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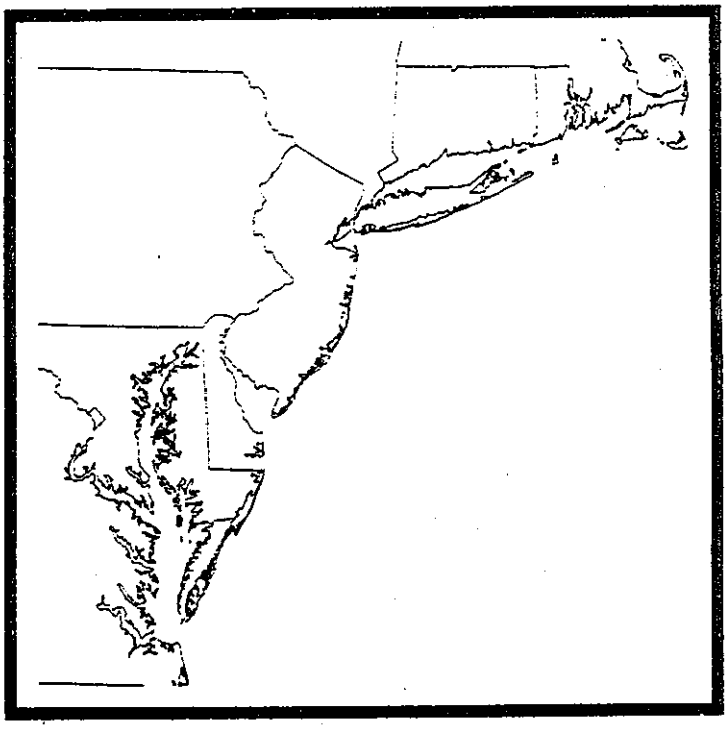
Statistical Summary

EMAP-Estuaries Virginian Province-1991



EMAP

Environmental Monitoring and Assessment Program

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March 1994

Statistical Summary
EMAP-Estuaries
Virginian Province - 1991

by

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ABSTRACT

Annual monitoring of indicators of the ecological condition of bays and estuaries within the Virginian Province (Cape Cod, MA to Cape Henry, VA) was conducted by the U.S. EPA's Environmental Monitoring and Assessment Program (EMAP) during July, August, and September, 1991. Data were collected at 154 stations within the Province. Indicators monitored included water quality (temperature, salinity, water clarity, and dissolved oxygen concentration), sediment contamination, sediment toxicity, benthic community structure, fish community structure, fish gross external pathology, and fish tissue contamination. Data are used to estimate the current status of the ecological condition of Virginian Province estuarine resources, and provide a baseline for identifying future trends. Cumulative distribution functions (CDFs) and bar charts are utilized to graphically display data. Estimates, with 95% confidence intervals, are provided of the areal extent of degraded resources within the Province for those indicators where "degradation" can be defined. Data are also presented by estuarine class: Large estuaries, small estuarine systems, and large tidal rivers. Included, as an appendix, are sub-population estimates for Chesapeake Bay and Long Island Sound.

KEY WORDS: EMAP; Environmental Monitoring and Assessment Program; Environmental Monitoring; Virginian Province; Indicators (biology); Estuaries; Estuarine pollution.

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EXECUTIVE SUMMARY

The Environmental Monitoring and Assessment Program (EMAP) is a nationwide program initiated by EPA's Office of Research and Development (ORD). EMAP was developed in response to the demand for information about the degree to which existing pollution control programs and policies protect the nation's ecological resources.

EMAP-Estuaries (EMAP-E) represents one portion of EMAP's efforts in near-coastal environments. These efforts are designed to provide a quantitative assessment of the regional extent of coastal environmental problems by measuring status and change in selected indicators of ecological condition. Specific issues investigated include:

- hypoxia,
- sediment contamination,
- coastal eutrophication, and
- habitat loss.

In 1990, EMAP-E initiated a demonstration project in the estuaries of the Virginian Province. The 1991 field season represents the second year of sampling in the Province, which includes the coastal region of the Northeast United States from Cape Cod south to the mouth of Chesapeake Bay. It is composed of 23,574 km^2 of estuarine resources including 11,469 km^2 in Chesapeake Bay and 3,344 km^2 in Long Island Sound.

