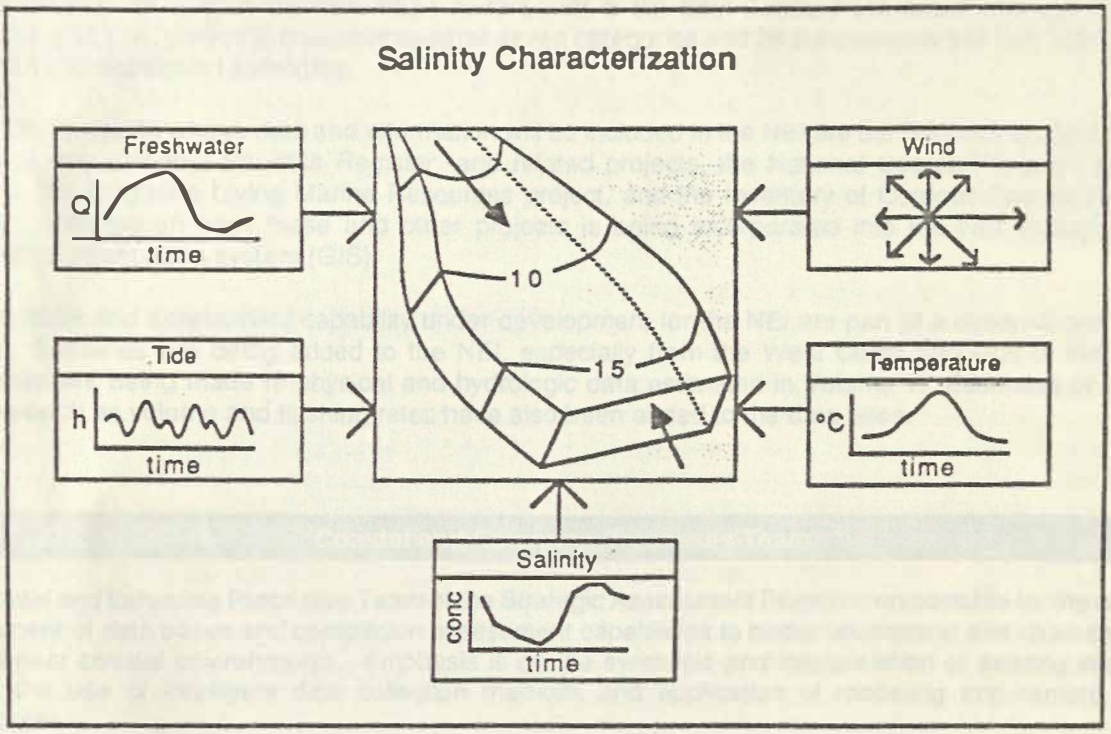
National Estuarine Inventory Supplement Series

A Project to Characterize Salinity in the Nation's Estuaries



October 1989

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

National Estuarine Inventory

The 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) to develop a national estuarine data base and assessment capability. The NEI was initiated in 1983 as part of NOAA's program of strategic assessments of the Nation's coastal and oceanic resources.

The cornerstone of the NEI is the *National Estuarine Inventory* data atlas series. Volume 1, completed in 1985, (1) identifies 92 of the most important estuaries and sub-estuaries of the contiguous USA, (2) presents information through maps and tables on physical and hydrologic characteristics of each estuary, and (3) specifies a commonly derived spatial unit for all estuaries, the estuarine drainage area (EDA), for which data are compiled (See inside back cover for sample map). These estuaries represent approximately 90 percent of the estuarine water surface area and 90 percent of the freshwater inflow to estuaries of the East Coast, West Coast, and Gulf of Mexico. Volume 2, Land Use, presents area estimates for seven categories and 24 subcategories of land use as well as 1970 and 1980 population estimates.

Other NOAA projects whose data and information will be included in the NEI are the National Coastal Wetlands Data Base, the *National Shellfish Register* and related projects, the National Coastal Pollutant Discharge Inventory, the Estuarine Living Marine Resources project, and the Inventory of Outdoor Coastal Recreation Facilities. Information from these and other projects is being incorporated into the NEI through NOAA's geographical information system (GIS).

