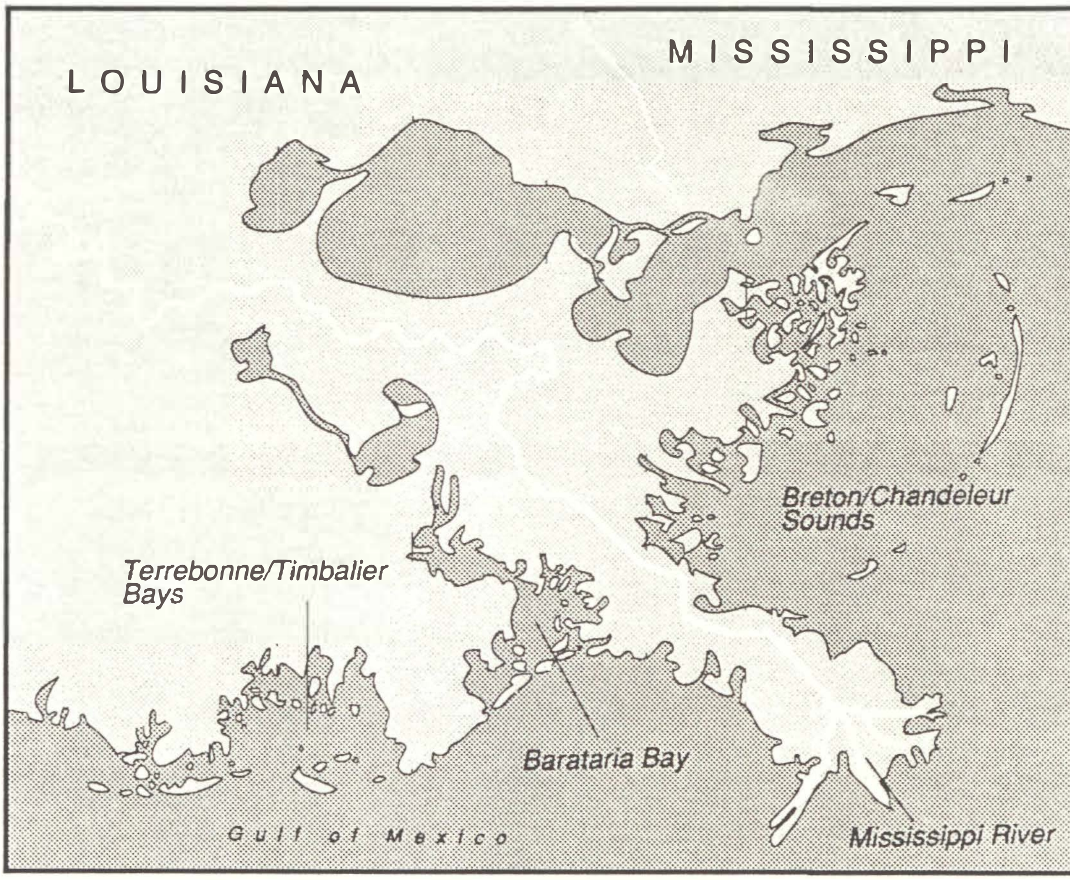
National Estuarine Inventory: Supplement 3

Revised Physical and Hydrologic Characteristics
For The Mississippi Delta Region Estuaries



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

National Estuarine Inventory: Supplement 3

Revised Physical and Hydrologic Characteristics
For The Mississippi Delta Region Estuaries

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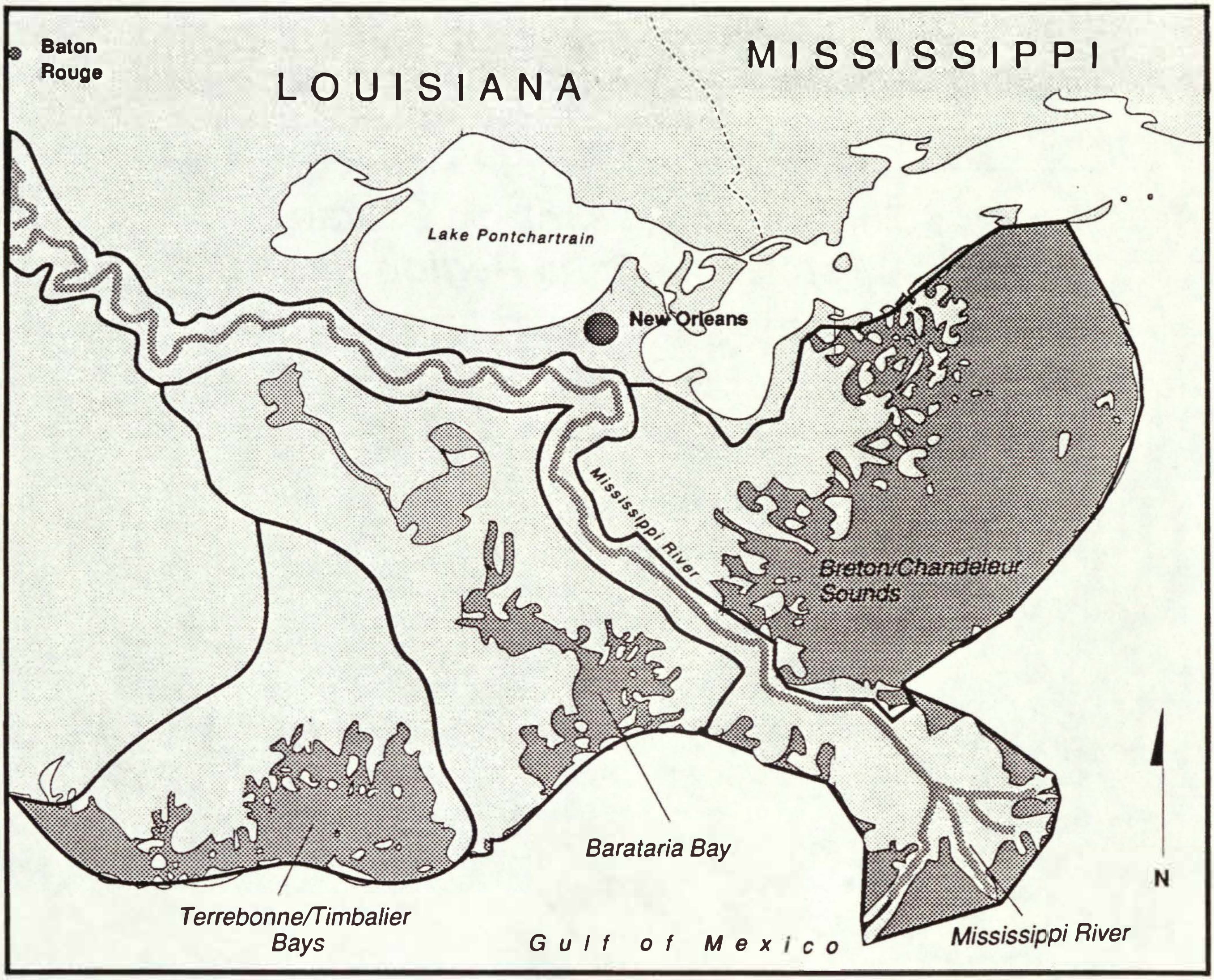
National Ocean Service

Figure 1: NEI New Division of Mississippi Delta Region



The Mississippi Delta System Estuaries

Introduction

This supplement is the third in a series presenting updates, additions, and/or enhancements to Volume 1 of the National Estuarine Inventory (NEI): Physical and Hydrologic Characteristics. This particular supplement represents the refinement of the Mississipi Delta (3.13) into four distinct systems: Breton and Chandeleur Sounds; Missisipi River; Barataria Bay; and Terrebonne and Timbalier Bays (Figure 1).

