CHAPTER TWO

Galveston Bay: An Overview

...the Bay exists at some remove from the daily lives of most Houstonians. Because it lacks the constant proximity and the visual splendor of a San Francisco Bay or a Puget Sound, it is easy to ignore. Its soil characteristics and land formation, combined with massive upstream erosion, produce water that bears a close resemblance to café au lait. Its flat and untimbered shorelines lack dramatic views and escarpments. Consequently, the casual visitor is not likely to leave his heart in Galveston Bay or even consider it, on visual evidence alone, a resource worth saving.

–James Noel Smith, *The Decline of Galveston Bay*, 1972

(Texas Bays) are a magnificent resource, shallow and brackish and marshy-bordered and rich with life .... The flat land runs to the flat bays, and beyond the flat sand islands is the blue flat Gulf, but it is dramatic enough for all that, because of the life that is there. Some of my own youngest outdoor memories are going out at dawn with one of my hunting and fishing uncles to anchor on an oyster reef in Aransas Bay and cast into the swarms of speckled trout.... that were slashing at shrimp and bait fish. Nearly any memory of that coast has in it a sense of teeming life....

–John Graves, in *The Water Hustlers*, 1971

Galveston Bay is full of surprises. While on the surface it may not look impressive, it is teeming with life despite steadily increasing pressures from human disturbances. It is large, complicated, productive, and a tremendous recreational, economic, and environmental asset to Texas and the nation.

WHAT IS AN ESTUARY?

Estuaries are unique waterbodies where fresh water from rivers, streams, and direct rainfall mixes with salt water from the sea. In Texas, estuaries are protected by barrier islands. Estuarine habitats include river deltas, emergent marshes, mud and sand flats, submerged seagrass beds, oyster reefs, and open bay bottoms–all of which occur in the Galveston Bay system. The abundance of nutrients and shelter provided in the estuary make the environment extremely productive biologically. Many finfish and shellfish species use the area as nursery habitat for their young. More than 90 percent of the commercially harvested seafood species in the Gulf of Mexico and its bay systems require estuarine environments like Galveston Bay for one or more of their life stages.

Galveston Bay is an ecosystem. An ecosystem is the total of all the living things and the non-living physical environment–and more importantly the relationships among these. The estuarine ecosystem includes the energy flow from green plants (such as planktonic algae) to higher consumers (such as bay anchovies, red drum, and humans). It includes the cycling of important compounds like the nutrients nitrogen and phosphorus (which are vital for life but can harm the system when over-abundant). Viewing the estuary as an ecosystem accounts for the fundamental connections of one component to another and reveals how inadvertent harm resulting from human activity affecting one component can inadvertently harm another.

THE VALUE OF GALVESTON BAY

Galveston Bay is valuable for many reasons (See Chapter Four). Any list of important uses of the bay would likely include the following:

- The bay is a great place to fish. Approximately one third of the state's commercial fishing income comes from the bay. Over half of the state's expenditures for recreational fishing are related to Galveston Bay.

- The bay is an important transportation artery. Measured by tons of materials transported, the Port of Houston is the third largest port in the country, sixth largest in the world. Many of the area's petrochemical and other industries rely on the Houston Ship Channel, Gulf Intracoastal Waterway, and other navigation channels for transportation.

Source: Galveston Bay National Estuary Program

Estuaries are among the most productive ecosystems in the world. The fertile mixture of fresh water from land runoff and salt water from the Gulf of Mexico supports an abundance of commercially and recreationally important fish and shellfish species. For example, the shrimp being harvested here spend their juvenile stages foraging in the productive marshes of the estuary.

The bay is the final recipient of treated wastewater from over 1400 industrial and municipal point source discharges. This amounts to about 60 percent of the wastewater discharged in Texas. It also receives non-point source pollutants in stormwater runoff from agricultural, urban, suburban, and rural lands in the watershed.

Galveston Bay provides important natural habitats for many species of particular environmental interest to Texans, such as colonial waterbirds, shorebirds, dolphins, sea turtles, alligators, and numerous other species.

Other uses of the bay include: cooling water, sailing, motorboat cruising, sightseeing, and oil and gas production.

Most important, perhaps, is the value of Galveston Bay as a general indicator of the health of the environment. Most people realize that the bay is an important regional ecosystem, and they have a keen interest in protecting and maintaining the productivity of the bay for future generations.

Even though the values and uses of the bay have long been recognized, fragmented management efforts in the past have been unable to address the system-wide problems that affect this complicated resource. Therefore, the Galveston Bay National Estuary Program was established in 1990 to establish management of Galveston Bay as an entire ecosystem. Although there was a general idea of what the problems were prior to the Galveston Bay National Estuary Program, there was still not enough information to develop a detailed management plan that would solve the problems. Neither was there any means to focus the attention of the various agencies, user groups and citizens on developing solutions to the bay's problems. To address these challenges, the Galveston Bay National Estuary Program adopted an ecosystem-based approach developed by the Environmental Protection Agency's National Estuary Program–an approach that has been applied to some other threatened estuaries across the country (TABLE 2.1).