The data base and assessment capability under development for the NEI are part of a dynamic and evolving process. Estuaries are being added to the NEI, especially from the West Coast and Gulf of Mexico, and refinements are being made to physical and hydrologic data estimated in Volume 1. Estimates of estuarine attributes such as volume and flushing rates have also been added to the data base.

Coastal and Estuarine Processes Team

The Coastal and Estuarine Processes Team of the Strategic Assessment Branch is responsible for the continued development of data bases and companion assessment capabilities to better understand and characterize our Nation's near coastal environments. Emphasis is on the synthesis and interpretation of existing information through the use of *intelligent* data collection methods and application of modeling and remote sensing technologies.

A Project to Characterize Salinity in the Nation's Estuaries

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INTRODUCTION

This report describes a new nationwide data collection and synthesis project that is part of NOAA's National Estuarine Inventory (NEI) activities (inside front cover). An extensive effort is now underway to develop detailed information on the spatial and temporal characteristics of the salinity patterns within the Nation's estuaries. The project is being conducted jointly through cooperative agreements with local universities and institutions and site visits to local experts for eache estuary. The objective is to make the most of what ise already known about salinity and its variability for eache estuary. Present efforts are being concentrated one approximately 30 estuaries in the Gulf of Mexico withe eventual application to over 100 estuaries nationally.e

BACKGROUND

Salinity is measured as the number of grams of dissolved salts in 1000 grams of seawater and ranges from an average of 35 parts per thousand (ppt) for the open ocean to freshwater in the upper reaches of tidally influenced tributaries. Salinity is a key parameter in determining the extent and character of an estuarine environment, and has been used as a means by which to classify estuaries indicative of certain types of transport behavior (Pritchard, 1955; Cameron and Pritchard, 1963) and biological potential (Symayda, 1983).

Volume 1 of the NEI identified three generic salinity zones: tidal fresh (0.0-0.5 ppt), mixing (0.5-25ppt), and seawater (>25ppt), representing depth-averaged and average-annual conditions for each of the 92 estuaries. This effort provided a basis for initial assessments and comparisons addressing relative flushing potential (Klein, et.al., 1989) and estuarine species distribution and abundance (Monaco, 1986). However, because salinity is affected by freshwater inflow, tide, and wind, it can exhibit significant temporal variability. An understanding this variability is essential to refining our current assessment strategies. In addition, higher spatial resolution beyond the three generic zones described above is required to better understand distributions of both biotic and abiotic parameters that are based upon salinity. This project will provide the next step, refining both the spatial and temporal aspects of estuarine salinity structure.

Salinity as a Surrogate for Pollutant Distribution. Ketchum (1951) showed that river discharge in an estuarine environment can be used as a natural tracer. Because salts are dissolved and conservative properties, salinity provides the background against which to trace freshwater inputs. The salinity structure and stability reflects both the ability of an estuary to transport as well as dilute river discharge.

In a similar fashion, the salinity structure and its response to various forcing mechanisms (i.e. freshwater inflow, tide, wind) may be used to infer an estuary's susceptibility to pollutant inputs. The ability of a system to concentrate a pollutant discharge is assueed to be affected by the same transport and dilution mechanisms that determine freshwater influences on salinity.

Salinity as a Descriptor of Habitat. Many biotic variables correlate closely to the structure of the salinity regime. Salinity poses significant physiological challenges limiting the extent to which certain organisms can survive. As such, it has been used as a factor to determine the likely distribution of estuarine-dependent species, based upon salinity tolerance. The Venice system (Symayda, 1983) is a recent example which classifies waters within an estuary, based upon biological observations.

The dynamic nature of the salinity structure (i.e. variability) is key to understanding the presence or absence of certain estuarine assemblages. Salinity can change from freshwater to marine salinity over a tidal cycle in small tidally dominated systems. In contrast, larger estuaries such as Chesapeake Bay experience gradual changes and are affected by seasonal freshwater inflow. If salinity is tidally versus seasonally regulated a greater effort is required for organisms that are salinity-sensitive to adapt.