The criteria for developing this supplement is based upon the need for increased spatial resolution within the Mississippi Delta Region. The format for presentation parallels that of the original Volume 1, having both tabular and mapped components. A two page presentation for each system addresses the physical and hydrologic characteristics, spatial depictions of salinity zones and their variability, tide gauges, and head of tide. New data, such as volume by salinity zone, and freshwater retention time as an indictator of flushing, have been added. The later parameters, for all NEI systems, will constitute a future supplement.

The approaches used in data generation and compilation are consistent with Volume 1 and are described below. Similarly, a reference section is provided in the back.

Definitions and Methods

Base Map, U.S. Geological Survey (USGS) topographic quadrangle maps (1:24,000), were used as a standard base to identify and map estuarine boundaries and features. The USGS maps were chosen because they clearly and consistently depict the boundaries of coastal drainage basins, identify numerous features important for plotting information, and provide reasonable coastline definition.

Estuarine and Fluvial Drainage Areas. The estuarine drainage area (EDA) is that land and water component of an entire watershed that most directly affects an estuary. The purpose of identifying an estuarine drainage area is to establish the spatial unit for compiling biotic and abiotic estuarine attributes.

EDAs were defined based on the limits of tidal influence within an estuarine system and the boundaries of U.S. Geological Survey (USGS) hydrologic cataloging units. A hydrologic unit is a geographic area representing part, or all of a surface drainage basin, or a distinct hydrologic feature. Cataloging units, the smallest of four levels of hydrologic units, are usually greater than 700 square miles.

EDAs were drawn to coincide with hydrologic cataloging unit(s) that contain the heads of tide and seaward estuarine boundaries. In many cases, this means the EDA extends landward beyond the head of tide. In other more limited instances, the EDA may intersect a cataloging unit.

Where the EDA coincided with cataloging units, area estimates were obtained from USGS. In cases where the EDA did not coincide with cataloging unit boundaries, the areas were digitized in NOAA's GEOCOAST Geographic Information System to derive a value for the estuarine drainage area.

In addition to identifying the EDA, the fluvial drainage area (FDA) was determined by inspection of hydrologic unit maps and reviews of USGS state water resource reports. The FDA is the land and water portion of the entire watershed upstream of the EDA.

Estuarine Surface Area. The surface water area of an estuary was estimated from the physical head of tide of the estuary and its tributaries, to the mouth, where the estuary empties into an ocean, bay, gulf, sound, or other waterbody. In cases where the tide encompases the estuary (ie: Breton/Chandeleur Sounds, Barataria Bay, Terrebonne/ Timbalier Bays), the surface area was estimated from the boundaries of the EDA to the mouth. Head of tide was interpreted from coastal ecological inventory maps prepared by the U.S. Fish and Wildlife Service, (DOI, 1980-81, scale 1:250,000). These maps indicate areas of change in the distribution of living marine resources due to salinity concentrations and approximate the average point on a stream where surface water elevation is no longer influenced by the rise and fall of the tide. In addition, data were obtained from *U.S. Coast Pilots*, published by NOAA, and from USGS district offices, U.S. Army Corps of Engineers, and state water or natural resource agencies.

The seaward boundary for each estuary was determined by inspection of USGS hydrologic unit maps and NOAA nautical charts, to identify significant physiographic characteristics and other features, such as barrier islands, rock outcrops, and man-made structures. If no clear physiographic limits existed, the charts were used to decipher bottom features that can affect circulation patterns and mixing processes. These include overall bathymetry, sills, and reefs. The shoreline at mid-tide level was measured for each salinity zone.

Estuary Length. Estuary length was delineated along the main axis of the estuary, from the head of tide of the principal tributary stream, to the midpoint of the estuary mouth, or principal opening to the sea.

Estuary Width. Average width was determined by measuring a series of regularly spaced perpendiculars to the main axis of the water body on NOAA nautical charts, drawn at mid-tide level and averaged. The number of perpendiculars for an individual system was a function of estuary length and the shoreline irregularity. Maximum and minimum estuary widths were measured on NOAA nautical charts along perpendiculars to the main axis at approximately mid-tide level.

Estuary Depth. Average estuary depth was calculated for each salinity zone by overlaying a transparent grid of equal horizontally - and vertically-spaced lines on NOAA nautical charts that show depth soundings. Depths were recorded at the intersection of these lines, or interpolated, where necessary, and combined and divided by the number of intersections. Because depth soundings are recorded for low-water level, the final average depth was obtained by adding the difference in elevation between low-water datum and mid-tide elevation. In cases where NOAA charts did not exist, depths were cited from published reports, or inferred from documented field surveys in which water column depths were recorded.

Average Depth to Width Ratio. This parameter provides an indication of the depth of an estuary relative to its width. It was calculated as a ratio of the values obtained for average depth and width.

Estuary Classification. Estuaries are classified based upon the degree of salinity stratification, which is often used to infer circulation features. Salinity profiles are affected by such factors as the amount of freshwater inflow, the size and shape of the basin, and the effects of tides and winds. Since estuaries are dynamic, circulation patterns may vary and salinity structures will change as a result. When using any classification scheme, it is important to recognize this dynamic quality, and to realize that generalizations concerning salinity profiles do not reflect such variability.

Stratification classification was determined for each estuary from published and unpublished data, and by consulting local experts. The classification assigned to an estuary is specific to the mixing zone of a system where freshwater interfaces with seawater. In certain cases, such as the estuaries in Maine, the area of the mixing zone is limited due to the strong oceanic influences. However, stratification occurs within this band, as freshwater maintains its continuity over a limited distance before its dispersion into the seawater zone.

Three classes of stratification, based on the degree of vertical stratification, are reported.

- Highly stratified (salt wedge estuary) - Very little mixing occurs between the surface and the bottom layers; mixing that does occur results from shear forces at the junction of upper and lower layers.

- Moderately stratified (surface salinity less than bottom salinity) - Significant mixing occurs between surface and bottom water, and the dominant mixing agent is turbulence caused by tidal action

- Vertically homogeneous (surface salinity equals bottom salinity) - An estuary is vertically homogeneous when tidal mixing and turbulence is sufficient to break down stratification.

Estuarine Zones. Each estuary was subdivided into three zones, between the heads of tide and the seaward boundaries, based on average annual and depth-averaged salinity concentrations. Salinity zones are important to determine since they often dictate the distribution of biological communities and contribute to the understanding of estuarine circulation. These zones correspond to the following salinity regimes:

Approximate Salinity Ranges for
Estuarine Zones (parts per thousand)

Tidal Fresh	0.0 to 0.5
Mixing	0.5 to 25.0
Seawater	25.0 and greater

Salinity data were obtained, and subsequent boundaries determined from published and unpublished sources and through consultation with experts.

