2. Introduction

Humans have long appreciated the worth of estuaries as sources of food and building materials and as sites for manufacturing, shipping, recreation, and tourism. But we now worry that we may have disrupted the balance of these sensitive ecosystems with our intensive practices of industry, agriculture, recreation, and urban development.

As a result of this concern, federal and state environmental agencies have been directed to evaluate the environmental condition of the nation's estuaries. This summary report reviews the results of an extensive study of estuaries in the mid-Atlantic region of the United States in the summers of 1997-98. The program is called the Mid-Atlantic Integrated Assessment and focuses on four adjacent estuaries: (1) the Delaware Estuary, (2) the Chesapeake Bay, (3) the coastal bays of Virginia and Maryland, and (4) the APES. Many of the smaller estuaries that comprise these systems are included in the study as well.

In this chapter, we highlight a few of the most important features of estuaries in general, and the mid-Atlantic estuaries in particular. The chapter also introduces several of the most serious problems that are evident in modern estuaries.

About Estuaries

An estuary is a semi-enclosed portion of the sea that is diluted by freshwater. This definition covers a wide variety of water bodies, including bays, tributaries, inlets, sounds, lagoons, canals, harbors, etc. All types are present in the mid-Atlantic region. Most estuaries receive freshwater from rivers. The mouths of these rivers are usually brackish and influenced by tides; therefore, they are considered to be estuaries as well. Many coastal bays lack rivers, but are diluted instead by fresh groundwater.

The larger systems in the region are good examples of drowned-river estuaries that formed thousands of years ago as the glaciers melted and the sea level rose. Remnants of the former drainage systems are still discernible as networks of deep channels in the Chesapeake Bay and Delaware Bay. The smaller coastal bays were isolated from the sea when barrier islands formed by processes that are still not well understood.

The mid-Atlantic bays are broad and shallow well-mixed systems. Waves and tides keep the waters relatively well-mixed vertically, except for summers when distinct surface layers of warm, buoyant freshwater may form. The turbulence, in part, also accounts for the notoriously poor water clarity in mid-Atlantic estuaries. It takes many months for river water to flush the large estuaries. Therefore, the estuaries are susceptible to the effects of excessive quantities of nutrients and toxic substances delivered by the rivers.

In some respects, estuaries are among the most changeable environments on earth. Water depth and clarity, salinity, sediment type, and many other physical properties can vary widely over short distances. Estuaries are also changeable over time in response to the tides, the seasons, and slower climatic changes. Such variability is stressful. Yet remarkably, thousands of species of estuarine organisms take advantage of the rich niches provided by the changeable conditions.

Are the mid-Atlantic estuaries threatened? Despite their adaptability and productivity, there are clear signs of disruptive changes within the estuaries. Most of the changes are traceable to the increasing presence of humans. Population in the mid-Atlantic estuarine watersheds has grown from 13 million in 1950 to 21 million in 1990, and is estimated to be 25 million by 2020. It is unlikely that we can restrain human development in estuaries. Therefore, the challenge is to understand how our presence affects estuarine ecosystems and minimize disruptions where possible.

Mid-Atlantic Estuaries

The mid-Atlantic region includes hundreds of large and small estuaries. This report emphasizes a few of the larger regional bays and tributaries when reviewing results of the MAIA program. In addition, a dozen smaller estuaries were selected as "intensively-sampled systems" which were sampled in higher spatial resolution both to highlight conditions in smaller estuaries and to evaluate variability in the measurements. Table 2-1 lists these regional and intensively-sampled estuaries. See Figures 3-1 and 3-2 for station locations.

- Chesapeake Bay is the largest estuary in North America, home to more than 3,600 species of plants and animals and more than 15 million people. The bay is long and narrow, about 200 miles by 35 miles (320 by 55 km), and is relatively shallow with an average depth of about 21 feet (6.5 m). Water quality issues have been a primary concern in the Chesapeake Bay over the past few decades. High nutrient concentrations were blamed for increased incidences of algal blooms, hypoxia, and loss of seagrasses. The bay was the first estuary in the United States targeted for intensive government-sponsored restoration efforts, an effort formalized in the Chesapeake Bay Agreement in 1983. There has been noticeable improvement on all issues, but further work is needed to meet restoration goals. Other problems in the bay include chemical contamination, air pollution, landscape changes, depleted shellfish and fish stocks, and concern about outbreaks of the toxin-producing organism *Pfiesteria*.

