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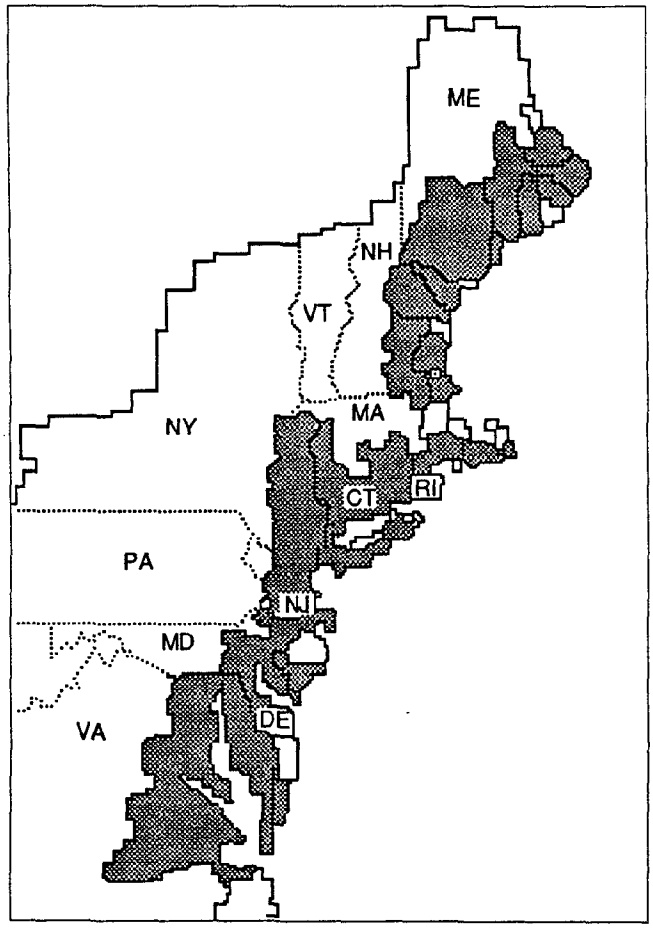
Strategic Assessment of Near Coastal Waters

Susceptibility of East Coast Estuaries to Nutrient Discharges: Passamaquoddy Bay to Chesapeake Bay

SUMMARY REPORT



NOAA/EPA Team
on Near Coastal Waters

June 1989

National Estuarine Inventory

The National Estuarine Inventory (NEI) is a series of related activities of the Strategic Assessment Branch (SAB), Office of Oceanography and Marine Assessment (OMA), National Oceanic and Atmospheric Administration, (NOAA), to develop a national estuarine data base and assessment capability. The NEI was initiated in June 1983 as part of NOAA's program of strategic assessments of the Nation's coastal and oceanic resources.

The cornerstone of the NEI is the National Estuarine Inventory Data Atlas. Volume 1, completed in November 1985, identifies 92 of the most important estuaries and subestuaries of the contiguous USA. The atlas presents information through maps and tables on physical and hydrologic characteristics of each estuary, and specifies a commonly derived spatial unit for all estuaries, the estuarine drainage area (EDA), for which data are compiled (see inside back cover for a sample map). These estuaries represent approximately 90 percent of the estuarine water surface area and 90 percent of the freshwater inflow to estuaries of the East Coast, West Coast, and Gulf of Mexico.

The data base and assessment capabilities under development are part of an evolving process. Estuaries are being added to the inventory, especially along the West Coast and in the Gulf of Mexico, and refinements are being made to the physical and hydrologic data presented in Volume 1. Estimates of additional estuarine attributes, such as volume by salinity zone, flushing rates, and length and characteristics of shoreline have been added to the data base.

Other volumes in the NEI data atlas series are Volume 2, Land Use Characteristics; Volume 3, Coastal Wetlands, and Volume 4, Public Recreational Facilities in Coastal Areas. Information from these atlases and other NOAA projects is being incorporated into the NEI through a NOAA geographic information system. The other NOAA projects are the National Coastal Pollutant Discharge Inventory, the National Shellfish Register and related projects; and the Estuarine Living Marine Resources project.

National Coastal Pollutant Discharge Inventory Program

The National Coastal Pollutant Discharge Inventory (NCPDI) Program is a series of data base development and analytical activities within NOAA's Strategic Assessment Branch (SAB) that assess the sources, magnitude, and impact of pollutant discharges within the Nation's coastal and estuarine areas. The cornerstone of the program is a comprehensive data base and computational framework that has been developed over the last eight years. The data base contains pollutant loading estimates for all major categories of point, nonpoint, and riverine sources located in coastal counties, or the 200-mile Exclusive Economic Zone, that discharge to the estuarine, coastal, and oceanic waters of the contiguous USA (excluding the Great Lakes). The NCPDI Program is part of NOAA's program of strategic assessments of the Nation's coastal and oceanic regions.

The pollutant discharge estimates in the NCPDI are made for the base year 1982, but can be considered to approximate pollutant discharge conditions during the period 1980-85. Estimates are made for 18 pollutants in nine major categories: 1) wastewater; 2) oxygen-demanding materials; 3) particulate material; 4) nutrients; 5) heavy metals; 6) petroleum hydrocarbons; 7) chlorinated hydrocarbons; 8) pathogens; and 9) sludges. The pollutant estimates can be aggregated by county, hydrologic cataloging unit, or estuarine drainage area.

A series of projects is currently underway within the NCPDI Program to improve and refine the estimates for selected pollutant source categories and coastal areas. These improvements include: expanding the study area to include more inland areas within estuarine drainage basins, updating the base year to 1987; using improved methods to estimate discharge, and adding a number of toxic pollutants to the inventory. In addition, projects are being undertaken to assess the impact of management practices on nonpoint source pollutant discharges and to develop computer applications that allow a user to better access and query the data base.

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PLEASE NOTE

Seventeen of the 23 estuarines in this report were included in a similar NOAA/EPA report, Strategic Assessment of Near Coastal Waters, Northeast Case Study, Chaper 3, published in July 1988. They have been repeated in this report for two reasons. First, for some estuaries there have been revisions to the nutrient discharge estimates, dissolved concentration potential values, or discharge estimates necessary to change estimated nutrient concentration. Second, the set of estuaries in this report coincide with those in the Northeast section of NOAA's National Estuarine Inventory with one exception, Massachusetts Bay has replaced Boston Bay.

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CONTENTS

Introduction

This report summarizes estimates of the relative susceptibility and status of twenty-three estuaries on the East Coast from Maine through Virginia with respect to nutrient-related pollution (figure 1). It is the third report in a series being developed to assist the U.S. Environmental Protection Agency implement its Near Coastal Waters and National Estuary Programs. It follows a case study for estuaries in the northeast (NOAA/EPA, 1988) and a similar assessment for estuaries in the Gulf of Mexico (NOAA/EPA, 1989). The information in this report is intended to increase understanding of coastal environmental problems and to serve as a screening tool for coastal resource decision-making.

The initial NOAA/EPA (1988) report includes background information on eutrophication, additional information on the dissolved concentration potential of estuaries, and detailed information on nutrient sources, discharge estimation methods, and nutrient loads. The reader is referred to NOAA/EPA (1988) for these discussions which are abbreviated or omitted here.

Two additional reports are being prepared for the estuaries along the West Coast and estuaries along the East Coast from North Carolina through Florida. These reports are being developed primarily on the basis of data compiled in NOAA's National Estuarine Inventory (NEI) and National Coastal Pollutant Discharge Inventory (NCPDI) Program.

A one-page summary is included for each of the twenty-three estuaries in the East Coast region from Passamaquoddy Bay through Chesapeake Bay. Each summary contains information on significant physical and hydrologic features, estimations of nutrient loading, pollution susceptibility, and nutrient concentrations, along with a narrative to assist the reader in interpreting the data.

Background

Eutrophication. Eutrophication is an over-abundance of nutrients (from natural or man-made sources) which may induce massive algal blooms and, due to subsequent algal decay, may result in the emission of noxious odors, depletion of dissolved oxygen in the water, and mass mortality of finfish and shellfish, among other problems. Important factors influencing eutrophication include the nutrient loads (chiefly nitrogen and phosphorus) and physical and hydrologic characteristics that affect nutrient distribution and concentration.

Towards Assessing Eutrophication Potential. Estimates of nutrient discharges and calculations of pollution susceptibility and nutrient concentration may indicate the potential for eutrophication within an estuary. This report presents estimates of annual loads of nitrogen and phosphorus entering each estuary in the region along with each estuary's flushing/dilution characteristics as based upon flushing time and estuarine volume. From these estimates average nutrient concentrations are predicted for each estuary. These data may provide a relative indication of which estuaries are more likely to experience high nutrient levels and, therefore, which may have greater potential for a eutrophication problem. However, the degree to which eutrophic conditions occur in an estuary is influenced by additional factors that affect nutrient concentration which are not specifically quantified here. These factors include nutrient recycling as well as temporal changes in loading (e.g. reduced agricultural runoff) and in hydrologic characteristics (e.g. fluctuation in freshwater inflow and periodic stratification) within each estuary.

It is important to note that assessments made in this and other reports in the series are based on estimated estuarine characteristics and nutrient loadings. Hence, they do not reflect actual estuarine measurements of nutrient concentration or documented symptoms of eutrophication. Standardized and quantitative long-term records of total nutrient discharges and concentrations in USA estuaries do not exist. Therefore, assessments of relative susceptibility to nutrient-related pollution and estimated status of nutrient concentrations provide water quality and resource managers with some initial insight into current and potential eutrophication problems on a regional and national scale. The characterization of actual eutrophication problems, or symptoms, in the estuaries is the next step in the process of understanding the effects of estuarine, nutrient-related pollution.