Ultimately, this project will help to better understand the relationship between salinity, the presence of certain biotic assemblages, and the potential for estuaries to concentrate and retain pollutants.

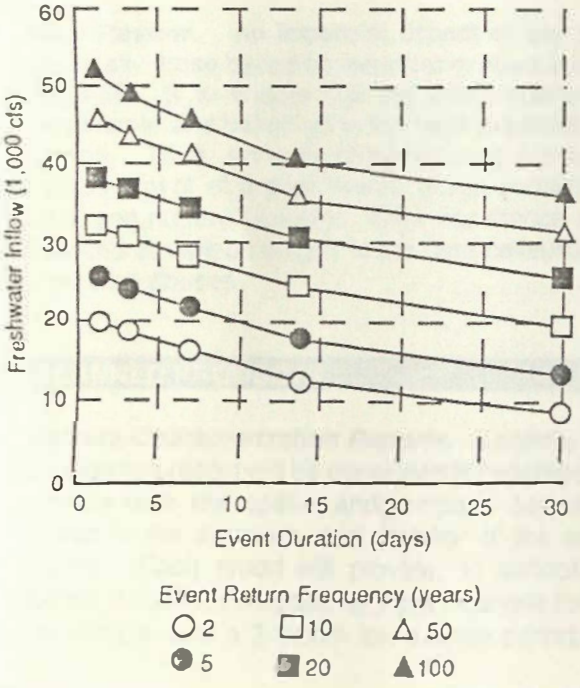
PROJECT COMPONENTS

This project has been designed to take advantage of existing data, sythesized at a level that is believed to be available for all estuaries nationally. The project consists of two components:

1. Refine the spatial and temporal aspects of salinity distributions. Refinements will include surface and bottom distributions at 5 part per thousand (ppt) increments for a typical 3-month high- and 3-month low salinity period.

The intent is to discuss the salinity structure using a data set believed to be representative of typical conditions within the estuary. An extensive screening process was developed to select the 3-month periods that adequately represent typical and present-day conditions within the estuary. Characterization is based on those data sets that: a) best approximate average hydrologic conditions, particularly with respect to freshwater inflow (Holliday, et.al., 1989) and meteorological events, and b) incorporate all significant modifications to the estuary (channels, dredged material disposal areas, jetties, etc.) and its watershed (freshwater diversions and withdrawls) that may potentially affect salinity distributions, spratification, and circulation. In the case of freshwater, inflow during the 3-month periods is compared to long-term data for selected durations (1,3,7,14, and 30-day events) at return frequencies of 2,5,10,20,50, and 100 years (Figure 1). The data set that best approximates the 2-year (average) return frequency is selected (assuming all other screening criteria are met). This process assumes that an adequate historical salinity data base exists. In some cases, data may be limited so that salinity distributions cannot be based on typical or present-day conditions.

Figure 1. Freshwater Inflow Screening Process



2. Characterize the stability of the salinity structure as it is affected by the physical forces of freshwater inflow, tide, and wind. This objective addresses the dynamic nature of each forcing mechanism at time scales that are smoothed as a result of data aggregation to the 3-month averaging periods and assesses the relative stability of the salinity structure. Freshwater inflow, for example, may affect salinity distributions over periods of hours (as rainfall events), days-to-weeks (as larger storm events), or months-to-seasons (as wet vs. dry seasons). Similarly, the influence of tide may be exhibited over periods of hours (diurnal tide cycle) or days-to-weeks (spring-neap cycle). Winds, fronts, and prevailing seasonal winds are considered for periods of hours, days-to-weeks, and months-to-seasons, respectively. Episodic events, such as hurricanes, are also examined. A matrix (Figure 2) was developed to summarize the time scales at which each mechanism influences bay-wide salinity and stratification.

