltin trends in California mussels (*Mytilus californianus*) collected at NS&T Mussel Watch site Moss Landing (Monterey Bay) (MBML) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 79. Mussel Watch site at Moss Landing (MBML), Monterey Bay, near the Elkhorn Slough NERR (TAMU/GERG).

Table 33. Trace element and trace organic contaminant concentrations in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Moss Landing (Monterey Bay) (MBML) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1990	5.5	2.45	11.3	180	11.5	3.36	0.05
1991	11.2	3.63	9.5	200	10.7	3.17	0.02
1992	26.0	7.23	9.7	150	8.1	3.47	0.04
1993	10.0	3.46	8.7	200	8.9	3.20	<
1994	13.5	3.01	9.0	150	7.9	3.44	0.03
1995	33.7	5.84	9.6	132	10.4	5.37	0.05
1997	8.3	2.40	12.4	186	12.3	2.48	<
1998	47.3	8.95	9.5	121	9.5	2.89	0.09
1999	24.0	5.58	8.7	148	6.2	3.60	0.04
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1990	3.80	0.36	<	5.10	108.4
1991	4.90	0.09	0.087	6.20	100.0
1992	2.05	0.10	0.070	2.26	42.1
1993	3.27	<	0.110	1.90	3.4
1994	2.96	0.11	0.090	1.13	58.4
1995	3.27	0.13	0.076	0.92	28.8
1997	7.20	0.21	0.087	1.70	35.4
1998	3.46	<	0.080	1.16	18.6
1999	8.09		0.100	0.76	20.0
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1990	111	66	161.7	41.65	5.99	<	2.03	<
1991	78	27	54.3	6.80	7.86	<	0.00	<
1992	110	45	171.5	9.07	15.83	<	0.97	<
1993	70	34	241.4	8.90	22.27	<	0.71	<
1994	57	28	107.0	3.49	10.59	0.14	0.34	0.34
1995	66	62	200.0	8.35	21.14	0.12	0.61	0.56
1997	89	144	567.1	21.76	79.18	0.19	0.43	1.20
1998	179	85	308.0	10.51	38.48	0.19	0.37	<
1999	108	96	260.9	7.82	12.69	1.03	0.22	0.65
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

SFB

San Francisco Bay NERR (proposed)

California

This proposed NERR would have three components: China Camp, Rush Ranch and Brown's Island. Of the five Mussel Watch sites in the area, Point San Pedro is closest to the China Camp proposed component. The Semple Point Mussel Watch sediment site is closest to the Rush Ranch and Brown's Island components.

The three southernmost sites (Dumbarton Bridge, San Mateo Bridge, Emeryville) have been sampled for both mussels and sediments. No mussels were found at Pt. San Pedro or Semple Point, so only sediments were sampled here.

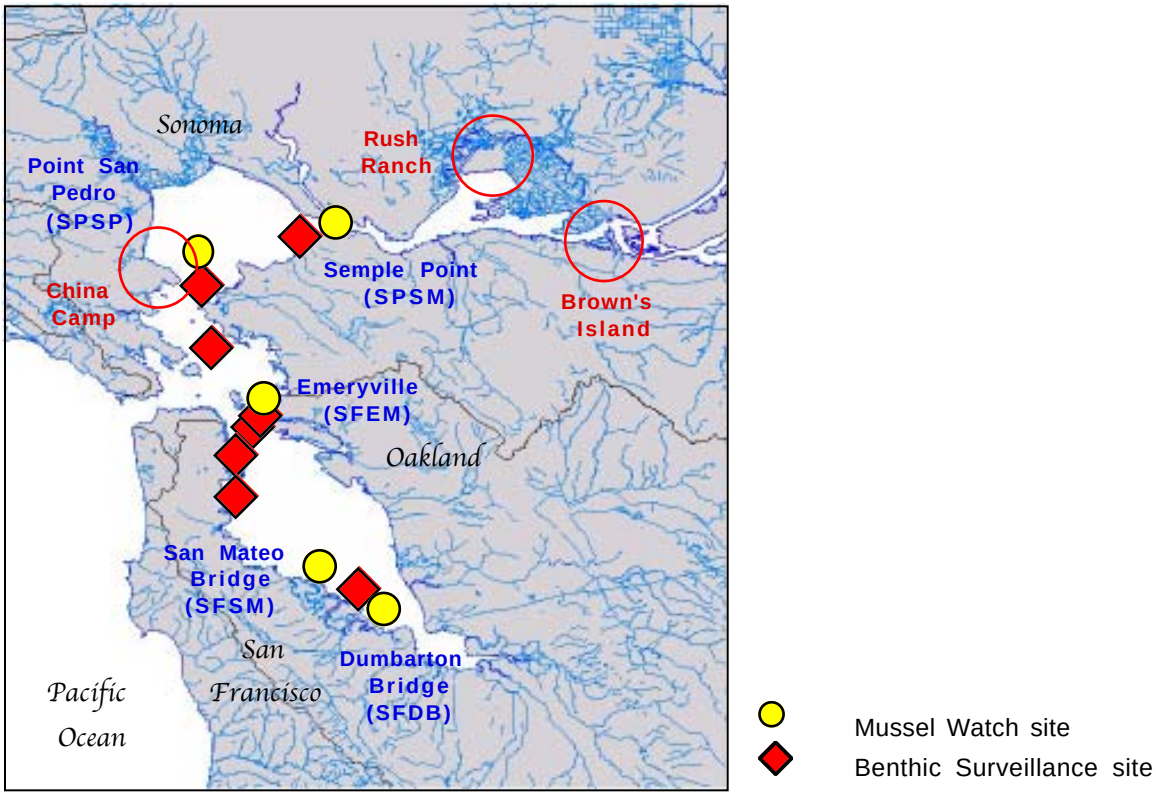

Figure 89. Proposed San Francisco Bay NERR and adjacent areas.

Plate 80. Golden Gate Bridge, San Francisco, California (America's Coastline Collection, line0538, NOAA Photo Collection, NOAA Central Library).

SOS
South Slough NERR
Oregon

The Mussel Watch Project has two sites in Coos Bay, which is north of the South Slough NERR. The Mussel Watch site at Coos Head, 2.5 miles from the Reserve, is indicative of the general conditions found in the Reserve. It is influenced by the estuarine outflow of the Reserve and also by Coos Bay to the north. The site at Russell Point is not only further away (9 miles), but is also in a more urban part of Coos Bay. The Reserve is minimally affected by urbanization.

Zinc was the only trace element exceeding the NS&T 'high' concentration at Russell Point. At Coos Head, nickel, copper, and mercury were all above the 'high' value one time.

Organic contaminants exceeding the 85th percentile at the Russell Point site were ∑PAHs, ∑BTs, hexachlorobenzene, Lindane and Mirex. Most of these higher levels occurred earlier in the monitoring program. At Coos Head, organic contaminants exceeding the 85th percentile were ∑PAHs, ∑Diel, hexachlorobenzene, Lindane, and Mirex.

No trends were found for trace elements at either site. Decreasing trends were found for ∑Cdane, ∑BTs, and Lindane at Russell Point. At Coos Head, decreasing trends were found for ∑BTs and Lindane. No increasing trends were found.

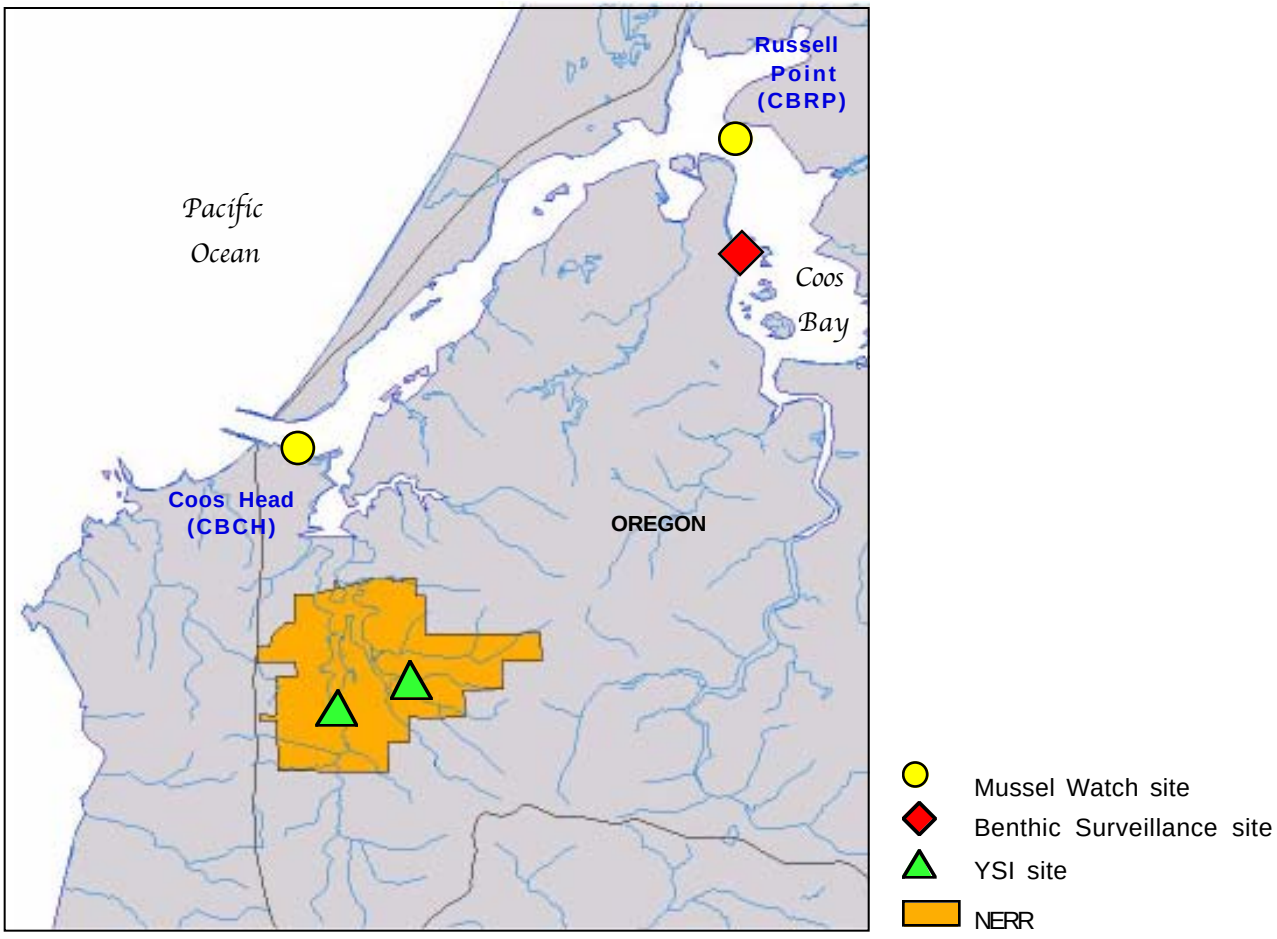

Figure 90. South Slough NERR and adjacent areas.

Plate 81. Mussel Watch site at Coos Head (AIAC), Coos Bay, in the South Slough NERR (TAMU/GERG).