Organizing the Data by Estuary. Nutrient discharges are estimated for each estuary by estuarine drainage area (EDA). The EDA is the land and water component of an entire watershed that most directly affects the estuary. The EDA generally corresponds to the U.S. Geological Survey (USGS) hydrologic cataloging unit(s) that contains the head of tide and the seaward estuarine

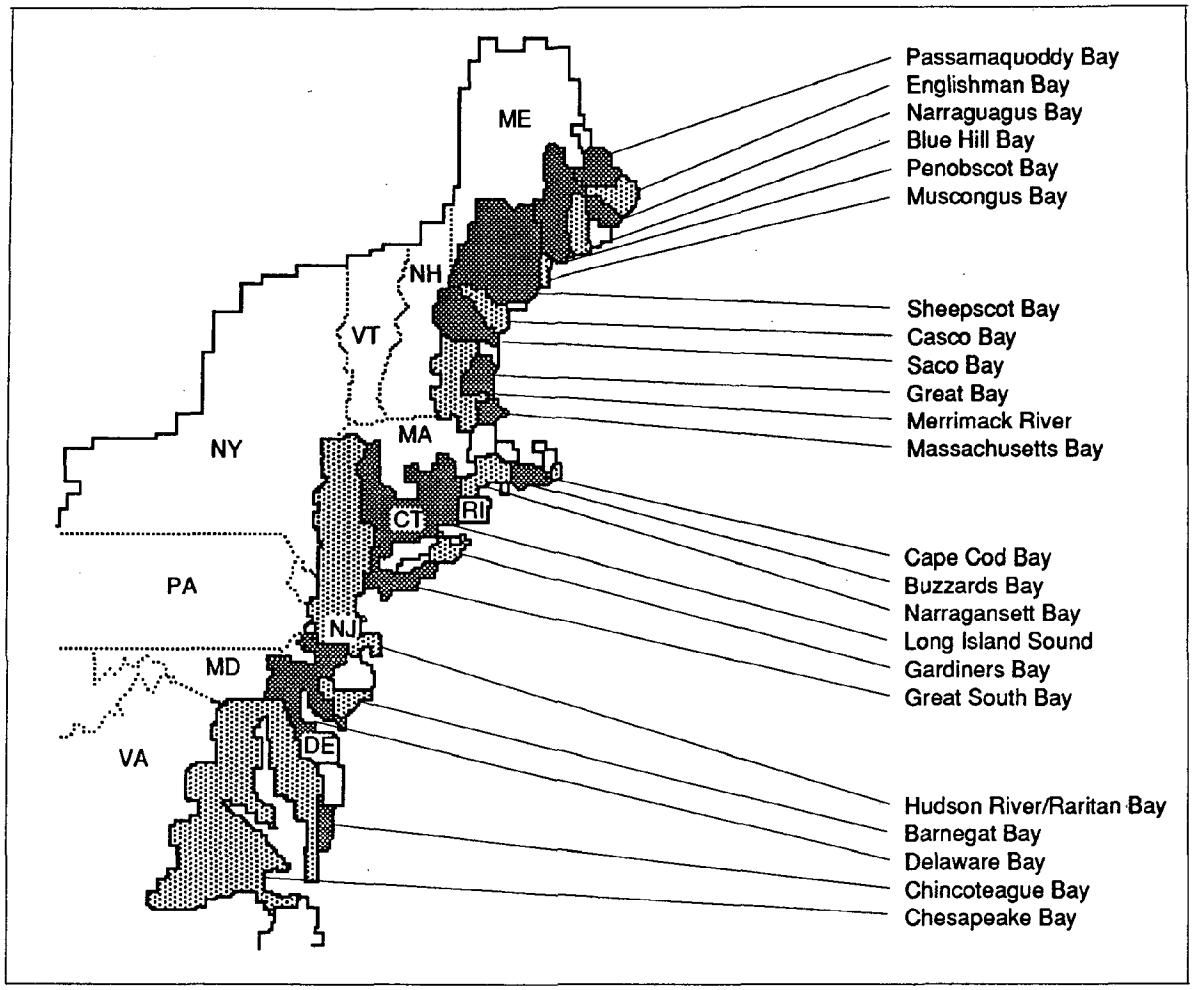


Figure 1. Estuarine Drainage Areas.

boundary. The EDAs are illustrated in detail in NOAA's National Estuarine Inventory Data Atlas of Physical and Hydrologic Characteristics (1985). EDAs may fall completely within, or extend beyond, coastal counties. Estimates of nutrient loadings from point and nonpoint sources are made only for the coastal county portion of the EDA. Estimates of nutrient loadings from upstream sources account for discharges from that portion of the EDA outside the coastal county and from the fluvial drainage area (FDA). The FDA is the land and water portion of the entire watershed upstream of the EDA. The percentage of EDA land within the coastal counties is given for each estuary in its one-page summary.

Nutrient Sources and Loads

Nitrogen and phosphorus originate from natural and man-made sources. Some specific sources of both nutrients include sediments, chemical fertilizers, feces, and wastes from meat processing, feedlots, and milk processing. Primary sources of nitrogen are from urea, feces, and other organic matter. Phosphorus sources include synthetic laundry detergent and water treatment chemicals. In this report, nutrient sources are divided into three broad categories: point, nonpoint, and upstream sources.

Basis for Estimates. The estimates of nitrogen discharge to estuaries in this region represent total nitrogen (i.e. nitrogen from ammonia, nitrate, nitrite, and the organic fraction). Estimates of total phosphorus include organic and inorganic forms of phosphorus. Data for nutrient loads are taken from NOAA's National Coastal Pollutant Discharge Inventory (NCPDI), and are based on a combination of monitored and estimated data, circa 1982. Methods used to estimate nutrient discharges for the NCPDI data base are briefly summarized in "Susceptibility and Concentration Status of Northeast Estuaries to Nutrient Discharges" (NOAA/EPA, 1988). The estimation methods are ex-

plained in detail in the NCPDI Methods Documents (NOAA, 1987a-d) available from NOAA's Strategic Assessment Branch (accuracy is discussed in NOAA/EPA, 1988, Appendix D).

Streamflow and nutrient concentration data used to calculate the NCPDI estimates of nutrient discharge from upstream sources were obtained from the USGS Water Resource Data Reports, the USGS National Stream Quality Accounting Network (NASQUAN), and other USGS and state water monitoring programs (NOAA, 1987c). Where streamflow and/or concentration data were unavailable, nutrient discharge was estimated using data from nearby streams with similar flows and land use characteristics, or nutrient discharge was prorated using drainage area information (NOAA, 1987c).

Point Sources. Point sources are those wastewater treatment plants (WWTPs) and industrial facilities that are land-based and discharge directly to surface water within a coastal county portion of the EDA through a pipe or similar conveyance on a regular basis. In this East Coast region, there are 300 major and 477 minor publicly owned wastewater treatment plants (POTWs). A major wastewater treatment plant discharges over 1 million gallons of treated water per day. The NCPDI estimates that 1,924 billion gallons of treated wastewater per year are discharged to surface water from POTWs in coastal counties of Maine through Virginia. There are 205 major and 1,941 minor industrial facilities. A major industrial facility discharges more than 0.5 million gallons of process water per day to surface waters. Industrial facilities are estimated to discharge 565 billion gallons of process water per year to surface waters in coastal counties in the region.

Nonpoint Sources. Nonpoint discharge is the transport of dissolved and particulate materials to surface waters within the coastal county portion of the EDA via surface runoff from precipitation. Nonpoint discharges are subdivided into four categories: agriculture, forest, urban, and other (nonurban). Urban discharges represent nutrient input from urban areas with populations greater than 2,500. Discharges from combined sewer overflows are included in estimates of nutrient loads from urban runoff. Throughout the coastal zone of the region there are 247 urban areas. Other (nonurban) sources include rangeland and pasture. The extent of data coverage for nonpoint discharges within the coastal county portion of each EDA is reported in the note following the pie diagram in the one-page summary for each estuary. Incomplete coverage is due to land areas from which no runoff data are available (principally wetlands and barren lands) and, therefore, affects only nonpoint discharge estimates. (The distribution of land use shown in pie diagrams reflects only the coastal county portion of the EDA from which there is nutrient data; wetlands and barren lands are not included in land use diagrams.)

Upstream Sources. Upstream sources include input from all riverine sources with an average annual flow in excess of 1,000 cubic feet per second (cfs). The upstream category accounts for pollutant loads to the estuary that originate from those portions of the EDA outside the coastal counties and from the remainder of the fluvial portion of the drainage area. In the East Coast region from Passamaquoddy Bay through the Chesapeake Bay, estimates are made for 20 upstream sources.

Limitations of Estimates. The estimates presented do not account for all possible sources of nutrient input to the estuary. Estimates are not available for nutrient input from ocean influx, groundwater inflow, bottom sediments, wetlands, barren lands, and direct atmospheric deposition to the estuarine surface. In some cases, the nutrient contributions from these sources may be substantial (e.g. Jaworski, 1981; Moshiri et al., 1981; Jones and Lee, 1981).

Further, the NCPDI estimates for point and nonpoint sources represent "end of pipe" and "edge of field" loadings. They do not take into account transport phenomena and thus portray a very conservative, or high, estimate of the pollutant loads reaching the estuary from these sources. Nevertheless, the NCPDI estimates do reflect the addition of nutrients from several important anthropogenic sources, and are valuable in evaluating the relative contributions of different sources.

Susceptibilty to Pollution

Susceptibility. An estuary's susceptibility to pollution is defined as its relative ability to concentrate dissolved and particulate pollutants. Pollutants in estuaries are either dissolved in the water or attached to particles in the water column or on the bottom. In general, nutrients occur in dissolved form and toxic substances occur in particulate form. Susceptibility is based upon the physical and hydrologic characteristics of the estuary.

Estuaries that are most susceptible to pollution are those which have poor ability to dilute or flush dissolved substances, and are likely to trap sediment and any associated toxic substances.

Susceptibility is quantified by two parameters: dissolved concentration potential (DCP) and particle retention efficiency (PRE). The DCP estimates the relative ability of an estuary to concentrate dissolved substances (total phosphorus and nitrogen in this study). The PRE estimates the relative ability of an estuary to retain suspended particles and attached pollutants (chiefly toxic materials). This paper focuses on the DCP and its role in the concentration of dissolved nitrogen and phosphorus in estuaries. Although PRE values are reported in this paper, discussion of the PRE is abbreviated, as this parameter will be discussed at length in a separate report on toxic pollutants.

A susceptibility classification scheme relating the DCP and PRE was developed to provide a relative ranking of estuaries in terms of susceptibility to pollution (both dissolved and particulate pollutants). This classification scheme was applied to estimates for 82 USA estuaries which are identified in NOAA's NEI (including those in this report) (Klein et al., 1988). Figure 2 illustrates the relative standing of the 82 estuaries in the classification scheme and highlights susceptibility estimates for the 23 estuaries in the study area.

Dissolved Concentration Potential (DCP). The DCP characterizes the effect of flushing and estuarine dilution on a load of a dissolved pollutant to an estuary, assuming average concentration throughout the estuary and steady-state conditions. The DCP is a relative measure of overall potential and does not reflect site-specific conditions within an estuary. A high DCP value suggests that an estuary is likely to retain or concentrate a load of dissolved pollutant. A low DCP suggests that an estuary has significant dilution ability (due to large estuarine volume) and/or flushing ability (due to rapid volume replacement).