Figure 2. Salinity Stability Matrix for Mobile Bay

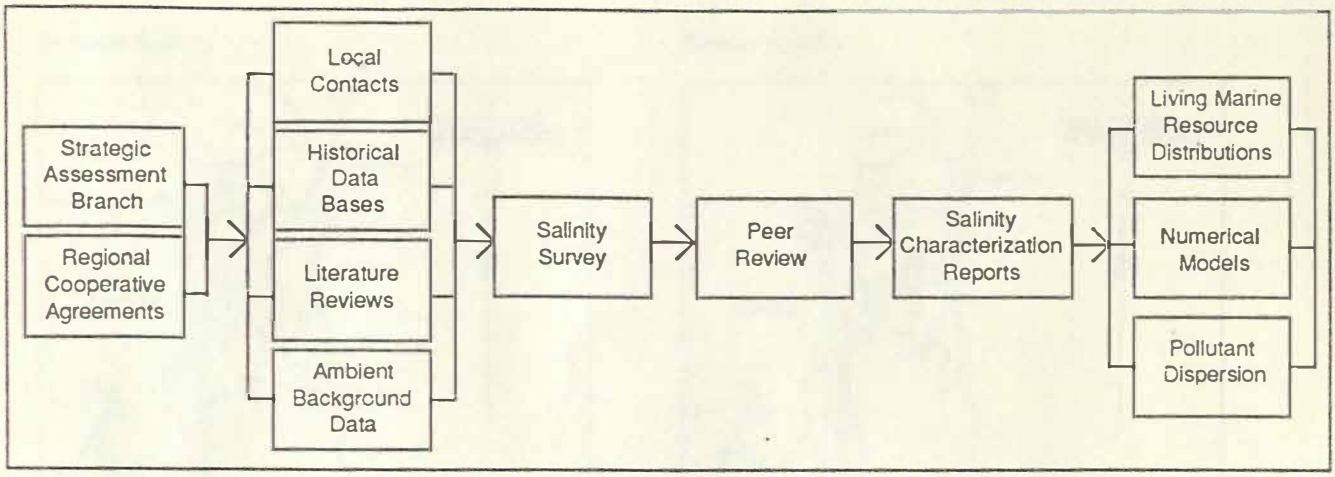
Mechanism	Hours		Days-Weeks		Months	
	Salinity	Stratification	Salinity	Stratification	Salinity	Stratification
Freshwater Inflow	SLI (rainfall)	INC	LOW (storms)	INC	HIGH (seasonal discharge)	INC
Tides	LOW (diurnal tide cycle)	n/a	LOW (tropic-equitorial)	n/a		
Wind	SLI (diurnal winds)	INC or DEC	MOD (fronts/storms)	INC or DEC	MOD (seasonal winds)	INC or DEC
Other Mechanisms			SLI to HIGH (hurricanes)	DEC		

Effect on bay-wide salinity: Slight (SLI) < 2ppt, Low 2-5 ppt, Moderate (MOD) 5-10 ppt; High >10 ppt. Effect on bay-wide stratification: Increase (INC) or Decrease (DEC).

DATA COLLECTION AND SYNTHESIS

Data necessary to complete these characterizations is based on historical information, which is generally available at the local level. To facilitate collection and synthesis, the project is being conducted through a series of regional cooperative agreements with selected universities. This approach is currently being applied to more than 30 estuaries in the Gulf of Mexico region in cooperation with Florida State University and Louisiana Universities Marine Consortium (LUMCON). This will provide the local knowledge and contacts

Figure 3. Salinity Project Flowchart



necessary to comprehensively investigate all data sources. Extensive contact with various academic and government institutions is required to collect data, obtain the insights of local experts, and conduct peer reviews of the information synthesized.

Salinity Survey. To ensure that data collection and assimilation are being conducted in a consistant manner for each estuary and region, a generically designed survey is used as the organizing framework (Available upon request). This approach assures that the criteria for evaluation and related data requirements are uniformly applied. Secondly, it provides a convenient format for purposes of peer review, and subsequent extraction for report purposes. Figure 3 illustrates the manner in which the project is currently being conducted.

Peer Review. An important aspect of any study, especially those based on literature reviews and consultations, is to ensure that the interpretations are reasonable and based upon the best available information. Thus, an integral component will be the establishment of a peer review group consisting of local and regional experts. Their assistance will be solicited at various stages in the data collection and synthesis phases.

