DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

U.S. GEOLOGICAL SURVEY STUDIES OF LOUISIANA BARRIER ISLAND EROSION AND WETLAND LOSS: AN INTERIM REPORT OF STATUS AND RESULTS

by

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INTRODUCTION

Louisiana contains 25% of the vegetated wetlands and 40% of the tidal wetlands in the 48 conterminous states. These coastal wetland environments, which include associated bays and estuaries, support a harvest of renewable natural resources with values estimated to exceed $1 billion per year. Louisiana also has the greatest rates of wetland loss and coastal erosion. Eighty percent of the Nation's wetland loss has occurred in Louisiana. Several scientists[1] have estimated rates of wetland loss in the Mississippi River delta plain to be approximately 130 km^2/yr (50 mi^2/yr). Since 1956, more than 2,500 square kilometers (1,000 mi^2) of freshwater wetlands in Louisiana have been eroded or converted to other habitats. If these rates continue, nearly 1 million acres of wetlands will be lost in the next 50 years. In places, erosion of the barrier islands, which lie offshore of the estuaries and wetlands and separate and protect them from the open marine environment, exceeds 20 m/yr (65 ft/yr). Within the past 100 years, Louisiana's barrier islands have decreased in area by more than 40% and some islands have lost 90% of their area. Recent field surveys confirm that the barriers will continue to erode at rapid rates and some barriers will become submerged within 20 years. Disappearance of these barriers is likely to accelerate loss and deterioration of wetlands and back-barrier estuaries.

The physical processes causing wetland loss and barrier island erosion are complex, varied, and not well understood. There is much debate in the technical and academic community about which of the many contributing processes, both natural and human-induced, are the most significant. Furthermore, there is controversy surrounding some of the measures that are being proposed to alleviate wetland loss. Much of the debate deals with whether we can adequately predict the result of a given management, restoration, or erosion mitigation technique. By better understanding the processes of wetland loss, such predictions should improve, and a clearer consensus should appear on how to reduce and mitigate landloss.

The U.S. Geological Survey (USGS) currently has two ongoing studies dealing with coastal erosion and wetland loss in Louisiana. The first of these studies, the Louisiana Barrier Island Erosion Study, is a cooperative effort with the Louisiana Geological Survey (LGS) and was begun in Fiscal Year (FY) 1986. Currently, the study

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[1] Gagliano, S. M., Meyer-Arendt, K. J., and Wicker, K. M., 1981, Landloss in the Mississippi River deltaic plain: GCAGS, v. 31, p. 295-300.

is in the fourth year of a planned five-year effort. During FY 1988, Congress directed the USGS, in cooperation with the U.S. Fish and Wildlife Service (FWS), to develop a study plan extending our ongoing research to include processes causing deterioration of wetland environments. The plan resulted in the Louisiana Wetland Loss Study. Funds were appropriated to initiate the study in the latter part of FY 1988.

This is an interim report describing the role of the USGS research in mitigating erosion and landloss, and the status and results of the two studies. Because the report is designed for non-technical, as well as technical readers, the technical detail and references are limited. After discussing the USGS's role, each study is addressed in sequence, providing overviews of the objectives and briefly presenting progress and results to date. As part of the discussion, the content of final products that will be prepared at the conclusion of each study is included. A listing of reports and publications resulting from the studies to date is included at the end. Copies of the complete papers are available from the authors.

ROLE OF USGS RESEARCH IN COASTAL EROSION AND LANDLOSS MITIGATION

The two Louisiana studies focus on developing a better understanding of the processes causing coastal erosion and landloss and deterioration of Louisiana's barrier islands and wetland environments. By better understanding these processes, our ability to predict erosion and wetland loss should improve. Better predictions in turn will allow proper management of our coastal resources, such as setting new construction a safe distance landward from an eroding shoreline. Improved predictions will also allow better assessments of the utility of different mitigation schemes. For instance, a better understanding of the processes forcing sediment and freshwater dispersal over wetlands will lead to assessments of the practicality and usefulness of large-scale fresh water sediment diversions from the Mississippi River. Understanding the processes responsible for barrier island erosion will also help assess the pros and cons of beach nourishment versus using hard coastal engineering structures.