The DCP is based upon the freshwater fraction method for predicting the concentration of a pollutant (Ketchum, 1955), as modified by Klein and Orlando (1989). (Some additional information on the DCP is provided in Appendix E of NOAA/EPA, 1988, and Klein et al., 1988). The distribution of a dissolved conservative pollutant, designated as nutrients in this case, is assumed to be affected by the physical forces of tide, freshwater inflow, and wind in the same manner that they affect the distribution of freshwater in an estuary. Assuming a uniform pollutant loading rate, the DCP is a function of flushing time and dilution as expressed by:

$$DCP = L\,(V_{fw} / i_{fw})\,(1 / V_{tot})$$

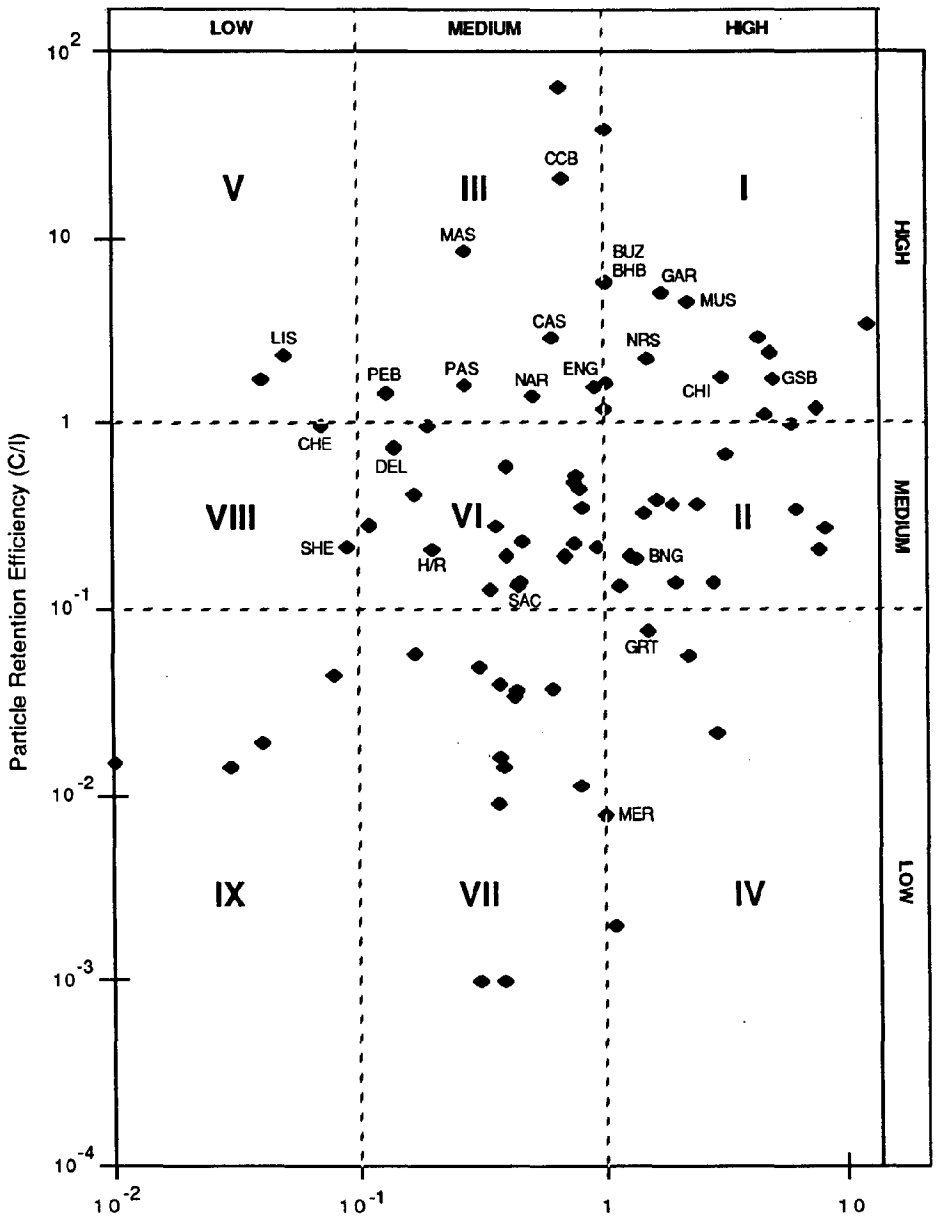
where: L = loading rate
V_{fw} = volume of freshwater in the estuary
i_{fw} = rate of freshwater inflow
V_{tot} = total volume of the estuary

To allow comparison of the DCP between estuaries, an equal pollutant load (10,000 tons/yr) is assumed for all estuaries when calculating the DCP. Average annual conditions are used for freshwater inflow and estuarine volumes. The volume of freshwater in the estuary is determined by estimating and summing the freshwater fraction of the tidal fresh, mixing, and seawater portions of the estuary, as depicted in NOAA's National Estuarine Inventory Data Atlas of Physical and Hydrologic Characteristics (1985). The estimated freshwater fractions of USA estuaries are recorded in Klein and Orlando (1989).

High, medium, and low DCP classes are based upon order-of-magnitude differences in DCP values. The range of values for low DCP is 0.01 to 0.1 milligrams/liter (mg/l), for medium DCP is 0.1 to 1.0 mg/l, and for high DCP is 1.0 to 10.0 mg/l. This order-of-magnitude classification scheme, used for comparison, is necessary because both the variability of discharge over time and the state-of-the-art techniques used to estimate loads set limitations on accuracy. (For discussion of accuracy of discharge estimates see NOAA/EPA, 1988, Appendix D.)

The DCP does not characterize all estuaries equally well. For example, the method assumes a vertically homogenous system. Reliability of the DCP increases with the degree of mixing that is exhibited in the estuary. The DCP is of limited utility in estuaries where salinity stratification persists for significant periods. Moreover, the DCP assumes a recognizable freshwater inflow component, as expressed in the resultant salinity regime, to infer pollutant distribution. For systems like Cape Cod Bay, which approaches the salinity concentration of seawater, the DCP is less reliable in predicting susceptibility to nutrient pollution.

Figure 2. Relative Susceptibility Classification for East Coast Estuaries (Maine through Virginia)



Estuary	Abbreviation
Passamaquoddy Bay	PAS
Englishman Bay	ENG
Narraguagus Bay	NRS
Blue Hill Bay	BHB
Penobscot Bay	PEB
Muscongus Bay	MUS
Sheepscot Bay	SHE
Casco Bay	CAS
Saco Bay	SAC
Great Bay	GRT
Merrimack River	MER
Massachusetts Bay	MAS
Cape Cod Bay	CCB
Buzzards Bay	BUZ
Narragansett Bay	NAR
Long Island Sound	LIS
Gardiners Bay	GAR
Great South Bay	GSB
Hudson River/Raritan Bay	H/R
Barnegat Bay	BNG
Delaware Bay	DEL
Chincoteague Bay	CHI
Chesapeake Bay	CHE

C = volume of the estuary at mean sea level; I = total volume of freshwater inflow over an annual cycle; DCP based upon a loading of 10,000 tons/year.

Particle Retention Efficiency (PRE). The PRE is an estimation of the relative ability of an estuary to trap suspended particles along with pollutants adhering to those particles. Although some forms of nitrogen and phosphorus can attach to particles, toxic substances are commonly associated with suspended sediments. The PRE method assumes that the relative ability of an estuary to trap sediment correlates to its ability to retain any associated toxic pollutant. The concept of PRE is based upon the empirical relationship between sediment trapping efficiency and the capacity/inflow ratio, which was originally developed for man-made freshwater impoundments and subsequently found to be loosely applicable to some estuaries in the USA (Biggs and Howell, 1984). The PRE is expressed by:

$$PRE = C/I$$

where: C = volume (capacity) of the estuary
I = annual freshwater inflow

The issue of toxic pollutants in estuaries will be dealt with in a separate report. Therefore, further discussion of sediment trapping efficiency is omitted here. PRE values are provided for each estuary to characterize overall susceptibility to both dissolved and particulate pollutant inputs as expressed in figure 2.

Nutrient Status: Concentration, Classification, and N/P Ratio

Nutrient Concentration and Classification. The level of nutrient pollution is indicated by the estimated concentrations of nitrogen and phosphorus, a classification of those concentrations, and an indication of how a change in nutrient load might affect the estuary's estimated nutrient concentration classification. All predictions of nutrient concentration are based upon the estimates of annual loads to the estuary. Estimates of nitrogen and phosphorus concentration do not take into account nutrient recycling, which may be substantial. Some studies suggest that nutrient recycling may account for a greater percentage of the ambient nutrient concentration than the new load entering the system each year (e.g. Boynton et al., 1982; Kemp et al., 1982). However, nutrient recycling rates, as well as peak and annual values of primary productivity, apparently are a function of long-term loading to the estuary (Boynton et al., 1982; Kemp et al., 1982).

The concentration of nitrogen or phosphorus is predicted by substituting the estimated nutrient loading rate of the estuary into the DCP formula (replacing the 10,000 tons/yr pollutant loading rate used for the DCP calculation). The estimated nitrogen and phosphorus concentrations for all estuaries identified in NOAA's National Estuarine Inventory are plotted on figures 3a and 3b, respectively. Nutrient concentrations for estuaries for this region of the East Coast are highlighted and both DCP and nutrient loads are shown on a log-log scale. Nutrient concentration zones are bounded by the diagonal lines. The diagrams illustrate that certain systems can exhibit medium to high concentrations even with low loadings if the DCP is very high. The reverse is also true, in that, medium to high concentrations may occur in estuaries with low DCPs if the loading is very high.

The concentrations used to designate high, medium, and low concentration classes differ for nitrogen and phosphorus. For nitrogen, concentrations less than 0.1 milligrams/liter (mg/l) are low, between 0.1 to 1.0 mg/l are medium, and greater than 1.0 mg/l are high. For phosphorus, concentrations less than 0.01 mg/l are low, between 0.01 and 0.1 mg/l are medium, and greater than 0.1 mg/l are high. This classification scheme is based upon observed estuarine characteristics at the different nutrient levels as reported for the Chesapeake Environmental Quality Classification Scheme (U.S. EPA, 1983). An estuarine characteristic associated with low concentrations is the maximum diversity of aquatic life whereas high nutrient concentrations are associated with high chlorophyll levels, low species diversity, and occasional red tides.

It is important to emphasize that the classification scheme divides a continuum of concentrations. Those estuaries whose nutrient concentrations are close to a class boundary are likely to exhibit some characteristics of both classes. A minor change (<20%) in nutrient loadings may affect the concentration class of these estuaries, but actual estuarine conditions may not drastically improve or decline due to the small change in concentration actually made. Moreover, a change in nutrient loadings may not affect estuarine conditions precisely as predicted due to the discrepancy that may exist between estimated nutrient concentrations and real concentrations.

