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Sediment inventory and characterization summary for the desk-top information system (COMPAS)

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et al

NOAA'S NATIONAL ESTUARINE INVENTORY

SEDIMENT INVENTORY AND CHARACTERIZATION SUMMARY FOR THE DESK-TOP INFORMATION SYSTEM (COMPAS)

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PROJECT DESCRIPTION

NOAA's National Estuarine Inventory (NEI) is a series of related activities of the Office of Oceanography and Marine Assessment (OMA), National Oceanic and Atmospheric Administration (NOAA) that aims to develop a national estuarine data base and assessment capability. Initiated in June 1983 as part of NOAA's program of strategic assessments, the broad goal of the NEI is to build a comprehensive computerized data base for evaluating the health and status of the Nation's estuaries. It aims to bring estuaries into focus as a national resource base. Without a systematic set of data with common coordinates, units and classifications, it is difficult to analyze or compare estuaries, to assess their regional influence and to generate useful information in the form of sediment charts or desk-top atlas summaries.

In May 1990 the Sediment and Contaminant Inventory (SCI) was initiated to develop a comprehensive information base on the distribution of bottom sediments and their contaminants. The desk-top information system termed Coastal Ocean Management, Planning and Assessment System (COMPAS) is one component of the SCI and National Estuarine Inventory. It is designed to make a wide range of data and information available to coastal resource managers. It aims to 1) bring existing but disparate, coastal resource information together into a single user-friendly computer system; and 2) to simplify the transfer of management information to and from state-level decision makers and the Federal government so that accurate and consistent resource assessments can be made. The computer will display the sediment maps together with living marine resource distributions, wetlands, pollutant sources and circulation routes to make comparisons and rankings. In this report sediment maps are compiled together with basic data on the morphology and hydrology as well as sediment sources, pathways and sinks for 21 estuarine systems in the Virginia Province (Figure 1). Additionally, it provides a process-oriented characterization summary. Supportive details, documentation and references are provided in companion characterization reports.

CONTENTS

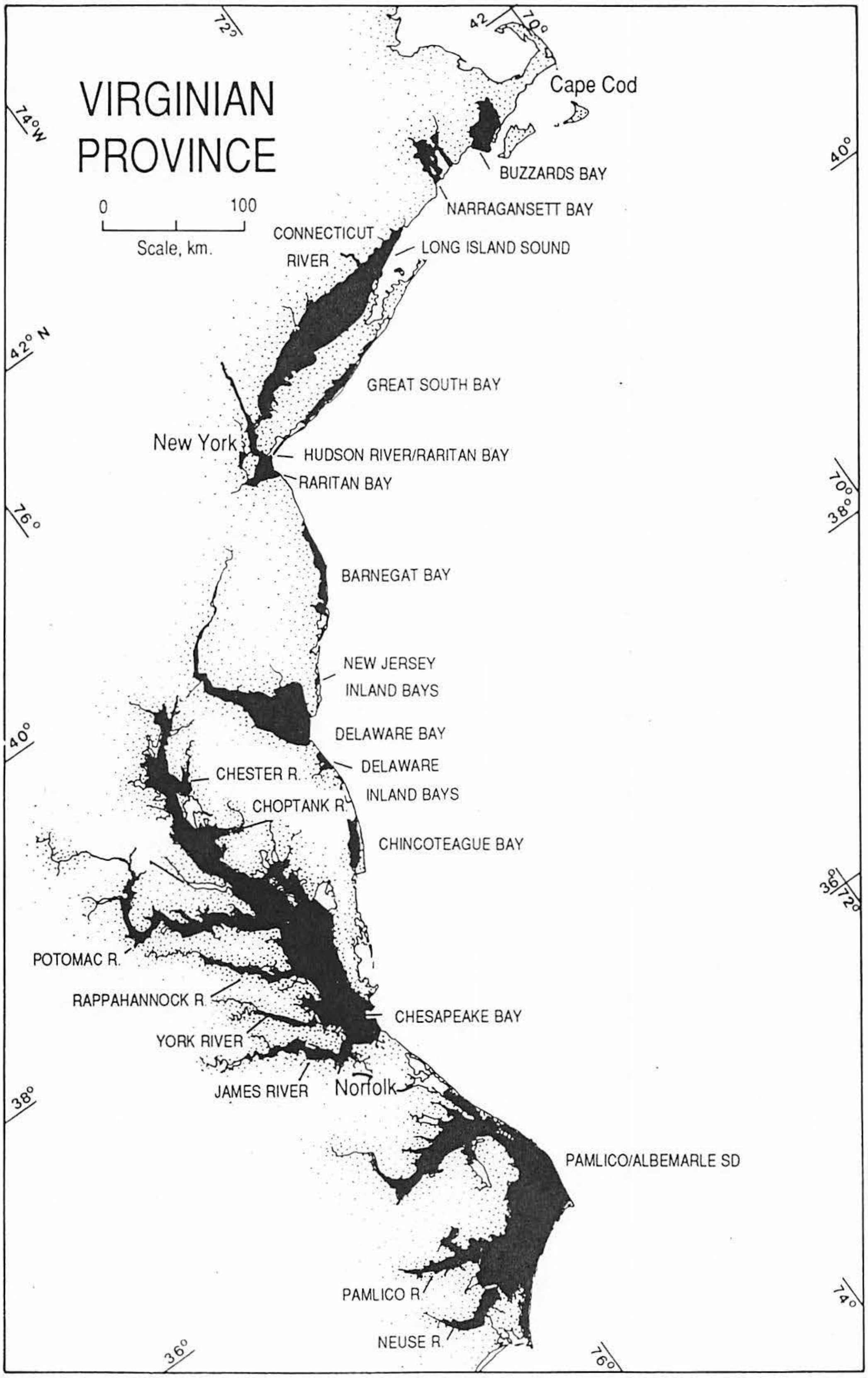


Figure 1. **Location of estuarine systems included in the desk-top information summaries for bottom sediments.**

KEY TO DESK TOP SUMMARY SHEET

Code Number is a NOAA code to identify estuary systems included in the National Estuarine Inventory (NEI). M numbers are for systems in the Middle Atlantic region, S numbers are for systems in the South Atlantic region.

Data Sources are the primary data sources used to compile the bottom sediment charts. The station data are included in the sediment data base. For documentation of information in the characterization summaries and sediment tables, see the VIMS/NOAA Sediment Characterization reports.

Data Quality is the overall relative quality including the quality of the data source(s) and the mappability of combined sources. Rankings range "highly certain," "moderately certain," "fairly certain," "reasonable inference" and "doubtful." For details see VIMS/NOAA Sediment Characterization Reports.

Bottom Sediment Charts

A. The mud abundance is broadly classified in percent, i.e. < 40%, 40 to 80%, > 80%. Hachured areas are sedimentation zones faster than a designated rate, e.g. 2 cm/yr.

B. The distribution of sediment types based on the Shepard classification (triangle). Because of the small page size scale, narrow transition zones such as occur between shoals and the channel or basin, are not always represented.

Where data for mud abundance and Shepard classification types is not available, other textural classes are substituted. When data come from several sources, the most recent and compatible data is used to form a consistent map mosaic.

Basics give the fundamental morphologic and hydrologic data from NOAA, 1990; width is the average width; depth the average depth for the entire system; drainage area embraces the total drainage area including the estuarine drainage area and the fluvial drainage area; river (stream) inflow is the annual average inflow for the entire system; sinuosity of river estuaries is the ratio of channel length to valley length.

Bottom Sediments

Mud area is the percentage of the total estuary area occupied by mud > 40%. In systems lacking mud > 40%, an alternate percentage or class is substituted as indicated.

Sand area is the percentage of the total NEI estuary (surface) area > 60% sand.

Sedimentation area is the percentage of the total NEI estuary (surface) area in which sedimentation rates are faster than a designated rate, e.g. 2 cm/yr. This is the hachured area on charts A.

Water content is the mean percentage water content expressed as wet weight (0 to 100%).

Organic matter is the mean percentage organic matter. Where original source data are expressed as organic carbon, the carbon values were multiplied by a factor of 1.8 to obtain organic matter values.

Pattern is the gross distribution of sand and mud, i.e. longitudinally along the channel from head to mouth or laterally across the middle or lower portion of the system.

Sources are the sediment sources for either: 1) the total sediment input, e.g. mud, sand and biogenic material, or 2) the total fine sediment, e.g. mud or silt plus clay. Where rates of input are not measured the source is reported qualitatively according to its relative strength; where input rates are known such as part of a mass balance, the strength is expressed as a percentage of the whole.

Sinks are sediment accumulation zones in the estuary for either: 1) total sediment, or 2) fine sediment. Where measured rates are not available the sink is reported qualitatively according to its relative strength; where accumulation rates are known such as part of a mass balance, the strength is expressed as a percentage of the whole.

Mass balance is a sediment budget for either: 1) total sediment, or 2) fine sediment, in which the sources (inputs) are balanced by the losses, i.e. into the sinks or through export to the ocean. Data come mainly from the published literature reported in the characterization reports. Two or more balances reflect a range of estimates from different data sources and in turn, different methodology or data uncertainties.

SPI is the sediment pollution index. This is a weighted index normalized to 100 and based on five parameters associated with polluted sediments, i.e. mud area percentage (> 40%), sedimentation area percentage, mean organic matter percentage, mean water content percentage, and the sediment storage efficiency in percent.

Storage Efficiency is the ability of an estuary to retain and accumulate fine sediment delivered to it. This is expressed as a ratio of the accumulation rate in all sinks to the drainage basin input rate. The rates come from the mass balance. A ratio of one implies the amount of sediment is equivalent to the amount supplied by the drainage basin. A ratio greater than one implies the estuary stores more sediment than is supplied by its drainage basin.

Pollution Susceptibility is the relative pollution potential of the system as determined by (1) hydraulic characteristics, i.e. ability of the system to flush dissolved pollutants, and (2) exposure to anthropogenic activities in the drainage basin. Relative rankings are from Biggs *et al.* (1989) and based on comparison of 78 U.S. estuaries.

Pathways are the likely routes of sediment transport from the source to the sink, or loss by export, displayed either in a schematic longitudinal profile or in plan view. Bold arrow represents relatively strong transport; thin arrow, weak transport. Near-bottom transport, dashed arrow; near-surface, solid.

Variability is the expected spatial distribution in the variability of sedimentary processes, i.e. erosion, transport and accumulation, inferred from expected fluctuations in the energy regime including river inflow, waves and tides. Additionally, man is an agent through dredging, filling and geometric modifications. The distributions are approximate. Patterns are keyed to the following processes or activities.

River flooding

Wave erosion and resuspension

Dredging and disposal

Inlet or tidal entrance channel migration, cut and fill

Flood tidal delta channel migration and/or shoal progradation

Relatively stable zones of fine sediment accumulation

Submarine mining

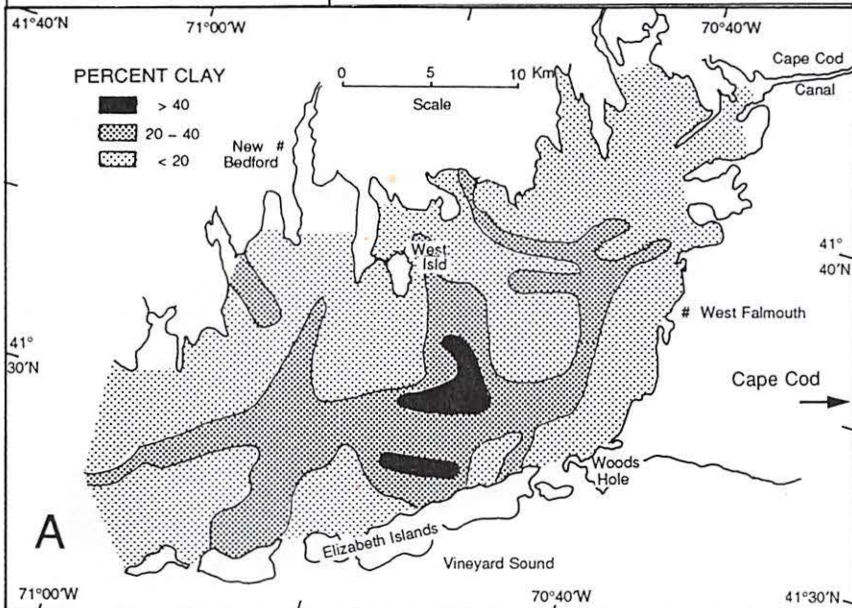
Bedforms and ripples

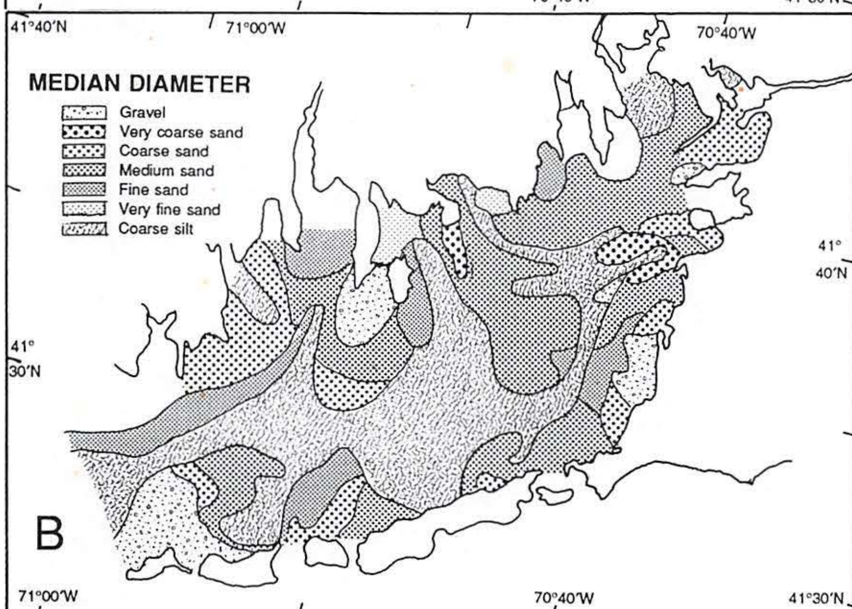
References

Biggs, R.B., T.B. DeMoss, M.M. Carter, and E.L. Beasley, 1989. Susceptibility of U.S. estuaries to pollution. *Reviews in Aquatic Sciences* 1:189-207.

NOAA, National Oceanic and Atmospheric Administration, 1990. Estuaries of the United States; vital statistics of a national resource base, 79 p.

M010 BUZZARDS BAY | **DATA SOURCE:** Moore, 1963 | **DATA QUALITY:** Fairly certain





BASICS:

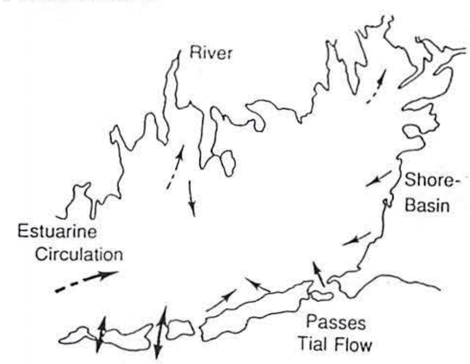
Length, km	45
Width, av. km	13
Depth, av. m	11
Surface Area, km^2	590
Drainage Area, km^2	1,554
River Inflow, m^3/s	34

BOTTOM SEDIMENTS:

Clay Area, >30%	19
Sand Area, %	81
Organic Matter, Av. %	3.8

Pattern:
Clay and silt in basins and north tributaries; sand on shoals; gravel at entrance

PATHWAYS



SOURCES

SOURCES	Rel. Strength*
Drainage basin	Very Low
Shores	Low
Marine	Moderate
Production & Sewage	Low
Relic	Very Low

SINKS

SINKS	Rel. Strength*
Central Floor	Moderate
Tributary Harbors	Low

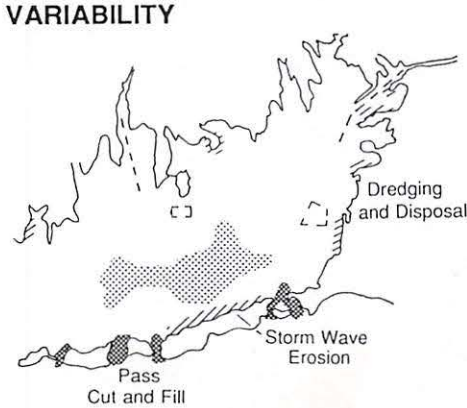
*For total sediment

SEDIMENTATION RATE, mm/yr

Central Floor 1.0 Harbors 15 to 40

POLLUTION SUSCEPTIBILITY: High due to low flushing ability and locally high populations in drainage basin

VARIABILITY



Characterization. Buzzards Bay is a large deep embayment at the western boundary of Cape Cod. Configuration and bathymetry are shaped by glacial action. The southeastern shore, i.e. the Elizabeth Islands, consists of a frontal moraine while the northwestern shore, which lies normal to the moraine, consists of drowned tributary valleys and elongate scoured troughs that follow former fluvial valleys. The bathymetry is modified by dredged channels cut about 10 m deep leading to New Bedford and to the Cape Cod Canal. Dump sites lie south of West Island and west of West Falmouth.

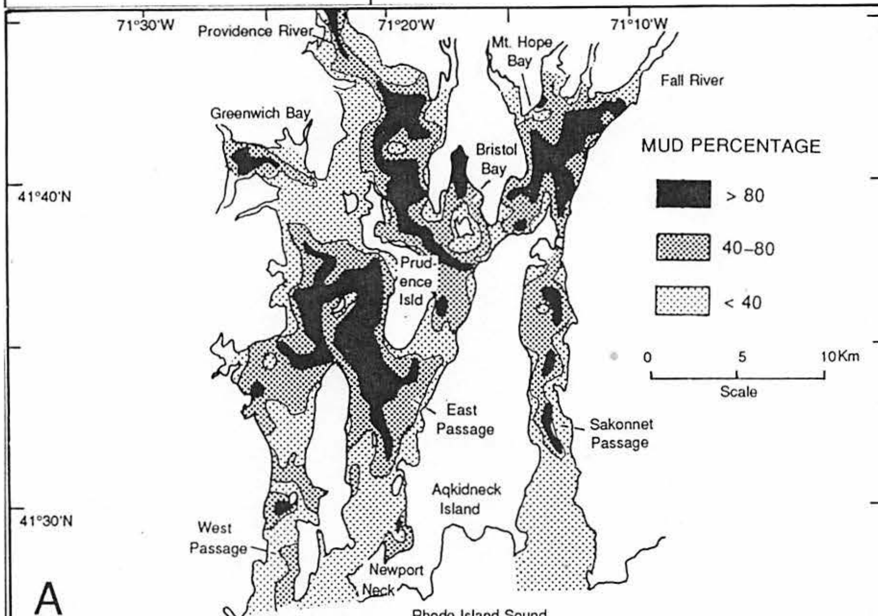
Sediment sources are poorly known but fluvial input of fine sediment is likely very low. Much silt comes from marine areas as well as erosion of shore bluffs typically composed of glacial till. Erosion and reworking of relic glacial deposits on the bay floor by storm waves supplies some fine material while benthic production on the bay floor supplies shell.

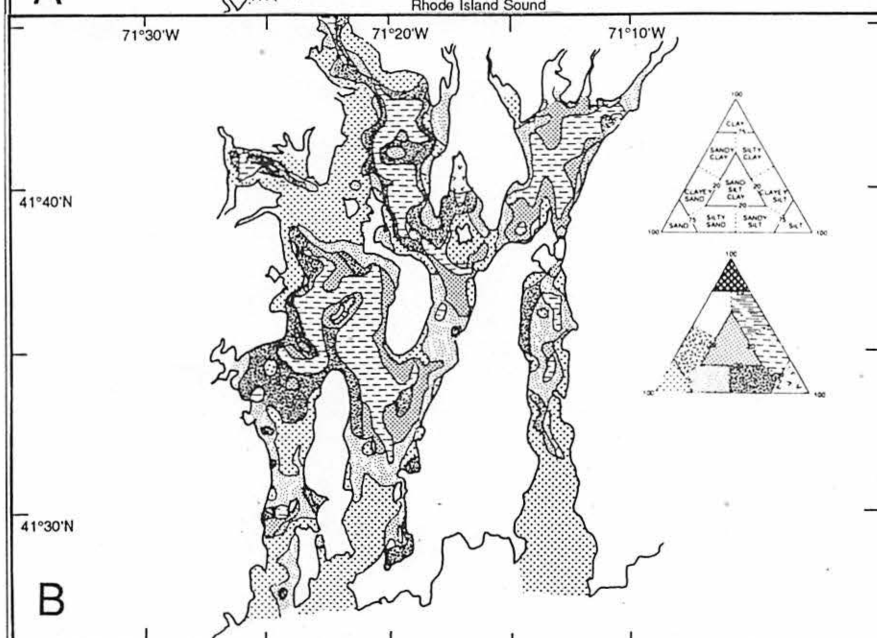
Fine sediment is likely transported into the bay from marine areas by tidal currents. The central floor is a major sink because of weak currents and accumulation has produced a gently sloping floor. Additionally, benthic organisms encourage deposition by pelletizing sediment filtered from overlying water. Prior to deposition, the top 2 to 3 cm of fine sediment is resuspended many times by storm waves. Most fluvial fine sediment is retained in the northwest harbors and tributaries together with marine material added by landward flow of the estuarine circulation. Small amounts however, escape to the central basin.