Table 2-1. Mid-Atlantic Estuaries Highlighted in the MAIA Program and This Report.

DELAWARE ESTUARY	
Delaware River	Schuylkill River*
Delaware Bay	Salem River*
CHESAPEAKE BAY	
Mainstem	Severn River*
Choptank River	South River*
Patuxent River	Eastern Bay*
Potomac River	Pocomoke River*
Rappahannock River	St. Jerome River*
York River	Pamunkey River*
James River	Mobjack Bay*
Cherrystone Inlet*	
COASTAL BAYS	
Chincoteague Bay	
Sinepuxent Bay*	
Virginia Coastal Bays*	
ALBEMARLE-PAMLICO ESTUARINE SYSTEM (APES)	
Chowan River	
Neuse River	

* Intensively-sampled systems

- The Delaware Estuary includes the Delaware Bay and Delaware River. The Delaware Estuary is about a fifth the area of the Chesapeake Bay, and is shallower, better mixed, and more turbid. Although nutrient levels in water have historically been high here, there are relatively few signs of detrimental processes such as algal blooms or severe oxygen depletion that often accompany nutrient enrichment. In part, the naturally turbid waters in the region may be responsible for holding the growth of algae in check. Seagrasses have apparently never colonized the estuary in the past; therefore, there is little concern regarding their present absence. Recent concern is focused on sediments contaminated with metals and organic compounds, and the condition of shellfish, crab, and fish populations.

- The coastal bays in this report refer to representative coastal lagoons, small bays and inlets situated along the Atlantic coast of

Maryland and Virginia. There are no major urban centers here, but the region is intensively farmed. The bays have long flushing times, making them susceptible to the accumulation of pollutants. Boynton, et al. (1993) report that water quality in the Maryland coastal bays is reasonably good in the open waters of the Chincoteague and Sinepuxent Bays, although more restricted parts of the bays suffer algal blooms, low levels of dissolved oxygen, and depleted benthic communities (those living in the sediments). Limited monitoring of sediments in the Maryland coastal bays shows signs of toxic contaminants associated with agricultural pesticide and herbicide use.

- The Albemarle-Pamlico Sound is the second largest estuary in the United States. Included in this estuary are the Albemarle and Pamlico Sounds and the Chowan, Pamlico, and Neuse rivers. The sounds are shallow basins, separated from the sea by barrier islands. Rivers here never drained extensive ice fields; thus they lack a network of deep channels. Because exchange with the sea is limited, the potential effects of excess quantities of nutrients or other pollutants are accentuated. Major concerns over the past decade include increasing incidence of algal blooms, sediments contaminated with toxic materials (e.g., dioxin), and the severe depletion of several species of finfish and shellfish.

- In addition to these large regional estuarine systems, twelve smaller estuaries were intensively sampled in space. These systems include two tributaries of the Delaware River, the heavily-developed Schuylkill River and the Salem River; two threatened rivers in the upper Chesapeake Bay, Severn River and South River; and the Eastern Bay along the eastern upper shore in Chesapeake Bay. Also included are Pocomoke River, site of the harmful outbreak of *Pfiesteria* during the summer of 1997 (the outbreak curtailed the MAIA sampling effort in the river); St. Jerome Creek, Mobjack Bay, and Cherrystone Inlet in lower Chesapeake Bay. Sinepuxent Bay to the north of Chincoteague Bay and numerous sites in the Virginia coastal bays were also measured intensively. Most of these systems are influenced by urban or agricultural development.

The MAIA Program

In 1995, the U.S. EPA Office of Research and Development (ORD) formed a partnership with the U.S. EPA Region 3 to implement a research, monitoring, and assessment program in the mid-Atlantic region. The intention of the program is to perform an environmental assessment of several key natural resources (lakes, streams, forests, agricultural areas, wetlands, and estuaries) in a single region. The study is called the Mid-Atlantic Integrated Assessment and this report is a summary of the estuarine component of the MAIA program. The goals of the MAIA-E program include providing the scientific knowledge needed to make sound environmental decisions in the mid-Atlantic region and making a well-documented and accessible data set available to the public. The program is a partnership of several federal, state, and local governments, non-governmental organizations, and academic institutions in the region.