N/P Ratio. The significance of the N/P ratio is that phytoplankton require nitrogen and phosphorus in the approximate proportion (atomic) of 16/1,

Figure 3a. Relative Status of East Coast Estuaries (Maine through Virginia) with Respect to Nitrogen

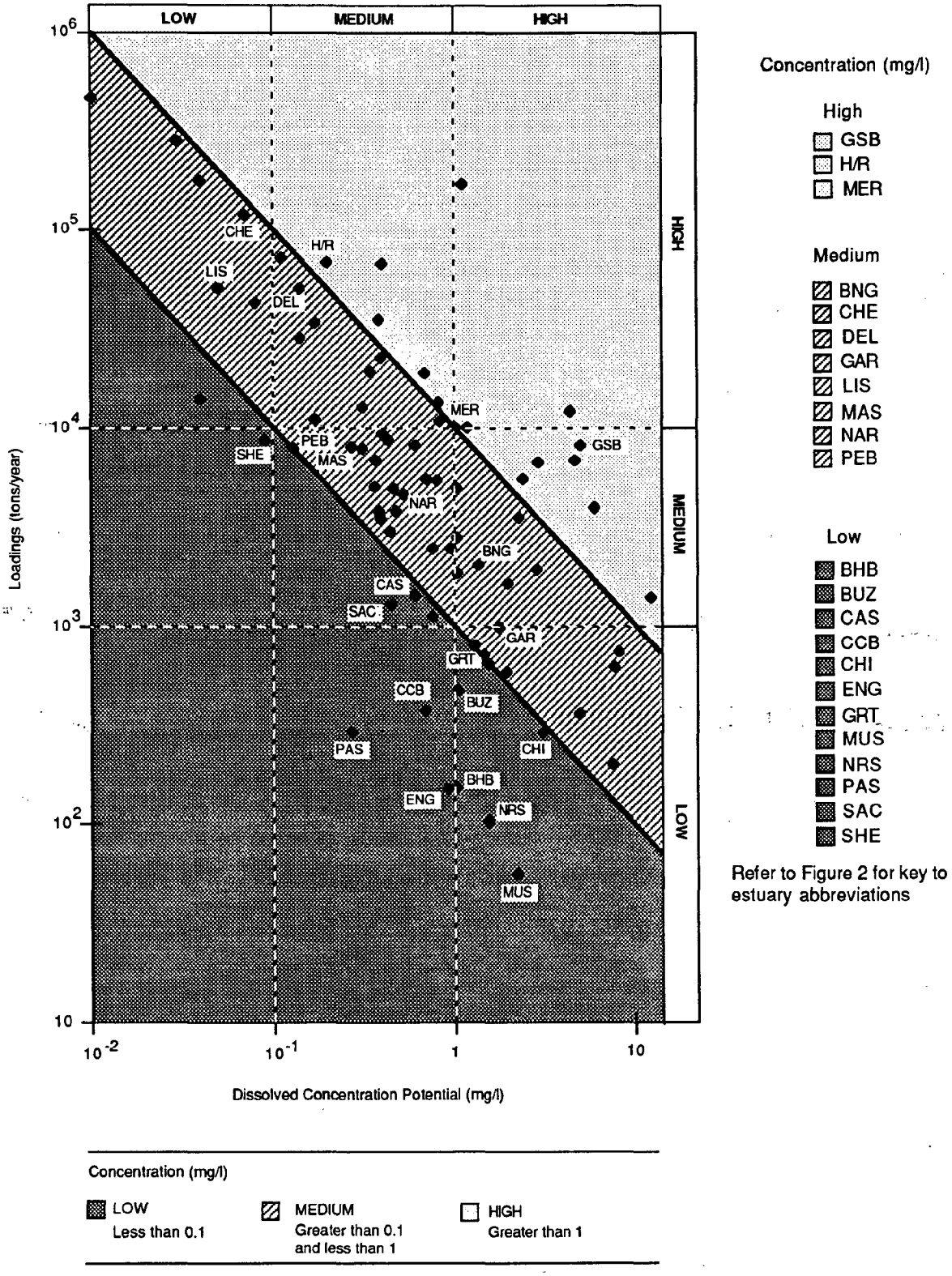
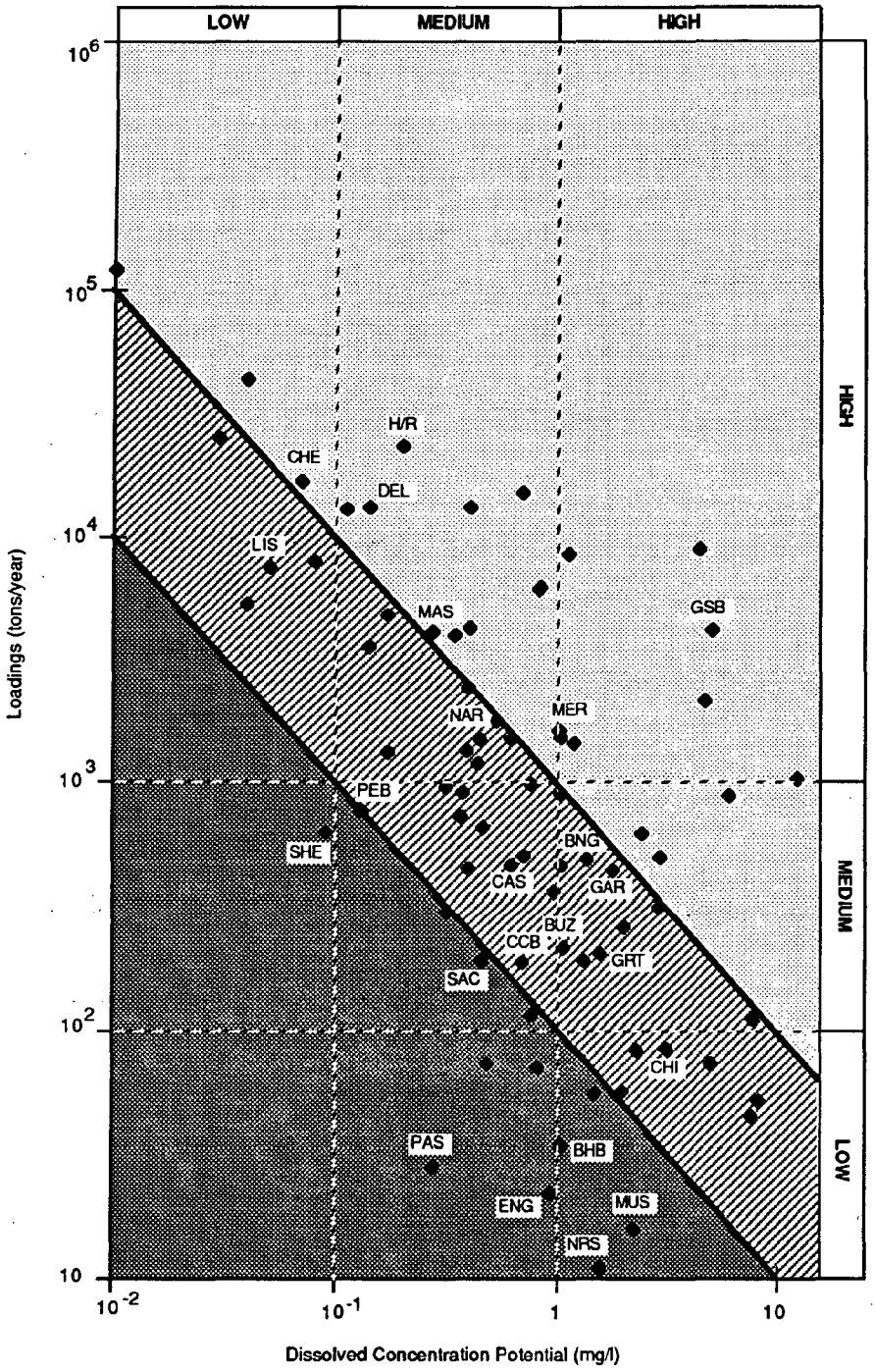


Figure 3b. Relative Status of East Coast Estuaries (Maine through Virginia) with Respect to Phosphorus



Concentration (mg/l)

High
- CHE
- DEL
- GSB
- H/R
- MAS
- MER

Medium
- BNG
- BUZ
- CAS
- CCB
- CHI
- GAR
- GRT
- LIS
- NAR
- PEB

Low
- BHB
- ENG
- MUS
- NRS
- PAS
- SAC
- SHE

Refer to Figure 2 for key to estuary abbreviations

Concentration (mg/l)

LOW	MEDIUM	HIGH
Less than 0.01	Greater than 0.01 and less than 0.1	Greater than 0.1

respectively, for growth (Redfield, 1934, 1958). However, there is some indication that this ratio varies slightly with different algal species and that a range of N/P ratios from 10/1 to 20/1 better describes nutrient requirements of algae (Boynton et al., 1982). Where the N/P ratio is 10/1 or less, there may be insufficient nitrogen to balance all of the available phosphorus. In such a situation, nitrogen may be the nutrient which limits increased plant production. In contrast, where the N/P ratio is 20/1 or greater, there may be insufficient phosphorus to allow complete use of all available nitrogen, and phosphorus may be a limiting nutrient. Where N/P ratios fall between 10/1 and 20/1, the limiting nutrient may be highly dependant upon the species of phytoplankton present. Therefore, without site-specific information, a limiting nutrient can not be determined with any assurance in the range of 10-20/1. In general, for the organisms that live in the different environments, phosphorus is the limiting nutrient in freshwater and nitrogen is the limiting nutrient in seawater; estuaries represent a transition zone from fresh to seawater. It is important to emphasize that an element other than nitrogen or phosphorus may be the production-limiting nutrient (e.g. silica, which is required by diatoms in proportions of S/N/P= 20/16/1, Redfield, 1958) or a physical parameter (e.g. light or temperature) may control primary production for all or part of the year.

The N/P ratio discussed in the one-page summaries is a highly speculative value based upon estimated nutrient loads; the ratio does not reflect actual estuarine measurements. Estimated nutrient loads represent the weights of nitrogen and phosphorus from organic and inorganic molecules which enter the estuary each year. The N/P ratios were approximated by converting these loads to the number of atoms (nitrogen or phosphorus load divided by the corresponding atomic weight) and dividing nitrogen by phosphorus to yield a ratio with the denominator, phosphorus, equal to one.

The estimated N/P ratios do not take into account recycling of nutrients within estuaries which may significantly affect the ambient nutrient concentrations and thus the actual N/P ratios. Other factors that may influence the N/P ratio and the limiting nutrient include the preferential uptake of different ionic forms (e.g. nitrate, nitrite, ammonium), and varying rate of nutrient uptake by different phytoplankton species. For example, some evidence supports the preferential uptake of ammonium (NH_4^+) over nitrate (NO_3^-) (McCarthy, 1981) and the repression of both nitrate (NO_3^-) and nitrite (NO_2^-) assimilation in phytoplankton by NH_4^+ (e.g. Falkowski, 1983). Unfortunately, studies of the different rates of chemical recycling and nutrient uptake are not common and tend to be site-specific. The impact of different nutrient ions on algal growth remains to be fully explored. Hence the N/P ratio provided should be used as only a first approximation for evaluating nutrient dominance.

Comparisons Among Estuaries

Comparisons of the estimated nutrient loads, DCPs, and nutrient concentrations between estuaries in the region can be used to assess the extent to which these estuaries may be experiencing nutrient-related problems under existing conditions and in the future. In addressing eutrophication problems, the N/P ratio of the loading gives a first estimate of which nutrient may be more influencial in limiting phytoplankton production in the estuaries.