The ecosystem-based approach relied on scientific *and* envi-

TABLE 2.1. Comparison of Estuaries in the National Estuary Program.

Project Location	Surface Area (sq mi)	Drainage Basin Area (sq mi)	Watershed Population	Priority Environmental Problems
Galveston Bay, TX	600	25,256	6,000,000	Habitat loss, urban runoff, sewage bypasses and overflows, potential inflow and circulatory modifications, toxic contamination of water and sediments, declining trends in certain species of birds and marine organisms.
Albemarle/Pamlico Sound, NC	2,900	30,880	1,898,000	Wetland losses, nutrient over-enrichment, fish disease, land use, fresh water flows, habitat loss.
Barataria-Terrebonne, LA	2,141	5,460	695,000	Hydrological modification, eutrophication, pathogen contamination of shellfish, changes in biological resources, habitat loss.
Buzzards Bay, MA	228	432	236,000	Pathogens, nitrogen loading, shoreline development, habitat loss, toxicants.
Casco Bay, ME	152	979	251,000	Toxicants, nutrient over-enrichment, pathogens, habitat loss.
Delaware Bay	768	475	6,000,000	Habitat loss, nonpoint source pollution, lack of public access, estuarine education, compliance.
Delaware Inland Bays	32	255	50,000	Habitat loss, eutrophication, land use, point/nonpoint pollutants.
Indian River Lagoon, FL	353	2,284	630,000	Nutrient over-enrichment, circulation, wetland loss, increased toxicants, pathogens and suspended sediments.
Long Island Sound CT/MA/NY/RI	1,281	16,000	8,400,000	Eutrophication, hypoxia, toxicants, pathogens, floatable debris, living resources.
Massachusetts Bays	2,000	2,900	4,000,000	Toxicants in water, sediments, fish and shellfish; pathogens; habitat loss and modification.
Narragansett Bay, RI/MA	146	1,677	1,800,000	Pollutants, pathogens, living resources management needs, habitat losses, sewer overflow.
New York / New Jersey Harbor	298	8,467	17,000,000	Urban runoff, contaminated sediments, shoreline development, pathogens.
Puget Sound, WA	931	16,000	3,000,000	Pollutants, loss of aquatic habitats, eutrophication, dredging.
San Francisco Bay/ Sacramento-San Joaquin Delta, CA	554	61,313	9,900,000	Decline of biological resources, altered fresh water flows, pollutants, dredging, land use.
Santa Monica Bay, CA	266	414	9,000,000	Contaminants in fish and sediments, marine habitat, swimmable waters, municipal effluent, urban runoff.
Sarasota Bay, FL	40	500	425,000	Nutrient over-enrichment, habitat loss, declines in living resources, population growth.
Tampa Bay, FL	398	2,300	2,100,000	Habitat loss and modification, altered fresh water inflow, natural flushing.