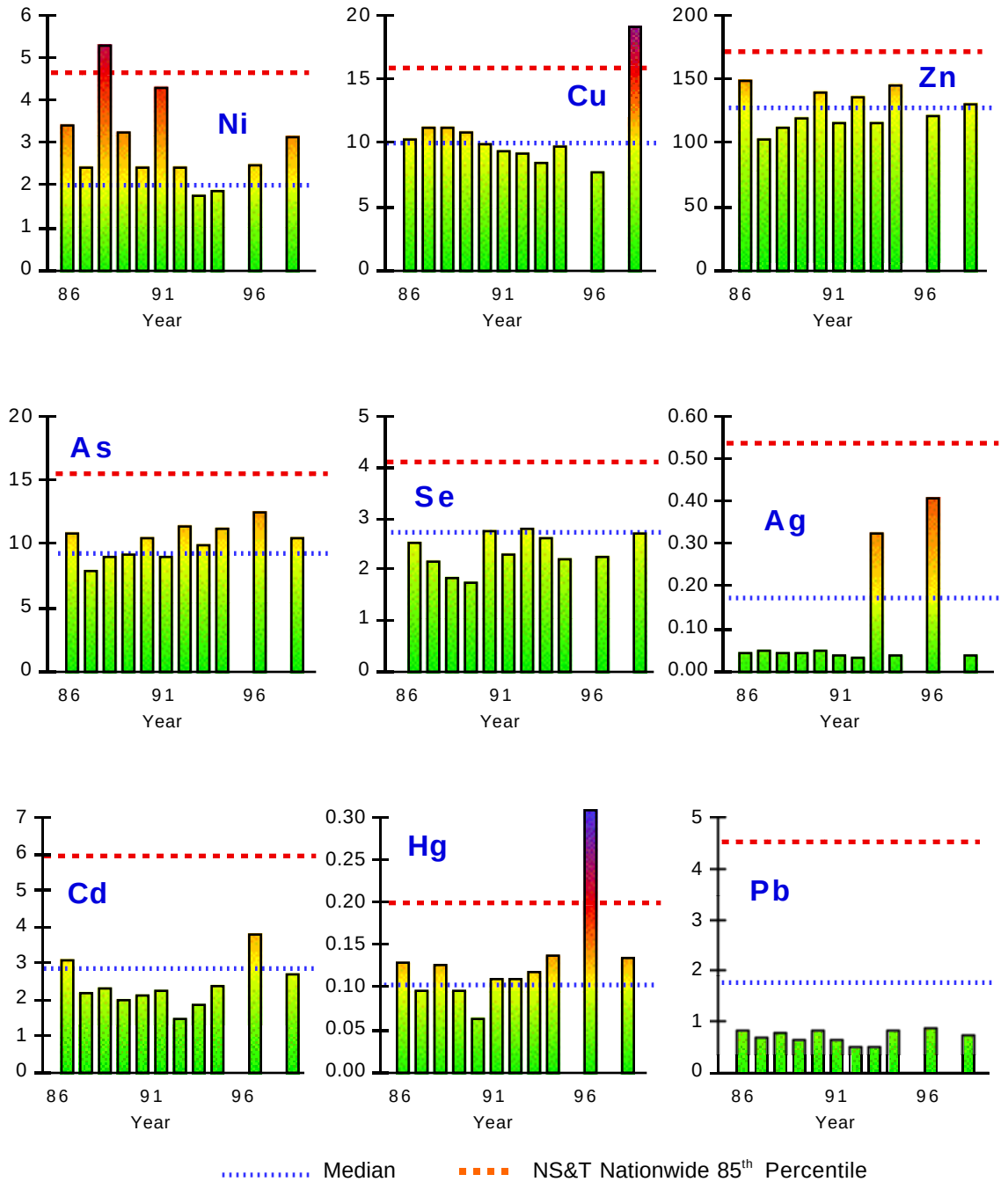

Figure 91. Trace element trends in California mussels (*Mytilus californianus*) collected at NS&T Mussel Watch site Coos Head (Coos Bay) (CBCH) (µg/g dry wt.).

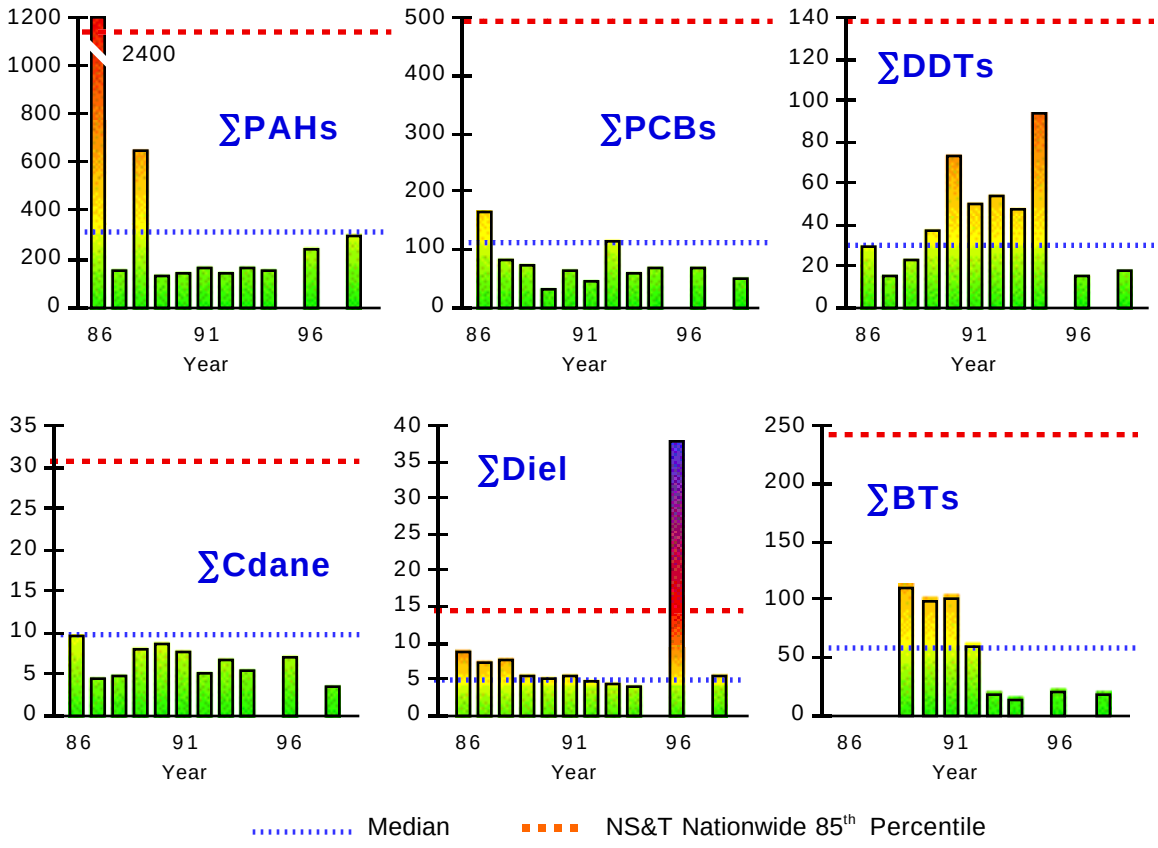

Figure 92. Trace organic contaminants and total butyltin trends in California mussels (*Mytilus californianus*) collected at NS&T Mussel Watch site Coos Head (Coos Bay) (CBCH) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 82. A Great Egret wades in a back channel of the lagoon at low tide, South Slough NERR (NOAA National Estuarine Research Reserve Collection, nerr0109, NOAA Photo Collection, NOAA Central Library).

Table 34. Trace element and trace organic contaminant concentrations in California mussels (*Mytilus californianus*) collected at NS&T Mussel Watch site Coos Head (Coos Bay) (CBCH) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

	Year	Mn	Ni	Cu	Zn	As	Se	Ag
CBCH	1986	10.7	3.27	9.7	143	10.3	2.37	0.03
CBCH	1987	8.6	2.23	10.6	97	7.4	2.00	0.03
CBCH	1988		5.10	10.7	106	8.4	1.70	0.03
CBCH	1989		3.10	10.3	113	8.7	1.60	0.02
CBCH	1990	8.8	2.24	9.4	133	9.8	2.60	0.03
CBCH	1991	6.5	4.13	8.7	110	8.5	2.17	0.02
CBCH	1992	7.2	2.24	8.7	130	10.8	2.66	0.01
CBCH	1993	<	1.56	7.8	110	9.4	2.46	0.31
CBCH	1994	6.0	1.72	9.2	140	10.6	2.08	0.02
CBCH	1996	9.8	2.30	7.2	115	11.9	2.10	0.39
CBCH	1998	37.8	2.98	18.5	125	9.9	2.57	0.02
NS&T 'median'			2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'			4.6	16	170	16	4.1	0.54

	Year	Cd	Sn	Hg	Pb	∑BTs
CBCH	1986	2.90	0.04	0.120	0.70	
CBCH	1987	2.00	0.04	0.087	0.54	
CBCH	1988	2.13	<	0.117	0.65	
CBCH	1989	1.80	0.08	0.087	0.49	103.1
CBCH	1990	1.91	0.11	0.053	0.69	91.7
CBCH	1991	2.03	0.02	0.100	0.51	94.6
CBCH	1992	1.26	0.05	0.100	0.36	52.6
CBCH	1993	1.67	<	0.110	0.36	10.0
CBCH	1994	2.16	0.04	0.130	0.67	5.2
CBCH	1996	3.62	0.10	0.300	0.70	12.1
CBCH	1998	2.51	<	0.126	0.59	10.6
NS&T 'median'		2.6		0.100	1.8	59
NS&T 'high'		6.1		0.200	4.6	240

	Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
CBCH	1986	2422	150	25.3	8.53	7.77	<	2.83	0.73
CBCH	1987	123	68	11.6	3.43	6.23	<	1.67	<
CBCH	1988	607	58	18.9	3.79	6.43	0.73	1.97	<
CBCH	1989	82	17	32.7	6.93	4.20	1.23	4.80	<
CBCH	1990	94	48	68.9	7.76	3.83	<	3.23	<
CBCH	1991	120	31	46.2	6.69	4.23	0.77	3.39	<
CBCH	1992	100	100	50.0	4.10	3.64	0.03	2.23	<
CBCH	1993	117	44	42.9	5.62	3.25	0.22	1.53	<
CBCH	1994	124	52	89.3	4.30	2.87	0.09	1.64	2.33
CBCH	1996	206	52	11.0	5.98	36.82	0.18	0.78	0.37
CBCH	1998	259	37	14.0	2.47	4.37	0.22	0.76	0.12
NS&T 'median'		300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'		1200	450	140	32	15	1.1	2.8	1.2