Bottom sediments are fine-grained, i.e. coarse silt, in deeper parts greater than 10 m, and display a pattern reflecting the remnant drainage troughs. In contrast, they are coarse-grained, i.e. very coarse to coarse sand or gravel, in shallow, wave exposed zones less than 6 m, either nearshore or on topographic highs. However, gravel occurs in deep zones of fast currents near the entrance and in passes through the Elizabeth Islands. Fine sediment also resides in nearshore tributaries and embayments which are zones of low energy.

Buzzards Bay receives contaminants from wastewater treatment plants and industrial discharges mainly at, or near, New Bedford. Sediment contamination by metals, i.e. Cu, Cr, Pb and Zn, in the harbor is marked, and extends to the central bay where concentrations are about 5% those at New Bedford. Additionally, the central bay is contaminated with PCBs and hydrocarbons; some are probably derived from atmospheric fallout. Pollution susceptibility for toxics is high because of low flushing ability and a locally high population in the drainage area relative to bay area.

M020 NARRAGANSETT BAY	DATA SOURCES: McMaster, 1956a,b,c; 1960	DATA QUALITY: Moderately certain





BASICS:

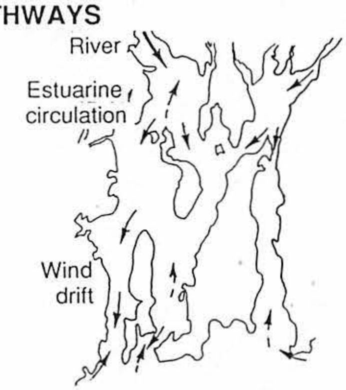
Length, km	64
Width, av. km	8.5
Depth, av. m	9.5
Surface Area, km^2	427
Drainage Area, km^2	4,660
River Inflow, m^3/s	90

BOTTOM SEDIMENTS:

Mud Area, %	50
Sand Area, %	50
Water Content, Av. %	48
Organic Matter, %	2.2-4.6

Pattern:
Mud in channels near-river and upper embayments.
Sand in passages and near entrance.

PATHWAYS



SOURCES	Rel. Strength*	SINKS	Rel. Strength*
Drainage basin	Very Low	Upper Channels	Moderate
Shores	Low	Lower Passages	Low
Marine	Moderate		
Sewage	Low		

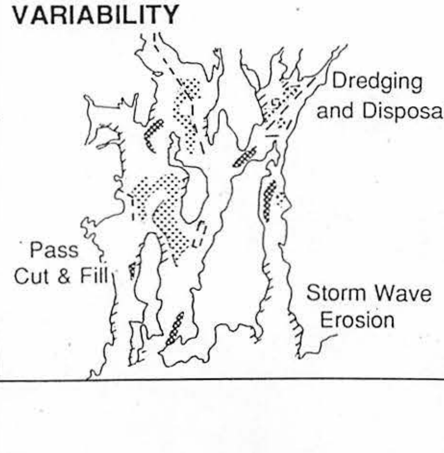
*For total sediment

SEDIMENTATION RATE, mm/yr

Average	3.0	Channels, upper	17.0
		Passages, lower	1.3

POLLUTION SUSCEPTIBILITY: High in upper Bay due to low flushing ability.

VARIABILITY



Characterization. Narragansett Bay is shaped into three main interconnected passages, small bays, reentrants and intervening islands which trend north-south. The present-day Bay began to form about 9,000 years ago as sea level rose, drowned and infilled the valleys with a variety of sediments. Dredged channels cut 10 - 12 m into the Providence River and 10 - 11 m into Mount Hope Bay - Fall River area. Much material is disposed in deep holes southeast of Prudence Island, as well as off Conanicut Island, around Spar Island in Mount Hope Bay while some is dumped offshore in Rhode Island Sound.

Fluvial sediment input is very low, about 0.1×10^6 m tons/yr. A turbidity maximum is lacking, the mid and lower bay is well-mixed vertically. Fine sediment is also derived from marine areas via the landward estuarine flow. Some material is derived by storm wave erosion of glacial deposits along the shore or by reworking of older Bay floor deposits.

Within the Bay, fine sediments are redistributed by tidal currents and the estuarine circulation with superimposed wind forcing. The estuarine circulation is pronounced in the Providence River where waters are partially mixed and the dredged channel focuses landward flow. East Passage is the main avenue of transport. Wind forcing on the offshore shelf causes landward flow through West and Sakonnet Passages and return flow through East Passage. For offshore winds the transport direction is reversed. Additionally, nearshore sand is likely transported into the Bay via littoral currents around entrance headlands.

The main sinks of mud accumulation are in channels of near-river areas, e.g. Providence River, upper Narragansett and Mount Hope Bays. Accumulation ranges 1.3 to 17.0 mm/yr being faster in the upper Bay than the lower Bay. Accumulation rates average 3.0 mm/yr for the entire Bay while sea level rise is 1.5 to 2.6 mm/yr. Total accumulation of fluvial fine sediment amounts to about 0.07 to 0.09×10^6 m tons or 70 to 90% of the fluvial input. Accumulation in dredged channels is 5 to 7 times greater than non-dredged areas. The Bay likely traps additional amounts of fine sediment from marine and shore sources.

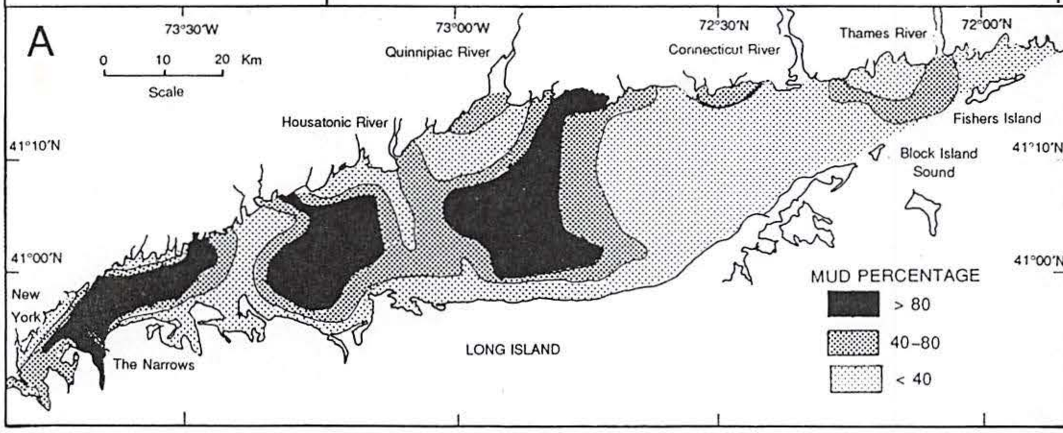
Mud (> 80%), is abundant in channels of near-river areas but also occurs in a large zone southwest of Prudence Island. Mud is also abundant in lateral reentrants as Greenwich Bay and in deeper parts of Sakonnet Passage. These zones are bordered by zones of coarser sediment that form a transition of mixed sediment between mud and sand. Gravel patches occur locally as unburied lag of older glacial deposits. In general, texture coarsens seaward from the mid-Bay to the entrance where currents and waves are stronger.

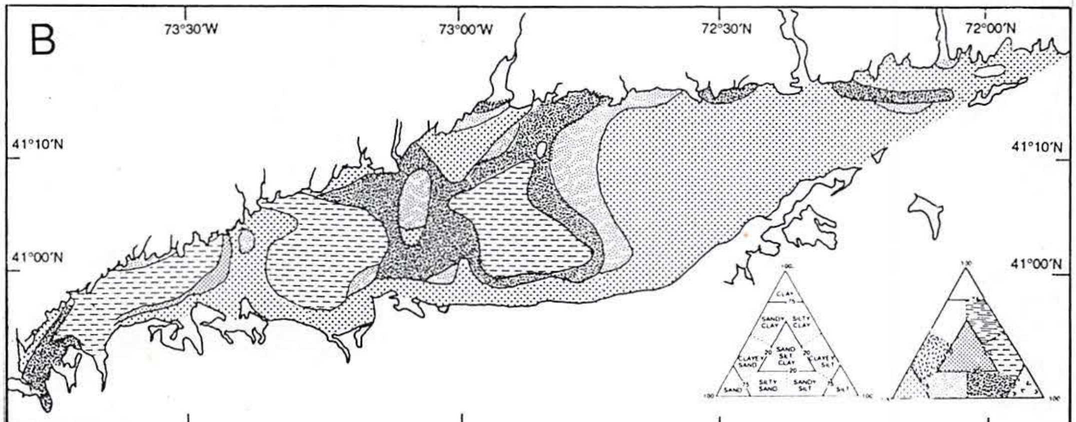
Narragansett Bay receives relatively heavy loads of nutrients and metals. Concentrations generally diminish exponentially seaward from the Providence River. Sewage treatment plants on the Providence River are the major source of anthropogenic metals. Additionally, sewage enters from the Fall River, Seekonk River, West and East Passages and Greenwich Bay. Besides metals, urban runoff and industrial discharges supply petroleum hydrocarbons and PAH's. Pollution susceptibility to toxics in the upper Bay is high due to low flushing ability.

M040 LONG ISLAND SOUND

DATA SOURCE: Reid et al. 1979

DATA QUALITY: Fairly certain





BASICS:

Length, km	204
Width, av. km	28
Depth, av. m	19
Surface Area, km^2	3,320
Drainage Area, km^2	44,550
River Inflow, m^3/s	850
Sinuosity	1.0

BOTTOM SEDIMENTS:

Mud Area, %	49
Sand Area, %	51
Organic Matter, Av. %	1.0
Range, %	1 to 9

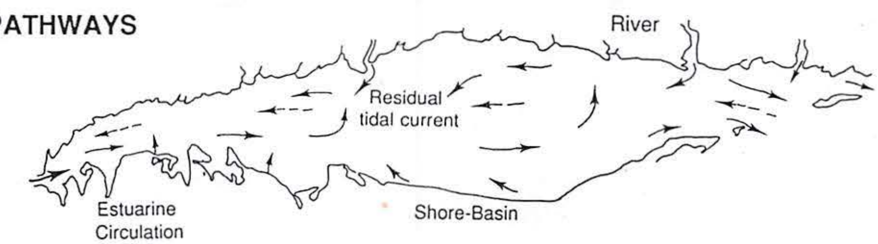
Pattern:
Mud basins, western portion. Sand, sills, eastern floor and near Long Island shore.

Sedimentation Rate, mm/yr:

Basins	0.7-0.9
Dredged harbors	10-76

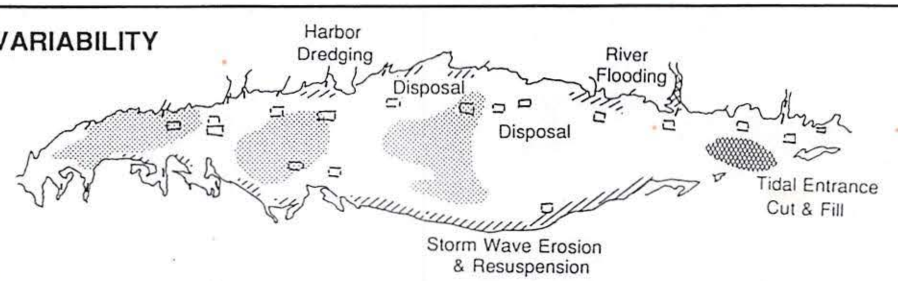
SOURCES	Strength, %*
Drainage Basin	40
Urban Runoff	13
Shores	2
Marine	45

PATHWAYS



SINKS	Strength %*
Basins	81
Dredged Harbors & Channels	19

VARIABILITY



STORAGE EFFICIENCY:* 2.6 to 3.3

MASS BALANCE*

sources = losses (sinks + export)

0.9 = 1.6 - .07 x 10^6 tons/yr

POLLUTION SUSCEPTIBILITY: High due to low flushing ability and high population relative to estuary area.

*For fine sediment

Characterization. Long Island Sound is a large, 200 km-long estuary that is highly impacted by massive urbanization of more than eight million people. It is used for shipping, waste disposal, recreational boating and it supports large recreational fisheries.

The Sound is shaped into a long trough with a deep central basin divided into three sub-basins, and bounded by sills at the east and west ends. The trough was carved by ancient fluvial erosion and later filled with glacial deposits of sand, gravel and boulder till as the last ice sheet melted. The present-day Sound began to form 8,000 years ago as sea level rose and drowned the trough. Dredged channels cut into 25 harbors around the Sound and the bulk of this material (~ 97×10^6 m^3) is dumped at open-water sites.

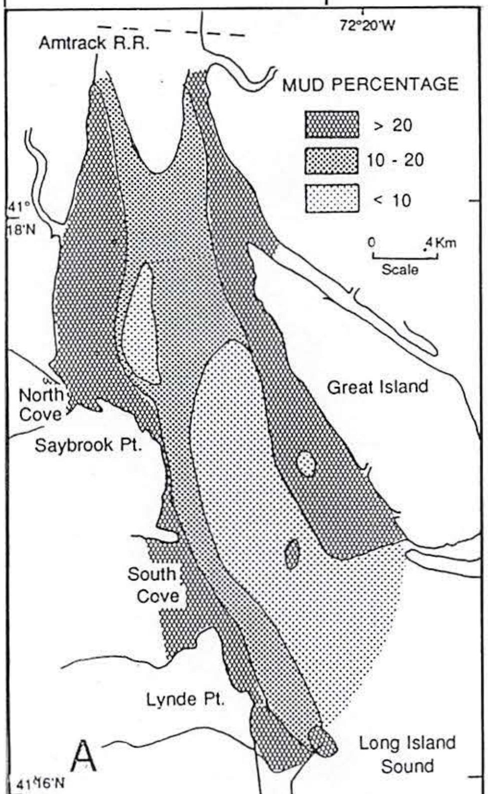
There is no large fluvial sediment input into the Sound. It is estimated that about 40% of the total fine sediment input is supplied from the drainage basin, mainly the Connecticut River. Additionally, about 13% comes from urban runoff and sewage in the drainage basin, and 2% from wave-cut bluffs of Long Island. The largest supply, an estimated 45%, is derived from marine areas but a portion may include material recycled from the Connecticut River.

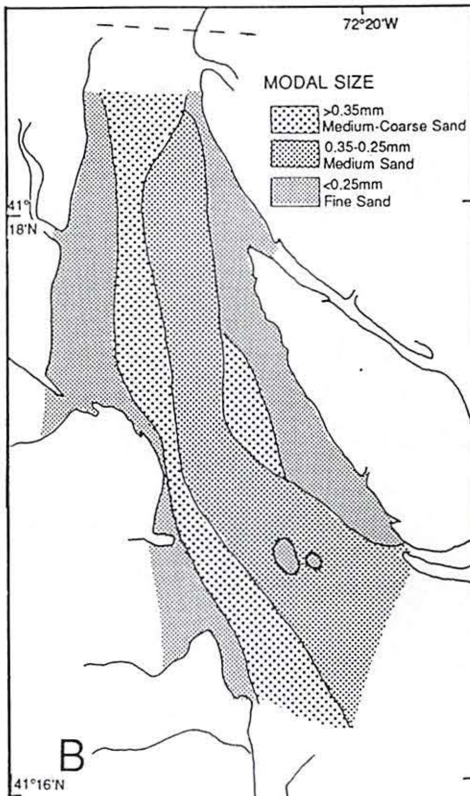
Once in the Sound, fine sediments are redistributed by tidal currents and the estuarine circulation. Marine material is carried westward in the lower layer. Prior to permanent deposition, a large amount of sediment is resuspended and redeposited by currents and storm waves, e.g., an estimated seven million tons daily. The bulk of the total input therefore, is maintained in suspension before it is deposited.

The main sink of mud sedimentation is in two basins of the central and western Sound, i.e. west off the Housatonic River. Accumulation averages about 0.7 to 0.9 mm/yr. This contrasts to 10 to 76 mm/yr or an average of 39 mm/yr, in the dredged harbors of Connecticut. The main sink of sand is on the eastern Sound floor. Sea level rise, i.e. 3 mm/yr, exceeds the sedimentation rate; therefore the Sound is an effective trap for fine sediment. Since the total deposition is estimated at 1.6×10^6 m tons/yr, then the storage efficiency is about 2.6 to 3.1. This means the Sound not only traps an amount equivalent to its river input but large amounts from other sources probably marine areas.

Mud (> 80%), mainly silt, covers the basin floor of the central and western Sound below the 10 m depth where tidal currents and wave action are relatively weak. In contrast, sand (> 60%) covers the eastern one-third of the Sound besides sills between the basins. The sand coarsens eastward toward the entrance where strong tidal currents and ocean waves scour and rework glacial outwash sand. In the process giant sand waves form, fine sediment is removed and is transported westward in the lower layer. Sand also extends nearshore along central Long Island close to its source in bluffs. Fine sediment is likely winnowed out and deposited in less energetic deep basins. Between mud and sand zones, at intermediate depths, there is a transition of mixed sediments (40 - 80% mud) representing a net flux of sand over accreting mud deposits. Organic matter is less than 1% in the sandy sediments of the eastern portion and 9 to 10% in muddy deepwater basins. Pollution susceptibility is high because of low flushing ability and the high population relative to estuary area.

M040a CONNECTICUT RIVER	DATA SOURCE: Horne and Patton, 1989	DATA QUALITY: Fairly certain





BASICS:

Length, km	>100
Width, av. km	0.9
Depth, av. m	4.0
Surface Area, km^2	52
Drainage Area, km^2	29,000
River Inflow, m^3/s	594
Sinuosity	1.1

BOTTOM SED

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SOURCES	Rel. Strength*
Drainage Basin	High
Shores	Very Low
Marine	Low

SINKS	Rel. Strength*
Channel	Very Low
Shoals	Low
Marshes	Low
Reentrants	High

MASS BALANCE*

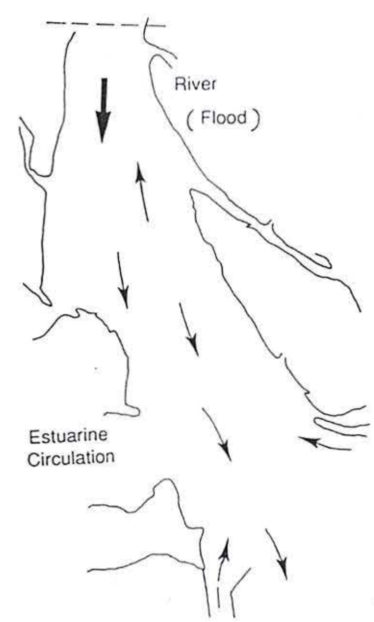
sources = losses (sinks + export)

0.3 = 0.06+ 0.24 x 10^6 tons/yr

STORAGE EFFICIENCY:
Very Low

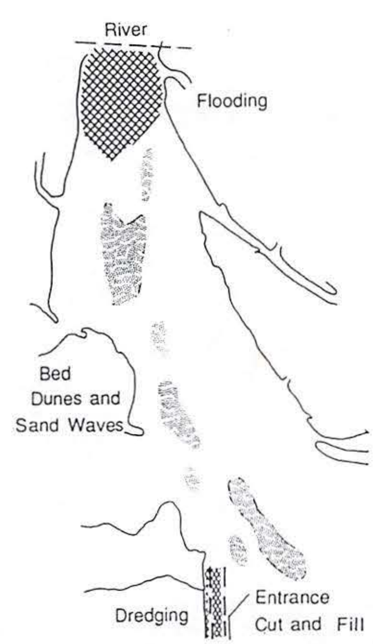
POLLUTION SUSCEPTIBILITY:
Relatively Low

PATHWAYS



*For fine sediment

VARIABILITY



Characterization. The Connecticut River is New England's largest and longest river with a drainage basin covering 29,000 km^2. It contributes 71% of the total freshwater input and much of the suspended sediment load, to Long Island Sound. Contaminant loading however, is limited because of low metal activity in the basin and low sewage input. Also, much waste is transported to Long Island Sound via barge.

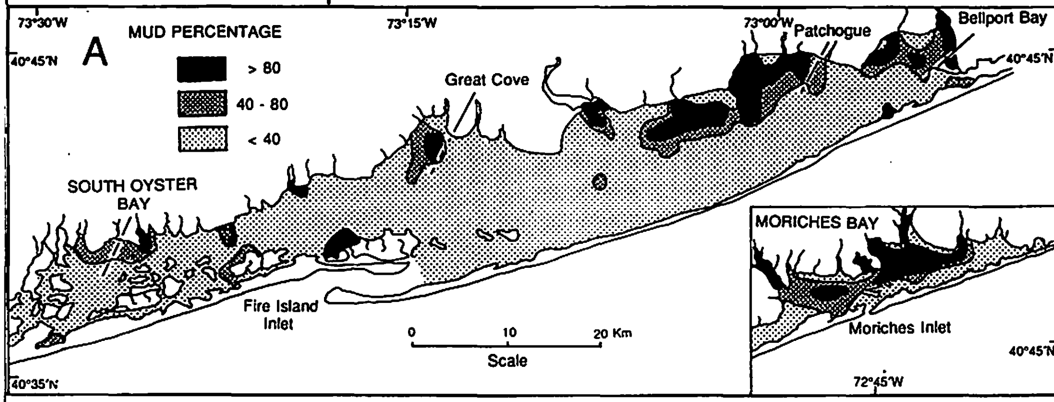
The Connecticut River estuary is a small river mouth estuary dominated by sand. Although the tide extends over 100 km landward the normal salinity limit extends only 15 km landward. This zone consists of a low relief coastal plain. The seaward portion of the estuary extending 5 km south of the Amtrak bridge, is funnel-shaped with an axial channel flanked by shoals. This bathymetry and the lateral reentrants, originated by drowning glaciated fluvial topography. Modern bathymetric changes are small, except where dredged channels cut across shoals in the main channel 3.3 to 4.0 m deep. Maintenance dredging however, is limited except in the jettied entrance channel. Changes also occur east of the jetties off Lynde Point where a broad shoal built up 1.5 m between 1925 and 1979. Overall, sedimentation and sediment storage is relatively low in the estuary because the bathymetry is in near-equilibrium with the river sediment supply.