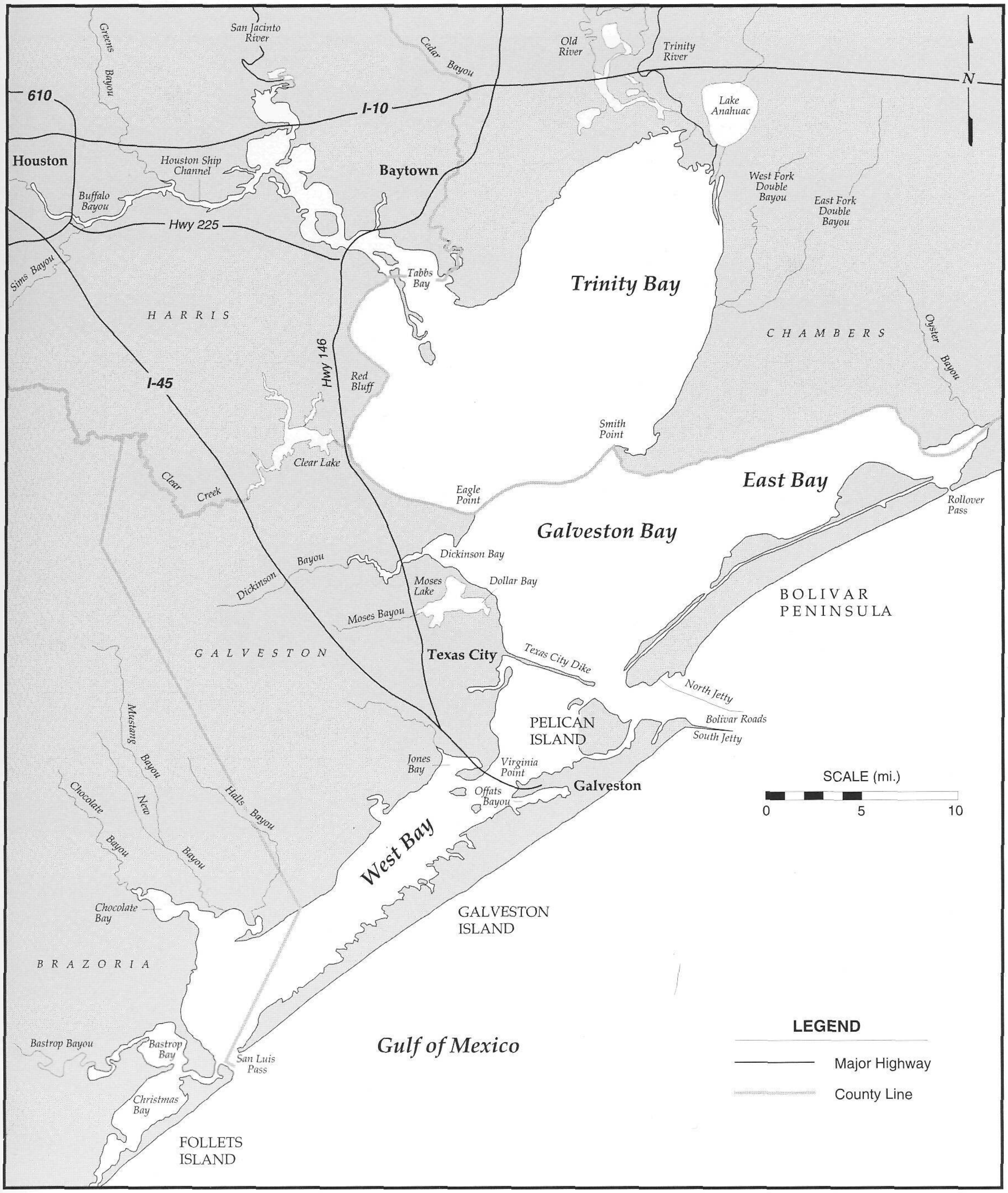
Source: National Estuary Program

Source: National Aeronautics and Space Administration

Galveston Bay as viewed from the Space Shuttle. The greater Houston area (upper left) dominates the regional population of more than three million people. In a closer view of the upper bay (inset) barge and ship traffic in the Houston Ship Channel and the worm-like trails of shrimp trawls are visible.

Source: National Aeronautics and Space Administration

ronmental management information. On the scientific side, the Galveston Bay National Estuary Program embarked on a four-year program of scientific studies that covered the bay's water quality, living resources, habitats, public uses, and many other topics. This book combines these recently completed Galveston Bay National Estuary Program studies with historical and recent scientific studies by others to describe the current state of Galveston Bay. On the management side (and not addressed in this book), the governance of Galveston Bay was scrutinized for its effectiveness in addressing



Source: Galveston Bay National Estuary Program

FIGURE 2.1. *Galveston Bay, encompassing some 600 sq mi of water area, is fed primarily by the Trinity River (upper right) and secondarily by the San Jacinto River (upper left).*

the emerging bay problems. Combining the scientific and management work, the Galveston Bay National Estuary Program undertook development of a comprehensive management plan for the bay, *The Galveston Bay Plan.*

GEOGRAPHY OF THE BAY AND WATERSHED

Galveston Bay

Galveston Bay is typically only six to 12 feet deep. The effects of wind dominate many physical processes, and biologically, extensive oyster reefs, marshes, and open water habitats predominate. The bay's 600 sq mi of surface area is commonly divided into four major sub-bays (FIGURE 2.1).

Galveston Bay receives the outflow of the San Jacinto River and much of the local drainage from the City of Houston via Buffalo Bayou and the Houston Ship Channel. *Trinity Bay* receives the outflow from the Trinity River, a large river system with a watershed that extends north to encompass the Dallas-Fort Worth region. The Trinity Basin contributes 54 percent of the inflow to Galveston Bay, compared to 28 percent for the San Jacinto Basin. *West Bay* is situated landward of Galveston Island,