In 1997, a coordinated monitoring effort was initiated to respond to the information gaps identified during the development of the "Condition of the Mid-Atlantic Estuaries Report" (USEPA 1998). More than 800 stations are included in this current study, most of which belong to the sampling networks of existing monitoring programs in the region. The stations meet the specifications of a probability-based design which was developed by EPA's EMAP (Weisberg, et al. 1993). In a probability-based design, all locations in an estuary have equal chance of being sampled, and the measured results are weighted in proportion to the area represented by the station. Estimates of condition are, therefore, unbiased, and the uncertainty in the estimates can be rigorously quantified. The

MAIA-E program also incorporates the EMAP approach of employing a consistent set of core indicators in all estuarine assessments, a policy that eases comparison with estuarine conditions in other regions and highlights changes in mid-Atlantic estuaries over time. Biologically-based indicators are particularly emphasized because they provide a view of the overall condition of the estuary.

During the summers of 1990-93, EMAP conducted a survey of estuarine conditions of the VP, which extends from Cape Cod through the Chesapeake Bay (Paul, et al. 1999). The EMAP-VP and MAIA-E programs overlapped in the Delaware Bay and Chesapeake Bay. Sampling and analysis methods were comparable for several parameters in both programs. In this report, we examine these two data sets for indications of change from 1990-93 to 1997-98. Other studies based on the EMAP approach were also recently performed in the mid-Atlantic region, including an assessment in the Carolinian Province (Cape Henry, Virginia to Indian River Lagoon on the east coast of Florida; Hyland, et al. 1998) and an assessment of the Delaware and Maryland coastal bays (Chaillou, et al. 1996). We do not look for signs of change in these cases either because too little time had elapsed between the studies or there are an insufficient number of stations in common in the respective programs.

A final goal of this cooperative research program is to develop an integrated monitoring approach that could be adopted in later monitoring efforts. The MAIA-E program served as the model for the Coastal 2000/National Coastal Assessment program, which is presently implemented nationally. The evolution of the monitoring programs (from EMAP, through MAIA-E, to the National Coastal Assessment) is discussed further in Appendix I.

Report Organization

The remainder of the report is organized as follows. Chapter 3 briefly discusses the sampling design and location of stations employed in the program. Chapters 4 through 6 present measured values of thirteen parameters that describe the chemical and biological condition of the estuaries. The chapters are organized to emphasize the issues of greatest concern in the region.

Chapter 4 – Eutrophication
- Total Nitrogen in Surface Water
- Total Phosphorus in Surface Water
- Chlorophyll *a* in Surface Water
- Total Organic Carbon in Sediments
- Water Clarity (Secchi Depth)
- Dissolved Oxygen in Bottom Water

Chapter 5 – Sediment Contamination
- Metal Contamination in Sediments
- Organic Contaminants in Sediments
- Sediment Toxicity (Amphipod Survival)

Chapter 6 – Condition of Living Resources
- Condition of Benthic Community
- Number of Fish Species
- Number of Fish Abnormalities
- Contamination of Fish and Shellfish Tissue

The measured data for each indicator are displayed on maps, employing three categories to show condition. In most cases, the categories are defined in terms of well-established thresholds of impairment, e.g., dissolved oxygen criteria used by states to designate non-compliance. The three categories are labeled “good,” “fair,” and “poor” and colored green, yellow, and red as an aid to interpreting the results. However, a few of the indicators are still under development and lack firm categories of condition. These categories are colored and labeled more neutrally. The criteria for these assessment categories are listed in Table 2-2.

Table 2-2. Indicator Ranges Used to Define Assessment Categories.