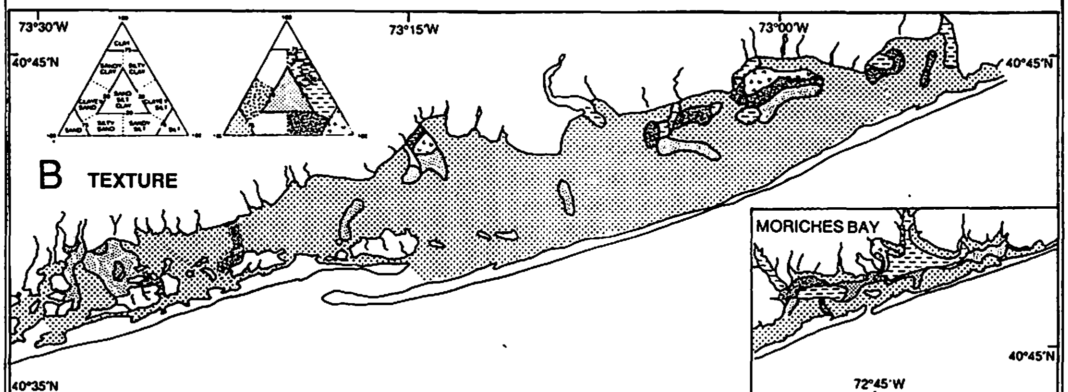
The drainage basin is the dominant sediment source supplying the bulk of the load during short periods of river flooding. Most river-borne fine suspended load is derived from river bank erosion, or from material temporarily stored on the bed during normal river inflow. Small amounts of fine sediment are carried into the lower estuary from Long Island Sound via the lower estuarine layer during normal or low river inflow. Although most of the suspended load is discharged into Long Island Sound during river floods, an estimated 0.3×10^6 m tons/yr, some fines are retained in coves and marginal reentrants, e.g. South Cove, North Cove, and marshes of Great Island. Accumulation in the estuary amounts to an estimated 0.06×10^6 m tons/yr or 20% of the input.

The bottom sediments are dominantly sand. Medium to coarse sand is abundant on subtidal shoals, bars and the channel floor. Mud (> 20%) is significant in coves, lateral reentrants and between entrance jetties. Large fields of subaqueous dunes and megaripples indicate bedload transport is active and their asymmetrical orientation indicates ebb dominance. Bedload is stored most of the year and then flushed into Long Island Sound during high river discharge.

Pollution susceptibility is lower than in most other large river estuaries of the Virginia Province due to substantial flushing ability of river floods and to moderate anthropogenic activity in the drainage basin.

M050 GREAT SOUTH BAY	DATA SOURCES: Nichols, 1957; Jones & Schubel, 1978; Jones & Schubel, 1980	DATA QUALITY: Moderately certain





BASICS:

Length, km	115
Width, av. km	3.5
Depth, av. m	2.2
Surface Area, km^2	390
Drainage Area, km^2	2,190
Stream Inflow, m^3/s	20

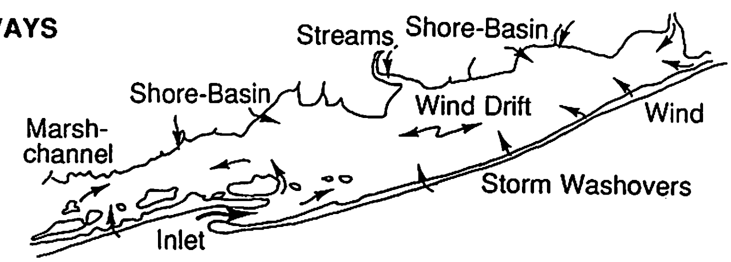
BOTTOM SEDIMENTS:

Mud Area, %	26
Sand Area, %	74
Organic Matter, %	2.5
Range, %	0.1 - 34.4

Pattern:
Sand; locally mud basins and mud reentrants along north shore

SOURCES	Rel. Strength*
Drainage basin	Low
Shores	Low
Marine	Moderate to High
Production	Low

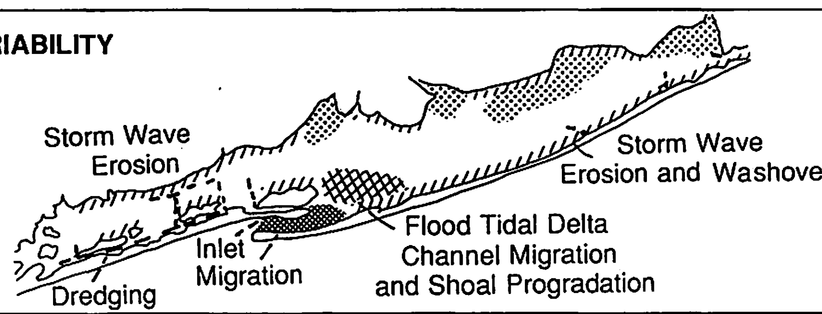
PATHWAYS



SINKS	Rel. Strength*
Basins & Reentr'ts	Moderate
Dredged Channels	Moderate
Washover Shoals	Low
Flood Tidal Delta	High
Marshes	Low

*For total sediment

VARIABILITY



POLLUTION SUSCEPTIBILITY: High due to low flushing ability and high anthropogenic activity in drainage basin

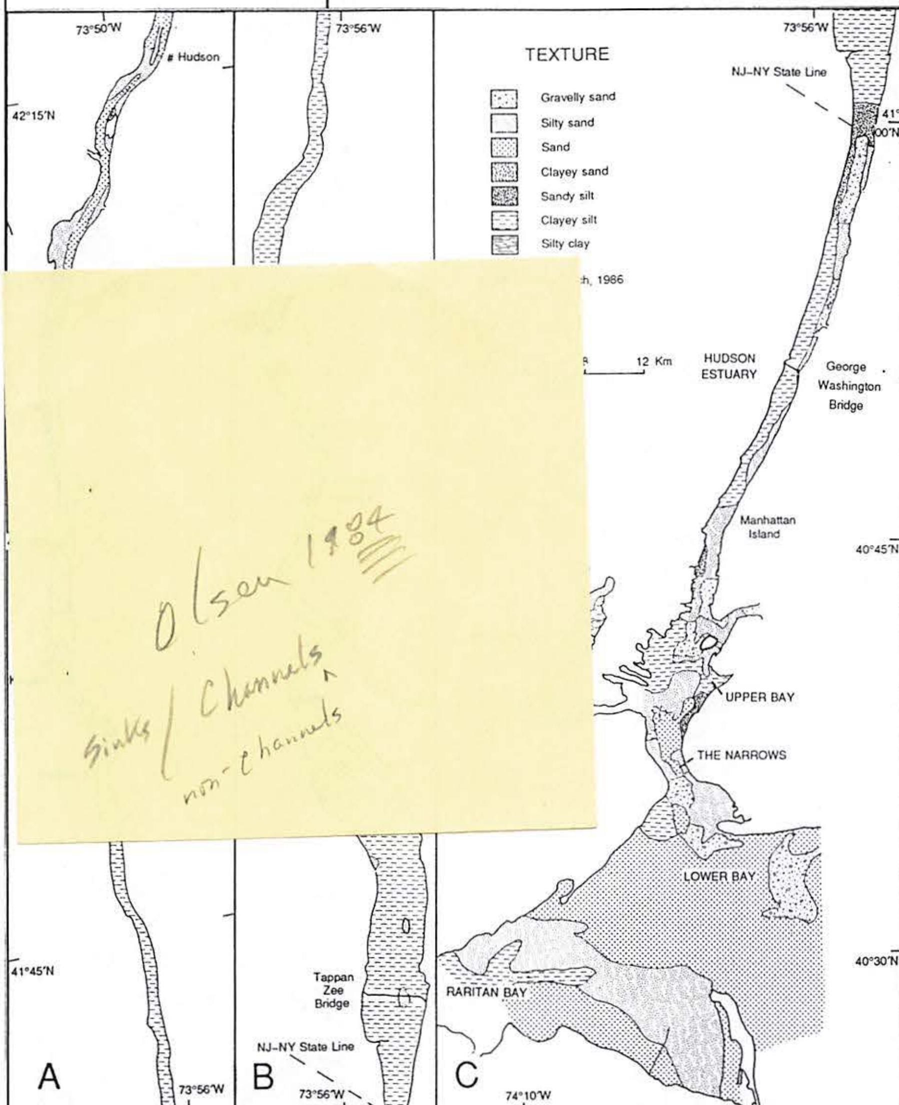
Characterization. The Great South Bay is the largest of a series of interconnecting shallow lagoons on Long Island's south shore. The Bay experiences varied and intensive impacts of urbanization by two million people in the drainage basin. Dredged channels forming the Intracoastal Waterway cut 1.4 to > 3.3 m deep behind the western barrier islands, through inlet approaches, through interconnecting bay passages and into numerous tributaries along the north shore.

Mud is supplied from the drainage basin via the larger streams, from biogenic production and from marine areas via flood tidal currents. Sand is supplied during storms from the barrier via temporary inlets and washovers as well as by flood tidal currents. Shores supply some material and locally eolian transport from barrier dunes is active. Sediment from marine areas likely exceeds inputs from streams, shores or production. Prior to accumulation fine sediment undergoes wind wave resuspension and is transported back and forth through the central bay.

The main sinks of mud sedimentation are the deep basins (> 2.2 m) along the north shore where wave action and tidal currents are diminished. Fines resuspended from the bay floor by storm waves deposit in marshes and dredged channels or are trapped by eelgrass on shoals. Sand is deposited in the flood tidal delta as tidal currents expand and decelerate inward from the inlet. Additionally, much sand is deposited in washover fans and storm surge platforms in backbarrier zones.

Less than 5% of the floor is covered with mud (> 80%), mainly patches in less energetic basins along the north shore off large streams. Sand (> 60%) covers 80% of the floor being coarse in Fire Island Inlet and fine in western and southern sectors and in deep central portions. Admixtures of sand and mud occur along the north shore where depth increases rapidly lagoonward. In Moriches Bay the pattern is mud in central basins and north shore reentrants; sand on backbarrier shoals, the flood tidal delta and along margins. The bay is renown for organic-rich mud in tributaries where duck farm runoff is discharged. Pollution susceptibility in both bays is high because of low flushing ability and the high ratio of chemical and metal activity in the drainage basin relative to estuary area.

M060 HUDSON RIVER/ RARITAN BAY	DATA SOURCES: Coch, 1986; Jones et al. 1979; Joseph, 1983; Kastens et al. 1978; Olsen, 1964; Suszkowski, 1978	DATA QUALITY: Moderately certain



Olsen 1984
sinks / channels
non-channels

BASICS:

Length, km	256
Width, av. km	2.7
Depth, av. m	6.4
Surface Area, km^2	772
Drainage Area, km^2	42,735
River Inflow, m^3/s	756
Sinuosity	1.1

BOTTOM SEDIMENTS:

Mud Area, %*	49
Sand Area, %*	51
Organic Matter, Av. %	6.5

Pattern:

Longitudinal:

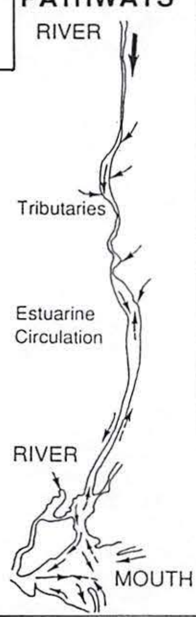
Channel, sand at head, mud middle, sand with gravel patches at Manhattan Island and seaward; tripartite pattern.

Lateral:

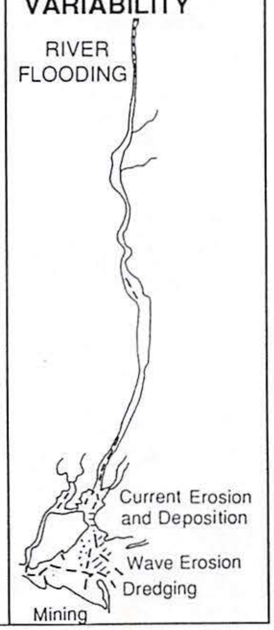
Highly variable; in Manhattan Island reach, mud west side, sand with gravel east side.

*Based on Coch '86 classification.

PATHWAYS



VARIABILITY



SOURCES	Strength, %*
Drainage basin	60-70
Marine	20-30
Wastes, inorganic	3
Production & sewage	8

SINKS	Strength, %*
Dredged Channel	66
Non-Dredged Channel	33
Marshes	<1
Reentrants	<3

MASS BALANCE*

sources = losses (sinks + export)

1.6 ± 0.5 = $1.5 \pm 0.5 \times 10^6$ tons/yr

*For fine sediment

Storage Efficiency: 1.3 to 1.6

POLLUTION SUSCEPTIBILITY: High due to low flushing ability and high anthropogenic activity

Characterization. The Hudson River/Raritan Bay system is large and complex. The main compartments are: (1) tidal river, landward of Beacon, (2) river estuary, The Narrows to Beacon, including the Upper Bay, (3) Lower Bay/Raritan/Sandy Hook Bay seaward of The Narrows. Fluvial and shore source material is highly variable. Geologically the system is a drowned river valley that began with the most recent submergence 11,500 years ago.

The drainage basin is the dominant fine sediment source supplying 60 to 70% of the input, mainly during river floods. Supply from shores is negligible because of extensive rock and bulkheaded shores. Sewage (solids) and biogenic production supply about 8% of the fine sediment while 20 to 30% comes from marine areas. Additionally, about 3% of the total input is introduced as inorganic sewage and industrial wastes. River-borne fine sediment is cycled by the estuarine circulation: i.e. (1) seaward through freshwater river reaches; (2) seaward through the upper estuarine layer and downward by settling; (3) landward through the lower estuarine layer to the inner salt limit (Beacon). Input from marine areas is transported landward via the lower layer. Large exchanges of suspended sediment can occur among different interconnected subsystems. Dredging and disposal activities are the chief process for transport of fine sediment from the system to marine areas.

Sand is carried into the Lower and Upper Bays partly from the east via longshore transport along Coney Island and partly from relic glacial outwash deposits on the Lower bay, or inner shelf, floor. Marine sands may move landward at least to the George Washington Bridge. Alternately, fluvial sand moves seaward via the main river from Hudson to Kingston together with sand supplied from lateral tributaries landward of Highlands Gorge.

Mud sedimentation is fastest (40 to 700 mm/yr) averaging about 90 mm/yr, in the dredged channel between Weehawken and Edgewater. Additionally, sedimentation rates are substantial (50 - 100 mm/yr) averaging 30 mm/yr, in non-dredged channels between The Battery and George Washington Bridge. This zone is close to the inner salt limit during extreme river floods. Between the bridge and Beacon sedimentation rates are 1 to 2 mm/yr in the channel, 1 to 5 mm/yr on shoals and 10 to 30 mm/yr in marginal reentrants. About 66% of the total sediment accumulation comes from dredged areas whereas 33% is from non-dredged areas. Mass balances indicate the Hudson stores most of the fluvial input plus sediment from other sources, marine, production and sewage. Consequently, the storage efficiency is substantial, 1.3 to 1.6.

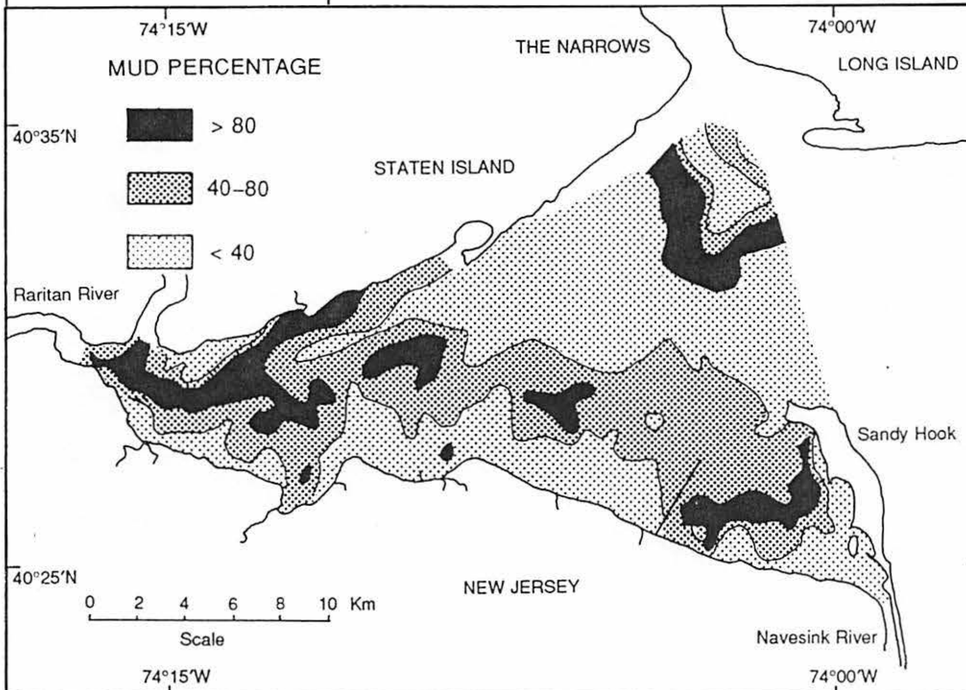
Silty clay and clayey silt is abundant in the inner estuary, i.e. between Esopus and NJ - NY state line. Farther landward and seaward the sediments progressively coarsen. This broad tripartite pattern, sand-mud-sand, partly reflects the energy regime, i.e. strong-weak-strong, i.e. river flooding, weak tides and storm waves or strong tides. It also reflects available coarse source material at ends of the system.

In the Upper Bay clayey silt is deposited in a less energetic zone on the west side (NJ) whereas on the east side and in the central portion fine sediment is removed, or deposited elsewhere because of strong tidal currents. Thus, the bed is covered with sand or gravelly sand besides anthropogenic wastes. The northern Lower Bay is covered with sand and gravelly sand patches as a result of the underlying glacial outwash material and the energetic wave regime.

Newark Bay is a subsystem with coarse-grained sediment (silty sand) at ends of the system and fine-grained sediment (clayey silt) in central portions. This is a tripartite pattern reflecting proximity to the river source at the north end and strong tidal currents at the south end.

The Hudson/Raritan system supports a major shipping, industrial and railroad complex which is one of the world's busiest seaports. The high population, about 15 million people, and intense industrialization, produce enormous waste loads of water and dredged material. In terms of pollution susceptibility the Hudson/Raritan system ranks high because of low flushing ability and the dense human population, including much chemical and metal activity in the drainage basin, relative to estuary surface area.

M060a RARITAN ESTUARY	DATA SOURCES: Kastens et al. 1978; Joseph, 1983; Multer et al. 1984	DATA QUALITY: Highly certain



BASICS:

Length, km	28
Width, av. km	10
Depth, av. m	4.6
Surface Area, km^2	197
Drainage Area, km^2	2,900
River Inflow, m^3/s	45

BOTTOM SEDIMENTS:

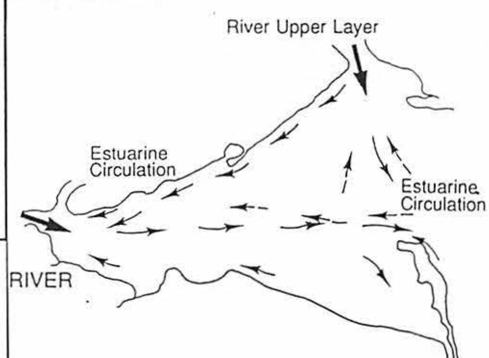
Mud Area, %	78
Sand Area, %	22
Organic Matter, Av.%	3.0
Water Content, Av. %	57

Pattern:
Mud near river, Sandy Hook Bay and deep central parts; sand on shoals and near mouth.

SOURCES	*Rel. Strength
Drainage basin	Moderate
Shores	Low
Marine	Moderate
Sewage & Production	Low

SINKS	*Rel. Strength
Dredged Channels	Moderate
Non-Dredged areas	Low
Borrow Pits	Low

PATHWAYS



SEDIMENTATION RATE, mm/yr*

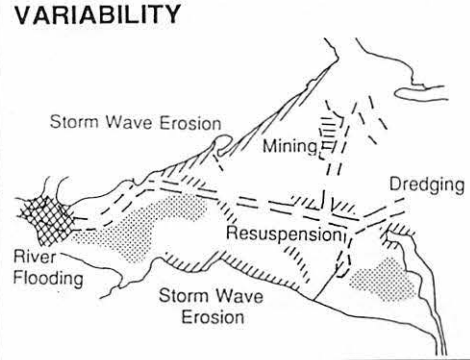
Dredged Channels, Av.	0.5 cm/yr
Non-Dredged Areas, Av.	0.15 cm/yr
Borrow Pits	2.2 cm/yr

Storage Efficiency:* 0.7 to 1.7

*For fine sediment

POLLUTION SUSCEPTIBILITY: High due to low flushing ability and high anthropogenic activity in the drainage basin.