For estuaries in the region, the dominant sources of nitrogen are WWTPs and upstream sources. The leading source of phosphorus is WWTP discharge. Of the twenty-three estuaries in the region, ten estuaries are estimated to have relatively poor dilution and/or flushing abilities (indicated by high DCPs) (figure 2). Only two of these ten estuaries with high DCPs, Merrimack River and Great South Bay, are estimated to receive high loads of either, or both, nutrient(s).

The predicted nutrient concentrations for the majority (fifteen) of the estuaries in the region are within the same concentration class for both nutrients (figures 3a and 3b). (Recall, however, that concentrations used to designate high, medium, and low concentration classes differ for nitrogen and phosphorus.) Three estuaries are predicted to have high concentrations of both nutrients and seven estuaries are estimated to have low concentrations of both nutrients. All seven estuaries with low predicted nitrogen and phosphorus concentrations are located in Maine.

In the eight estuaries where nitrogen and phosphorus concentrations fall in different classes, the concentration of phosphorus is always predicted to be one class higher than that of nitrogen. Generally, in these estuaries, the contribution by WWTPs to the overall nutrient load is quite significant and input from upstream sources—an important contributor of nitrogen—is virtually zero. Exceptions to this are Delaware Bay and Chesapeake Bay where upstream sources are present.

In each of the two estuaries the phosphorus class is high (while the nitrogen class is medium) because upstream sources, as well as WWTPs, contribute significant phosphorus loads. It is important to note that for five of the eight estuaries a minor increase of nitrogen or decrease of phosphorus (<20% of the current estimated load) would cause the predicted nutrient concentrations to be in the same class.

Differences in loadings, DCPs, and nutrient concentrations among the estuaries are important considerations in developing regional strategies for the control of nutrient-related pollution. The following discussion identifies and describes significant differences among the region's estuaries that may be cause for concern, and is presented to stimulate further regionwide discussion.

Estuaries of Concern under Existing Conditions. Estuaries which have high predicted concentrations of nitrogen and phosphorus are the most likely to be experiencing eutrophication problems. Three estuaries in the region are estimated to have high concentrations of both nutrients: Merrimack River, Great South Bay, and Hudson River/Raritan Bay. (Predicted nutrient concentration is a function of the estimated loading and the DCP). Both Merrimack River and Great South Bay have high DCPs (poor dilution and/or flushing abilities) and generally high loads (the exception is the medium nitrogen load to Great South Bay). For Hudson River/Raritan Bay, which has a medium DCP, high concentrations are predicted largely due to high loads. The N/P ratio of the loadings suggests that Great South Bay and Hudson River/Raritan Bay may be nitrogen limited. Should this be the case, reduction of nitrogen loading would have the greatest effect on algal growth in these estuaries. For these two estuaries, Great South Bay and Hudson River / Raritan Bay, WWTPs are the leading source of both nitrogen and phosphorus. The N/P ratio for Merrimack River does not indicate if either or both of the nutrient(s) are limiting to algal growth. For Merrimack River, the leading source of nitrogen is discharge from upstream sources and the leading source of phosphorus is discharge from WWTPs.

Three additional estuaries are estimated to have high concentrations of phosphorus: Massachusetts Bay, Delaware Bay, and Chesapeake Bay. For these three estuaries, the high concentration of phosphorus is due to high phosphorus loads. These high concentrations occur despite medium DCPs of Massachusetts Bay and Delaware Bay and the low DCP of Chesapeake Bay. Discharge from WWTPs is the leading source of phosphorus in each estuary. All three estuaries are estimated to have medium nitrogen concentrations, although nitrogen loadings for the Delaware Bay and Chesapeake Bay are estimated to be high. The leading source of nitrogen in each estuary is discharge from upstream sources. The N/P ratio of the loadings suggests that Delaware Bay and Massachusetts Bay may be nitrogen limited. If nitrogen is indeed the limiting nutrient, then reduction of nitrogen loading would have the greatest effect on algal growth in these two estuaries. The N/P ratio for Chesapeake Bay does not indicate if either or both of the nutrient(s) are limiting to algal growth.

Future Concerns. Most estuaries require a change in load greater than 20% of the present estimated load to change concentration class. However, nine estuaries are exceptions to this and the concentration class may change for one or both nutrients with a minor (<20%) change in nutrient loading(s). Of these nine estuaries, four involve borderline medium-high concentration classes: Chesapeake Bay, Merrimack River, Massachusetts Bay, and Narragansett Bay. Both the nitrogen and phosphorus concentrations of Chesapeake Bay are likely to change—the nitrogen level increasing from medium to high and the phosphorus concentration decreasing from high to medium—with a relatively minor (<20%) increase in nitrogen and decrease in phosphorus from the present estimated loads. For Merrimack River, Massachusetts Bay, and Narragansett Bay, the concentration class of only one nutrient is likely to be influenced with minor increases or decreases from the present estimated loading. Specifically, with a minor reduction in nitrogen load, the nitrogen concentration class for Merrimack River is likely to change (from high to medium). The phosphorus concentration classes are likely to change for Massachusetts Bay (from high to medium) and Narragansett Bay (from medium to high) with a minor increase and decrease, respectively, in phosphorus loads.

Concluding Comments

Inferred pollution susceptibility and nutrient concentrations described above provide a first estimate of the relative status of one estuary compared to another with respect to potential nutrient-related pollution problems and responsiveness to changes in nutrient loads. Such estimates may be useful for regional resource management and planning for coastal waters, particularly in the absence of standardized and quantitative long-

term measures of nutrient concentrations in estuaries and their state of eutrophism.

However, an assessment of "actual" eutrophication problems and their characteristics can only be made by gathering site-specific information. A nationwide project starting in FY1990 is planned to collect such information. Site-specific information of eutrophication will be collected through site visits and the use of a standardized questionnaire completed by regional experts. Experts will include both government and scientific personnel, who have knowledge of the absence or presence (and nature) of eutrophication problems in an estuary, or who can identify the existence or lack of site-specific data that could lead to determining the occurrence of a current or impending eutrophication problem.

For additional information on NOAA's program of strategic assessments contact:

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(301) 443-8921

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Strategic Assessment of Near Coastal Waters

Susceptibility of East Coast Estuaries to Nutrient Discharges Passamaquoddy Bay to Chesapeake Bay

ESTUARY SUMMARIES

Passamaquoddy Bay
Englishman Bay
Narraguagus Bay
Blue Hill Bay
Penobscot Bay
Muscongus Bay
Sheepscot Bay
Casco Bay
Saco Bay
Great Bay
Merrimack River
Massachusetts Bay
Cape Cod Bay
Buzzards Bay
Narragansett Bay
Gardiners Bay
Long Island Sound
Great South Bay
Hudson River/Raritan Bay
Barnegat Bay
Delaware Bay
Chincoteague Bay
Chesapeake Bay

1.01 Passamaquoddy Bay ME, NB

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	3.15×10^{11}
Surface Area (sq. mi.)	157
Average Daily Inflow (cfs)	6,200
Estuarine Drainage Area (sq. mi.)	3,200
%EDA Land within coastal counties	43
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	3,200

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.27	(M)
Particle Retention Efficiency (C/I)	1.61	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

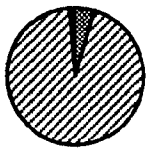
	Nitrogen	Phosphorus
Point	102	12
Nonpoint	191	16
Upstream	0	0
Total	293 (L)	28 (L)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class. Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.008	(L)	3,411	1,164	NA	NA
Phosphorus	0.001	(L)	342	1,223	NA	NA

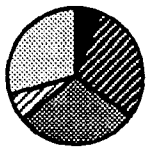
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

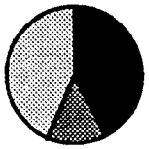


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Phosphorus



Note: Data based on 90% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Passamaquoddy Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the low range for both nitrogen and phosphorus. In Passamaquoddy Bay, these low concentration classifications are not likely to be influenced by minor increases (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 23, suggesting that phosphorus may be a limiting nutrient in the estuary.

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1.02 Englishman Bay
ME

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	7.97×10^{10}
Surface Area (sq. mi.)	76
Average Daily Inflow (cfs)	1,600
Estuarine Drainage Area (sq. mi.)	883
%EDA Land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	883

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.92	(M)
Particle Retention Efficiency (C/I)	1.58	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

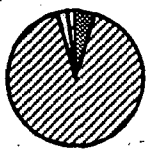
	Nitrogen	Phosphorus
Point	25	12
Nonpoint	125	10
Upstream	0	0
Total	150 (L)	22 (L)

Predicted Concentration Status
(load in tons/yr)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.014	(L)	937	625	NA	NA
Phosphorus	0.002	(L)	87	394	NA	NA

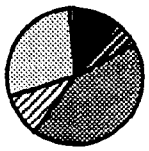
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

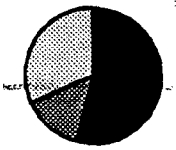


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Phosphorus



Note: Data based on 90% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Englishman Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the low range for both nitrogen and phosphorus. In Englishman Bay, these low concentration classifications are not likely to be influenced by minor increases (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 15, and does not strongly indicate the presence of a limiting nutrient in the estuary.

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1.03 Narraguagus Bay ME

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	6.33×10^{10}
Surface Area (sq. mi.)	70
Average Daily Inflow (cfs)	900
Estuarine Drainage Area (sq. mi.)	416
%EDA Land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	416

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	1.54	(H)
Particle Retention Efficiency (C/I)	2.23	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

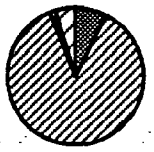
	Nitrogen	Phosphorus
Point	13	4
Nonpoint	91	7
Upstream	0	0
Total	104 (L)	11 (L)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class. Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.016	(L)	545	524	NA	NA
Phosphorus	0.002	(L)	54	490	NA	NA

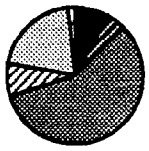
Abbreviations: *cfs, cubic feet per second; mg/l, milligrams per* liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

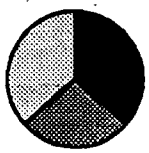


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Phosphorus



Note: Data based on 87% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Narraguagus Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the low range for both nitrogen and phosphorus. In Narraguagus Bay, these low concentration classifications are not likely to be influenced by minor increases (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 21, suggesting that phosphorus may be a limiting nutrient in the estuary.