Eutrophication in Estuarine Waters	
Indicator Ranges	**Rationale**
Total Nitrogen (in surface water) Low: TN $\leq$ 0.5 mg N/L Intermediate: TN > 0.5 to 1.0 mg N/L High: TN > 1.0 mg N/L	The draft report of the Nutrient Criteria Technical Guidance Report: Estuarine and Coastal Waters recommends using total nitrogen as the measure of N-nutrient availability, but no specific categories of impairment have yet been set (EPA 2001). The thresholds used to define the map categories are the 25th and 75th percentile of all MAIA TN values. The categories are useful when comparing conditions among estuaries but are not unequivocal designations of degradation.
Total Phosphorus (in surface water) Low: TP $\leq$ 0.05 mg P/L Intermediate: TP > 0.05 to 0.1 mg P/L High: TP > 0.1 mg P/L	The Nutrient Criteria Guidance Manual also recommends using Total Phosphorus as the best measure of P-nutrient levels in estuaries (EPA 2001). In lieu of firm thresholds for map categories, this report uses the 25th and 75th percentile values of all data collected in the MAIA program.
Chlorophyll *a* (in surface water) Low: Chl *a* $\leq$ 15 µg/L Intermediate: Chl *a* > 15 to 30 µg/L High: Chl *a* > 30 µg/L	15 µg/L is the SAV restoration goal in parts of Chesapeake Bay (Batiuk *et al.* 2000). Both limits, 15 µg/L and 30 µg/L, have been used in previous Mid-Atlantic assessments, e.g., Chaillou et al. 1996 and Paul et al. 1998.
Total Organic Carbon in Sediments Low: TOC $\leq$ 1% dry weight Intermediate: TOC > 1 to 3% High: TOC > 3%	Analysis of TOC data collected in the EMAP-Virginian Province study indicated that TOC values in the 1 to 3% range were associated with impacted benthic communities, while values less than 1% were not (Paul et al.1999).
Water Clarity (Secchi depth) Clear: Secchi Depth > 1 m Intermediate: Secchi Depth > 0.3 to 1 m Turbid: Secchi Depth $\leq$ 0.3 m	The 1 meter limit is equivalent to the SAV restoration goal in Chesapeake Bay (Batiuk *et al.* 2000), and is comparable to the "Bernie Fowler Sneaker Index", measured annually since 1988 by the former Maryland State Senator. The limits 0.3 and 1.0 m have been used consistently in previous mid-Atlantic assessments.
Dissolved Oxygen (in bottom water) Low: DO $\leq$ 2 mg/L Intermediate: DO > 2 to 5 mg/L High: DO > 5 mg/L	Prolonged exposure to oxygen concentrations less than 5 mg/L may result in altered behavior, reduced growth, adverse reproductive effects, and mortality (Vernberg 1972). Exposure to levels below 2 mg/L from 1 to 4 days causes mortality in most biota (Theede 1973; Brongersma 1957). EPA's proposed salt water quality criteria cite DO thresholds of 2.3 and 4.8 mg/L (EPA 2000). Most states have set their water quality standard for DO at 5 mg/L.
Chemical Contaminants in Sediments	
Indicator Ranges	**Rationale**
Metallic Contamination in Sediments Low: No ERL Exceedances Intermediate: Any ERL Exceedance High: Any ERM Exceedance	ERL (effects range low) and ERM (effects range median) limits are the concentrations of contaminants in sediments that will result in ecological effects 10 and 50% of the time, respectively (Long et al. 1995).
Organic Contaminants in Sediments Low: No ERL Exceedances Intermediate: Any ERL Exceedance High: Any ERM Exceedance	ERL (effects range low) and ERM (effects range median) limits are the concentrations of contaminants in sediments that will result in ecological effects 10 and 50% of the time, respectively (Long et al. 1995).
Sediment Toxicity (amphipod survival) Low Tox: Survival > 80% Intermediate: Survival > 60% to 80% High Tox: Survival $\leq$ 60%	The National Status and Trends and Environmental Mapping and Assessment programs have been conducting surveys of sediment toxicity throughout the US since 1981(Swartz et al. 1985; ASTM 1991), and have consistently used thresholds of 80 and 60% to designate toxic and severely toxic conditions.

Table 2-2 (con't). Indicator Ranges Used to Define Assessment Categories.

Biological Community Condition	
Indicator and Threshold Values	**Justification for Threshold Values**
Benthic Community Index Good Conditions: B.I. > 0 Poor Conditions: B.I. $\leq$ 0	The Benthic Community Index uses discriminant analysis to determine a weighted combination of parameters which distinguish impacted and unimpacted sites in the EMAP-Virginian Province (Paul et al. 1999). A comparable index developed for the Carolinian Province was used to evaluate conditions in the Albemarle-Pamlico Estuarine System. Zero by definition distinguishes good and poor conditions.
Fish Diversity Higher Diversity: > 3 Species Lower Diversity: $\leq$ 3 Species	Fish catch data are sensitive to methodological details; therefore, no critical thresholds are used by assessment programs. In this report, a threshold value of 3 species highlights the lowest third of sites ranked by the number of fish species measured.
Fish Abnormalities No Abnormalities Abnormalities Present	The map categories highlight the absence or presence of abnormalities.
Fish and Shellfish Tissue Contamination No Exceedances Any Exceedances	The number of exceedances is calculated using concentration thresholds issued by the USEPA and American Fisheries Society (EPA 2000).