Estuarine resources in the Virginian Province were stratified into classes by physical dimension for the purposes of sampling and analysis. Large estuaries in the Virginian Province were defined as those estuaries greater than 260 km^2 in surface area and with aspect ratios (*i.e.*, length/average width) of less than 18. The areal extent of large estuaries in the Province was 16,097 km^2. Large tidal rivers were defined as that portion of the river that is tidally influenced (*i.e.*, detectable tide > 2.5 cm), greater than 260 km^2, and with an aspect ratio of greater than 18. Approximately 2,602 km^2 were classified as tidal rivers. The third class was the small estuaries and small tidal rivers which were those systems whose surface areas fell between 2.6 km^2 and 260 km^2. This class represented 4,875 km^2 of the Virginian Province.

Three field crews sampled 154 of the scheduled 155 sites in the Virginian Province during the seven-week sampling period beginning on July 22, 1991. Of these, 102 were "Base Sampling Sites" (BSS) which were the probability-based sites selected according to the EMAP-E design for assessing the condition of the estuarine resources of the Province (see Appendix A). Only data collected at these sites were used in the generation of this report.

Field crews collected data and samples for three categories of "ecological indicators": Biotic condition, abiotic condition, and habitat which are described in Appendix A.

The 1991 data reported in this document represent only one year of sampling of a four-year cycle; *i.e.*, the total number of samples needed by EMAP to characterize the Province are sampled over a four-year period (Holland, 1990). Therefore, the reader must use these data carefully, and be aware that the proportion of degraded area calculated for 1991 may differ somewhat from the regional assessment to be generated following the completion of the four-year cycle.

All EMAP-Virginian Province (EMAP-VP) data used in the generation of this report were subjected to rigorous quality assurance measures as described in the 1991 Quality Assurance Project Plan (Valente and Schoenherr, 1991).

Biotic Condition Indicators

Biotic condition indicators are characteristics of the environment that provide quantitative evidence of the status

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of ecological resources and biological integrity of a sample site from which they are collected (Messer, 1990). Ecosystems with a high degree of biotic integrity (*i.e.*, healthy ecosystems) are composed of balanced populations of indigenous benthic and water column organisms with species compositions, diversity, and functional organization comparable to undisturbed habitats (Karr and Dudley, 1981; Karr *et al.*, 1986).

A benthic index which uses measures of individual health, functionality, and community condition to evaluate the condition of the benthic assemblage was utilized in the assessment of biological resources of the Virginian Province. The index under development was determined from the combined 1990/1991 data and is assumed to represent a combination of ecological measurements that best discriminates between good and poor ecological conditions. The reader should be cautioned that this index has not yet been validated with an independent dataset, and therefore, should be used with caution.

A benthic index critical value of zero was determined from the combined 1990/1991 Virginian Province dataset. Fourteen (± 6) percent of the bottom area of the Virginian Province sampled in 1991 had an index value of < 0, indicating likely impacts on the benthic community (Figure 1). The lowest incidence was found in the large estuaries (6 ± 7%), and the highest in small estuaries (32 ± 17%).

"Standard" fish trawls (trawling at a specified speed for a specified time) were performed at each station to collect information on the distribution and abundance of fish. Because many factors influence fish abundance, poor catch may not be an indication of degraded conditions, but simply the natural habitat. Catches of <10 fish/trawl (catch per unit effort) occurred at stations representing approximately 31 ± 10% of the Province, and "high" catches (>100 fish/trawl) were experience in approximately 18 ± 9% (Figure 2). Tidal rivers produced the greatest percent area with "high" catches.