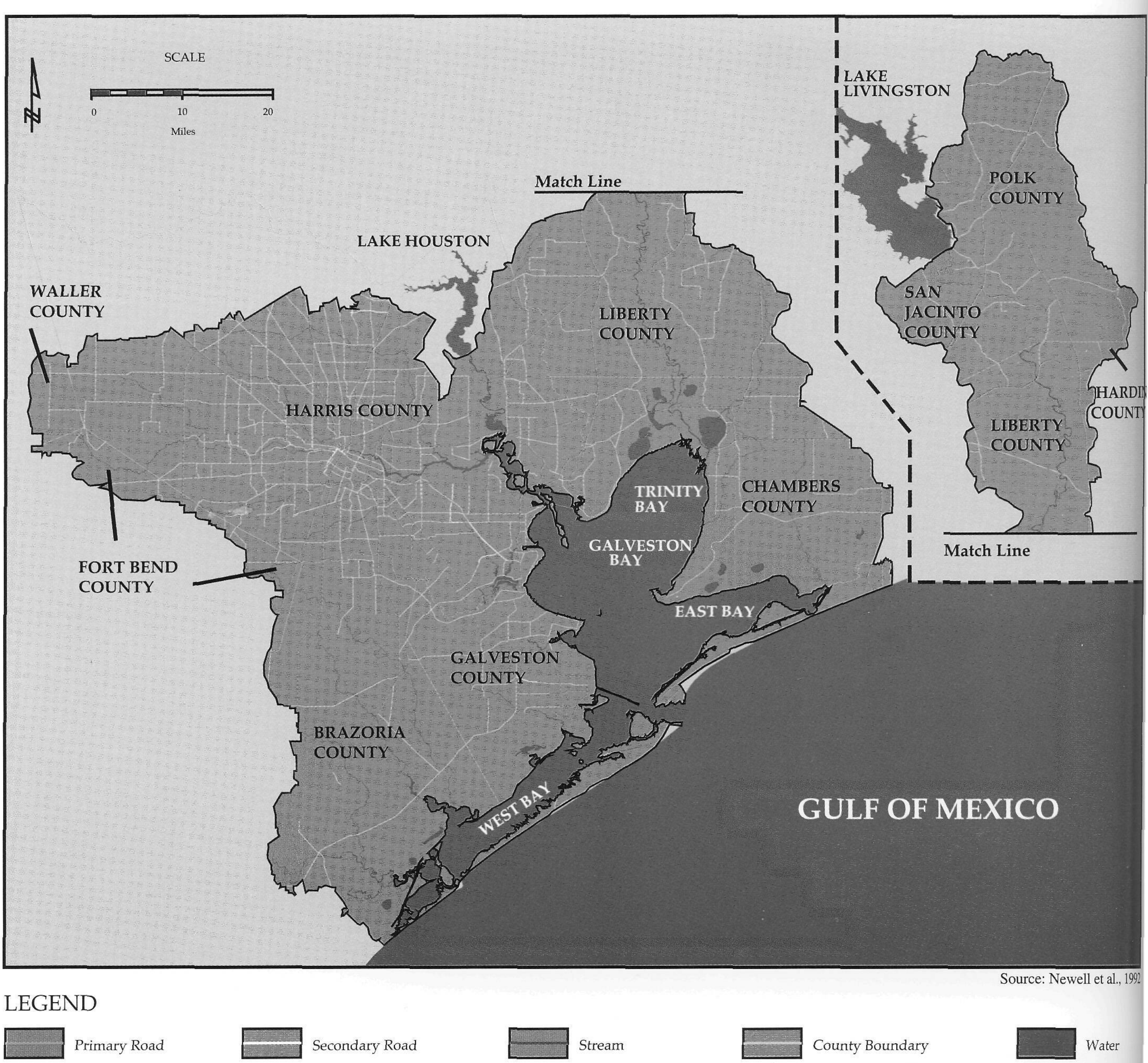
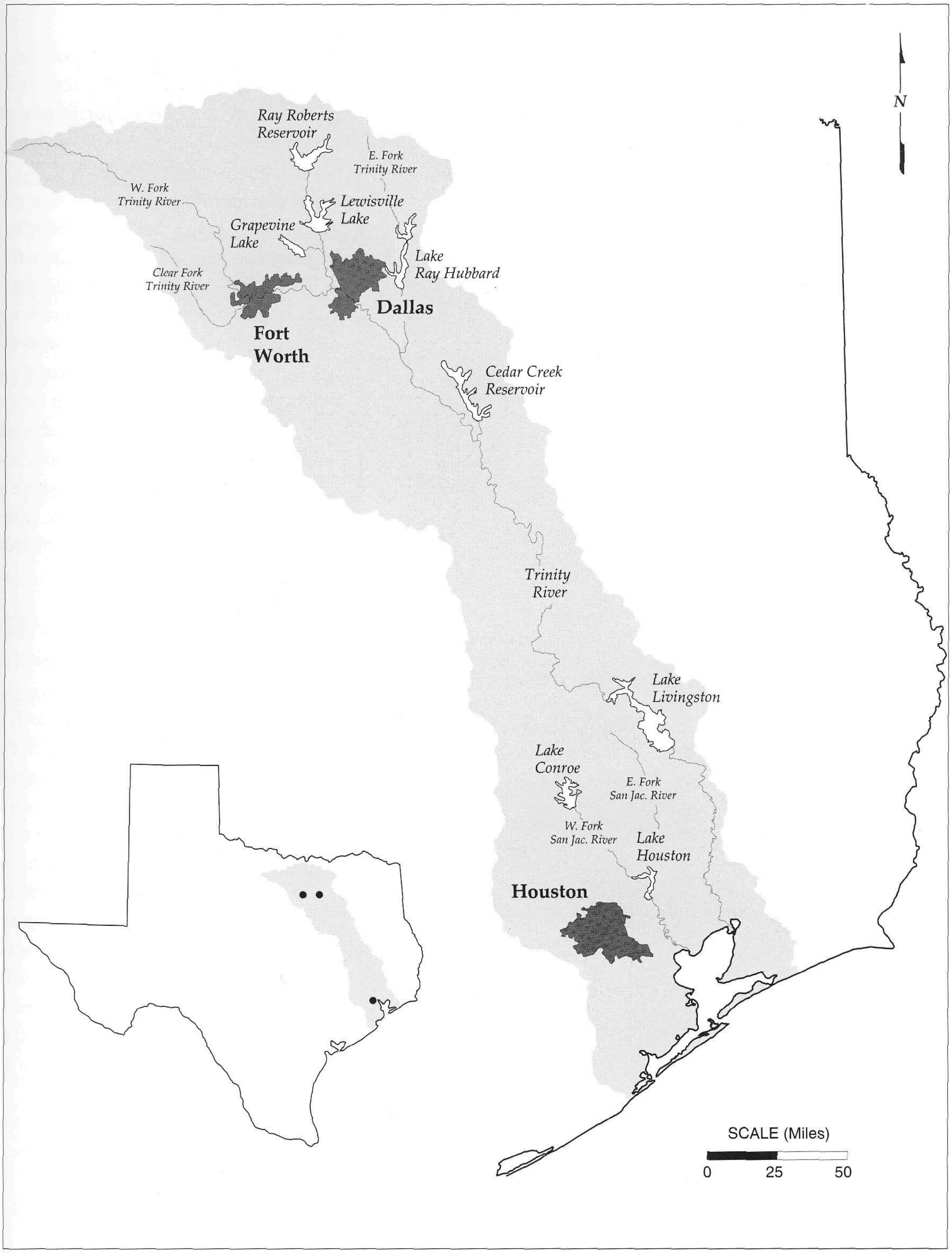