VARIABILITY



Characterization. Raritan Estuary receives a wide variety of contaminants from domestic sewage, industrial discharges and agricultural runoff in the drainage basin. Additionally, the estuary is used for sand and gravel mining, for fisheries and recreation and it is part of one of the world's great seaports, New York. A network of dredged channels is cut through the bay 9 to 11 m deep.

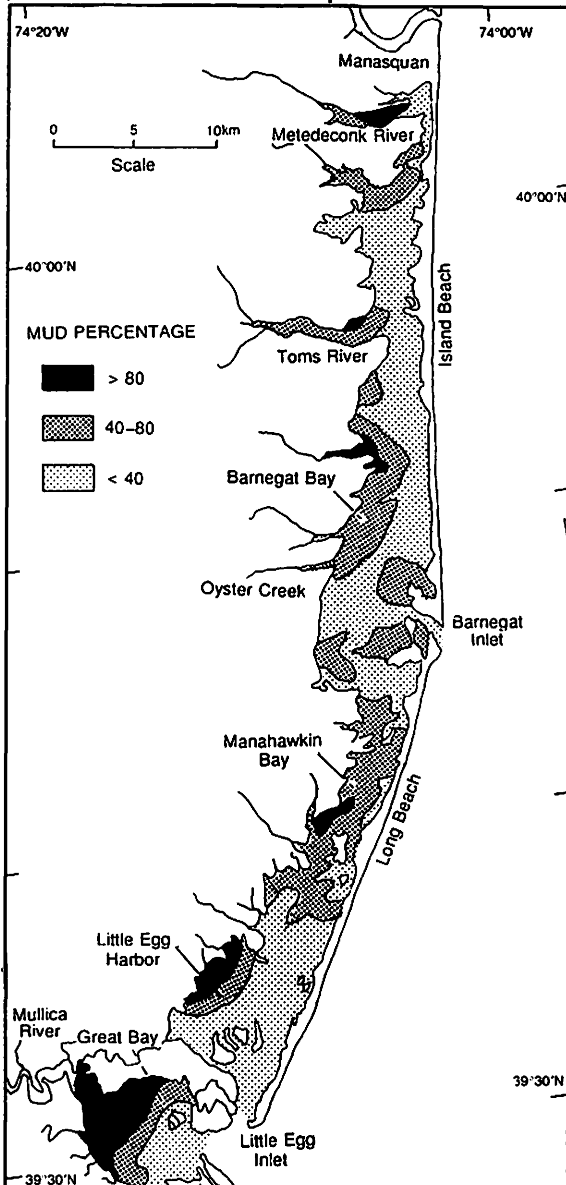
Mud is supplied mainly from the drainage basin via the Raritan River and also from the Hudson River and upper bay via the upper estuarine layer. A portion of the mud is deposited in the bay but another portion is transported to sea. Supply from shore erosion comes mainly from Staten Island and secondarily from northern New Jersey but the bulk of the shore input is likely sand. Sewage (solids) and production contribute about 13 to 20% of the total fine sediment input while 8 to > 20% of the total comes from marine areas via the lower estuarine layer. Relatively large amounts of sand are supplied to Sandy Hook and vicinity via longshore drift from the south. Fine bed sediments undergo resuspension by storm waves and by shipping activity. Additionally, strong winds create perturbations in the normal tidal and non-tidal currents.

The main sink of mud sedimentation is off the Raritan River mouth. Deposition is encouraged by protection from westerly winds, by diminished tidal currents, by inputs from major sewage outfalls and by the confluence of littoral drift. Another mud sink is Sandy Hook Bay, an area protected from ocean waves and tidal currents that receives fine sediment from the Navesink River and from wastewater discharge. About 75% of the total deposited fine sediment input accumulates in dredged areas including borrow pits, while 25% resides in non-dredged areas. Mass balances indicate a range of storage efficiency for the estuary from 0.7 to 1.7.

Mud (> 80%) is abundant near the estuary head, but also occurs in patches through the central estuary and in Sandy Hook Bay. The patches (> 80%) reside within a broad belt delineated by the 40 to 80% mud isopleths. Mud is also abundant at creek mouths and in borrow pits. Sand (> 60%) covers areas north of the New Jersey shore, south of Staten Island and west of Sandy Hook. Where sand passes into mud there is a sharp transition of mixed sediment (40 - 60% mud) that is subject to textural change with time. This is likely caused by storm resuspension, bed transport or human activity.

Pollution susceptibility is high because of low flushing ability and high anthropogenic activity in the drainage basin relative to estuary surface area.

M070 BARNEGAT BAY	DATA SOURCES: Joseph, 1984-1988	DATA QUALITY: Fairly certain



BASICS:

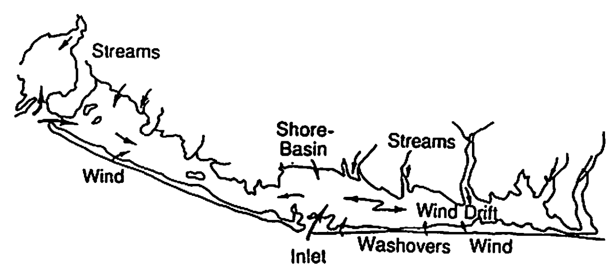
Length, km	68
Width, av. km	4.5
Depth, av. m	1.4
Surface Area, km^2	264
Drainage Area, km^2	3,500
Stream Inflow, m^3/s	65

BOTTOM SEDIMENTS:

Mud Area, %	59
Sand Area, %	41
Sedimentation Rate mm/yr	
Creeks, landward	30-70
Main Bay	<10
Organic Matter, %	2.7 - 8.5

Pattern:
Sand, tidal deltas and back barrier shoals; mud belt and mud-sand admixtures in tributaries and reentrants along landward shore

PATHWAYS

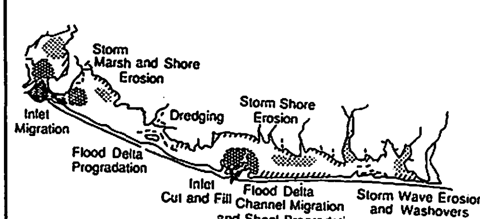


SOURCES	Rel. Strength*
Drainage basin	Low
Shores	Low
Marine	Moderate
Production	Low

*For total sediment

SINKS	Rel. Strength*
Basins & Reentr'ts	Moderate
Dredged Channels	Moderate
Washover Shoals	Low
Flood Tidal Delta	High
Marsh	Low

VARIABILITY



POLLUTION SUSCEPTIBILITY: High due to low flushing ability but low due to low anthropogenic agricultural and chemical activity

Characterization. The Barnegat Bay system is a shallow microtidal lagoon with ocean water exchange through two inlets, Barnegat Inlet and Little Egg Inlet. The bay is affected by waste disposal, dredging, boating and a nuclear generating station. Dredged channels cut 1.2 to 2.4 m deep through portions of Manahawkin Bay, inlet approaches and off the Toms River mouth. Barnegat Inlet is the most frequently dredged.

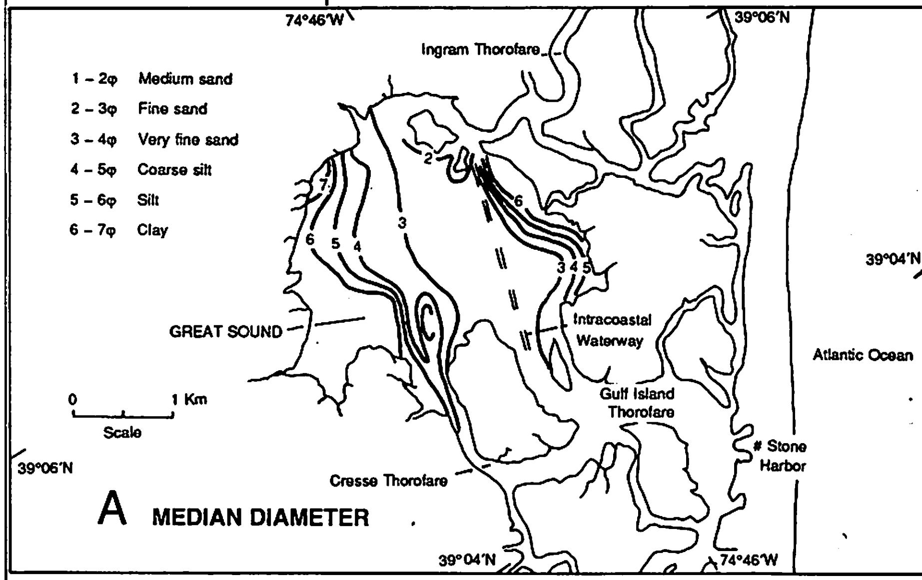
The main source of sediment, mostly sand, is from marine areas, i.e. inner shelf and beaches via flood tidal currents through inlets. Some sand is supplied from the barrier via washovers during extreme storms or via eolian transport. Mud is supplied from the landward drainage basin via streams and small rivers however, some likely comes from marine areas including headlands north of the bay (e.g. Atlantic Highlands). Wind waves along the bay axis resuspend bottom sediment and drive an intermittent transport back and forth. Resuspended fines deposit in marshes, less energetic basins or reentrants. Some radionuclide contaminated fines escape through the inlet and accumulate in inner shelf depressions.

Flood tidal deltas that are built landward of the inlets, are the main sediment sinks for sand. Washovers were probably common prior to man's development of the barriers. Fines accumulate in reentrants and creeks along the landward shore and in basins. Sedimentation rates vary from 30 - 70 mm/yr in the creeks to < 10 mm/yr on the bay floor.

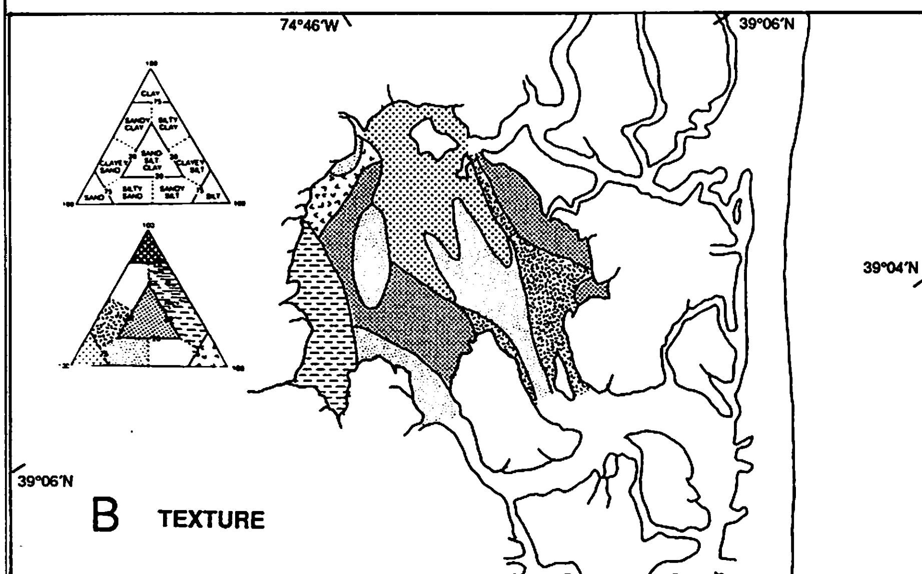
Mud (> 80%) covers 15% of the system. Together with mixtures of mud and sand, the mud forms a discontinuous zone along the west shore. Sand (> 60%) covers 44% of the bay, mainly in a backbarrier zone. Inlet sediments are medium to coarse-grained sand whereas tidal delta sands are fine to medium-grained sand.

Barnegat Bay receives nutrients from fertilized agriculture areas and organic wastes of residences and boats. Pollution susceptibility ranks high because of poor flushing ability but anthropogenic activity per unit lagoon area is low.

M080 NEW JERSEY INLAND BAYS, GREAT SOUND	DATA SOURCES: Faas and Carson, 1988	DATA QUALITY: Moderately certain



A MEDIAN DIAMETER



B TEXTURE

BASICS:

Length, km	3
Width, av. km	2.3
Depth, av. m	0.6
Surface Area, km^2	6
Total Discharge, fld, m^3/s	700
Total Discharge, ebb, m^3/s	400

BOTTOM SEDIMENTS:

Mud Area, %	25
Sand Area, %	75
Organic Content, %	0.5-76.0

Pattern:

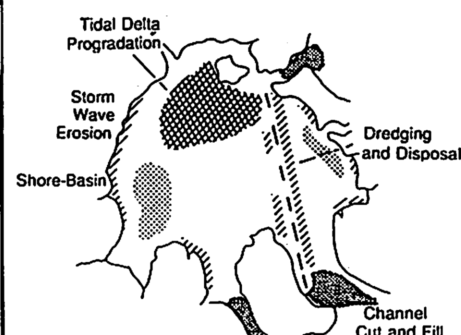
Sand in central portions, mud in lateral basins and marginal reentrants

Decreasing grain size inward from channel and across tidal deltas

SEDIMENTATION RATE, mm/yr

Tidal Deltas, av.	5.4
Basins, av.	1.8
Transitional areas	0.5-10

VARIABILITY

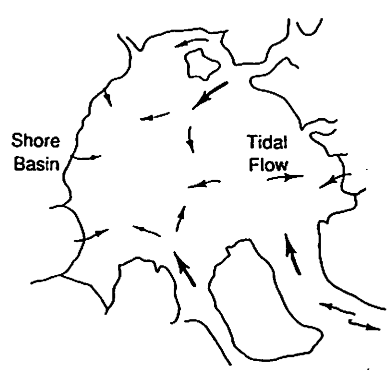


SOURCES	Rel. Strength*
Drainage basin	Nil
Shores	Low
Marine	High

SINKS	Rel. Strength*
Flood Tidal Deltas	High
Dredged Channel	Moderate
Marsh	Low
Basins	Low

*For total sediment

PATHWAYS



Characterization. Great Sound is one of many small marsh-filled lagoons connected to inlets by meandering through-flowing channels. It is surrounded by marshes and stream inflow is nil. The tide range is about 1.5 m and channel currents reach 50 to 90 cm/s. The lagoon is relatively free of disturbance except for a channel serving the Intracoastal Waterway cut across the central portion to depths of 2.4 m. Dredged material is disposed in open water along channel flanks.

Most sediment is supplied from marine areas via flood-dominated currents through the channels. The sand originates from erosion of the beach, shoreface or channel sides. Mud originates from reworking of the inner shelf by storm waves or from reworking of bottom sediment in northeastern Delaware Bay. Some fines are likely derived from production within the lagoon. When flood channel flow enters the lagoon, the jet flow expands and decelerates thus allowing deposition in tidal deltas or, on flanks of the dredged channel. Fines settle out in less energetic basins or reentrants especially on the southwest side. Deposition is aided by biogenic aggregation and benthic filter feeders. Once deposited the sediment is subject to intense bioturbation. Besides basins, flood tidal deltas are the most prominent sinks; they build sand flats near the channel entrance. Marshes, dredged channels and dead-end channels are also sites for mud accumulation.

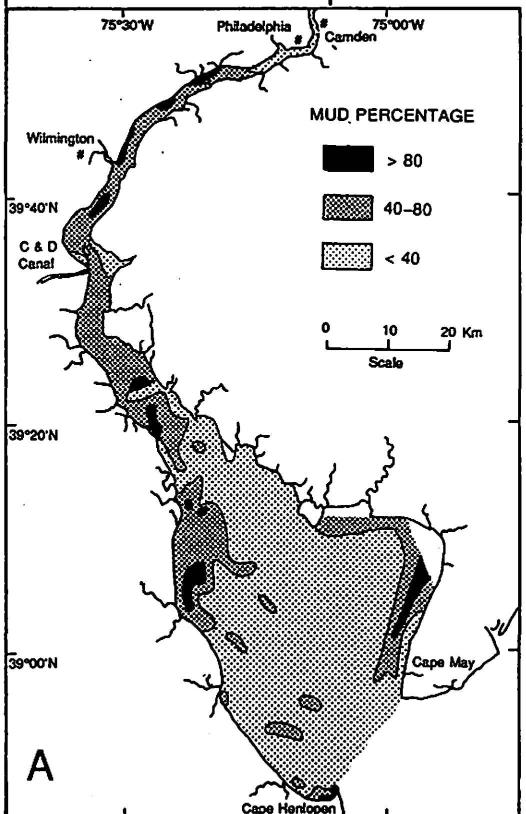
Sand (> 75%) covers 22% of the lagoon whereas mud (< 25% silt and clay) covers 15%. The rest is mixed, i.e. sand-silt-clay. Median grain size decreases progressively from tidal deltas and the dredged channel through transitional zones to the basins. This distribution reflects decreasing currents inward into the lagoon and away from the channels.

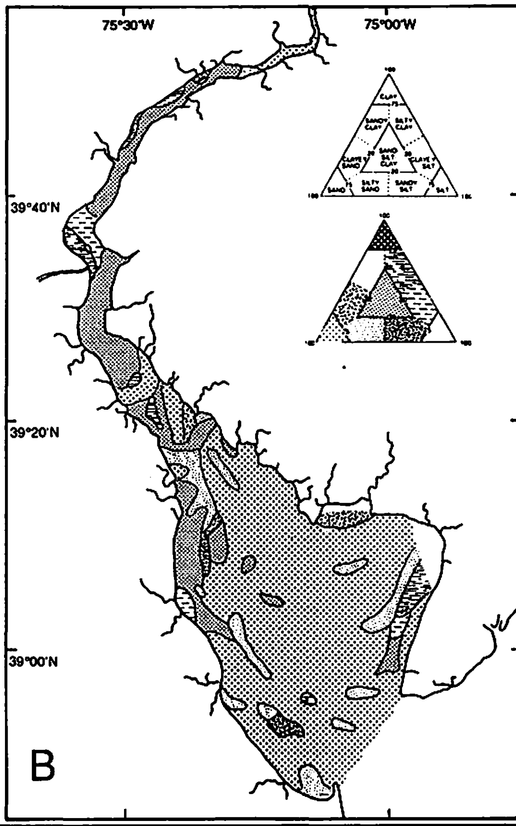
Although there are no significant contaminant sources on Great Sound, the lagoon receives some arsenic from Delaware Bay via the continental shelf. Additionally, the metals Cu, Pb and Hg are supplied from organic wastes discharged at Stone Harbor and transported landward via a channel. Concentrations of metals are enhanced in the lagoon by normal sediment fractionation processes that lead to accumulation of fines in the lagoon.

M090 DELAWARE BAY

DATA SOURCE: Weil, C. B. 1977; Neiheisel, 1973

DATA QUALITY: Moderately certain





BASICS:

Length, km	221
Width, av. km	24
Depth, av. m	6.4
Surface Area, km^2	2,036
Drainage Area, km^2	350
River Inflow, m^3/s	560
Sinuosity	1.5

BOTTOM SEDIMENTS:

Mud Area, %	32
Sand Area, %	68
Organic Matter, Av. %	3.2
Range, %	0.3-8.0

Pattern:
- Longitudinal: Channel, sand at head, mud middle, sand mouth; tripartite pattern.
- Lateral: Lower estuary, channel sand flanked by mud along shore.

SOURCES	Strength, %*
Drainage Basin	25-33
Shores, Marshes	26-28
Marine	14
Production	10-19
Sewage, Industrial	5-15

SINKS	Strength, %*
Natural Channel	Low
Shipping Channel	High
Marsh, Creeks	Moderate

MASS BALANCE*

sources	=	losses (sinks + export)
4.2	=	$3.6 + 0.6 \times 10^6$ tons/yr
8.0	=	$6.8 + 1.2 \times 10^6$ tons/yr

*For fine sediment

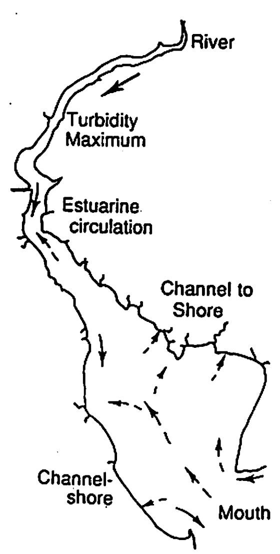
SEDIMENTATION RATE, mm/yr

Dredged Channel	>27
Mid-Upper Estuary, Av.	6.8
Lower Estuary, Av.	1.8

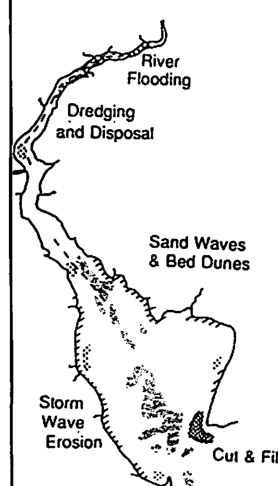
STORAGE EFFICIENCY: 2.1 to 4.0

POLLUTION SUSCEPTIBILITY: High because of low flushing ability and high anthropogenic chemical and metal activity

PATHWAYS



VARIABILITY



Characterization. The Delaware Estuary contains a major shipping and industrial complex which includes the third largest seaport in the United States. Its watershed houses 7.1 million people; together with industrial plants, they produce enormous waste loads of water and much dredged material.