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1.04 Blue Hill Bay ME

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	2.41×10^{11}
Surface Area (sq. mi.)	115
Average Daily Inflow (cfs)	1,300
Estuarine Drainage Area (sq. mi.)	825
%EDA Land within coastal counties	97
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	825

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	1.03	(H)
Particle Retention Efficiency (C/I)	5.88	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

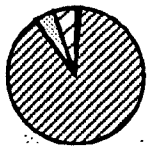
	Nitrogen	Phosphorus
Point	48	22
Nonpoint	106	13
Upstream	0	0
Total	154 (L)	35 (L)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class. Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.016	(L)	817	530	NA	NA
Phosphorus	0.004	(L)	62	177	NA	NA

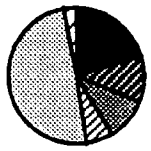
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

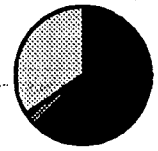


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Phosphorus



Note: Data based on 92% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Blue Hill Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the low range for both nitrogen and phosphorus. In Blue Hill Bay, these low concentration classifications are not likely to be influenced by minor increases (<20%) in nutrient loadings. The N/P molecular ratio of the loading is10, suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.05 Penobscot Bay ME

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	7.25×10^{11}
Surface Area (sq. mi.)	361
Average Daily Inflow (cfs)	16,100
Estuarine Drainage Area (sq. mi.)	3,160
%EDA Land within coastal counties	35
Fluvial Drainage Area (sq. mi.)	6,250
Total Drainage Area (sq. mi.)	9,410

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.13	(M)
Particle Retention Efficiency (C/I)	1.43	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

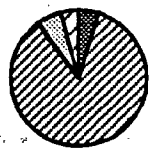
	Nitrogen	Phosphorus
Point	173	58
Nonpoint	350	28
Upstream	7,285	685
Total	7,808 (M)	771 (M)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class. Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.102	(M)	69,115	885	116	1
Phosphorus	0.010	(M)	6,921	898	2	0

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

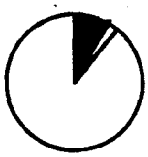
Nitrogen

Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Phosphorus



Note: Data based on 95% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Penobscot Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the medium range for both nitrogen and phosphorus. In Penobscot Bay, the medium phosphorus concentration classification may be influenced by a minor reduction (<20%) in phosphorus loading. The N/P molecular ratio of the loading is 22, suggesting that phosphorus may be a limiting nutrient in the estuary.

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1.06 Muscongus Bay
ME

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	8.55×10^{10}
Surface Area (sq. mi.)	72
Average Daily Inflow (cfs)	600
Estuarine Drainage Area (sq. mi.)	346
%EDA Land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	346

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	2.25	(H)
Particle Retention Efficiency (C/I)	4.52	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

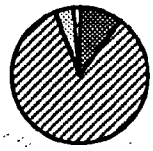
	Nitrogen	Phosphorus
Point	13	11
Nonpoint	43	5
Upstream	0	0
Total	56 (L)	16 (L)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class. Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.013	(L)	388	694	NA	NA
Phosphorus	0.004	(L)	28	178	NA	NA

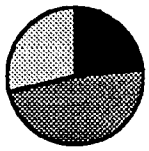
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Phosphorus

Note: Data based on 89% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Muscongus Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the low range for both nitrogen and phosphorus. In Muscongus Bay, these low concentration classifications are not likely to be influenced by minor increases (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 8, suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.07 Sheepscot Bay
ME, NH

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.18×10^{11}
Surface Area (sq. mi.)	103
Average Daily Inflow (cfs)	17,600
Estuarine Drainage Area (sq. mi.)	6,150
%EDA Land within coastal counties	16
Fluvial Drainage Area (sq. mi.)	3,920
Total Drainage Area (sq. mi.)	10,070

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.088	(L)
Particle Retention Efficiency (C/I)	0.21	(M)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

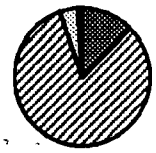
	Nitrogen	Phosphorus
Point	78	53
Nonpoint	472	44
Upstream	8,195	544
Total	8,745 (M)	641 (M)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class. Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.077	(L)	2,619	30	NA	NA
Phosphorus	0.006	(L)	495	77	NA	NA

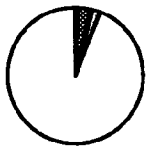
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

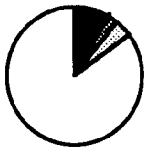


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Phosphorus



Note: Data based on 96% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetalnds and barren lands.

INTERPRETATION

Sheepscot Bay is estimated to have a low susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the low range for both nitrogen and phsophorus. In Sheepscot Bay, these low concentration classifications are not likely to be influenced by minor increases (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 30, suggesting that phosphorus may be a limiting nutrient in the estuary.

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1.08 Casco Bay ME

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.91×10^{11}
Surface Area (sq. mi.)	164
Average Daily Inflow (cfs)	2,100
Estuarine Drainage Area (sq. mi.)	1,159
%EDA Land within coastal counties	84
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	1,159

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.61	(M)
Particle Retention Efficiency (C/I)	2.89	(H)

NUTRIENT CHARACTERISTICS

Loadings
(tons/year)

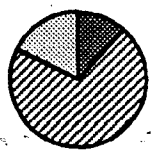
	Nitrogen	Phosphorus
Point	744	408
Nonpoint	668	57
Upstream	0	0
Total	1,412 (M)	465 (M)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.086	(L)	227	16	NA	NA
Phosphorus	0.028	(M)	1,174	253	301	65

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- ☐

Phosphorus

Note: Data based on 97% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren

INTERPRETATION

Casco Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loading results in a predicted concentration within the low range for nitrogen. The DCP combined with the estimated phosphorus loading results in a predicted concentration within the medium range for phosphorus. In Casco Bay, the low nitrogen concentration classification may be influenced by a minor increase (<20%) in nitrogen loading. The N/P molecular ratio of the loading is 7, suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.09 Saco Bay
ME, NH

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.53×10^{10}
Surface Area (sq. mi.)	17
Average Daily Inflow (cfs)	3,600
Estuarine Drainage Area (sq. mi.)	1771
%EDA Land within coastal counties	31
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	1,771

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.45	(M)
Particle Retention Efficiency (C/I)	0.13	(M)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

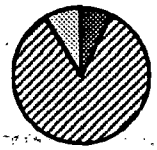
	Nitrogen	Phosphorus
Point	187	117
Nonpoint	195	21
Upstream	875	55
Total	1,257 (M)	193 (M)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.057	(L)	965	77	NA	NA
Phosphorus	0.009	(L)	29	15	NA	NA

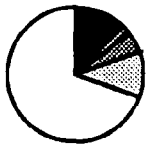
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Phosphorus

Note: Data based on 96% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Saco Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the low range for both nitrogen and phosphorus. In Saco Bay, the low phosphorus concentration classification may be influenced by a minor increase (<20%) in phosphorus loading. The N/P molecular ratio of the loading is 14, and does not strongly indicate the presence of a limiting nutrient in the estuary.

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1.10 Great Bay
ME, NH

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	4.75×10^9
Surface Area (sq. mi.)	15
Average Daily Inflow (cfs)	2,000
Estuarine Drainage Area (sq. mi.)	950
%EDA Land within coastal counties	95
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	950

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	1.54	(H)
Particle Retention Efficiency (C/I)	0.08	(L)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

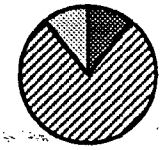
	Nitrogen	Phosphorus
Point	242	161
Nonpoint	394	43
Upstream	0	0
Total	636 (L)	204 (M)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.098	(L)	13	2	NA	NA
Phosphorus	0.031	(M)	445	218	139	68

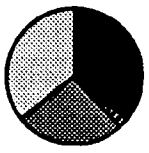
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

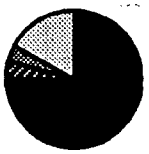
Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Phosphorus



Upstream Sources

Note: Data based on 97% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Great Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loading results in a predicted concentration within the low range for nitrogen. The DCP combined with the estimated phosphorus loading results in a predicted concentration within the medium range for phosphorus. In Great Bay, the low nitrogen concentration classification may be influenced by a minor increase (<20%) in nitrogen loading. The N/P molecular ratio of the loading is 7, suggesting that nitrogen may be a limiting nutrient in the estuary

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1.11 Merrimack River NH, MA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	2.08×10^9
Surface Area (sq. mi.)	6
Average Daily Inflow (cfs)	8,400
Estuarine Drainage Area (sq. mi.)	2,300
%EDA Land within coastal counties	30
Fluvial Drainage Area (sq. mi.)	2,680
Total Drainage Area (sq. mi.)	4,980

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	1.01	(H)
Particle Retention Efficiency (C/I)	0.01	(L)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

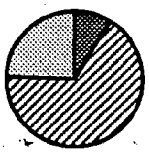
	Nitrogen	Phosphorus
Point	1,343	813
Nonpoint	614	90
Upstream	8,154	722
Total	10,111(H)	1,625 (H)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	1.021	(H)	NA	NA	210	2
Phosphorus	0.164	(H)	NA	NA	635	39

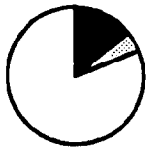
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

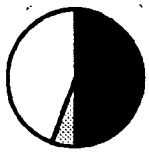


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources
- □

Phosphorus



Note: Data based on 96% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Merrimack River has high susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the high range for both nitrogen and phosphorus. In Merrimack River, the high nitrogen concentration classification may be influenced by a minor reduction (<20%) in nitrogen loading. The N/P molecular ratio of the loading is 14, and does not strongly indicate the presence of a limiting nutrient in the estuary.

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1.12 Massachusetts Bay MA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	7.85×10^{11}
Surface Area (sq. mi.)	364
Average Daily Inflow (cfs)	2,900
Estuarine Drainage Area (sq. mi.)	1,202
%EDA Landwithin coastal counties	98
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	1,202

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.27	(M)
Particle Retention Efficiency (C/I)	8.58	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

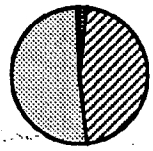
	Nitrogen	Phosphorus
Point	6,181	3,845
Nonpoint	1,814	246
Upstream	0	0
Total	7,995 (M)	4,091 (H)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class. Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.216	(M)	29,042	363	4,291	54
Phosphorus	0.110	(H)	NA	NA	387	9

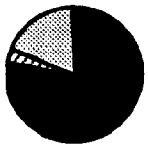
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Phosphorus

Upstream Sources
- □

Note: Data based on 96% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Massachusetts Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loading results in a predicted concentration within the medium range for nitrogen. The DCP combined with the estimated phosphorus loading results in a predicted concentration within the high range for phosphorus. In Massachusetts Bay, the high phosphorus concentration classification may be influenced by a minor rediction (<20%) in phosphorus loading. The N/P molecular ratio of the loading is 4 suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.13 Cape Cod Bay MA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.18×10^{12}
Surface Area (sq. mi.)	548
Average Daily Inflow (cfs)	1,800
Estuarine Drainage Area (sq. mi.)	771
%EDA Land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	771

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.69	(M)
Particle Retention Efficiency (C/I)	20.75	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

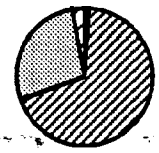
	Nitrogen	Phosphorus
Point	268	169
Nonpoint	109	18
Upstream	0	0
Total	377 (L)	187 (M)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.026	(L)	1,072	284	NA	NA
Phosphorus	0.013	(M)	1,262	675	42	22