FIGURE 2.2. *The lower Galveston Bay watershed. This portion of the watershed, below lakes Houston and Livingston, defines the study area for most findings in this book. The reservoirs mediate upper watershed influences on the bay by trapping nutrients, sediment and pollutants. While Dallas and Fort Worth are within the watershed (see FIGURE 2.3) the most important human influences on Galveston Bay occur within the area depicted. Nonpoint sources of pollution are among the most important lower watershed influences. With each rainfall, runoff from this area carries fertilizers, pesticides, oil from roadways, and numerous other pollutants to the bay. Water quality, particularly in the western urbanized tributaries, suffers.*

and receives runoff from Chocolate and Mustang Bayous and other local streams. *East Bay* lies landward of Bolivar Peninsula and receives inflow from Oyster Bayou and other runoff from Chambers County. Christmas Bay and Bastrop Bay are two relatively undisturbed secondary bays in the far southwestern part of the estuary that are somewhat isolated from the rest of the estuary.

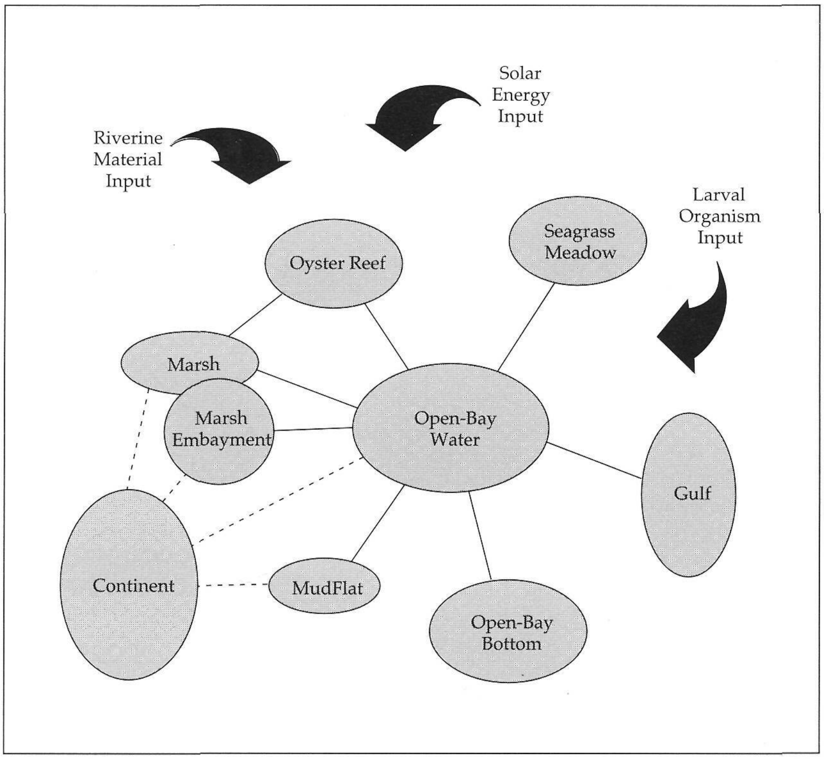
There are three tidal inlets to the bay, but only two are of major importance with regard to flow. Bolivar Roads (between Galveston Island and Bolivar Peninsula) accounts for over 80 percent of the tidal exchange between the bay and the Gulf of Mexico. As shown in FIGURE 2.1, both sides of Bolivar Roads have long jetties that were built to extend out into the Gulf and stabilize the inlet. San Luis Pass, between the western end of Galveston Island and Follets Island to the southwest, is a natural inlet that provides slightly less than 20 percent of the bay's tidal exchange but provides important access for commercial and recreational fishermen. Rollover Pass is a man-made cut through Bolivar Peninsula that provides minor tidal exchange between the Gulf and East Bay.