PLANNED PRODUCTS

Salinity Characterization Reports. A salinity characterization report will be generated for each estuary refining both the spatial and temporal aspects as related to the *structure* and *stability* of the salinity regime. Each report will provide: 1) surface and bottom isohalines mapped at 5 ppt intervals for a 3-month high- and a 3-month low salinity period; 2) a salinity stability matrix; and 3) a description of the estuary, its watershed, and data bases used to characterize the estuary.

A prototype report for Mobile Bay was recently completed (Orlando and Klein, 1989). Figure 4 illustrates a typical salinity profile for the low salinity period (February-April) within Mobile Bay. The salinity stability matrix in Figure 2 characterizes the temporal variability of the salinity structure for Mobile Bay. Overall, the bay is classified as a seasonal estuary due to a strong seasonal freshwater inflow signal, but it is susceptible to shorter term wind-driven fluctuations.

Digital Data Base. All information will be organized by estuary and will include surface and bottom isohalines by 5 ppt increment for both high and low periods. In addition, this information will be integrated within two NOAA information systems: GeoCoast, a GIS framework for national-level assessment of near-coastal waters and COMPAS (Coastal Ocean Management Planning and Assessment System) specific to estuarine characterizations.

Schedule. Completion of salinity characterizations for all GOM estuaries is anticipated by Fall 1990. Individual characterizations will be available upon completion. Eventually, the approach will be applied nationally, relying on other local institutions to provide the necessary expertise.

For more information on this project contact:

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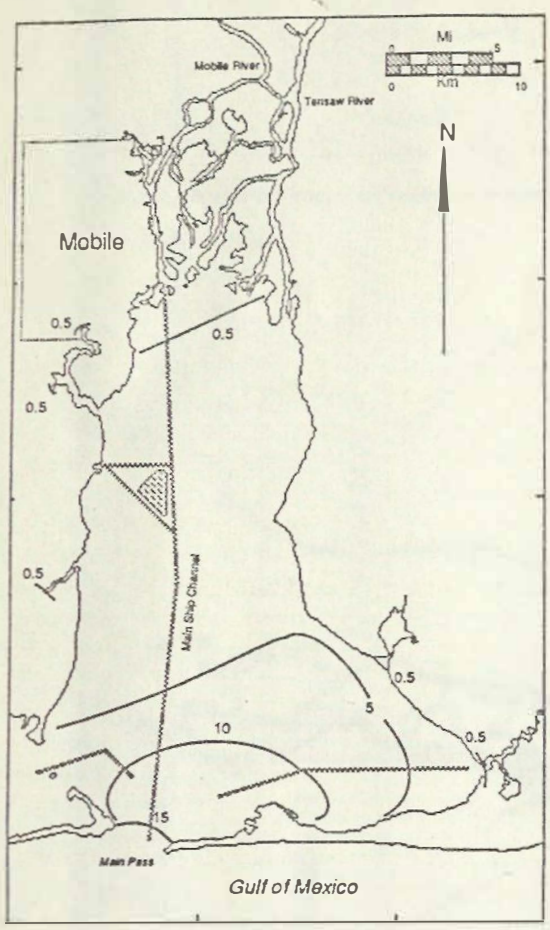
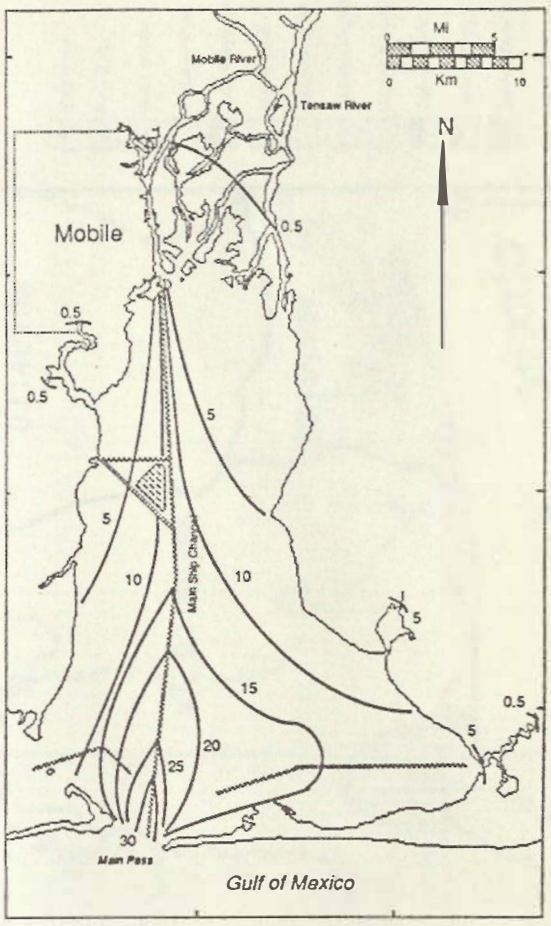
Figure 4. Surface and Bottom Salinity Profiles for Mobile Bay (Low salinity period: February-April 1969)a