Whereas the USGS conducts relevant research on coastal erosion and landloss, other Federal and State agencies have the mandate to design and construct projects, and otherwise implement measures for coastal zone management and for the mitigation of coastal erosion or wetland loss. The state of Louisiana, through the Governor's Coastal Restoration Policy Committee, presented a report in August 1988 that prioritizes different projects and policies that could be implemented to mitigate Louisiana's severe landloss problem. They categorize the projects according to "immediate response, implement in the short term, and implement in the long term." The

U.S. Army Corps of Engineers (ACOE) has completed the first phase of developing a Louisiana Coastal Comprehensive Wetlands Plan to mitigate landloss in Louisiana. If phase two is funded, the ACOE will work closely with other Federal and State agencies (including USGS) to assess the costs and utility of projects to mitigate land loss.

Most technical people agree that there are projects and policies that have a sufficient information base that they can be adequately undertaken in the short term without the need for further research. The State through the Governor's Coastal Restoration Policy Committee has provided their view of projects of this nature. However, for many potential projects, such as the utility of hard engineering structures on beaches and of large fresh water and sediment diversions, the information needed is not sufficient and further research would benefit the decision-making and planning process. Mitigation of coastal erosion and wetland loss should be approached through a two-pronged effort. The appropriate Federal and State agencies could implement projects about which sufficient information is available on each project's utility. At the same time, relevant research should continue on critical processes. The research will allow incremental improvement in the state-of-the-art of erosion and landloss mitigation, as well as evaluating the success of the implemented projects.

LOUISIANA BARRIER ISLAND EROSION STUDY

Study Overview

The study area includes most of the barrier islands in the deltaic plain region of coastal Louisiana. The study is divided into three overlapping elements: geologic development of barrier islands, processes of barrier island erosion, and transfer and application of results. An initial step in determining processes of erosion was to establish the shallow geologic framework within which the barriers formed and have eroded and migrated landward. These efforts, which involve both stratigraphy and geomorphology, are the basis upon which a regional understanding of the processes involved is being developed. Many processes contribute to the erosion of Louisiana's barrier islands. In this study, the focus is on the processes that are not well understood, but that are approachable experimentally. These processes are sea-level rise, storm overwash, onshore-offshore movement of sand, and longshore sediment transport. The efforts involve direct measurements of waves and currents during storms, modeling, and determination of historical patterns of erosion and accretion. The results of the study are directly applicable to various practical problems. For example, a better understanding of the rates of removal of sand from the beaches is crucial to determining how often an artificially nourished beach will need to be renourished. Investigations of the geologic framework within which barriers formed also lead

to identification and assessment of sand resources useful for beach nourishment as well as a greater capacity to forecast future coastal conditions.

A particularly important aspect of the study will be to improve our understanding of the significance of barrier islands to the protection of wetlands, bays, and estuaries behind the islands. Barrier islands potentially serve to reduce wave energy at the margin of wetlands and, thus, limit mechanical erosion. Barriers also limit storm surge heights and retard salt water intrusion. The bays between the barriers and wetlands are ecologically productive and would be changed significantly once the barriers are completely eroded. There are proposals to restore and protect barrier islands in Louisiana for the purpose of preserving estuaries and reducing wetland loss. However, there is not enough information or understanding of the processes to make a thorough assessment of the significance of barrier islands. The ACOE, in a feasibility study of limited scope, estimated that the protection by engineering means of the island of Grand Terre would limit wetland loss by 10%, approximately 163,000 acres. This was an office study and computer modeling effort of a limited stretch of coast. The results of the present USGS field study, which monitors storm activity, will help improve our understanding of the role and importance that barrier islands play in protecting wetlands.

Interim Results

During the course of the study thus far, a very large and high quality data base relevant to erosion of Louisiana's barrier islands has been assembled. Currently these data sets are undergoing extensive analyses. Below, some results to date are summarized that focus directly on erosion mitigation.

Offshore Sand Resources for Coastal Restoration.