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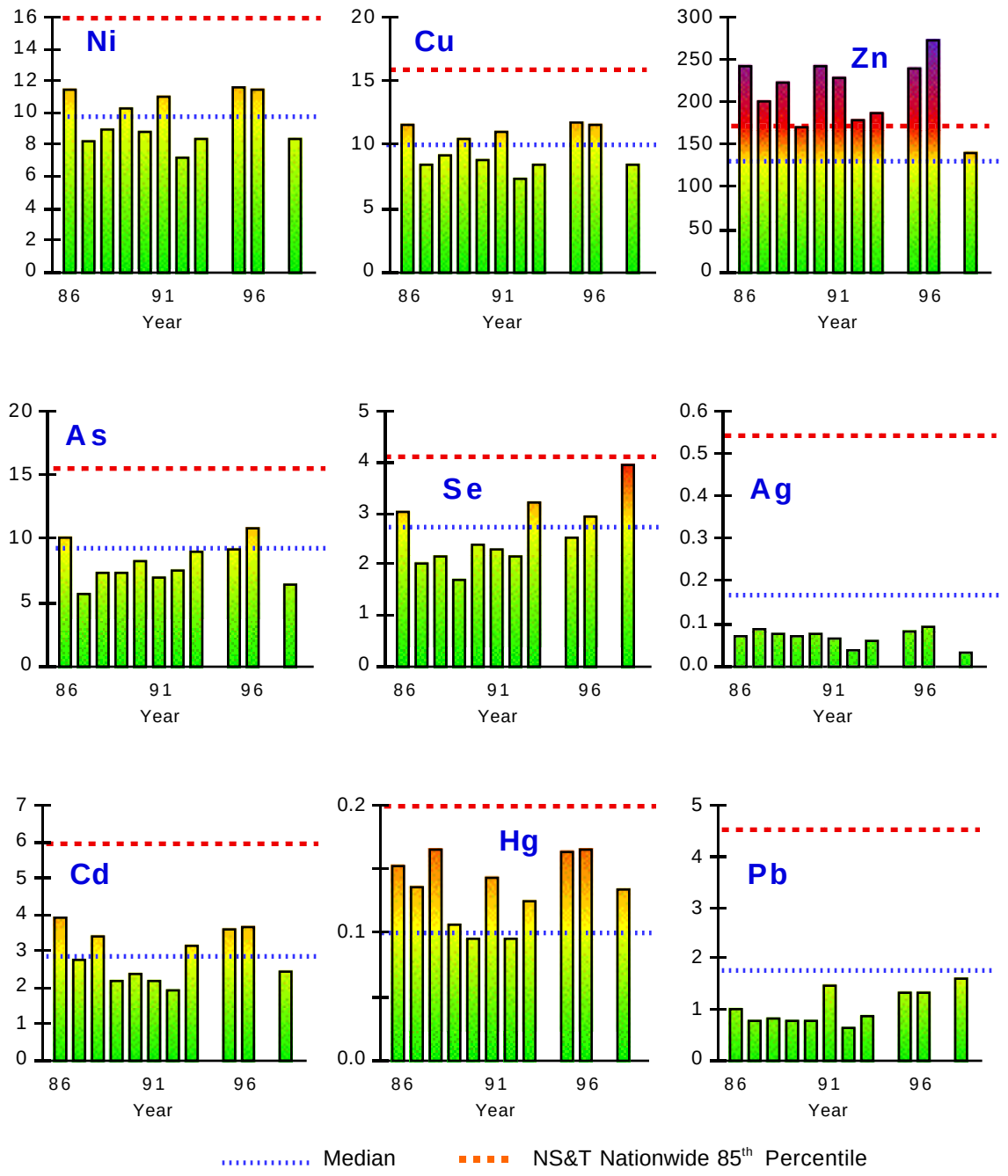

Figure 93. Trace element trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Russell Point (Coos Bay) (CBRP) (µg/g dry wt.).

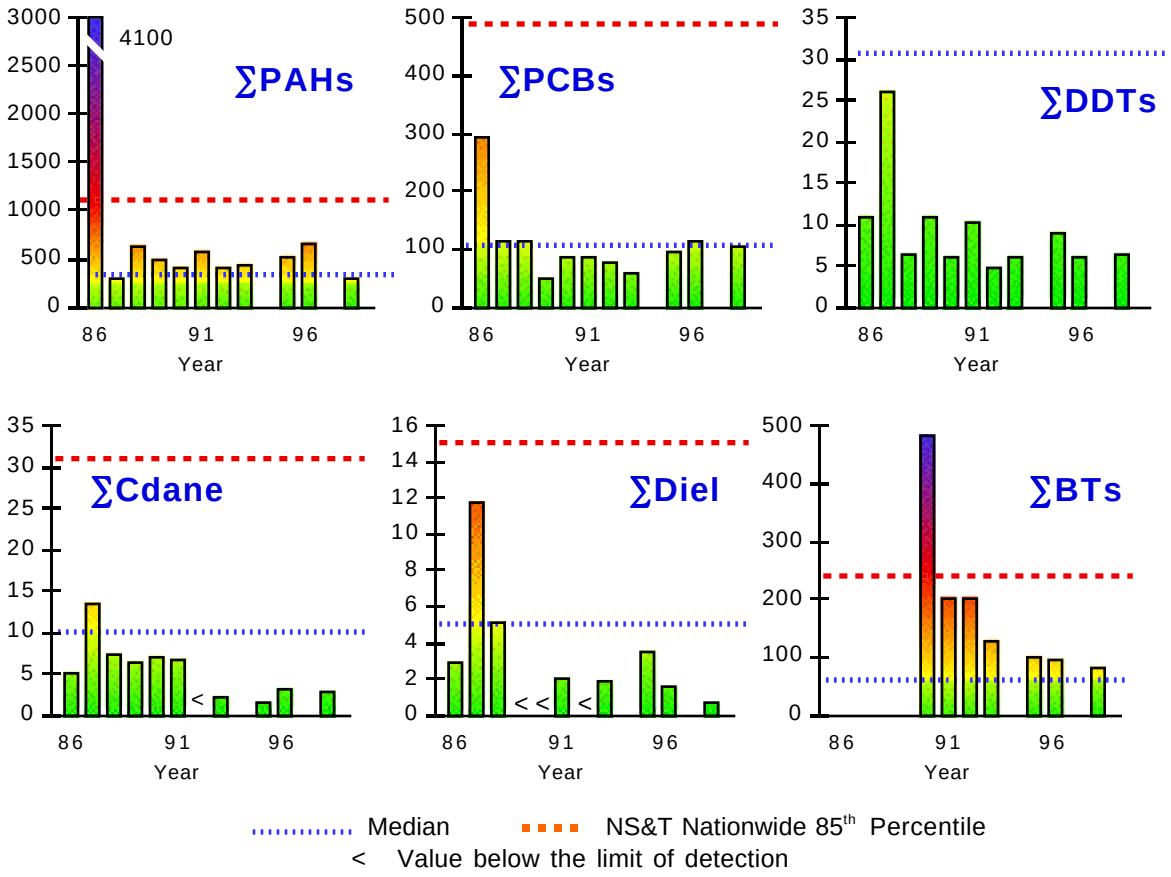

Figure 94. Trace organic contaminants and total butyltin trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Russell Point (Coos Bay) (CBRP) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 83. Aerial view, south of Charleston, Oregon, South Slough NERR (NOAA National Estuarine Research Reserve Collection, nerr0440, NOAA Photo Collection, NOAA Central Library).

Table 35. Trace element and trace organic contaminant concentrations in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Russell Point (Coos Bay) (CBRP) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1986	63.0	2.93	11.0	233	9.5	2.90	0.05
1987	37.3	2.03	7.8	193	5.1	1.87	0.07
1988		3.83	8.6	213	6.7	2.03	0.06
1989		3.87	9.8	163	6.8	1.57	0.05
1990	35.1	2.49	8.3	233	7.7	2.24	0.06
1991	73.3	3.63	10.5	220	6.3	2.13	0.05
1992	16.0	1.97	6.7	170	6.9	2.01	0.02
1993	20.0	2.36	7.9	180	8.5	3.05	0.04
1995	76.0	3.60	11.1	231	8.6	2.40	0.06
1996	106.0	7.50	11.0	264	10.3	2.80	0.08
1998	225.0	5.62	7.9	132	5.9	3.82	0.02
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1986	3.70	0.11	0.147	0.87	
1987	2.53	0.01	0.130	0.62	
1988	3.23	0.11	0.160	0.69	
1989	1.97	0.26	0.100	0.64	
1990	2.20	0.28	0.090	0.63	466.9
1991	2.00	0.23	0.137	1.33	187.8
1992	1.75	0.21	0.090	0.49	185.3
1993	2.97	0.29	0.120	0.70	114.5
1995	3.41	0.43	0.157	1.20	85.3
1996	3.49	0.04	0.160	1.20	82.1
1998	2.26	<	0.129	1.44	66.4
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1986	4143	279	9.9	3.93	2.53	<	1.73	1.87
1987	202	98	25.1	12.40	11.30	0.33	4.53	<
1988	550	102	5.5	6.20	4.73	1.00	1.97	1.37
1989	415	34	9.8	5.50	<	2.00	7.33	<
1990	331	70	5.1	6.03	<	0.69	<	<
1991	477	70	9.3	5.63	1.57	1.41	4.27	<
1992	313	61	3.8	<	0.00	<	0.88	<
1993	345	44	5.0	1.20	1.45	<	1.41	<
1995	433	83	8.0	0.67	3.02	0.30	0.53	<
1996	580	102	5.2	2.00	1.20	0.94	0.25	0.42
1998	222	91	5.5	1.93	0.30	0.42	0.26	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

PDB

Padilla Bay NERR

Washington

There is no Mussel Watch site representative of the Padilla Bay NERR. The nearest Mussel Watch site, Squalicum Marina Jetty in Bellingham Bay, is 12 miles away. It is more representative of urban conditions, while the Padilla Bay NERR is affected by the estuarine outflow of agricultural lands, not urbanized areas.

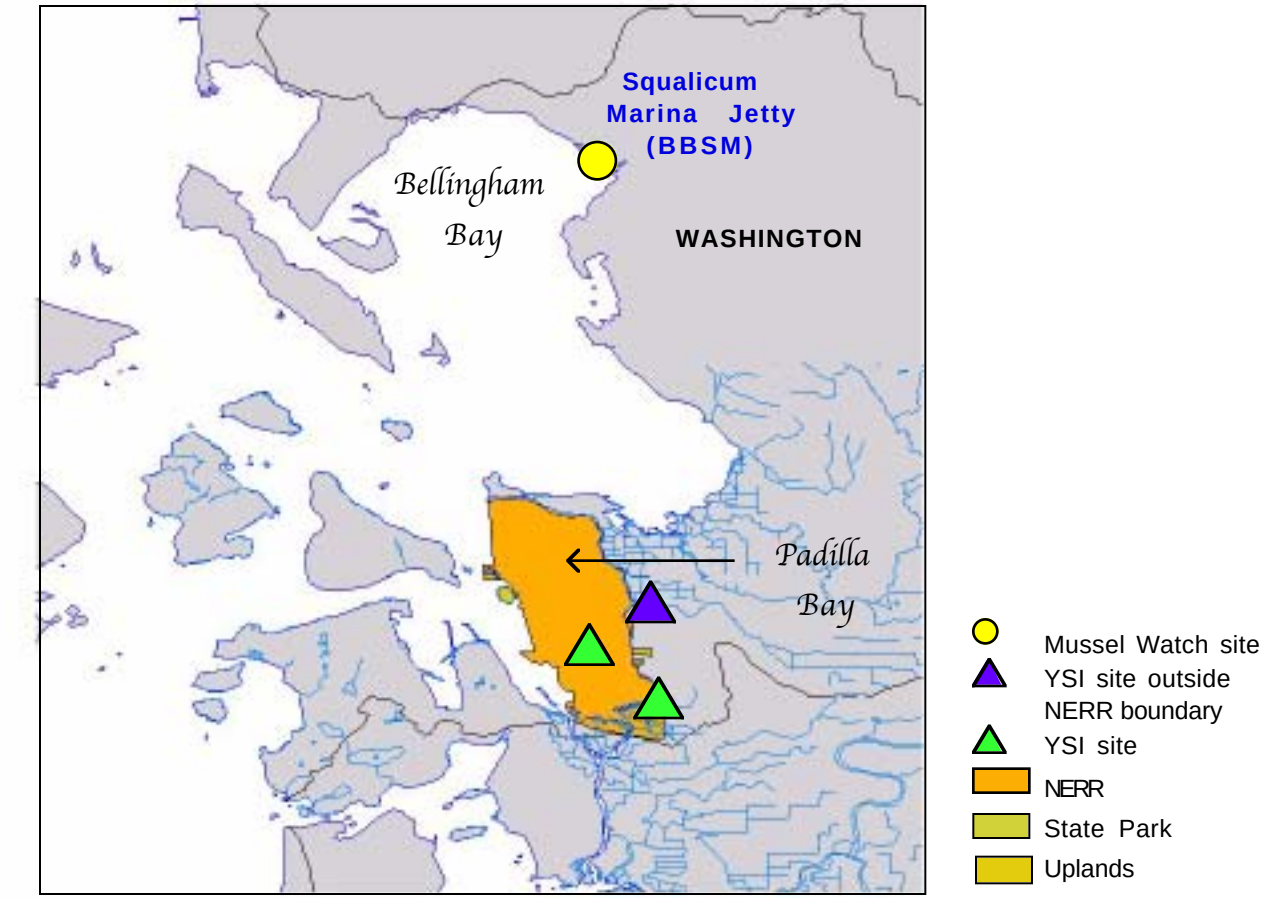

Figure 95. Padilla Bay NERR and adjacent areas.