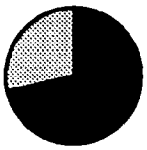
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

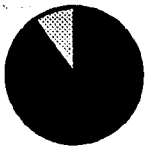
Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Phosphorus



Upstream Sources

Note: Data based on 85% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Cape Cod Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loading results in a predicted concentration within the low range for nitrogen. The DCP combined with the estimated phosphorus loading results in a predicted concentration within the medium range for phosphorus. In Cape Cod Bay, these concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 4, suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.14 Buzzards Bay MA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	2.15×10^{11}
Surface Area (sq. mi.)	228
Average Daily Inflow (cfs)	1,200
Estuarine Drainage Area (sq. mi.)	576
%EDA Land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	576

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	1.04	(H)
Particle Retention Efficiency (C/I)	5.68	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

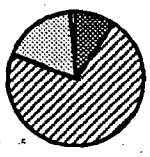
	Nitrogen	Phosphorus
Point	306	193
Nonpoint	164	22
Upstream	0	0
Total	470 (L)	215 (M)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class. Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.049	(L)	492	105	NA	NA
Phosphorus	0.022	(M)	747	347	119	55

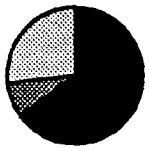
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

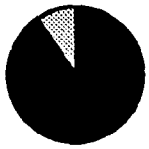
Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Phosphorus



Upstream Sources
- ☐

Note: Data based on 93% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Buzzards Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loading results in a predicted concentration within the low range for nitrogen. The DCP combined with the estimated phosphorus loading results in a predicted concentration within the medium range for phosphorus. In Buzzards Bay, these concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 5, suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.15 Narragansett Bay MA, RI

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.39×10^{11}
Surface Area (sq. mi.)	165
Average Daily Inflow (cfs)	3,200
Estuarine Drainage Area (sq. mi.)	1,330
%EDA Land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	451
Total Drainage Area (sq. mi.)	1,781

Pollution Susceptibility

	mg/l	Class
Dissolved Concentration Potential (mg/l)	0.52	(M)
Particle Retention Efficiency (C/I)	1.38	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

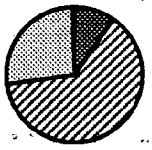
	Nitrogen	Phosphorus
Point	2,854	1,541
Nonpoint	1,717	235
Upstream	0	0
Total	4,571 (M)	1,776 (H)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class. Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.238	(M)	14,660	321	2,648	58
Phosphorus	0.092	(M)	147	8	1,584	89

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



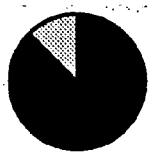
- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Phosphorus



Upstream Sources

Note: Data based on 96% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Narragansett Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the medium range for both nitrogen and phsophorus. In Narragansett Bay, the medium phosphorus concentration classification may be influenced by a minor increase (<20%) in phosphorus loading. The N/P molecular ratio of the loading is 6, suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.16 Gardiners Bay NY

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.11×10^{11}
Surface Area (sq. mi.)	197
Average Daily Inflow (cfs)	700
Estuarine Drainage Area (sq. mi.)	400
%EDA Land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	400

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	1.77	(H)
Particle Retention Efficiency (C/I)	5.03	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

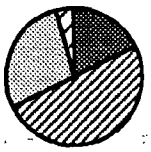
	Nitrogen	Phosphorus
Point	643	407
Nonpoint	341	34
Upstream	0	0
Total	984 (L)	441 (M)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class. Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.174	(M)	4,666	474	419	43
Phosphorus	0.078	(M)	124	28	385	87

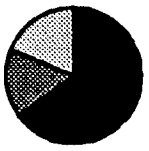
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

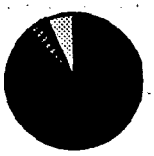
Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Phosphorus



Upstream Sources
- □

Note: Data based on 95% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Gardiners Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the medium range for both nitrogen and phosphorus. In Gardiners Bay, these medium concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 5, suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.17 Long Island Sound
NY, CT, MA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	2.19×10^{12}
Surface Area (sq. mi.)	1,281
Average Daily Inflow (cfs)	30,000
Estuarine Drainage Area (sq. mi.)	7,230
%EDA Land within coastal counties	49
Fluvial Drainage Area (sq. mi.)	10,010
Total Drainage Area (sq. mi.)	17,240

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.054	(L)
Particle Retention Efficiency (C/I)	2.32	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

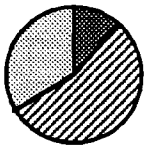
	Nitrogen	Phosphorus
Point	19,980	4,987
Nonpoint	5,532	630
Upstream	24,652	1,899
Total	50,164(H)	7,516(H)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.271	(M)	135,021	269	31,645	63
Phosphorus	0.041	(M)	11,003	146	5,664	75

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

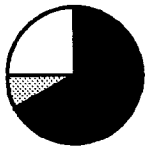
Nitrogen

Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Phosphorus



Note: Data based on 98% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Long Island Sound is estimated to have low susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the medium range for both nitrogen and phosphorus. In Long Island Sound, these medium concentration classifications are not likely to be influenced by minor changes (<20%) in the nutrient loadings. The N/P molecular ratio of the loading is 15, and does not strongly indicate the presence of a limiting nutrient in the estuary.

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1.18 Great South Bay NY

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	3.73×10^{10}
Surface Area (sq. mi.)	151
Average Daily Inflow (cfs)	700
Estuarine Drainage Area (sq. mi.)	845
%EDA Land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	845

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	5.07	(H)
Particle Retention Efficiency (C/I)	1.69	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

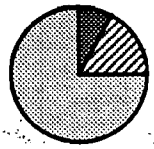
	Nitrogen	Phosphorus
Point	6,114	3,868
Nonpoint	1,990	284
Upstream	0	0
Total	8,104 (M)	4,152 (H)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	4.109	(H)	NA	NA	6,132	76
Phosphorus	2.105	(H)	NA	NA	3,955	95

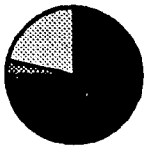
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

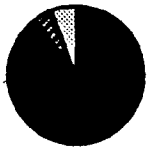
Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Phosphorus



Upstream Sources

Note: Data based on 92% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Great South Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the high range for both nitrogen and phosphorus. In Great South Bay, these high concentration classifications are not likely to be influenced by minor reductions (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 4, suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.19. Hudson River/Raritan Bay NY, NJ, MA, CT

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.73×10^{11}
Surface Area (sq. mi.)	298
Average Daily Inflow (cfs)	26,700
Estuarine Drainage Area (sq. mi.)	8,467
%EDA Land within coastal counties	79
Fluvial Drainage Area (sq. mi.)	8,037
Total Drainage Area (sq. mi.)	16,504

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.20	(M)
Particle Retention Efficiency (C/I)	0.20	(M)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

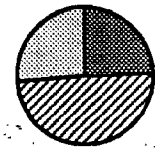
	Nitrogen	Phosphorus
Point	34,526	20,688
Nonpoint	13,161	1,162
Upstream	21,000	1,271
Total	68,687 (H)	23,121 (H)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	1.374	(H)	NA	NA	18,687	27
Phosphorus	0.462	(H)	NA	NA	18,121	78

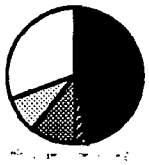
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Phosphorus

Note: Data based on 97% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATIION

The Hudson River/Raritan Bay estuary is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the high range for both nitrogen and phosphorus. In Hudson River/Raritan Bay, these high concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 7, suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.20 Barnegat Bay NJ

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	1.34×10^{10}
Surface Area (sq. mi.)	102
Average Daily Inflow (cfs)	2,300
Estuarine Drainage Area (sq. mi.)	1,350
%EDA Land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	1,350

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	1.36	(H)
Particle Retention Efficiency (C/I)	0.18	(M)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

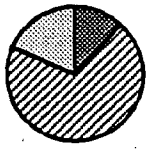
	Nitrogen	Phosphorus
Point	816	312
Nonpoint	1,212	179
Upstream	0	0
Total	2,028 (M)	491 (M)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.276	(M)	5,325	263	1,293	64
Phosphorus	0.067	(M)	244	50	417	85

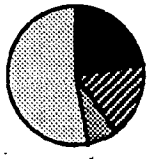
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen



Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Phosphorus

Upstream Sources

Note: Data based on 76% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Barnegat Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential combined with the estimated nutrient loadings results in predicted concentrations within the the medium range for both nitrogen and phosphorus. In Barnegat Bay, these medium concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 9, suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.21 Delaware Bay
DE, NJ, PA, MD

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	4.48×10^{11}
Surface Area (sq. mi.)	768
Average Daily Inflow (cfs)	19,800
Estuarine Drainage Area (sq. mi.)	4,750
%EDA Land within coastal counties	79
Fluvial Drainage Area (sq. mi.)	8,700
Total Drainage Area (sq. mi.)	13,450

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.14	(M)
Particle Retention Efficiency (C/I)	0.72	(M)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

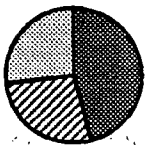
	Nitrogen	Phosphorus
Point	18,675	10,815
Nonpoint	4,224	596
Upstream	27,220	1,698
Total	50,119 (H)	13,109 (H)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class. Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.702	(M)	21,310	43	42,976	86
Phosphorus	0.184	(H)	NA	NA	5,966	46

Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Phosphorus

Note: Data based on 85% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Delaware Bay is estimated to have a medium susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loading results in a predicted concentration within the medium range for nitrogen. The DCP combined with the estimated phosphorus loading results in a predicted concentration within the high range for phosphorus. In Delaware Bay, these concentration classifications are not likely to be influenced by minor changes (<20%) in nutrient loadings. The N/P molecular ratio of the loading is 8, suggesting that nitrogen may be a limiting nutrient in the estuary.

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1.22 Chincoteague Bay MD, VA

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	2.25×10^{10}
Surface Area (sq. mi.)	137
Average Daily Inflow (cfs)	400
Estuarine Drainage Area (sq. mi.)	300
%EDA Land within coastal counties	100
Fluvial Drainage Area (sq. mi.)	NA
Total Drainage Area (sq. mi.)	300

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	3.08	(H)
Particle Retention Efficiency (C/I)	1.79	(H)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

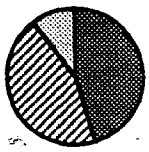
	Nitrogen	Phosphorus
Point	110	62
Nonpoint	182	22
Upstream	0	0
Total	292 (L)	84 (L)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.090	(L)	33	11	NA	NA
Phosphorus	0.026	(M)	241	287	52	61

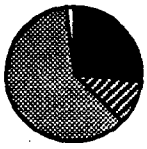
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



- Agriculture
- Forest
- Urban
- Range & Other Nonurban

Nitrogen

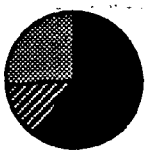


Point Sources
- Wastewater Trt. Plants
- Industrial Facilities

Nonpoint Sources
- Agriculture
- Forest
- Urban
- Other Nonurban

Upstream Sources

Phosphorus



Note: Data based on 69% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Chincoteague Bay is estimated to have a high susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loading results in a predicted concentration within the low range for nitrogen. The DCP combined with the estimated phosphorus loading should result in a predicted concentration within the medium range for phosphorus. In Chincoteague Bay, the low nitrogen concentration classification may be influenced by a minor increase (<20%) in nitrogen loading. The N/P molecular ratio of the loading is 8, suggesting that nitrogen may be a limiting nutrient in the estuary.

