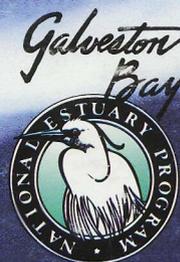


The State

A CHARACTERIZATION
OF THE GALVESTON BAY
ECOSYSTEM

of the Bay



The State of the Bay

A CHARACTERIZATION OF THE GALVESTON BAY ECOSYSTEM

A Publication of
The Galveston Bay National Estuary Program

Edited by

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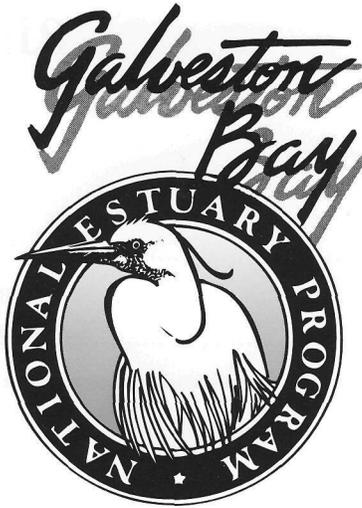
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Contents

Preface.....	xi
Acknowledgements	xiii
A Note to the Reader.....	xv

CHAPTER ONE • On Knowing the State of the Bay	1
Boundaries to Guide Scientists and Resource Managers.....	1
Unexpected Findings	2
<i>Salinity</i>	2
<i>Nutrients</i>	2
<i>Wildlife, Fish and Shellfish</i>	3
<i>Toxicants</i>	4
A Revision of Management Expectations.....	4
<i>Seventeen Priorities</i>	4
References.....	12

CHAPTER TWO • Galveston Bay: An Overview.....	13
What is an Estuary?	13
The Value of Galveston Bay	13
Geography of the Bay and Watershed.....	17
<i>Galveston Bay</i>	17
<i>The Lower Watershed</i>	20
<i>The Upper Watersheds</i>	20
The Bay as an Interrelated System of Processes.....	20
<i>Consequences of Human Activities in and Around the Bay</i>	21
<i>Galveston Bay National Estuary Program Characterization Studies</i>	23
For More Information	24
References.....	24

CHAPTER THREE • An Ecosystem Conceptual Model.....	25
Overview of the Ecosystem	25
<i>The Estuary as an Ecosystem</i>	26
Components of the Estuarine Ecosystem.....	27
<i>Open-Bay Water</i>	28
<i>Open-Bay Bottom</i>	28
<i>Oyster Reef</i>	30
<i>Seagrass Meadow</i>	31

<i>Marsh</i>	31
<i>Intertidal Mud Flat</i>	33
<i>Secondary and Tertiary “Lakes”</i>	33
Interconnectedness of the Ecosystem	34
<i>Riverine/Floodplain Dynamics</i>	35
<i>The Influence of Human Activities</i>	36
Summary	37
For More Information	38
References.....	38

CHAPTER FOUR • The Human Role, Past and Present	39
Changes in Bay Use: An Historical Perspective	39
<i>The Houston Ship Channel and Other Navigation Channels</i>	41
<i>Petroleum and Petrochemical Industries</i>	43
<i>The Growth of the Houston Metropolitan Region</i>	44
Current Uses of the Bay	45
<i>Current Population</i>	45
<i>Land Use</i>	49
<i>Economic Activity</i>	51
<i>Commercial Fishing and Oystering</i>	52
<i>Shipping</i>	53
<i>Oil and Gas Production</i>	54
<i>Shell Dredging</i>	54
<i>Recreational Uses</i>	55
<i>Agriculture</i>	59
<i>Water Use</i>	60
<i>Discharge of Treated Wastewater</i>	62
<i>Other Uses: Real Estate Development</i>	63
Summary	64
For More Information	65
References.....	65

CHAPTER FIVE • Physical Form and Processes	67
Origin of Galveston Bay	67
<i>Geologic History</i>	67
<i>Contemporary Natural Processes</i>	68
The Nature of the Watershed	69
<i>Regional Climate</i>	69
<i>The Upper Watershed</i>	71
<i>The Lower Watershed</i>	73
The Bay-Watershed Link: Fresh Water Inflow	75
<i>Fresh Water Inflow Patterns</i>	75
<i>Human Alterations</i>	76

