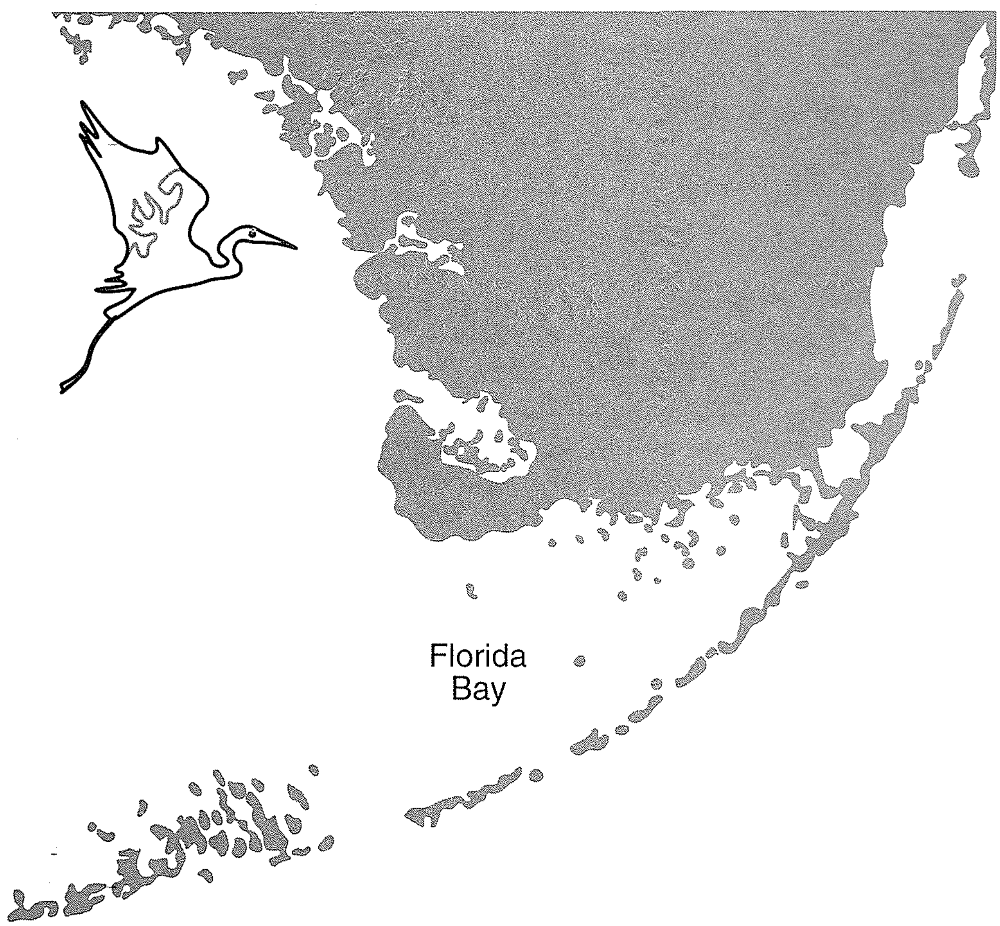
NOAA Technical Memorandum NOS ORCA 75

National Status and Trends Program
for Marine Environmental Quality

South Florida Environmental Quality



Silver Spring, Maryland
December, 1993

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Coastal Monitoring and Bioeffects Assessment Division
Office of Ocean Resources Conservation and Assessment
National Ocean Service

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National Oceanic and Atmospheric Administration
U.S. Department of Commerce
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Notice

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A. Y. Cantillo, T. P. O'Connor and G. G. Lauenstein

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United States Department of Commerce	National Oceanic and Atmospheric Administration	National Ocean Service
Ronald H. Brown Secretary	D. James Baker Under Secretary	W. Stanley Wilson Assistant Administrator

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South Florida Environmental Quality

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ABSTRACT

Florida Bay has undergone environmental change caused by man-made reduction of freshwater flow from the Everglades. The reduction in the freshwater flow resulted from the construction of drainage canals built to meet agricultural requirements and the demand for dry land by the increasing population of South Florida. This document is a summary of the environmental conditions of Florida Bay, Biscayne Bay, and the southern portion of the Gulf Coast of Florida; the levels of contaminants found at the NOAA National Status and Trends (NS&T) Program sites in the area; and how these levels compare with those found in other NS&T sites nationwide.

1. INTRODUCTION

Florida Bay has been subject to environmental change caused by anthropogenic reduction of freshwater flow into the Bay from the Everglades (Boesch *et al.*, 1993). This change occurred in part as the result of the construction of drainage canals built to meet the demand for dry land by the increasing population of South Florida and by agricultural interests in the area. The reduction of freshwater flow may have resulted in increased salinities in Florida Bay as evaporation in the shallow lagoon exceeded freshwater inflow from the Everglades, rainfall and tropical storms. Increased salinities have altered species distribution and abundance throughout large portions of the Bay. The water flow pattern of Florida Bay was also altered by the construction of the railway line connecting Key West to the mainland (Boesch *et al.*, 1993), and the subsequent conversion of this railway line into the Florida Keys Overseas Highway after its destruction during a hurricane. This document is a summary of the environmental conditions of Florida Bay, Biscayne Bay and the southern portion of the Gulf Coast of Florida; the levels of contaminants found at the National Oceanic and Atmospheric Administration's (NOAA) National Status and Trends (NS&T) Program sites in the area; and how these levels compare with those found in other NS&T sites nationwide. Existing and proposed NS&T monitoring projects in South Florida are discussed.

2. DESCRIPTION OF ECOSYSTEM

2.1. Florida Bay

Florida Bay is a coastal lagoon, on average less than 3 m deep, approximately 1,000 square miles in area, located between the South Florida mainland and the Florida Keys (Figure 1). Approximately 80% of the Bay is protected as part of the Everglades National Park, and the rest is under the protection of the NOAA Florida Keys National Marine Sanctuary. The Bay is open to the Gulf of Mexico in the southwest. During most years, Florida Bay is a negative estuary since evaporation exceeds freshwater input resulting in a hypersaline (>35°/oo) environment (Table 1). Such conditions were observed for 12 of the 17 years of recorded data since 1956 examined by Robblee *et al.* (1989). Salinities greater than 50°/oo have been

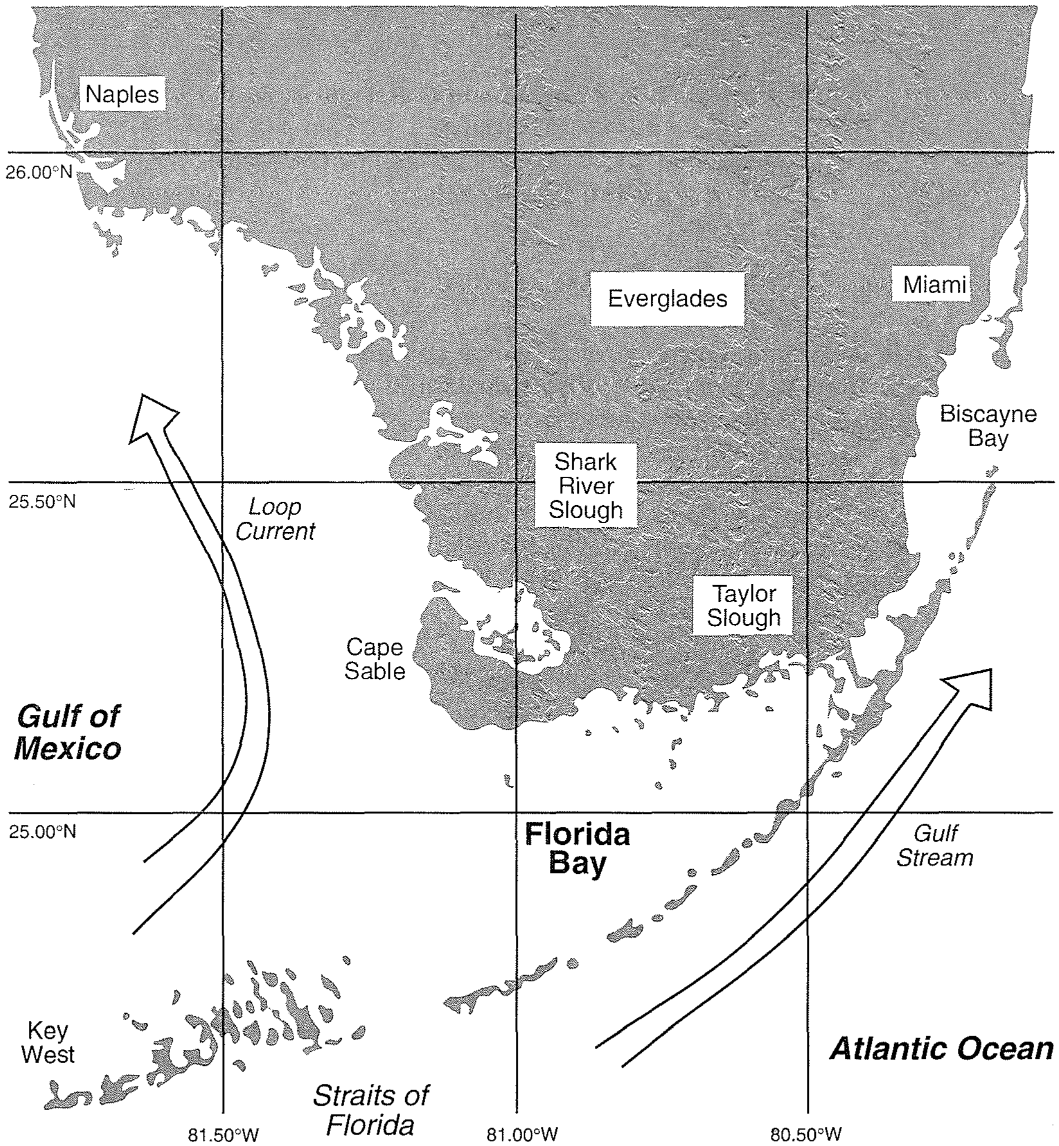

Figure 1.-Florida Bay.

routinely measured, and maximum levels of approximately 70°/oo have been observed. Highest salinities occur in the central basins, usually during late spring, and lowest salinity conditions occur in the northeast region, usually during late summer. Seasonal variations of salinity appear to be related to the rainfall conditions in South Florida, where highest rainfall occurs during the summer and early fall.

Freshwater drainage into the Bay is limited to runoff from Taylor Slough, from the coastal wetlands south of Shark River Slough, and seepage of groundwater from the mainland (Schomer and Drew, 1982).

Table 1. Typical salinity, dissolved oxygen, and nutrient concentration levels in the open ocean and Florida Bay.

	Oceanic range	Florida Bay range
Salinity	26 - 37 ‰	38 - 70 ‰ ◊
Dissolved oxygen	0 - 10 μg/L	0 - 10 μg/L
Nutrients		
Silicate	0 - 130 μM * ♦	-
Phosphate	0 - 4 μM ♦	<0.12 μM △
Nitrite	0 - 10 μM ♦	-
Nitrate	0 - 50 μM ♦	0.25 - 2.10 μM △
Ammonia	0 - 3 μM ♦	0.30 - 1.2 μM △

◊ Zieman *et al.*, 1989. * μg-at./L is equivalent to μM and to (μg/L)/atomic weight. ♦ G. Berberian, NOAA/AOML, personal communication, 1993. △ Powell *et al.*, 1989a.

Florida Bay opens to the Gulf of Mexico in the southwest. Open water effects on the Bay, however, are dampened by interconnecting mudbanks which cordon the Bay into a series of internal basins or "lakes" (Merriam, 1989). Major morphological changes in the Bay occur during major storms such as hurricanes. The intense runoff and increased rainfall that accompanies these storms appear to be very significant in maintaining the Florida Bay ecosystem (Meeder and Meeder, 1989). Storms that affect the Bay bottom and coastline occur about once every 3-5 years, and those that produce extreme freshwater runoff occur once every 6-7 years.

There are 237 muddy islands with areas smaller than 100 m^2 unevenly distributed in Florida Bay (Enos, 1989). Most of these islands are connected by narrow mudbanks (Merriam and Quinn, 1989). They are most common in the central region of the Bay. In general, these islands are larger in the northeast region adjacent to the mainland than in the rest of the Bay, and the mudbanks are thicker and wider in the western part adjacent to the Gulf of Mexico. These islands are composed of soft carbonate mud accumulated over the Miami Limestone (Pleistocene) bedrock during the sea level rise through the past 5,000 years. Florida Bay is a source of biogenic carbonate sediments (Merriam, 1989; Bosence, 1989). The principal habitats of the small islands are associated with: red and black mangrove swamps, algal and halophyte marshes, grass "prairies", and hardwood-buttonwood hammocks (Enos, 1989). The islands are dynamic and the habitats are subject to sudden catastrophic alterations. The islands also migrate through erosion on exposed margins and lateral accretion on sheltered margins. Geological stratigraphy of the islands as determined by cores showed no obvious relationship to habitat.

Based on the distribution of benthic mollusks, Turney and Perkins (1972) proposed four subenvironments for Florida Bay (Figure 2). The physical, geological, and biological characteristics of these subenvironments are summarized in Table 2.

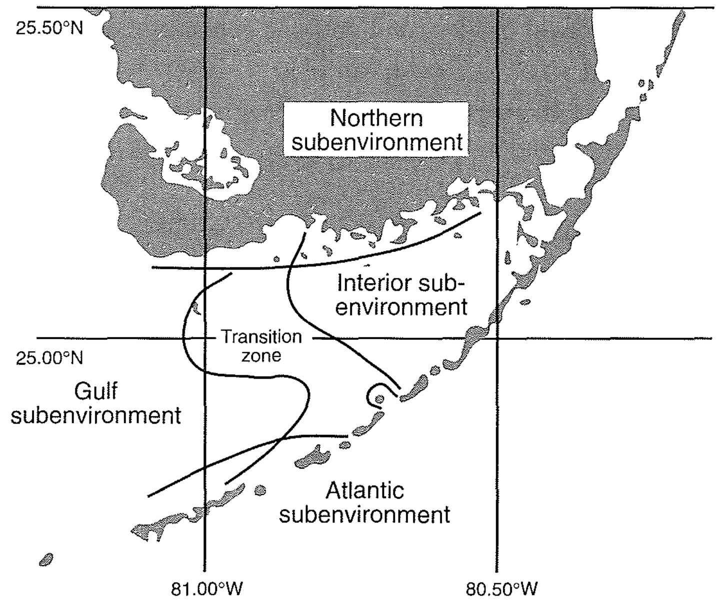

Figure 2. Florida Bay subenvironments based on distribution of benthic mollusks (adapted from Turney and Perkins, 1972).

Northern subenvironment

Mangrove coast. Barely submerged. Influenced by seasonal freshwater runoff. Salinities range from 13-48 ‰, and temperatures from 15-38°C (59-100°F). Only the western edge is subject to tidal flushing. Hypersaline conditions are commonly detected during the dry season.

Atlantic subenvironment

From the middle Keys along the northern edge of the reef. Nearly normal oceanic salinities (35-41 ‰) and moderate temperatures 17-32°C (63-90°F) are found in this region. Beginning at the low coral keys, there is exchange of Florida Bay waters with those of the Straits of Florida through numerous channels between the Florida Keys. Also, there is some seepage across porous Key Largo limestone. Flushing increases southward towards the sluiceway and the Gulf of Mexico.

Interior subenvironment

Northeastern half of the Bay. Contains most of the "lakes" and is characterized by restricted circulation and by wildly fluctuating salinities of between 22-52 ‰. There is negligible flushing except for wind-driven movement across mud banks and low lying islands. Net seasonal deficits and excesses of runoff and rainfall are strongly reflected in this zone.

Gulf subenvironment

Just inside the 1.8 m (6 ft) contour between Cape Sable and Fiesta Key. Salinities are at nearly normal marine levels. There is an exchange of water in this region through tidal flux and long-shore currents. Current spinoffs regularly traverse the area forming the "sluiceway" across the low coral keys between Long Key and Big Pine Key into the Straits of Florida (Stockman *et al.*, 1967).

Table 2. Physical, chemical, and biological conditions in subenvironments of Florida Bay [adapted from Turney and Perkins (1972) by Schomer and Drew (1982)].

Northern subenvironment	Atlantic subenvironment	Interior subenvironment	Gulf subenvironment
Salinity			
Salinity range: 13-48°/oo. Temp range: 15°-38°C.	Salinity range: 35-41°/oo. Temp. range: 17°-32°C.	Salinity range: 22-52°/oo Temp. range: 15°-38°C. Restricted circulation little affected by tidal exchange.	Near-normal marine salinity and temperatures.
Circulation			
Restricted circulation little affected by tidal exchange. Subject to irregular influx of freshwater from mainland.	Open circulation with daily tidal flushing.	Not subject to daily fluctuations, but wet years produce low salinity, dry years produce high salinity.	Mixing of waters with Gulf of Mexico probably slow because of position in wind and current "shadow."
Types of bottom			
Banks: Mud.	Highly variable: Banks and lakes can be either mud, clean sand, or mixtures, depending on local variation.	Banks: Mud.	Highly variable: Banks and lakes can be either mud, clean sand, or mixtures, depending on local variation.
Most lakes: Sandy mud.	Deepest lakes are rocky with veneer of muddy or clean sand.	Most lakes: Sandy mud.	Deeper lakes: Rocky with veneer of muddy sand.
Deeper lakes: Rocky with veneer of muddy sand.		Deeper lakes: Rocky with veneer of muddy sand.	
Near-shore mud, sometimes very peaty.		Occasional beaches and windward (eastern) points of bank are sand or muddy sand.	
Grass			
Banks usually carpeted with *Thalassia* and/or *Cymodocea* with some *Halodule*.	Highly variable in banks, lakes, and passes, usually with sparse to heavy *Thalassia* and rarely with *Cymodocea*.	Banks usually carpeted with *Thalassia*.	Highly variable in banks, lakes, and passes, usually with sparse to heavy *Thalassia* and rarely with *Cymodocea*.
Lakes with heavy to sparse cover of Thalassia and/or *Cymodocea.*		Rare *Cymodocea* and *Halodule*.	
		Lakes usually with sparse, but occasionally heavy, *Thalassia*.	

Table 2. Physical, chemical, and biological conditions in subenvironments of Florida Bay [adapted from Turney and Perkins (1972) by Schomer and Drew (1982)] (cont.).

Northern subenvironment	Atlantic subenvironment	Interior subenvironment	Gulf subenvironment
Algae			
Rare *Batophora.*	Abundant *Halimeda* and Penicillus.	*Penicillus* and *Batophora* common.	Abundant *Halimeda* and *Penicillus.*
Rare *Penicillus* and *Acetabularia* on margins.	Common *Udotea.*	Few *Acetabularia.*	Common *Udotea.*
		Rare *Halimeda* and *Udotea* on margins.	Few *Caulerpa.*
			Rare *Rhipochephalus*, *Acetabularia*, *Batophora*, *Dasycladus* and *Avrainvillea.*
Coral			
Absent	Abundant *Porites furcata.*	Very rare *Siderastrea.*	Common *Porites furcata.*
	Common *Siderastrea* and *Alcyonaria.*	Rare *Porites*, *Solenastrea*, and *Alcyonaria* near margins.	Rare Solenastrea and *Alcyonaria.*
	Few *Solenastrea.*		
Mollusks			
Characteristic species			
Anomalocardia cuniemeris	*Codakia orbicularis*	*Brachidontes exustus*	*Nucula proxima*
	Tegula fasciata	*Pinctada radiata*	*Noculana acuta*
	Astrea longispina	*Cerithium muscarum*	*Tellina similis*
	Astrea americana	*Bittium varium*	*Corbula* sp.
	Cerithium literatum		
Species more common here than elsewhere			
Ostrea sp.	*Barbatia cancellaria*	*Lucina multilineata*	*Noetia ponderosa*
Parastarte triquetra	*Glycymeris pectinata*	*Rissoina bryerea*	*Cardita floridana*
Lyonsia floridana	*Lucina pensylvanica*	*Modulus modulus*	*Phacoidea nassula*
Rissonia browniana	*Codakia orbiculata*	*Olivella* sp.	*Anodontia philippiana*
Melongena corona	*Trigoniocardia medium*		*Trachycardium muricatum*
Retusa canaliculata	*Laevicardium laevigatum*		*Tellina alternata*
	Chione Pygmaea		*Mactra fragilis*

Table 2. Physical, chemical, and biological conditions in subenvironments of Florida Bay [adapted from Turney and Perkins (1972) by Schomer and Drew (1982)] (cont.).

Northern subenvironment	Atlantic subenvironment	Interior subenvironment	Gulf subenvironment
Species more common here than elsewhere (cont.)			
	Acmaea sp.		*Barnea costata*
	Tricolia sp.		*Dentalium* sp.
	Vermicularia sp.		*Calliostoma jujubinum*
	Cerithium eburneum		*Turbo castaneus*
	Malenella sp.		*Anachis obsea*
	Natica carena		*Margelia*, sp.
	Columbella mercatoria		
	Terebra sp.		

The bottom of the Bay is dominated by seagrasses, especially *Thalassia testudinum* (turtle grass). There is a gradient in seagrass communities from the enclosed northeast region of the Bay to the open western regions (Fourqurean *et al.*, 1992). The northeast region is dominated by sparse *T. testudinum* with denser cover on localized areas of increased sediment accumulation. The seagrass communities in this region are nutrient limited (Powell *et al.*, 1989a; Lapointe, 1989). Seagrass cover increases towards the west where *T. testudinum* is intermixed with *Halodule wrightii* (shoalgrass) and *Syringodium filiforme*. Large bird colonies in some of the mangrove islands in the northeast Bay increase nutrient availability and therefore seagrass density in the vicinity of the colonies. Since 1987, a major die-off of seagrass and benthic macrophytes has been observed in Florida Bay (Zieman *et al.*, 1989). Anomalies in the recent climate record including excessively warm waters during the summer and fall of 1986-88 and 1990, and a reduction of tropical storm frequency, may have contributed to the die-off. Recent reports of seagrass die-offs on the Atlantic Ocean side of the Florida Keys between Long and Grassy Key have been reported in the media (Dewar, 1993a).

Shaw (1989) classified the mollusk species collected in Florida Bay into nine major biofacies or assemblages and several minor ones. Salinity patterns seem to influence the distribution of the major biofacies in the interior of the Bay, but the influence is not rigid or constant as salinity patterns and levels can change from year to year. Water depth also correlates with molluscan species assemblage, but the overall variation of depth in the Bay is small.

Florida Bay has a diverse fish community dominated by forage species and juvenile forms of commercial and sports fishes (Thayer and Chester, 1989). Channel areas within the Bay displayed the highest diversity of fish and the largest density of seagrasses. The composition of the larval fish community in Florida Bay and adjacent waters has been described by Powell *et al.* (1989b). Sogard *et al.* (1989) investigated the distribution of benthic and epibenthic fishes in seagrass beds growing on shallow mudbanks in Florida Bay. They found a strong heterogeneity in species composition and abundance of both benthic and epibenthic species in the different subenvironments of the Bay.

Limited information on the chemistry of sediments is available in the scientific literature. Ryan *et al.* (1989) compared the levels of Cd, Cr, Cu, Hg, Ni, Mn, and Zn and the levels of total organic carbon, total Kjeldahl nitrogen, and total phosphorus in sediments collected from a variety of bottom types in Florida Bay with similar analysis from other sites in Florida. Metal and nutrient levels were low and typical of those reported for clean carbonate sediments.

2.2. Biscayne Bay

Biscayne Bay is a subtropical coastal lagoon located on the east coast of Florida, open to the sea at several locations (Bader and Roessler, 1972; Uhl Wilson, 1975). It is separated from the Atlantic Ocean by a series of barrier islands that include Miami Beach and the northern end of Key Largo. The northern half of Biscayne Bay is surrounded by the Miami-Miami Beach-Ft. Lauderdale metropolitan area. Urbanization of the coastal boundaries has resulted in an environmental decline and reduced public access to the Bay. This is most severe in the northern half of the Bay. Biscayne National Park, located in the southern half of the Bay, was established in 1968 as a national monument, and formally established as a national park by the US Congress in 1980. The composition of benthic communities in Biscayne Bay varies with sediment or substrate type, depth, temperature, salinity, light, wave energy, and currents (Metro-Dade County, 1985). Seagrasses cover approximately 64% of the Bay bottom, provide a habitat for juvenile fish and crustaceans, and stabilize the bottom substrate. Hard bottom communities cover approximately 17% of the Bay and are characterized by sponges, soft corals, and seaweeds. These communities are mostly found where limestone is exposed or covered by a thin layer of sediment. Portions of the Bay bottom have been altered by dredging and filling, or by the passage of storms. Water quality in Biscayne Bay is generally good, although the northern portion of the Bay is impacted by canal and river discharges. Biscayne Bay and Miami River sediments are contaminated, and higher levels of PCBs, insecticides, pesticides, and trace metals are found north of the Rickenbacker Causeway and near canals or rivers discharging into the Bay. Further details on the Biscayne Bay ecosystem can be found in Thorhaug and Volker (1976), Bader and Roessler (1972), and Uhl Wilson (1975).

2.3. Everglades National Park

The Everglades National Park is located on the southern tip of Florida. An excellent description of the Park can be found in the official guidebook (George, 1988). The Everglades is a low, flat region, mostly under water, which sustains a variety of habitats. The Everglades also is a river, about 6 in. deep, which originally flowed from Lake Okeechobee, more than 100 miles north in central Florida, into Florida Bay and the Gulf of Mexico. Drainage canals constructed after the turn of the century changed both the rate and direction of freshwater outflow. The coastal ecosystem of the Everglades is composed of a variety of habitats: Florida Bay; the coastal prairie; the vast mangrove forest and its waterways; cypress swamps; the true everglades, the extensive freshwater marsh dotted with tree islands and occasional ponds; and the driest zone, the pine-and-hammock rockland. Underlying the entire Park is porous limestone covered by a thin mantle of marl and peat which provides soil for rooting plants. The Everglades fauna and flora are a blend of tropical species, most of which migrated from the Caribbean islands, and species from the Temperate Zone, which embraces all of Florida. These species have adapted to the region's peculiar cycles of flood, drought, and fire. The coastal mangrove forests, traversed by thousands of estuarine channels and containing numerous bays and sounds, are extremely productive biologically. On the west side of the Park is the Flamingo Visitor Center, located on Cape Sable. Whitewater Bay is located between Cape Sable and the mainland Everglades. An ecological study of the Cape Sable-Whitewater Bay ecosystem can be found in Tabb and Dubrow (1962) and Tabb and Manning (1962).

2.4. Florida Keys

The Florida Keys encompass the 345-km long Florida Reef Track, the only living tropical coral reef along the mainland United States (Miller, 1988). There are three National Marine Sanctuaries established and managed by NOAA along the reef track: the Florida Keys National Marine Sanctuary; the Key Largo National Marine Sanctuary; and the Looe Key National Marine Sanctuary. There are also other sanctuaries in the area such as the National Key Deer Refuge, the John Pennekamp Coral Reef State Park, the Great White Heron National Wildlife Refuge, and the Key West National Wildlife Refuge. The ecosystem on the northern side of the Reef is similar to that of Florida Bay and the shore lines are characterized by mangrove communities. Urban development has resulted in riprap and gravel beaches, rocky shores, and seawalls. There are few sand beaches in the Florida Keys. The coral species most abundant in the Florida Reef Track are *Montastrea annularis*, *M. cavernosa*, *Acropora palmata*, *A. cervicornis*, *Diploria* spp., *Siderastrea siderea*, and *Colpophyllia* spp. Many of these species have been affected by coral bleaching, and white band and black band disease (Miller, 1988). Also, cold water resulting from the passage, in recent years, of severe cold fronts across the reefs from Florida Bay has stressed or killed many corals. The ecosystem has been impacted by excessive amounts of nutrients from Florida Bay and non-point sources, the effects of overdevelopment of the Keys, and of damage by large vessels such as ship groundings and minor oil spills. There are a number of mechanisms transporting water within the Keys (Schomer and Drew, 1982). These include oceanic currents, evaporation processes, tides, winds, freshwater flow (from land runoff and rainfall), and catastrophic climatological events such as hurricanes. Salinities are variable but are approximately 36 $^{o}/_{oo}$.

2.5. Rookery Bay and Naples Bay

The Rookery Bay ecosystem spans the area, on the southwest side of Florida, between the city of Naples and Marco Island (Clark, 1974). This area, also known as the Ten Thousand Islands, is a complex system of tidal creeks, mangrove swamps, salt marshes, and islands. Most of it is undeveloped but is not in a natural state. A large portion of the area is incorporated into the National Audubon Society's 5,000-acre Rookery Bay Sanctuary. The drainage basin for the Rookery Bay ecosystem includes the Big Cypress Swamp located west and north of the Everglades National Park. The shoreland that surrounds the Rookery Bay vicinity is flat and low. Drainage canals have changed the character of much of the land. Remnants of wet soil vegetation, mainly stands of cypress, remain in many of the natural drainageways. These remaining wet areas form a network of connected drainageways marked by typical wet-soil vegetation, which is essential to the proper functioning of the whole ecosystem.