Source: Galveston Bay National Estuary Program

FIGURE 2.3. *The entire Galveston Bay watershed. At 33,066 sq mi, the watershed represents just 12.6 percent of Texas' surface area, but receives about 60 percent of the state's wastewater discharges.*

The total shoreline length of Galveston Bay is a difficult parameter to define. It is greatly dependent upon the scale of resolution employed; as the scale becomes finer, the measured shoreline length increases. For example, an estimate of 232 miles used by Paine and Morton (1991) to measure erodable shoreline along Galveston Bay varies significantly from the 743-mile figure used by Orlando et al. (1988). The latter measurement includes such features as small boat basins, service canals, and other forms of modified shoreline that substantially expand the measurable length of the Bay shoreline. While the measurements vary considerably, each is valid in the context of its intended use.



Source: McFarlane, 1994

FIGURE 2.4. *A conceptual model of Galveston Bay, indicating the major habitats and their connections to the continent and the Gulf of Mexico. The complexity of the interactions among the various components of this natural system make management a challenge. This model is the basis of a detailed discussion in Chapter Three.*

The Lower Watershed

For the purpose of this book, the lower watershed is defined as the 4,238 sq mi area draining to the bay, downstream of two major impoundments: Lake Houston on the San Jacinto River, and Lake Livingston on the Trinity River (FIGURE 2.2). These two reservoirs provide some attenuation of runoff and pollutant loads, and therefore the lower watershed acts as a more direct contributor of runoff and runoff-borne pollutants to the bay than does the upper watershed.

The sprawling city of Houston with its associated urban communities occupies the western side of the bay, while the eastern side remains largely agricultural and undeveloped. Urban development becomes most important in its contribution of polluted rainfall runoff from parking lots, streets, highways, roofs, and yards (Newell et al., 1992), while the eastern shore remains largely grassland, marshes and rice fields, with the potential to contribute nonpoint sources of herbicides and pesticides.

The Upper Watersheds

Galveston Bay has two large "upper watersheds," consisting of 2,828 sq mi upstream of Lake Houston and 26,000 sq mi upstream of Lake Livingston. The Trinity River extends north past the Dallas-Fort Worth metroplex (FIGURE 2.3) with tributaries that flow through numerous man-made reservoirs in the upper watershed in addition to Lake Livingston on the main stem to the south. Land uses within the watershed include forested and wetland areas along the Trinity River Bottom; intense agricultural in many parts of the watershed; urban areas; and dry rangeland in the far northwestern part of the drainage area. The San Jacinto River is mostly forested upstream of Lake Houston, with some urbanization in its lower drainage area. The entire watershed lies within Texas, a fact that simplifies management planning.

Source: Galveston Bay National Estuary Program

Humans have dramatically altered Galveston Bay. The Houston Ship Channel, shown here, is a 51-mile cut dredged to 40 feet deep. This feature has altered circulation and salinity patterns in this otherwise shallow (eight to ten foot deep) system. The vessels shown here have just engaged in a maneuver known as "Texas Chicken," in which the vessels approach head on, then veer apart at the last minute. The resulting hydrostatic forces provide a "cushion" of water between the two vessels and the side-slopes of the channel, allowing the vessels to pass without running aground. This maneuver has occurred an estimated 40,000 times in the last five years. Also visible on each side of the channel are wakes washing over the berms parallel to the channel, caused by open-water disposal of dredged material.

THE BAY AS AN INTERRELATED SYSTEM OF PROCESSES

The maps presented in this chapter show where different parts of the bay are located, but do not indicate how the bay functions. FIGURE 2.4 diagrams the different habitats that comprise the Galveston Bay estuary and various external influ-

Valued Ecosystem Components

Sources of Perturbation	Water Quality	Circulation	Sediment	Phytoplankton	Zooplankton	Oysters	Shellfish	Other Benthos	Finfish	Birds	Marine Mammals	Sea Turtles	Human Health	Wetlands	Submerged Plants	Shoreline	Aesthetic Appeal
Northers		••		?	?	•			••	•							
Hurricanes		••	•	?	?	•	•	••		•			?	?	•••	•••	
Inflow Modification	•••	•••	•	?	?	••••	•••	•••	••			?		•••	••		
Subsidence/Sea Level		••				•	••		•	•				••••	•••	••••	
Shoreline Development	••	•	•	•			••		••	••				••••	••	••••	•••
Dredging	•••	••••	••••	?		••	•	••	••	•••	?	?	?	•••	••	•••	••
Shipping	••		•								?			••		••	
Point Sources	••••		••••	•••	••	•••	••	••	••	••	?	?	••••	•	••		••
Non-Point Sources	••••		••••	•••	?	•••	••	••	••	••	?	?	•••	••	••		••
Commercial Fishing	?		?			••	••••	?	•••		?	?			••		
Recreational Fishing						•	•		•••					?	•		
Boating/Marinas	•••		•••	?	?			••	•					•	•	•	?
Petroleum Activity	•••		•••	?	?	•	••	••	•	•	?	?	•	••	•		?
Oil/Chemical Spills	•••		•••	?	?	••	?	?	?	••	?	?	••	•••	?		•••
Marine Debris									?	•	•	••					•••