Circulation.....	79
<i>The Influence of Bathymetry</i>	79
<i>Bay Sediments</i>	80
<i>Oyster Reefs</i>	80
<i>Wind Forces</i>	81
<i>Tidal Forces</i>	81
<i>Effects on Salinity</i>	84
<i>Variability Related to Inflow and Intrusion</i>	84
Human Alterations	85
<i>Nineteenth Century Navigation Projects</i>	85
<i>Twentieth Century Projects</i>	86
<i>Dredging and Disposal of Dredged Material</i>	86
<i>Influences on Circulation</i>	89
<i>Subsidence</i>	90
<i>Other Modifications</i>	90
Summary	92
For More Information	93
References.....	93

CHAPTER SIX • Water and Sediment Quality: Status and Trends95

Review of Water and Sediment Quality Parameters	96
<i>Types of Pollutants</i>	96
<i>Key Water Quality Indicators</i>	97
<i>Relationships Among Parameters</i>	98
Water Quality Segments and Bay Monitoring Programs.....	99
Water Quality	100
<i>Water Quality Status and Trends</i>	102
<i>Violations of State Standards and Federal Criteria</i>	109
<i>Discussion</i>	110
Sediment Quality	111
<i>Sediment Quality Status and Trends</i>	111
<i>Sediment Toxicity</i>	112
<i>Contaminant Potential of Dredged Material</i>	115
Human Impacts: Point Source Discharges.....	116
<i>Permitted Discharges</i>	116
<i>Bypasses and Overflows</i>	118
<i>Fecal Coliform Bacteria</i>	118
<i>Unpermitted or Illegal Discharges</i>	119
<i>Produced Waters</i>	119
Human Impacts: Nonpoint Sources and Loadings.....	121
<i>Overview of Nonpoint Sources</i>	121
<i>Pollutant Loadings from Runoff</i>	122
<i>Marina/Boater Impacts</i>	126

Pollutant Loading to Galveston Bay: a Synthesis.....	128
<i>Relative Contributions from Five Sources</i>	128
<i>Other Pollutant Sources</i>	131
<i>Patterns at the Ecosystem Level</i>	132
Summary	134
For More Information	136
References.....	136
<hr/>	
CHAPTER SEVEN • Wetlands and Reefs: Two Key Habitats	139
Wetlands.....	139
<i>The Origin and Importance of Wetlands</i>	139
<i>General Classification</i>	140
<i>The Need to Determine Wetland Status and Trends</i>	143
<i>Distribution of Wetland Communities</i>	143
<i>Wetlands Loss Over Time</i>	143
<i>Causes of Wetlands Loss</i>	144
Oyster Reefs.....	149
<i>Reef Distribution and Trends</i>	149
<i>Large-Scale Impacts to Oyster Habitat</i>	151
Summary	153
For More Information	154
References.....	154
<hr/>	
CHAPTER EIGHT • The Bay's Living Resources	155
The Estuarine Food Web.....	156
<i>Primary Production</i>	157
<i>Indicator Species</i>	158
Phytoplankton	158
<i>Types of Phytoplankton in Galveston Bay</i>	159
<i>Production Rates</i>	159
<i>Trends in Space and Time</i>	159
Zooplankton	161
Benthic Organisms.....	162
<i>Open Bay Benthos</i>	162
<i>Marsh Benthos</i>	164
<i>Man-Made Perturbations to Benthos</i>	164
Oysters	165
<i>Physical Factors</i>	166
<i>Biological Factors</i>	166
<i>Trends in Space and Time</i>	167
<i>Vitality of Reefs</i>	167
Finfish, Shrimp, and Crab Populations	167
<i>Methodology and Data</i>	168

<i>Selected Species Summaries</i>	169
<i>Probable Causes of Fish and Shellfish Declines</i>	178
Birds.....	182
<i>Colonial Waterbirds</i>	184
<i>Waterfowl</i>	185
<i>Shorebirds</i>	185
<i>Threatened or Endangered Bird Species</i>	185
Amphibians and Reptiles	186
Mammals.....	186
Summary	187
For More Information	188
References.....	188