Plate 84. Harbor seal, *Phoca vitulina*, North Puget Sound, Anacortes, Washington, Padilla Bay NERR (NOAA National Estuarine Research Reserve Collection, nerr0793, NOAA Photo Collection, NOAA Central Library).

KAC
Kachemak Bay NERR
Alaska

While there are two Mussel Watch sites relatively near the Kachemak Bay NERR (Homer Spit and Windy Bay), only the Homer Spit site is surrounded by the waters of the Bay. This Mussel Watch site was established in 1995.

The only trace element that even approached the NS&T 'high' concentration is copper; that was in 1997. The remaining trace elements were at or below their NS&T median concentrations. All summed organics were below their NS&T median concentrations. Hexachlorobenzene exceeded the NS&T 'high' concentration once, in 1999.

No trends were determined because there are only three years of data.

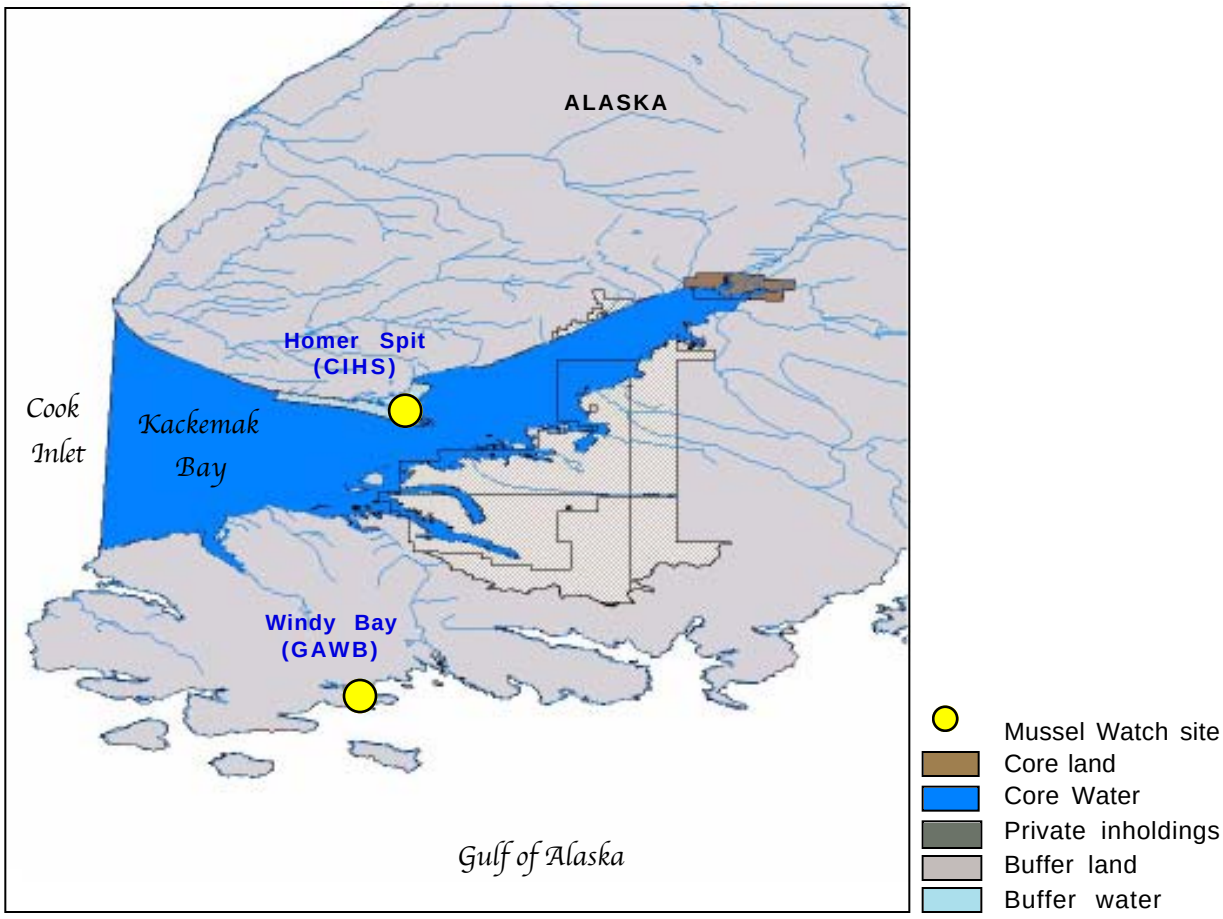

Figure 96. Kachemak Bay NERR and adjacent areas.

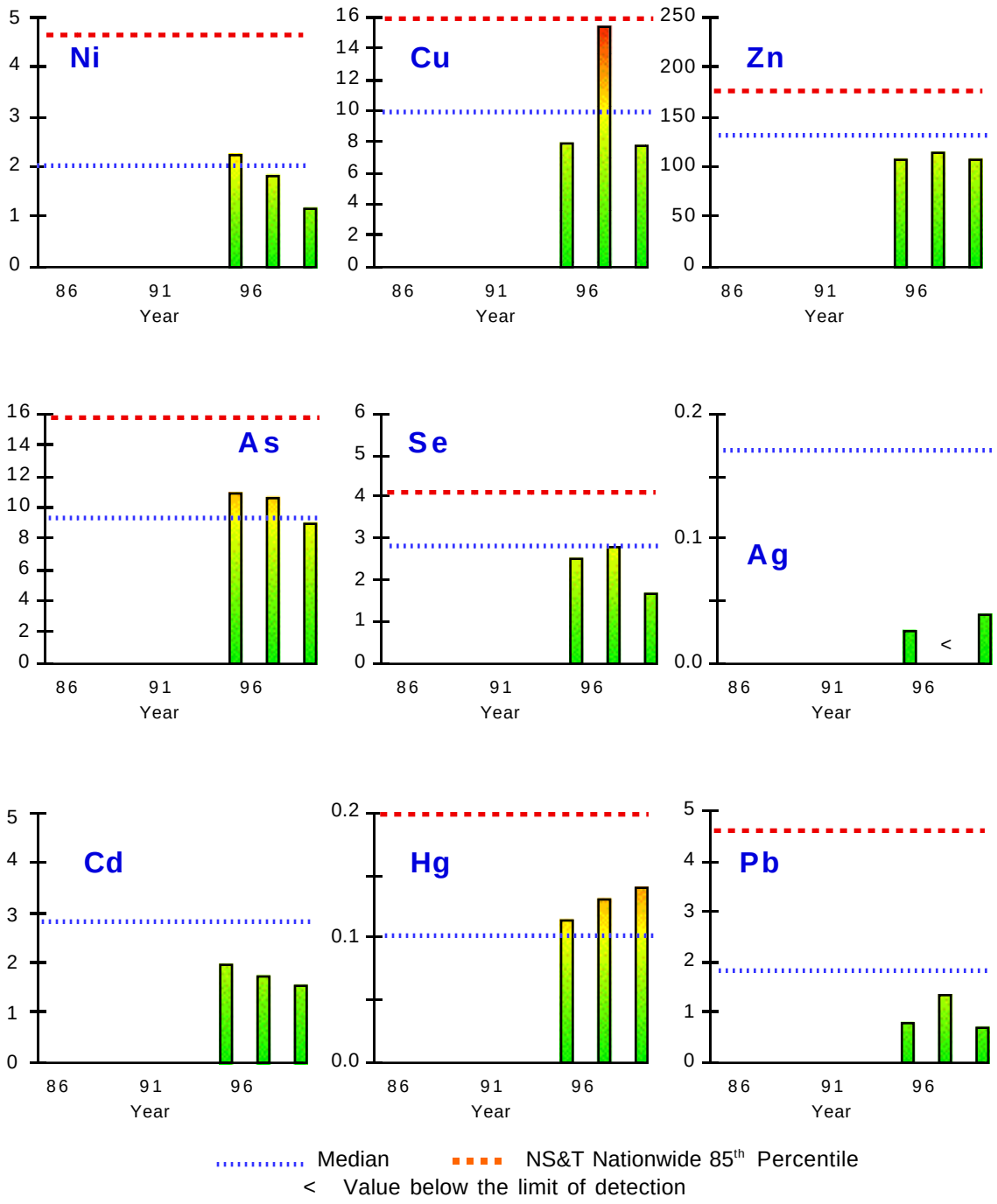

Figure 97. Trace element trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Homer Spit (Cook Inlet) (CIHS) (µg/g dry wt.).

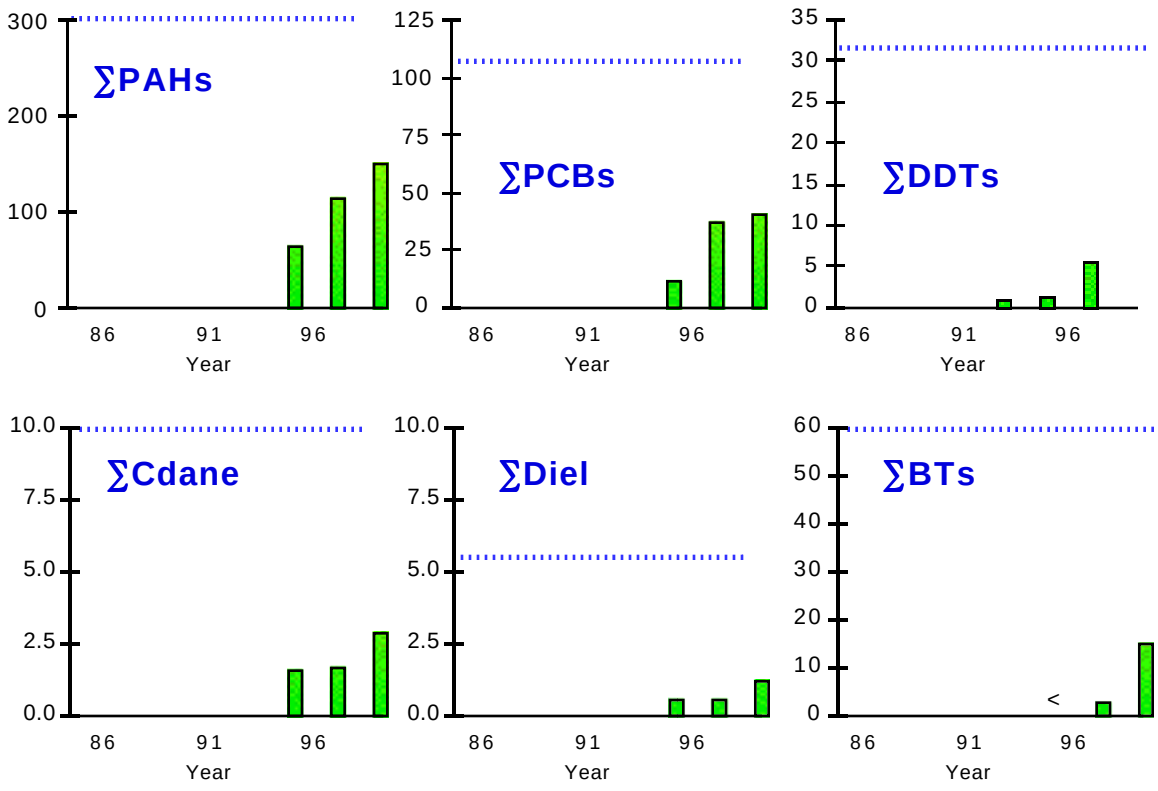

Figure 98. Trace organic contaminants and total butyltin trends in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Homer Spit (Cook Inlet) (CIHS) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 85. Sea otter, Kachemak Bay NERR (NOAA National Estuarine Research Reserve Collection, nerr0875, NOAA Photo Collection, NOAA Central Library).