• = Slight influence ••• = Significant influence ? = Unknown relationship
•• = Moderate influence •••• = Major influence (shaded) = Possible management priority

Source: Galveston Bay National Estuary Program

Figure 2.5. Matrix of environmental impacts to Galveston Bay. Valued elements of the estuary (across the top) are influenced by both natural and human perturbations (down the left side). Some of the influences highlight potential management needs. The matrix was constructed as a consensus of expert opinion among participants of the Galveston Bay National Estuary Program.

ences on these habitats (McFarlane, 1994). Example habitats include open-bay water and marshland, while examples of the external inputs are solar energy and river inflow.

The bay system is in a constant state of change, responding to many short and long-term natural forces. For example, the bay responds to changes in tide and runoff (short-term), seasonal changes in light and temperature (medium-term), and other changes such as the slow, naturally-occurring rise in sea level (long-term).

Of course, man often dramatically influences the bay, either by influencing the natural pattern of bay inputs, or by disrupting its habitats. Changes in inputs include discharging pollutants into the bay or altering the natural patterns in fresh water inflow. Conversion of marshland to other land uses is an example of how human activities can alter some of the bay's most critical habitats.

Consequences of Human Activities in and Around the Bay

The major problems facing Galveston Bay have been defined using various approaches. By examining existing scientific data, involving experts, and talking with bay users, important cause-and-effect relationships were identified. Some of the cause-and-effects were similar to those found in other bays around the county. Others appeared to be unique to Gulf Coast situations or the Galveston Bay system.

One outcome of the problem-defining process was creation of the *Environmental Impact Matrix* shown in FIGURE 2.5. The matrix presents a consensus view of the effects of different perturbations (natural and man-made disturbances) on various ecosystem resources and processes (labeled "valued ecosystem components"). The circles indicate the degree of influence and the shaded areas denote possible management issues. For example, nonpoint source pollution was considered a major influence on water quality to an extent suggesting management actions. On the other hand, recreational fishing has only a slight influence on oysters, a relationship not suggesting that conservation efforts be undertaken.

The matrix points out that Galveston Bay is a complex sys-

Source: National Aeronautics and Space Administration

This high-altitude photograph of lower Galveston Bay during ebb tide reveals many human alterations affecting estuarine processes such as circulation. The Texas City Dike (extending from the west shore on the left) forces currents to converge and exit the bay via Bolivar Roads. Before dike construction on 1915, substantial water would have flowed through West Bay (lower left). The strong currents between the jetties has led to formation of "Big Reef" adjacent to the south (lower) jetty and a deep scour hole at the base of the north jetty. Extending up the center of the bay, the Houston Ship Channel is clearly visible as a line of dark water. Heavy salt water from the gulf of Mexico enters the bay via a "density current" up the 40 ft deep channel, as fresher bay water moves seaward in the shallow areas to the sides of the channel. The wavy pattern on the edge of the Ship Channel near the Texas City Dike (see inset), results from "Kelvin-Helmholtz billows" that indicate current shear resulting from the density current. The lighter areas adjacent the the Channel, from which plumes of turbid water are emanating, are open-bay disposal areas for dredged material. A discussion of these and other human modifications to Galveston Bay appears in Chapter Five, Physical Form and Processes.

TABLE 2.2. Technical Characterization Projects on Galveston Bay.