The Estuary's broad funnel configuration and its axial channel were initially shaped by fluvial erosion at lower sea level. Subsequent rise of sea level in the last 8,000 years drowned the fluvial topography, eroded the shore and enlarged the estuary. A major dredged channel cuts through shoals 7.6 to 12 m deep in middle and upper reaches, 80 to 200 km landward of the mouth. Formerly much material was disposed in open water along channel margins but in about 1970 most material was placed in diked areas on islands and along shores. This practice decreased maintenance dredging about 2.5 times.

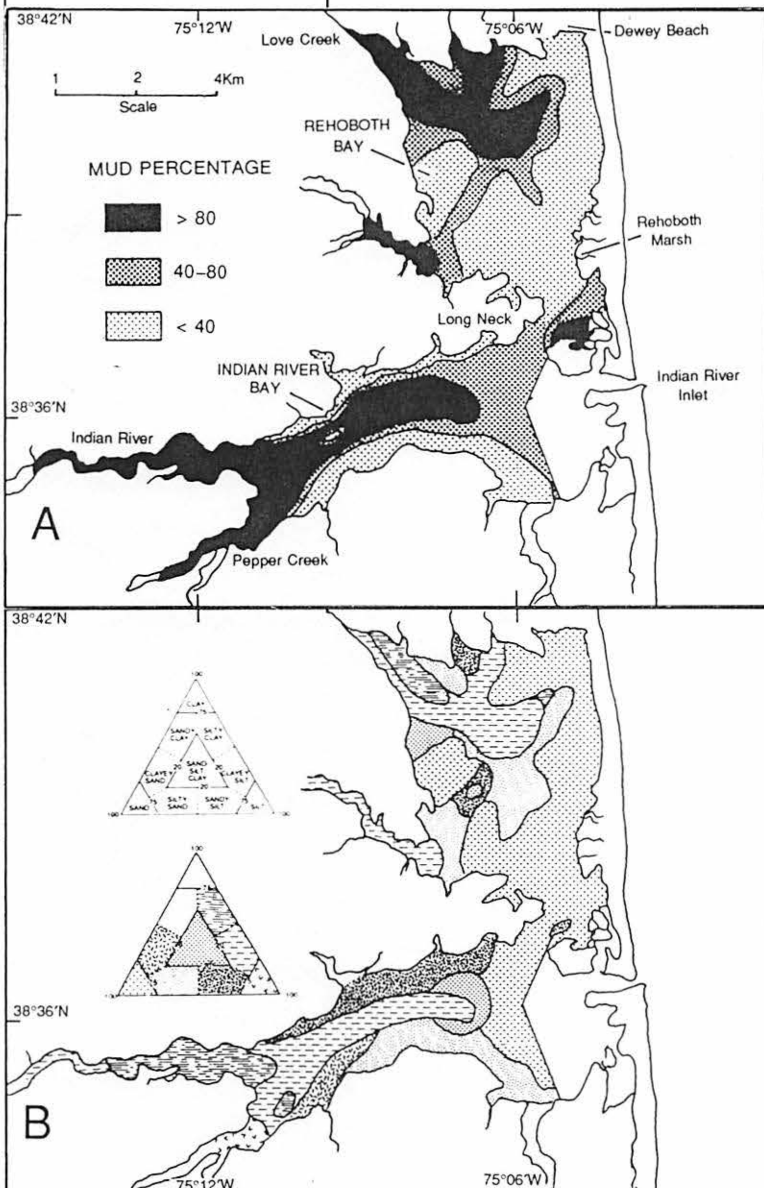
The main source of fine sediment input is the drainage basin which supplies 25 to 33% of total input, mainly during floods. Erosion of marshes, shores and the nearshore bottom supplies 26 to 28%; however, this is partly fine material derived from reworking of the estuary bed and recycled channelward. Mean marsh erosion amounts to 3.2 m/yr. Additionally, some fine sediments (~ 5 to 15%) are supplied by sewage and industrial discharges, from organic production of diatoms (10 to 19%), which are stimulated by sewage-derived nutrients, and from marine areas (~ 14%).

Fine sediment experiences repeated tidal and intermittent wave resuspension prior to accumulation. A portion is transported from open water into marshes or alternately, exported to the ocean. The river-borne suspended material partly follows the estuarine circulation. The lower bay receives coarse-grained bedload from the shore zone of New Jersey and is transported landward around Cape May via longshore current and net density currents. Another part is derived from the inner shelf and transported through the central channel via net density currents. This material builds long linear sand ridges 1.5 to 6.0 m high along channels through the lower and middle estuary.

The main sink of mud sedimentation is in the main shipping channel of the turbidity maximum zone, i.e. between the C&D Canal and Philadelphia. A secondary sink occurs 189 to 206 km landward of the mouth. Accumulation reaches 27 mm/yr and averages 6.8 mm/yr. This contrasts to a rate of 1.8 mm/yr in the lower bay which is the main sink of sand. The storage efficiency ranges 2.1 to 4.0 assuming an average river input of 1.7 x 10^6 m tons/yr.

Patches of mud (> 80%) occur in the main channel 90 to 140 km landward of the mouth. Additionally, patches occur farther seaward along the west side, behind the Capes and in sub-tidal shoals and bordering marshes. In the central and lower estuary, sediments become coarser-grained with depth. Coarse to medium sand occurs on the channel floor while fine to very fine sand occurs on linear shoals. This pattern reflects vigorous tidal action in the channel and transport of fine material, together with reworked material, landward in less energetic zones. The overall longitudinal distribution exhibits a tripartite distribution, sand-mud-sand, following the energy regime, and the dual input of sand from marine and fluvial sources. Pollution susceptibility is high because of low flushing ability and the high chemical and metal activity (workers) relative to estuary area.

M100 DELAWARE INLAND BAYS	DATA SOURCES: Chrzastowski, 1986	DATA QUALITY: Moderately certain



BASICS:

Length, km	16
Width, av. km	6.5
Depth, av. m	1.2
Surface Area, km^2	83
Drainage Area, km^2	780
River Inflow, m^3/s	8.5

BOTTOM SEDIMENTS:

Mud Area, %	40
Sand Area, %	60

Pattern:
Mud, basins and river channels landward; sand, back barrier shoals and tidal delta

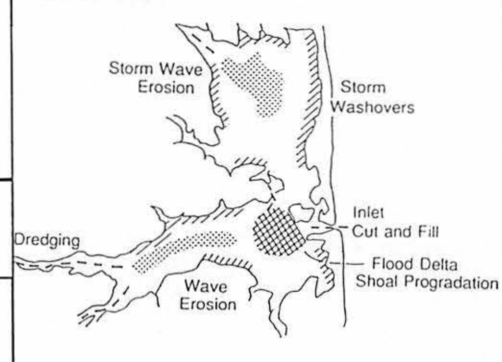
PATHWAYS

SOURCES	Rel. Strength*
Drainage basin	Low
Shores	Moderate
Marine, barrier	Moderate

*For total sediment

SINKS	Rel. Strength*
Flood Tidal Delta	High
Barrier Washovers	Moderate
Marsh	Low
Basins	Low

VARIABILITY



SEDIMENTATION RATE, mm/yr

Basins	2.6 to 3.0	Marsh	3.3

POLLUTION SUSCEPTIBILITY: High due to low flushing ability and moderate anthropogenic activity in drainage basin

Characterization. The Delaware Inland Bays, Rehoboth and Indian River Bays, are open water lagoons residing behind a bay mouth barrier coast. Configuration is controlled by the shape of the Pleistocene drowned stream valley system. Bathymetry is modified by shallow dredged channels cut about 1.4 m deep in Indian River Bay, between the bays and locally into creeks. Although the inlet is stabilized, it is frequently dredged because of rapid shoaling.

Sediments are supplied from multiple sources. Mud comes mainly from the drainage basin via streams, but some comes from marshes through erosion and from marine areas via the inlet. Sand is supplied from marine areas, mainly via strong flood current through the inlet, but also from the barrier via washovers or storm surge channels. Pathways are varied. Streams carry flood-borne fines down channels and into tidal creeks and main tributaries (rivers) where flow decelerates in weak flow regimes. Fines eroded from marshes or banks are moved lagoonward into less energetic zones. Some material together with sand is transported landward and deposited on the marsh surface or in adjacent beaches. Flood currents through the inlet decelerate landward as the flow expands thus allowing sand deposition forming the flood tidal delta. Within the lagoon, storm wind waves resuspend bottom sediments and drive an intermittent back and forth transport.

The major sediment sinks are the flood tidal deltas, both modern and relic, which extend 4 km landward and 10 km along the backbarrier zone. Additionally, storm washovers are superimposed on the deltas. Shallow basins and tributary channels are the chief sinks for fine material.

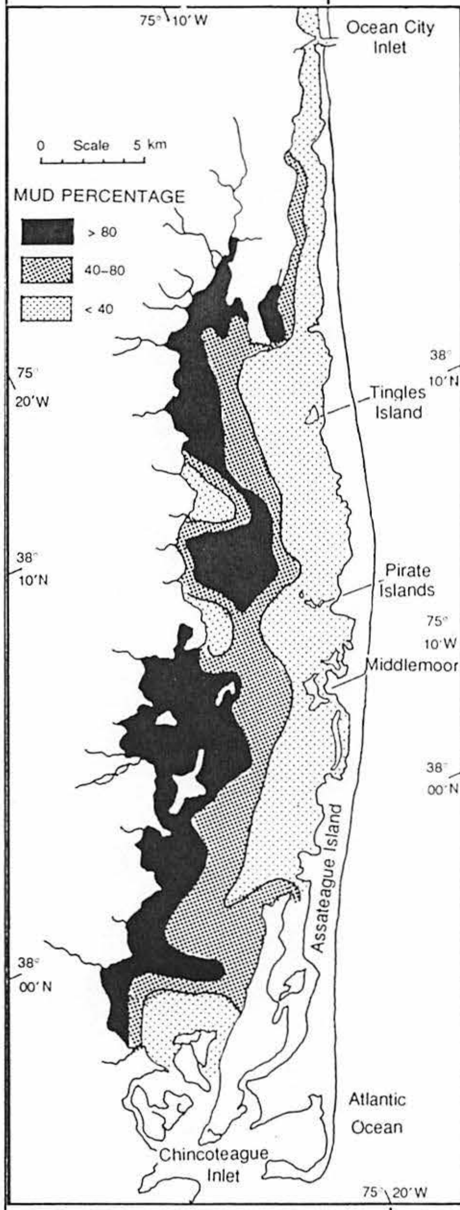
Sand (> 60%) covers about 60% of the floor, mainly in a broad backbarrier zone. Mud (> 40%) covers about 40% of the bay, mainly landward in basins and tributary rivers and creeks. Between sand and mud zones, often at intermediate depths, mixtures of mud and sand with poor sorting prevail. Bottom sediments throughout are bioturbated thus reducing sediment sorting and eliminating physical sedimentary structures.

The bays receive nutrients from agricultural runoff, from treatment plants and residences. Pollution susceptibility ranks high because of low flushing ability however, anthropogenic activity in the drainage basin compared to bay surface area, is moderate.

M110 CHINCOTEAGUE BAY

DATA SOURCES: Bartberger, 1976

DATA QUALITY: Moderately certain



BASICS:

Length, km	51
Width, av. km	7
Depth, av. m	1.3
Surface Area, km^2	355
Drainage Area, km^2	777
River Inflow, m^3/s	13

BOTTOM SEDIMENTS:

Mud Area, %	76
Sand Area, %	24

Pattern:

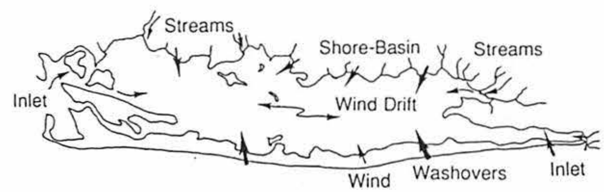
Sand, tidal deltas and back barrier shoals; mud belt along landward shore

Decreasing size inward from inlet

SEDIMENTATION RATE, mm/yr*

Bay-wide average, short-term decades	0.3
Bay-wide average, long-term millennia	1.8

PATHWAYS

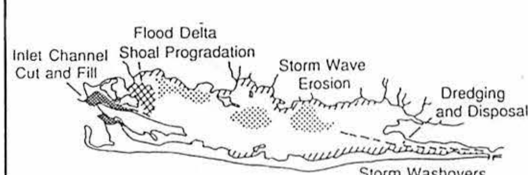


SOURCES	Strength, %*
Drainage basin	6
Shores	46
Marine, wind	10
Marine, washover	32

*For total sediment

SINKS	Rel. Strength*
Basins & Reentr'ts	Moderate
Washover Shoals	Moderate
Flood Tidal Delta	Low
Marsh	Low
Dredged Channels	Low

VARIABILITY



POLLUTION SUSCEPTIBILITY: High due to low flushing ability but low with respect to anthropogenic agricultural and chemical activity

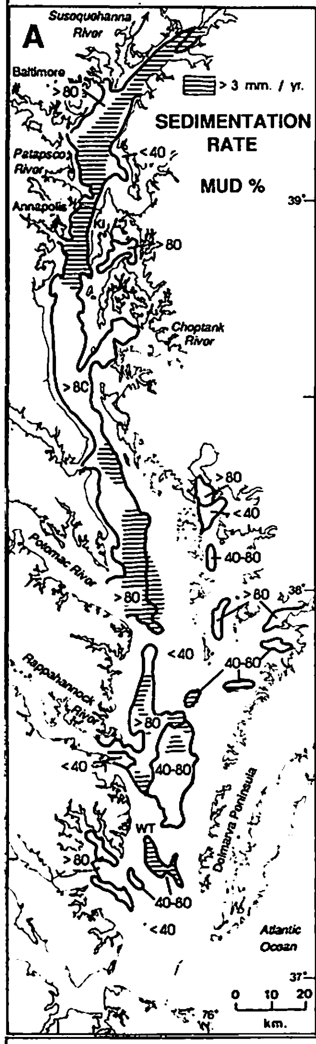
Characterization. Chincoteague Bay is the largest lagoon on the Delmarva Peninsula. It lies behind Assateague Island, a 60 km long barrier, managed by the U.S. National Park Service. The lagoon exchanges water with the ocean through two inlets, Ocean City Inlet and Chincoteague Inlet. Dredging is limited to an Intracoastal Waterway channel 18 km long and 1.8 m deep in the northern bay.

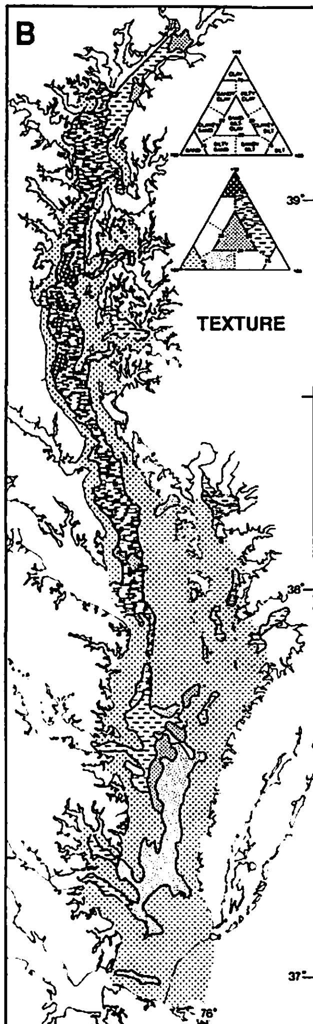
Sediments are supplied from multiple sources. About 6% of the total input, mainly mud comes from the drainage basin via streams while shore and marsh erosion releases both mud and sand, contributing about 46%. The barrier supplies about 32% via washovers while 16% is carried in via wind. The amount supplied from the ocean via the inlet is unknown but probably small. Flood tidal deltas formerly were more extensive than today. Once in the lagoon, sediments are redistributed by storm wind wave resuspension and wind drift back and forth (NE - SW) through the central bay. Fines eroded from shores, or winnowed from shoals, deposit in less energetic basins. The most prominent sinks are the washover fans and storm surge platforms in backbarrier zones. Some are colonized by eelgrass or salt marsh and thus accrete vertically.

Sand (> 60%) covers about 24% of the bay area whereas mud (> 40%) covers 76%. The broad textural pattern consisting of sand along backbarrier zones and mud along the landward shore, reflects proximity to major sources. Secondarily, it follows an energy format with fine sediment in deep less energetic zones and sand in shoaler water subject to normal wave action. Also, grain size decreases inward from the inlet in accord with decreasing current velocity inward.

Chincoteague Bay receives small amounts of organic wastes and nutrients from Chincoteague Village and Trappe Creek in the northwest. These loadings are the same order of magnitude as export from marshes. Pollution susceptibility is low with respect to anthropogenic activity in the drainage basin but high with respect to low flushing ability of the bay.

M120 CHESAPEAKE BAY	DATA SOURCES: Byrne et al., 1982; Kerhin et al., 1988	DATA QUALITY: Highly certain





BASICS:

Length, km	290
Width, av. km	.25
Depth, av. m	8.4
Surface Area, km^2	6,500
Drainage Area, km^2	160,000
River Inflow, m^3/s	1,110
Sinuosity	1.1

BOTTOM SEDIMENTS:

Mud Area, %	36
Sand Area, %	64
Sedimentation Area, %, >3 mm/yr	14
Water Matter, %	41
Organic Content, %	2.7

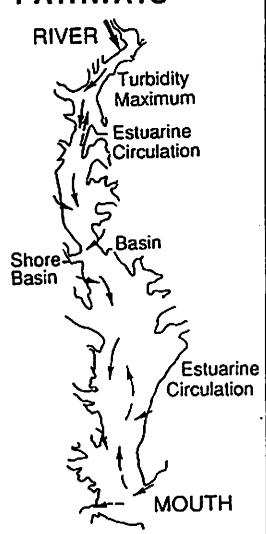
Pattern:
- Longitudinal:
  Channel, sand at extreme head, mud middle, sand mouth; tripartite pattern
- Lateral:
  Channel mud flanked by broad sand shoals

SOURCES*	Strength, %
Drainage Basin	52-95
Shores	20-30
Marine	13-20

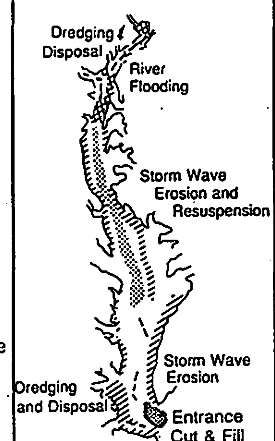
SINKS*	Strength, %
Natural Channel	94
Marsh	6

*Northern Bay only, fine sediment

PATHWAYS



VARIABILITY



MASS BALANCE*

sources	=	losses (sinks + export)
2.1	=	2.9 - 0.8 x 10^6 tons/yr
3.0	=	3.3 - 0.3 x 10^6 tons/yr

SPI: 87

Storage Efficiency: 1.0 - 1.6

POLLUTION SUSCEPTIBILITY: High because of low flushing ability and high anthropogenic metal activity

Characterization. The Chesapeake Bay is the largest estuary in the Virginia Province. It has a slight meandering axial channel and dendritic configuration, i.e. indented with numerous tributaries that lead headward to streams. This pattern represents a drowned river valley system inherited from Pleistocene erosion. Dredged channels cut through shoals in the axial channel 10.7 and 15.2 m deep. Material is mainly disposed in open water near channel margins.

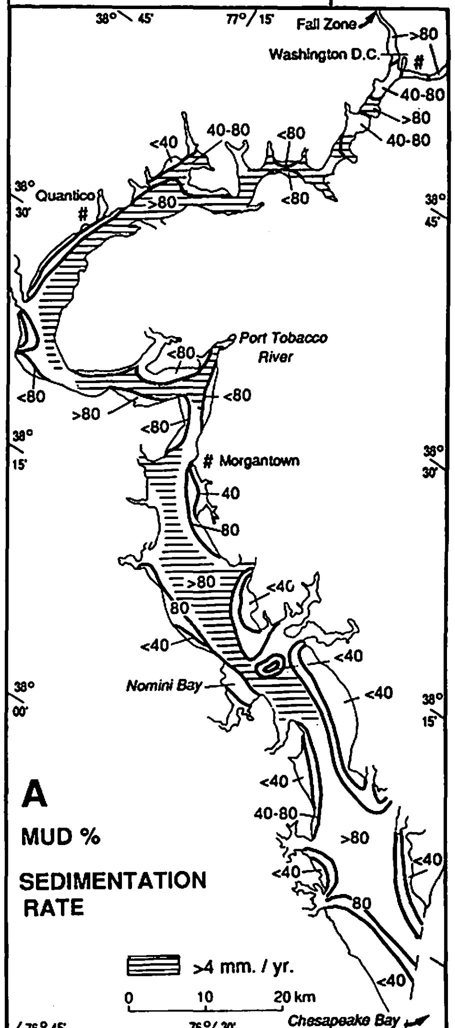
The drainage basin is the dominant sediment source supplying 52 to 95% of the fine sediment input to the northern bay, mainly during floods. Supply from shore erosion increases seaward through the northern bay whereas marine input dominates near the mouth. Fine sediment is cycled by the estuarine circulation. For fluvial sediment the pathways are: (1) seaward through freshwater reaches; (2) seaward through the upper estuarine layer and downward by settling; (3) landward through the lower estuarine layer to the turbidity maximum zone. Additionally, some fine sediments are dispersed channelward from the shores and shoals. Others are transported landward from marine areas via the lower layer. Sand is carried into the bay mouth via landward flow as the Delmarva Peninsula progrades southwestward with time.