Table 36. Trace element and trace organic contaminant concentrations in blue mussels (*Mytilus edulis*) collected at NS&T Mussel Watch site Homer Spit (Cook Inlet) (CIHS) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

	Year	Mn	Ni	Cu	Zn	As	Se	Ag
CIHS	1995	44.1	2.10	7.8	97	10.9	2.39	0.02
CIHS	1997	17.0	1.70	15.6	116	10.4	2.69	<
CIHS	1999	15.6	1.58	7.6	111	8.6	1.47	0.03
NS&T 'median'			2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'			4.6	16	170	16	4.1	0.54
NS&T 'median'		2.6		0.100	1.8	59		
NS&T 'high'		6.1		0.200	4.6	240		

	Year	Cd	Sn	Hg	Pb	∑BTs
CIHS	1995	1.94	0.02	0.110	1.18	0.0
CIHS	1997	1.72	0.04	0.125	0.95	2.4
CIHS	1999	1.37		0.131	0.54	13.3

	Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
CIHS	1995	75	9	0.6	1.42	0.50	0.69	0.84	<
CIHS	1997	118	32	0.9	1.47	0.48	0.34	0.12	<
CIHS	1999	145	33	6.6	2.73	1.06	2.73	0.34	<
NS&T 'median'		300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'		1200	450	140	32	15	1.1	2.8	1.2

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Plate 86. Sampling at the Mussel Watch site at Cook Inlet (CIHS), Homer Spit, in the Kachemak Bay NERR (TAMU/GERG).

OWC
Old Woman Creek NERR
Ohio

A Mussel Watch site was established at the Old Woman Creek NERR in 1995. Sediment sampling was conducted within the slough of the Reserve, but zebra mussels (the sentinel organism) were not found there. So the mussels were collected from rip-rap protecting the Lake Erie shoreline adjacent to the Reserve.

Trace elements found above the NS&T 'high' concentration were nickel, copper, and lead. Selenium approached the NS&T 'high' in 1997. These 'high' concentrations may be a function of the sentinel organism and that they are found in freshwater, rather than being an indication of elevated concentrations. (See the discussion for the Hudson River Reserve).

Both ∑Diel and hexachlorobenzene exceeded their respective NS&T value in one or more years. ∑PCBs, which are generally considered to be high in the Great Lakes, did not exceed the NS&T 'high' value.

No trends were determined because only four years of data are available for this site.

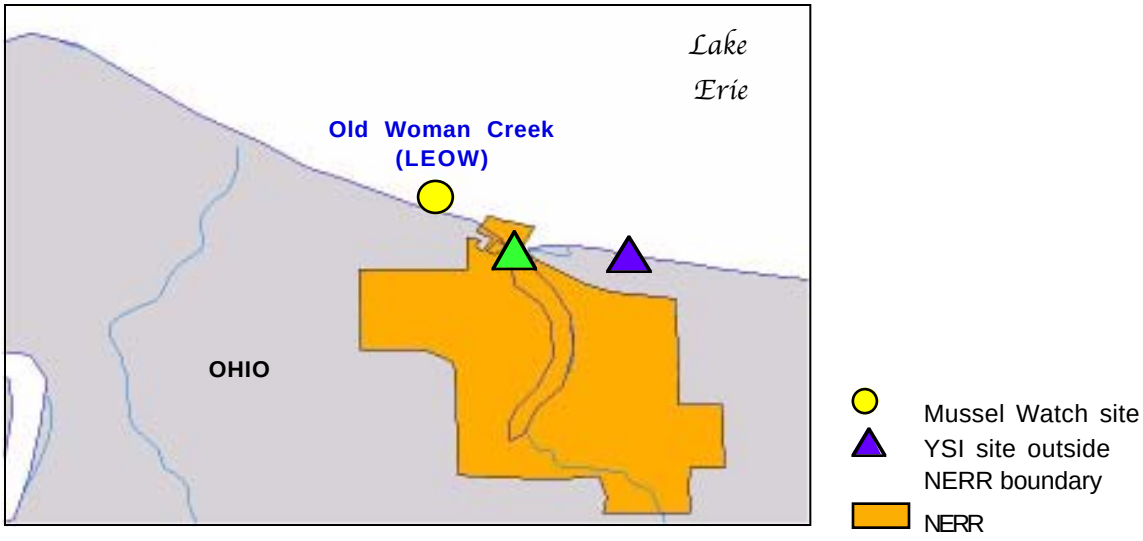

Figure 99. Old Woman Creek NERR and adjacent areas.

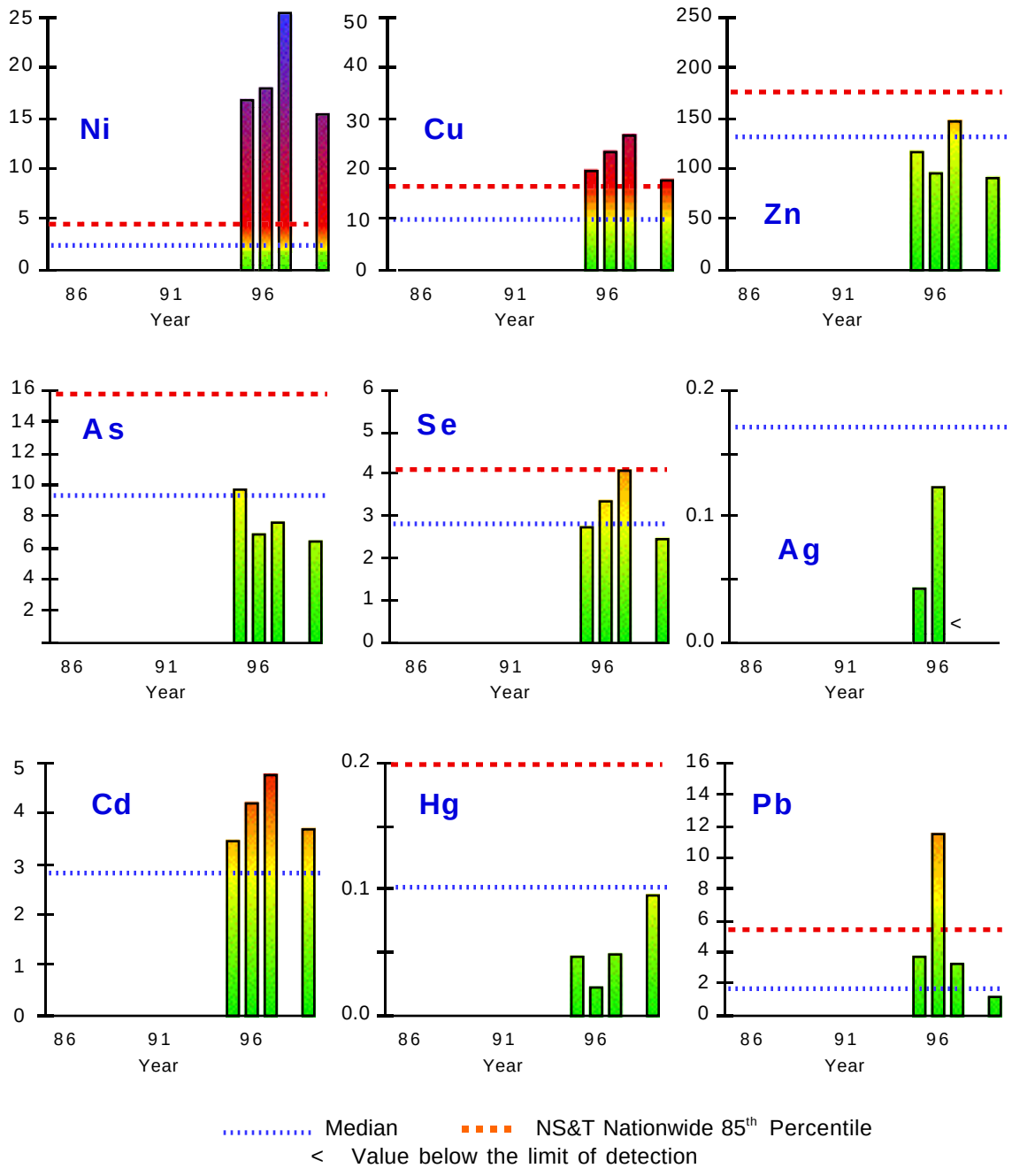

Figure 100. Trace element trends in zebra mussels (*Dreissena polymorpha* and *D. bugensis*) collected at NS&T Mussel Watch site Old Woman Creek (Lake Erie) (LEOW) (µg/g dry wt.).

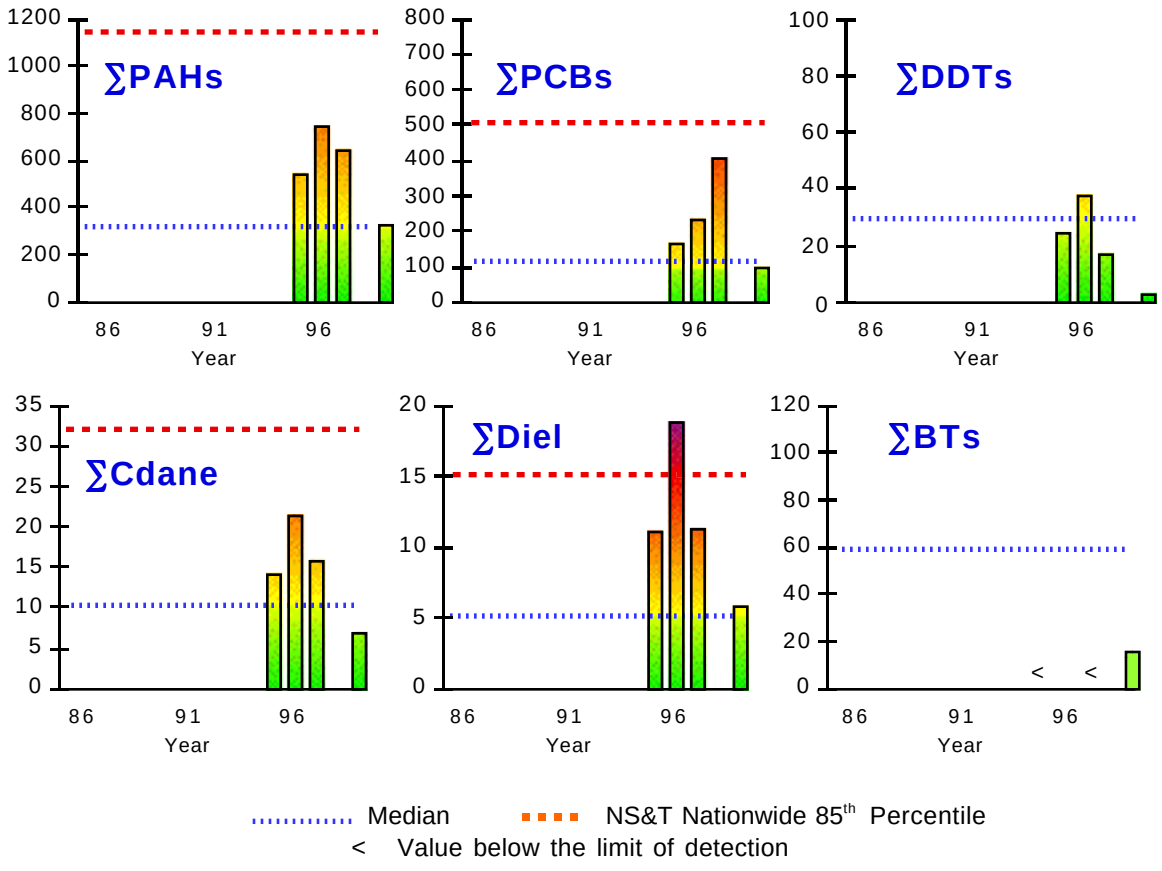

Figure 101. Trace organic contaminants and total butyltin trends in zebra mussels (*Dreissena polymorpha* and *D. bugensis*) collected at NS&T Mussel Watch site Old Woman Creek (Lake Erie) (LEOW) (ng/g dry wt.; ∑BTs, ng Sn/g dry wt.).