Project Title	Conducted By
Point Source Loading Study	*University of Texas at Austin*
Shoreline Survey for Unpermitted Point Sources	*Texas A&M University, GERG*
Nonpoint Source Loading Study	*Groundwater Services, Inc.*
Treated/Untreated Effluent Loadings	*Texas Natural Resource Conservation Commission*
Ambient Water/Sediment Quality	*University of Texas at Austin*
Dredge/Fill Impacts	*University of Texas at Austin*
Toxicants in Sediment and Benthos	*U. S. Fish and Wildlife Service*
Oyster Survey	*Texas A&M University*
Living Resources Status and Trends	*Texas Parks and Wildlife Department*
Trawling By-Catch	*National Marine Fisheries Service*
Recreational By-Catch	*FTN Associates, LTD*
Non-Fishing Incidental Mortality	*Jones and Neuse, Inc.*
Wetland Habitat Survey	*Bureau of Economic Geology*
Ecosystem Conceptual Model	*McFarlane & Associates*
Bay Debris Survey	*Texas Parks and Wildlife Department*
Toxicants in Seafood Organisms	*Texas A&M University, GERG*
Public Health Synopsis	*Espey, Huston & Associates*
Regional Monitoring/Data Management	*Tetra Tech, Inc.*
Regional Monitoring Methods Standardization	*Tetra Tech, Inc.*
Data Base Inventory	*University of Texas at Austin*
Galveston Bay Information Center	*Texas A&M University at Galveston, TIO*
Galveston Bay Bibliography	*Texas A&M University at Galveston, TIO*
Acquisition of 1930 Aerial Photo Set	*TOBIN Research, Inc.*
Natural Resource Economics	*University of North Carolina*
Segmentation of Galveston Bay	*Jones and Neuse, Inc.*
History of Resource Utilization	*Margaret Henson*
Socioeconomics of Bay Utilization	*University of Houston–Clear Lake*
Environmental Inventory of Armand Bayou	*Galveston Bay Foundation*
Environmental Inventory of Christmas Bay	*Galveston Bay Foundation*

Source: Galveston Bay National Estuary Program

tem affected by numerous human activities and natural processes. The process of developing the matrix focused attention on several key cause-and-effect relationships, such as:

The impacts of sea level rise, shoreline modification, and dredging on important habitats such as wetlands and submerged aquatic vegetation;

The effect of runoff (nonpoint sources), wastewater discharges (point sources), marinas, petroleum production, transportation, and refining on water and sediment quality;

The response of aquatic organisms and birds living in and around the bay to a wide variety of man-made and natural perturbations.

The matrix stimulated and helped to guide efforts to learn more about these cause-and-effect relationships and determine the overall status and trends of the major components that make up the Galveston Bay ecosystem.

Galveston Bay National Estuary Program Characterization Studies

Guided by the early problems identification, the Galveston Bay National Estuary Program then commissioned a series of characterization studies. These projects were designed to fill knowledge gaps about key problems and management issues. During the period 1990 to 1993, over 25 different studies were undertaken, ranging from measuring unwanted by-catch from shrimping to investigating the effects of toxic contaminants on sediment and bottom-dwelling organisms (TABLE 2.2). These studies form the primary basis for findings presented in this book.

FOR MORE INFORMATION

Fisher, W. L., J. H. McGowen, L. F. Brown, Jr., and C. G. Groat. 1972. Environmental Geologic Atlas of the Texas Coastal Zone–Beaumont-Port Arthur Area. University of Texas at Austin, Bureau of Economic Geology. Austin, Texas.

Jensen, R., R. W. Kiesling, and F. S. Shipley, eds. 1993. Proceedings, the Second State of the Bay Symposium. Feb. 4-6, 1993. Galveston Bay National Estuary Program Publication GBNEP-23. Webster, Texas.

National Oceanic and Atmospheric Administration. 1989. Galveston Bay: Issues, Resources, Status and Management. NOAA Estuary-of-the-Month Seminar Series No. 13. Washington, D. C.

Shipley, F. S., and R. W. Kiesling, eds. 1991. Proceedings. Galveston Bay Characterization Workshop, February 1991. Galveston Bay National Estuary Program Publication GBNEP-6. Webster, Texas.

Stanley, D. W. 1992. Historical Trends. Water Quality and Fisheries. Galveston Bay. University of North Carolina Sea Grant College Program Publication UNC-SG-92-03. Institute for Coastal and Marine Resources, East Carolina University. Greenville, North Carolina.

REFERENCES

Boyle, R. H., R. H. Graves, and T. H. Watkins, eds. 1971. The Water Hustlers. Sierra Club. San Francisco, CA.

McFarlane, R. W. 1994. A Conceptual Model of Galveston Bay. Galveston Bay National Estuary Program Publication GBNEP-42. Webster, Texas.

Newell, C. J., H. S. Rifai, and P. B. Bedient. 1992. Characterization of Nonpoint Sources and Loadings to Galveston Bay. Volume I, Technical Report. Galveston Bay National Estuary Program Publication GBNEP-15. Webster, Texas.

Orlando, P., F. Shirzad, J. Schuerholz, P. Mathieux, and S. Strassner. 1988. Shoreline Modification, Dredged Materials, and Dredged Material Disposal Areas in the Nation's Estuaries. Unpublished draft report. Strategic Assessment Branch, National Ocean Service, National Oceanic and Atmospheric Administration. Rockville, Maryland.

Paine, J. G., and R. A. Morton. 1991. Historical Shoreline Changes in the Galveston Bay System. Pp. 165-167, *in* Proceedings. Galveston Bay Characterization Workshop, February 21-23, 1991, (Shipley, F. S. and R. W. Kiesling, eds.), Galveston Bay National Estuary Program Publication GBNEP-6. Webster, Texas.

Smith, J. N. 1972. The Decline of Galveston Bay. A Profile of Government's Failure to Control Pollution in an Endangered American Estuary. The Conservation Foundation. Washington, D. C.