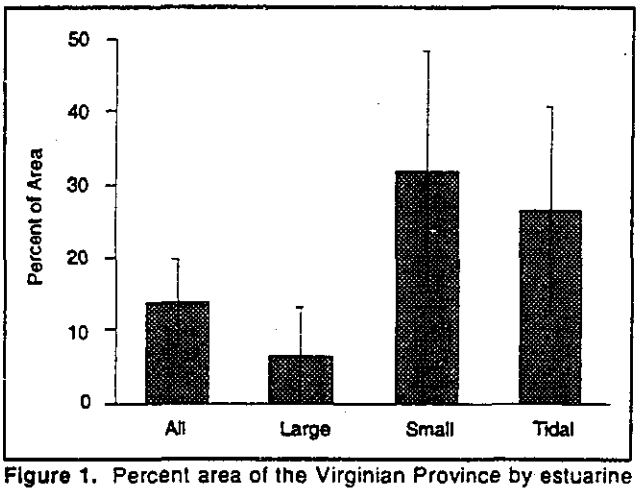

Figure 1. Percent area of the Virginian Province by estuarine class with a benthic index value below 0 in 1991. (Error bars represent 95% confidence intervals).

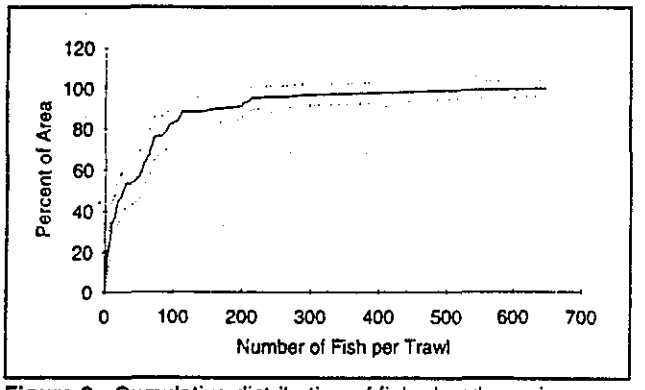

Figure 2. Cumulative distribution of fish abundance in numbers per standard trawl as a percent of area in the Virginian Province, 1991. (Dashed lines are the 95% confidence intervals).

The incidence of the gross external pathologies; growths, lumps, ulcers, and fin erosion, among "target" species in the Virginian Province in 1991 was 0.6%. Of the 2,513 fish examined, 16 were identified as having one or more of these pathologies. These individuals were collected at six of the 101 base stations sampled during the index period (one additional station could not be sampled). It should be noted that fewer than half of these pathologies were verified by an expert pathologist.

Eighty-four composites of up to five individuals of target species were analyzed for contaminants in muscle. No sample exceeded FDA action limits (or, where FDA action limits were not available, international limits) for any of the organic analytes for which criteria were available (see Table 3-2). Several metals (arsenic, chromium and selenium) exceeded criteria values, with the highest incidence of exceedences being measured for arsenic. Fourteen of the 82 composite samples analyzed for metals (two samples were lost) exceeded the mean of international criteria values for As (2 µg/g wet weight).

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Abiotic Condition Indicators

Abiotic condition indicators historically have been the mainstay of environmental monitoring programs, because these indicators quantify the levels of stresses to which organisms are exposed.

One potential stress to aquatic organisms is a low concentration of dissolved oxygen (DO). Two and five mg/L are values employed by EMAP to define severe and moderate hypoxia, respectively. Approximately 18 ± 8% of the sampled area of the Province lies in waters with bottom DO concentrations less than or equal to 5 mg/L (Figure 3). "Bottom" is defined as one meter above the sediment-water interface. Approximately 5 ± 5% of the sampled area exhibited bottom DO conditions ≤2 mg/L. Dissolved oxygen conditions ≤ 2 mg/l were evident in 4 ± 6, 1 ± 2, and 15 ± 28% of the area of the large estuaries, small estuaries, and large tidal rivers sampled within the Province, respectively.

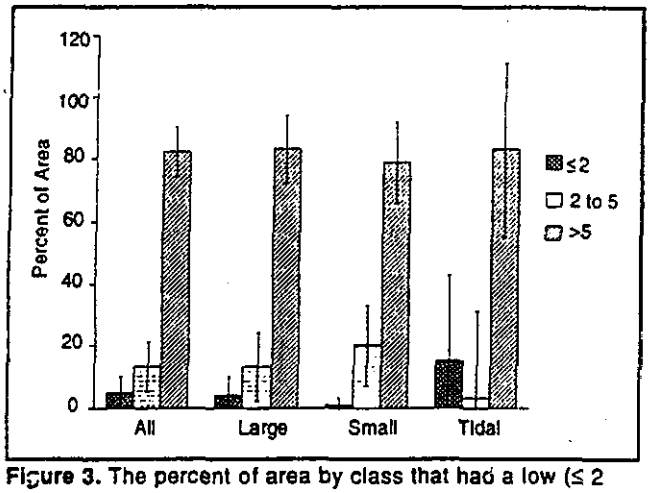

Figure 3. The percent of area by class that had a low (≤ 2 mg/L), medium (2 to 5 mg/L), or high (>5 mg/L) oxygen concentration in the bottom waters. (Error bars represent 95% confidence intervals).