Plate 87. Old Woman Creek, Erie County, Ohio, Old Woman Creek NERR (NOAA National Estuarine Research Reserve Collection, nerr0093, NOAA Photo Collection, NOAA Central Library).

Table 37. Trace element and trace organic contaminant concentrations in zebra mussels (*Dreissena polymorpha* and *D. bugensis*) collected at NS&T Mussel Watch site Old Woman Creek (Lake Erie) (LEOW) (trace elements, µg/g dry wt.; ∑BTs, ng Sn/g dry wt.; organic compounds, ng/g dry wt.).

Year	Mn	Ni	Cu	Zn	As	Se	Ag
1995	206	16	18	107	9.0	2.8	0.03
1996	82	17	22	81	6.5	3.2	0.12
1997	100	27	26	144	7.1	4.0	<
1999	60	15	16	83	6.1	2.4	
NS&T 'median'		2.0	9.9	130	9.2	2.8	0.17
NS&T 'high'		4.6	16	170	16	4.1	0.54

Year	Cd	Sn	Hg	Pb	∑BTs
1995	3.29	0.32	0.037	3.6	<
1996	4.10	0.43	0.020	11.4	
1997	4.66	0.14	0.037	3.1	<
1999	3.70		0.025	0.9	14.8
NS&T 'median'	2.6		0.100	1.8	59
NS&T 'high'	6.1		0.200	4.6	240

Year	∑PAHs	∑PCBs	∑DDTs	∑Cdane	∑Diel	Hexachloro-benzene	Lindane	Mirex
1995	582	166	26.90	13.07	11.16	0.63	1.23	<
1996	733	231	38.58	21.52	18.55	1.67	0.89	0.45
1997	634	372	17.21	14.59	11.28	1.17	0.40	0.47
1999	292	98	7.19	5.76	5.26	0.36	<	<
NS&T 'median'	300	100	33	10	5.1	0.23	1.2	0.24
NS&T 'high'	1200	450	140	32	15	1.1	2.8	1.2

< Value below the limit of detection

Plate 88. Aerial image, Old Woman Creek NERR (NOAA National Estuarine Research Reserve Collection, nerr0095, NOAA Photo Collection, NOAA Central Library).

SLR

St. Lawrence River NERR (proposed)

New York

The Mussel Watch Project established a site to the east of Cape Vincent on the St. Lawrence River in 1994. This site is approximately 95 miles from the proposed Reserve on the St. Lawrence River. While trace elements and organic contaminants that are collected near Cape Vincent may be generally indicative of the environmental conditions of the proposed Reserve, there is no match.

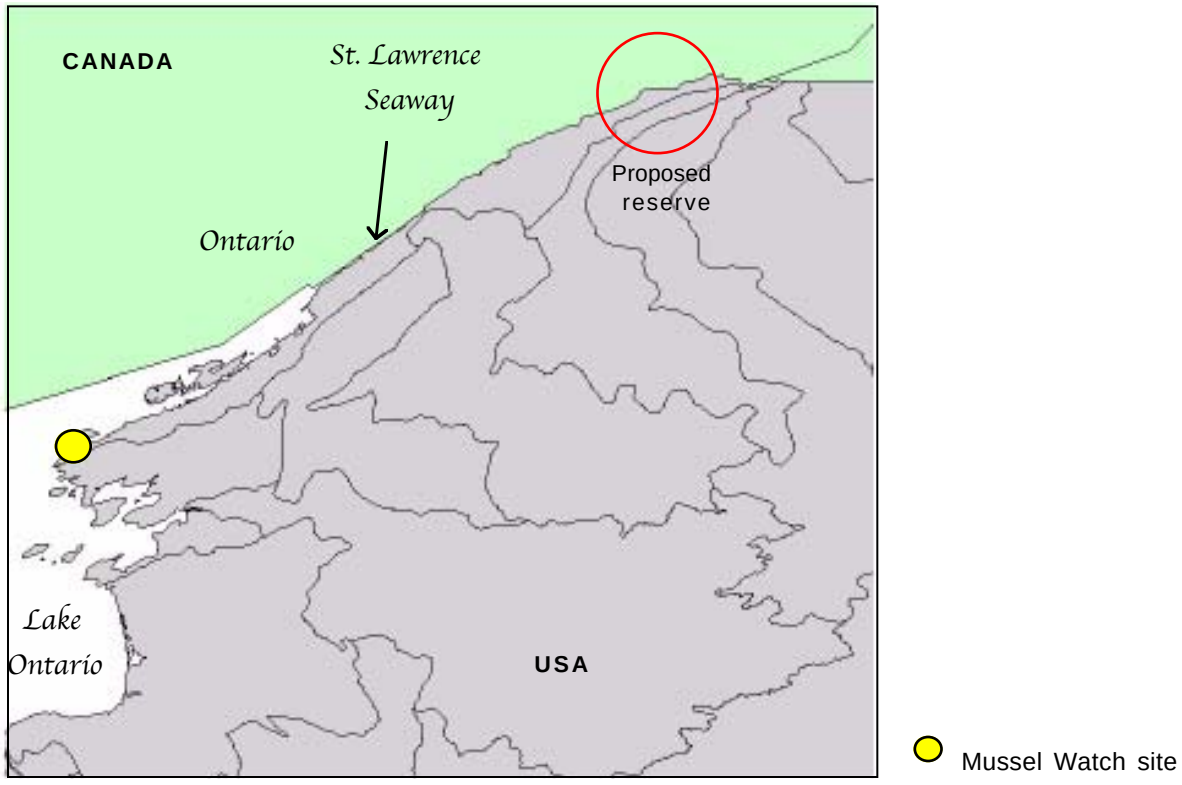

Figure 102. St. Lawrence River NERR and adjacent areas.

Plate 89. Winter oyster sampling for the Mussel Watch Project in Chesapeake Bay (TAMU GERG).

APPENDIX I

Directions to Mussel Watch Sites in the National Estuarine Research Reserves

Sites are in geographical order beginning in the Northeast and proceeding around the U.S. in a clockwise fashion. This follows the order of the individual site reports.

Wells NERR

SITE – KENNEBUNKPORT, CAPE ARUNDEL, ME
SITE CODE – CAKP
TARGET SPECIES – *Mytilus edulis*
NOMINAL SITE CENTER – 43° 20.72' N ,70° 28.46' W
LOCATED ON NOAA CHART – 13286

SITE ACCESS – This site is accessible by vehicle, and can only be sampled at low tide. From I-95 traveling north into Maine, take Exit 3 and head towards Kennebunkport on Hwy. 35 (south). Drive into Kennebunkport and over the Kennebunk River, then turn right onto Ocean Ave. in the town square. Follow Ocean Ave. to the parking lot, at the base of the jetty, at the mouth of the river (on the right hand side of the road).

SITE DESCRIPTION – The eastern breakwater on the Kennebunk River forms a small cove in the shoreline. The nominal center of the site is there. Mussels were collected by hand where the jetty (inside) granite blocks meet the granite boulders. The site is intertidal, +0.5 m MLLW.

Great Bay NERR

SITE – DOVER POINT, GREAT BAY, NH
SITE CODE – GBDP
TARGET SPECIES – *Mytilus edulis*
NOMINAL SITE CENTER – 43° 07.24' N, 70° 49.59' W
LOCATED ON NOAA CHART – 13285

SITE ACCESS – From Interstate 95 in the Portsmouth, NH area turn onto Route 4 to Dover, NH. Immediately after crossing the large bridge that goes over the northern most part of Great Bay look for signs for Hilton State Park. The site and State Park are under the northern end of the bridge.

SITE DESCRIPTION – The site was established in 1997 just North of the Great Bay National Estuarine Research Reserve. The site is located on the southeast part of Dover point. Station samples were located around a point of land projecting into the Piscataqua River. Dover Point is at the confluence of Great Bay and the Piscataqua River.

Narragansett NERR

SITE – PATIENCE ISLAND, NARRAGANSETT BAY, RI
SITE CODE – NBPI
TARGET SPECIES – *Mytilus edulis*
NOMINAL SITE CENTER – 41° 39.19' N, 71° 21.35' W
LOCATED ON NOAA CHART – 13224

SITE ACCESS – This site has to be accessed by boat, launched from the Bristol Harbor boat ramp. Follow Hwy. 114 north into Bristol, turn left (west) onto State Ave. just after the town library and drive down to the boat ramp. From here, follow the channel southwest out into Narragansett Bay and then northwest to Providence Point, and then southwest again to Patience Island.

SITE DESCRIPTION – The site is located on the southeast side of Patience Island, along the shoreline just to east of the rocks. Mussels were collected by hand. Site is intertidal, +1.0 m MLLW.

SITE – DYER ISLAND, NARRAGANSETT BAY, RI
SITE CODE – NBDI
TARGET SPECIES – *Mytilus edulis*
NOMINAL SITE CENTER – 41° 36.29' N, 71° 18.31' W
LOCATED ON NOAA CHART – 13223

SITE ACCESS – This site has to be accessed by boat, launched from the Bristol Harbor boat ramp. Follow Hwy. 114 north into Bristol, turn left (west) onto State Ave. just after the town library and drive down to the boat ramp. From here, follow the channel southwest for about 4.5 mi to the Sandy Point Light on Prudence Island, in Narragansett Bay.

SITE DESCRIPTION – The original site was located in the middle of the channel to the east of Sandy Point Light, in 25 m of water. After a number of unsuccessful dredging attempts to find mussels, the site was moved to an intertidal area just south of Sandy Point Light. Mussels were collected by hand. Site is intertidal, +0.5 m MLLW.

Hudson River NERR

SITE – CRUGER ISLAND, HUDSON RIVER, NY
SITE CODE - HRCI
TARGET SPECIES – *Dreissena sp.*
NOMINAL SITE CENTER – 42° 02.03' N, 53° 55,76' W
LOCATED ON NOAA CHART – 12347

SITE ACCESS – From Watertown, travel Interstate 81 south to Syracuse. From Syracuse, travel east on the New York Thruway (Interstate 90) to Albany and continue south to Kingston on Interstate 87. Take exit 19. Go around the traffic circle, then through a light toward the Kingston Rhinecliff Bridge. After crossing the bridge, turn left on Rout3 9. Turn left (north) onto Route 9G where it intersects with Route 9. Follow route 9G to the town of Tivoli. Travel west through Tivoli toward the Hudson River on CR 78. A small boat may be launched at a point where a gravel road crosses the train tracks. The railroad tracks run along the bank of the river.

SITE DESCRIPTION – Zebra mussels were found on the northwest part of Cruger Island, adjacent to the Tivoli Bay National Estuarine Research Reserve. The samples are taken near navigational aid Fl 2.5s 28 ft 4M "86".

Sediments were collected near the same navigation aid as the zebra mussel samples, though the fine grained sediments are found in a shallow embayment on the north side of Cruger island.

Jacques Costeau NERR

SITE – BARNEGAT LIGHT, BARNEGAT INLET, NJ
SITE CODE – BIBL
TARGET SPECIES – *Mytilus edulis*
NOMINAL SITE CENTER – 39° 45.70' N, 74° 05.70' W
LOCATED ON NOAA CHART – 12324

SITE ACCESS – This site is a walk-up site. The site is located in the Barnegat Light State Park. Travel south on the Garden State Parkway (toll road) and take Exit 63 east onto Hwy. 72. In Ship Bottom, NJ, turn left and follow the signs to Barnegat Light. Follow the walkway out along the breakwater to the end, and then out on the jetty.