CHAPTER NINE • Public Health	191
Pathogens	191
<i>Indicator Organisms</i>	191
<i>Contact Recreation</i>	193
<i>Non-Contact Recreation</i>	194
<i>Shellfish Bed Closures</i>	195
Toxicants in Seafood Organisms.....	199
<i>PAHs–Polynuclear Aromatic Hydrocarbons</i>	199
<i>Chlorinated Hydrocarbons</i>	200
<i>Dioxin and Furans</i>	200
<i>Trace Metals</i>	201
Human Health Risks Associated With Seafood Consumption	202
<i>Seafood Advisories</i>	202
<i>The Galveston Bay National Estuary Program/ Texas A&M Seafood Study</i>	203
Summary	206
For More Information	208
References.....	208

EPILOGUE • The Future of Comprehensive Management	209
For More Information	211

Glossary	213
Index	221

Preface

Galveston Bay is a resource of immense value to Texas and the nation. It is also an exceedingly interesting coastal ecosystem. In this volume, produced by the Galveston Bay National Estuary Program, these two features highlight a comprehensive review of the State of the Bay—an overview of the ecosystem from an environmental management perspective.

Our purpose in undertaking this ambitious task was clear: we sought to establish a factual basis for improving the way we govern Galveston Bay. This book is about stewardship, providing information that is one step removed from the hands-on management of bay resources, but which nevertheless is absolutely vital for effective conservation in the long run. Specifically, we sought to understand the State of the Bay in order to draft *The Galveston Bay Plan*, a comprehensive blueprint for bay governance. In this role, this book may well help determine the State of the Bay twenty, or even fifty years hence.

The work leading to completion of this book has a significant history. In 1987, the United States Congress designated Galveston Bay as an Estuary of National Significance in its passage of the Water Quality Act of 1987. Along with other nationally significant bay systems on all three coasts, Galveston Bay was recognized for its premier values to man—economic, biological, and cultural. Through this legislation, Galveston Bay entered the National Estuary Program (NEP), a focused attempt to remedy the pressing problems affecting bays besieged by human pollution, development, and overuse.

Based on lessons learned from Chesapeake Bay in the mid-1980s, the National Estuary Program prescribed reliable science as the basis for comprehensive bay management. For Galveston Bay, this process began with the support of an ad hoc consortium of university, agency, and private sector scientists interested in Galveston Bay. Leaders of this consortium presented a seminar in Washington, D.C. on March 14, 1988, to key federal agencies and legislators. They described the physical, biological, and economic significance of the bay and produced a seminal report which identified critical bay issues and associated information needs (*Galveston Bay: Issues, Resources, Status, and Management*, number 13 in the National Oceanic and Atmospheric Administration Estuary-of-the-Month series, 1989).

Shortly thereafter, a Scientific/Technical Advisory Committee (STAC) was appointed by the Governor and Environmental Protection Agency Regional Administrator as part of the Galveston Bay NEP Management Conference, a consortium that would develop *The Galveston Bay Plan*. The STAC would provide scientific and technical guidance to the Management Conference by identifying estuarine problems and by overseeing studies to establish the trends and probable causes necessary for management action (a list of these projects is given on page 23). The STAC began their work in March, 1989 and convened symposia in 1991 and 1993 (both of which resulted in published proceedings). The culmination of the Committee's work is this volume.

The work undertaken by the STAC from 1989 through 1994 has been the most ambitious yet attempted for Galveston Bay on an ecosystem scale. In commencing this work, some guiding principles were agreed upon, establishing a clear focus for projects, and preventing the distraction of research proposals on peripheral issues. These principles were:

Projects would address an understanding of estuarine problems agreed upon by the entire Management Conference (reflecting a consensus among all the varied participants with interests in the bay);

The focus would be on analysis of existing data, with new data collected only to fill identified data gaps; and

Projects would be completed in time for use in creating *The Galveston Bay Plan*. Pure research questions and long-term investigations, while recognized as important, would not be funded.