Surface Salinity



Bottom Salinity



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National Estuarine Atlas

Mobile Bay
AL

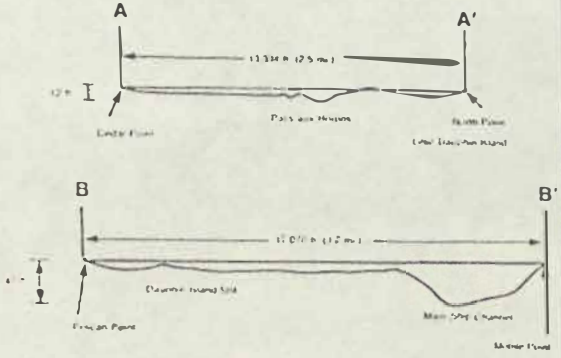
PHYSICAL AND HYDROLOGIC CHARACTERISTICS

PHYSICAL		FRESHWATER INFLOW		TIDAL DATA			
Surface Area (km²)		Flow Rates (1000 cfs)		Prevailing Tide Station			
Estuarine Drainage Area	35,725	Period of Record	1975 1984	Tidal Prism m³			×10⁶
Estuarine Shoreline	4,875	Long Term Average Daily	79.3	Mean Range of Tide (m)			
Estuarine Zones			J 129.6 J 92.3	Map Key	Station	Range	
Tidal Fresh	75		F 109.7 A 79.4	A			
Mixing Zone	121	Long Term Average Monthly	M 101.6 S 79.5	B			
Seawater	53		A 179.4 O 36.9	C			
Land	409		M 83.3 N 43.4	D			
Depth (m)			J 44.5 D 64.0				
Length (km)	170.6	7 Day 10 Year Low Flow	7Q10				
Width (km) Average	13.8	50 Year Flood	595.7				
Maximum	8.8	100 Year Flood	653.0				
Minimum	23.5	Flow Ratios					
Average Tidal Range (m)	0.6	Average Annual	0.449				
Average Volume (m³)	1.3x10⁹	High Flow Period	0.870				
Shoreline Classification		Low Flow Period	0.173				
Estuarine High Low	MS						
Estuarine Low Flat	MS						

All measurements Vertically Homogeneous Well Mixed Partially Stratified MS Highly Stratified HS

Cross Sections
(at mean high water)