SITE DESCRIPTION – The site is located about 1/3 to 1/2 the way out on the jetty, on the inlet side. The site is about as far out on the jetty as can be safely collected, due to ocean waves.

SITE – ATLANTIC CITY, ABSECON INLET, NJ
SITE CODE – AIAC
TARGET SPECIES – *Mytilus edulis*
NOMINAL SITE CENTER – 39° 22.03' N, 74° 24.67' W
LOCATED ON NOAA CHART – 12316

SITE ACCESS – This is a walk-up site. From the Atlantic City Parkway, turn left onto Arctic Ave. and then a right onto Pennsylvania Ave. Turn left again onto Pacific Ave, and the site is located at the jetty at the end of the road. Walk under the Boardwalk to reach the jetty.

SITE DESCRIPTION – The sampling site is located on the western (inlet) side of the Absecon Inlet rock jetty wall.

Delaware Bay NERR

SITE – HOPE CREEK, DELAWARE BAY, NJ
SITE CODE – DBHC
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 39° 25.60' N, 75° 29.60' W
LOCATED ON NOAA CHART – 12311

SITE ACCESS – A boat may be launched at the Woodland Beach launch ramp, at the end of Rte. 6 out of Smyrna, DE.

SITE DESCRIPTION – Adult bivalve populations exist at the mouth of Hope Creek and extend to Fishing Creek. The oysters in Hope creek are adversely affected during the spring runoffs and do best when salinities are higher later in the season. A more stable bivalve population exists further down river at the bivalve site center, west of Adler Cove and Fishing Creek. Bearings for this area are 150 degrees from the Hope Creek Jetty (Fl 4 sec 16 ft 5 m) and 100 degrees from R "8l" Fl R 4 sec.

SITE – KELLY ISLAND, DELAWARE BAY, DE
SITE CODE – DBKI
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 39° 12.19' N, 75° 21.54' W
LOCATED ON NOAA CHART – 12304

SITE ACCESS – This site can only be accessed by boat. There is a good boat ramp at Port Mahon. From Hwy. 13 in Dover, DE, take Route 8 east heading towards Little Creek. At the "T" junction, turn right onto Route 9 and take the first left turn onto the Port Mahon Rd. Follow the road east to the end where the ramp is located, the surface will change from paved to dirt. The road reportedly floods at very high tides. This is not an all-weather ramp, as the ramp was frozen in for several days in December, 1995. From the boat launch, follow the cut out to the channel. Take care, as the cut has several shallow areas. Follow the channel out to green channel marker "3".

SITE DESCRIPTION – The site is located just to the north of green channel marker "3", and appears to be on a staked oyster bed. There is very little clutch on this site, which is on mud.

Chesapeake Bay, Virginia NERR
Godwin Island Component

SITE – DANDY POINT, CHESAPEAKE BAY, VA
SITE CODE – CBDP
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 37° 05.90' N, 76° 17.69' W
LOCATED ON NOAA CHART – 12238

SITE ACCESS – The site has to be accessed by boat, from the Dandy Point public boat ramp. The run time is less than three minutes. Follow Interstate 64 through Newport News into Hampton, then take a left onto Mercury Blvd. (also 4517) away from the James River Bridge. Turn left again onto Hwy. 169 south (also called Fox Hill Rd.) and follow the road to Dandy Point Rd. and on to the end. The site is too shallow to be accessed by vessels larger than a small boat, except through a very narrow channel and only at high tide.

SITE DESCRIPTION – The site lies just to the north of a marsh island to the northwest of Dandy Point. There is a small brown wooden cabin, with an orange roof, on the east end of the island. There is also a small wooden pier extending out to the east from the cabin. Station 1 is located at the western point of the island, Station 2 is on the north side off the middle of the island and Station 3 is at the eastern end of the island.

North Carolina NERR

Rachel Carson Component

SITE – PIVERS ISLAND, BEAUFORT INLET, NC
SITE CODE – BIPI
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 34° 43.10' N, 76° 40.53' W
LOCATED ON NOAA CHART – 11545

SITE ACCESS – This site is a walk-up site. Follow U.S. 70 east from Beaufort, NC, until you see the NOAA Research Lab. Turn right off the highway and cross over a small bridge. Take the first road to the left after the bridge and park in the NOAA parking lot. Obtain access permission from NOAA officials before sampling the site, which is located under the bridge.

SITE DESCRIPTION – The samples are collected from the concrete pilings and rubble under the bridge. The discrete stations are some 10 m apart.

Zeke's Island Component

SITE – BATTERY ISLAND, CAPE FEAR, NC
SITE CODE – CFBI
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 33° 54.95' N, 78° 00.21' W
LOCATED ON NOAA CHART – 11537

SITE ACCESS – This site is an easy site to sample by hand, but has to be accessed by boat. Follow Hwy. 70 all the way south into Southport, make a right turn at the bank and drive to the boat ramps and marina at the end of the road.

SITE DESCRIPTION – The site is visible from the ramp, and is located at the northeastern corner of Battery Island. This site can easily be collected by hand at low tide, or by using a dredge at high tide. Samples were collected on the northern tip of the island, on the spit.

North Inlet-Winyah Bay NERR

SITE – LOWER BAY, WINYAH BAY, SC
SITE CODE – WBLB
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 33° 14.60' N, 79° 11.83' W
LOCATED ON NOAA CHART – 11532

SITE ACCESS – From boat ramp on the ICCW, head north approximately 1 mi to Winyah Bay, at the cut proceed at a heading of 140 degrees for approximately 3.0 mi straight out to the site. The site is located between the Red Channel Marker "16" and Green Channel Marker "17", which is further to the northeast. Care should be taken here, as there are some very strong currents in this area of the bay when the tide is going out.

SITE DESCRIPTION – The site is next to two small islands, that have the tops of partially submerged power poles sticking out of the water next to them. Due to the scarcity of oysters, this site was collected as a composite site and the stations were not differentiated.

SITE – NORTH BAY, SANTEE RIVER, SC
SITE CODE – SRNB
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 33° 10.10' N 79° 14.50' W
LOCATED ON NOAA CHART – 11532

SITE ACCESS – This site has to be accessed by boat and the samples collected using a dredge. Head south down Hwy. 17, south of Georgetown, and turn left onto South Island Rd. Travel for about 5 mi to the end of the road where there is a Ferry, and the boat ramps are on your left. Follow the Intercoastal Waterway to the Esterville Minum Cut and on to the red channel "4". Bear left (south) through the channel and on for about 1.5 mi to the southeast to the site.

SITE DESCRIPTION – The site is located in the North Santee Bay, just off the mouth of Beach Creek.

Sapelo Island NERR

SITE – SAPELO ISLAND, SAPELO SOUND, GA
SITE CODE – SSSI
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 31° 23.57' N, 81° 17.28' W
LOCATED ON NOAA CHART – 11507

SITE ACCESS – This site can only be accessed by boat, and can only be successfully sampled by hand at low tide. Sampling at high tide with a dredge is not an option. Follow I-95 south from Savannah to Exit 10, and then go east to Darien. In Darien, take Rd 99 north towards Ridgeville. In Ridgeville, take the first right (large blue house) and follow the road until it dead ends at the McIntosh Rod and Gun Club where there is a boat ramp and hoist. The ramp is useless at low tide, as it is high and dry. From the ramp proceed down the North River to the ICWW, at red channel marker "182". The Black River is directly across the ICWW from here, and this will lead you out into Doboy Sound. The old lighthouse is visible 1.4 mi away, at a bearing of 30°. Note there are many sand bars and various confusing cuts in the north part of the river when traveling to the site.

SITE DESCRIPTION – The site is located on the north side of Doboy Sound on Sapelo Island, nearby the old lighthouse. Station 1 is located on the shoreline to the east of the lighthouse, and just west of Deans Creek, Station 2 is 100 m closer to the lighthouse and Station 3 is opposite the lighthouse.

SITE – WOLFE ISLAND, ALTAMAHA RIVER, GA
SITE CODE – ARWI
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 31° 19.45' N, 81° 18.65' W
LOCATED ON NOAA CHART – 11507

SITE ACCESS – This site can only be accessed by boat, and can only be successfully sampled by hand at low tide. Sampling at high tide with a dredge is not an option. Follow I-95 south from Savannah to Exit 10, and then go east to Darien. In Darien, take Rd 99 north towards Ridgeville. In Ridgeville, take the first right (large blue house) and follow the road until it dead ends at the McIntosh Rod and Gun Club where there is a boat ramp and hoist. The ramp is useless at low

tide, as it is high and dry. From the ramp proceed down the North River to the ICWW, at red channel marker "182". Follow the ICWW to the north until you come to red channel marker "198". The site lies 0.5 mi at a bearing of 35° from the marker.

SITE DESCRIPTION – The site is located in the Altamaha River on the southern side of Wolfe Island. There are no really good landmarks in the area other than the navigation marker. There is a six-foot high wall of dead oyster shell along the bank next to the site. The stations were not differentiated due to the scarcity of oysters in the entire area.

Guana Tolomato Matanzas NERR

SITE – CRESCENT BEACH, MATANZAS RIVER, FL
SITE CODE – MRCB
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 29° 45.84' N, 81° 15.71' W
LOCATED ON NOAA CHART – 11485

SITE ACCESS – This site is best sampled by hand at low tide. From I-95 or Hwy. 1 south of St. Augustine, take Rt. 206 east towards the Matanzas River/ICWW Bridge. Just before you cross the bridge, turn right and drive to the end of the dirt road.

SITE DESCRIPTION – The site is located south of the Matanzas River bridge on the western shoreline. Station 1 is to the south of the promontory; Station 2 lies at the eastern tip, and Station 3 lies on the northwest side of the spit. Station 3 Lies due south of the 7th set of bridge pilings.

Jobos Bay NERR

SITE – BAHIA DE JOBOS, PUERTO RICO, PR
SITE CODE – PRBJ
TARGET SPECIES – *Crassostrea rhizophorae*
NOMINAL SITE CENTER – 17° 56.35' N, 66° 10.88' W
LOCATED ON NOAA CHART – 25687

SITE ACCESS – This site is located in the east end of Bahia de Jobos (Jobos Bay) and can only be reached by boat. To reach the boat anchorage, proceed down Hwy. 7710 from Puerto Jobos toward Pozuelo and go to the second small bay on the right, where there are numerous small boats anchored (there is a sign at the turn – Asociacion De Pescadores Independientes, Inc.). There are also a few fishing boats located in the first bay, next to the small "Cafe". By boat, go through the mangroves north into the bay and then turn east. Proceed to the east end of the Bahia de Jobos, and then into the inlet into Laguna de las Mareas.

SITE DESCRIPTION – Oyster collections occurred at the east end of Bahia de Jobos. The oysters were found growing on the roots of red mangrove trees. Turtle and manatee grass was abundant throughout the bay, starting near the edge of the mangrove roots. An obvious landmark is the electric power station at Aguirre, located at the west end of the bay.

Rookery Bay NERR

SITE – HENDERSON CREEK, ROOKERY BAY, FL
SITE CODE – RBHC
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 26° 01.62' N, 81° 44.33' W
LOCATED ON NOAA CHART – 11430

SITE ACCESS – The site is accessed from I-75 by driving west (or south) on Florida 951. Approximately 2.6 mi past the intersection of U.S. Hwy. 41, turn right on Shell Island Rd. Shell Island Rd. is marked by a sign for the Briggs Nature Coinsurance and Marine Research Lab. Proceed to the Rookery Monument. Go past the Rookery Headquarters and on to the boat ramp at the end of the road.

SITE DESCRIPTION – The site is located in Rookery Bay Aquatic Preserve, in Henderson Creek. All three oyster stations are near the mouth of the creek, in the vicinity of the Children's Monument. Station 1 is on the same shoreline as the monument, approximately 150 m to the south at the first bare reef patch in the mangroves. Station 2 is located on the shore opposite the monument, at a small cove in the mangroves, next to a manatee sign. Station 3 is located on the shoreline opposite the monument, approximately 200 m to the northeast at the bare patch in the mangroves, where the channel begins to constrict from the passage out of Henderson Reef into Rookery Bay.