Segmentation of an estuary on the basis of salinity is highly variable due to the many interacting factors affecting salinity concentrations, such as variations in freshwater inflow, wind and tides. Several guidelines were therefore developed to provide a uniform approach, and to account for variability in data presentation.

First, episodic anomalies of salinity conditions that occur during low or high freshwater inflows were screened out to provide an average annual scenario of the system. Second, surface and bottom salinities were averaged. Finally, delineation between zones was depicted by a band which indicated the spatial variability which could be experienced over an annual cycle. Low, moderate, and high variability classifications are a function of the relative proportion of the variability to the length of the estuary. For example, an estuary with a length of five miles, and salinity zone boundary of four miles, would be classified as highly variable.

Estuarine Volume. Volume was estimated for each salinity zone at mid-tide level. This estimate is the product of the surface area and average depth for each zone.

Freshwater Inflow. Flow statistics were determined for the entire drainage basin from flows measured by USGS flow gages, estimation techniques for ungaged areas, and from records of significant diversions of flow regulations (dams) unaccounted for by flow gages. Long-term average flow, and extreme low- and high-flow conditions, were determined for each estuary. These conditions are used to characterize the hydrology of a system and are important for determining estuarine hydrodynamics.

Flow Rates. Gaged flows - Average for daily freshwater inflow for streams discharging to an estuary were obtained from the USGS WATSTORE hydrologic data base system. The statistics developed for each gage were long-term daily average flows calculated on an annual and monthly basis, 7-day, 10-year low flow, and the 50- and 100-year high flows. It was verified that no major flow regulations or diversions were constructed during the period of record which would have significant effect on flow.

Ungaged Flows - Unit runoff factors (URF) were used to determine ungaged flows. The URF represents the ratio of gaged flow to the drainage contributing to this flow, calculated from nearby gaged areas that were comparable in size and land use to the ungaged area. The area of ungaged drainage was then multiplied by the URF to derive its flow contribution to the estuary. These additional flow data were then added to the gaged portion of a gaged stream, or were substituted for unacceptable gaged data.

Tidal Prism. The tidal prism is the volume of water entering a coastal system during flood tide, excluding freshwater inputs. Data for each estuary were obtained from NOS mean tidal range information and nautical charts. Tidal prisms were calculated using the cubature method (Jarrett, 1976). The cubature method takes into account the time required for a flood wave to propagate through the system, rather than assuming a uniform and simultaneous rise and fall of tide over the entire estuary.

Flow Ratios. Flow ratio is the proportion of the volume of freshwater entering a coastal system during a tidal cycle to the volume of the tidal prism. This ratio provides an estimate of whether freshwater inflow, or tidal influence, is the dominant factor affecting the water body. Higher ratios indicate freshwater, or riverine inputs, dominate the system. Conversely, tidal domination is indicated by a small flow ratio value. Average annual high and low-flow period ratios were calculated for each estuary.

Freshwater Retention Time. This parameter is based on Ketchum's (1955) fractional freshwater method. It is derived from the replacement of the freshwater component of the total system volume due to freshwater inflow. Volumes of fresh and saltwater are estimated for the three salinity zones, as depicted for each estuary, and combined to obtain system totals. Computations are based on average annual freshwater inflow and salinity characteristics.

Tides. Tides are grouped into two types based on the number of high and low tides per day, the relationship between the heights of successive highs or lows, and the time between corresponding high or low stands of sea level. The two types of tides are, diurnal (one high and low per day, and semidiurnal (two highs and two lows per day). The tide type is reported for each estuary. In general, tides along the east and west coasts are semidiurnal, and those along the Gulf of Mexico are diurnal or semidiurnal. The tidal period is either 12 hours and 25 minutes (semidiurnal), or 24 hours and 50 minutes (diurnal). The tidal range calculated for each estuary is the difference in water level between mean high water (MHW) and mean low water (MLW) for semidiurnal and diurnal tides. Tidal ranges were obtained from NOS tidal observation stations.

Each estuary was segmented, based upon areas that experience the same phase range. The phase range is defined as the difference in tidal elevation at a particular location relative to the occurrence of high and low tide at a tidal reference station, which is usually located at the mouth of the estuary. The time interval between two succeeding high and low tides represents the time during which water flows into the estuary. The surface water elevation at each tide gage station was plotted versus time for each station on a common chronological scale, assuming a 12-hour 25-minute period for semidiurnal tide, and a 24-hour, 50-

-minute period for a diurnal tide. From this curve, the high and low water elevations for each tide gage were determined. The difference between these two elevations for a specific station represents its phase range.

After determining the phase range for each station, the estuary was segmented into subareas of approximately the same phase range. The mean surface area of each subarea was estimated by digitizing each in NOAA's GEOCOAST geographic information system The tidal prism for each subarea was then computed by multiplying the mid-tide water surface area for each subarea by the average phase range corresponding to that segment. The sum of the tidal prisms for each subarea is the average tidal prism volume for the estuary.

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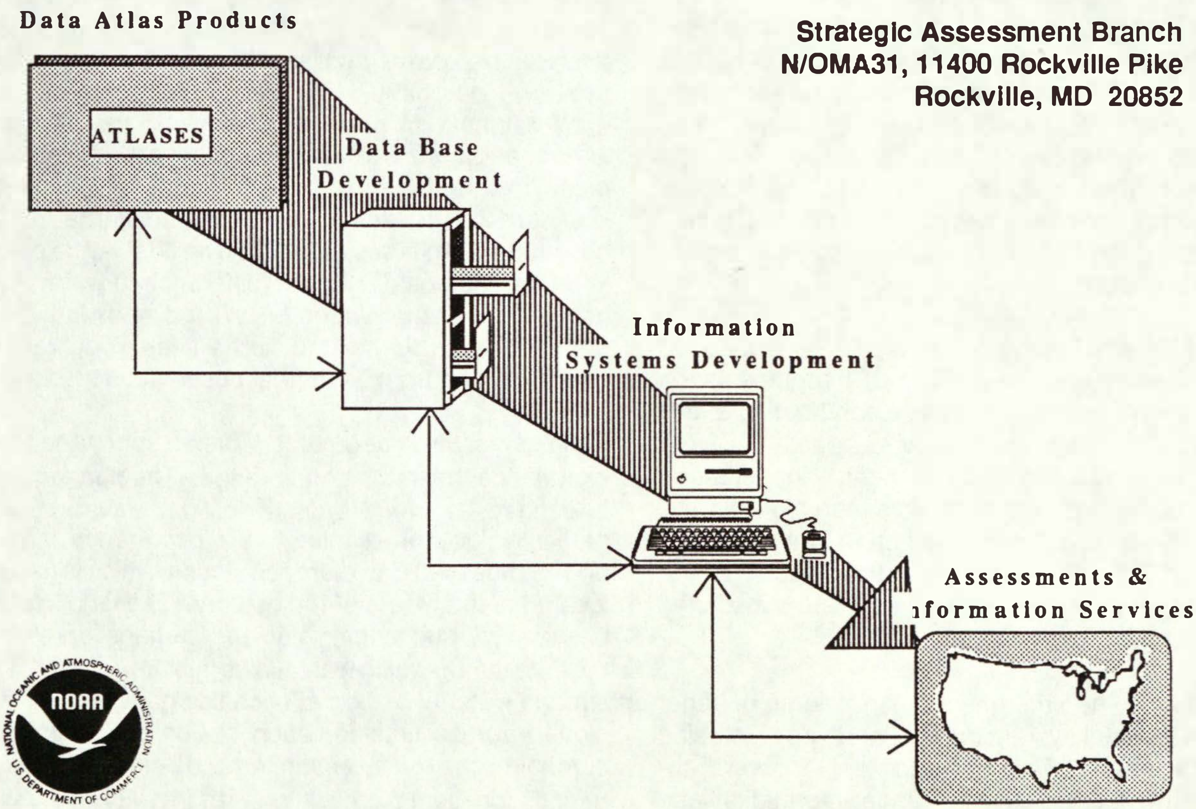
Additional Information on NOAA's National Estuarine Inventory is available from:

Strategic Assessment Branch
N/OMA31, 11400 Rockville Pike
Rockville, MD 20852



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Estuary Summaries

•Breton/Chandeleur Sounds
•Misssissippi River
•Barataria Bays
•Terrebonne/ Timbalier Bays

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Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service

Drainage Areas (sq. mi.)

Estuarine Drainage Area	1,357
Fluvial Drainage Area	1,129,800
Total Drainage Area	1,131,157

Dimensions

Length (mi.)		248.0
Average Depth (ft)		26.2
Width (mi.)	Average	0.5
	Minimum	0.4
	Maximum	0.8
Average Depth to Width Ratio (unitless)		0.00992

	Avg. Depth (ft)	Area (sq. mi.)	Volume (cu. ft)
Tidal Fresh	60.4	76.4	1.28×10^{11}
Mixing	17.6	523.6	2.57×10^{11}
Seawater	-	0.0	-
Total	-	600.0	3.86×10^{11}

Freshwater Inflow (1000 cfs)

Period of Record	1934- 1984
Long Term Average Daily Discharge	464.4

Long Term Average Monthly Discharge:

Jan	483.9	Jul	406.5
Feb	585.3	Aug	278.7
Mar	700.5	Sep	223.4
Apr	781.3	Oct	231.3
May	707.7	Nov	261.8
Jun	546.4	Dec	378.0

7 Day, 10 Year Low Flow	131.9
50 Year Flood	2026.5
100 Year Flood	2129.9

Flow Ratios	Average Annual	1.950
	3 - Month High Flow Period	3.065
	3 - Month Low Flow Period	1.003

Freshwater Retention Time (days)	4.4

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; EDA, estuarine drainage area; FDA, fluvial drainage area; ND, No data

The Mississippi River estuary discharges by far more freshwater than any other system. Its fluvial drainage area is also the largest. The highly variable mixing/ freshwater salinity boundary is 45 miles upstream of Head of Passes. The river is leveed, and it's flow is managed through outlet canals and channels

Tides

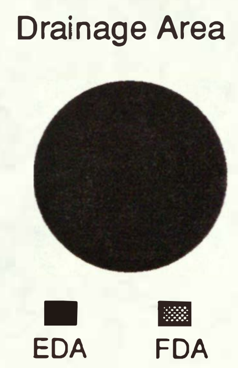
Prevailing Tide	Diurnal
Tidal Prism Volume (cu. ft.)	1.88×10^{10}

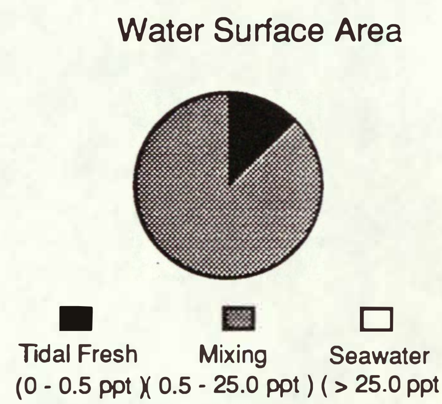
Tide Ranges (ft)

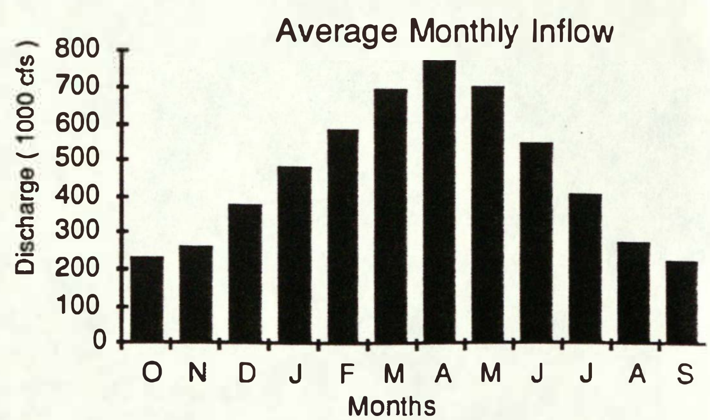
Station	Gauge Number	Range
A	3717	0.9
B	3709	1.2
C	3715	1.3