Scale Factor 36



Notes
Approximately 40% of Estuarine Drainage Area is shown on map

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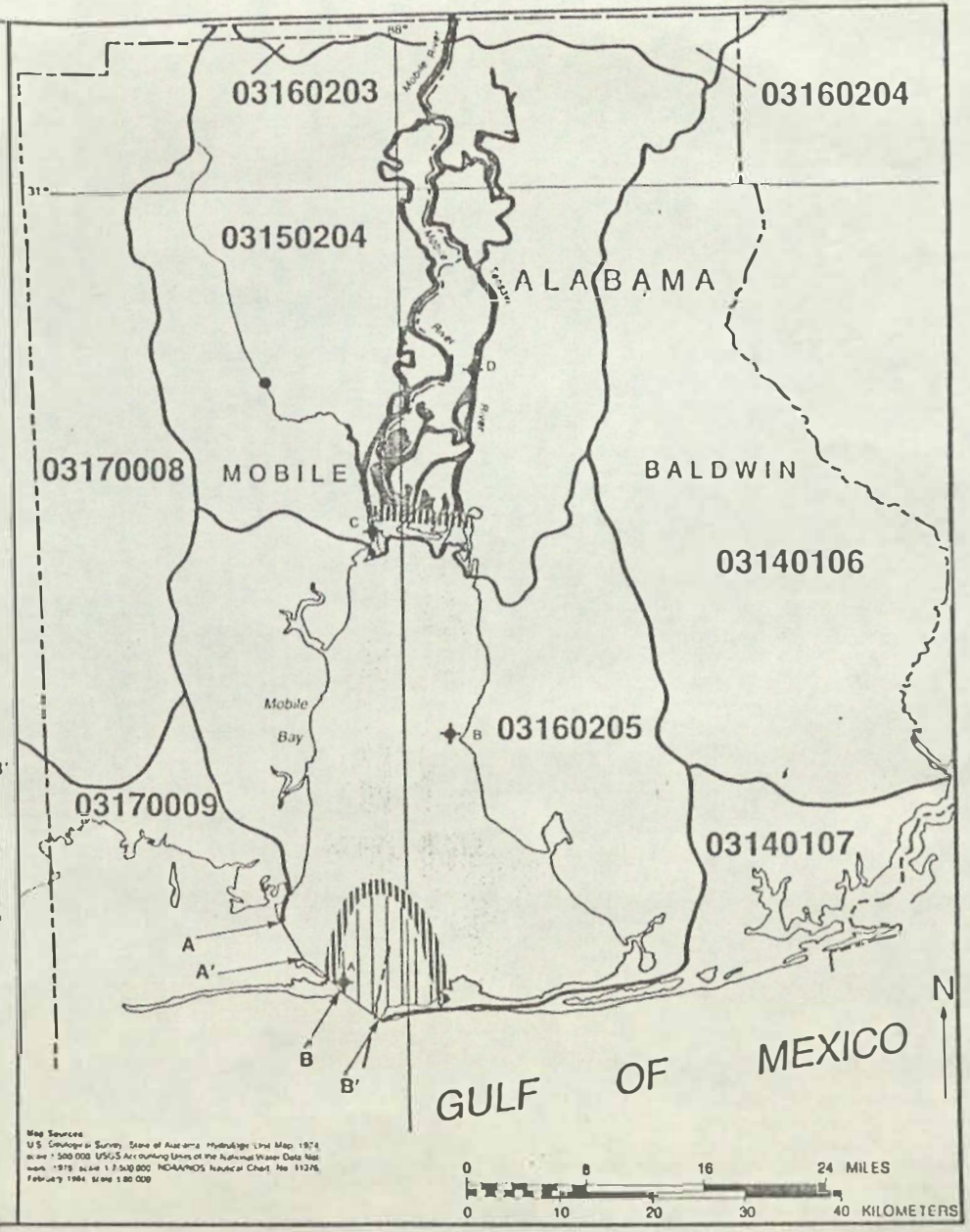
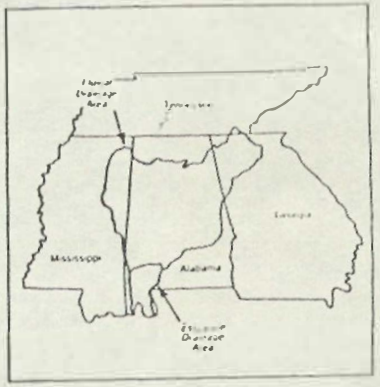


Map Sources
U.S. Geological Survey, State of Alabama, Hydrologic Unit Map, 1974, scale 1:500,000; USGS Accounting Units of the National Water Data Network, 1978, scale 1:7,500,000; NOAA/NOS Nautical Chart No. 11376, February 1984, scale 1:80,000



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

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