In addition to measuring individual stressors (*i.e.*, individual chemical analytes) sediment toxicity tests were performed on sediments collected at each site to determine if they were toxic to the tube-dwelling amphipod, *Ampelisca abdita*. Sediments were classified as toxic if amphipod survival in the test sediment was less than 80% of that in the control sediment. Approximately 21 ± 10% of the sampled area of the Virginian Province contained sediments which were toxic to the amphipod during 10-day exposures (Figure 4).

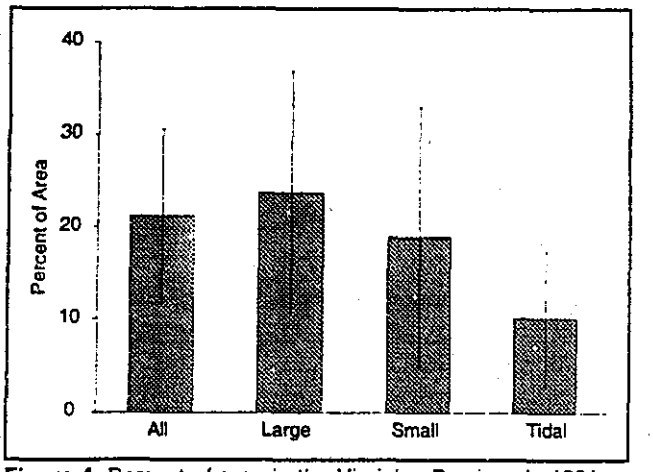

Figure 4. Percent of area in the Virginian Province in 1991, by estuarine class, with low amphipod survival (<80% of control) in sediment toxicity tests. (Error bars represent 95% confidence intervals).

Sediments collected at each station were analyzed for both organic contaminants and metals. Because of the complex nature of sediment geochemistry, the ecological impact of elevated contaminant levels is not well understood. Therefore, no attempt is made to estimate the overall aerial extent of sediment contamination in the Virginian Province.

Figure 5 shows the distribution of the sum of measured polycyclic aromatic hydrocarbons (PAHs) in the Virginian Province. The complete list of analytes included in this summation can be found in Section 3. Approximately 94 ± 6% of the Province has concentrations of PAHs below 4,000 ng/g dry weight, with a maximum measured concentration at any station of 80,100 ng/g.

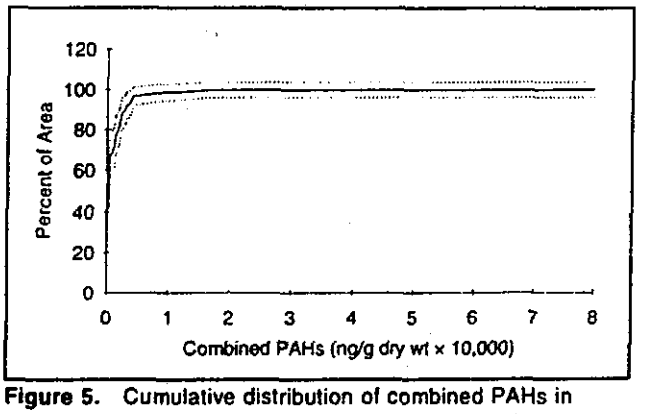

Figure 5. Cumulative distribution of combined PAHs in sediments as percent of area in the Virginian Province, 1991. (Dashed lines are the 95% confidence intervals).