- As part of the joint USGS-LGS work, ten high-resolution geophysical surveys have been conducted and more than 300 core samples measuring 7 m to 12 m (23-39 ft) in length have been collected. Interpretation of the geophysical data, surface sediment samples, and sediment cores have resulted in the identification of 55 potential sources of sediment in the nearshore that could be used as high quality fill for shoreline nourishment projects. These nourishment projects would include dredging and transporting sediment in order to maintain beaches, restore barrier islands, or create marshes.

Coastal Change Analysis.

- Using vertical aerial photography and historical charts, shorelines have been mapped for all of Louisiana's barrier islands for the past 130 years. These data can be used by coastal zone managers and engineers in planning shoreline mitigation and will be one part of a state-of-the-art Geographical Information System (GIS) that will allow users to rapidly utilize the data via computer and display it at scales appropriate for their needs. Like all data generated in this study, these data are being archived and will be available to all users.

- Historical bathymetry of the nearshore dating back to the 1850's has been digitized for much of the Louisiana barrier island coast. In addition, as part of this study, new precision bathymetric surveys have been conducted along much of the Louisiana barrier island coast. This updated bathymetry, the latest survey since the 1930's, is basic data useful for erosion mitigation or coastal management.

The historical data have been compared to the new data, yielding maps showing volumes of sediment eroded and accreted along the shore and on the inner continental shelf. With these data, the rates at which sediments are eroded and accreted can be determined, as well as the pathways of sediment transport. These analyses can be used, for example, to make first order judgments on the amount of sand required to nourish a beach and how often the beach will need to be renourished.

Future Coastal Conditions.

- Many of the barrier islands in Louisiana are narrowing as they migrate landward. The islands are basically composed of a veneer of fine-grained sand overlying older, muddy marsh deposits; the marsh is being eroded on both the ocean and bay sides of the islands. In agreement with earlier assessments, our data suggest that the islands will continue to narrow to a critical width where the sandy part of the barrier is overwashed into the back bays. Once frequent overwash occurs over much of the length of the islands, there may be insufficient sand to maintain the subaerial (above sea level) profile of the islands. Based on historic rates of erosion and loss of land area, our most recent estimate for the longevity of the Isles Dernieres barrier island arc is approximately two decades.

Sea Level Rise and Land Subsidence.

- Records from tide gauges throughout coastal Louisiana have been carefully analyzed to determine rates of sea level rise relative to the land. Most of the sea level rise is due to subsidence or downward movement of the land. The highest rates, 1 to 1.5 cm/yr (2 to 4 in/yr) over the past 18 years, are found in

the Terrebonne coastal region.[2] To some extent, these data show the highly regional variability of subsidence. Furthermore, these data are important in attempts to forecast the response of the barrier shoreline and wetlands to future sea level rises due to other factors such as global warming and the Greenhouse Effect.

Coastal Sediment Dynamics.

- Measurements of the response of barrier islands to storms, during which waves wash completely over the islands, have shown that the islands do not reach an equilibrium configuration. Even with no sea level rise, the islands are so low lying that they would be overwashed even during moderate winter storms and would continue to erode. As a consequence, the traditional scientific methods used to calculate erosion due to sea level rise do not work adequately in this environment. In order to forecast future erosion, additional details of sediment movement are needed. Our ongoing studies are measuring waves, currents, and resulting sediment transport across an island in the Isles Dernieres barrier arc during storms, with the objective of improving methods to forecast future erosion.

Coastal Sediment Budget Analysis.

- The Isles Dernieres barrier islands have been considered a closed system in regard to sediment transport. That is, the wide Cat Island Pass inlet, east of the islands, was considered an obstruction to longshore sediment transport. The implication was that the Isles Dernieres are severely sand starved. Analysis of historical patterns of erosion and accretion, however, show evidence of extensive sand bypassing around Cat Island Pass. Over a 50 year period, a sand body (18 km (11 mi) long, 4 km (2.5 mi) wide, and 1.5 m (5 ft) thick) developed from east to west in water depths of 4 to 8 meters (13 to 26 ft). The sediment volume is an estimated 44 million cubic meters (58 million yd^3). This natural sand bypassing of the inlet may be lessening the net erosion on the eastern end of the Isles Dernieres.