Chapter 7 summarizes information regarding all parameters in the form of a Report Card that permits ready comparison of conditions across regions. This chapter also compares the MAIA results with the EMAP study conducted a few years earlier in the mid-Atlantic region.

The references used in preparing this report are listed in the References section, page 111. Ten appendices contain information that supplements the main chapters:

A – MAIA Estuaries sampling design

B – MAIA Estuaries methods and indicators

C – Criteria for assessment categories

D – Values presented on maps

E – Percent estuarine area with impairment

F – Statistical correlation coefficients

G – Selected MAIA and EMAP data

H – Index of Environmental Integrity

I – Recommendations for MAIA monitoring

J – MAIA Estuaries Partners

All data measured in the MAIA Estuaries program are available on the web at: http://www.epa.gov/emap/maia/html/data.html

3. Methodology

Background

A number of federal and state agencies have been involved in monitoring a variety of parameters in the mid-Atlantic estuaries. From 1990 to 1993, the U.S. EPA research initiative known as EMAP was active in this geographic area. As data from this effort were assessed, it became apparent that small estuarine systems merited further investigation. In order to facilitate this additional research, partnerships were developed with other agencies actively interested in estuarine science.

Many monitoring programs sponsored by federal and state agencies are geographically based within the mid-Atlantic region. The Chesapeake Bay Program (CBP) in conjunction with the states of Maryland and Virginia has been active in monitoring the Bay since the program inception in 1984. The Delaware River Basin Commission, in cooperation with the states of Delaware, New Jersey and Pennsylvania, has conducted monitoring studies on the Delaware River and Bay for a number of years. Individual states have also designed and implemented complementary monitoring programs. In the case of other federal agencies, the National Park Service (NPS) has an ongoing program to monitor in the Assateague National Seashore, a large preserve on the Delmarva peninsula. The National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce has been active in monitoring both estuarine and marine environments through the National Status and Trends (NS&T) program and other initiatives.

In order to accomplish the MAIA Estuaries project, partnerships have been forged among the federal and state agencies listed in Table 3-1. These partnerships recognize that each of the governmental entities plays an important and vital role in estuarine monitoring. Shared experiences, data, and information contribute to the system-wide approach that was implemented.

Table 3-1. Federal and State Partners in the Monitoring of Mid-Atlantic Estuaries.

MAIA Partners
U.S. Environmental Protection Agency - Offices of Research and Development, of Water, and of Policy, Planning, and Evaluation; Regions II, III, and IV
Chesapeake Bay Program
Department of Commerce - National Oceanic and Atmospheric Administration
Department of the Interior - National Park Service and U.S. Fish and Wildlife Service
States of Delaware, Maryland, North Carolina, Virginia, New Jersey, and Pennsylvania
Delaware River Basin Commission
National Estuary Programs - Delaware Estuary Program, Delaware Inland Bays Program, Maryland Coastal Bays Program, Albemarle-Pamlico National Estuary Program

Field Activities in 1997 and 1998

Over 700 sampling sites were visited during the summer of 1997 to assess water and sediment quality. These sites were selected using statistical survey designs (random selection, refer to Appendix A for details). Figure 3-1 presents the geographic distribution of these sampling sites for water and sediment quality. One of the objectives of this project was to investigate small estuarine systems; twelve of these systems were selected for spatial intensification of sampling (Table 3-2). These systems were selected both by random selection and input from environmental managers.