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College of Marine Studies
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U.S. Environmental Protection Agency

1.23 Chesapeake Bay VA, MD, DE, PA, DC

PHYSICAL CHARACTERISTICS

Dimensions

Volume (cu. ft.)	2.59×10^{12}
Surface Area (sq. mi.)	3,830
Average Daily Inflow (cfs)	85,800
Estuarine Drainage Area (sq. mi.)	21,955
%EDA Land within coastal counties	80
Fluvial Drainage Area (sq. mi.)	47,325
Total Drainage Area (sq. mi.)	69,280

Pollution Susceptibility

	Conc	Class
Dissolved Concentration Potential (mg/l)	0.072	(L)
Particle Retention Efficiency (C/I)	0.96	(M)

NUTRIENT CHARACTERISTICS

Estimated Loadings
(tons/year)

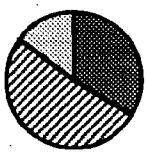
	Nitrogen	Phosphorus
Point	21,707	11,147
Nonpoint	10,973	1,433
Upstream	87,249	4,233
Total	119,929(H)	16,813 (H)

Predicted Concentration Status
(load in tons/year)

	Concentration		To Change Conc. Class, Increase by		Decrease by	
	mg/l	Class	Load	%	Load	%
Nitrogen	0.863	(M)	18,960	16	106,040	88
Phosphorus	0.121	(H)	NA	NA	2,924	17

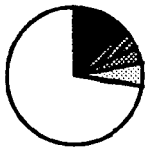
Abbreviations: cfs, cubic feet per second; mg/l, milligrams per liter; NA, not applicable; L, low; M, medium; H, high; C/I, volume/inflow.

Land Use



Agriculture
Forest
Urban
Range & Other Nonurban

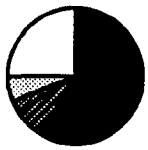
Nitrogen



Point Sources
Wastewater Trt. Plants
Industrial Facilities

Nonpoint Sources
Agriculture
Forest
Urban
Other Nonurban

Phosphorus



Upstream Sources

Note: Data based on 94% of coastal county portion of EDA. Nutrient discharge estimates are unavailable for wetlands and barren lands.

INTERPRETATION

Chesapeake Bay is estimated to have a low susceptibility for concentrating dissolved substances. This dissolved concentration potential (DCP) combined with the estimated nitrogen loading results in a predicted concentration within the medium range for nitrogen. The DCP combined with the estimated phosphorus loading should result in a predicted concentration within the high range for phosphorus. In Chesapeake Bay, the medium nitrogen concentration classification may be influenced by minor increases(<20%) in nitrogen loading, and the high phosphorus concentration classification may be influenced by minor reductions (<20%) in phosphorus loading. The N/P molecular ratio of the loading is 16, and does not strongly indicate the presence of a limiting nutrient in the estuary.

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National Estuarine Atlas

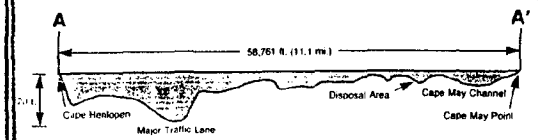
PHYSICAL AND HYDROLOGIC CHARACTERISTICS

PHYSICAL		FRESHWATER INFLOW				TIDAL DATA			
Surface Area (mi²)		Flow Rates (1000 cfs)				Prevailing Tide: Semidiurnal			
Fluvial Drainage	8,700	Period of Record		1963 1982		Tidal Prism (cf)		1.02x10¹²	
Estuarine Drainage	4,750	Long Term Average Daily			19.6	Phase Range of Tide (ft.)			
Estuarine Zones			J 23.1	J 13.2		Map Key	Station	Range	
Tidal Fresh	23		F 24.3	A 10.3		A	1809	4.2	
Mixing Zone	209		M 30.9	S 10.1		B	1793	4.8	
Seawater	545	Long Term Average Monthly	A 32.4	O 12.2		C	1765	5.0	
Total	768		M 23.9	N 15.7		D	1779	7.0	
Dimensions			J 18.4	D 22.1		E	1791	6.0	
Length (mi.)	138	7 Day 10 Year Low Flow		2.3		F	1823	4.5	
Width (mi.) Average	15.0					G	1827	2.6	
Maximum	4.2					H	1841	0.9	
Maximum	28.4	50 Year Flood		252.1					
Average Depth (ft.)	24.7	100 Year Flood		293.2					
Average Depth to Width Ratio	3.1x10⁻⁴	Flow Ratios							
Stratification Classification		Average Annual		0.009					
Average Flow		Mean Flow Period		0.013					
Average Low Flow		Low Flow Period		0.005					

Abbreviations: Vertically Homogeneous, VH; Moderately Stratified, MS; Highly Stratified, HS

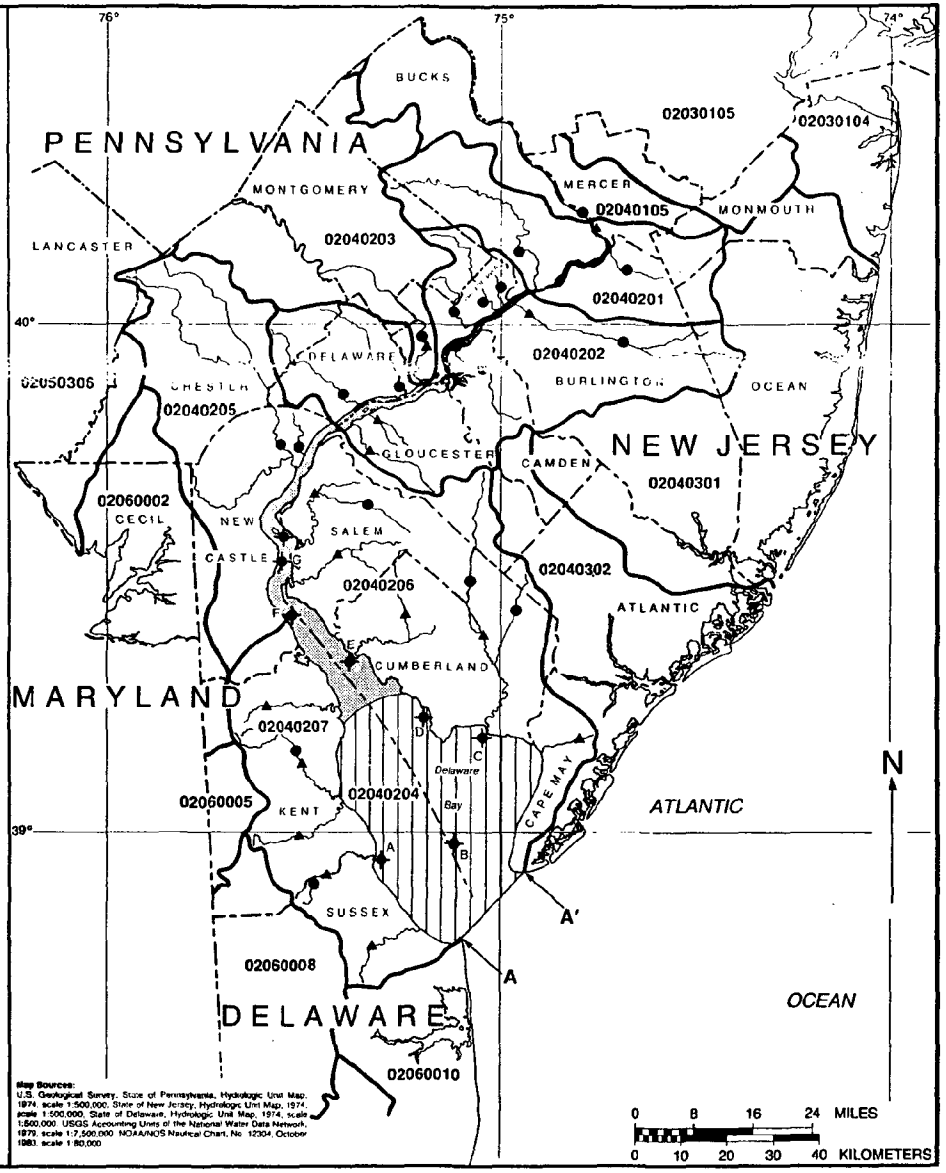
Cross Section
(at mean high water)

55 : 1 Scale Ratio



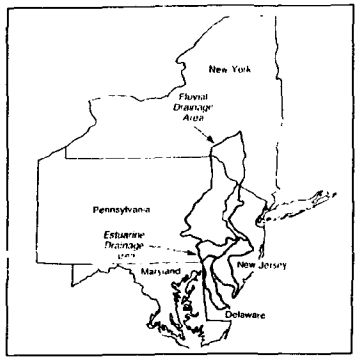
Notes:
One hundred percent of Estuarine Drainage Area is shown on map. Drainage Divide represents portion of Estuarine Drainage Area boundary not coinciding with U.S. Geological Survey cataloging unit boundary.

References:
Albert, 1982. Ambrose and Roesch, 1982. Buchanan, 1983. Delaware River Basin Commission, 1980. Flippo, 1982. Hatcher and Harleman, 1981. James, et al., 1982. New Jersey Department of Environmental Protection, 1978. Schaefer, et al., 1982. Simmons, 1967. Simmons and Carpenter, 1978. Thatcher and Harleman, 1978. U.S. Department of Commerce, 1983a. Voytik, et al., 1982.



Map Sources:
U.S. Geological Survey, State of Pennsylvania, Hydrologic Unit Map, 1974, scale 1:500,000, State of New Jersey, Hydrologic Unit Map, 1974, scale 1:500,000, State of Delaware, Hydrologic Unit Map, 1974, scale 1:500,000. USGS Accounting Units of the National Water Data Network, 1979, scale 1:7,500,000. NOAA/NOS Nautical Chart, No. 12304, October 1983, scale 1:80,000

Delaware Bay
DE, NJ, PA, MD



- Tide Gage
- Flow Gage
- Head of Tide
- Estuarine Drainage Area (EDA)
- Tidal Fresh Zone
- Mixing Zone
- Seawater Zone
- Hydrologic Cataloging Unit Boundary
- County Boundary
- Salinity Zone Boundary - Low Variability
- Salinity Zone Boundary - Moderate Variability
- Salinity Zone Boundary - High Variability

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