When this work began in earnest, the high level of commitment to Galveston Bay on the part of the scientists involved produced a level of effort far out of proportion to the available time and money. The efforts of STAC members and many of the project principal investigators and reviewers frequently exceeded the call of duty. Additional zeal was sparked by the synergism of simultaneously addressing different research questions in a collaborative ecosystem context.

Much work was accomplished by university scientists, and some projects were contracted to private consultants. But throughout the process, state and federal natural resource agencies played a key role. These agencies employ numerous highly committed scientists and resource managers engaged in projects with a bearing on Galveston Bay. For example, the existing two-dimensional (length and breadth) hydrodynamic models were believed inadequate to address the potential impacts which might result from deepening and widening of navigation channels. A three-dimensional (length, breadth, and depth) model has been developed by the U.S. Army Corps of Engineers and their Waterways Experiment Station, with a budget that exceeds the total Galveston Bay National Estuary Program program budget. Similarly, the determination of fresh water inflow needs of the bay relied on the development and implementation of a Texas Water Development Board model.

Some questions were necessarily addressed with use of cursory surveys rather than full-scale studies. For example, the Texas Department of Health has been hampered for years by inadequate

funding to determine the accumulation of toxic substances by seafood organisms. Although the public identified this issue as a priority problem, high analytical costs have placed constraints on this type of work. A full-scale detailed survey, while perhaps justified, would have consumed the entire Galveston Bay National Estuary Program scientific budget.

In describing the State of the Bay, we have attempted to simplify and summarize this wealth of new understanding. You will find conclusions which differ from "conventional wisdom" and prior opinions. The effects of early human interventions, some more than a century old, clearly emerge. Such projects as the Texas City Dike, the navigation channels, and petroleum and groundwater extraction, have fundamentally altered the ecosystem. Throughout the presentation, we have sought to guide the interested reader to publications that can amplify what is presented here.

Above all, the difficulty of managing Galveston Bay as a self-sustaining ecosystem clearly emerges. We have discovered that the most compelling problems afflicting Galveston Bay are truly ecosystem problems, not limited to individual natural resources, nor circumscribed by political boundaries. In solving these problems, decades of traditional, narrowly focused management practices will be difficult to overcome—the governance of the bay remains a tangled mosaic of narrow and fragmented jurisdictions and public policies. Now, however, our appreciation of the myriad connections between human activities and bay components is greatly enhanced. Each action, however great or small, has produced an effect elsewhere. It is truly impossible to do merely one thing in an ecosystem; our challenge is to establish stewardship that mirrors this fundamental truth.

—Robert W. McFarlane
Frank S. Shipley

January, 1994

Acknowledgements

ENDORSEMENT OF THE SCIENTIFIC/TECHNICAL ADVISORY COMMITTEE

This volume is the culmination of five years' effort by the Scientific/Technical Advisory Committee of the Galveston Bay National Estuary Program. Its purpose is to improve future management of Galveston Bay by acquiring the most complete scientific and technical understanding possible. On November 4, 1993 the Scientific/Technical Advisory Committee approved the contents of this document by unanimous consent, forwarding their findings to the Management Committee. On November 17, 1993, the Management Committee ratified the work of the Scientific/Technical Advisory Committee, also by unanimous consent. Finally, in January, 1994, the Policy Committee granted final approval for publication and approved the distribution of this work to the citizens of the Galveston Bay region, Texas and the Nation.

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Many individuals also helped us complete this project. The overwhelming complexity of the Galveston Bay ecosystem required that we adopt a multi-disciplinary approach to draw from such diverse fields as engineering, biology, physics, economics, ecology, and chemistry. When we sought to involve some of the foremost practitioners in these disciplines in the work of advancing our knowledge of the State of the Bay, we received an exceedingly positive response. Only a collaborative approach could possibly have produced this work, and it is with a great sense of accomplishment that we thank our many contributors.