Salinities in Rookery Bay are lowest during the summer rainy season and highest during the spring dry season, when they reach about 35 $^{o}/_{oo}$ or higher during extreme drought (Clark, 1974). Tidal exchange is an important part of the water circulation system of the area. Sediment samples reveal that the upper portion of the submerged bottom consists of fine sand mixed with shell debris and organic material. The abundant oyster production of the Sanctuary has resulted in oyster shells forming a large portion of the sediment overlying the bedrock. The primary vegetation of the Rookery Bay estuarine ecosystem is the mangrove complex. Predominant species include the red, black, and white mangrove, buttonwood, and a variety of salt-tolerant shrubs, worts, and ground covers. Seagrasses are also an important element in the Rookery Bay ecosystem, but they are not so abundant as in other areas of South Florida with more favorable growing conditions. The dominant seagrass presently found in the ecosystem is Cuban shoalweed. It is most abundant in the shallow areas, especially the northern and southern ends of Rookery Bay. Green algae and several species of red algae are also abundant, particularly in association with the seagrass beds. The waters of the Sanctuary also represent a refuge for young fish and shellfish where fluctuating salinities and shallow depths discourage marine predators, and where food abounds.

3. ANTHROPOGENIC IMPACT AND CURRENT STATUS

Evidence of the onset of the environmental degradation of the Bay is found in diverse sources. As early as 1913, a system of drainage canals was proposed to drain "excess" water from Lake Okeechobee and the Florida Everglades (Florida Everglades Engineering Commission, 1913). These canals interrupted the flow of the Everglades, which is a very shallow, slow moving river, flowing from Lake Okeechobee south-southwest into Florida Bay. The slope of this drainage basin in only 2 inches per mile.

Natural fluorescence of river water, caused by dissolved humic acids, has been used as a tracer of freshwater input to nearshore environments (Smith *et al.*, 1989). It has been shown that massive hermatypic corals such as *Solenastrea bournoni* possess fluorescent bands within their skeletons, and the frequency and intensity of the bands have a high correlation with terrestrial runoff. A core taken from the *S. bournoni* specimen from the Petersen Key Basin showed clear fluorescent banding under ultraviolet light. The relationship between flow in the Shark River and Taylor Sloughs and the fluorescent banding from 1940 to the present were used to hindcast flow for the period of 1881-1939. From the fluorescence pattern, a sustained, marked decline in freshwater flow, which began in 1912 and ended around 1931, was noted. Fluorescence was significantly higher earlier in the record (prior to 1932) than later on, and Smith *et al.* (1989) interpreted this as indicating decreased freshwater flow from the Everglades into Florida Bay of perhaps as much as 59% in the later period. This onset of decreased freshwater flow coincided with the construction of drainage canals to the east and south of Lake Okeechobee. Periods of reduced growth observed in growth patterns of a 1-m-high specimen of the coral *S. bournoni* from the Petersen Key Basin, Florida Bay, appeared to correlate with major anthropogenic environmental perturbations (Hudson *et al.*, 1989). This coral species is resistant to sedimentation and water temperature extremes, and no correlation was apparent between growth rates and major meteorological events such as hurricanes and freezes.

The recorded history of fishing in Florida Bay and the Florida Keys can be traced back to the Caloosa Indians at the time of the early Spanish explorers (Tilmant, 1989). Indians from the Upper Keys grew and exported fish to Cuba and early explorers reported excellent fish catches in the Keys. Prior to the 1940s, fishing was largely subsistence oriented. Fishing activities increased during the 1950s and commercial activities reached a peak in the late 1970s. During this time, fishing guides became concerned with declining catches (Thayer and Chester, 1989). Evidence of the effect of salinity changes on the fish population of Florida Bay is circumstantial but there is evidence that the population size and behavior of several species has changed in recent years (Boesch *et al.*, 1993). These effects do not seem to extend to the open areas of the Bay.

Although the case cannot be proven because there were no data collected prior to the flow restrictions, the decreased freshwater flow into Florida Bay has resulted very probably in changes in the ecosystem. Recent changes include seagrass die-offs that first appeared in the 1980s. Seagrasses are a prime habitat for shrimp and juvenile fishes. Algal blooms and declining shrimp and fish catches also appear to be symptoms of the degradation of the Bay. High salinities (45 - 70 ‰) may be partially responsible for declines in abundance and diversity of fish species in the Bay (Tabb and Roessler, 1989). During the past year, a sharp decline in the number of nesting ospreys and brown pelicans has been noted in Florida Bay after population levels appeared to have recovered after the DDT ban in the 1970s (Dewar, 1993a). The number of nesting pairs of ospreys is less than a third of what it was 20 years ago, and the number of pelicans has been halved. For years, land in the Everglades was drained and irrigated. The agricultural activities around Lake Okeechobee and Dade County have contributed a variety of anthropogenic chemicals, such as pesticides. These contaminants flow south-southwest through the Everglades and into the coastal ecosystem.

The population of the southeast United States has increased in recent decades and is projected to continue to do so at the highest rate of all regions in the Nation (Culliton *et al.*, 1990) further stressing the ecosystems within the Southeast. Eastern Florida counties are expected to grow at the fastest rate, and are projected to have the highest population density in the Southeast United States by 2010. Florida counties on the Gulf coast are also expected to increase in population, except for Monroe County, which is expected to have a low population density.

Agricultural pesticide use in coastal areas has been summarized in the NOAA Agricultural Pesticide-Use Data Base which contains information on 35 pesticides (Pait *et al.*, 1992). In the southern portion of the Atlantic coastal region, crops such as citrus and sugarcane are common. The Indian River estuarine drainage area is reported to have the highest citrus acreage (over 84,000 acres) in the region, while Biscayne Bay has the highest sugarcane acreage (over 45,000 acres). The tomato acreage (approximately 9,000 acres) in the Biscayne Bay estuarine drainage area accounted for almost 76% of all tomato acreage in the region. Pait *et al.* (1992) defined the hazard normalized application (HNA) of the inventoried pesticides as the agricultural use of the inventoried pesticides normalized to the hazard they pose to estuarine organisms. The HNA rating system combines four parameters for each pesticide that represent important factors affecting its fate and effects in the aquatic environment: LC_{50} for fish, LC_{50} for crustaceans, soil half-life, and bioconcentration factors in fish. This factor, when multiplied by the use of each pesticide, yields the amount of HNA resulting from the use of such chemicals. Further details on calculation of HNA can be found in Pait *et al.* (1992).

The South Atlantic region ranked second in the Nation behind the Gulf of Mexico with over 16.8 million pounds of HNA. Biscayne Bay, Indian River, Charleston Harbor, St. Catherines/Sapelo Sounds, and Savannah River estuarine drainage areas had substantially higher HNAs compared to total use than those of other coastal areas. These watersheds represent areas where the more hazardous compounds comprised a significant portion of the total pesticide use, and thus where the potential for acute impacts to estuarine resources may also exist. The intensity of HNA (i.e., HNA divided by estuarine drainage area) provides additional information to help identify estuarine systems that may be at risk due to a higher per-unit-area application of the more hazardous pesticides. Biscayne Bay and Albemarle/Pamlico Sounds estuarine drainage areas ranked in the Nation's top 10 in the intensity of HNA. Although the Albemarle/Pamlico Sounds estuarine drainage area had the highest HNA in the Nation, its lower per-unit-area application produced a lower intensity of HNA estimate.

The Gulf of Mexico region extends from the southern tip of Florida to the US-Mexico border. This region contains four of the top 10 estuarine drainage areas in the Nation in terms of the intensity of HNA. The Rookery Bay and Tampa Bay estuarine drainage areas in Florida ranked number one and three in the Nation in the highest per-unit-area application of the more hazardous pesticides in the inventory. Endosulfan on tomatoes was primarily responsible for the ratings in the Rookery Bay, Tampa Bay, and South Ten Thousand Islands estuarine drainage areas, while endosulfan applied to tomatoes and chlorpyrifos used on citrus were responsible for the rating in Charlotte Harbor.

During the past months, a plethora of newspaper articles has focused on the environmental degradation of Florida Bay, and proposed efforts to restore the ecological health of the Everglades and the associated ecosystems of the Bay (i.e., Dewar, 1993b and 1993c; Keating, 1993; Anderson and Rozca, 1993; and others). Agricultural interests have recently agreed to pay a maximum of $322 million over the next 20 years to help restore the Everglades in an effort described by Interior Secretary Bruce Babbitt as "the largest, most ambitious ecosystem restoration ever undertaken" (Anderson and Rozca, 1993). The rest of the cost of restoration will come from taxpayers and other sources.

4. NOAA NATIONAL STATUS AND TRENDS PROGRAM

4.1. Program description

NOAA's National Status and Trends (NS&T) Program assesses the current status of, and changes over time in the environmental health of the estuarine and coastal waters of the United States, including Alaska and Hawaii. The NS&T Program consists of seven major component projects: National Benthic Surveillance, Mussel Watch, Bioeffects Surveys, Coastal Contaminant Assessments, Historical Trends Assessments, Specimen Banking, and Quality Assurance (QA). In addition, a database of NS&T data is being maintained. The National Benthic Surveillance Project and the Mussel Watch Project are the major producers of data concerning environmental concentrations of contaminants.

Concentrations of organic and inorganic contaminants in sediments and bottom-dwelling fish taken in the same area are determined as part of the National Benthic Surveillance Project at sites located around the nation. The analytes include 24 polycyclic aromatic hydrocarbons, 20 polychlorinated biphenyl congeners, DDT and its metabolites, 9 other chlorinated pesticides, organotins, 4 major elements, and 12 trace elements (Table 3). Concentrations of aryl hydrocarbon hydroxylase, and the frequency of external disease conditions and internal lesions in the livers of bottomfish are being documented. The prevalence of DNA adducts is being measured in fish from selected sites.

Analytical methods are described in Section 4.2, and typical detection limits are listed in Tables I.8 - I.10 (Appendix I). Method detection limits (MDL) are based on the variability of the signal from replicate analyses of real matrix samples containing, in principle, low levels of the analyte (CFR, 1990). The MDL is defined as the Student's *t*-distribution for the 99% confidence limit times the standard deviation of 7 replicate measurements of the same sample (i.e., with n = 7, the MDL = 3.5 x S.D).*

Currently, there are about 80 National Benthic Surveillance sites in estuaries and coastal water around the United States, including both urban and rural areas. Samples are generally collected biennially at these sites. Sample collection and analyses for the National Benthic Surveillance Project are currently done by the NOAA National Marine Fisheries Service (NMFS) Northwest Fisheries Science Center, Seattle, WA, and the NMFS Southeast Fisheries Science Center, Beaufort Laboratory, Beaufort, NC. NS&T Program sampling methods are described in Lauenstein and Cantillo (1993). NS&T sampling sites are described in Lauenstein, Harmon, and Gottholm (1993).

The same contaminants are determined in sediments and mussels or oysters as part of the Mussel Watch Project. The bivalves are collected on a biennial basis from approximately 240 sites in the United States, while sediments are collected at the same sites on a less frequent

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* Detection limits (LODs) based on spiked blanks are not the same as MDLs based on actual matrices such as fish, mollusc tissues, or sediments. The variance of an analysis increases as the actual concentration increases, so if the matrix being used to define the detection limit has any contaminants that are somewhat elevated with respect to a background sample, t'.e resulting detection limit will be higher than concentrations that can actually be quantified. It is difficult, however, to find a reference material that is low in all the contaminants quantified by the NS&T Program. In these situations, detection limits calculated using MDLs result in higher detection limits being reported than when detections limits are derived from limits of detection (LODs).

Table 3. Organic contaminants, and major and trace elements determined as part of the NOAA National Status and Trends Program.

Analytes	CAS Numbers ◊	Analytes	CAS Numbers ◊
Polycyclic aromatic hydrocarbons			
Low molecular weight PAHs (2- and 3-ring structures)		**High molecular weight PAHs** (4-, 5-, and 6-rings)	
1-Methylnaphthalene	90-12-0	Benz[*a*]anthracene	56-55-3
1-Methylphenanthrene	832-69-9	Benzo[*a*]pyrene	50-32-8
2-Methylnaphthalene	91-57-6	Benzo[*b*]fluoranthene	205-99-2
2,6-Dimethylnaphthalene	581-42-0	Benzo[*e*]pyrene	192-97-2
1,6,7-Trimethylnaphthalene	2245-38-7	Benzo[*ghi*]perylene	191-24-2
Acenaphthene	83-32-9	Benzo[*k*]fluoranthene	207-08-9
Acenaphthylene	208-96-8	Chrysene	218-01-9
Anthracene	120-12-7	Dibenz[*a,h*]anthracene	53-70-3
Biphenyl	92-52-4	Fluoranthene	206-44-0
Fluorene	86-73-7	Indeno[1,2,3-*cd*]pyrene	193-39-5
Naphthalene	91-20-3	Perylene	198-55-0
Phenanthrene	85-01-8	Pyrene	129-00-0
DDT and metabolites		**Chlorinated pesticides other than DDT**	
2,4'-DDD	53-19-0	Aldrin	309-00-2
4,4'-DDD	72-54-8	*cis*-Chlordane	5103-71-9
2,4'-DDE	3424-82-6	Dieldrin	60-57-1
4,4'-DDE	72-55-9	Heptachlor	76-44-8
2,4'-DDT	58633-27-5	Heptachlor epoxide	1024-57-4
4,4'-DDT	50-29-3	Hexachlorobenzene	118-74-1
		gamma-HCH	58-89-9
		Mirex	2385-85-5
		trans-Nonachlor	39765-80-5

Polychlorinated biphenyl congeners (numbering system of Ballschmiter and Zell, 1980)

Individual congeners	IUPAC Numbers	CAS registry numbers◊
2,4'-Dichlorobiphenyl	8	34883-43-7
2,2',5-Trichlorobiphenyl	18	37680-65-2
2,4,4'-Trichlorobiphenyl	28	7012-37-5
2,2',3,5'-Tetrachlorobiphenyl	44	41464-39-5
2,2',5,5'-Tetrachlorobiphenyl	52	35693-99-3
2,3',4,4'-Tetrachlorobiphenyl	66	32598-10-0
3,3',4,4'-Tetrachlorobiphenyl	77(110)	32598-13-3 (38380-03-9)
2,2',4,5,5'-Pentachlorobiphenyl	101	37680-73-2
2,3,3',4,4'-Pentachlorobiphenyl	105	32598-14-4

Table 3. Organic contaminants, and major and trace elements determined as part of the NOAA National Status and Trends Program (cont.).

Polychlorinated biphenyl congeners (numbering system of Ballschmiter and Zell, 1980)

Individual congeners	IUPAC Numbers	CAS registry numbers ◊
2,3',4,4',5-Pentachlorobiphenyl	118	31508-00-6
3,3',4,4',5-Pentachlorobiphenyl	126	57465-28-8
2,2',3,3',4,4'-Hexachlorobiphenyl	128	38380-07-3
2,2',3,4,4',5'-Hexachlorobiphenyl	138	35065-28-2
2,2',4,4',5,5'-Hexachlorobiphenyl	153	35065-27-1
2,2',3,3',4,4',5-Heptachlorobiphenyl	170	35065-30-6
2,2',3,4,4',5,5'-Heptachlorobiphenyl	180	36065-29-3
2,2',3,4',5,5',6-Heptachlorobiphenyl	187	52663-68-0
2,2',3,3',4,4',5,6-Octachorobiphenyl	195	52663-78-2
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	206	40186-72-9
2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl	209	2051-24-3

Major and trace elements

Symbol	Element	Symbol	Element	Symbol	Element
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		

Organotin species

Compound	CAS registry numbers
Monobutyltin trichloride	1118-46-3
Dibutyltin dichloride	683-18-1
Tributyltin chloride	1461-22-9
Tetrabutyltin	1461-25-2

◊ Chemical Abstracts Service registry numbers basis. Sample collection and analysis for the Mussel Watch Project are currently done by the Texas A&M University (TAMU) Geochemical and Environmental Research Group (GERG), College Station, TX, and the Battelle Ocean Sciences laboratories at Duxbury, MA, and Sequim, WA.

The quality of the NS&T analytical data is overseen by the QA Project, which is designed to assure and document the quality of the data, to document sampling protocols and analytical procedures, and to reduce intralaboratory and interlaboratory variation (Cantillo and Lauenstein, 1993). To document laboratory expertise, the QA Project requires all NS&T Program laboratories to participate in a continuing series of intercomparison exercises utilizing a variety of materials. The NS&T QA Project is performance-based and no analytical methodology is currently specified. Laboratories can use any analytical procedure as long as the results of the intercomparison exercises are within specified limits of the certified or consensus values of reference or control materials. All analytical methodology and sampling protocols used by NS&T Program monitoring projects have been documented (Lauenstein and Cantillo, 1993).

Two organizations have been responsible for all sample collection and analysis of samples from South Florida: TAMU GERG for the Gulf Coast and Florida Keys, and Battelle Ocean Sciences for the Atlantic Coast. The NS&T data for the South Florida sites are listed in Appendix I and selected data sets are shown graphically in Appendices II and III. NS&T bivalve and sediment data published to date for all sites can be found in NOAA (1988, 1989, and 1991).

4.1.1. Mussel Watch Project sites

Five NS&T sites are located in South Florida and one in the Florida Keys (Table 4, Figure 3). At these NS&T sites, either the American oyster (*Crassostrea virginica*) or the smooth-edged jewel box (*Chama sinuosa*) are collected.

There are three NS&T sites in Biscayne Bay. The NS&T site in North Miami (Maule Lake, NMML) is located in the northern basin of Biscayne Bay. All the shoreline in this section of the Bay has been bulkheaded. The other NS&T sites in the Bay are at Goulds Canal and Princeton Canal, located in the southern basin. This area of the Bay is largely undeveloped. Homestead Air Force Base and the Turkey Point Nuclear Power Plant are located near this area. The NS&T site in the Florida Keys is in Bahia Honda, at the western end of the Seven Mile Bridge of the Overseas Keys Highway. The NS&T site located in Faka Union Bay, in the Ten Thousand Islands region, is northwest of the Everglades National Park boundary. There are two NS&T sites in the Rookery Bay ecosystem. These are located in Henderson Creek, Rookery Bay, which connects to the Henderson Creek Canal and the drainage canal system that spans South Florida; and in Naples Bay proper.

4.1.2. National Benthic Surveillance Project sites

There are two NS&T National Benthic Surveillance Project sampling sites in South Florida, both in Biscayne Bay, one at Chicken Key and the other at the northern end of Biscayne Bay (Table 4, Figure 3). Sampling began at these sites in 1990, and as of this writing, data are not yet available. The species collected is pinfish (*Lagodon rhomboides*).

Table 4. Current NS&T sampling sites in South Florida and the Florida Keys.

Site	Main location	Site code	Latitude (N)	Longitude (W)	Species
Mussel Watch Project					
North Miami	Maule Lake	NMML	25° 56.13'	80° 08.77'	American oyster
Biscayne Bay	Goulds Canal	BBGC	25° 31.39'	80° 18.85'	American oyster
Biscayne Bay	Princeton Canal	BBPC	25° 31.13'	80° 19.75'	American oyster
Florida Keys	Bahia Honda Key	BHKF	24° 39.52'	81° 16.43'	Smooth-edged jewel box
Everglades	Faka Union Bay	EVFU	25° 54.08'	81° 30.78'	American oyster
Rookery Bay	Henderson Creek	RBHC	26° 1.50'	81° 44.20'	American oyster
Naples Bay	Naples Bay	NBNB	26° 6.85'	81° 47.20'	American oyster
Benthic Surveillance Project					
Biscayne Bay	North Bay	BISNB	25° 48.9'	80° 09.6'	Pinfish
Biscayne Bay	Chicken Key	BISCK	25° 36.9'	80° 17.6'	Pinfish

4.2. Analytical methods

4.2.1. Major and trace element analysis

4.2.1.1. Battelle

The methods used by Battelle for sediment and mollusk major and trace element analyses are described in detail in Crecelius *et al.* (1993).

Briefly, sediment samples underwent complete dissolution by nitric acid and perchloric acid digestion at high temperature in a Teflon bomb using a conventional oven. Hydrofluoric acid and further heating was used to assure complete dissolution of silica. Sample digestates were dried at high temperature to remove the chloride and fluoride, and redissolved using nitric acid. Sample digestates were analyzed for major and minor elements using graphite furnace and/or flame atomic absorption spectrometry, or x-ray fluorescence. Sample dissolution was not required for the use of x-ray fluorescence. Samples were ground, when necessary, and homogenized prior to undergoing quantitation.

Freeze dried and homogenized oyster tissue underwent complete dissolution using nitric acid and perchloric acid in a Teflon digestion bomb in a conventional oven. Sample microwave digestion was also used to reduce the time required to digest tissue samples. QA samples, including reagent blanks, control materials, and SRMs, were included as part of each analytical sample string. Analyte quantitation techniques were flame atomic absorption, graphite furnace atomic absorption, cold vapor atomic absorption, hydride generation atomic absorption, neutron activation analysis, and x-ray fluorescence.

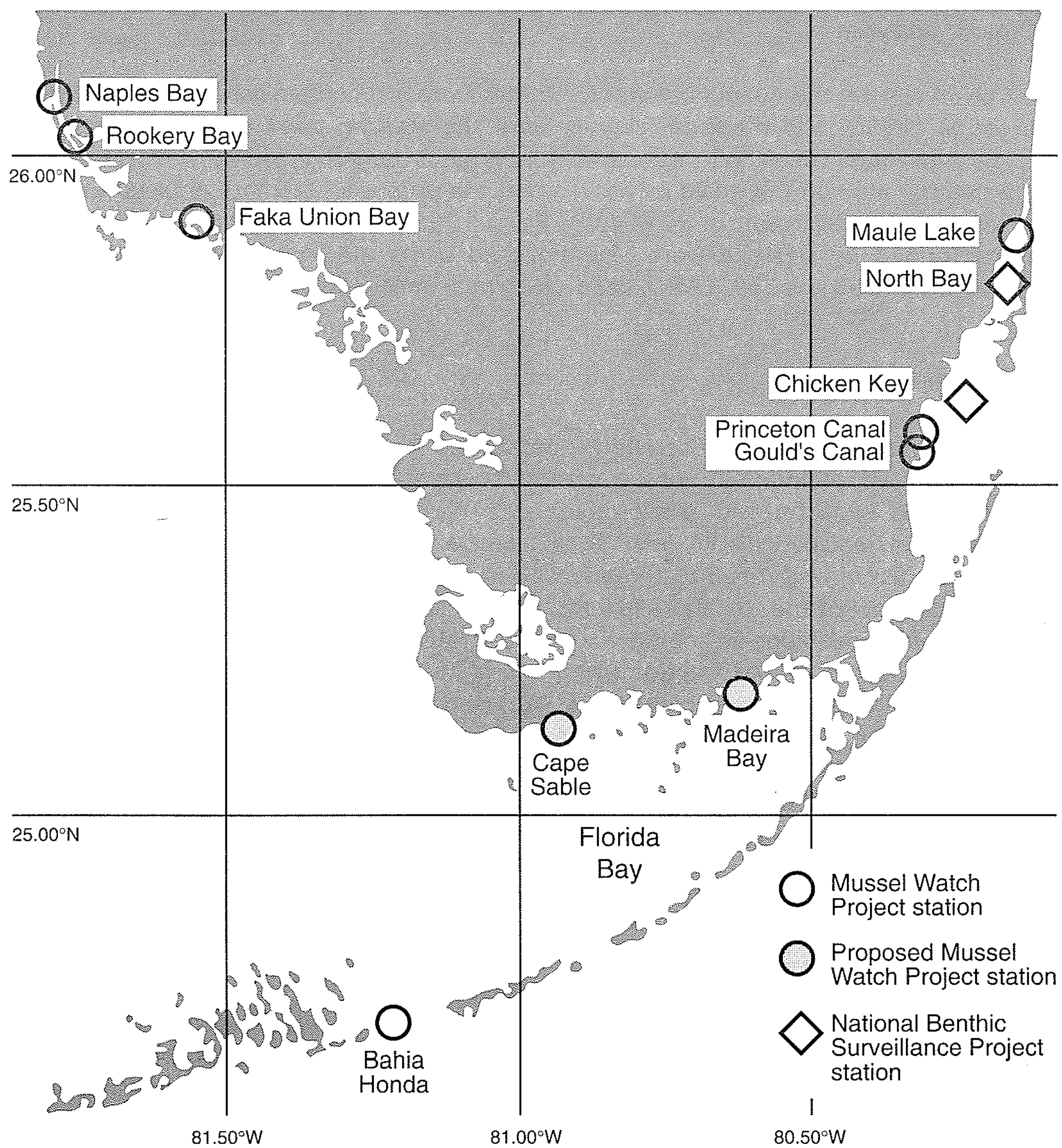

Figure 3. NS&T sampling sites in South Florida.

4.2.1.2. TAMU

Complete descriptions of the methods used by TAMU GERG are found in Taylor and Presley (1993) and Brooks *et al.* (1987 and 1990). Similar techniques to those of Battelle were used for the chemical analyses. Briefly, approximately 0.2 g of dried homogenized sediment underwent complete dissolution using nitric acid and perchloric acid in a Teflon bomb and heating in a conventional oven. Hydrofluoric acid, boric acid, and further heating were used to assure complete dissolution of silicates. Approximately 0.2 g of dried homogenized mollusk tissue was used for tissue analysis. The samples underwent complete dissolution using nitric acid and perchloric acid and heating in a conventional oven. Analyte quantitation techniques were flame atomic absorption spectrophotometry, graphite furnace atomic absorption spectrophotometry, and neutron activation analysis.

4.2.2. Organic analyses

Analytical protocols for the quantification of the NS&T organic contaminants were developed by MacLeod *et al.* (1993) and these techniques were the starting point for NS&T trace organic analysis. By the time the NS&T Mussel Watch Project began in 1986, laboratories were allowed to use any method if it could be proven that the proposed alternate procedure was equal or better than that of MacLeod *et al.* (1993). From 1986 to 1989 inclusive, sediment sample analyses performed by Battelle were accomplished using modifications of the method of MacLeod *et al.* (1993), while TAMU used analytical methodology already in place in its laboratory.

4.2.2.1. Battelle

The analytical methods used by Battelle are described in detail in Peven and Uhler (1993). Briefly, homogenized sediment or tissue composite samples were combined with anhydrous sodium sulfate and extracted with dichloromethane. The dichloromethane solvent in the sample extracts was then replaced by hexane. Silica/alumina column chromatography was used to separate the extracted analytes into three fractions: the saturated aromatic hydrocarbons and possibly hexachlorobenzene (HCB), aliphatic hydrocarbons and chlorinated pesticides, and coprostanol. Lipids and biogenic material were separated from the aromatic and chlorinated pesticides in the second eluted fraction using a Sephadex column. Since the beginning of the project Battelle has used gas chromatography (GC) and an electron capture detector (ECD) for the quantification of chlorinated contaminants. During the first year of the Mussel Watch Project, Battelle quantified PAHs using GC with a flame ionization detector. Since 1987, a GC/mass spectrometer detector (MSD) has been used. Starting in 1988, MS was used in the selected ion monitoring (SIM) mode rather than in the GC/MSD full-scan mode. This step was taken to improve sensitivity of the GC/MSD method, since many of the PAH compounds were found to be very near the GC/MSD full-scan detection limit in the bivalve tissue samples.

4.2.2.2. TAMU

The TAMU GERG analytical methods are described in detail in Wade *et al.* (1993). Briefly, homogenized sediment or tissue composite samples were extracted using anhydrous sodium sulfate and dichloromethane. The dichloromethane solvent in the sample extracts was replaced by hexane. Silica/alumina column chromatography was used to separate the extracted analytes into three fractions. Further purification using HPLC was required to further reduce matrix interferences. Quantitation of PAHs was performed by GC/MSD in the SIM mode and of chlorinated hydrocarbons using GC/ECD.

4.3. Results

4.3.1. Bivalve data

C. virginica specimens were collected at five Mussel Watch sites in South Florida during 1990: North Miami Maule Lake (NMML); Biscayne Bay Princeton Canal (BBPC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB). The NS&T national geometric means and "high" concentrations, and concentration levels at South Florida sites are listed in Table 5. The levels of contaminants in these specimens have been compared to the levels found in oysters and mussels collected at all the other NS&T sites. However, oysters and mussels are not equal in their ability to concentrate trace elements (O'Connor, 1993). At a few sites, two species have been collected by the NS&T Program. Data from these collections demonstrate that the trace elements Ag, Cu, and Zn are enriched in the oyster,

Table 5. NS&T national geometric means and "high" concentrations and concentration levels in bivalves found in South Florida sites ($\mu g/g$ dry wt. unless noted).