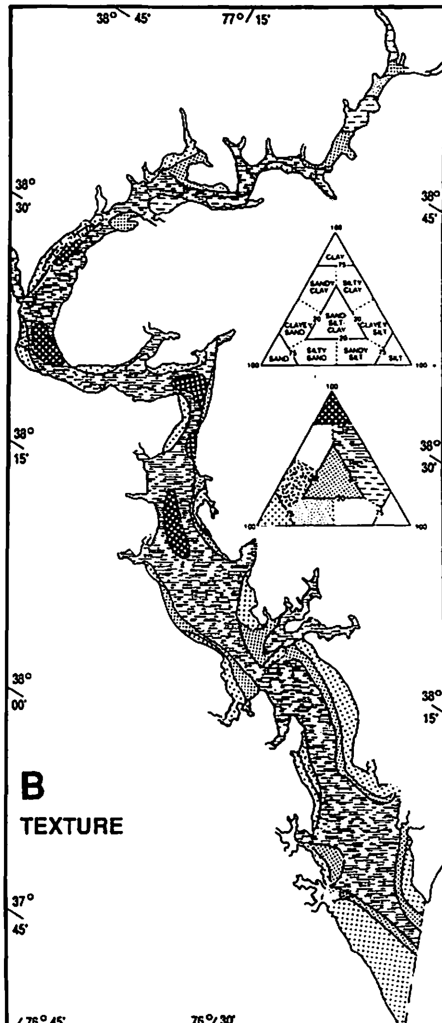
The main sink of mud sedimentation is the axial channel of the turbidity maximum zone. Flood-borne sediments make up 25 to 50% of the bottom deposits. The main sink for sand is near the mouth. This distribution reflects filling from ends of the system, i.e. close to major sediment sources. Mass balances indicate the northern bay stores the bulk of the fluvial input plus sediment from other sources as the shores.

Mud (> 80%) is abundant in the northern bay channel landward of the Rappahannock River mouth, whereas sand is abundant in the southern bay channel and shoals seaward of Wolf Trap. Mean size of channel sediments generally decreases toward the central bay from the Susquehanna mouth and landward from the bay mouth. This trend reflects less energetic conditions in deep central parts than near the bay head or mouth. Laterally, channel mud passes shoreward through a transition of mixed sediments into sand on shallow margins.

Compared to major tributaries the northern Chesapeake Bay has substantial percentages of mud and relatively high organic matter. These factors contribute to an intermediate SPI, i.e. 87. Pollution susceptibility is high because of low flushing ability and high anthropogenic metal activity in the drainage basin relative to the bay surface area.

M120b POTOMAC RIVER	DATA SOURCES: Glenn et al., 1986	DATA QUALITY: Fairly certain





BASICS:

Length, km	187
Width, av. km	10
Depth, av. m	7.0
Surface Area, km^2	1,250
Drainage Area, km^2	37,800
River Inflow, m^3/s	500
Sinuosity	1.5

BOTTOM SEDIMENTS:

Mud Area, %	79
Sand Area, %	21
Sedimentation Area %, >4 mm/yr	31
Water Content, %	62
Organic Matter, %	3.2

Pattern:

Longitudinal:
Channel, sand near head; mud middle and near mouth

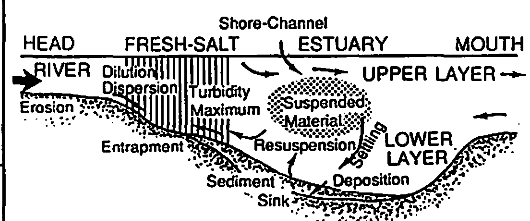
Lateral:
Channel mud bordered by admixtures on slopes and sand on marginal flats

SOURCES	Strength, %*
Drainage basin	57
Tributaries	37
Shores	6-12
Marine	0.3-14

SINKS	Strength, %*
Main Channel	73
Tributaries	24
Marsh, Swamp	3

*For fine sediment

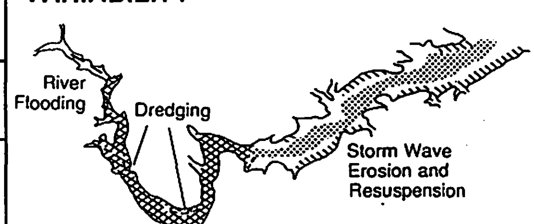
PATHWAYS



MASS BALANCE*

sources	=	losses (sinks + export)
2.4	=	3.7 - 1.3 x 10^6 tons/yr
2.9	=	3.7 - 0.8 x 10^6 tons/yr

VARIABILITY



SPI: 100	Storage Efficiency: 1.3 - 1.5

POLLUTION SUSCEPTIBILITY: High due to low flushing ability and high anthropogenic metal activity relative to estuary area

Characterization. The Potomac River or "nation's river" is the longest and broadest tributary entering Chesapeake Bay. Its configuration is shaped into a meandering funnel with a sinuous axial channel. These features together with tributary creeks, are inherited from an ancestral Pleistocene river system drowned by rising sea level in the last 10,000 years. Dredged channels are cut through shoals in the axial channel to 7.3 m deep and into selected tributaries to 1.8 to 2.1 m deep.

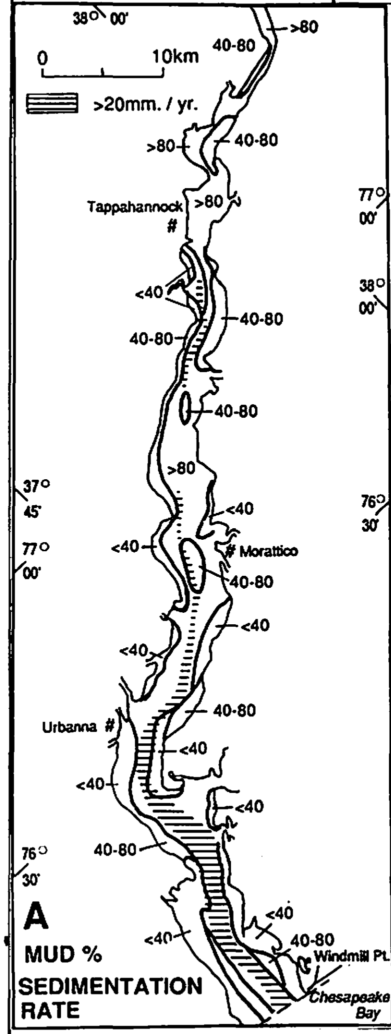
The drainage basin supplies about 57% of the fine sediment input mainly during floods, while tributaries supply about 37%. Shore erosion contributes 6 to 12% whereas marine input is limited, 0.3 to 14%. River-borne suspended sediment mainly follows the estuarine circulation pattern: (1) seaward through freshwater reaches; (2) seaward through the upper estuarine layer and downward by settling; (3) landward through the lower layer to the inner salt limit, the turbidity maximum zone landward of the Port Tobacco River mouth. Fine sediment undergoes repeated tidal resuspension prior to accumulation. On shoals exposed to a long wave fetch, wind waves erode shores and resuspend bottom sediments thus facilitating transport to deep water. Tributaries are closed systems that retain most sediment supplied from local drainage basins.

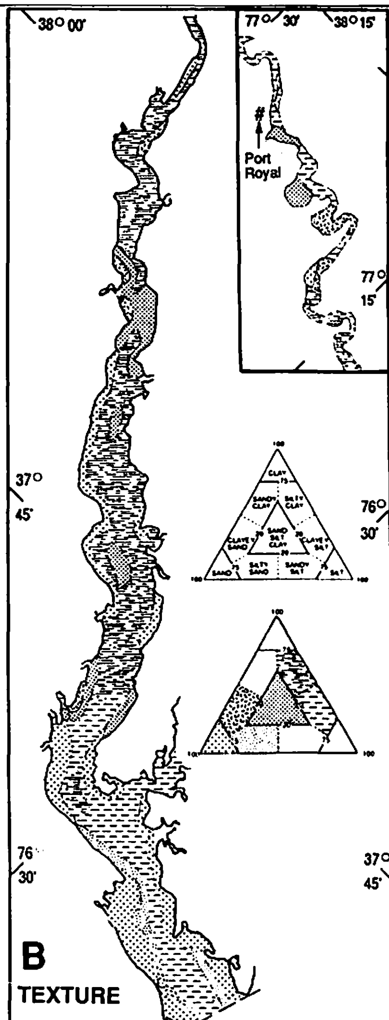
The main sink of mud sedimentation lies between Morgantown and Nomini Bay, close to the site of the turbidity maximum during river floods. Elsewhere, the heads of tributaries such as Port Tobacco, are sites of fast sedimentation. Mass balance estimates indicate an "excess" accumulation of 0.8 to 1.3 x 10^6 tons/yr greater than all source inputs. Storage efficiency is 1.3 to 1.5 indicating the estuary stores an amount of fine sediment equal to the entire drainage basin input besides sediment from other sources.

Mud (> 80%) is abundant in the axial channel except near the head where mixtures of sand-silt-clay occur. Sand is common on shoreline flats and margins while mixtures of sand-silt-clay occur on irregular slopes. Particle size generally decreases with increasing water depth, especially between 5 to 10 m, in the lower estuary.

Compared to other Chesapeake systems (6) the Potomac has a high sediment pollution index, 100. It is affected by relatively large areas of mud and sedimentation. Pollution susceptibility is high because of low flushing ability and high anthropogenic metal activity relative to the estuary surface area.

M120c RAPPAHANNOCK RIVER	DATA SOURCES: Ellison et al., 1965; Lukin, 1983; Natale, 1982; Nelson, 1961; Schaffner, 1981	DATA QUALITY: Fairly certain





BASICS:

Length, km	173
Width, av. km	4.2
Depth, av. m	5.5
Surface Area, km^2	376
Drainage Area, km^2	6,970
River Inflow, m^3/s	821
Sinuosity	1.6

BOTTOM SEDIMENTS:

Mud Area, %	74
Sand Area, %	26
Sedimentation Area, %, >2 cm/yr	18
Water Content, %	68
Organic Content, %	11

Pattern:

Longitudinal:

Channel, sand at extreme head; mud in middle and seaward of Urbanna

Lateral:

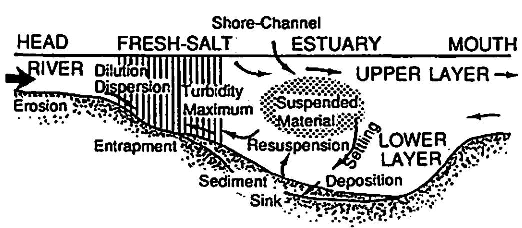
Channel mud flanked by sand margins and sand-mud admixtures with scattered oyster reefs on shoals

SOURCES	Strength, %*
Drainage Basin	26
Shores	28
Marine	26 to 45
Production	<1

SINKS	Strength, %*
Channel	96
Marsh, Swamp	4

*For fine sediment

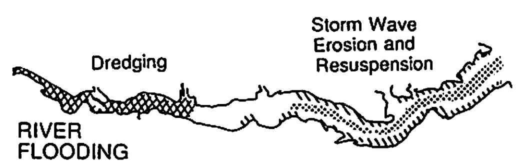
PATHWAYS



MASS BALANCE

sources	=	losses (sinks + export)
0.7	=	2.3 - 1.6 x 10^6 tons/yr
1.0	=	3.8 - 2.8 x 10^6 tons/yr

VARIABILITY



SPI: 100

Storage Efficiency: 1.6 - 3.1

POLLUTION SUSCEPTIBILITY: High due to low flushing ability

Characterization. The Rappahannock River is the least-impacted of five western tributaries to Chesapeake Bay. Dredging is limited to tributary creeks and shoals in the axial channel to a depth of 3.0 m, between Tappahannock and Fredericksburg. Like other major tributaries, the estuary is a drowned river valley formed about 7,000 years ago when sea level was 12 m lower than today.

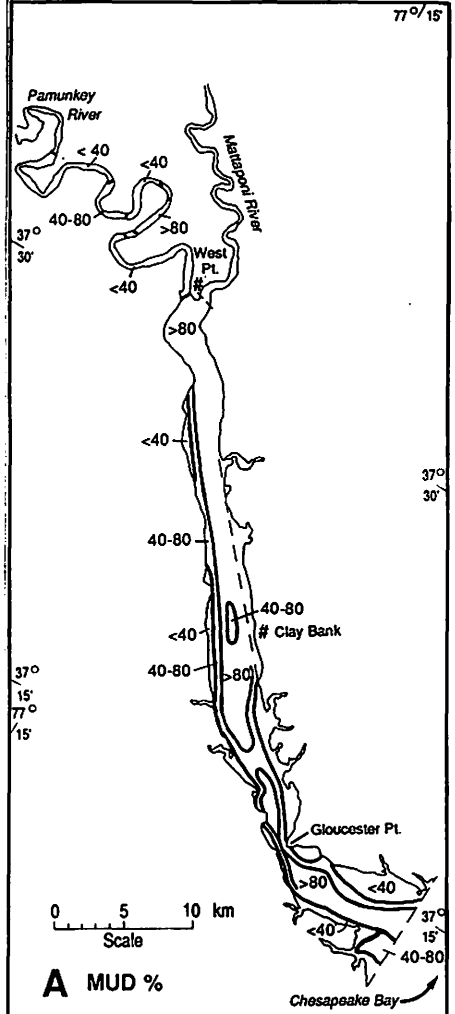
The drainage basin supplies about 26% of the fine sediment input, mainly during floods, while shore erosion supplies about 28% of the total input. Marine input is estimated at 26 to 45%. River-borne suspended sediment transport mainly follows the estuarine circulation: (1) seaward through freshwater reaches; (2) seaward through the upper estuarine layer and downward by settling; (3) landward through the lower layer to the turbidity maximum zone in the vicinity of Tappahannock. Prior to accumulation fine sediment goes through repeated tidal cycles of resuspension, a process especially active in the turbidity maximum. Additionally, fine sediment released by bank erosion is deposited on marginal shoals or dispersed into the main channel.

The lower estuary channel, seaward of Morattico, is the main sink of mud sedimentation. This zone is partly supplied by storm resuspended fine sediment from Chesapeake Bay. Accumulation exceeds inputs from all sources and suggests a much larger amount of fill enters from seaward areas than can be accounted for. The storage efficiency is substantial, 1.6 to 3.1, and reflects the large input from non-fluvial sources.

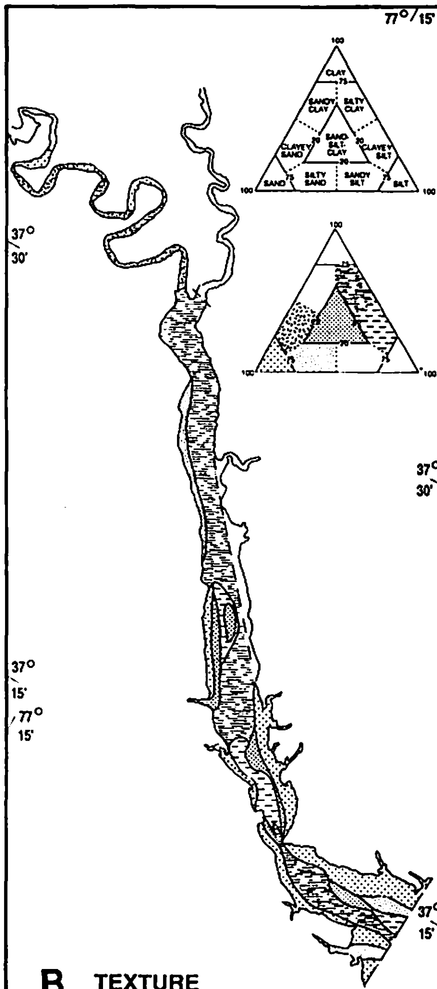
Mud (> 80%) is abundant in the axial channel but landward of Port Royal it is replaced by mixtures of sand-silt-clay. Sand is common along margins seaward of Tappahannock and on shoals close to its source in the banks. Laterally, the sand passes channelward into mixtures of sand-silt-clay with oyster reefs or mud patches, on shoals, and channelward into mud at about 5 to 7 m depth.

Compared to other Chesapeake systems the Rappahannock has a relatively high SPI (95). It is affected by a large mud area, 74%, substantial storage efficiency, and large areas of fast sedimentation. Although anthropogenic metal activity in the drainage basin is low pollution susceptibility is high because of low flushing ability.

M120d YORK RIVER	DATA SOURCES: Boesch, 1971; Carron, 1976; Byrne et al., 1982; Nichols, 1990; Schaffner, 1989	DATA QUALITY: Fairly certain



A MUD %



B TEXTURE

BASICS:

Length, km	55
Width, av. km	3.8
Depth, av. m	6.6
Surface Area, km^2	192
Drainage Area, km^2	6,900
River Inflow, m^3/s	71
Sinuosity	1.1

BOTTOM SEDIMENTS:

Mud Area, %	39
Sand Area, %	61
Sedimentation Area, %, >5 mm/yr	28
Water Content, %	–
Organic Matter, %	4.5

Pattern:

Longitudinal:
Channel, mud but with mud patches and mud-sand admixtures above West Point

Lateral:
Channel mud flanked by sand margins and admixtures on shoals with scattered oyster reefs

SOURCES	Strength, %*
Drainage Basin	55
Shores	13
Marine	32

SINKS	Strength, %*
Channel	83-86
Marsh, Swamp	14-17

MASS BALANCE*

sources	=	losses (sinks + export)
0.4	=	0.7 - 0.3 x 10^6 tons/yr
0.4	=	0.8 - 0.4 x 10^6 tons/yr

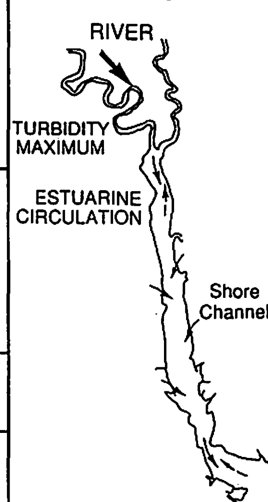
*For fine sediment

SPI: 96

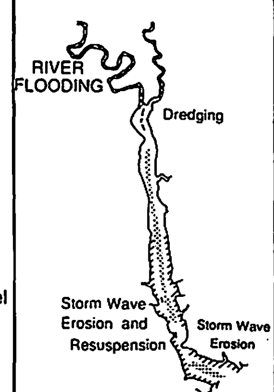
Storage Efficiency: 3.0 - 3.6

POLLUTION SUSCEPTIBILITY: High because of low flushing ability

PATHWAYS



VARIABILITY



Characterization. The York River is 55 km long and remarkably straight between West Point and Gloucester Point. Landward of West Point it divides into two major tributaries, the Mattaponi and Pamunkey Rivers. The York is a drowned river valley formed about 7,000 years ago. The axial channel, which is flanked by broad shoals and lateral tributaries reflect the ancestral river system and bordering flood plain. Dredging is limited to four pier facilities seaward of Clay Bank, and a short channel seaward of West Point.

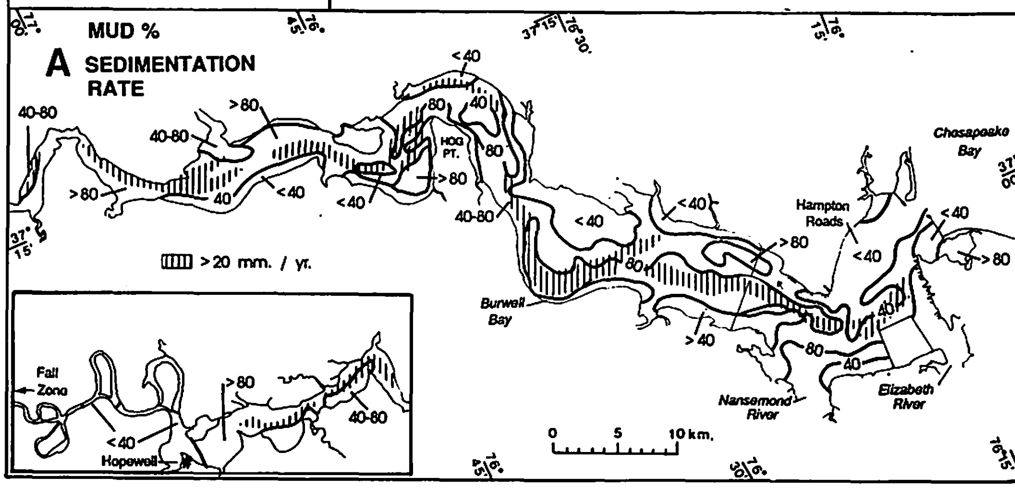
The drainage basin supplies about 55% of the fine sediment input, mainly during floods, while shore erosion supplies 13%. An estimated 32% is marine input. River-borne suspended sediment transport follows the estuarine circulation: (1) seaward through freshwater reaches of the major tributaries; (2) seaward through the upper estuarine layer and downward by settling; (3) landward through the lower estuarine layer to the turbidity maximum zone just landward of West Point. Additionally, fine sediment released by bank erosion is dispersed across shoals into the main channel. Prior to accumulation the sediment undergoes repeated tidal resuspension.