Stratification

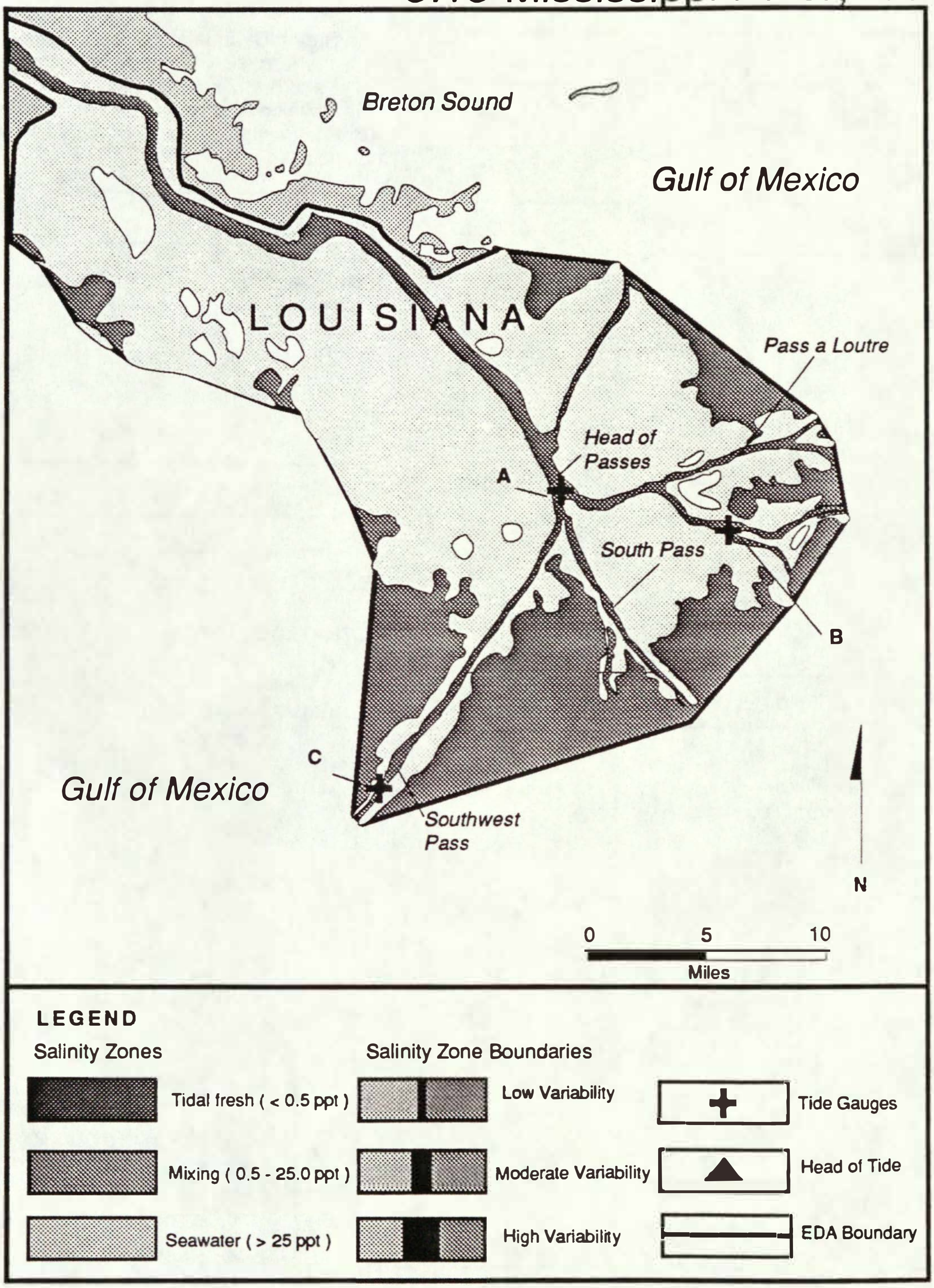
3- Month High Flow Classification	HS
3- Month Low Flow Classification	HS







3.13 Mississippi River, LA



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Drainage Areas (sq. mi.)

Estuarine Drainage Area	2537
Fluvial Drainage Area	0
Total Drainage Area	2537

Dimensions

Length (mi.)		60.0
Average Depth		8.1
Width (mi.)	Average	28.0
	Minimum	9.0
	Maximum	65.0
Average Depth to Width Ratio (unitless)		0.00005

	Avg. Depth (ft)	Area (sq. mi.)	Volume (cu. ft)
Tidal Fresh	-	0.0	-
Mixing	4.3	1087.1	1.30×10^{11}
Seawater	10.4	998.9	2.90×10^{11}
Total	-	2086.0	4.20×10^{11}

Freshwater Inflow (1000 cfs)

Period of Record	1961-1988
Long Term Average Daily Discharge	10.3

Long Term Average Monthly Discharge:

Jan	10.7	Jul	12.5
Feb	13.1	Aug	12.5
Mar	10.0	Sep	11.6
Apr	8.8	Oct	6.4
May	9.1	Nov	8.3
Jun	9.9	Dec	10.9

7 Day, 10 Year Low Flow	ND
50 Year Flood	ND
100 Year Flood	ND

Flow Ratios	Average Annual	1.08×10^{-7}
	3 - Month High Flow Period	1.93×10^{-7}
	3 - Month Low Flow Period	6.11×10^{-8}

Freshwater Retention Time (days)	83

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; EDA, estuarine drainage area; FDA, fluvial drainage area; ND, No Data

The Breton/Chandeleur Sounds Estuary is among the systems with the largest water area. It is bordered by the Mississippi River and the Mississippi Sound. The inflow data for this table was developed through the Thornthwaite Water budget. The extreme flow statistics have not yet been developed, and thus not included in the table.

Tides

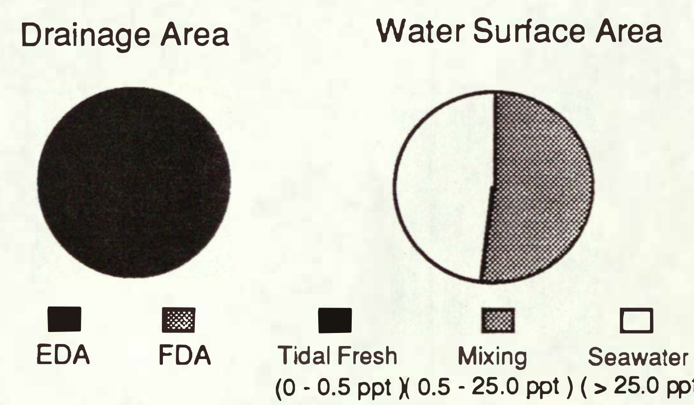
Prevailing Tide	Diurnal
Tidal Prism Volume (cu. ft.)	6.11×10^{10}

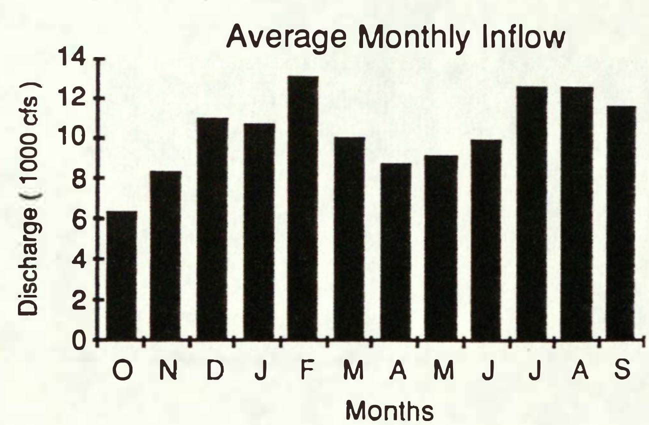
Tide Ranges (ft)