Mollusks collected in 1990 at 214 sites (*C. virginica* collected at 105 sites)

Analyte	Geometric mean	1990 US range	n	NS&T "high" Δ	South Florida range *	n
Oysters and mussels:						
∑PCB (ng/g)	110	MDL - 5300	214	470	35 - 430	5
∑DDT (ng/g)	37	1.5 - 1200	214	120	4.7 - 58	5
∑Cdane (ng/g)	14	MDL - 111	214	31	2.8 - 25	5
∑PAH (ng/g)	260	9 - 11000	214	890	110 - 790	5
As	10	3.0 - 87	214	17	6.6 - 17	5
Cd	2.7	0.25 - 15	214	5.7	0.25 - 2.3	5
Hg	0.094	MDL - 1.5	214	0.24	0.05 - 0.21	5
Ni	1.7	MDL - 11	214	3.3	0.23 - 1.1	5
Se	2.5	0.49 - 9.4	214	3.5	0.49 - 2.3	5
Oysters only:						
Ag	1.9	0.28 - 13	105	3.7	1.0 - 4.0	5
Cr	0.48	0.073 - 2.1	105	0.93	0.39 - 2.1	5
Cu	150	9.3 - 850	105	360	37 - 850	5
Pb	0.52	0.12 - 6.6	105	0.94	0.38 - 1.6	5
Zn	2400	217 - 17000	105	5200	840 - 4700	5

MDL - Method limit of detection.
* Data from sites: North Miami Maule Lake (NMML); Biscayne Bay Gould's Canal (BBGC); Everglades Faka Union Bay (EVFU); Rookery Bay Henderson Creek (RBHC); and Naples Bay (NBNB).
Δ NS&T "high" values are defined as one standard deviation above the geometric mean of the concentration distribution of any given analyte.

C. virginica (Figure 4). Conversely, Cr and Pb are more than three times higher in the mussel *Mytilus edulis*. For other elements and for organic compounds there is no strong species effect between mussels and oysters. Only oyster data in the NS&T data base were used for comparison purposes for the five metals where a strong species difference was found.

An approximation of the impact of human activity at a site is the population within a given area centered on the site location. The populations within a 20 km radius of each of the Mussel Watch sites in South Florida encompass a wide range: from 3,246 for Faka Union Bay, Everglades National Park, to 1,310,765 for Maule Lake, North Miami (B. Davis, TIGER System Staff, US Census Bureau. Data in Table I.2, Appendix I).

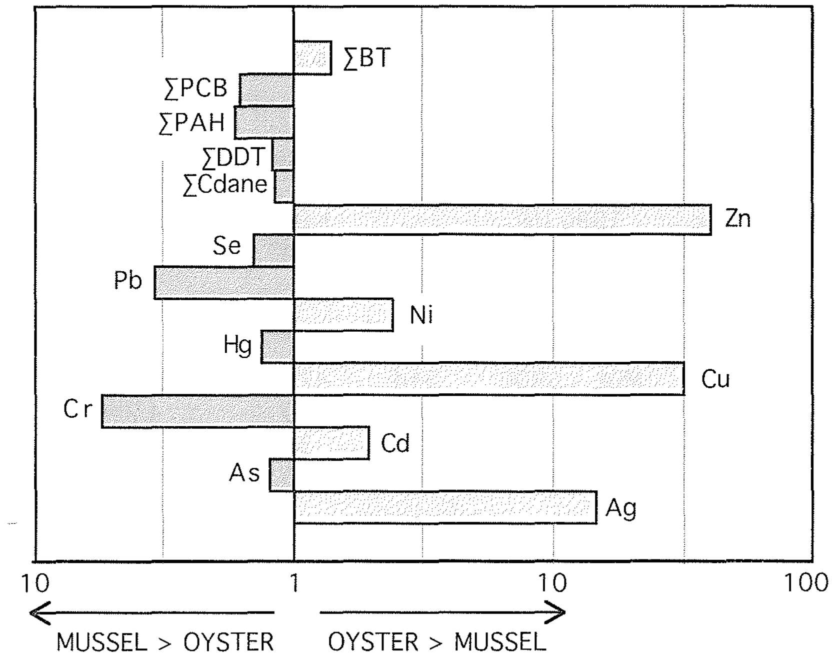

Figure 4. Factors by which mean concentrations in oysters (*C. virginica*) differ from those in mussels (*M. edulis*) collected at the NOAA NS&T Housatonic River site in Long Island Sound in 1989 (∑BT is the sum of the concentrations of tributyltin and its breakdown products, dibutyltin and monobutyltin. ∑PCB is total PCB concentration calculated from the sum of the concentrations of the 18 congeners determined as part of the NS&T Program. ∑PAH is the sum of the concentrations of 24 PAHs. ∑DDT is the sum of the concentrations of DDT and its metabolites. ∑Cdane is the sum of the concentrations of the two major constituents of chlordane mixtures, *cis*-chlordane and *trans*-nonachlor, and of those of two minor constituents, heptachlor and heptachlor epoxide.) (Redrawn from O'Connor, 1992).

Cumulative (quantile*) distribution plots of the concentrations of selected parameters determined by the NS&T Program in oysters and mussels collected during 1990 are shown in Appendix II. These plots are annotated with the levels of these contaminants found in the South Florida sites.

4.3.1.1. Trace organics compounds

Cumulative distribution plots of the concentrations of PCBs and DDT and metabolites in oysters and mussels collected during 1990 are shown in Figure 5. Only data for specimens collected during one year (1990) were used to eliminate any effects due to temporal trends. The sources of PCBs and of DDT and metabolites are anthropogenic and a correlation between population density and concentration would be expected. Contaminant concentrations at the Mussel Watch sites in South Florida show a significant range, although none of the values are at the extreme high end of the distribution of U.S. concentrations. There is a good correlation between population density within 20 km of the sampling sites and contaminant levels except for Faka Union in the Everglades (Figure 6). The anomalously high values found in the coastal area of the

* Quantiles are categories within any ranked set of numbers. Usually if a set is divided into ten quantiles, each containing 10% of all the numbers, the quantiles are termed "percentiles" or "deciles". The ranked set can, however, be divided into any number of quantiles and all numbers in quantile "x" are larger than numbers in all quantiles "less than x".

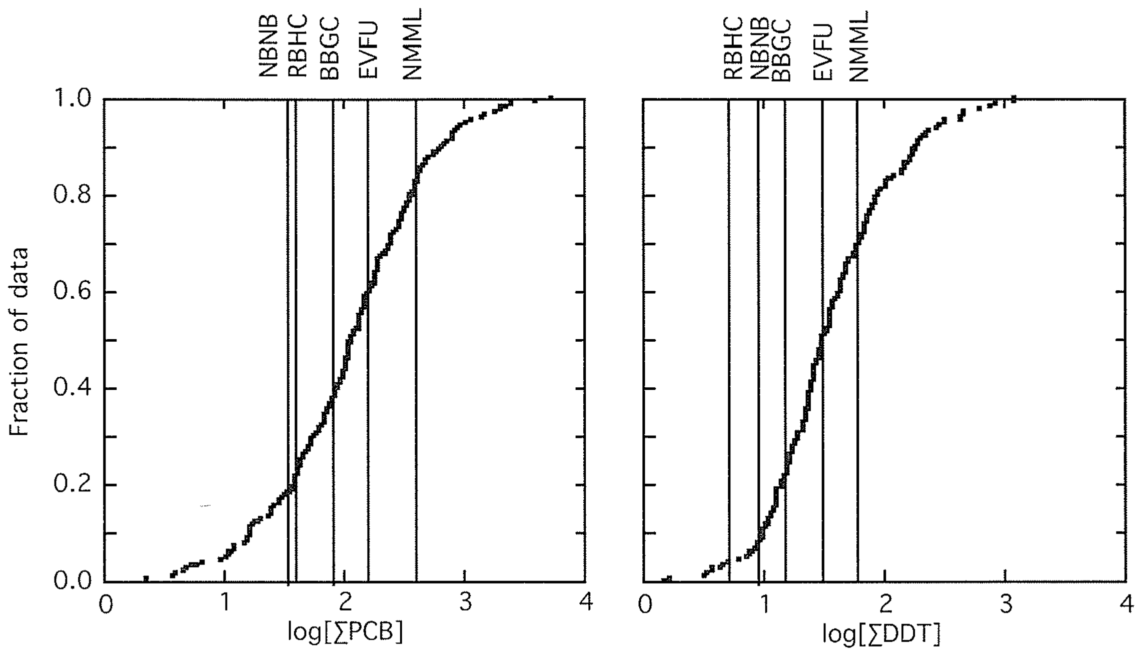

Figure 5. Cumulative distribution plots (logarithmic scale) of 1990 NS&T bivalve body burden of total PCBs, and DDT and metabolites [North Miami Maule Lake (NMML), Biscayne Bay Goulds Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

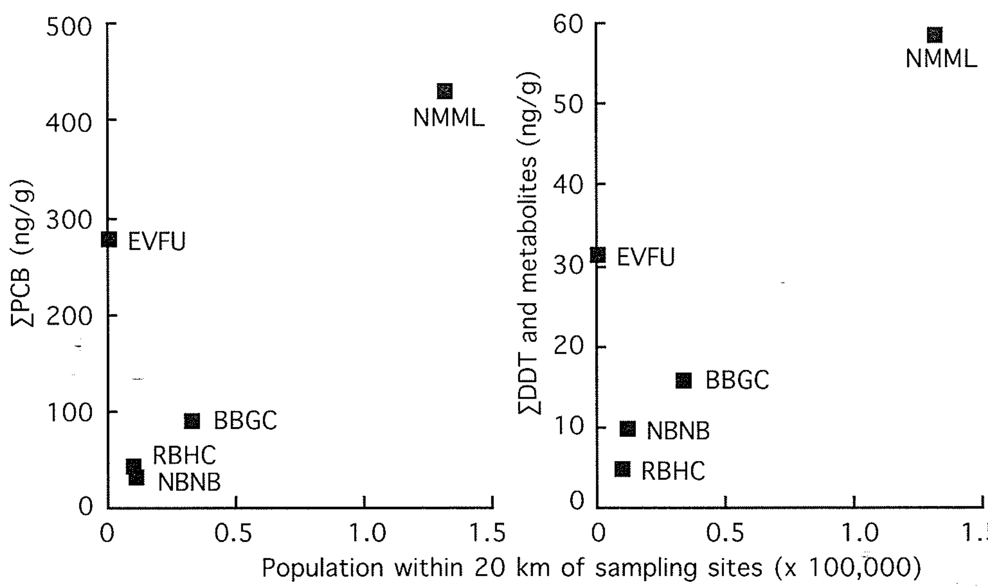

Figure 6. Total PCBs and DDT and metabolite concentrations in oysters (*C. virginica*) collected in 1990 from five NS&T sites in South Florida. [North Miami Maule Lake (NMML), Biscayne Bay Goulds Canal (BBGC), Everglades Faka Union Bay (EVFU), Naples Bay (NBNB), and Rookery Bay Henderson Creek (RBHC)]. ∑PCB is total PCB concentration calculated using the concentrations of the 20 congeners determined as part of the NS&T Program. ∑DDT is the sum of the concentrations of DDT and its metabolites (ng/g dry wt.).

Everglades may be the result of contamination from non-point sources. Also, while not as high as at the North Miami site, high molecular weight PAHs were high at the Everglades site. For other organic compounds (gamma-HCH, mirex, HCB, total chlordane pesticides and the low molecular weight PAHs), the North Miami values where higher than those found in the Everglades site.

DDT (4,4'-DDT) or 1,1'-(2,2,2-trichloroethylidene)bis[4-chlorobenzene] has been used as an insecticide since 1939 (Klaassen *et al.*, 1986). Its use was banned in the United States in 1972. 4,4'-DDT is metabolized by the loss of a chlorine to yield the non-insecticidal 4,4'-DDE {(1,1'-(dichloroethylidene)bis[4-chlorobenzene]}, and by the substitution of a chlorine by a hydrogen to yield 4,4'-DDD {(1,1'-(2,2-dichloroethylidene)bis[4-chlorobenzene]}. DDT and some of its metabolites are toxicants, with long-term persistence in soil and water. They are widely dispersed by erosion, runoff, and volatilization, and accumulate in adipose tissue in wildlife and humans. As in the case of PCBs, no known natural source of these compounds exists. The levels of 4,4'-DDT and its metabolites found in oysters collected in 1990 in South Florida are shown in Figure 7. The highest concentrations observed were those of 4,4'-DDE, the most stable DDT metabolite in the environment. The levels of 4,4'-DDE show a good correlation with population within 20 km of the site. The levels of 4,4'-DDT, 2,4'-DDD, and 4,4'-DDD were high at the Faka Union site, almost as high in the case of 4,4'-DDD as the levels found in North Miami.

NOAA used a number of criteria to select the twenty PCB congeners that it quantifies in the NS&T Program. One criterion was that the PCB congeners selected would be ones already being quantified by other scientific organizations such that even though NOAA only quantifies 20 of the possible 209 congeners, resulting data would be comparable over the largest geographic areas possible. Two congeners, PCB 77 and 126, whose structures are similar to that of dioxins and furans, are quantified. Other PCB congeners (PCBs 118, 128, 138, and 170) were added because of their ubiquitousness in the marine environment. It should be noted that even though the NS&T currently "quantifies" the concentrations of the planar PCBs 77 and 126, the reported concentrations are not necessarily for individual PCB components. With the analytical methods presently used by NS&T participating laboratories, a number of PCB congeners coelute. PCB 77 is the lesser contributor of the PCB congener pair 77 and 110, and PCB 126 is the lesser contributor of the PCB congener group 126, 129, and 178 (Schulz *et al.*, 1989).

Clarke *et al.* (1989) divided a sub-set of the possible 209 PCB congeners into four categories of environmental interest. Group 1 includes 3-methylcholanthrene type mixed function oxidase (MFO) inducers along with five mixed-type inducers that have frequently been reported in environmental samples. Of the 8 PCB congeners in this group, the NS&T Program quantifies 6 of them (i.e., PCBs 77, 118, 126, 128, 138, and 170). The second group of concern is considered to result in phenobarbital type induction. The NS&T PCBs that are in this category are 101, 153, and 180. Group 3 congeners are weak MFO inducers but occur frequently in environmental samples. The NS&T PCBs in this category include PCBs 18, 44, 52, and 187. The congeners in the fourth group are found in relatively low concentrations in environmental samples, but are of interest because they are mixed-type inducers. PCB 105, quantified by the NS&T Program, is in this category. Concentrations of congeners in each of the groups defined by Clarke *et al.* found in the NS&T sites in South Florida are shown in Figure 8.

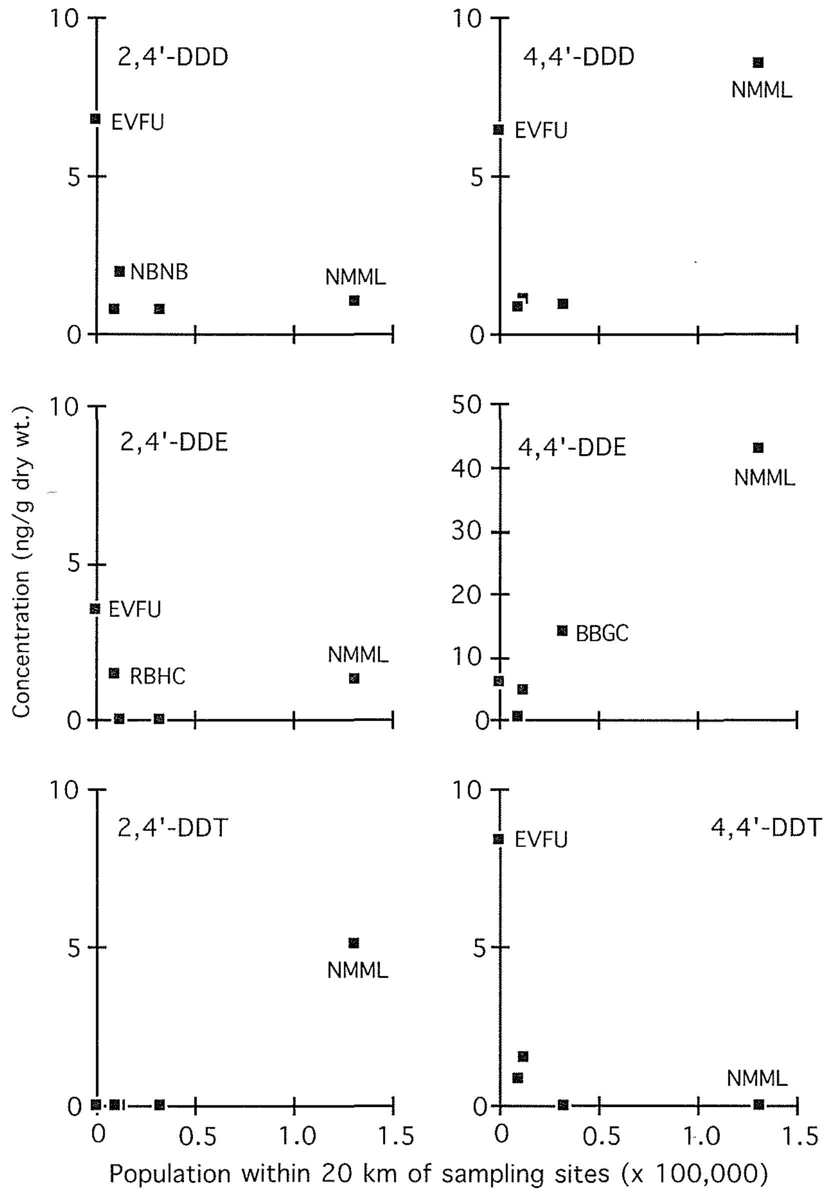

Figure 7. DDT and metabolic products in oysters (*C. virginica*) collected in 1990 from five NS&T sites in South Florida. [North Miami Maule Lake (NMML), Biscayne Bay Goulds Canal (BBGC), Everglades Faka Union Bay (EVFU), Naples Bay (NBNB), and Rookery Bay Henderson Creek (RBHC)]. Values below detection are plotted as zeroes (μg/g dry wt.).

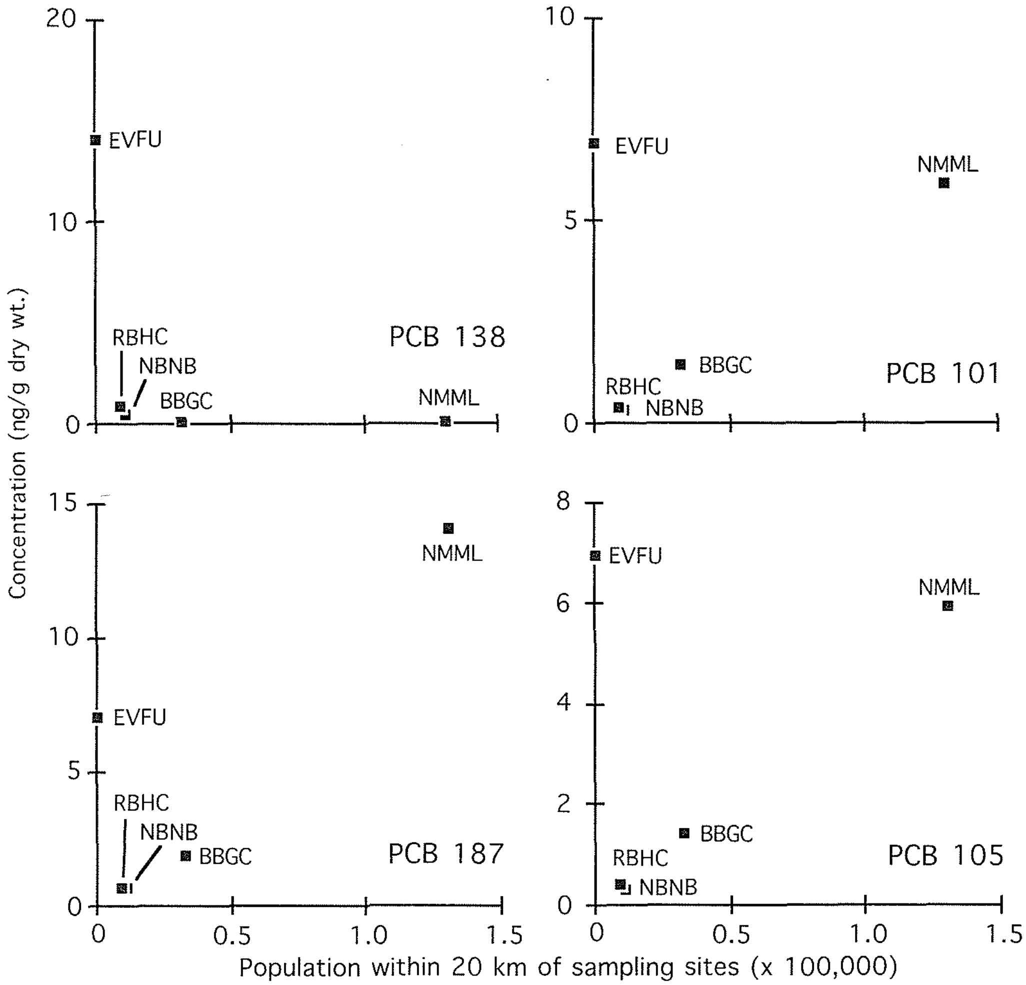

Figure 8. Concentrations of representative PCB congeners of the four groups described by Clarke *et al.* (1989) found in 1990 at the NS&T sites in south Florida. [North Miami Maule Lake (NMML), Biscayne Bay Goulds Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)] (ng/g dry wt.).

Of the five PCB congeners in Group 1, the MFO inducers, 4 were found to have the highest concentration in 1990 at the Everglades Faka Union site (PCB 126, 128, 138 and 170). The highest concentrations of PCB 118 were found at the North Miami site. The concentrations of two of the congeners in Group 2, the phenobarbital type induction producers, PCB 101 and 153, were found in similar concentrations at the Everglades and North Miami sites. The level of PCB 180, however, was much higher at the Everglades site. The concentrations of the Group 3 congeners (PCB 18, 44, 52 and 187), the weak MFO inducers, were found to be highest in North Miami. PCB 105, classified in Group 4, was found to be highest at the Everglades site. These differences may be attributed to different Aroclor formulations being used in different parts of Florida.

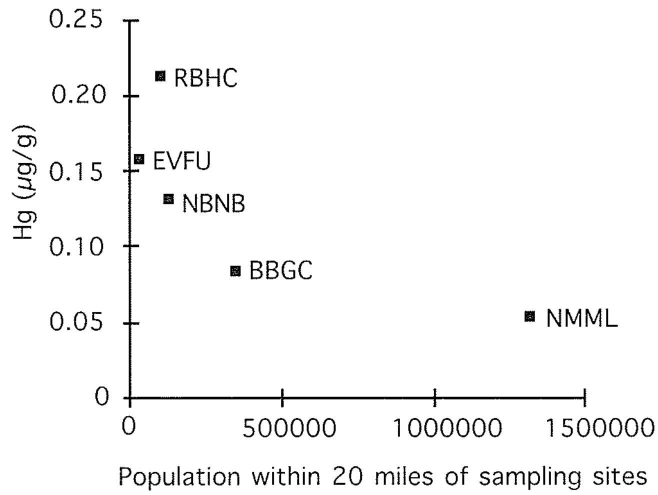

Figure 9. Hg in oysters (*C. virginica*) collected in 1990 from five NS&T sites in South Florida. [North Miami Maule Lake (NMML), Biscayne Bay Goulds Canal (BBGC), Everglades Faka Union Bay (EVFU), Naples Bay (NBNB), and Rookery Bay Henderson Creek (RBHC)] (µg/g dry wt.).

4.3.1.1. Major and trace elements

Concentration distributions where the analyte levels found in the Everglades station were as high or higher than those found at the Biscayne Bay and North Miami sites were observed for Pb, Hg, Ni, Cd, Cr, Mn, and Fe. Distribution of concentrations where the North Miami values where higher than those found in the Everglades site were found for Sn, As, Zn, and Cu.

The highest levels of Se in South Florida were found at the Naples Bay station, followed by the Rookery Bay and Everglades sites. The lowest values were found in Biscayne Bay and North Miami. Silver was also highest at the Naples Bay site, but the next highest values were found in North Miami and Biscayne Bay, followed by those for Rookery Bay and the Everglades site.

Mercury levels appear to show an inverse correlation with population density; the highest levels were found in the NS&T sites on the west coast of Florida (Figure 9). These high values are close to the NS&T "high" value for Hg, 0.24 µg/g, defined as one standard deviation above the mean of the national concentration distribution of any given analyte. Increasing Hg contamination in the Everglades has been noted in the literature (Rood *et al.*, 1993). Newspapers and magazines have been actively reporting on this problem, attributing the Hg contamination to smoke stacks (Staff, Miami Herald, 1993; Zaneski, 1993; and others).

4.3.2. Sediment data

The NS&T Program has analyzed samples of surface sediment collected at almost 300 coastal and estuarine sites throughout the US since 1984. The overall distributions for concentrations of each element are approximately lognormal, allowing the use of geometric means and allowing for a definition of "high" concentrations as those exceeding the mean plus one standard deviation of the lognormal distribution. Those mean and "high" concentrations should be useful for comparing the NS&T data set with other reports on sediment contamination.

Table 6. NS&T national geometric means and "high" concentrations, and concentration levels in sediments collected in South Florida sites. [Data for 1984 - 1989 for mud fraction only (NOAA 1991)]. (μg/g dry wt. unless noted).

Sediments collected at 214 sites

Analyte	Geometric mean	US range	n	NS&T "high" $^{\Delta}$	South Florida range *	n
∑PCB (ng/g)	39	MDL - 2100	233	200	8.1 - 122	5
∑DDT (ng/g)	6.6	MDL - 5900	233	37	0.81 - 9.6	5
∑Cdane (ng/g)	1.3	MDL - 93	233	NA	0.26 - 3.8	5
∑LMWPAH (ng/g)	170	MDL - 19000	233	980	23 - 460	5
∑HMWPAH (ng/g)	570	MDL - 38000	233	2900	65 - 2300	5
∑PAH (ng/g)	810	MDL - 57000	233		88 - 2800	5
Ag	0.35	MDL - 23	233	1.2	0.04 - 0.37	5
As	13	1.6 - 60	233	24	3.6 - 12	5
Cd	0.48	0.06 - 11	233	1.2	0.21 - 0.29	5
Cr	110	5.2 - 2800	233	230	5.2 - 82	5
Cu	35	4.2 - 310	233	84	4.5 - 54	5
Hg	0.17	MDL - 4.6	233	0.49	0.066 - 0.23	5
Ni	36	1.0 - 240	233	69	1.0 - 18	5
Pb	43	MDL - 280	233	89	5.9 - 82	5
Se	0.61	MDL - 23	233	NA	0.10 - 0.99	5
Zn	140	20 - 690	233	270	20 - 122	5

MDL - Method limit of detection.
NA - Not available.
* Data from sites: North Miami Maule Lake (NMML), Biscayne Bay Goulds Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB).
Δ NS&T "high" values are defined as one standard deviation above the mean of the log transformed concentration distribution of any given analyte.

The NS&T sediment database containing analytical results from 1426 composite samples from 266 sites and detailed statistical analysis of the data can be found in NOAA (1991). Contaminants in sediments are associated with particle surfaces, and differences in contaminant concentrations among sites can be the result of differences in particle size distributions. To compensate for this, sediment data have been adjusted by dividing the raw concentration in a composite by the fraction by weight of sediment particles which are less than 63μ in diameter (i.e., the fine-grained or silt and clay fraction). This is equivalent to assuming that no contaminants are associated with sand-sized particles and that the only effect of sand in a sample is to dilute its level of contamination. This method can lead to errors when the sediments involved are composed primarily of sand-sized or larger particles, so only sediments with greater than 80% fine-grained particles were considered in the overall assessment (O'Connor, 1990; NOAA, 1991). The NS&T national sediment geometric means and "high" concentrations, and concentration levels in South Florida sites are listed in Table 6. Quantile distribution plots of the concentrations of selected parameters determined by the NS&T Program in sediments are shown in Appendix II. These plots are annotated with the levels of these contaminants found in the South Florida sites.