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Draft EPA Sediment Quality Criteria (SQC) are currently available for the PAHs acenaphthene, phenanthrene, and fluoranthene; and the pesticide dieldrin. Exceedences of the PAH criteria were measured at only three stations within the Province (2 ± 5% of the area). The station representing the largest area was located in a shipping channel at the mouth of Chesapeake Bay in a sandy environment. Sediments from this station did not show any toxicity, and the benthic community was indicative of a healthy environment. All evidence suggests that this exceedence was an artifact, possibly due to a "chip" of material dislodged from the smokestack of a passing ship. Eliminating this station results in 0 ± 0%, 0.3 ± 5% (one station) and 0.4 ± 4% (two stations) of the sampled area of the Province exceeding SQC for acenaphthene, phenanthrene and fluoranthene, respectively. No station sampled in 1991 exceeded the SQC for dieldrin.

The extent to which polluting activities have affected concentrations of metals in sediments is complicated by the natural variation of metals in sediments. Crustal aluminum concentrations are generally many orders of magnitude higher than anthropogenic inputs; therefore, aluminum can be used to "normalize" for differing crustal abundances of trace metals (see Appendix A for a description of the normalization process). Figure 6 presents the results of this normalization. Approximately 41 ± 10% of the area of the Province showed enrichment of sediments with at least one metal. Thirty five (± 14), 53 ± 22, and 51 ±23 percent of the large estuary, small estuary, and large tidal river class areas sampled contained sediments with metals concentrations exceeding predicted background levels. This only shows the percent of the Province with elevated concentrations of metals, and does not indicate the magnitude of enrichment, *i.e.*, this does not imply concentrations are elevated to the point where biological effects might be expected.

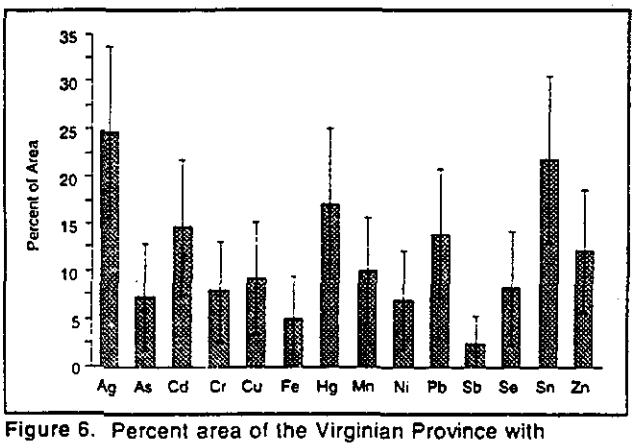

Figure 6. Percent area of the Virginian Province with enriched concentrations of individual metals in sediments in 1991. (Error bars represent 95% confidence intervals).

Presence of marine debris in fish trawls was documented by field crews as being encountered at stations representing 18 ± 8% of the Virginian Province area (Figure 7). The small estuary class had the largest percent area (35 ± 17%) where trash was found.

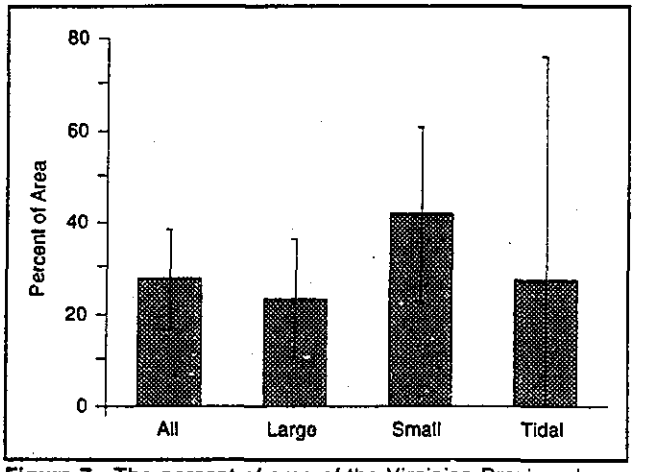

Figure 7. The percent of area of the Virginian Province by estuarine class where anthropogenic debris was collected in *fish trawls, 1991.*

Habitat Characterization

Habitat indicators describe the natural physical and chemical conditions of the sites sampled. These parameters are important modifying factors controlling both abiotic and biotic condition indicators.

Figure 8 shows the distribution of water depth in the Virginian Province. The area shallower than 2 m is underestimated because this was the minimum depth sampled.