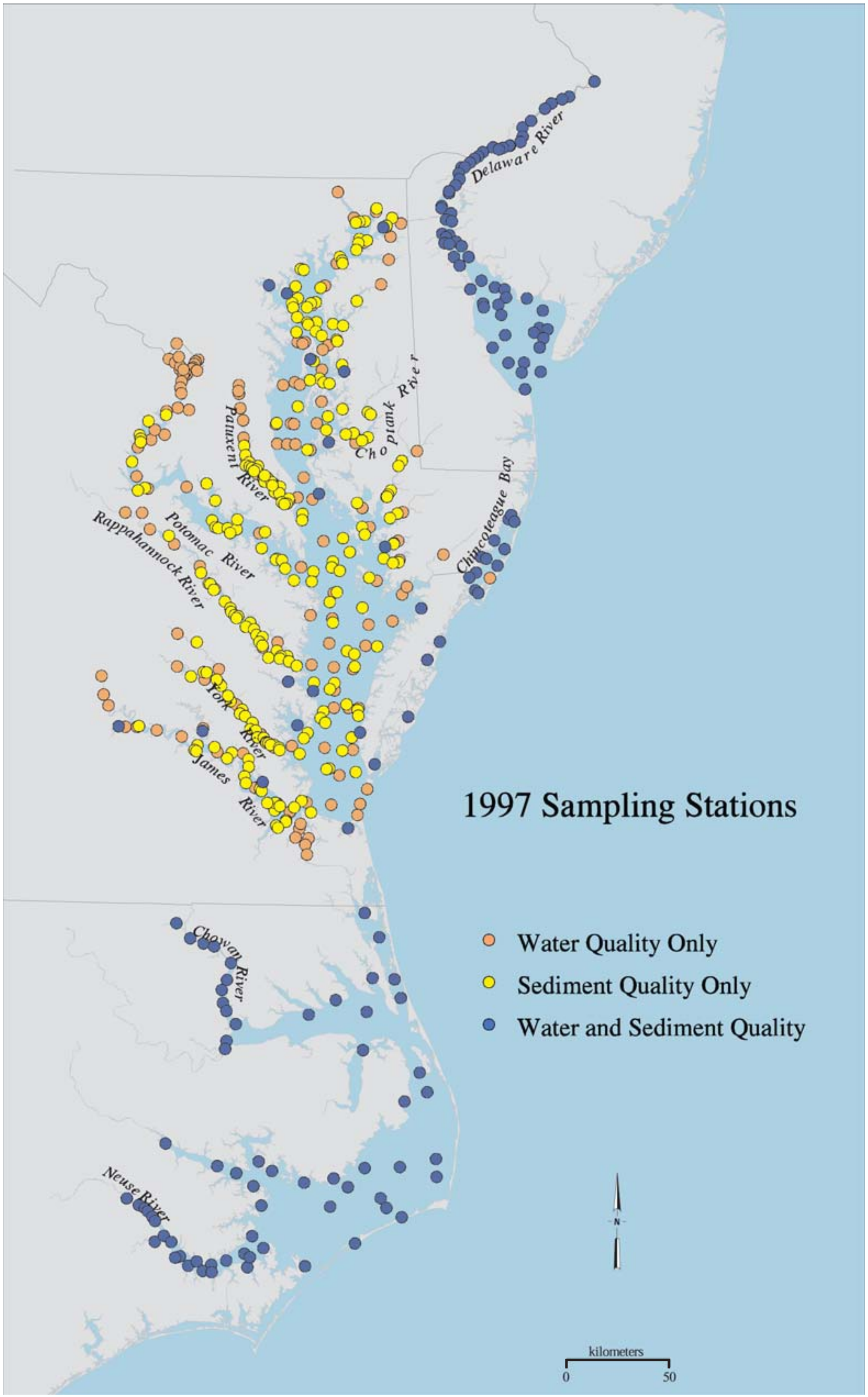

Figure 3-1. MAIA Stations Sampled During Summer 1997 in the MAIA Program.

Approximately 110 sampling sites were visited during the summer of 1998, with fish trawling conducted at 80 sites. Figure 3-2 shows the locations of the 1998 stations.

Table 3-2. Estuarine Systems Selected for Spatial Intensification of Sampling.