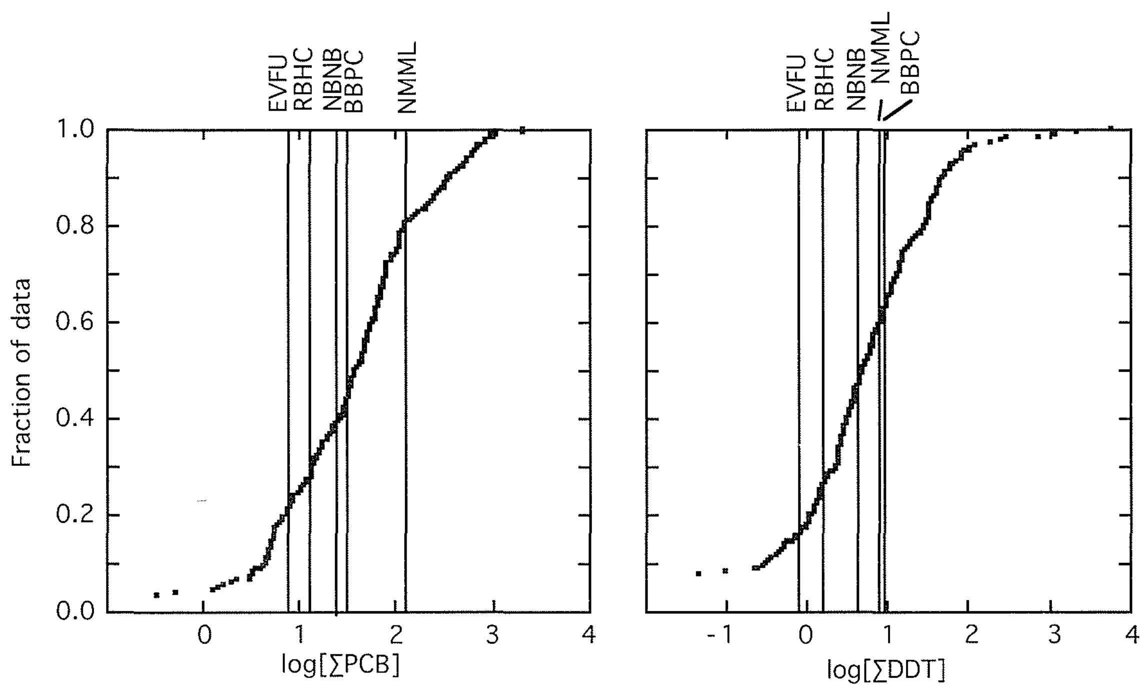

Figure 10. Cumulative distribution plots (logarithmic scale) of NS&T sediment data of total PCBs, and DDT and metabolites [North Miami Maule Lake (NMML), Biscayne Bay Goulds Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

Cumulative distribution plots of the concentrations of DDT and metabolites, and PCBs in sediments are shown in Figure 10. The concentrations of these contaminants correlates well with population within 20 km of the site, and the levels found at the Everglades site are the lowest of those in NS&T sites in South Florida (Figure 11). The level of DDT and metabolites was highest at the site in Biscayne Bay. Similar correlations were found for Cu, Zn, Ag, Se, and the low molecular weight PAHs (Figure 12). The concentration pattern in sediments is different than that found in oysters sampled at the same site. This lack of correlation between sediment and bivalve data has been observed before in mussel watch studies elsewhere.

Chromium was found to be high at the Rookery Bay and Everglades sites, and lowest in Biscayne Bay (Figure II.6, Appendix II). The relative differences between the levels found in the five sites, however, are small and may not be significant.

4.3.2. Trends

Bivalve body burden data are available for six years for several of the NS&T sites in South Florida. Graphical presentations of annual means for selected NS&T analytes for the South Florida sites are in Appendix III. The data are in Appendix II.

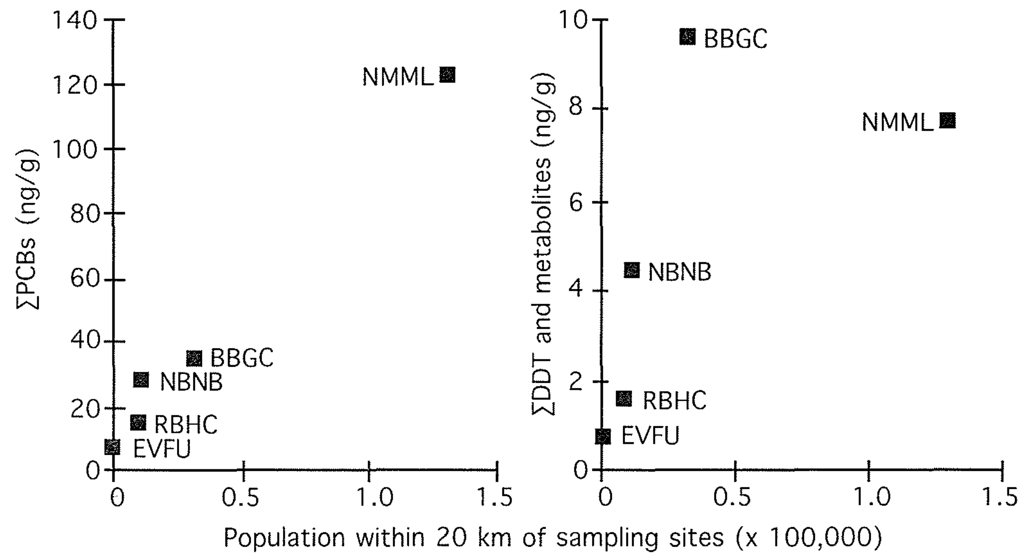

Figure 11. Total PCBs, and DDT and metabolites concentrations in sediments from five NS&T sites in South Florida. [North Miami Maule Lake (NMML), Biscayne Bay Goulds Canal (BBGC), Everglades Faka Union Bay (EVFU), Naples Bay (NBNB), and Rookery Bay Henderson Creek (RBHC)] (ng/g dry wt.).

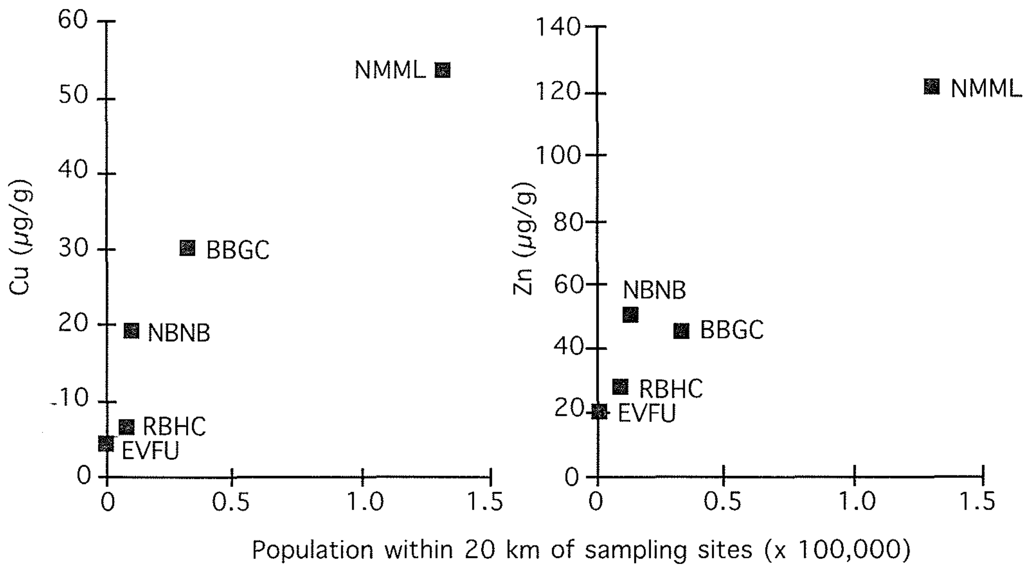

Figure 12. Copper and zinc concentrations in sediments from five NS&T sites in South Florida. [North Miami Maule Lake (NMML), Biscayne Bay Goulds Canal (BBGC), Everglades Faka Union Bay (EVFU), Naples Bay (NBNB), and Rookery Bay Henderson Creek (RBHC)] (μg/g dry wt.).

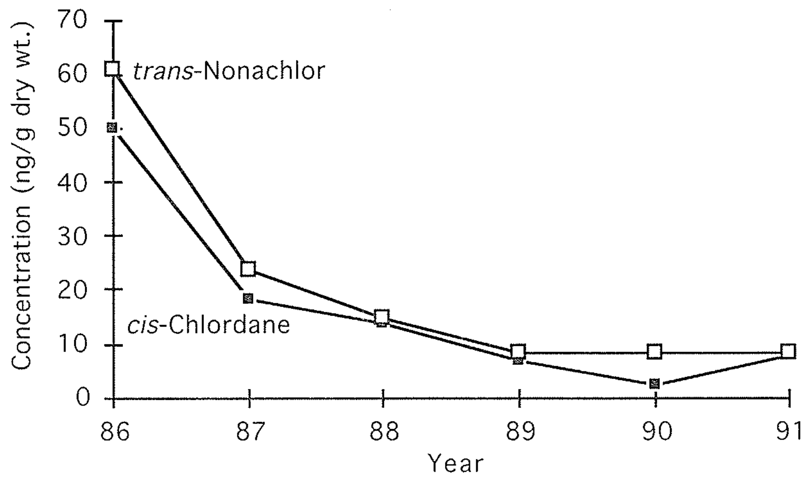

Figure 13. *cis*-Chlordane and *trans*-nonachlor in oysters collected at the NS&T site in Naples Bay (NBNB) (ng/g dry wt.).

4.3.2.1. Temporal fluctuations

Similarities in temporal trends among specific NS&T sites and analytes have been observed. There are several cases where the 6-year trend of two or more analyte levels at a site or a single analyte level at two or more sites show coincident short period temporal fluctuations. Examples are shown and discussed below.

The cyclopentadiene pesticides form a family of compounds with similar structures, which include aldrin, dieldrin, *cis*-chlordane, *trans*-nonachlor, heptachlor and heptachlor epoxide. Technical chlordane is a mixture of compounds including heptachlor, *cis*-chlordane, *trans*-chlordane, and others, all with similar structures. The levels of *cis*-chlordane and *trans*-nonachlor in oysters collected at the NS&T site in Naples Bay (NBNB) from 1986 to 1991 are shown in Figure 13. There are coincident short period fluctuations in the two sets of data. This behavior is probably the result of there being a single source of both compounds, and of similar chemical behavior resulting from similar chemical structures. Coincident short period fluctuations were also observed for these two analytes at the NS&T site in North Miami (Figure III.6, Appendix III).

The levels of As in oysters collected from 1986 to 1991 at the NS&T sites in Naples Bay and Rookery Bay show coincident fluctuations for all six years (Figure 14). These two sites are geographically close. The other site on the Gulf Coast, Faka Union Bay, and those on the Atlantic Coast also follow this temporal pattern (Figure III.2, Appendix III). The values found at the Naples Bay, Rookery Bay, North Miami, and Biscayne Bay NS&T sites are high for As when compared to those of the rest of the country. The source of As is under study.

Another example of coincident fluctuations is shown in Figure 15. The totals for low molecular weight PAHs for the sites on the Gulf Coast, i.e. Naples Bay, Rookery Bay, and Faka Union Bay, for 1986 through 1991 show similar variations, indicating perhaps a similar source. Such coincident fluctuations were not observed for the other two sites. The total high molecular weight PAHs showed coincident fluctuations at Naples Bay and Rookery Bay, but not at the Faka Union Bay or Biscayne Bay sites.

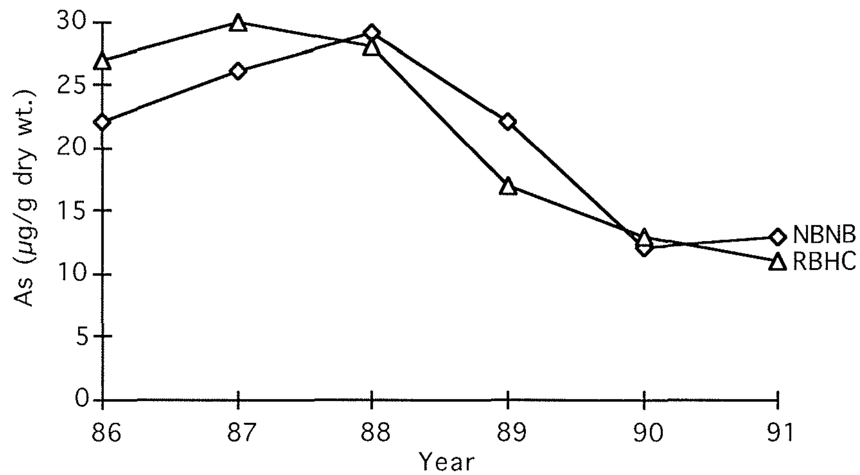

Figure 14. Arsenic in oysters collected at the NS&T sites in Naples Bay (NBNB) and Rookery Bay (RBHC) (ng/g dry wt.).

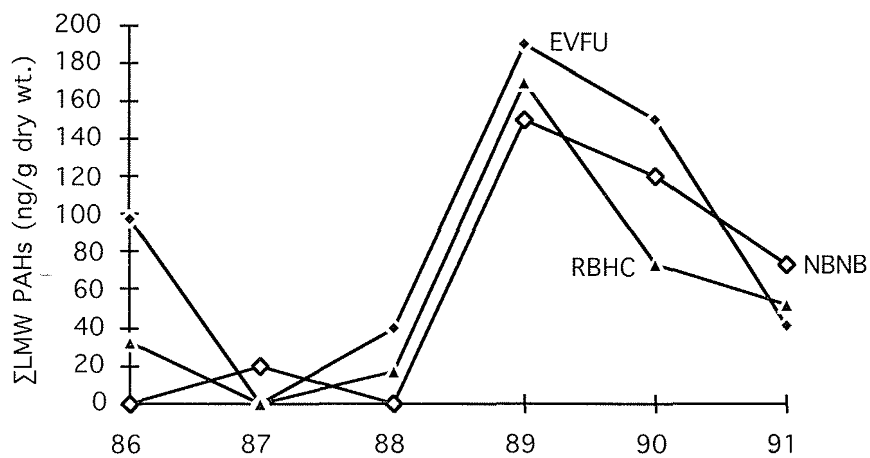

Figure 15. Total low molecular weight PAHs in oysters collected at the NS&T sites in Naples Bay (NBNB), Rookery Bay (RBHC), and Faka Union Bay (ng/g dry wt.).

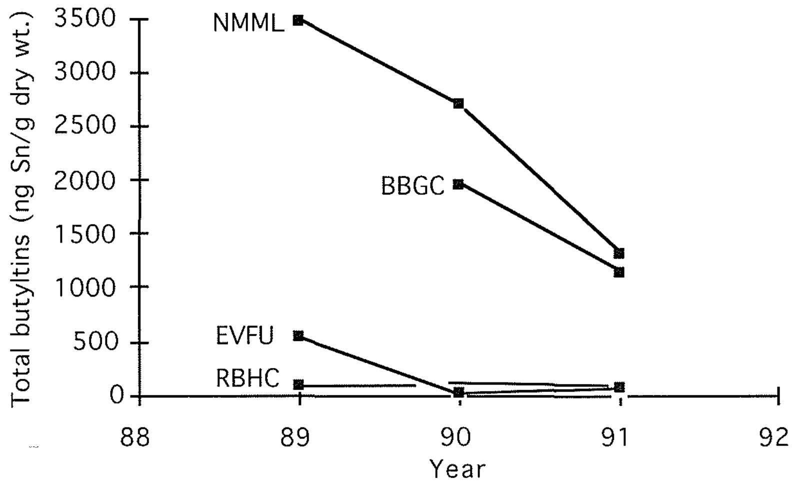

Figure 16. Total mono-, di-, and tributyltin concentrations in oysters (*C. virginica*) from four NS&T sites in South Florida [North Miami Maule Lake (NMML), Biscayne Bay Goulds Canal (BBGC), Everglades Faka Union Bay (EVFU), and Rookery Bay Henderson Creek (RBHC)] (ng Sn/g dry wt.).

Mussels and oysters were first collected and analyzed for tributyltin and its breakdown products, mono- and dibutyltin, as part of the Mussel Watch Project in 1987 (Wade *et al.*, 1991). Tributyltin, as it leaches from antifouling paints, inhibits the attachment of marine organisms to surfaces coated with the paint. Vessels and boats coated with tributyl tin antifouling paints and vessel repair facilities are major sources for the release of tributyltins into the marine environment. In 1987, tributyltin in *C. virginica* was found at most of the NS&T sites quantified in the range of <5 - 1560 ng Sn/g dry wt. Tributyltin accounted for 74% of the total butyltins in oysters and mussels nationwide (Wade *et al.*, 1988). At the NS&T sites on the Gulf Coast, quantifiable concentrations of butyltins were found at 75% of the sediment sites and at an even larger percentage of the bivalve sites. Tributyltin was found to be the dominant chemical species of the butyltins. The mean bivalve butyltin concentrations were found to be 18 times higher than the mean sediment concentrations indicating possible bioaccumulation (Wade *et al.*, 1990). Between 1989 and 1990, 85% of the NS&T sites along the Gulf Coast showed a decrease in butyltins in oyster tissue. This decrease coincides with the passage of the Organotin Paint Control Act designed to limit the use of organotin antifouling paints on small boats. The temporal trends in the concentrations of tributyltin and its breakdown products at the four South Florida NS&T sites are shown in Figure 16. As expected, the highest concentrations were found at sites with the highest populations, because population level correlates with the degree of boating activities. The concentrations at all the South Florida sites show a decrease with time, as is also seen at most NS&T sites nationwide.

4.3.2.2. Weather

Weather may influence the bioaccumulation of chemicals as changes in temperature and salinity affect biochemical processes. Rainfall is one of the most important ways of mobilizing contaminants in soil and urban areas and may affect the amounts of contaminants that reach coastal and estuarine environments. The effect of global climate changes in tropical marine systems, such as mangroves, seagrass beds, and coral reefs, is being examined by several

Table 7. NOAA annual average temperature and precipitation for Miami, Key West, Ft. Myers, and Orlando.

Year	Temperature (°F)				Precipitation (in)			
	Miami	Key West	Ft. Myers	Orlando	Miami	Key West	Ft. Myers	Orlando
86	76.40	78.20	75.80	73.8	66.12	40.82	56.86	49.83
87	76.50	77.50	74.60	72.6	50.27	48.90	69.01	56.79
88	76.60	77.30	74.90	72.2	44.59	36.56	35.00	52.49
89	77.50	78.60	75.40	73.4	42.63	31.16	49.89	45.66
90	78.20	79.30		74.8	51.71	36.43	49.09	31.68
91	77.80	79.40	76.40	74.0	71.42	41.15	67.50	60.90
92	77.00	78.00	75.00	72.7	57.82	37.09	55.45	52.96

workers (e.g., Cubit, 1992; Davis, 1992; Zieman *et al.*, 1992; and others). The possible influence of weather on contaminant body burden trends as determined using NS&T data has been examined. Three NOAA weather stations bracket the South Florida area: Miami, Key West, and Ft. Myers. NOAA weather stations are located at airports. The annual average temperature and precipitation for the NOAA weather stations in Miami, Key West, and Ft. Myers are listed in Table 7 and shown in Figure 17. The monthly average temperatures and precipitation for these weather stations are shown in Figures IV.1 - IV.4 in Appendix IV.

Miami is located to the west of Biscayne Bay, and its climate is subtropical marine, with a long and warm summer with abundant rainfall followed by a mild, dry winter (NOAA, 1993a). The NS&T sites closest to Miami are those in Biscayne Bay: North Miami Maule Lake (NMML), Biscayne Bay Goulds Canal (BBGC), Biscayne Bay Princeton Canal (BBPC), Biscayne Bay North Bay (BISNB), and Biscayne Bay Chicken Key (BISCK).

Key West is located at the end of the Overseas Highway and near the western end of the Florida Keys. The nearest point of the mainland is the Everglades National Park, about 60 mi to the northeast, while Cuba at its closest point, is approximately 90 mi south. Because of the nearness of the Gulf Stream in the Straits of Florida, and the tempering effects of the Gulf of Mexico to the west and north, Key West has a notably mild, tropical maritime climate (NOAA, 1993b). The NS&T site closest to Key West is that at Bahia Honda (BHKF). The NS&T station at Faka Union Bay in the Everglades (EVFU) is to the northwest, and its climate is quite different from that found in Key West.

Fort Myers is located on the Gulf Coast of Florida, north of Naples. It has a climate characterized as subtropical, with temperature extremes of both summer and winter tempered by the marine influence of the Gulf of Mexico (NOAA, 1993c). The NS&T sites closest to Ft. Myers are Naples Bay (NBNB), and Rookery Bay Henderson Creek (RBHC). These sites, however, are located some distance to the south and their weather characteristics may be different from those at Ft. Myers.

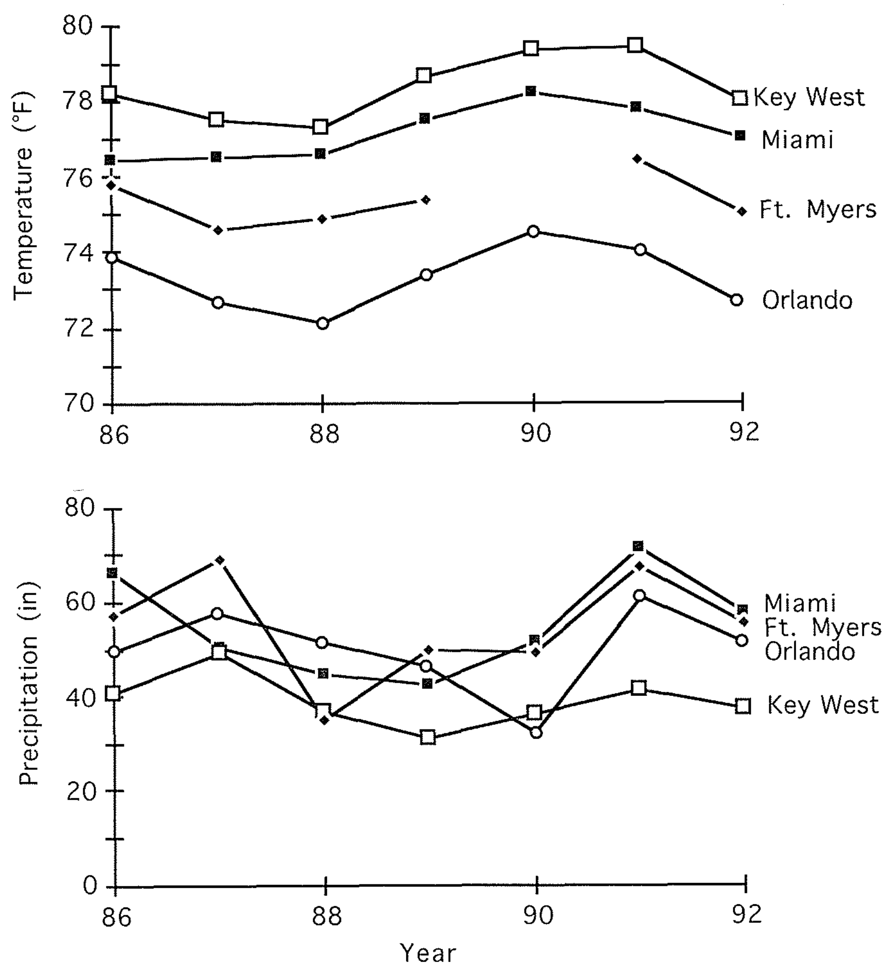

Figure 17. Annual average temperature and precipitation for NOAA weather stations in Miami, Key West, Ft. Myers, and Orlando.

Since the Everglades system originates at Lake Okeechobee, the weather station data for Orlando were also examined. Orlando is located in the central section of Florida, north of Lake Okeechobee, and data collected at this location may not be representative of conditions south of the Lake. The monthly average temperature and precipitation for the Orlando weather station are shown in Figures III.5 in Appendix III.

While none of these stations may represent weather conditions at the NS&T sites, no obvious connections would be found between patterns of change in contaminant levels and patterns of temperature and rainfall. Additional weather data from non-NOAA sources in locations such as the Everglades National Park, small airports, Homestead Air Force Base, and research facilities are being sought.

5. PROPOSED NATIONAL STATUS AND TRENDS PROGRAM TASKS IN FLORIDA BAY

In order to evaluate the impact on Florida Bay of the restoration project in the Everglades, it is proposed that the NS&T Program be expanded to provide coverage of the area. Mussel Watch sites will be sampled beginning in 1994 at two sites in Florida Bay known to receive land runoff (Figure 3). The new sites will allow the determination of conditions prior to the restoration work in the Everglades National Park and subsequent monitoring of changes as the restoration work progresses. The proposed sites are:

Madeira Bay vicinity, that receives water from the Taylor Slough.

East Cape area (east of Cape Sable), that receives water from the East Cape Canal draining White Bay/Shark River Slough.

The species of choice for this effort are the American oyster, mangrove oyster or the smooth-edge jewel box. If the American oyster can be found, data for the Florida Bay sites could be put into a larger context by comparing them with data for oysters from all along the Gulf of Mexico and the Atlantic Southeast coasts. Alternate sites in the Florida Bay have been designated in case no bivalve specimens are found at the primary sampling sites. These are:

Barnes Sound, south of Florida City. The estuary receives water from the C-111 Canal.

Shark River Island which is down-stream from the Shark River and the Shark River Slough.

An NS&T Bioeffects Survey of Biscayne Bay in cooperation with the NOAA Coastal Ocean Program and the State of Florida is being planned. The survey will include sediment toxicity, fish reproduction, genetic damage, and other studies.

The NS&T Program will also conduct a joint monitoring survey of the benthos in Florida Bay and the region to the west with the Estuarine component of the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP-E). Samples of macrobenthos will be collected at 50-100 sites in Florida Bay and the adjacent waters out to a line between Naples and Key West. The number of species and individuals of each species will be used to calculate a Benthic Index of the health of the benthic community and to obtain baseline information on the composition and biodiversity of the macrobenthic community of this region. Sampling is planned for the summer 1994.

6. CONCLUSIONS

The coastal environment of South Florida has undergone changes during the past decades as the result of man's presence and activities. The results of monitoring five sites by the NS&T Program during the past six years show evidence of high levels of man-made chemicals, such as PCBs and DDTs, at the NS&T site closest to the Everglades National Park. High levels of Hg in oysters were also observed. In response to the concern about the ecological status of Florida Bay, the NS&T Program will expand its Mussel Watch activities in the area and will conduct additional studies in the Bay.

7. ACKNOWLEDGEMENTS

The authors wish to thank Linda Pikula, NOAA/AOML, and the staff of the NOAA Central Library, Silver Spring, for their assistance in obtaining publications for use in the preparation of this document. The authors also wish to thank L. Huff, K. Daskalakis, and D. Harris for their assistance.

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APPENDIX I

National Status and Trends Program data for sites in South Florida

Table I.1. NS&T sites in south Florida.

Site	Main Location		Latitude (N)			Longitude (W)			Laboratory
Mussel Watch Program									
NMML	North Miami	Maule Lake	25°	56'	8"	80°	8'	46"	BATT
BBGC	Biscayne Bay	Goulds Canal	25°	31'	23"	80°	18'	51"	BATT
BBPC	Biscayne Bay	Princeton Canal	25°	31'	8"	80°	19'	45"	BATT
BHKF *	Florida Keys	Bahia Honda	24°	39'	31"	81°	16'	26"	GERG
EVFU	Everglades	Faka Union Bay	25°	54'	5"	81°	30'	47"	GERG
RBHC	Rookery Bay	Henderson Creek	26°	1'	30"	81°	44'	12"	GERG
NBNB	Naples Bay	Naples Bay	26°	6'	51"	81°	47'	12"	GERG

Crassostrea virginica (American oyster) sampled at all sites unless noted.

National Benthic Surveillance Project									
BISNB	Biscayne Bay	North Bay	25°	48'	54"	80°	9'	36"	NMFS
BISCK	Biscayne Bay	Chicken Key	25°	36'	54"	80°	17'	36"	NMFS

Lagodon rhomboides (pinfish) collection was attempted at both sites. No data are yet available for these stations.

* *Chama sinuosa* (smooth edge jewel box) was sampled at this station in 1991 and 1992. Limited data available for this station.

Table I.2. Population within 20 km of the NS&T sites in South Florida.

Site	Main Location		Population within 20 km
BBGC	Biscayne Bay	Goulds Canal	329,729
BBPC	Biscayne Bay	Princeton Canal	329,729
BHKF	Florida Keys	Bahia Honda	Not available
EVFU	Everglades	Faka Union Bay	3,246
NBNB	Naples Bay	Naples Bay	117,791
NMML	North Miami	Maule Lake	1,310,765
RBHC	Rookery Bay	Henderson Creek	91,001

Table I.3. NS&T Mussel Watch Project major and trace elements in *Crassostrea virginica* (American oyster). Average of three stations per site (< DL - Value below the limit of detection) (μg/g dry wt. unless noted).