Station	Gauge Number	Range
A	3697	1.2
B	3701	1.3

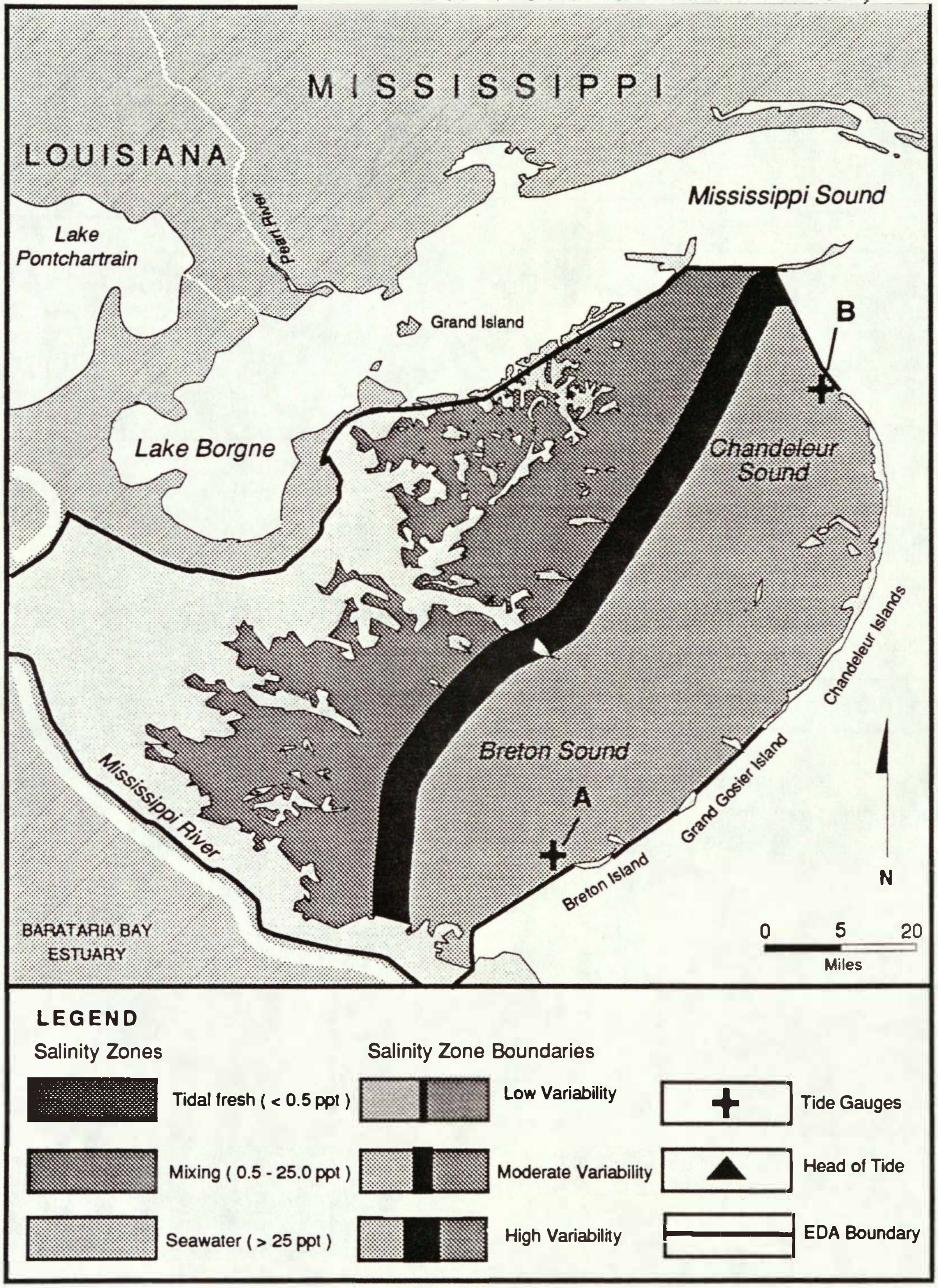
Stratification

3- Month High Flow Classification	VH
3- Month Low Flow Classification	VH





3.24 Breton/ Chandeleur Sounds, LA



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Drainage Areas (sq. mi.)

Estuarine Drainage Area	2191
Fluvial Drainage Area	0
Total Drainage Area	2191

Dimensions

Length (mi.)		60.0
Average Depth		4.8
Width (mi.)	Average	8.0
	Minimum	0.4
	Maximum	19.3
Average Depth to Width Ratio (unitless)		0.00011

	Avg. Depth (ft)	Area (sq. mi.)	Volume (cu. ft)
Tidal Fresh	6.5	158.4	2.87×10^{10}
Mixing	4.2	431.9	5.06×10^{10}
Seawater	3.7	55.7	5.75×10^{9}
Total	-	646.0	9.04×10^{10}

Freshwater Inflow (1000 cfs)

Period of Record	1961-1988
Long Term Average Daily Discharge	5.5
Long Term Average Monthly Discharge:	

Jan	8.5	Jul	4.0
Feb	10.4	Aug	4.5
Mar	6.8	Sep	4.7
Apr	5.2	Oct	2.8
May	3.9	Nov	4.3
Jun	3.7	Dec	7.7

7 Day, 10 Year Low Flow	ND
50 Year Flood	ND
100 Year Flood	ND

Flow Ratios	Average Annual	7.1×10^{-7}
	3 - Month High Flow Period	8.5×10^{-7}
	3 - Month Low Flow Period	5.9×10^{-7}

Freshwater Retention Time (days)	102

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; EDA, estuarine drainage area; FDA, fluvial drainage area; ND, No Data

The Barataria Bay estuary is highly influenced by the discharge of the Mississippi River. The inflow statistics were developed with the Thornthwaite Water budget. The extreme flow statistics have not yet been developed, and thus not included in the table

Tides

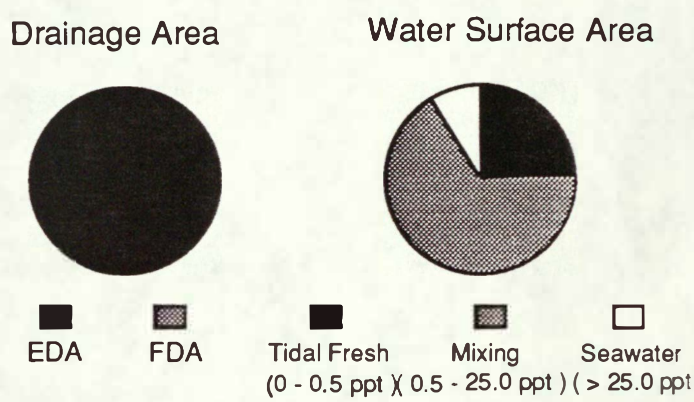
Prevailing Tide	Diurnal
Tidal Prism Volume (cu. ft.)	1.85×10^{10}

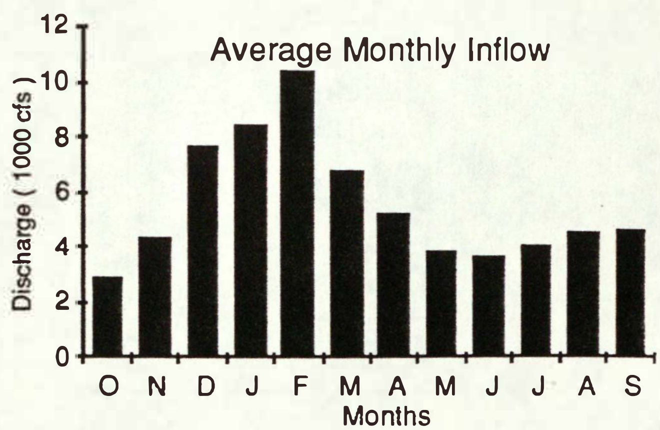
Tide Ranges (ft)

Station	Gauge Number	Range
A	3731	1.0
B	3735	1.0

Stratification

3- Month High Flow Classification	VH
3- Month Low Flow Classification	VH





3.25 Barataria Bay, LA

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Drainage Areas (sq. mi.)