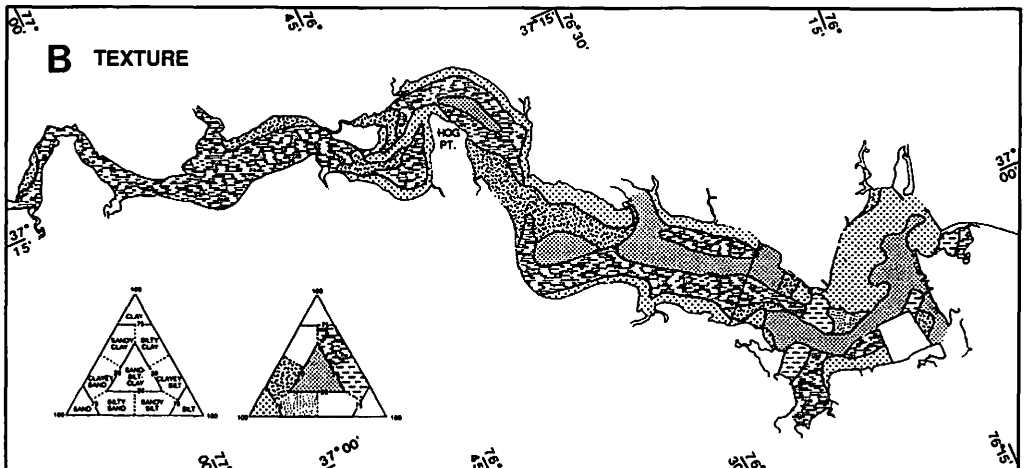
The main sink of mud accumulation occurs in the main channel 10 km landward of Clay Bank. This is the turbidity maximum zone during strong river floods. Accumulation exceeds inputs from all sources and suggests more sediment enters the estuary, possibly from seaward areas, than can be accounted for. The storage efficiency is high, 3.0 to 3.6; and reflects a large input from non-fluvial sources.

Mud (> 80%) is abundant throughout the axial channel but above West Point it is partly replaced by mud-sand admixtures. Sand is common along margins and on shoals close to its source in banks seaward of Clay Bank. Laterally, the sand passes channelward into patches of mixed sand-silt-clay, besides scattered oyster reefs.

Compared to other Chesapeake systems (6), the York has a relatively high SPI, 96. This is influenced by high organic matter contributed by marshes. Although anthropogenic activity is relatively low pollution susceptibility ranks high because of low flushing ability.

M120e JAMES RIVER	DATA SOURCES: Byrne et al., 1982; Nichols, 1990; Moncure & Nichols, 1968; Trotman & Nichols, 1978	DATA QUALITY: Moderately certain





BASICS:

Length, km	161
Width, av. km	5.1
Depth, av. m	5.8
Surface Area, km^2	611
Drainage Area, km^2	26,400
River Inflow, m^3/s	213
Sinuosity	1.2-1.7

BOTTOM SEDIMENTS:

Mud Area, %	87
Sand Area, %	13
Sedimentation Area, %, >2 cm/yr	17
Water Content, %	48
Organic Matter, %	2.3

Pattern:

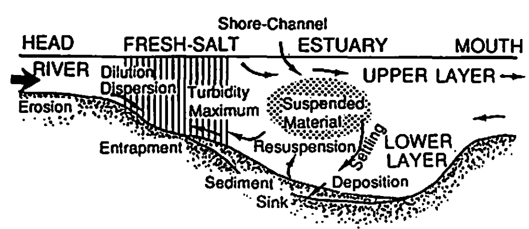
Longitudinal:
Channel, mud-sand-mud, tripartite pattern

Lateral:
Channel mud flanked by sand shoals with mud patches and oyster reefs

SOURCES	Strength, %*
Drainage Basin	75
Shores	9
Marine	16
Production	<1

SINKS	Strength, %*
Natural Channel	75-84
Shipping Channel	13-20
Marsh, Swamp	3-5

PATHWAYS

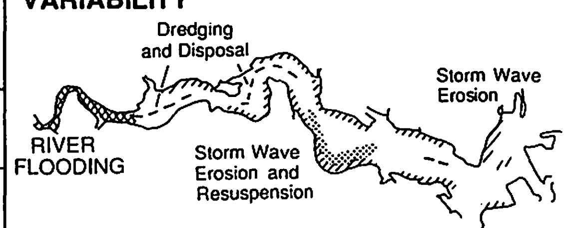


MASS BALANCE*

sources	=	losses (sinks + export)
3.2	=	2.0 + 1.2 x 10^6 tons/yr
3.0	=	3.1 - 0.1 x 10^6 tons/yr

*For fine sediment

VARIABILITY



SPI: 78	Storage Efficiency: 0.8 - 1.2

POLLUTION SUSCEPTIBILITY: High because of low flushing ability and high anthropogenic metal activity

<u>Characterization</u>. The James River is renown for its turbid waters and its seed-producing oyster reefs. It has a meandering funnel configuration and a sinuous axial channel inherited from an ancestral Pleistocene river system. This system has been drowned by rising sea level in the last 7,000 years. A major dredged channel cuts through shoals to a depth of 7.6 m landward of Hampton Roads; most dredged material is dumped in open water along channel margins.

The drainage basin is the dominant sediment source supplying 75% of the fine sediment input, mainly during floods. Shore erosion and marine input are secondary sources however, marine input is important near the mouth. River-borne suspended sediment mainly follows the estuarine circulation: (1) seaward through freshwater reaches; (2) seaward through the upper estuarine layer and downward by settling; (3) landward through the lower layer to the inner salt limit, the turbidity maximum zone. Fine sediment undergoes repeated tidal resuspension prior to accumulation. Coarse-grained fluvial bedload is dispersed through freshwater reaches from the fall zone to Hopewell, while some sand is transported landward through the mouth via the lower layer. Another fraction is removed from banks and deposited nearshore or on marginal shoals.

The main sink of mud sedimentation is the Burwell Bay channel, a site of the turbidity maximum during river floods. Elsewhere, sinks develop in less energetic tidal zones, the main channel, dredged channels and tributary mouths. On balance, the James retains about 80% of its river-borne input whereas 20% escapes seaward.

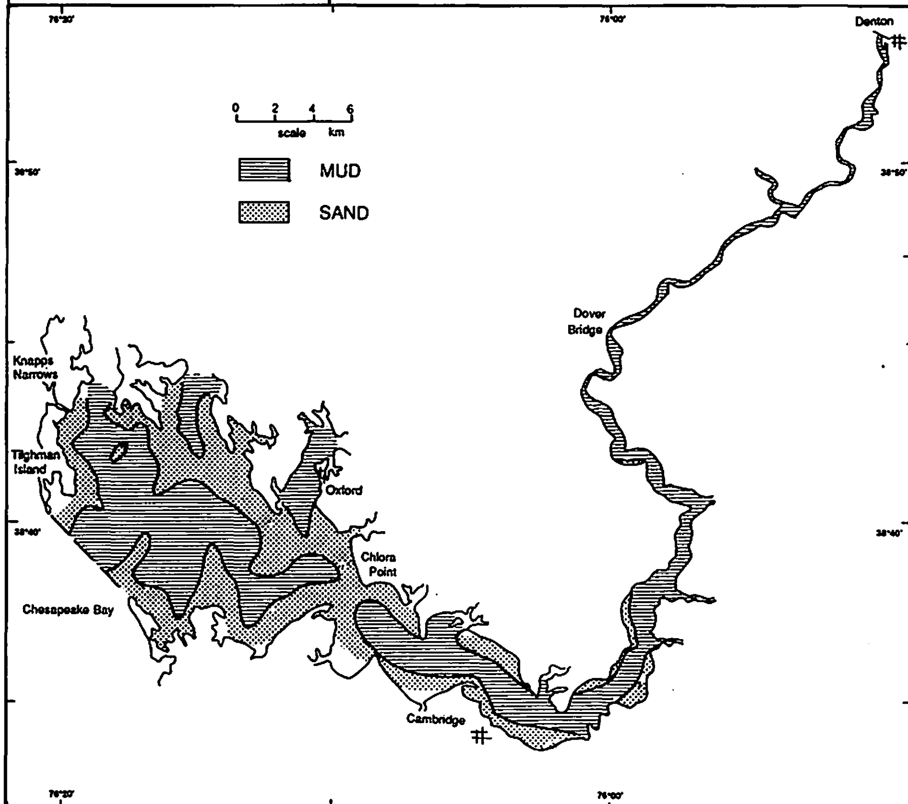
Mud (> 80%) is abundant in the main channel, marginal embayments, meander loops and tributary mouths. Sand is common near the mouth and near the head, landward of Hopewell. These variations exhibit a longitudinal tripartite distribution, sand-mud-sand, following the energy regime strong (floods) - weak (tides) - strong (storm waves and tides). Laterally, channel mud passes shoreward into admixtures of sand-silt-clay with oyster reefs or mud patches on shoals and then into sand near shore. Textural variations are pronounced on the shoals and also in freshwater reaches subject to river flooding. Dredging and dumping in Hampton Roads and along the axial channel add to the textural variability.

Compared to other Chesapeake systems (6) the James has a relatively large area of mud, 88%. Its SPI however, is relatively low, 78, because of its low sediment organic matter, small sedimentation area and limited storage efficiency. Pollution susceptibility is high because of its high anthropogenic metal activity in the drainage basin relative to estuary area.

M120g CHOPTANK RIVER

DATA SOURCES: Kerhin et al., 1988; U.S. National Ocean Survey Charts #12266, 12268

DATA QUALITY: Moderately certain



BASICS:

Length, km	109
Width, av. km	2.3
Depth, av. m	4.0
Surface Area, km^2	285
Drainage Area, km^2	2,330
River Inflow, m^3/s	3.7
Sinuosity	2.9

BOTTOM SEDIMENTS:

Mud Area, %	56
Sand Area, %	44
Sedimentation Area, %	16
Water Content, %	54
Organic Matter, %	1.8

Pattern:

Longitudinal:

Channel mud

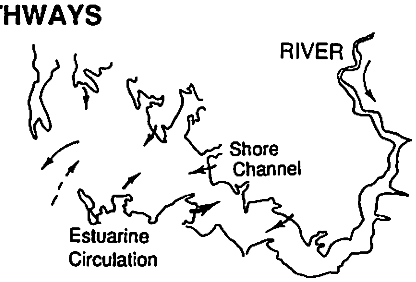
Lateral:

Channel mud; marginal shoals sand seaward of Cabin Creek

SOURCES	Strength, %*
Drainage Basin	11
Shores	79
Marine	3-10

SINKS	Strength, %*
Natural channels & slopes	84-100
Export to Ches. Bay	16-19

PATHWAYS

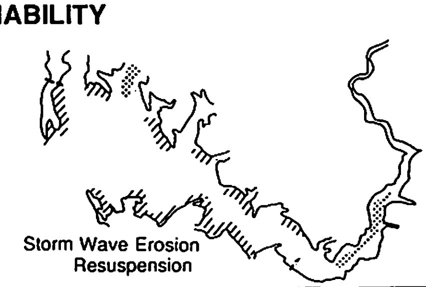


MASS BALANCE*

sources	=	losses (sinks + export)
.46	=	.37 + .09 x 10^6 tons/yr
.54	=	.45 + .09 x 10^6 tons/yr

*For fine sediment

VARIABILITY



SPI: 92

Storage Efficiency: 7.4 - 9.0

Characterization. The Choptank River of the central Delmarva Peninsula is a relatively short estuary. It is funnel-shaped and wide at the mouth with a meandering configuration and a sinuous axial channel flanked by wide submerged terraces at the 1.8 m and 3.8 m depths. The configuration is submergent and inherited from the ancestral Pleistocene fluvial drainage. Dredged channels are limited to local cuts in tributaries, channel bars near the head and a cut across Tilghman Island.

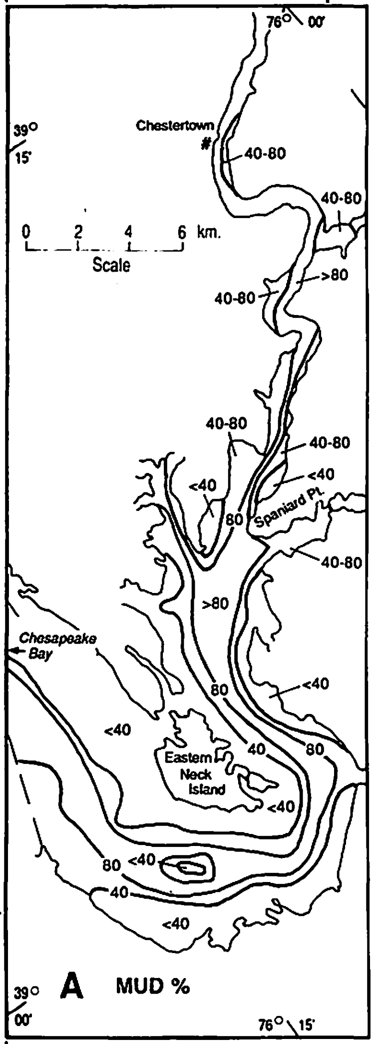
Shore erosion supplies the major input of fine sediment. High erosion is caused by waves which have a large wave fetch across the lower estuary, and by the poor consolidation of banks. Banks supply about seven times more sediment than the drainage basin. Some fine sediment comes from Chesapeake Bay (3 to 10% of total input) but this is offset by a greater seaward transport (16 to 19% of the total losses), or export, to the Chesapeake Bay. Export is promoted by high suspended sediment concentrations in the lower estuary which are maintained by shore erosion, and by tidal resuspension. The chief transport pathway is from banks and shoals toward the channel. For fluvial suspended sediment the route is seaward through freshwater reaches landward of Cabin Creek, with deposition in marshes and brackish areas just seaward of Cabin Creek. Seaward of Chlora Point sediments accumulate on slopes off eroding headlands at depths of 5 to 10 m. On balance, accumulation in marshes, channels and slopes is 84 to 100% of the total losses whereas 16 to 19% is exported to Chesapeake Bay. The sources nearly balance the losses. Storage efficiency is high, 7.4 to 9.0, because the estuary stores a large amount of sediment from sources other than the drainage basin, mainly from the shores.

Mud (> 80%) is abundant in the channel below the 1.8 m depth landward of Chlora Point while sand covers shoals at lesser depths. Seaward of Chlora Point mud covers the channel and basins below 5.5 m while sand prevails at shoaler depths. This distribution reflects proximity to the sand source in banks and the energy distribution. Mud is deposited in deep less energetic zones where waves and currents are weak. Compared to other Chesapeake systems (6), the SPI is relatively high, 92, as it is influenced by high storage efficiency. Although metal loadings in the drainage basin are relatively low, the estuary is susceptible to nitrogen enrichment caused by cropland runoff.

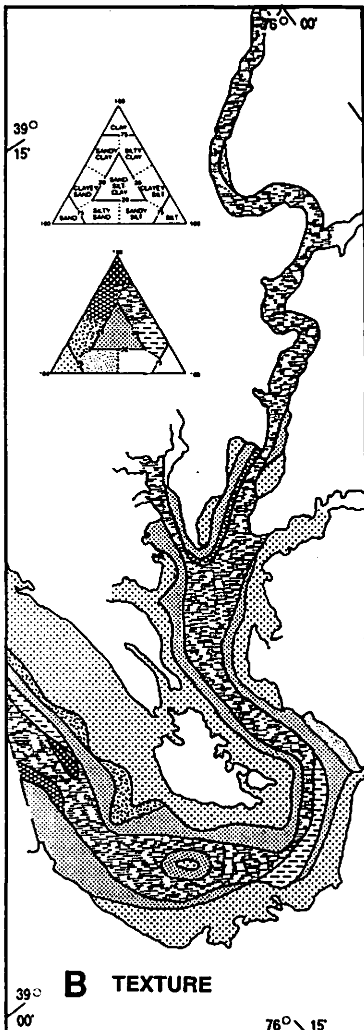
M120f CHESTER RIVER

DATA SOURCES: Clarke et al., 1972

DATA QUALITY: Moderately certain



A MUD %



B TEXTURE

BASICS:

Length, km	82
Width, av. km	2.6
Depth, av. m	4.3
Surface Area, km^2	148
Drainage Area, km^2	1,140
River Inflow, m^3/s	1.9
Sinuosity	1.5

BOTTOM SEDIMENTS:

Mud Area, %	58
Sand Area, %	42
Water Content, %	–
Organic Matter, %	–

Pattern:

Longitudinal:

Channel, mud throughout

Lateral:

Channel mud flanked by sand shoals and margins

SOURCES

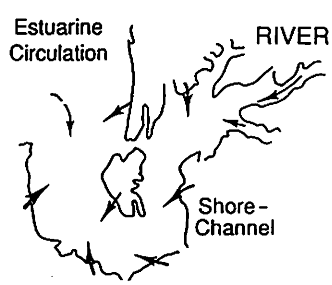
SOURCES	Rel. Strength*
Drainage Basin	Low
Shores	High
Marine	Low

SINKS

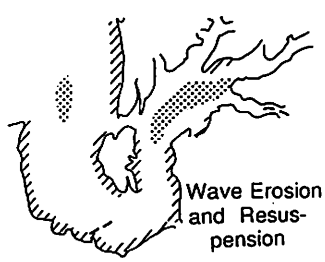
SINKS	Rel. Strength*
Channel, middle	High
Channel near-mouth	High
Marsh, swamp	Low

*For fine sediment

PATHWAYS



VARIABILITY



Characterization. The Chester River of the northern Delmarva Peninsula is a relatively short estuary with a small drainage basin. The shoreline configuration and bathymetry reflect a drowned relic fluvial drainage system. Dredging is limited to shallow cuts near the mouth and at the head of a few tributaries.

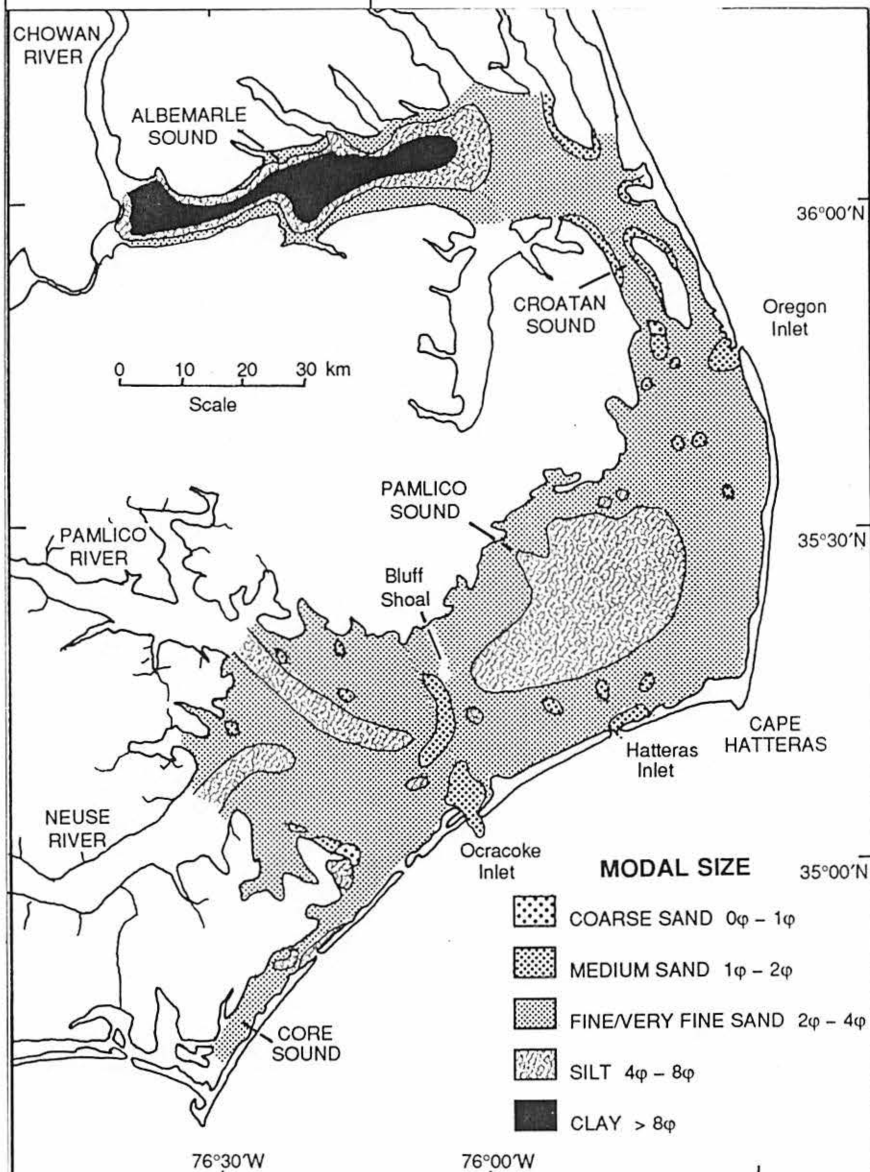
Shore erosion provides the major sediment input but some fine material is supplied from the drainage basin and from seaward areas, the Chesapeake Bay, particularly during Susquehanna River floods. The chief transport pathway is channelward from banks and shoals to the channel. Enroute silt and clay are winnowed out and fractionated from sand by wave action. Another route is landward through the mouth from Chesapeake Bay. The main sites of mud sedimentation are just seaward of Spaniard Point and just landward of the estuary mouth.