Station	Year	Al	Si	Cr	Mn	Fe	Ni	Cu	Zn
BBGC	90	26	< DL	0.39	6.9	130	0.23	370	3300
BBGC	91	47	1000	1.3	11	140	0.69	480	3700
BBPC	86	63	< DL	0.21	13	250	0.60	110	2700
BBPC	87	37	600	0.21	16	180	1.0	70	1600
EVFU	86	280	570	1.5	8.8	280	1.6	45	930
EVFU	87	70	230	0.30	10	160	0.72	40	860
EVFU	88			0.40	5.9	250	0.99	48	1200
EVFU	89			1.5	12	450	1.1	70	1100
EVFU	90			2.1	12	560	1.1	37	840
EVFU	91			0.72	8.3	220	0.90	43	900
NBNB	86	88	260	0.55	8.7	200	0.63	330	2400
NBNB	87	170	400	0.65	8.4	250	0.86	330	2300
NBNB	88			1.1	10	440	0.93	330	3400
NBNB	89			0.79	7.9	270	0.71	370	3200
NBNB	90			0.95	7.5	340	0.89	460	3400
NBNB	91			0.98	7.4	280	0.80	370	2600
NMML	88	55		0.42		170	0.74	820	5500
NMML	89	11		0.34		89	0.43	670	4100
NMML	90	88	< DL	0.63	7.4	170	0.24	850	4700
NMML	91	33	920	0.98	9.9	180	1.1	940	5300
RBHC	86	150	350	1.2	5.8	260	1.2	68	720
RBHC	87	690	100	2.4	9.2	570	1.2	170	1400
RBHC	88			1.4	11	360	1.1	130	1300
RBHC	89			0.90	6.9	250	0.89	97	1200
RBHC	90			1.0	8.2	310	0.98	79	850
RBHC	91			0.81	6.6	210	0.93	35	810
BHKF	91			0.95		81	5.3	5.2	140

Table I.3. NS&T Mussel Watch Project major and trace elements in *Crassostrea virginica* (American oyster). Average of three stations per site (< DL - Value below the limit of detection) (μg/g dry wt. unless noted) (cont.).

Station	Year	As	Se	Ag	Cd	Sn	Sb	Hg	Tl	Pb
BBGC	90	17	0.49	1.3	0.25	2.7	0.04	0.08		0.38
BBGC	91	15	0.93	1.7	0.27	1.1	0.02	0.14		0.48
BBPC	86	8.8	1.9	1.5	0.39	0.01	< DL	0.12	< DL	0.16
BBPC	87	20	2.0	0.77	0.34	0.02	< DL	0.16	< DL	0.41
EVFU	86	8.8	1.9	0.70	3.2	0.05	< DL	0.25	< DL	0.11
EVFU	87	7.6	2.0	1.4	1.8	< DL	< DL	0.19	< DL	0.24
EVFU	88	7.5	2.4	0.75	2.2	< DL		0.15		0.25
EVFU	89	8.0	2.5	1.3	2.2	0.07		0.18		0.52
EVFU	90	6.6	1.8	1.0	2.3	0.09		0.16		0.78
EVFU	91	5.2	1.8	0.79	2.1	< DL		0.16		0.35
NBNB	86	22	1.2	4.0	1.7	0.58	< DL	0.15	0.58	0.20
NBNB	87	26	2.0	3.9	1.0	0.80	< DL	0.10	< DL	0.34
NBNB	88	29	2.0	4.4	2.0	0.69		0.10		0.16
NBNB	89	22	1.6	2.5	1.4	0.35		0.12		0.35
NBNB	90	12	2.3	4.0	1.1	0.88		0.13		0.58
NBNB	91	13	2.3	3.7	1.4			0.12		0.42
NMML	88	6.4	0.40	0.85	1.2	3.2		0.19		1.0
NMML	89	10	0.40	0.57	0.83	1.6		0.12		0.49
NMML	90	13	0.95	3.1	0.84	2.4	0.04	0.05		1.6
NMML	91	15	0.92	3.2	1.1	0.82	0.02	0.11		1.2
RBHC	86	27	1.8	1.6	2.4	< DL	< DL	0.23	< DL	0.17
RBHC	87	30	2.4	2.2	1.8	< DL	< DL	0.28	< DL	0.67
RBHC	88	28	2.2	2.4	1.6	0.08		0.18		0.14
RBHC	89	17	1.6	1.9	1.9	< DL		0.19		0.33
RBHC	90	13	2.1	1.9	1.9	0.18		0.21		0.58
RBHC	91	11	2.4	1.0	2.7	< DL		0.12		0.39
BHKF	91	78	2.9	0.07	3.3	0.40		0.12		0.27

Table I.4. NS&T Mussel Watch Project aggregated trace organic contaminant concentrations in *Crassostrea virginica* (American oyster). Average of 3 stations per site (< DL - Value below the limit of detection) (ng/g dry wt.).

Site	Year	Total DDTs	Total PCBs	PAHs Low mol. wt.	PAHs High mol. wt.	PAHs Total
BBGC	90	16	88	610	170	780
BBGC	91	19	80	270	230	500
BBPC	86	6.8	10	< DL	380	380
BBPC	87	83	400	680	930	1600
EVFU	86	2.8	27	98	< DL	98
EVFU	87	5.7	30	< DL	< DL	< DL
EVFU	88	20	65	39	200	240
EVFU	89	11	74	190	84	270
EVFU	90	31	280	150	84	230
EVFU	91	2.2	7.0	41	17	58
NBNB	86	10	77	< DL	260	260
NBNB	87	51	75	20	120	140
NBNB	88	34	160	< DL	180	180
NBNB	89	24	90	150	200	350
NBNB	90	9.5	35	120	100	220
NBNB	91	16	54	74	260	330
NMML	88	54	480	1100	640	1700
NMML	89	55	490	62	160	220
NMML	90	58	430	69	250	320
NMML	91	25	160	60	190	250
RBHC	86	5.6	26	32	< DL	32
RBHC	87	3.6	27	< DL	< DL	< DL
RBHC	88	18	71	17	54	71
RBHC	89	15	54	170	110	280
RBHC	90	4.7	41	74	36	110
RBHC	91	7.9	24	52	41	93
BHKF	91	2.2		55	34	89

Table I.5. NS&T Mussel Watch Project individual compound trace organic contaminant concentrations in *Crassostrea virginica* (American oyster). Average of 3 stations per site (< DL - Value below the limit of detection) (ng/g dry wt.).

Low molecular weight PAHs

Station	Year	1-Methyl= naphthalene	1-Methyl= phenanthrene	1,6,7-Trimethyl= naphthalene	2,6-Dimethyl= naphthalene	2-Methyl= naphthalene	Acenaphthene
BBGC	90	95	19	29	100	220	< DL
BBGC	91	29	29	30	50	62	< DL
BBPC	86	< DL		< DL	< DL	< DL	< DL
BBPC	87	43	70	< DL	43	43	43
EVFU	86	< DL	< DL		< DL	14	< DL
EVFU	87	< DL	< DL	< DL	< DL	< DL	< DL
EVFU	88	< DL	< DL	< DL	< DL	10	< DL
EVFU	89	16	5.6	7.0	14	42	4.2
EVFU	90	20	8.8	4.0	14	18	8.6
EVFU	91	4.5	1.0	2.1	4.4	6.9	1.7
NBNB	86	< DL	< DL		< DL	< DL	< DL
NBNB	87	< DL	< DL	< DL	< DL	20	< DL
NBNB	88	< DL	< DL	< DL	< DL	< DL	< DL
NBNB	89	11	19	11	13	27	3.7
NBNB	90	29	4.1	8.4	12	19	3.7
NBNB	91	6.3	5.9	6.5	8.3	12	1.6
NMML	88	120	22	49	147	280	< DL
NMML	89	15	< DL	< DL	< DL	31	< DL
NMML	90	3.6	16	< DL	2.6	11	< DL
NMML	91	7.4	6	1.1	6.9	13	< DL
RBHC	86	< DL	< DL		< DL	14	< DL
RBHC	87	< DL	< DL	< DL	< DL	< DL	< DL
RBHC	88	7.3	< DL	< DL	< DL	< DL	< DL
RBHC	89	12	12	7.2	12	31	5.0
RBHC	90	10	3.1	4.8	3.7	12	2.4
RBHC	91	7.4	1.7	3.8	5.6	11	1.1
BHKF	91	8.1	2.4	2.3	6.7	14	1.1

Table I.5. NS&T Mussel Watch Project individual compound trace organic contaminant concentrations in *Crassostrea virginica* (American oyster). Average of 3 stations per site (< DL - Value below the limit of detection) (ng/g dry wt.) (cont.).

Station	Year	Acenaphthylene	Anthracene	Biphenyl	Fluorene	Naphthalene	Phenanthrene
BBGC	90	10	14	12	10	76	27
BBGC	91	1.4	6.6	7.0	8.2	20	29
BBPC	86		< DL	< DL	< DL	< DL	< DL
BBPC	87		53	170	47	66	97
EVFU	86		< DL	35	< DL	48	< DL
EVFU	87	< DL	< DL	< DL	< DL	< DL	< DL
EVFU	88	7.1	11	< DL	< DL	11	< DL
EVFU	89	5.9	11	7.8	12	42	18
EVFU	90	4.3	4.2	13	9.8	20	21
EVFU	91	0.68	0.80	3.2	2.0	12	2.1
NBNB	86		< DL	< DL	< DL	< DL	< DL
NBNB	87	< DL	< DL	< DL	< DL	< DL	< DL
NBNB	88	< DL	< DL	< DL	< DL	< DL	< DL
NBNB	89	4.9	13	5.5	7.8	26	13
NBNB	90	4.1	4.7	6.1	4.2	15	8.1
NBNB	91	2.1	7.3	3.0	3.2	9.5	8.4
NMML	88	2.7	49	120	7.3	260	64
NMML	89	< DL	< DL	< DL	< DL	16	< DL
NMML	90	< DL	14	< DL	< DL	10	11
NMML	91	< DL	3.3	1.7	0.72	12	8.1
RBHC	86		< DL	< DL	< DL	18	< DL
RBHC	87	< DL	< DL	< DL	< DL	< DL	< DL
RBHC	88	9.2	< DL	< DL	< DL	< DL	< DL
RBHC	89	5.9	12	7.1	10	36	17
RBHC	90	1.8	1.9	6.5	3.1	18	7.5
RBHC	91	0.78	2.0	3.1	1.8	10	3.5
BHKF	91	1.0	1.1	2.4	1.5	9.9	4.4

Table I.5. NS&T Mussel Watch Project individual compound trace organic contaminant concentrations in *Crassostrea virginica* (American oyster). Average of 3 stations per site (< DL - Value below the limit of detection) (ng/g dry wt.) (cont.).

High molecular weight PAHs

Station	Year	Benzo[a]= pyrene	Benzo[b]= fluoranthene	Benzo[e]= pyrene	Benzo[ghi]= perylene	Benzo[k]= fluoranthene	Benz[a]= anthracene
BBGC	90	< DL		12	2.3	13	17
BBGC	91	4.1		13	19	14	20
BBPC	86	< DL		< DL			140
BBPC	87	< DL		180			24
EVFU	86	< DL		< DL			< DL
EVFU	87	< DL	< DL	< DL	< DL		< DL
EVFU	88	15	17	20	8.4		30
EVFU	89	2.2		3.2	7.5	3.1	5.3
EVFU	90	1.7		3.8	1.8	3.4	5.2
EVFU	91	0.19		0.96	0.63	0.79	1.1
NBNB	86	< DL		< DL			< DL
NBNB	87	< DL	1.0	6.7	< DL		18
NBNB	88	7.9	24	18	19		11
NBNB	89	0.95		11	6.1	6.8	7.8
NBNB	90	1.5		5.6	3.1	3.7	5.2
NBNB	91	1.6		17	6.9	17	16
NMML	88	2.5		66	< DL	87	28
NMML	89	< DL		11	< DL	< DL	< DL
NMML	90	1.8		26	7.9	33	15
NMML	91	1.6		16	5.7	23	11
RBHC	86	< DL		< DL			< DL
RBHC	87	< DL	< DL	< DL	< DL		< DL
RBHC	88	< DL	25	6.8	< DL		11
RBHC	89	3.4		6.0	7.9	5.6	6.4
RBHC	90	0.96		2.4	0.85	1.5	2.2
RBHC	91	0.36		2.0	1.0	1.8	2.0
BHKF	91	1.1	1.5	2.5	2.1	1.5	2.4

Table I.5. NS&T Mussel Watch Project individual compound trace organic contaminant concentrations in *Crassostrea virginica* (American oyster). Average of 3 stations per site (< DL - Value below the limit of detection) (ng/g dry wt.) (cont.).

Station	Year	Chrysene	Dibenzo=[*a,h*]anthracene	Fluoranthene	Indeno=[1,2,3-*cd*]pyrene	Perylene	Pyrene
BBGC	90	20	< DL	37	< DL	< DL	67
BBGC	91	24	< DL	43	1.7	< DL	86
BBPC	86	< DL	60	< DL		< DL	180
BBPC	87	14	< DL	210		31	13
EVFU	86	< DL	< DL	< DL		< DL	< DL
EVFU	87	< DL	< DL	< DL	< DL	< DL	< DL
EVFU	88	47	< DL	29	8.1	< DL	23
EVFU	89	4.0	10	14	11	0.59	19
EVFU	90	10	1.1	31	1.3	3.3	17
EVFU	91	2.1	0.44	4.2	0.55	0.43	5.3
NBNB	86	4.0	< DL	120		< DL	100
NBNB	87	31	< DL	28	< DL	< DL	23
NBNB	88	15	< DL	4.0	9.8	< DL	32
NBNB	89	22	6.4	67	7.4	0.64	57
NBNB	90	14	1.3	30	2.8	1.5	27
NBNB	91	41	0.70	63	2.1	1.6	82
NMML	88	110	< DL	120	< DL	< DL	21
NMML	89	28	< DL	53	< DL	< DL	64
NMML	90	45	< DL	48	< DL	0.60	63
NMML	91	28	< DL	45	< DL	0.52	53
RBHC	86	< DL	< DL	< DL		< DL	< DL
RBHC	87	< DL	< DL	< DL	< DL	< DL	< DL
RBHC	88	11	< DL	< DL	< DL	< DL	< DL
RBHC	89	6.7	12	18	13	3.3	18
RBHC	90	4.1	0.65	10	0.57	2.4	7.7
RBHC	91	4.9	0.46	14	0.40	0.44	12
BHKF	91	5.2	0.40	7.5	1.1	0.87	8.1

Table I.5. NS&T Mussel Watch Project individual compound trace organic contaminant concentrations in *Crassostrea virginica* (American oyster). Average of 3 stations per site (< DL - Value below the limit of detection) (ng/g dry wt.) (cont.).

PCB congeners

Station	Year	PCB 8	PCB 18	PCB 28	PCB 44	PCB 52	PCB 66	PCB 101	PCB 105	PCB 110/77	PCB 118
BBGC	90	2.8	0.87	2.5	2.1	4.4	6.9	3.7	1.4	< DL	5.5
BBGC	91	2.5	0.74	3.9	2.4	4.8	7.8	3.3	1.8	< DL	3.6
BBPC	86										
BBPC	87	9.7	6.9	9.8	12	26	0.77	28	16		25
EVFU	86										
EVFU	87	3.2	< DL	0.93	0.17	< DL	< DL	0.40	< DL		11
EVFU	88	2.5	2.8	0.67	< DL	1.6	< DL	4.3	2.3		3.0
EVFU	89	2.3	0.74	0.34	1.5	0.26	9.5	3.2	< DL		1.6
EVFU	90	0.35	< DL	3.6	3.0	3.3	5.4	4.5	6.9	1.4	3.0
EVFU	91	< DL	0.04	< DL	0.03	0.04	< DL	0.08	0.04	0.09	0.03
NBNB	86										
NBNB	87	1.1	0.50	2.5	< DL	< DL	0.80	2.4	2.1		11
NBNB	88	2.0	< DL	4.1	2.5	12	3.6	11	2.0		3.8
NBNB	89	1.5	0.88	0.98	4.5	2.6	2.5	4.3	0.98		5.3
NBNB	90	0.07	0.01	0.29	0.57	1.1	1.5	1.3	0.28	1.3	3.4
NBNB	91	0.63	0.05	0.52	1.6	2.4	0.73	2.5	0.32	3.8	3.3
NMML	88	< DL	5.3	15	7.6	33	37	22	5.0		33
NMML	89	< DL	5.1	12	13	19	37	29	< DL		35
NMML	90	0.46	3.9	9.6	8.9	31	14	28	5.9	< DL	35
NMML	91	< DL	0.75	3.4	5.4	8.5	3.6	10	1.5	< DL	14
RBHC	86										
RBHC	87	2.0	< DL	< DL	< DL	< DL	< DL	5.6	< DL		3.4
RBHC	88	0.43	2.0	3.2	0.77	0.97	2.4	3.4	2.7		5.0
RBHC	89	0.40	0.21	0.27	1.6	1.2	2.6	2.2	0.31		1.2
RBHC	90	0.10	< DL	0.16	0.40	0.15	0.19	0.20	0.36	0.05	1.7
RBHC	91	< DL	0.22	0.42	0.50	0.37	0.54	0.47	0.30	0.43	0.81
BHKF	91	< DL	23	0.30	0.15	0.19	0.12	0.27	0.11	< DL	0.10

Table I.5. NS&T Mussel Watch Project individual compound trace organic contaminant concentrations in *Crassostrea virginica* (American oyster). Average of 3 stations per site (< DL - Value below the limit of detection) (ng/g dry wt.) (cont.).

Station	Year	PCB 126	PCB 128	PCB 138	PCB 153	PCB 170	PCB 180	PCB 187	PCB 195	PCB 206	PCB 209
BBGC	90	< DL	< DL	3.0	8.8	< DL	< DL	1.8	< DL	< DL	< DL
BBGC	91	< DL	1.8	2.6	4.0	< DL	< DL	< DL	< DL	< DL	< DL
BBPC	86										
BBPC	87		6.7	34	22	2.5	4.3	3.1	< DL	< DL	< DL
EVFU	86										
EVFU	87		< DL	1.6	< DL	< DL	< DL	< DL	< DL	< DL	< DL
EVFU	88		< DL	4.0	4.0	< DL	3.0	< DL	< DL	< DL	0.43
EVFU	89		< DL	10	0.86	< DL	0.54	0.26	5.9	0.45	0.25
EVFU	90	14	7.6	47	2.5	4.0	8.8	7.0	< DL	3.6	0.04
EVFU	91	< DL	< DL	1.3	0.14	< DL	0.34	< DL	< DL	< DL	< DL
NBNB	86										
NBNB	87		< DL	4.5	< DL	< DL	< DL	< DL	< DL	< DL	< DL
NBNB	88		0.70	21	7.2	< DL	1.1	0.47	< DL	< DL	< DL
NBNB	89		0.28	6.7	2.8	< DL	1.5	1.4	4.4	0.32	0.40
NBNB	90	0.39	0.09	2.8	< DL	0.06	0.77	0.65	< DL	< DL	0.13
NBNB	91	< DL	0.63	2.9	2.3	< DL	0.85	1.0	< DL	< DL	< DL
NMML	88		0.14	40	29	3.1	< DL	16	0.17	< DL	< DL
NMML	89		7.8	23	44	7.1	6.1	16	< DL	< DL	< DL
NMML	90	< DL	1.3	21	40	< DL	0.33	14	3.0	< DL	< DL
NMML	91	< DL	< DL	9.4	18	< DL	0.01	5.3	< DL	< DL	< DL
RBHC	86										
RBHC	87		0.53	< DL	< DL	< DL	< DL	< DL	< DL	< DL	0.37
RBHC	88		< DL	1.1	4.4	1.2	3.4	< DL	< DL	< DL	0.33
RBHC	89		0.09	7.7	0.51	< DL	0.68	0.46	1.8	1.7	1.2
RBHC	90	0.79	0.10	11	0.20	0.15	0.98	0.62	0.20	0.09	0.23
RBHC	91	0.23	0.45	1.8	0.66	0.22	0.59	0.59	0.49	0.33	0.52
BHKF	91	< DL	0.04	2.7	0.67	< DL	0.47	0.22	0.39	< DL	< DL

Table I.5. NS&T Mussel Watch Project individual compound trace organic contaminant concentrations in *Crassostrea virginica* (American oyster). Average of 3 stations per site (< DL - Value below the limit of detection) (ng/g dry wt.) (cont.).

Pesticides

Station	Year	2,4'-DDE	4,4'-DDE	2,4'-DDD	4,4'-DDD	2,4'-DDT	4,4'-DDT
BBGC	90	< DL	14.	0.76	0.96	< DL	< DL
BBGC	91	8.6	9.3	0.11	0.65	0.41	< DL
BBPC	86	< DL	4.6	< DL	< DL	< DL	2.2
BBPC	87	12	28	9.0	18	7.0	9.0
EVFU	86	< DL	2.8	< DL	< DL	< DL	< DL
EVFU	87	< DL	1.5	0.22	4.0	< DL	< DL
EVFU	88	1.4	5.1	3.0	8.1	1.8	0.78
EVFU	89	3.1	3.7	3.0	0.62	< DL	0.82
EVFU	90	3.5	6.0	6.8	6.5	< DL	8.4
EVFU	91	0.20	1.6	0.01	0.17	< DL	0.15
NBNB	86	0.38	8.8	< DL	< DL	< DL	0.81
NBNB	87	< DL	18	1.7	29	< DL	2.3
NBNB	88	1.6	7.4	3.8	14	3.0	4.2
NBNB	89	5.1	13	2.9	1.9	0.13	0.54
NBNB	90	< DL	4.8	2.0	1.1	< DL	1.5
NBNB	91	1.7	11	0.11	2.1	< DL	0.60
NMML	88	2.0	44	1.1	4.1	< DL	2.8
NMML	89	< DL	51	3.8	< DL	0.21	< DL
NMML	90	1.3	43	1.0	8.56	5.1	< DL
NMML	91	1.6	21	< DL	2.3	< DL	< DL
RBHC	86	0.52	4.0	0.21	0.93	< DL	< DL
RBHC	87	0.37	2.7	< DL	0.53	< DL	< DL
RBHC	88	2.2	3.9	3.8	6.8	0.76	0.98
RBHC	89	6.3	4.7	2.9	0.66	0.16	0.52
RBHC	90	1.5	0.67	0.75	0.89	< DL	0.85
RBHC	91	1.5	4.6	0.33	0.86	< DL	0.57
BHKF	91	2.0	0.21	< DL	0.27	< DL	< DL

Table I.5. NS&T Mussel Watch Project individual compound trace organic contaminant concentrations in *Crassostrea virginica* (American oyster). Average of 3 stations per site (< DL - Value below the limit of detection) (ng/g dry wt.) (cont.).

Station	Year	Aldrin	*cis*-Chlordane	Dieldrin	Heptachlor	Heptachlor epoxide
BBGC	90	< DL	2.4	< DL	< DL	< DL
BBGC	91	< DL	3.1	< DL	< DL	< DL
BBPC	86	< DL	2.4	5.0	< DL	< DL
BBPC	87	10	16	19	6.3	13
EVFU	86	< DL	1.2	0.38	< DL	< DL
EVFU	87	< DL	2.6	1.3	0.31	0.98
EVFU	88	2.7	9.7	3.9	0.21	2.1
EVFU	89	1.1	0.77	0.62	< DL	0.20
EVFU	90	2.7	8.6	7.2	1.6	2.5
EVFU	91	< DL	0.96	< DL	0.05	< DL
NBNB	86	0.12	50	3.2	2.5	1.4
NBNB	87	< DL	18	6.9	0.95	2.2
NBNB	88	1.2	14	3.9	0.63	1.4
NBNB	89	0.94	6.7	2.1	0.80	0.95
NBNB	90	0.04	2.5	2.0	0.11	0.21
NBNB	91	0.40	7.6	6.0	0.16	0.30
NMML	88	< DL	10	5.4	2.0	0.83
NMML	89	< DL	9.4	< DL	< DL	< DL
NMML	90	< DL	5.9	4.1	1.2	0.73
NMML	91	< DL	26	1.1	< DL	< DL
RBHC	86	< DL	1.87	0.96	< DL	0.17
RBHC	87	< DL	2.1	0.08	< DL	0.75
RBHC	88	1.6	9.2	1.1	< DL	3.2
RBHC	89	0.34	1.5	0.86	0.21	0.35
RBHC	90	< DL	1.2	0.64	0.17	0.33
RBHC	91	0.43	2.4	1.3	0.36	0.44
BHKF	91	< DL	0.63	0.98	< DL	< DL

Table I.5. NS&T Mussel Watch Project individual compound trace organic contaminant concentrations in *Crassostrea virginica* (American oyster). Average of 3 stations per site (< DL - Value below the limit of detection) (ng/g dry wt.) (cont.).

Station	Year	Hexachlorobenzene	gamma-HCH	Mirex	*trans*-Nonachlor
BBGC	90	< DL	< DL	< DL	2.6
BBGC	91	< DL	5.2	< DL	2.5
BBPC	86	< DL	< DL	< DL	2.4
BBPC	87	4.3	5.5	7.0	16
EVFU	86	< DL	< DL	< DL	0.83
EVFU	87	0.55	0.21	< DL	1.6
EVFU	88	0.15	2.5	0.54	10
EVFU	89	0.33	0.39	< DL	0.59
EVFU	90	2.0	2.4	7.0	12
EVFU	91	0.01	0.06	< DL	0.23
NBNB	86	0.45	0.34	< DL	61
NBNB	87	< DL	0.81	0.67	24
NBNB	88	< DL	1.6	0.82	14
NBNB	89	0.75	0.35	0.06	8.5
NBNB	90	< DL	0.77	0.14	8.4
NBNB	91	< DL	0.51	0.03	8.3
NMML	88	< DL	0.53	0.87	12
NMML	89	< DL	< DL	< DL	9.2
NMML	90	0.19	2.5	0.58	9.1
NMML	91	< DL	< DL	< DL	33
RBHC	86	0.18	< DL	< DL	1.9
RBHC	87	1.4	< DL	< DL	0.73
RBHC	88	< DL	0.95	0.97	6.8
RBHC	89	0.11	0.31	< DL	1.2
RBHC	90	< DL	0.43	0.26	1.1
RBHC	91	0.14	0.57	0.30	2.2
BHKF	91	0.04	0.23	< DL	0.14

Table I.6. NS&T Mussel Watch Project butyltins in *Crassostrea virginica* (American oyster) (< DL - Value below the limit of detection) (ng Sn/g dry wt.).

Site	Year	Monobutyltin	Dibutyltin	Tributyltin
BBGC	90	220	810	1700
BBGC	91	80	330	890
NMML	89	210	1000	2200
NMML	90	64	500	1400
NMML	91	43	250	830
EVFU	89	74	100	360
EVFU	90	< DL	< DL	32
EVFU	91	7	5	39
RBHC	89	< DL	24	75
RBHC	91	2	16	49
BHKF	91	52	23	58

Table I.7. NS&T Mussel Watch Project sediment data. Average of 3 stations per site (< DL - Value below the limit of detection) (μg/g dry wt. unless noted).

Station	Year	TOC (%)	TIC (%)	Particle size (%) Gravel	Sand	Silt	Clay	Grain size * (%)
BBGC	90	3.6	6.7	14	40	30	16	46
BBPC	86	3.4	3.3	2.9	5.6	58	34	92
BBPC	87	5.3	6.2	3.7	17	56	23	79
EVFU	86	1.2	0.77	1.2	74	13	12	25
EVFU	87	6.4	0.45	0.0	9.3	39	52	91
NBNB	86	1.6	1.7	5.7	65	18	12	30
NBNB	87	2.0	0.47	0.0	38	27	34	61
NMML	88	2.8	6.3	0.0	31	51	18	69
RBHC	86	3.3	3.0	3.9	17	33	39	72
RBHC	87	5.7	0.58	3.3	25	33	38	71

Major and trace elements

Station	Year	Al (%)	Si (%)	Cr	Mn	Fe (%)	Ni	Cu	Zn
BBGC	90	0.79	2.3	34	42	0.36	9.1	32	45
BBPC	86	0.94	2.7	< DL	58	0.51	< DL	26	38
BBPC	87	< DL	2.0	9.0	64	0.53	1.7	25	39
EVFU	86	0.69	33		31	0.27	4.3	1.5	5.7
EVFU	87	1.5	15	75	120	1.1	11	3.7	19
NBNB	86	0.65	28		36	0.41	4.0	12	31
NBNB	87	1.1	22	42	61	0.67	5.3	9.0	24
NMML	88	0.20		46		0.14	12	37	84
RBHC	86	1.9	9.3		95	0.62	10	4.2	20
RBHC	87	1.5	17	55	54	0.67	8.0	4.2	17

* Percent of particles < 64 μ in size defined as the total silt and clay fractions.