Estuarine Drainage Area	1578
Fluvial Drainage Area	0
Total Drainage Area	1578

Dimensions

Length (mi.)		50.0
Average Depth (ft)		6.0
Width (mi.)	Average	23.0
	Minimum	0.5
	Maximum	34.5
Average Depth to Width Ratio (unitless)		0.00005

	Avg. Depth (ft)	Area (sq. mi.)	Volume (cu. ft)
Tidal Fresh	4.4	20.0	2.45×10^9
Mixing	4.9	514.0	7.02×10^{10}
Seawater	9.1	146.0	3.70×10^9
Total	-	680.0	1.10×10^{11}

Freshwater Inflow (1000 cfs)

Period of Record	1961- 1988
Long Term Average Daily Discharge	4.6

Long Term Average Monthly Discharge:

Jan	6.3	Jul	4.2
Feb	7.6	Aug	4.4
Mar	5.2	Sep	4.4
Apr	4.2	Oct	2.5
May	3.5	Nov	3.6
Jun	3.6	Dec	5.9

7 Day, 10 Year Low Flow	ND
50 Year Flood	ND
100 Year Flood	ND

Flow Ratios	Average Annual	2.5×10^{-7}
	3 - Month High Flow Period	3.2×10^{-7}
	3 - Month Low Flow Period	2.0×10^{-7}

Freshwater Retention Time (days)	80

Abbreviations: cfs, cubic feet per second; cu. ft, cubic feet; sq. mi., square miles; VH, vertically homogeneous; MS, moderately stratified; HS, highly stratified; NA, not applicable; EDA, estuarine drainage area; FDA, fluvial drainage area; ND, No Data

The Terrebonne/Timbalier Bays Estuary is bounded on the east by Bayou Lafourche and Caillou Bay on the west. The freshwater inflow data was developed through the Thornthwaite Water Budget. The Extreme flow statistics have not yet been developed, and thus were not included in the table

Tides

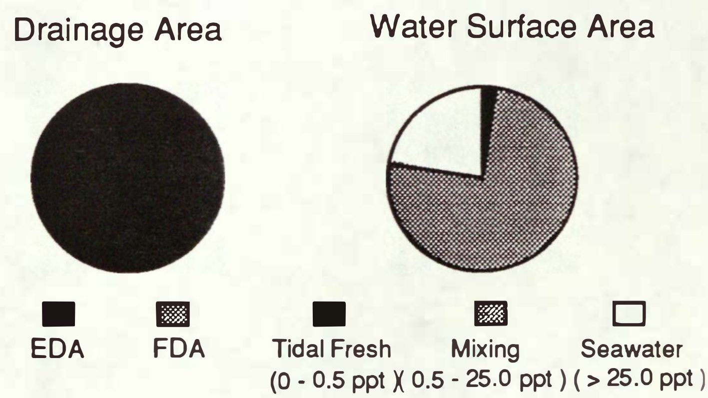
Prevailing Tide	Diurnal
Tidal Prism Volume (cu. ft.)	2.65×10^{10}

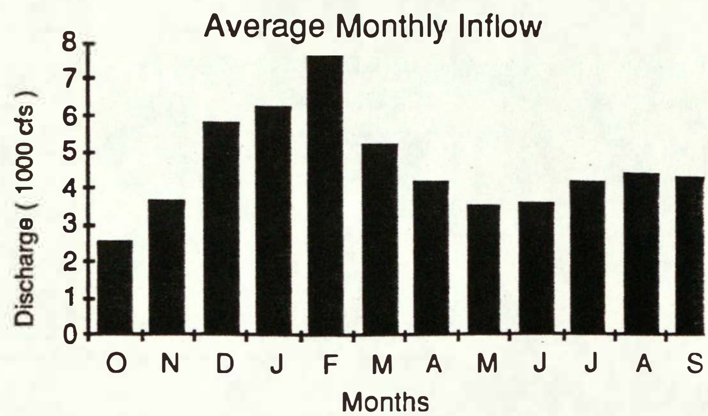
Tide Ranges (ft)