Mud (> 80%) covers the channel floor from the mouth to the head. Sand is abundant along shoals and margins. Sand passes channelward into mixtures of sand-silt-clay on slopes between 1.8 and 5.0 m depths. Lacking data for sediment influx and accumulation rates precludes estimates of mass balance, SPI and storage efficiency. However, as a first approximation, the relative strength of source and sink terms is likely similar to the Choptank River. Anthropogenic influence is relatively small except locally near marinas.

S010 ALBEMARLE/ PAMLICO SOUNDS

DATA SOURCES: Wells and Kim, 1989

DATA QUALITY: Fairly certain



BASICS:

Length, km	190
Width, av. km	24
Depth, av. m	4.0
Surface Area, km^2	7,640
Drainage Area, km^2	76,660
River Inflow, m^3/s	1,300

BOTTOM SEDIMENTS:

Silt & Clay* Area, %	28
Sand Area, %	72
Organic Matter, Av. %	3.0
Range	0-8.6

Pattern:
Basin, silt or clay;
Shoals fine sand;
backbarrier fine sand; flood delta med. sand

*Based on modal size

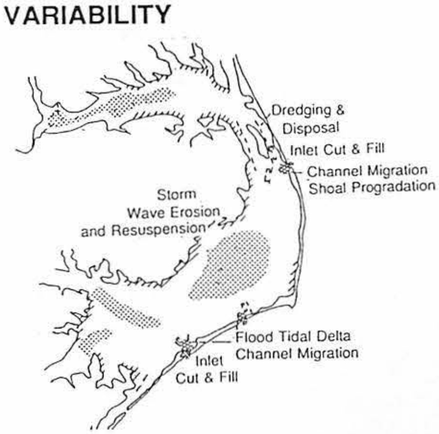
PATHWAYS

SOURCES	Rel. Strength*
Drainage basin	Low
Shores	Low to Moderate
Marine	Low
Production	Low

SINKS	Rel. Strength*
Central Basin	Low
Washover Shoals	Low
Flood Tidal Deltas	Low
Marsh	Low

*For total sediment

VARIABILITY



SEDIMENTATION RATE

Basins	Low
Barrier Shoals	Moderate

STORAGE EFFICIENCY: High

POLLUTION SUSCEPTIBILITY: High due to low flushing ability and high transport ability of river to transport non-point contaminants.

Characterization. The Albemarle and Pamlico Sound system is the largest lagoonal system in North America. It is distinguished by limited exchange with the ocean, low tide range (~ 10 cm) and by an irregular mainland shore configuration. The Sounds are part of a large drowned river valley system formed by Pliocene-Pleistocene erosion at lowered sea level more than 10,000 years ago. Pamlico Sound is divided into two basins and it has four relatively small inlets. Changes in inlet configuration account for the most abrupt changes in erosion and deposition in the Sounds. The bathymetry is locally modified by dredged channels cut 2.4 to 2.7 m through Crotan and Roanoke Sounds and 2.1 m into Core Sound as part of the Intracoastal Waterway. Much material is dumped in open water along the channels.

Fluvial input of fine sediment from the drainage basin is relatively low. An estimated 0.96 x 10^6 m tons/yr is supplied from four major rivers but much of this is trapped in the tributaries. Some fine material, an estimated 0.74 x 10^6 m tons/yr, is also supplied by shore erosion, including mainland bluffs and marshes. Fines from marshes likely come from the bay floor and thus are "returned" by erosion or winnowing. Additionally, small amounts of fines are supplied from the marine areas via inlets. Sand and some shell, are supplied during storms from the barrier islands via washovers, eolian transport or through inlets via flood tidal currents. Additionally, biogenic production of shell, e.g. oysters, is active in central basins and tributary mouths.

Once in the Sounds, fine sediments are largely confined within the system by the barrier islands and limited tidal exchange with the ocean. They undergo intermittent resuspension induced by storm waves and wind driven transport, dominantly either northeast or southwest. Although pathways are indistinct there are four general subsystems: (1) a landward transport promoted by the estuarine circulation from the Sounds into tributaries, the Neuse and Pamlico Rivers; (2) a barrier subsystem for sand driven by onshore wind transport or storm wave washovers; (3) an inlet subsystem whereby some fine suspended material and sandy bedload enters via flood currents; (4) a shore to basin subsystem whereby fine sediment and organic detritus is eroded from marshes or sandy bluffs, moved lagoonward and deposited into less energetic basins.

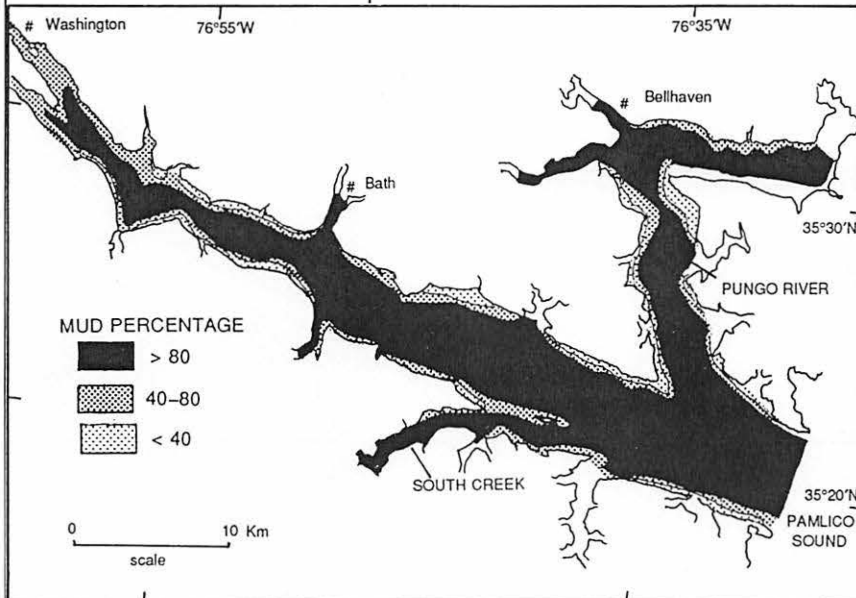
The central basins are the main sinks for fine sediment. Accumulation in the Pamlico basin is relatively low but likely greater than the Neuse River mouth, which is < 0.3 mm/yr. The chief sand sinks are the flood deltas, washover fans and storm surge platforms lagoonward of the barriers.

Bottom sediments in Pamlico Sound are predominantly fine to very fine sand on shoals and silt in the basins. Medium sand occurs locally in flood deltas, on finger shoals between basins as Bluff Shoal, or on marginal shoals near the end of peninsulas. In both Sounds where fine sand grades basinward to silt or clay, a marked textural transition occurs. This denotes a change in transport mode; whereas sand is carried as bedload transport by wave action, the silt and clay settles from the suspended load.

In Albemarle Sound the pattern is similar; silt and clay in the central basin and fine sand on marginal shoals and near-barrier shoals. The fine sediment is renown for its high organic content, ranging up to 8.6 to 15%, derived from marshes and swamps. Sandy sediments near shoals and the barrier are layered but most fine sediments are either homogeneous or mottled by sand and mud mixtures caused by burrowing organisms.

Albemarle Sound is vulnerable to a variety of point and non-point source contaminants including nutrients and trace metals. Sequestering of trace metals is enhanced by high organic matter. Most metal concentrations tend to decrease seaward from sources near the Chowan and Roanoke Rivers and creek heads. Pollution susceptibility in Albemarle Sound is high because of low flushing ability and the high ability of freshwater to transport contaminants from non-point sources in the watershed. In Pamlico Sound susceptibility is high only with respect to low flushing ability; most contaminants are trapped and retained in tributary estuaries.

S010a PAMLICO/ PUNGO RIVERS	DATA SOURCES: Riggs et al. 1989	DATA QUALITY: Moderately certain



BASICS:

Length, km	67
Width, av. km	5.6
Depth, av. m	3.7
Surface Area, km^2	438
Drainage Area, km^2	11,140
River Inflow, m^3/s	1,300
Sinuosity, Pamlico	1.0
Pungo	1.7

BOTTOM SEDIMENTS:

Mud Area, %	86
Sand Area, %	14
Organic Matter, Av. %	11.1
Range	0.3-43.1

Pattern:

Longitudinal:
Channel mud in middle and lower estuary; sand and organic detritus in extreme upper estuary.

Lateral:
Channel mud bordered by sand shoals nearshore.

SOURCES	Rel. Strength*
Drainage basin	Moderate
Shores	Low
Marine, Pamlico Sd.	Moderate
Production	Low

SINKS	Rel. Strength*
Channel	High
Tributaries	Moderate
Marsh	Low

*For fine sediment

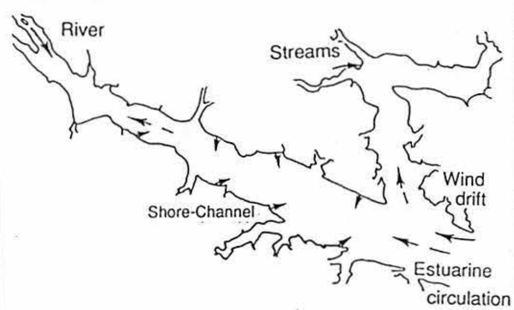
SEDIMENTATION RATE, mm/yr

Channel, average	0.61
Channel, range	0.45 - 0.75

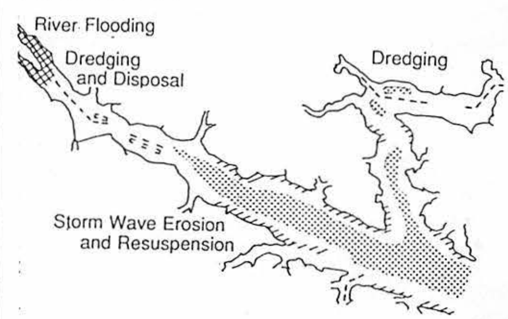
STORAGE EFFICIENCY: Moderate to high

POLLUTION SUSCEPTIBILITY: High due to low flushing ability and high ability of river to transport contaminants from non-point sources.

PATHWAYS



VARIABILITY



Characterization. The Pamlico and Pungo Rivers are shallow drowned river valley estuaries leading to Pamlico Sound. The Pamlico is a narrow straight funnel with a broad axial channel and narrow marginal shoals. Shallow dredged channels are cut through shoals in the axial channel to a depth of 2.7 m between Bath Creek and Washington, to 3.7 m through the upper Pungo River, which is a section of the Intracoastal Waterway, and locally to 2 m at Belhaven. Much material is dumped in open water along the channels.

Fine sediment is supplied from the drainage basin via the Tar River, an estimated 0.21 x 10^6 m tons/yr. Shore erosion of bluffs supplies about 0.1 x 10^6 m tons/yr. Mud is also supplied from seaward areas (i.e. Pamlico Sound) via the lower estuarine layer. Organic matter, which averages 11% of the total sediment, is supplied by erosion of the fluvial swamp forest and bordering marshes; alternately, it is incorporated into the estuary floor by submergence of swamps and marshes. Biogenic production of shell, mainly oysters, and input of sewage are of secondary importance.

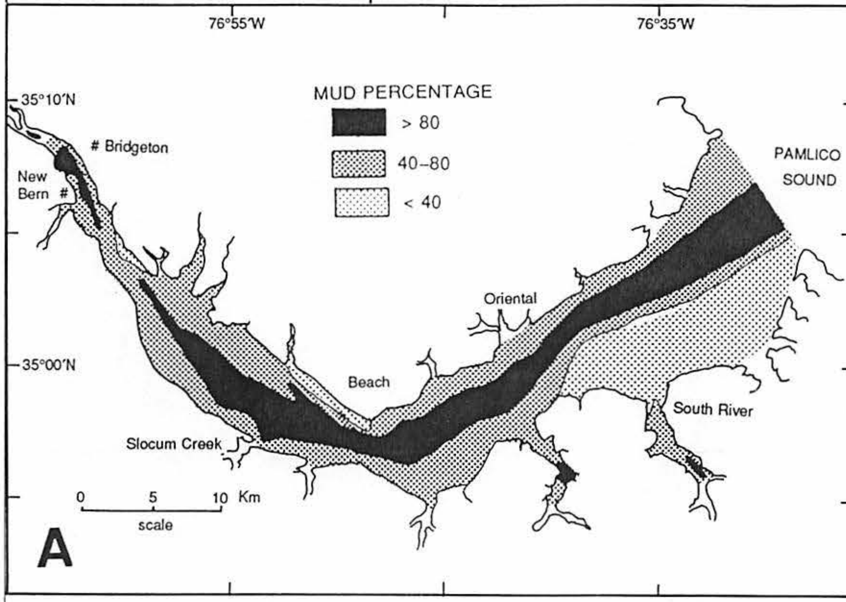
Once in the estuary fine sediments undergo resuspension by storm waves and transport by wind drift currents. After deposition they undergo bioturbation by organisms; polychaetes are important in concentrating, pelletizing and depositing mud. Large-scale transport pathways are limited. Sandy material eroded from shores is spread channelward and deposited on shoals to the break in slope at about 1 to 2 m depth. In contrast, fine sediment is winnowed out and spread further into the channel. The slope is marked by a sharp textural transition from sand to mud.

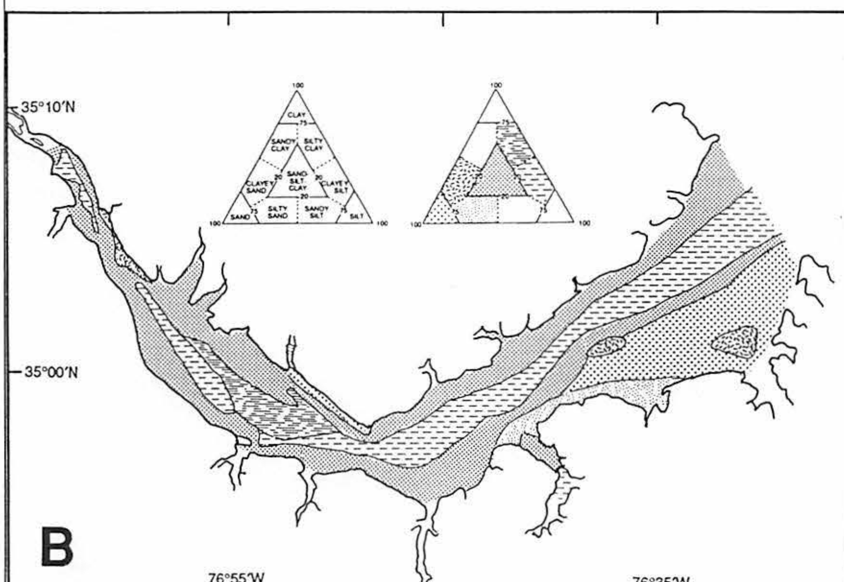
The broad axial channel is the major sink of mud sedimentation. Long-term accumulation rates over the last 5,000 years range 0.45 to 0.70 mm/yr in Blounts Bay 18 km seaward of Washington. This is less than the rate of submergence, an estimated 1.0 to 2.8 mm/yr, which increases toward the mouth. Storage efficiency is moderate to high. Sedimentation of fines is favored by formation of large aggregates or "marine snow" that settle fast, by weak tidal circulation and by the long residence time of suspended sediment in the turbidity maximum.

Mud (> 80%) dominates the axial channel except near the head where coarse sand or mixtures of sand and mud plus coarse organic detritus occur. Sand and mixtures of mud and sand, reside on shallow margins less than 1 to 2 m deep. The transition from mud to sand along the channel margin is extremely sharp. Organic content ranges 0.3 to 43% and generally decreases seaward in the channel and in tributary creeks.

The Pamlico/Pungo systems are enriched with trace metals supplied from point sources, i.e. sewage and industrial discharges at Washington, Belhaven, Kennedy, Broad and Battalina Creeks. The middle Pamlico estuary and South Creek are enriched in cadmium caused by a major phosphate mining. The sedimentary environment favors high contaminant loading by virtue of clay minerals with high adsorption capabilities and the high chemical reactivity of organic matter. Pollution susceptibility is high because of low flushing ability of the estuary and high ability of freshwater discharge to transport nutrients and toxics from nonpoint sources in the watershed.

S010b NEUSE RIVER	DATA SOURCES: Riggs et al. 1991	DATA QUALITY: Moderately certain





BASICS:

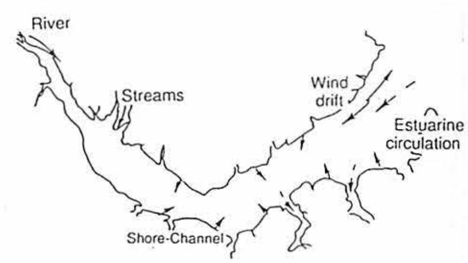
Length, km	80
Width, av. km	6.6
Depth, av. m	3.6
Surface Area, km^2	450
Drainage Area, km^2	14,500
River Inflow, m^3/s	175
Sinuosity	1.2

BOTTOM SEDIMENTS:

Mud Area, %	78
Sand Area, %	22
Organic Matter, Av. %	15
Range	0.4-79

Pattern:
- Longitudinal:
  - Channel mud
- Lateral:
  - Channel mud bordered by sand and mixture of mud-sand shoals

PATHWAYS

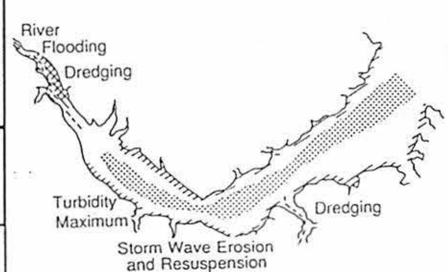


SOURCES	Rel. Strength*
Drainage basin	Moderate
Shores	Moderate
Marine (Pamlico Sd.)	Moderate
Production & Sewage	Low

SINKS	Rel. Strength*
Channel	High
Tributaries	Moderate
Marsh	Low

*For fine sediment

VARIABILITY



SEDIMENTATION RATE, mm/yr

Channel, range <0.3 - 5.0

STORAGE EFFICIENCY: Moderate to high

POLLUTION SUSCEPTIBILITY: High due to low flushing ability.

Characterization. The Neuse River estuary is a shallow drowned river valley leading to Pamlico Sound. It is a narrow funnel with a broad axial channel flanked by narrow shoals. Its shape reflects the ancestral river channel inherited from Pleistocene erosion. Submergence of the river valley, which is bordered by swamp forest floodplains, continues today at about 1.5 to 3.0 mm/yr. Shallow dredged channels cut through shoals in the axial channel 2.7 to 3.1 m deep 15 km seaward and 5 km landward of New Bern. Additionally, an Intracoastal Waterway channel is cut 3.7 m deep through Adams Creek.

Fine sediment, an estimated 0.24×10^6 m tons/yr, is supplied from the drainage basin mainly during floods. Shore erosion of banks and bluffs which are undercut during storms, supplies about 0.21×10^6 m tons/yr. Another portion of mud is supplied from seaward areas (i.e. Pamlico Sound) via the lower estuarine layer. Organic matter, which averages 15% of the total bottom sediment, is supplied by erosion of the fluvial swamp forest and bordering marshes; alternately, it is incorporated into the estuary floor by submergence of swamps and marshes. Of secondary importance is biogenic production of shell, i.e. clams and oysters, as well as sewage input.

Once in the estuary, fine sediments undergo intermittent resuspension by storm waves and transport by wind drift currents. After deposition they undergo bioturbation; polychaetes are important in concentrating, pelletizing and depositing mud. Large-scale transport pathways are limited. The chief transport pathway is channelward from banks to shoals and to the channel. Enroute sand is spread on shoals while silt and clay are winnowed out by wave action and deposited in the channel or alternately, in tributary creeks.

The broad axial channel is the main sink of mud sedimentation. Accumulation rates over the last 60 to 100 years range 5 mm/yr near New Bern to < 0.3 mm/yr near the mouth. Most sediment is retained in the estuary; storage efficiency is moderate to high. Sedimentation is encouraged by a long residence time of suspended sediment in the turbidity maximum. Additionally, dispersed fines tend to form aggregates or "marine snow" that settle fast, benthic organisms promote biodeposition.

Mud (> 80%) covers the channel floor mainly from the mouth to 15 km landward of New Bern. Sand and mixtures of mud and sand, reside on shallow margins less than 2 to 3.5 m deep. The transition from mud to sand along the channel margin is sharp occurring along a slope. Organic content ranges 0.4 to 79% and generally decreases seaward in the channel from 20 to 9%.

The Neuse River estuary is enriched with 15 trace metals supplied from point sources, i.e. sewage and industrial discharges at New Bern, Bridgeton and Slocum Creek. Sequestering of trace metals is enhanced by high organic content both natural and anthropogenic, including input of sewage and agricultural drainage. Marinas supply substantial amounts of Cu and some Pb and Zn. Most anthropogenic metal inputs are concentrated at the estuary head and they decrease seaward. Pollution susceptibility is high because of low flushing ability of the estuary and the high ability of freshwater to transport nutrients and toxics from nonpoint sources in the watershed.