Table I.7. NS&T Mussel Watch Project sediment data. Average of 3 stations per site (< DL - Value below the limit of detection) ($\mu g/g$ unless noted). (cont.).

Station	Year	As	Se	Ag	Cd	Sn	Sb	Hg	Tl	Pb
BBGC	90	3.9	0.24	0.11	0.18	2.7	0.15	0.050		19
BBPC	86	4.6	0.98	0.08	0.18	< DL	0.61	0.050	0.20	12
BBPC	87	1.9	0.56	0.13	0.21	0.58	0.50	0.080	0.28	15
EVFU	86	1.8	< DL	0.01	0.08	0.10	0.18	0.015	< DL	1.1
EVFU	87	4.4	0.13	0.03	0.16	0.43	0.31	0.056	0.06	7.7
NBNB	86	4.9	< DL	0.07	0.13	0.60	0.12	0.030	< DL	3.0
NBNB	87	5.2	0.75	0.06	0.14	0.43	0.19	0.050	< DL	6.2
NMML	88	8.3	0.68	0.26	0.21	2.2		0.16		56
RBHC	86	6.3	< DL	0.03	0.18	0.80	0.13	0.040	< DL	1.2
RBHC	87	3.9	0.48	0.03	0.13	0.33	0.25	0.070	< DL	7.0

Site	Year	Total DDTs (ng/g dry wt.)	Total PCBs (ng/g dry wt.)	PAHs		
				Low mol. wt.	High mol. wt.	Total
BBGC	90	2.8	30	87	360	450
BBPC	86	1.7	< DL	200	97	300
BBPC	87	13	29	59	220	280
EVFU	86	23		10	3.0	13
EVFU	87	0.71	2.3	13	100	110
NBNB	86	3.3	< DL	36	230	270
NBNB	87	2.4	4.6	80	350	430
NMML	88	5.5	43	380	2100	2500
RBHC	86	1.4		31	32	63
RBHC	87	0.77	3.3	9.6	100	110

Table I.7. NS&T Mussel Watch Project sediment data. Average of 3 stations per site (< DL - Value below the limit of detection) (μg/g unless noted). (cont.).

Low molecular weight PAHs (ng/g)

Station	Year	1-Methyl= naphthalene	1-Methyl= phenanthrene	1,6,7-Trimethyl= naphthalene	2,6-Dimethyl= naphthalene	2-Methyl= naphthalene	Acenaphthene
BBGC	90	7.1	6.7	9.5	10	16	< DL
BBPC	86	20	< DL	< DL	< DL	< DL	< DL
BBPC	87	< DL	2.7	< DL	31	< DL	< DL
EVFU	86	< DL	7.7		< DL	< DL	< DL
EVFU	87	1.7	< DL	< DL	< DL	2.0	< DL
NBNB	86	2.3	7.0		< DL	3.0	3.0
NBNB	87	< DL	< DL	2.0	< DL	7.3	< DL
NMML	88	14	49	7.4	27	19	13
RBHC	86	< DL	18		4.3	< DL	< DL
RBHC	87	< DL	< DL	< DL	< DL	< DL	< DL

Station	Year	Acenaphthylene	Anthracene	Biphenyl	Fluorene	Naphthalene	Phenanthrene
BBGC	90	< DL	5.4	4.3	3.0	13	11
BBPC	86	< DL	130	< DL	46	< DL	< DL
BBPC	87	< DL	< DL	< DL	< DL	3.5	8.9
EVFU	86		2.7	< DL	< DL	< DL	< DL
EVFU	87	< DL	< DL	< DL	< DL	< DL	8.0
NBNB	86		5.3	< DL	2.3	3.3	9.7
NBNB	87	< DL	10	< DL	3.3	38	16
NMML	88	33.70	37	4.0	9.6	17	130
RBHC	86		6.3	< DL	< DL	< DL	2.3
RBHC	87	< DL	< DL	< DL	< DL	< DL	7.7

Table I.7. NS&T Mussel Watch Project sediment data. Average of 3 stations per site (< DL - Value below the limit of detection) (μg/g unless noted). (cont.).

High molecular weight PAHs (ng/g)

Station	Year	Benzo[*a*]=pyrene	Benzo[*b*]=fluoranthene	Benzo[*e*]=pyrene	Benzo[*ghi*]=perylene	Benzo[*k*]=fluoranthene	Benz[*a*]=anthracene
BBGC	90	19	28	21	34	18	20
BBPC	86	< DL	< DL	6.3	< DL	< DL	2.5
BBPC	87	27	< DL	18	< DL	< DL	30
EVFU	86	< DL		< DL			< DL
EVFU	87	6.0		7.7	8.1		21
NBNB	86	23		33			23
NBNB	87	19		20	24		40
NMML	88	230	150	180	170	100	190
RBHC	86	2.3		6.0			< DL
RBHC	87	8.1		9.0	12		4.3

Station	Year	Chrysene	Dibenzo=[*a,h*]anthracene	Fluoranthene	Indeno=[1,2,3-*cd*]pyrene	Perylene	Pyrene
BBGC	90	21	90	33	20	6.1	48
BBPC	86	43	< DL	15	< DL	< DL	30
BBPC	87	26	7.5	51	< DL	9.3	43
EVFU	86	3.0	< DL	< DL		< DL	< DL
EVFU	87	13	2.1	16	8.7	8.1	12
NBNB	86	40	2.3	54		9.3	42
NBNB	87	34	3.4	94	20	8.3	86
NMML	88	230	15	320	23	54	390
RBHC	86	12	< DL	5.3		1.7	4.7
RBHC	87	13	2.2	22	12	4.2	11

Table I.7. NS&T Mussel Watch Project sediment data. Average of 3 stations per site (< DL - Value below the limit of detection) (μg/g unless noted). (cont.).

PCB congeners (ng/g)

Station	Year	PCB 8	PCB 18	PCB 28	PCB 44	PCB 52	PCB 66	PCB 101	PCB 105	PCB 110/77	PCB 118
BBGC	90	< DL	< DL	1.4	7.1	< DL	< DL	0.34	0.44	2.9	< DL
BBPC	86	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL
BBPC	87	< DL	< DL	< DL	2.2	4.2	4.1	1.4	< DL	< DL	1.5
EVFU	86										
EVFU	87	0.13	< DL	0.07	< DL	< DL	0.93	0.07	< DL		0.07
NBNB	86										
NBNB	87	< DL	< DL	0.20	< DL	< DL	0.07	0.13	0.13		0.40
NMML	88	0.59	0.78	1.1	1.3	2.7	5.2	4.3	< DL		1.8
RBHC	86										
RBHC	87	0.13	< DL	0.13	< DL	< DL	0.87	0.13	< DL		< DL

Station	Year	PCB 126	PCB 128	PCB 138	PCB 153	PCB 170	PCB 180	PCB 187	PCB 195	PCB 206	PCB 209
BBGC	90	15	1.3	0.21	< DL	0.08	0.04	< DL	0.75	< DL	< DL
BBPC	86	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL	< DL
BBPC	87	< DL	3.1	3.9	2.1	3.5	2.9	0.53	< DL	< DL	< DL
EVFU	86										
EVFU	87		0.03	0.33	0.20	0.47	0.07	0.07	0.03	< DL	0.20
NBNB	86										
NBNB	87		< DL	0.50	0.27	2.3	0.27	0.27	0.03	0.03	< DL
NMML	88		1.5	5.8	6.9	2.0	3.3	2.4	1.2	1.3	1.0
RBHC	86										
RBHC	87		0.13	0.13	< DL	0.27	0.97	< DL	0.17	0.03	0.37

Table I.7. NS&T Mussel Watch Project sediment data. Average of 3 stations per site (< DL - Value below the limit of detection) (μg/g unless noted). (cont.).

Pesticides (ng/g)

Station	Year	2,4'-DDE	4,4'-DDE	2,4'-DDD	4,4'-DDD	2,4'-DDT	4,4'-DDT
BBGC	90	0.49	0.88	< DL	1.4	< DL	< DL
BBPC	86	< DL	1.7	< DL	< DL	< DL	< DL
BBPC	87	< DL	10	< DL	3.4	< DL	< DL
EVFU	86	< DL	0.18	< DL	0.05	< DL	< DL
EVFU	87	< DL	0.26	0.07	0.31	< DL	0.07
NBNB	86	< DL	1.7	0.31	1.2	< DL	0.07
NBNB	87	< DL	1.0	0.17	1.2	0.01	0.01
NMML	88	< DL	5.5	< DL	< DL	< DL	< DL
RBHC	86	< DL	0.57	< DL	0.45	0.08	0.29
RBHC	87	0.02	0.59	0.08	< DL	< DL	0.08

Station	Year	Aldrin	*cis*-Chlordane	Dieldrin	Heptachlor	Heptachlor epoxide
BBGC	90	< DL	< DL	0.64	2.7	110
BBPC	86	< DL	0.87	0.55	< DL	< DL
BBPC	87	< DL	1.5	3.4	< DL	0.67
EVFU	86	< DL	0.02	< DL	< DL	< DL
EVFU	87	0.10	0.09	0.17	0.04	0.04
NBNB	86	0.02	2.0	0.81	0.04	0.05
NBNB	87	< DL	0.38	0.30	0.10	< DL
NMML	88	< DL	< DL	1.8	< DL	1.1
RBHC	86	< DL	0.39	0.14	0.17	< DL
RBHC	87	< DL	0.79	0.01	0.06	< DL

Table I.7. NS&T Mussel Watch Project sediment data. Average of 3 stations per site (< DL - Value below the limit of detection) (μg/g unless noted). (cont.).

Pesticides (ng/g)

Station	Year	Hexachlorobenzene	Lindane	Mirex	*trans*-Nonachlor
BBGC	90	1.9	< DL	2.1	9.5
BBPC	86	0.12	< DL	< DL	0.21
BBPC	87	< DL	< DL	< DL	2.0
EVFU	86	< DL	< DL	< DL	0.01
EVFU	87	0.06	0.14	< DL	0.10
NBNB	86	0.01	0.02	< DL	2.5
NBNB	87	0.07	< DL	< DL	0.53
NMML	88	0.73	0.33	< DL	0.88
RBHC	86	0.04	0.14	0.08	0.37
RBHC	87	0.19	0.01	0.02	0.27

Table I.8. Typical NS&T Mussel Watch Project sediment and bivalve tissue major and trace element method limits of detection [Brooks *et al.* (1990) unless noted] (μg/g dry wt.).

Element	Sediments	Bivalve tissue	Element	Sediments	Bivalve tissue
Al	100	10*	As	0.09	0.1
Si	10000*	100*	Se	0.07	0.3
Cr	1.0	0.04	Ag	0.02	0.02
Mn	6	2	Cd	0.002	0.004
Fe	150	8	Sn	0.2	0.2
Ni	0.07	0.08	Sb	0.2*	0.2*
Cu	0.04	4	Hg	0.01	0.01
Zn	1	1	Pb	0.2	0.09

Table I.9. Typical NS&T Mussel Watch Project Gulf Coast sediment and bivalve tissue polycyclic aromatic hydrocarbon method limits of detection [Brooks *et al.* (1990) unless noted] (ng/g dry wt.).

Element	Sediments	Bivalve tissue	Element	Sediments	Bivalve tissue
1-Methylnaphthalene	0.8	25	Benzo[*ghi*]perylene	0.3	15
1-Methylphenanthrene	0.6	29	Benzo[*k*]fluoranthene	1.9	19
2-Methylnaphthalene	0.8	36	Biphenyl	2.0	15
2,6-Dimethylnaphthalene	2.4	26	Chrysene	0.5	19
1,6,7-Trimethylnaphthalene	2.4	22	Dibenz[*a,h*]anthracene	2.6	20
Acenaphthene	4.5	10	Fluoranthene	0.4	6.3
Acenaphthylene	3.7	21	Fluorene	2.5	12
Anthracene	4.1	9.1	Indeno[1,2,3-*cd*]pyrene	1.6	23
Benz[*a*]anthracene	1.4	25	Naphthalene	0.5	23
Benzo[*a*]pyrene	1.2	22	Perylene	3.3	9.9
Benzo[*b*]fluoranthene	1.8	20	Phenanthrene	0.5	11
Benzo[*e*]pyrene	2.4	19	Pyrene	3.1	9.0

Table I.10. Typical NS&T Mussel Watch Project Gulf Coast sediment and bivalve tissue pesticides and PCB method limits of detection (Brooks *et al.*, 1990) (ng/g dry wt.).

Compound	Sediments	Bivalve tissue	Compound	Sediments	Bivalve tissue
Aldrin	0.25	2.4	Mirex	0.17	1.2
cis-Chlordane	0.23	2.9	*trans*-Nonachlor	0.10	1.7
Dieldrin	0.16	2.5			
Heptachlor	0.20	2.1	DDT*	0.85	7.0
Heptachlor epoxide	0.16	0.85			
Hexachlorobenzene	0.37	0.60	PCB$^{\Delta}$	0.81	7.2
gamma-HCH	0.22	2.6			

* The highest detection limit of DDT and 5 metabolites.

$^{\Delta}$ The highest detection limit of the 20 PCB congeners quantified by the NS&T Program.

APPENDIX II

Graphical presentation of selected National Status and Trends Program data

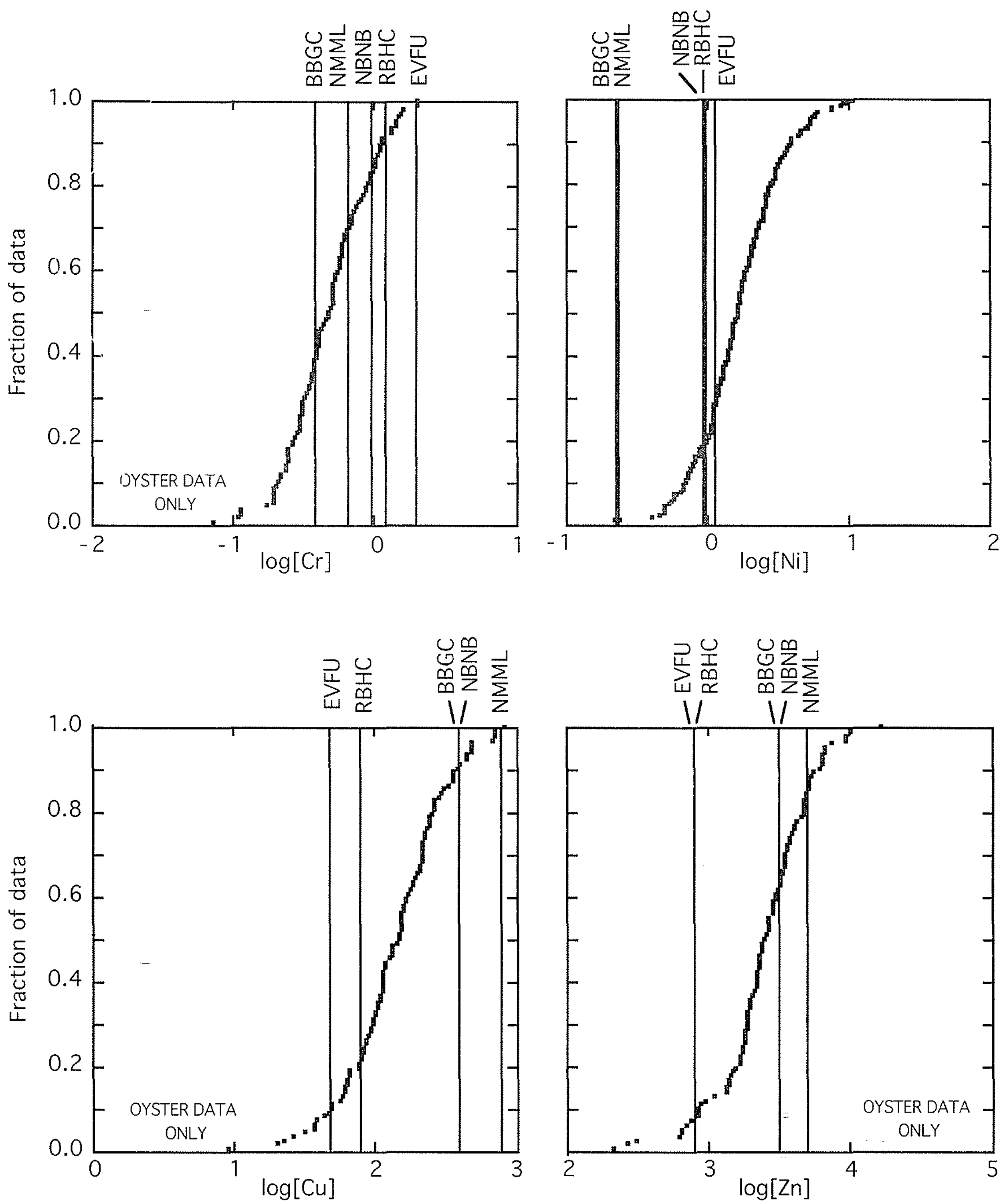

Figure II.1. Cumulative distribution plots (logarithmic scale) of 1990 NS&T bivalve body burdens of Cr, Ni, Cu and Zn [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

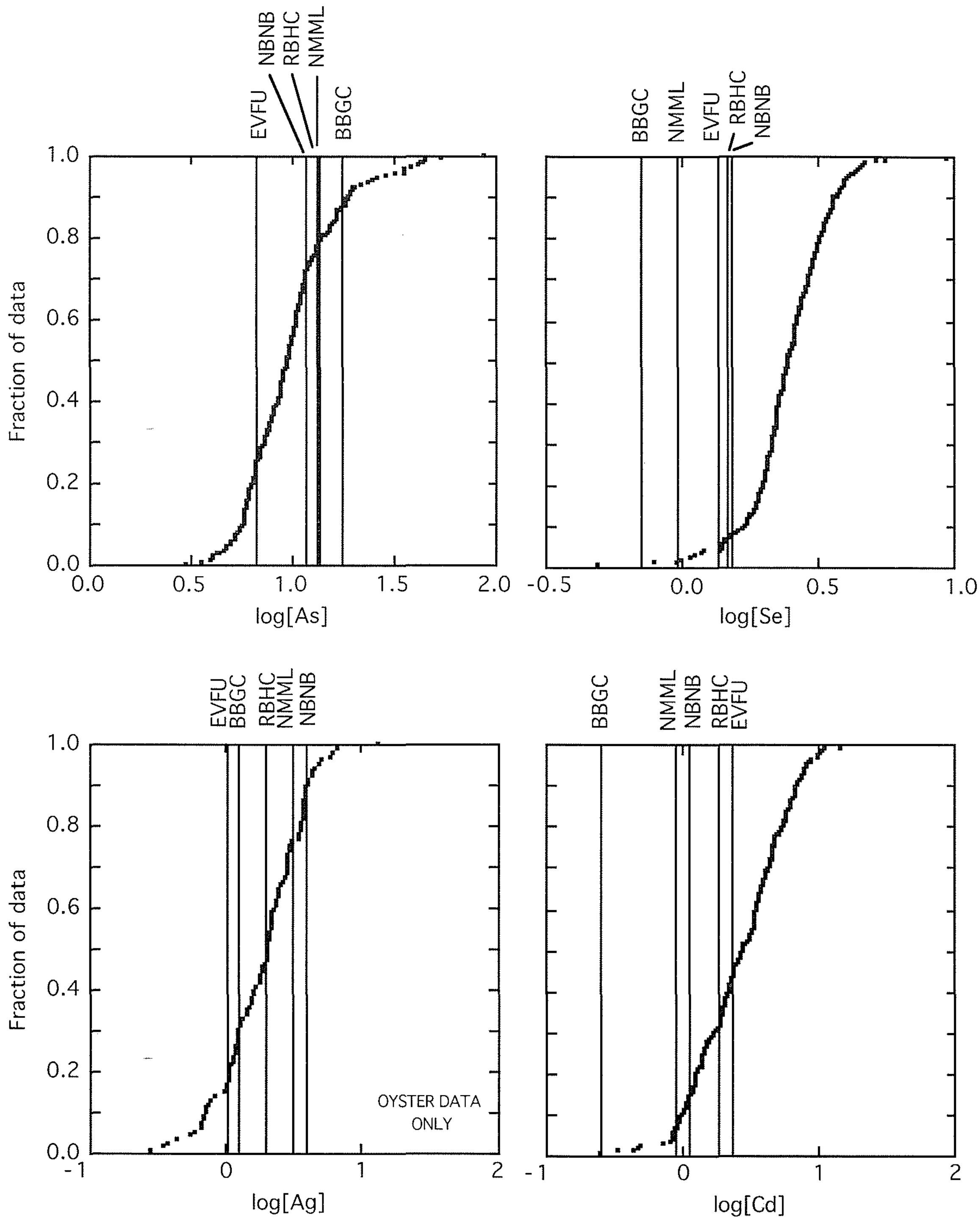

Figure II.2. Cumulative distribution plots (logarithmic scale) of 1990 NS&T bivalve body burdens of As, Se, Ag, and Cd [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

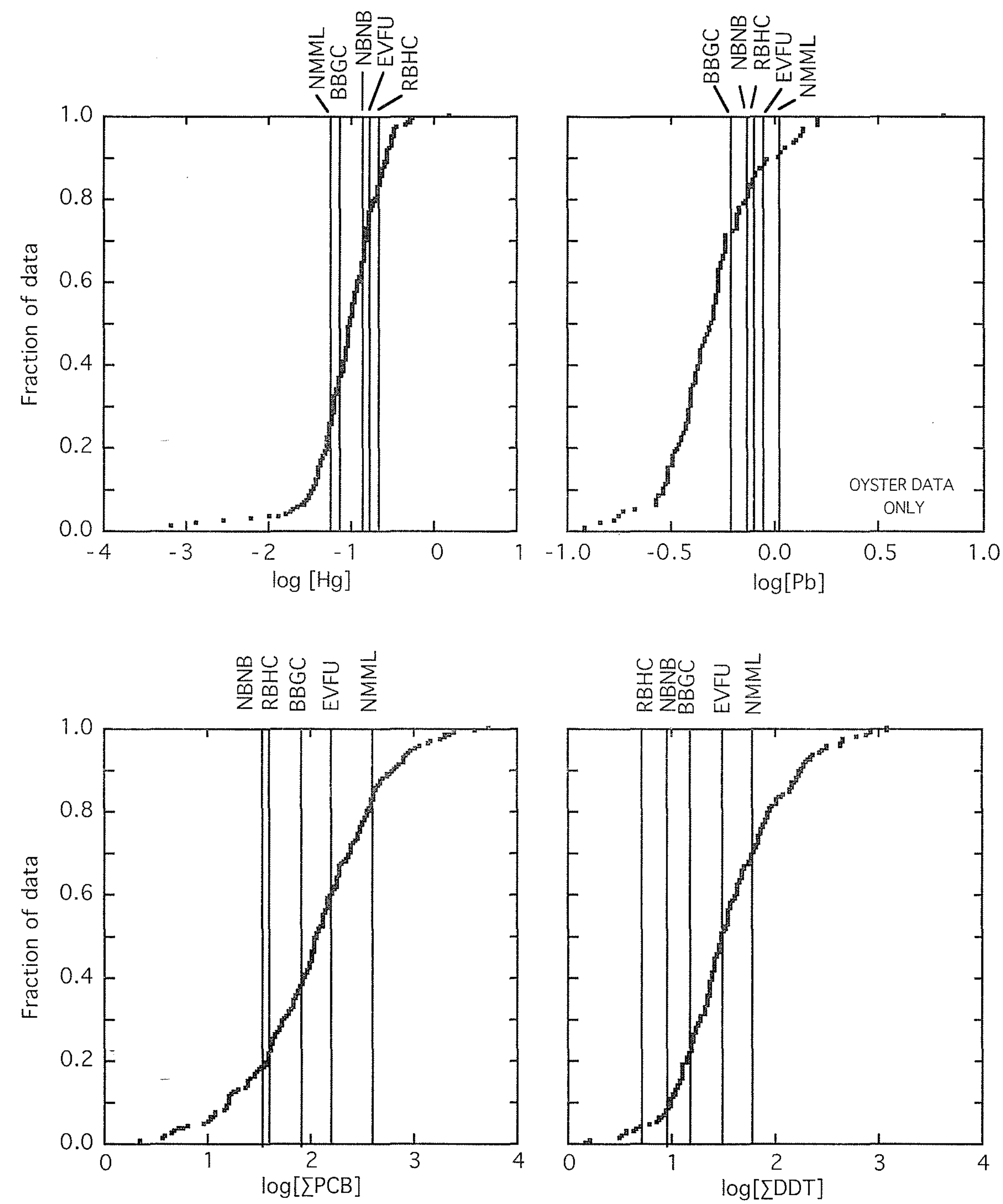

Figure II.3. Cumulative distribution plots (logarithmic scale) of 1990 NS&T bivalve body burdens of Hg, Pb, ∑PCBs and ∑DDT [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

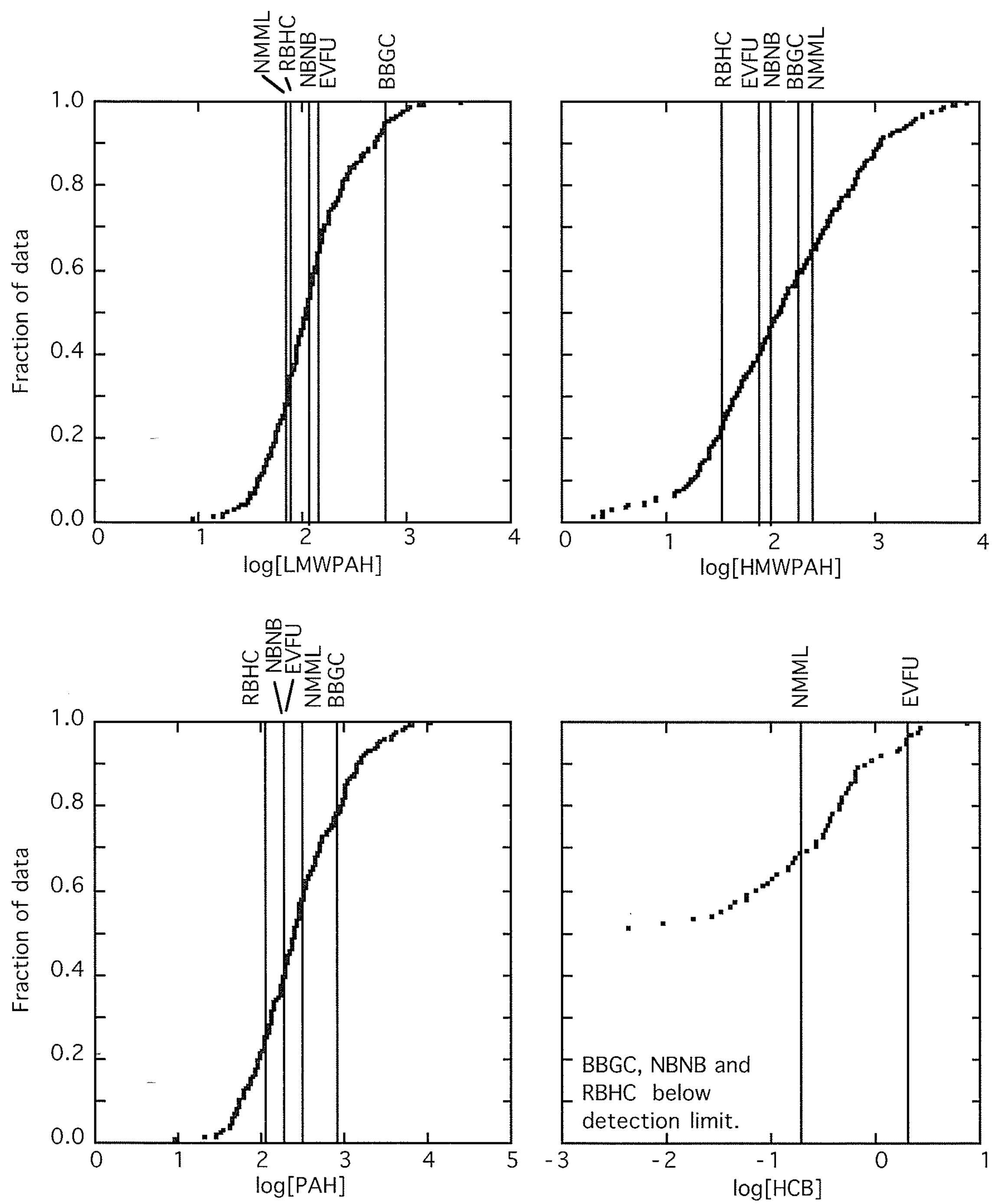

Figure II.4. Cumulative distribution plots (logarithmic scale) of 1990 NS&T bivalve body burdens of ∑PAH, ∑LMWPAH, ∑HMWPAH and hexachlorobenzene [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