Station	Gauge Number	Range
A	3747	1.7
B	3745	1.4
C	3739	1.2

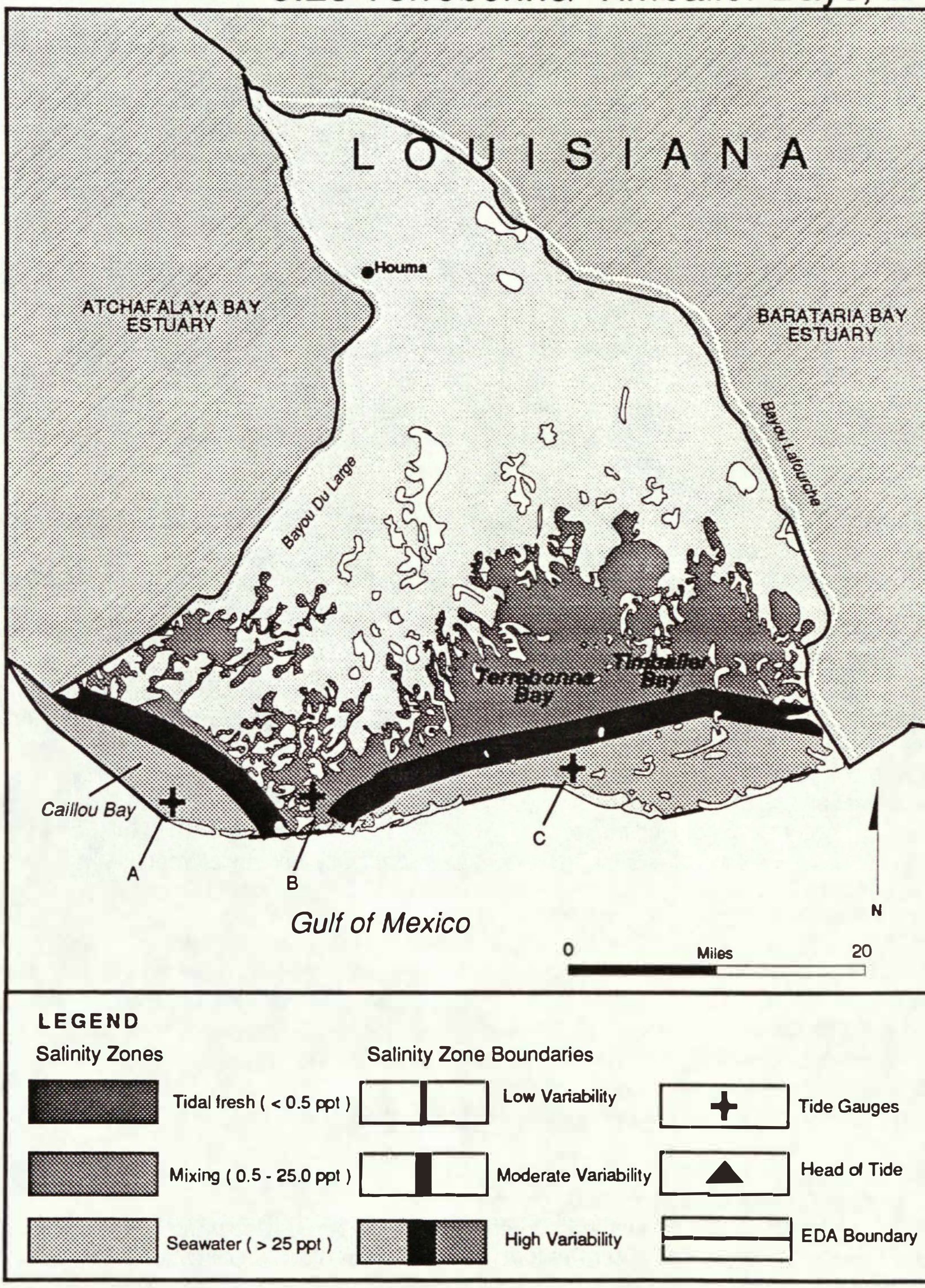
Stratification

3- Month High Flow Classification	VH
3- Month Low Flow Classification	VH





3.26 Terrebonne/ Timbalier Bays, LA



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References

Bahr Jr, Leonard M., et. al. September 1983. "Ecological Characterization of the Mississippi Deltaic Plain Region: A narrative with Management Recommendations". U.S. Fish and Wildlife Service - Mineral Management Service, U.S. Department of Interior, Publ. No.: FWS/OBS - 82/69.

Boesch, Don. Personal Communication. L.U.M.C.O.N.. Cocodrie, LA.

Bureau of Land Management, Fish and Wildlife Service. May 1980. "Mississippi Deltaic Plain Region Ecological Characterization: A Habitat Mapping Study". U.S. Department of the Interior, FWS/OBS - 79/07.

Carlson, D.D., et al. "Water Resource Data, Louisiana Water Year 1985". U.S. Geologic Survey Water Data Report LA - 85 - 1.

Gagliano, S.M., and R.A. Muller, and P. Light. "Water Balance in Louisiana Estuaries". Center for Wetlands Resources , LSU, Baton Rouge.

Jarrett, J.T.. 1976. "Tidal Prism: Inlet Area Relationships". GITI Report 3. Vicksburg, MS: U.S. Army Corps of Engineers.

Ketchum, B.H. . 1955. " Distribution of Coliform Bacteria and other Pollutants in tidal Estuaries". *Sewage Indust. Wastes*, 27, 1288-1296.

Louisiana Department of Wildlife and Fisheries - Seafood Division. April 1978 "A Study of Louisiana's Major Estuaries and Adjacent Offshore Waters". Technical Bulletin No. 27.

Louisiana Office of State Climatology. "Water Budget Components Calculated by the Thornthwaite Water Budget Method". Southwest Climate Division. Computer Printout.

McHugh G.F. ."Development of a Two Dimensional Hydrodynamic Numerical Model for use in a Shallow Well - Mixed Estuary". Center for Wetlands Resources - LSU, Sea Grant Publication number: LSU - T - 76 - 008.

McIntire, Williams G., et al. November 1975. " A Rationale for Determining Louisiana's Coastal Zone". Report Number 1, Coastal Zone Management Series. Center for Wetland Resources - LSU.

Muller, Robert A.. June 20 1975. "Freshwater Potential in the Louisiana Coastal Marshes and Estuaries". *Geoscience and Man* vol. XII Coastal Resources, p 1-7.

Muller, Robert A., and P.B. Larimore; "Water Balance Atlas of Louisiana", Publ. Climatology.

Murrey S.P. .June 1976 "Currents and Circulation in the Coastal Waters of Louisiana". Center For Wetland Resources, LSU, Baton Rouge LA, Sea Grant Publication No. LSU - T - 76 - 003.

National Ocean Service. Nautical Charts of Louisiana and Mississippi. National Oceanic and Atmospheric Administration.

National Ocean Service. "1986 Tide Tables-East Coast of North and South America". National Oceanic and Atmospheric Administration, Department of Commerce.

Strategic Assessment Branch. Nov. 1985 "National Estuarine Inventory Data Atlas vol.1, Physical and Hydrologic Characteristics". Rockville Maryland, National Oceanic and Atmospheric Administration.

Swenson, Eric. Personal Communication. Louisiana State University, Baton Rouge, LA.

Turner, Gene. Personal Communication. Louisiana State University, Baton Rouge, LA.

U.S. Army Corp of Engineers. Mississippi River Commission Maps.

U.S. Geologic Survey. Hydrodata Compact Disc database.

U.S. Geologic Survey. 71/2 minute Topographic sheets.

NEI Estuarine Reports & Publications

1. Data Atlas Vol. 1 - Physical and Hydrologic Characteristics; Nov. 1985.

2. 1985 National Shellfish Register of Classified Estuarine Waters; Dec. 1985.

3. An Inventory of Coastal Wetlands of the U.S.A.; Jan. 1986.

4. Coastal Wetlands: Establishing a National Data Base; Nov. 1986.

5. The National Coastal Pollutant Discharge Inventory - Estimates for Long Island Sound; Dec. 1986.

6. National Estuarine Inventory: Classified Shellfish Growing Waters by Estuary; Dec. 1986.

7. Data Atlas, Vol. 2 - Land Use Characteristics; Jan. 1987.

8. Land Use and the Nation's Estuaries; Mar. 1987.

9. The Quality of Shellfish Growing Waters in the Gulf of Mexico; Jan. 1988.

10. Shoreline Modification, Dredged Channels, and Dredged Material Disposal Areas in the Nation's Estuaries; Feb. 1988.

11. How Representative are the Estuaries Nominated for EPA's National Estuary Program?; Mar. 1988.

12. Estuarine Living Marine Resources Project - Washington State Component; May 1988.

13. The National Coastal Pollutant Discharge Inventory - Estimates for San Francisco Bay; Jun. 1988.

14. The National Coastal Pollutant Discharge Inventory - Estimates for Santa Monica Bay, San Pedro Bay, and San Diego Bay; Jul. 1988.

15. Strategic Assessment of Near Coastal Waters (Northeast Case Study) -Susceptibility and Status of Northeastern Estuaries to Nutrient Discharges; Jul. 1988.

16. The National Coastal Pollutant Discharge Inventory - Estimates for Columbia River; Aug. 1988.

17. The National Coastal Pollutant Discharge Inventory - Estimates for Puget Sound; Aug. 1988.

18. The Distribution and Areal Extent of Coastal Wetlands in Estuaries of the Gulf of Mexico; Nov. 1988.

19. (NEI: Supplement 1) Physical and Hydrologic Characteristics - The Oregon Estuaries; Nov. 1988.

20. Data Atlas, Vol. 4 - Public Recreation Facilities in Coastal Areas; Dec. 1988.

21. Data Atlas, Vol. 3 - Coastal Wetlands: New England Region; Jan. 1989.

22. The National Coastal Pollutant Discharge Inventory - Agricultural Pesticide Use in Estuarine Drainage Areas: A Preliminary Summary for Selected Pesticides; Jan. 1989.

23. (NEI Supplement 2) Characterization of Salinity and Temperature for Mobile Bay; Mar. 1989.

24. (NEI Supplement 3) Physical and Hydrologic Characteristics - The Mississippi Delta System Estuaries; Mar. 1989.

25. The Quality of Shellfish Growing Waters on the East Coast of the United States; Mar. 1989.