Intensively Sampled Systems	# of sites	
Delaware Estuary:		
Salem River	10	
Schuylkill River	10	
Delmarva Coastal Bays:		
Sinepuxent Bay	5	
Virginia Coastal Bays	11	
Chesapeake Bay:		
Severn River	29	
South River		27
Pocomoke River	5	
Mobjack Bay	10	
Cherrystone Inlet	10	
Saint Jerome Creek		10
Pamunkey River	11	
Eastern Bay		10

MAIA Indicators

A unique aspect of this collaborative project was the sampling for a set of consistent measurements across the mid-Atlantic estuaries by all of the partners conducting the sampling and analysis. The list of the parameters collected was developed in conjunction with federal, state, and county partners to address critical scientific issues affecting these estuaries. These parameters focus on many aspects of the estuarine biotic community, both plants and animals, as well as provide important information about the exposure to stresses in the estuarine environment. In general, the measurements include data on fish and shellfish, benthic (bottom-dwelling) community structure, water quality, toxic contaminants in bottom sediment, and sediment toxicity. A complete list of all parameters measured in the MAIA program is included in Table 3-3.

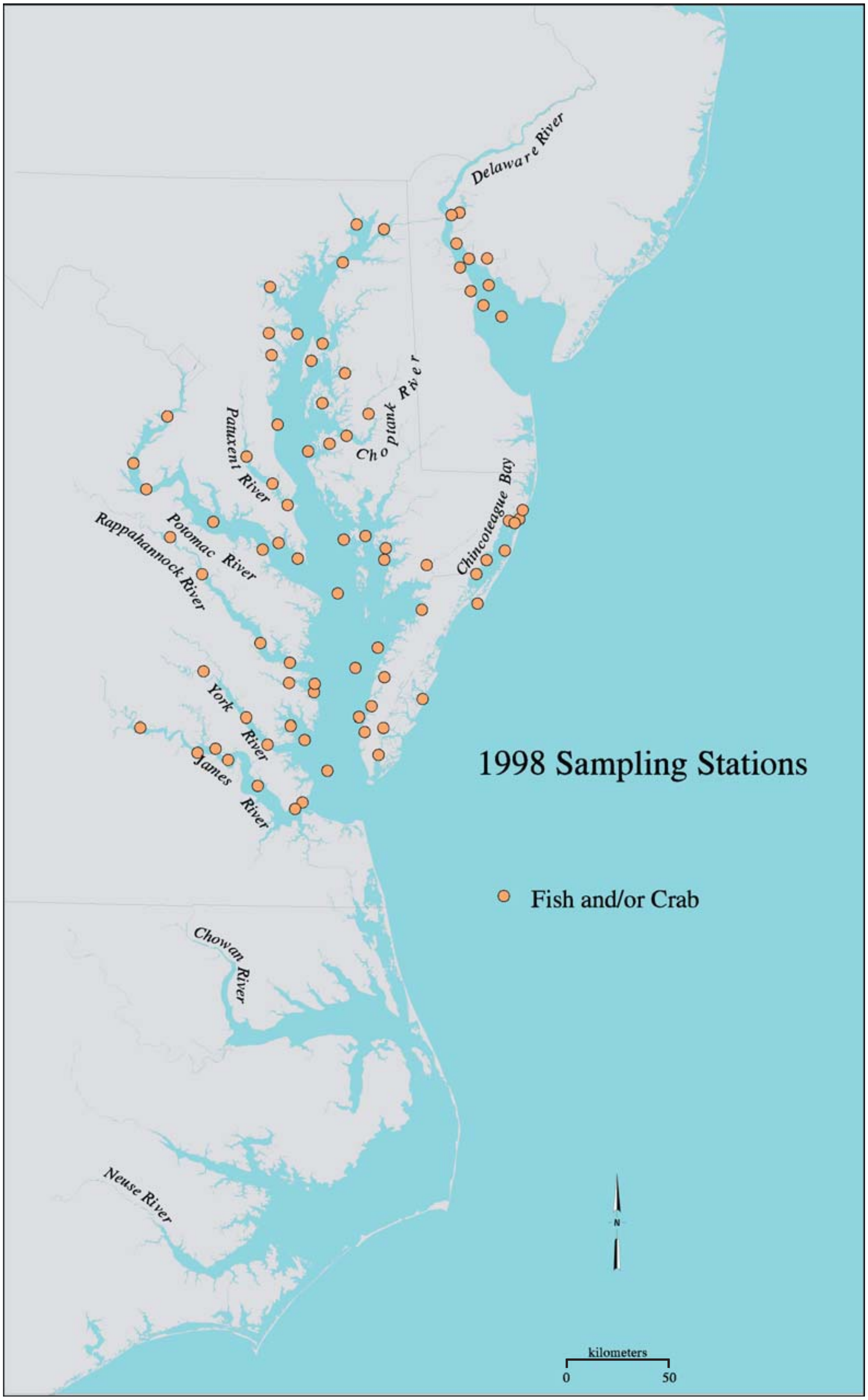

Figure 3-2. MAIA Stations Sampled During Summer 1998 in the MAIA Program.