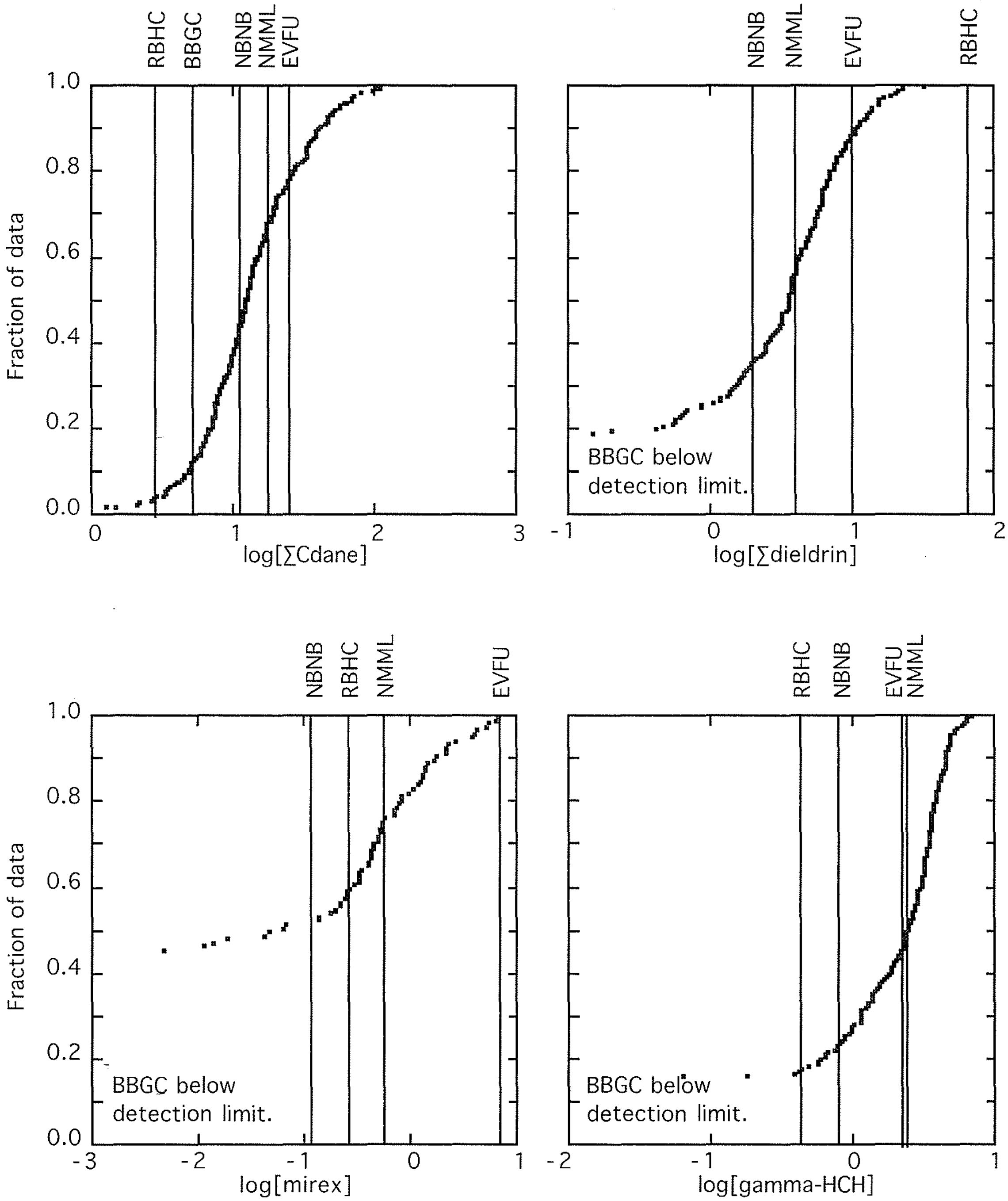

Figure II.5. Cumulative distribution plots (logarithmic scale) of 1990 NS&T bivalve body burdens of ∑chlordane, ∑dieldrin, mirex and gamma-HCH [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

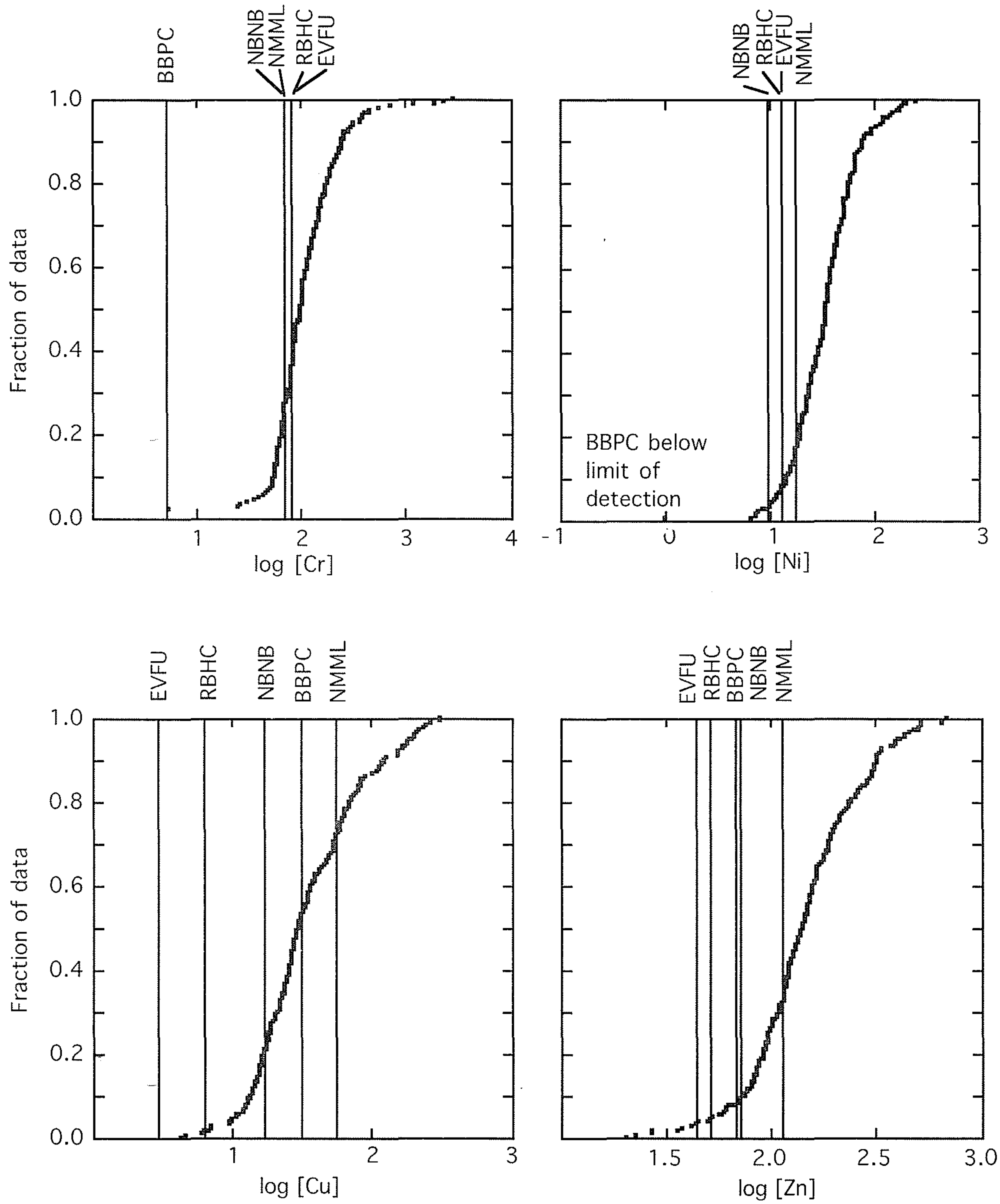

Figure II.6. Cumulative distribution plots (logarithmic scale) of NS&T sediment data of Cr, Ni, Cu and Zn [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

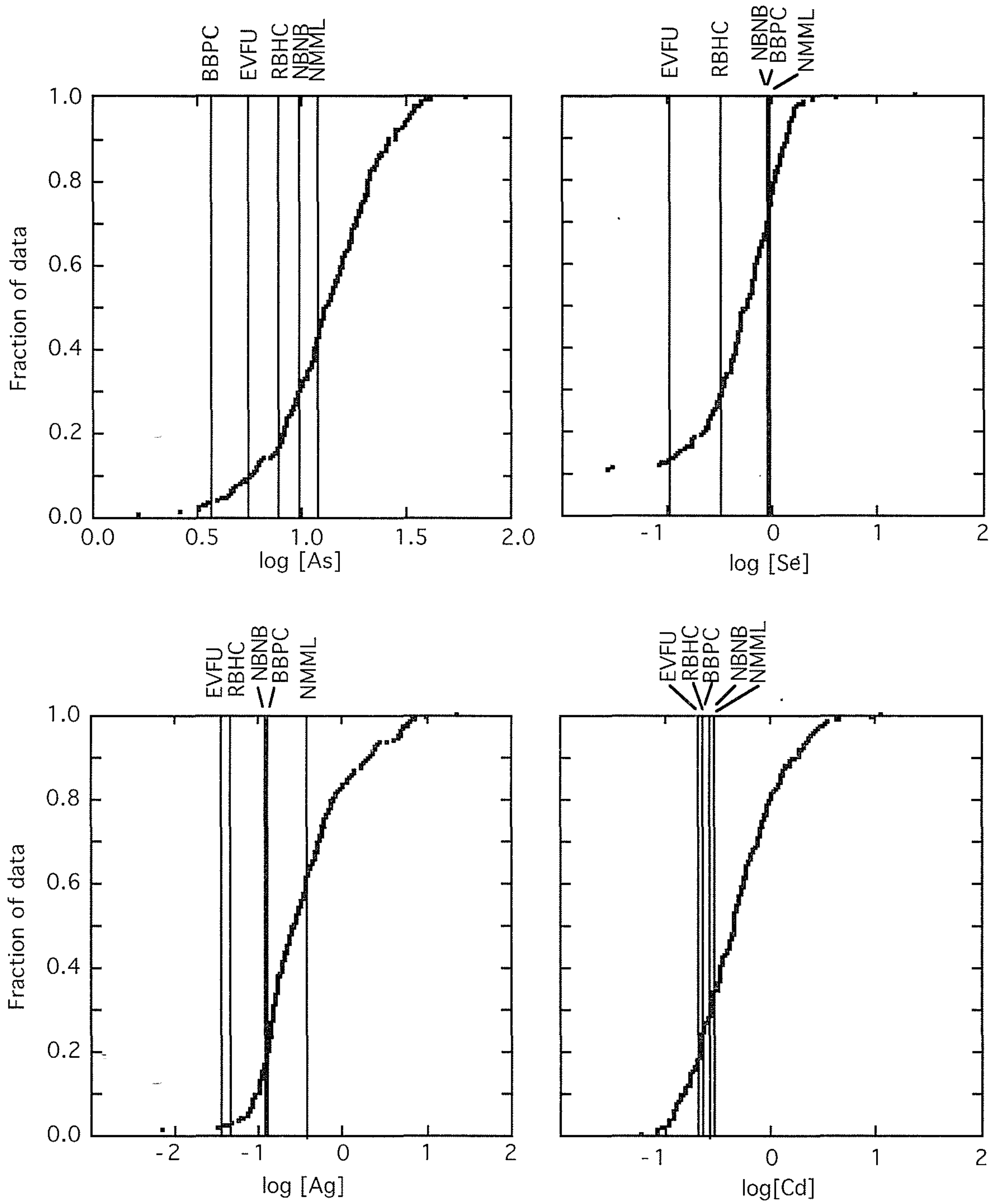

Figure II.7. Cumulative distribution plots (logarithmic scale) of NS&T sediment data of As, Se, Ag and Cd [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

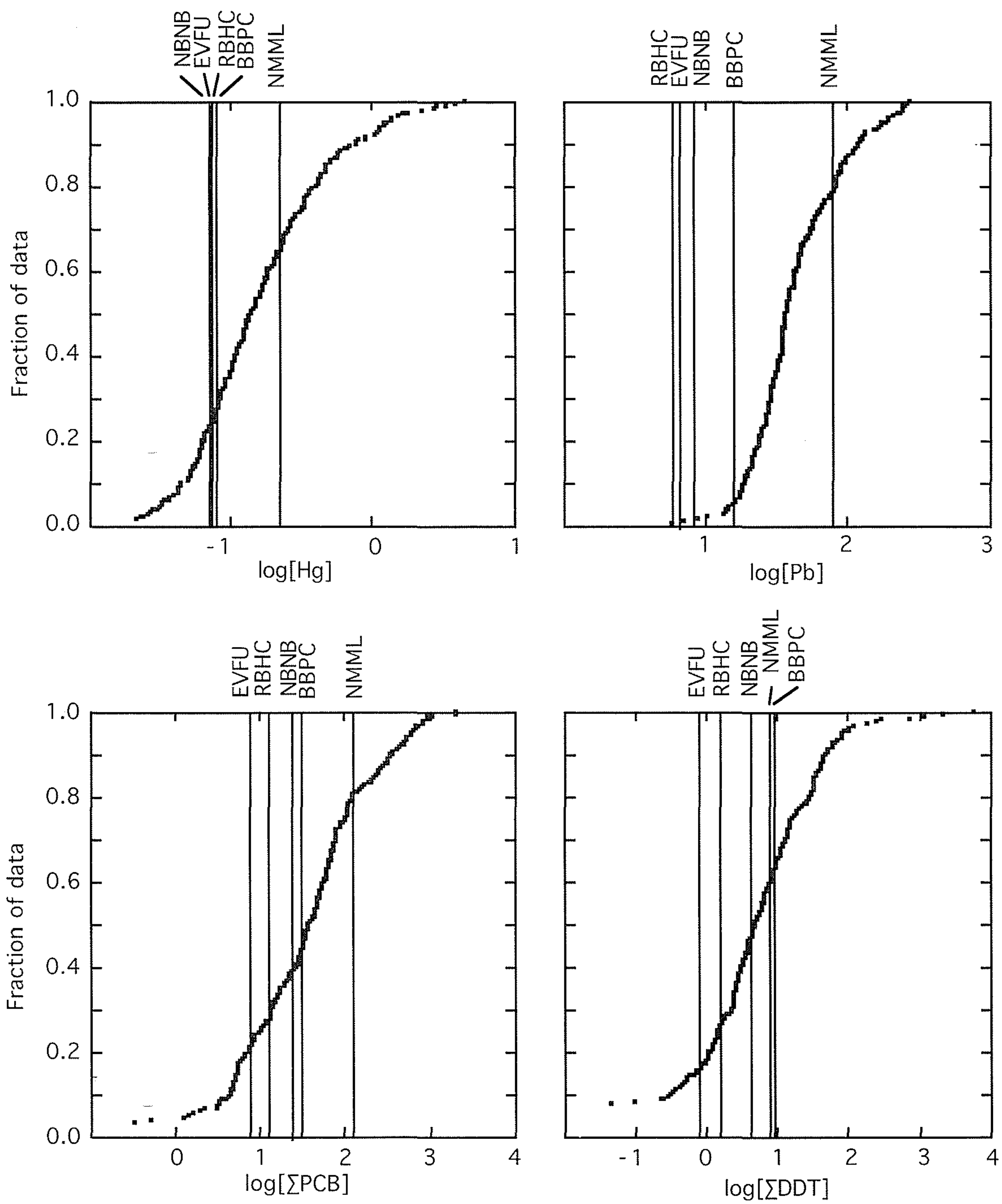

Figure II.8. Cumulative distribution plots (logarithmic scale) of NS&T sediment data of Hg, Pb, ∑PCBs and ∑DDT [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

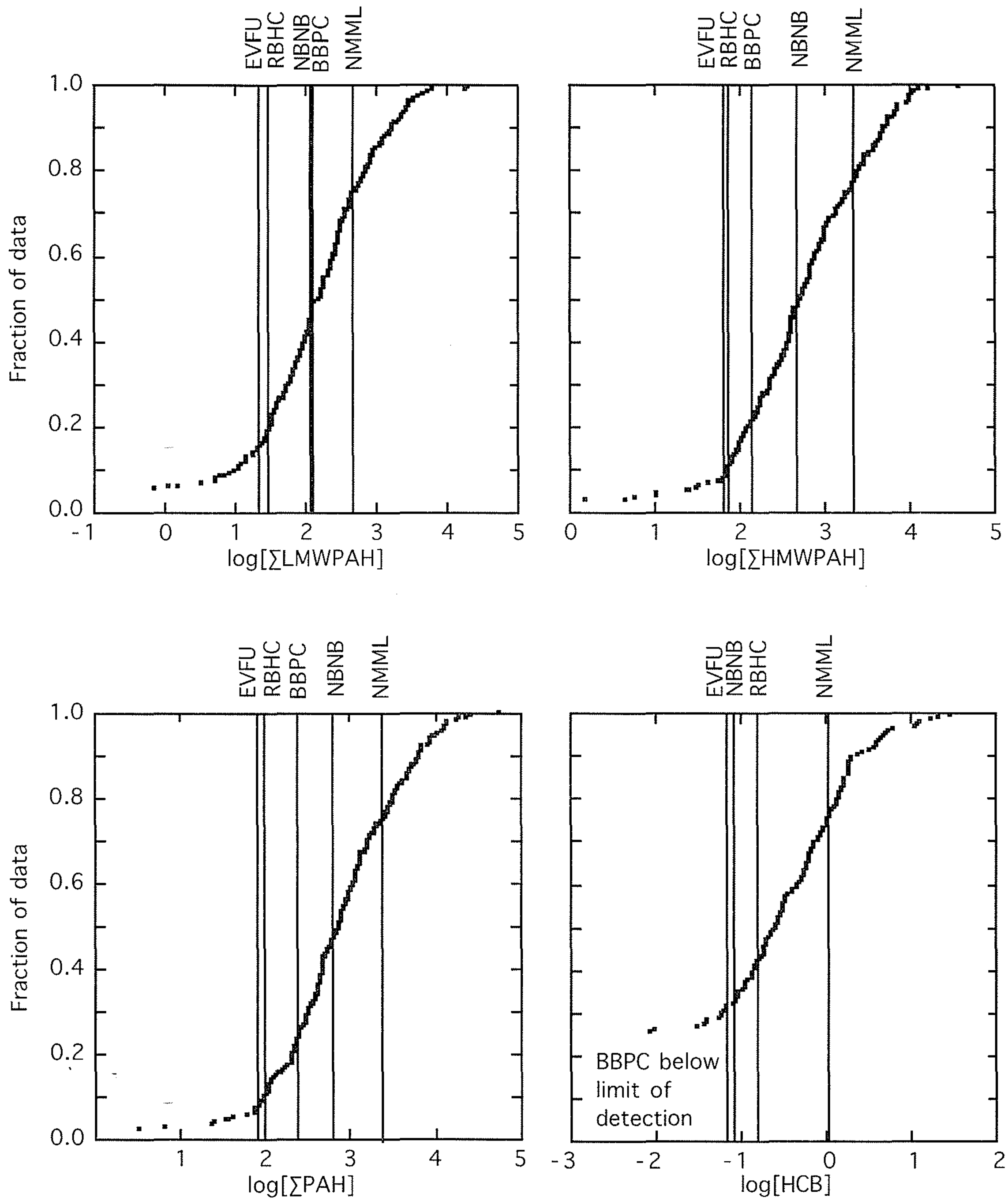

Figure II.9. Cumulative distribution plots (logarithmic scale) of NS&T sediment data of ∑PAH, ∑LMWPAH, ∑HMWPAH and hexachlorobenzene [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

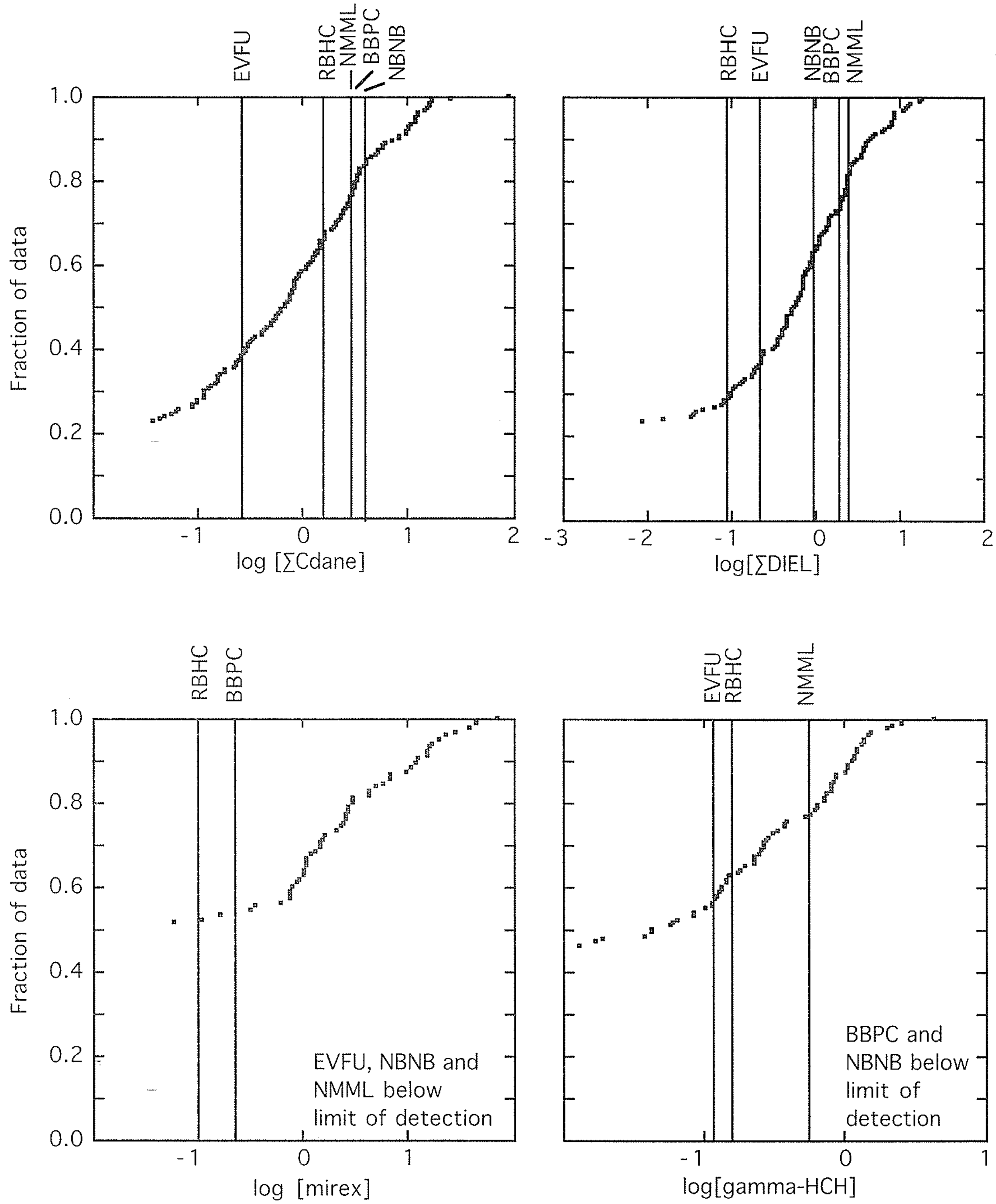

Figure II.10. Cumulative distribution plots (logarithmic scale) of NS&T sediment data of ∑chlordane, ∑dieldrin, mirex and gamma-HCH [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

APPENDIX III

Graphical presentation of selected National Status and Trends Program temporal trends

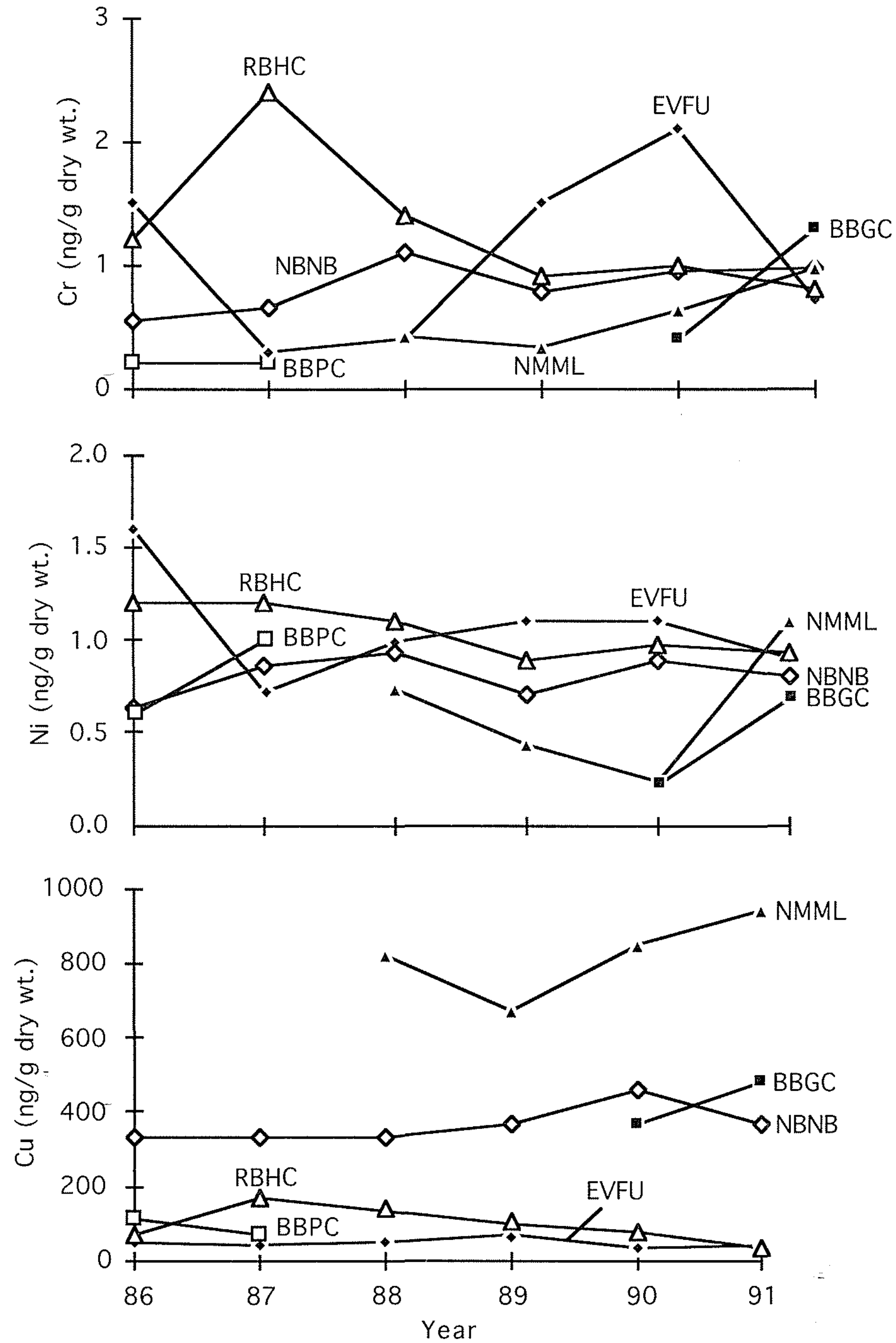

Figure III.1. Annual means of NS&T bivalve body burdens of Cr, Ni, and Cu (ng/g dry wt.). [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Biscayne Bay Princeton Canal (BBPC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