Based on the sampling design where a single station represents a statistical area (*e.g.*, 70 km^2 for large estuary sites), 12% of the area of large estuaries of the Province to be sampled in 1991 was unsampleable due to inadequate water depth. Small systems were considered unsampleable if the water depth did not exceed 2 m anywhere in the system. Such systems account for approximately 1.5% of the area of small systems in the Virginian Province. No large tidal river stations were unsampleable due to water depth in

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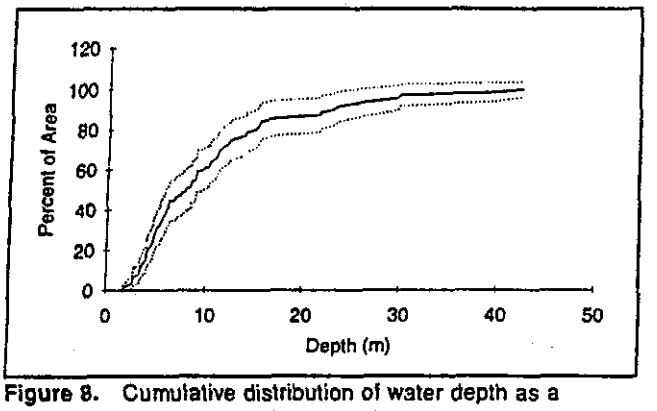

Figure 8. Cumulative distribution of water depth as a percent of area in the Virginian Province, 1991. (Dashed lines are the 95% confidence intervals).

1991. Overall, 9% of the area of the Province to be sampled in 1991 was deemed unsampleable due to water depth.

Bottom water temperature in the Virginian Province ranged from 16.2°C to 30.0°C during the summer sampling season.

Figure 9 illustrates the distribution of oligohaline (<5 ‰ salinity), mesohaline (5-18‰), and polyhaline (>18‰) water in the Virginian Province and by estuary class.

Vertical density differences (a function of both salinity and temperature) in the waters of the Virginian Province can be large enough to result in a reduction in mixing between surface and bottom waters, potentially allowing the bottom waters to become hypoxic. Degree of stratification in the Virginian Province was measured as the delta (Δ) σ_t, which is the σ_t (sigma-t density) difference between surface and bottom waters. Approximately 76 ± 10% of the Province area had a $\Delta\sigma_t$ of <1 unit; thus the majority of the water in the Virginian Province was well-mixed (Figure 10). Only 7 ± 7% of the Province area was strongly stratified ($\Delta\sigma_t$ >2).

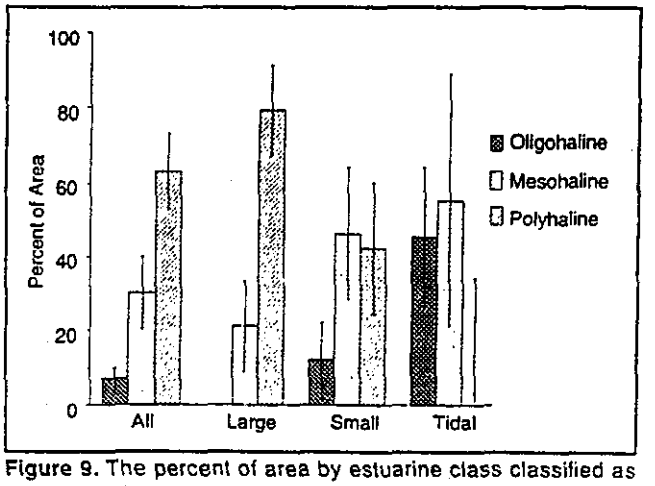

Figure 9. The percent of area by estuarine class classified as oligohaline (<5 ppt), mesohaline (5 to 18 ppt), and polyhaline (>18 ppt). (Error bars represent 95% confidence intervals).