Table 3-3. Suite of Indicators Measured by Partners in MAIA Estuaries in 1997-98.

Location (latitude and longitude)
Time and Date of Sampling
Depth of Water Column
Water Column Measurements (Water Quality)

Physical measurements (surface and bottom; water column profiles at some stations)

Temperature	Conductivity
Salinity	Water Clarity (Secchi disk or turbidity)
Dissolved oxygen	(measured once per station)
pH	

Water Column Chemistry (surface and bottom)

Dissolved silica	Dissolved orthophosphate
Dissolved ammonia	Total particulate phosphorus
Dissolved nitrite and nitrate	Particulate organic carbon
Dissolved nitrite	Total suspended solids
Particulate organic nitrogen	Chlorophyll *a*
Total dissolved nitrogen	Pheaophytin
Total dissolved phosphorus	

Sediment Measurements (Sediment Quality)

- Benthic macroinvertebrates (1997 emphasis)
- Species composition and enumeration
- Biomass
- Silt-clay content (% silt/clay)
- Observational SAV (in conjunction with benthic grab)
- Sediment Chemistry (1997 emphasis)
  - NOAA NS&T contaminants (see table below)
  - Acid volatile sulfides (AVS) and simultaneously extractable metals (SEM)
  - Silt-clay content (% silt/clay)
  - Total organic carbon
- Sediment Bioassay (1997 emphasis)
  - Pore water concentrations of ammonia and hydrogen sulfide
  - Microtox® sediment toxicity
  - *Ampelisca abdita* sediment toxicity

Fish/Shellfish Measurements (1998 emphasis)

- Fish tissue contaminants
- Fish community
- External pathology
- Macrophage aggregates
- Crab hemolymph^{2+}, Tributyltin, Tetrabutyltin

Table 3-3 (con't). Suite of Indicators Measured by Partners in MAIA Estuaries in 1997-98.

Organic contaminants and major trace elements measured in sediments.
List is as used in NOAA NS&T program (Valette-Silver 1992)

Polycyclic Aromatic Hydrocarbons

Low molecular weight PAHs (2- and 3-ring structures)	**High molecular weight PAHs** (4-, 5-, and 6-rings)
1-Methylnaphthalene	Benzo[a]anthracene
1-Methylphenanthrene	Benzo[a]pyrene
2-Methylnaphthalene	Benzo[b]flouranthene
2,6-Dimethyl naphthalene	Benzo[e]pyrene
1,6,7-Trimethylnaphthelene	Benzo[ghi]perylene
Acenaphthene	Benzo[k]flouranthene
Acenaphthylene	Chrysene
Anthracene	Dibenz[a,h]anthracene
Biphenyl	Flouranthene
Fluorene	Indeno[1,2,3-cd]pyrene
Naphthalene	Perylene
Phenanthrene	Pyrene

Chlorinated Pesticides

2,4'-DDD	Endosulfan I
2,4'-DDE	Endosulfan II
2,4'-DDT	Endrin
4,4'-DDD	alpha-Hexachlorohexane
4,4'-DDE	gamma-Hexachlorohexane (lindane)
4,4'-DDT	Heptachlor
Aldrin	Heptachlor epoxide
beta-Hexachlorohexane	Hexachlorobenzene
Chlorpyrifos	Mirex
cis-Chlordane	Oxychlordane
cis-Nonachlor	trans-Chlordane
delta-Hexachlorohexane	trans-Nonachlor
Dieldrin	

Polychlorinated Biphenyl congeners (UPAC numbering system)

PCB 8, PCB 18, PCB 28, PCB 44, PCB 52, PCB 66, PCB 101, PCB 105, PCB 118/108/149, PCB 128, PCB 138, PCB 153, PCB 170, PCB 180, PCB 187/182/159, PCB 195, PCB 206, PCB 209

Major and trace elements

Al, Si, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Sb, Ag, Cd, Hg, Tl, Pb

Organotins

Monobutyltin^{3+}, Dibutyltin