Our help came in phases as the work progressed. First, more than two dozen specific studies of the estuary were commissioned, most of which were major collaborative projects in themselves. The authors of these special studies drafted reports published in the Galveston Bay National Estuary Program publication series (these reports are cited throughout the work). Their efforts frequently (but not always) exceeded the expectations of reviewers and the level of funding provided. In many instances, wording from these authors has been directly adopted by the contributing authors of this work. Principal project investigators, and others who contributed substantially to our efforts to characterize Galveston Bay, include:

Neal Armstrong, Richard Allison, Phil Bedient, Clyde Bohmfalk, James Brooks, Scott Carr, Roger Durand, Bill Evans, Robert McFarlane, Roger Fay, Al Green, Tom Greib, Galveston Bay Foundation, George Guillen, Dick Gorini, Larry Handly, Margaret Henson, Cindy Howard, Paul Jensen, Robert Nailon, James Nance, Charles Newell, Eduardo Martinez, Anita Morgan, Dennis Palafox, Victor Palma, Cathy Palmer, James Pateck, Eric Powell, Hanadi Rifai, R. Will Roach, Gary Saul, Edward Seidensticker, Priscilla Seymour, Mark Shibata, Annie Walton, George Ward, E. G. Wermund, Natalie Wiest, Dale Whittington, Nancy Worst.

Initial drafts by the contributing authors of this volume were assembled with ongoing help from the staffs of Groundwater Services, Incorporated (particularly for creation of the figures), the Rice University Department of Environmental Science and Engineering, and the Galveston Bay National Estuary Program. Most chapters were then submitted to a team consisting of several to numerous reviewers, led by a "Designated Reviewer" conscripted by the Scientific/Technical Advisory Committee. Designated Reviewers were responsible for the complex task of compiling review comments and determining the acceptability of revisions.

The expertise of the Designated Reviewers in the estuarine disciplines, and the sheer time and effort devoted to the review process provided valuable improvements to the developing work. The Designated Reviewers were:

Chapter Four	Glenda Callaway;
Chapter Five	E. G. Wermund;
Chapter Six	George Guillen;
Chapter Seven	Will Roach;
Chapter Eight	Al Green;
Chapter Nine	Kirk Wiles.

The peer-reviewed chapters were then reassembled and the compiled draft work was distributed to members of the Scientific/Technical Advisory Committee and other committees of the Galveston Bay National Estuary Program, and to staff members of several state and federal resource agencies involved in the work. At this point, the draft document was fair game to approximately one hundred and twenty individuals, many of whom took up the torch to suggest substantial additional improvements. In alphabetical order (and with varying levels of torch-bearing), these were:

DeGraaf Adams, Bob Bass, Teresa Battenfield, Lynn Benefield, Linda Broach, Dick Brown, Dave Buzan, Glenda Callaway, Tom Calnan, Jim Davenport, Ernst Davis, Marty Entringer, Ed Feith, Theo Glanton, George Guillen, David Hankla, Margaret Henson, Mike Hightower, Herbert Hudson, Bill Jackson, Alan Jones, Jim Kachtick, Richard Kiesling, Russell W. Kiesling, B.D. King, Ken Kirkpatrick, Tommy Knowles, Larry Land, Fred Liscum, William Longley, Robert W. McFarlane, Larry McEachron, Carl Masterson, Eduardo Martinez, Rick Medina, Tom Minello, Don Moore, Gary Powell, Warren Pulich, Walt Precourt, Don Reynolds, Tom Remaley, Will Roach, Peter Rubec, Eddie Seidensticker, Willie Scalero, Pete Sheridan, Rubin Solis, Bob Spain, Steve Spencer, Jack Steele, Steve Smith, Arthur Talley, Windle Taylor, Kenneth Teague, Richard Thompson, Lial Tischler, Steve Twidwell, George Ward, E. G. Wermund, Bill White, Terry Whitledge.

Finally, the entire text was edited, re-drafting many sections to incorporate review suggestions and additional information. At this point, photographs were obtained from various sources and archived at Imáge Realize, Inc. (noted throughout the text) to illustrate various points. Design and layout were accomplished by Anne Darrah and Calzone and Associates to yield a seamless and appealing final product. Pre-press and printing were done in Houston, Texas by Imáge Realize, Inc. and Lee Printing.