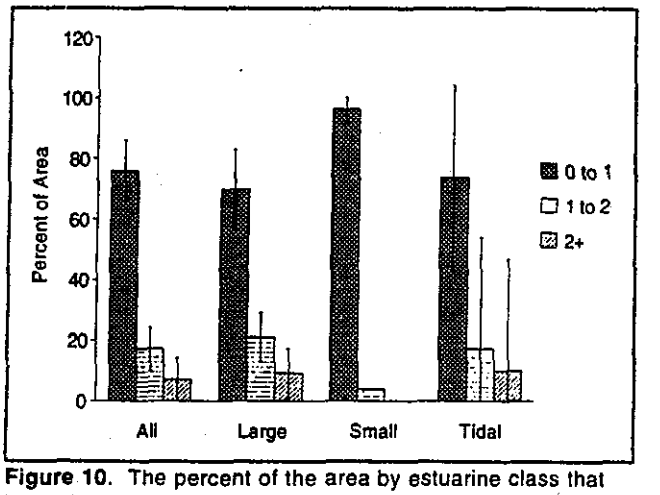

Figure 10. The percent of the area by estuarine class that had a low (<1), medium (1 to 2), or high (>2) degree of stratification ($\Delta\sigma_t$). (Error bars represent 95% confidence intervals).

Water clarity was determined from light extinction coefficients, which describe the attenuation of light as it passes vertically through the water column. We are defining low water quality as water in which a diver would not be able to see his/her hand when held at arms length in front. Moderate water clarity, in terms of human vision, is defined as water in which a wader would not be able to see his/her feet in waist deep water.

Water clarity was good in 80 ± 7% of the area of the Virginian Province (Figure 11). Water of low clarity was found in 8 ± 6% of the Province and an additional 12 ± 7% had water of moderate clarity.

The silt-clay (mud) content of sediments (the fraction <63μ particle diameter) is an important factor determining the composition of the biological community at a site; and is therefore important in the assessment of the benthic community. The distribution of mud (>80% silt-clay) vs sand (<20% silt-clay) is illustrated in Figure 12.

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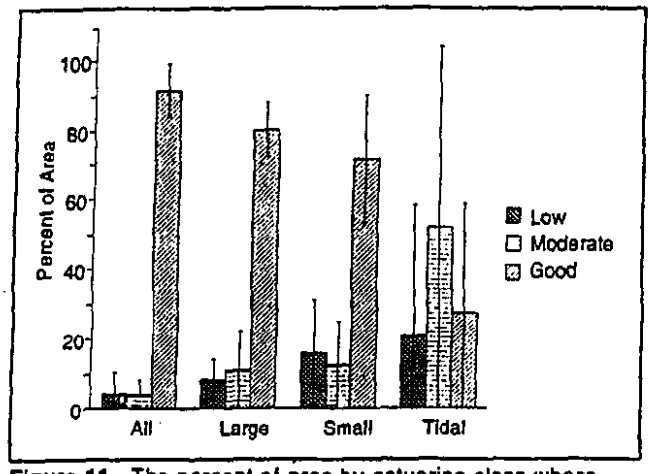

Figure 11. The percent of area by estuarine class where water clarity was poor, moderate, or good. (Error bars represent 95% confidence intervals).

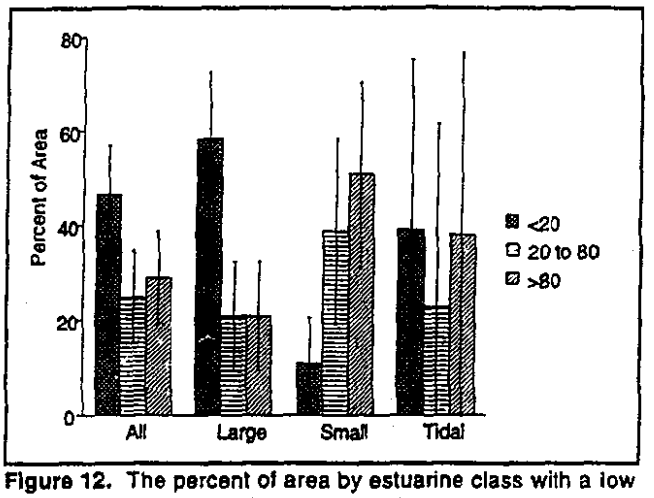

Figure 12. The percent of area by estuarine class with a low (<20), medium (20 to 80), or high (>80) percent silt-clay in the sediments. (Error bars represent 95% confidence intervals).

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