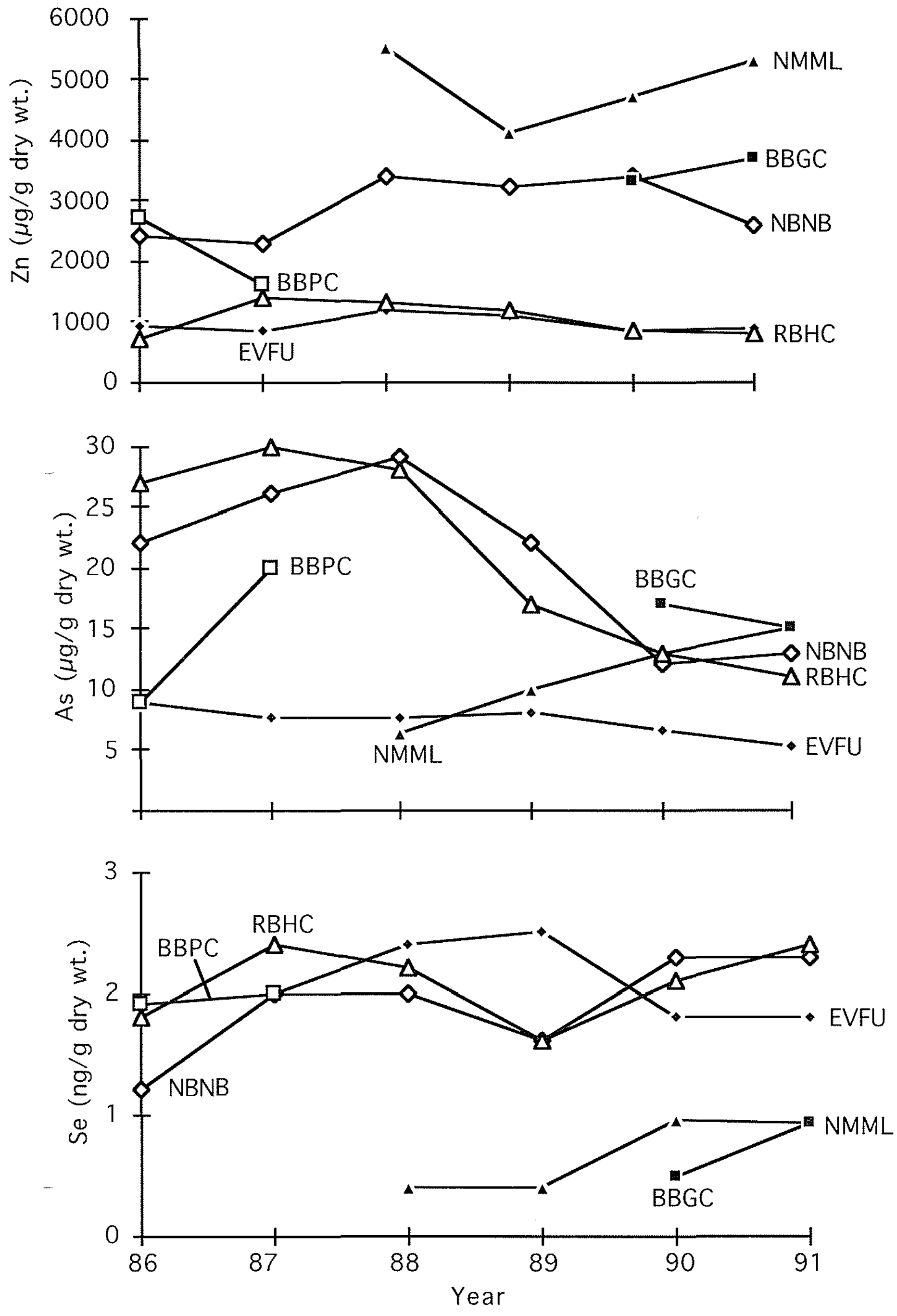

Figure III.2. Annual means of NS&T bivalve body burdens of Zn, As, and Se (ng/g dry wt.) [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Biscayne Bay Princeton Canal (BBPC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

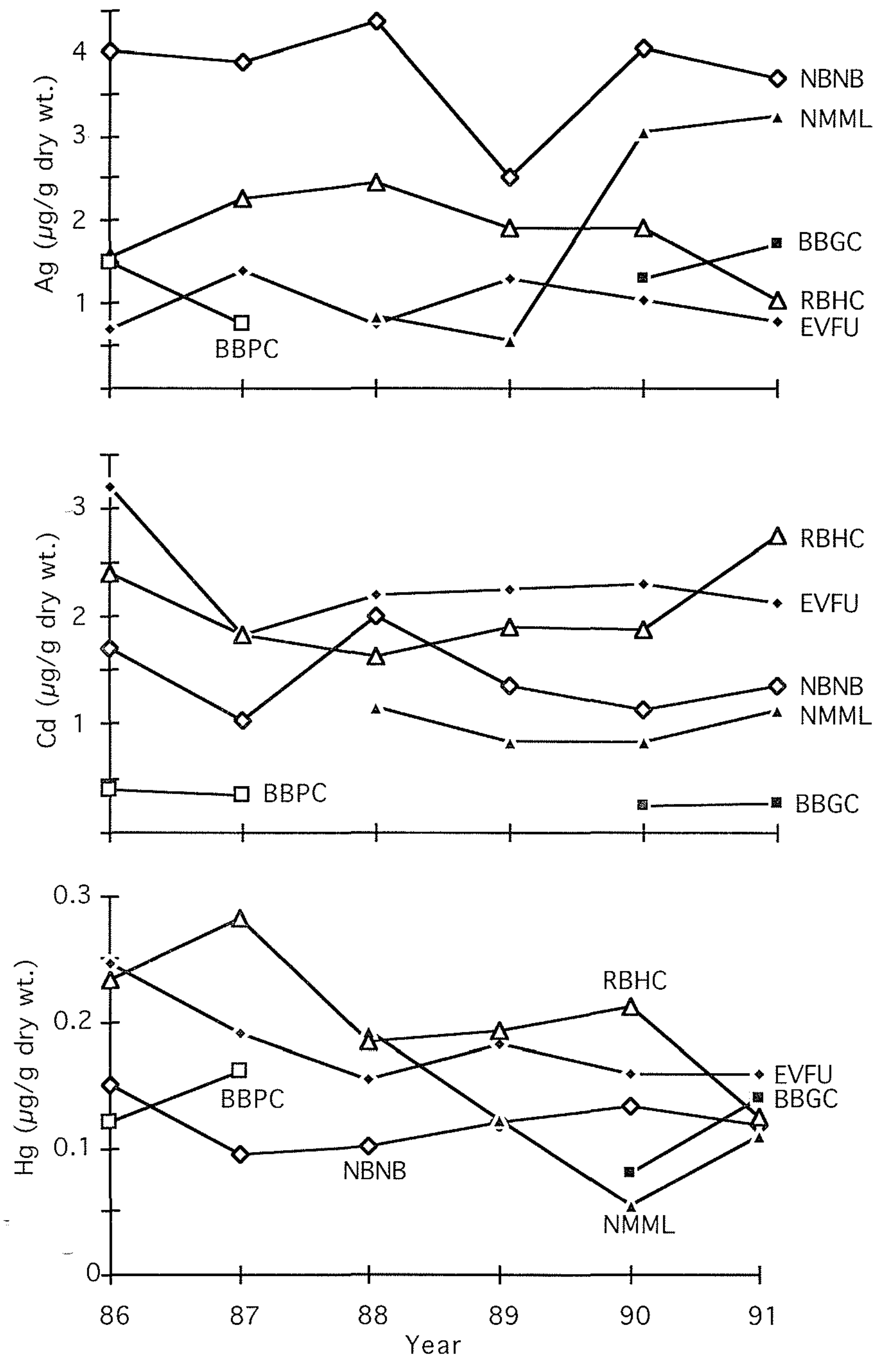

Figure III.3. Annual means of NS&T bivalve body burdens of Ag, Cd, and Hg (ng/g dry wt.) [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Biscayne Bay Princeton Canal (BBPC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

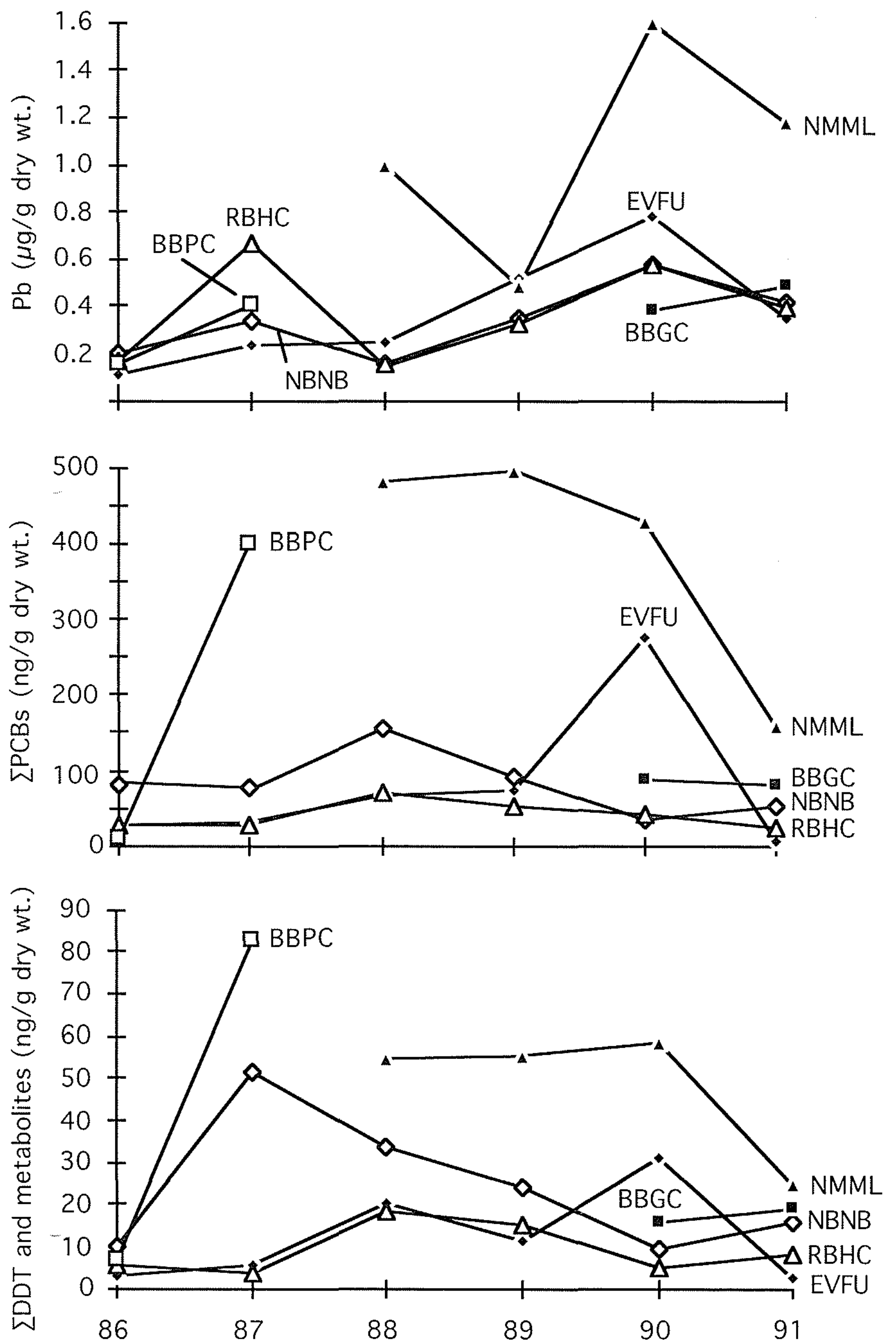

Figure III.4. Annual means of NS&T bivalve body burdens of Pb, ∑PCB, and ∑DDT and metabolites (ng/g dry wt.) [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Biscayne Bay Princeton Canal (BBPC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

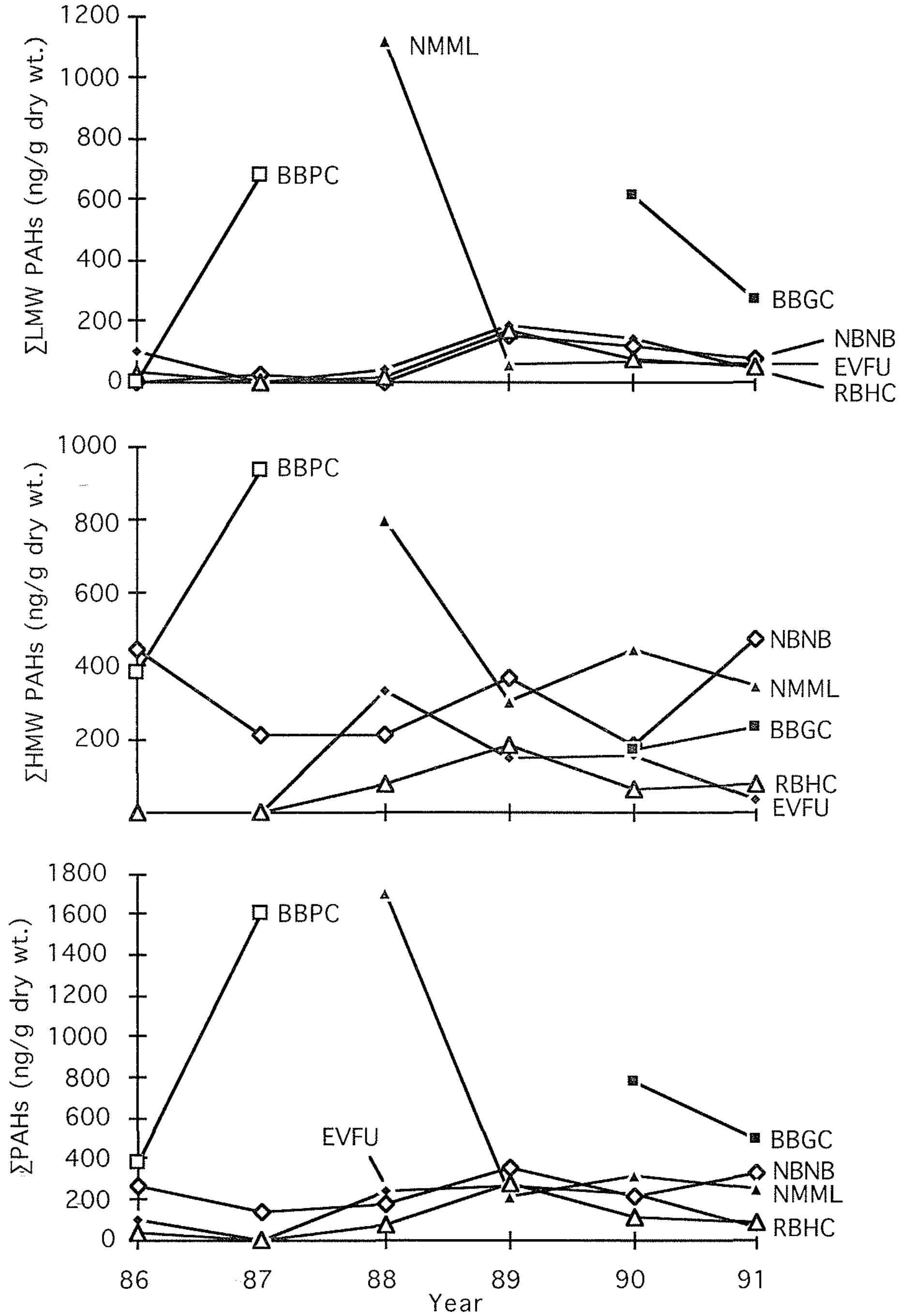

Figure III.5. Annual means of NS&T bivalve body burdens of ∑LMWPAH, ∑HMWPAH and ∑PAH (ng/g dry wt.) [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Biscayne Bay Princeton Canal (BBPC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

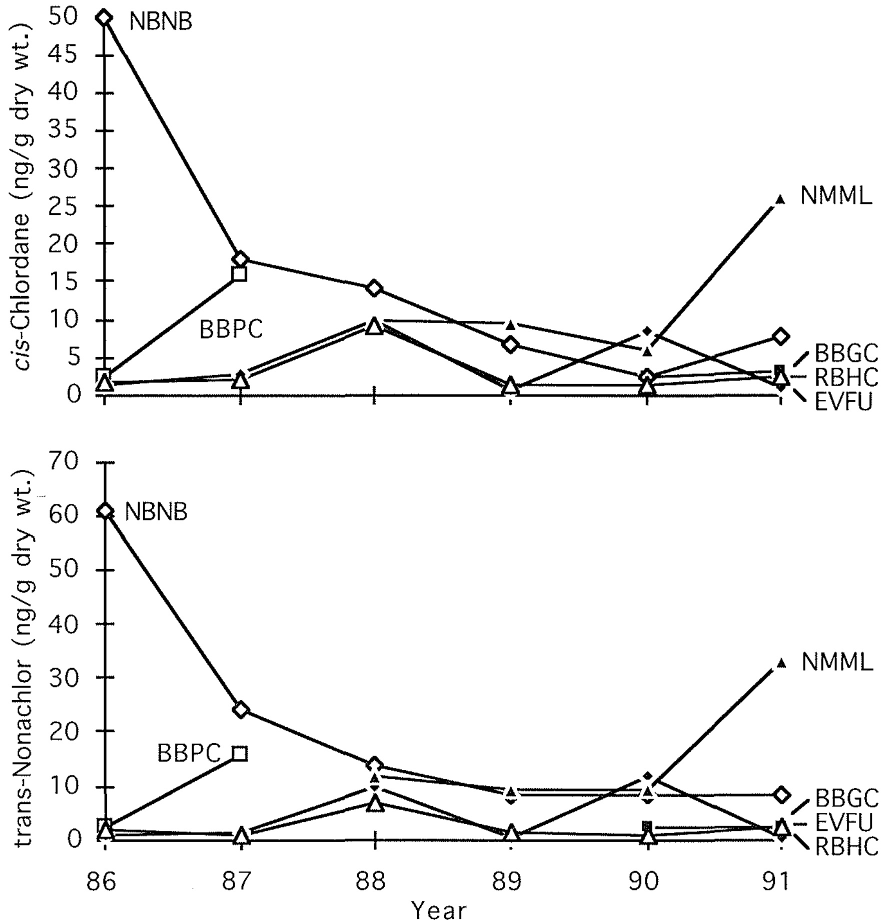

Figure III.6. Annual means of 1990 NS&T bivalve body burdens of *cis*-chlordane and *trans*-nonachlor (ng/g dry wt.) [North Miami Maule Lake (NMML), Biscayne Bay Gould's Canal (BBGC), Biscayne Bay Princeton Canal (BBPC), Everglades Faka Union Bay (EVFU), Rookery Bay Henderson Creek (RBHC), and Naples Bay (NBNB)].

APPENDIX VI

Graphical presentation of NOAA weather data for South Florida

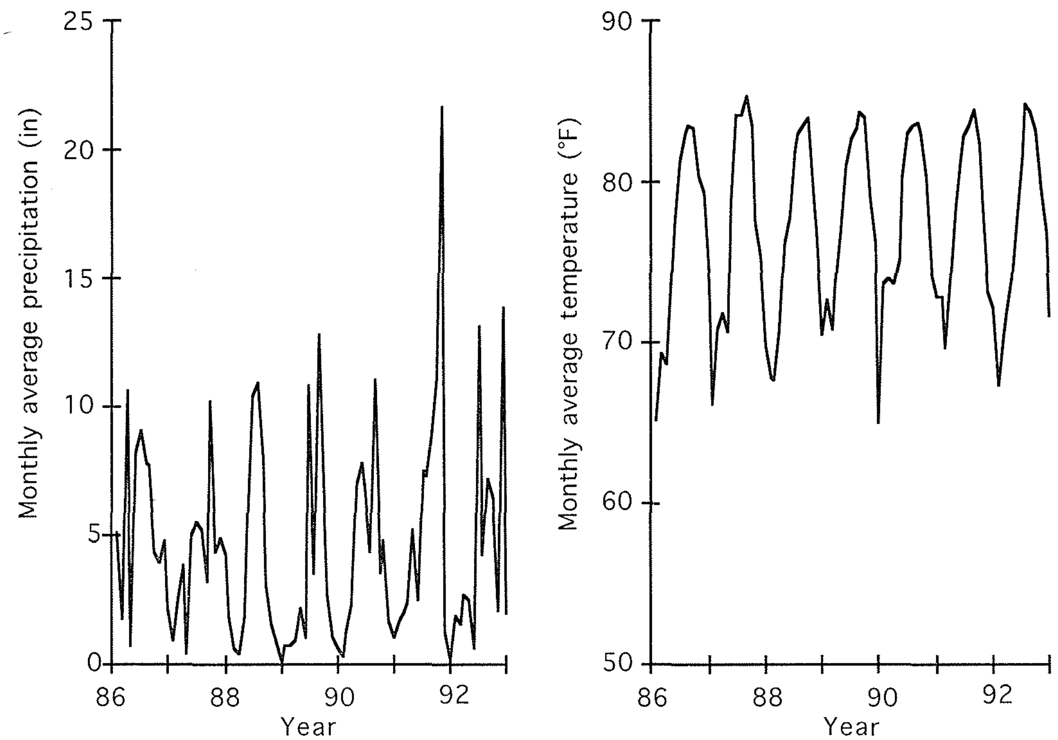

Figure IV.1. Monthly average temperature (°F) and precipitation (in.) recorded at the Miami NOAA weather station from 1986 to 1992.

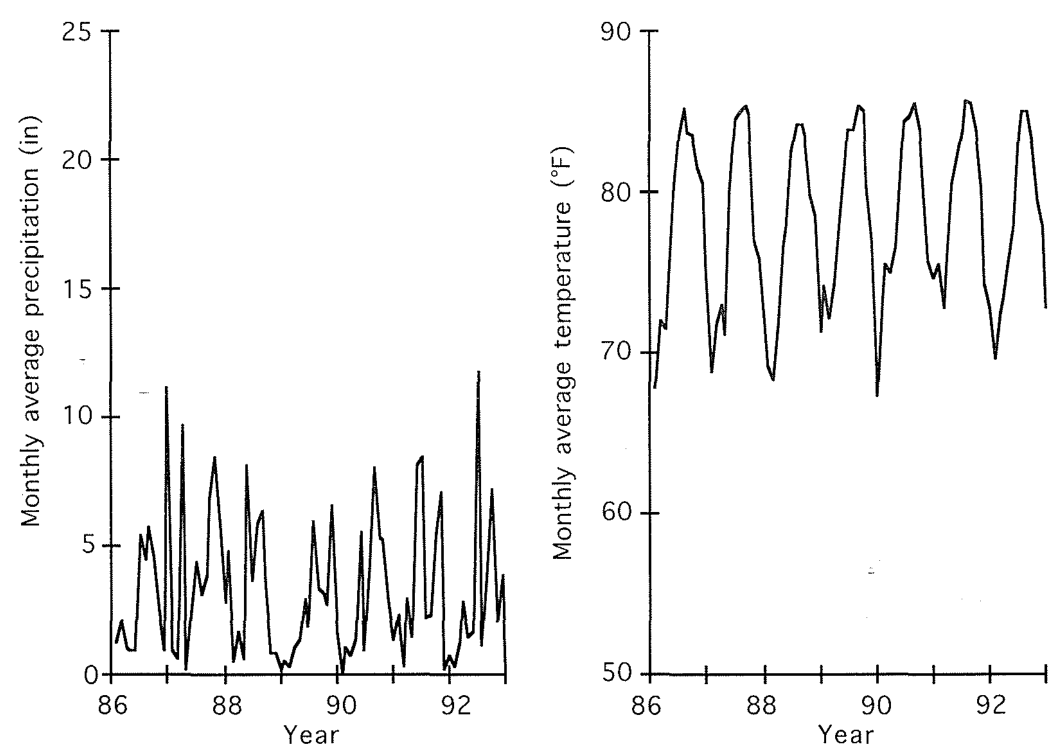

Figure IV.2. Monthly average temperature (°F) and precipitation (in.) recorded at the Key West NOAA weather station from 1986 to 1992.

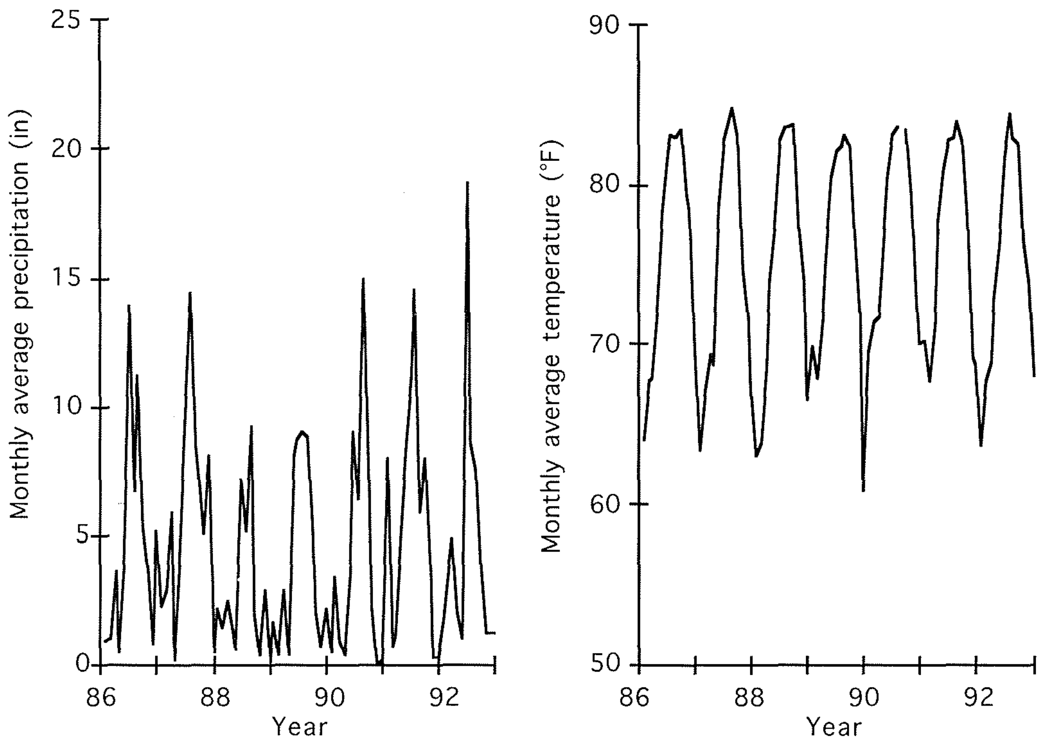

Figure IV.3. Monthly average temperature (°F) and precipitation (in.) recorded at the Ft. Myers NOAA weather station from 1986 to 1992.

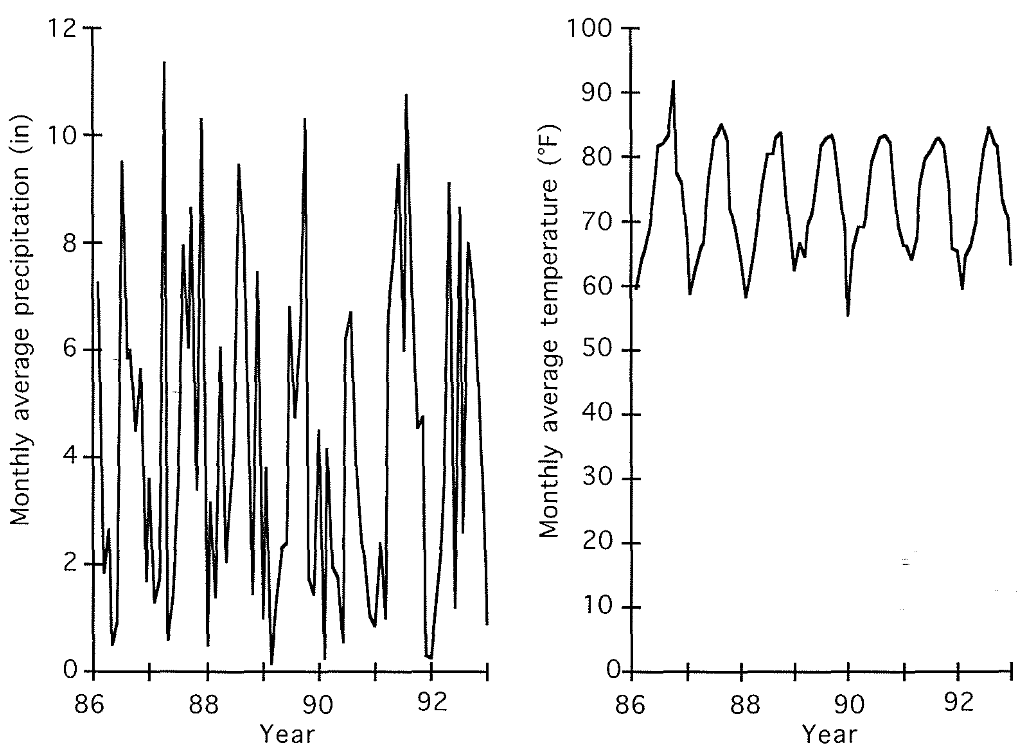

Figure IV.4. Monthly average temperature (°F) and precipitation (in.) recorded at the Orlando NOAA weather station from 1986 to 1992.

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