SITE – NAPLES BAY, NAPLES BAY, FL
SITE CODE – NBNB
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 26° 06.71' N, 81° 47.11' W
LOCATED ON NOAA CHART – 11430

SITE ACCESS – The site is accessed off U.S. I-95, at the Hwy. 951 exit for Marco island. Proceed south to Hwy. 864, and then turn left onto Rattlesnake Hummock Rd. Turn right (north) onto Hwy. 41 and the left onto Thommason Rd. When Thommason road ends, go left onto Fern Rd. and then right on Danford Rd. Follow the signs to the Bayview Park boat ramp.

SITE DESCRIPTION – The oyster reefs are located to the east and adjacent to the red channel marker "24". The area has a number of old reefs that are primarily consolidated and cemented shell fragments. The nominal site center is around a small shell reef with a few mangroves, 50 m southeast of the channel marker. Station 1 is located around the mangroves, Station 2 is to the east of the mangroves and Station 3 is to the west of the mangroves.

Apalachicola Bay NERR

SITE – DRY BAR, APALACHICOLA BAY, FL
SITE CODE – APDB
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 29° 40.35' N, 85° 03.94' W
LOCATED ON NOAA CHART – 11402

SITE ACCESS – The site is accessed by a 30 min boat ride originating at the boat ramp in Apalachicola, near the southwest end of the John Gorrie Memorial Bridge. Proceed west along

the inside channel to the first channel going south into Apalachicola Bay. Run a compass course (bearing 250°) about 7 mi to the northeast end of St. Vincent Island, at St. Vincent Point.

SITE DESCRIPTION – The site was located on the northeast corner of St. Vincent Island, at St. Vincent Point. The oysters were located north of the point, on an intertidal shell and sand reef. Station 1 is about 300 m east of the point on the reef, station 2 a further 100 m northeast and station 3 yet another 100 m to the northeast.

SITE – CAT POINT BAR, APALACHICOLA BAY, FL
SITE CODE – APCP
TARGET SPECIES – *Crassostrea virginica*
NOMINAL SITE CENTER – 29° 43.45' N, 84° 53.05' W
LOCATED ON NOAA CHART – 11404

SITE ACCESS – This is a walk-up beach site, best done at low tide. It can be accessed by boat, when the tides are high. To reach the site from Hwy. 98, drive south on road G1A towards the toll booth. Turn left (east) on the dirt road to East Point Beach, just before the bridge toll booths. Park and walk to the East Point Beach, where the oysters can be picked up by hand at low tide. If the tide is high, the boat can be launched at one of the ramps on Hwy. 30, which is to the north-east of the site.

SITE DESCRIPTION – The site is located just to the east of Cat Point. The reef is exposed at low tide and is the major source for oysters in eastern Apalachicola Bay. At high tide the oysters can be collected by tonging, as oyster dredges are not permitted in Apalachicola Bay. Station 1 oysters were collected from the old bridge pilings, just to the east of the toll bridge, station 2 oysters 100 m to the north-northeast of the bridge, and station 3 oysters were collected a further 100 m to the north-northeast.

Grand Bay NERR

SITE – PASCAGOULA BAY, MISSISSIPPI SOUND, MS
SITE CODE – MSPB
Target Species – Crassostrea virginica
NOMINAL SITE CENTER – 30° 20.16' N, 88° 35.35' W
LOCATED ON NOAA CHART – 11375

SITE ACCESS – To reach the boat ramp on the Pascagoula River, turn off Hwy. 90 onto Market St. and head south. When the road dead-ends at the beach, turn right and drive west to the end of the road. The boat is launched at the public ramp in the channel leading into Lake Yazoo. Then, by boat, proceed west to the northwest corner of Singing River Island. Run time to the site is less than 10 min.

SITE DESCRIPTION – The site is located just west of the south end of the new causeway going to the Naval Base on Singing River Island, near the mouth of the West Pascagoula River. Oysters are generally abundant, and were found by poling on the subtidal reef. Station 1 is 100 m offshore next to the causeway, station 2 is 50 m further south and station 3 is another 50 m to the south.

Tijuana River NERR

SITE – NORTH JETTY, IMPERIAL BEACH, CA
SITE CODE – IBNJ
TARGET SPECIES – *Mytilus californianus*
NOMINAL SITE CENTER – 32° 35.26' N, 117° 08.01' W
LOCATED ON NOAA CHART – 18772

SITE ACCESS – This site is located on a jetty at the north end of Imperial Beach. From Interstate 5 south in Imperial Beach, take the Palm Ave. exit west to Seacoast Drive. Turn right (north) onto Seacoast Drive and park near Carnation Ave. Walk to the end of Carnation Ave. and around the vehicle gate. The jetty is to the right (north) approximately 150 m.

SITE DESCRIPTION – The site center is below the tallest rock on the jetty, approximately 2/3 of the way out to the seaward end of the jetty. The three discrete collection stations are on the south side of the jetty, with the middle station located directly below the site center, and the other two stations approximately 15 m inshore and offshore of the center station.

Elkhorn Slough NERR

SITE – ELKHORN SLOUGH, MONTEREY BAY, CA
SITE CODE – MBES
TARGET SPECIES – *Mytilus edulis*
NOMINAL SITE CENTER – 36° 48.59' N, 121° 47.11' W
LOCATED ON NOAA CHART – 18685

SITE ACCESS – This site is on the Hwy. 1 bridge across Elkhorn Slough near Moss Landing. A boat is required. From Moss Landing Harbor, take a small boat toward the harbor entrance to the west. At the range markers, turn right and proceed to the Hwy. 1 bridge across the mouth of Elkhorn Slough.

SITE DESCRIPTION – The site center is the boat speed-limit sign posted on the seaward side of the Hwy. 1 bridge. Discrete collection stations were on the seaward bridge-support pilings in the first, second, and fourth rows of pilings, counting from the west end of the bridge.

SITE – MOSS LANDING BEACH, MONTEREY BAY, CA
SITE CODE – MBML
TARGET SPECIES – *Mytilus californianus*
NOMINAL SITE CENTER – 36° 48.07' N, 121° 47.38' W
LOCATED ON NOAA CHART – 18685

SITE ACCESS – This site is located on a small rock outcrop just north of the Moss Landing pier. From California Hwy. 1 in Moss Landing, just south of the Pacific Gas and Electric power plant, take Moss Landing Rd. toward the sea. Take the first right and cross the one-lane bridge. Just across the bridge, turn left and park in the parking lot. Walk over the dunes and out to the beach. Proceed to the right along the beach and under the pier.

SITE DESCRIPTION – The site is a rock outcrop approximately 30 m north of the pier, in front of the south end of the MBARI building. The outcrop was approximately 10 m long. The site center is on the beach approximately 10 m above the rock outcrop. Discrete collection stations were in the middle and at either end of the rock outcrop, approximately 5 m apart.

South Slough NERR

SITE – COOS HEAD, COOS BAY, OR
SITE CODE – CBCH
TARGET SPECIES – *Mytilus californianus*
NOMINAL SITE CENTER – 43° 21.00' N, 124° 19.85' W
LOCATED ON NOAA CHART – 18587

SITE ACCESS – The site is located on the jetty at the Oregon Institute of Marine Biology, which used to be the old Coos Head Coast Guard Station. From Hwy. 101 in Coos Bay, turn west onto Newmark Rd. and drive to the end. Then go south (left) onto South Empire Rd. and follow the road for about 4.5 mi down to Charlestown. Cross over the bridge into the town and take the first right onto Boat Basin Rd. Follow the road to the end and then into the old Coast Guard Station grounds. The Institute Administration building is on the left hand side of the road before the old USCG station. Permission should be obtained from the laboratory director for access to the site, which is now on the Institute's grounds. If sediments are to be collected, a boat is needed to access the sediment site. There is a good public boat ramp at North Bend, next to the Municipal Airport.

SITE DESCRIPTION – The bivalve site is located on the jetty at the Oregon Institute of Marine Biology, which used to be the old Coos Head Coast Guard Station. The discrete stations are located on the concrete pilings under the jetty.

SITE – RUSSELL POINT, COOS BAY, OR
SITE CODE – CBRP
TARGET SPECIES – *Mytilus edulis*
NOMINAL SITE CENTER – 43° 25.88' N, 124° 13.27' W
LOCATED ON NOAA CHART – 18587

SITE ACCESS – This site is located under the Hwy. 101 bridge across Coos Bay, just to the north of North Bend. Access is via private property. To reach the site, turn east onto East Bay Drive, just north of the Hwy. 101 bridge over Coos Bay (connecting Russell Point to North Point). On East Bay Drive, turn right onto the first private driveway. If sediments are to be collected, a boat is needed to access the sediment site. There is a good public boat ramp at North Bend, to the northeast of the Municipal Airport. Access to the ramp is via California St. Follow the sign to the ramp. It is also easier to sample the bivalve site from a small boat.

SITE DESCRIPTION – At this site, mussels were found in a single small patch, hanging upside down from the bottom of the center section of the 6th bridge support, counting from the north end of the bridge (approximately 150 m south of the north end of the bridge). No farther than the 7th bridge support was accessible without a boat, and mussels were not present on the 7th support. Consequently, collections were pooled from the 6th support, without designating three discrete collection stations. The target location (i.e., the 8th, 9th, and 10th bridge supports) was not accessible without a boat.

Kachemak Bay NERR

SITE – HOMER SPIT, COOK INLET, AK
SITE CODE – CIHS
TARGET SPECIES – *Mytilus edulis*
NOMINAL SITE CENTER – 59° 36.87' N, 151° 26.65' W
LOCATED ON NOAA CHART – 16645

SITE ACCESS – This site is easily accessed by vehicle, with a short walk out onto the mud flat at low tide. The site is located on the northeast side of Homer Spit. From the Tesora Alaska and Texaco gas stations at the corner of Ocean Drive and Homer Spit, follow the road out about 2.75 mi towards Coal Point (at the end of Homer Spit). Turn left onto a small dirt road that continues northeast for about 30 m and then ends. From here, walk out some 75 m to the shoreline where the site is located.

SITE DESCRIPTION – The site is situated along the shoreline of the extensive mud flats to the northeast of Homer Spit. During the winter months, the entire area is frozen over with a thick (0.5 – 1.0 meter) layer of ice. Along the shoreline, the layer of ice is broken up and the mussels can be found by searching along these breaks.

Old Woman Creek NERR

SITE – OLD WOMAN CREEK, LAKE ERIE, OH
SITE CODE – LEOW
TARGET SPECIES – *Dreissena sp.*
NOMINAL SITE CENTER – 41° 23.10' N, 82° 31.12' W
LOCATED ON NOAA CHART – NOAA Chart 14830. This is the only NOAA chart available for the site. Unfortunately, the scale does not provide much detail.

SITE ACCESS – Traveling from the west (e.g., South Bass Is.) proceed east on Route 6 past the town of Huron. The entrance road to the site is immediately to the left (North) before the Route 6 bridge that crosses Old Woman Creek. The Old Woman Creek visitor center is reached by proceeding over the bridge and traveling approximately another quarter mi. The entrance to the visitor center is on the south side of the highway.

SITE DESCRIPTION – Small zebra mussels are attached to stones lying near the base of the jetty to the West of the mouth of Old Woman Creek. This jetty borders the boundary of this National Estuarine Research Reserve. When the creek is flowing this site is affected by water and contaminants that might be associated with the creek water or its sediments.

Sediments were collected within Old Woman Creek. There is a projection, to the east, within the creek near its mouth. Samples were taken along this projection. The first sample was taken nearest to the main channel of the Creek with the other two stations progressing, sequentially, further to the east.

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