These, then, are the individuals who have helped define the State of the Bay, circa 1994. We thank this spirited group of contributors, one and all.

—Frank S. Shipley
Russell W. Kiesling

A Note to the Reader

This book is organized in three sections: an overall summary of findings and their implications (Chapter One); an introduction to Galveston Bay, its watershed, and its uses (Chapters Two, Three, and Four); and specific discussions of key aspects of the ecosystem (Chapters Five through Nine).

Chapter One encapsulates bay management issues in the form of seventeen key conclusions. These conclusions are of central importance to *The Galveston Bay Plan*, a comprehensive conservation and management plan drafted by the Galveston Bay National Estuary Program to guide future stewardship of this estuary. Chapter One, in this sense, can stand alone as a summary for managers and policy makers.

Chapters Two, Three and Four introduce the reader to Galveston Bay itself, providing a context for presentation of specific technical findings in the remainder of the book. Chapter Two provides a generalized overview of the estuary and its watershed, and an introduction to the effects of human activities. Chapter Three describes the “interconnectedness” of the various components of the estuary: a conceptual model is used to show how various bay habitats compose the functioning estuarine ecosystem. Chapter Four provides a brief history of the bay from pre-settlement to the present, emphasizing contemporary diverse uses and values associated with its resources.

The remainder of the book is a more detailed and technical presentation of specific subject areas. Chapter Five describes the physical form and processes of the bay and its watershed. Here the emphasis is on fresh water inflow and physical factors like wind and tides, which influence hydrology and circulation. Human alterations, particularly to enhance navigation, have profoundly affected some of these physical processes, which underlie many biological functions and affect the fate and effects of pollutants.

Water and sediment quality issues are presented in Chapter Six. A review of water quality parameter definitions is followed by a summary of water and sediment quality status and trends. The role of point sources of pollution (“end of the pipe”) and nonpoint sources (transported as rainfall runoff) in determining overall environmental quality are addressed. A synthesis of this information highlights the relative importance of different sources of pollution—as they affect the bay as a whole, and for the upper Houston Ship Channel where the impacts are greatest.

Chapter Seven is devoted to wetlands and oyster reefs—key habitats which give rise to much of the abundant life in the bay, and which support important commercial seafood fisheries in both the bay and (in the case of wetlands) the larger Gulf of Mexico. Wetlands and oyster reefs also serve important natural roles in maintaining water quality. The changes in these critical habitats since the 1950s are identified with reference to the probable causes of trends, where causes are sufficiently known.

Chapter Eight describes status and trends for particular species of plankton, benthos (bottom-dwellers), shrimp, crabs, fish, birds, alligators, turtles, and dolphins. Galveston Bay teems with life, but declines in the populations of certain species pose management concerns. Living species not only support the economy and aesthetic values, they also serve as indicators of overall environmental health and life-support capability of the ecosystem.

Chapter Nine addresses the safety of eating Galveston Bay seafood and engaging in contact recreation in its waters. To the general public, these issues are frequently among the most important and controversial of all. Information is presented on bacterial contamination affecting oyster reef harvest closures, the concentrations of toxic compounds in seafood organisms, and the resulting levels of potential risk to consumers.

Finally, the Epilogue points toward the future of Galveston Bay. How can knowing “The State of the Bay” today help us determine its fate tomorrow and decades hence? Public policy makers and the larger

community of individuals, organizations, enterprises, and agencies which depend upon or interact with this remarkable section of Texas coast are called upon to take up the challenge for stewardship.

Throughout, this book uses several conventions aimed at augmenting its value to those interested in learning more about Galveston Bay. Selected technical terms are printed in boldface where they first appear and are defined in the glossary. At the con-

clusion of each chapter, additional reading is recommended under the heading "For More Information." Citations are given throughout the text, listed in the "References" section. However this book is not primary scientific literature, and does not use the same rigor for citations as technical journals. One of the values of this volume is its compilation of previously unpublished, sometimes obscure information. Reports which were either unpublished or published with limited distribution were frequently consulted.