Final Reports

The scientific results of the barrier island studies are being presented in publications and at workshops and scientific meetings. The reports from the study to date are listed at the end of this report. In addition to these kinds of reports, two types of final reports will be completed by the end of the study. A series of

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[2] Penland, S., Ramsey, K. E., and McBride, 1987, Delta plain development and sea level history in the Terrebonne coastal region, Louisiana: Coastal Sediments 87, ASCE, p. 1689-1705.

atlases, displaying in figures and map form many of the results, will be produced. These atlases will include information on historical shoreline changes, bathymetric changes, sediment composition and thickness, relative sea level change, climatology, including effects of winter storms and hurricanes, shallow geologic framework, and offshore sand resources. In addition, a narrative report that summarizes all of the scientific findings of the study will be prepared. The emphasis in the narrative report will be on the explanation of the relevance of the scientific findings to the practical problem of erosion and landloss mitigation. This information will provide the basic data sets and technical knowledge needed by Federal, State, and local agencies in formulating realistic and cost-effective appproaches to coastal restoration and erosion mitigation.

LOUISIANA WETLAND LOSS STUDY

Study Overview

As mentioned above, the processes causing wetland loss are complex, varied, and not particularly well understood. Both human activities (e.g. flood control, navigation, river damming, and canal dredging) and natural processes (e.g. land subsidence and sea level rise) have accelerated wetland loss and deterioration.

There is much debate about which of the many processes (both natural and human induced) are most significant in contributing to wetland loss. In the past few years, numerous meetings, conferences, and workshops including Federal, State, international, and private interests have been held to discuss the problem of wetland loss and identify potential solutions. Among them, the USGS and the Louisiana Department of Natural Resources, co-hosted a workshop in September 1987 to identify and evaluate the critical processes leading to wetland loss. Approximately 60 managers and researchers from Louisiana, including representatives from the U.S. Fish and Wildlife Service (FWS), Corps of Engineers, Soil Conservation Service, Environmental Protection Agency, Minerals Management Service (MMS), National Marine Fishery Service, Louisiana Department of Natural Resources, Louisiana State University (LSU), and Louisiana Department of Wildlife and Fisheries, attended the workshop. Several representatives from other universities and private industry were also present.

Managers and researchers at this workshop all agreed that wetland loss is a critical problem; however, there is controversy surrounding the factors which contribute to landloss and measures that are being undertaken and proposed to lessen wetland loss. Much of the debate centers on being able to adequately predict the result of a given management or restoration technique. By better understanding the physical process of wetland loss, such predic-

tions should improve, and a clearer consensus on methods to retard loss and restore wetlands should emerge.

Recognizing that wetland loss is a serious national problem and likely to worsen in the future, the USGS and FWS have been directed by Congress to carry out research on wetland loss in Louisiana. In cooperation with the State of Louisiana, the USGS and FWS are in the second year of a research study of coastal wetlands. Emphasis of the study is on understanding the critical physical processes that cause the extreme rates of wetland loss in coastal Louisiana, and the identification of the best management practices to address those losses.

The USGS/FWS wetlands study includes four parts: (1) Baseline data is being compiled and will be put into a computer (GIS) retrievable format. (2) On a basin scale, research is being conducted to better understand critical processes causing wetland loss. (3) At specific sites, research is being conducted on the effects and utility of various wetland management activities on the processes. (4) The information and results from these studies are being transferred to the user community by means of reports, maps, and workshops.

The wetlands study element dealing with research on some of the critical physical processes is being undertaken by USGS scientists as well as scientists at LGS and LSU under contract with the USGS. During the course of investigations, field studies will be carried out in two separate hydrologic basins. One basin will be sediment-rich, the Atchafalaya, and the other sediment-poor, in order to compare and contrast the dominant processes in each. During FY 1988 and this year, investigations are underway on the sediment-deficient Terrebonne Basin/Timbalier Bay and parts of Barataria Basin. A brief description of the six research tasks under way is as follows:

1. Meteorological Forcing

Meteorological knowledge is critical for most wetland processes. For example, salt water intrusion into intermediate and fresh wetlands can result from storm surges caused by tropical cyclones and extra tropical storms. Basic historic information on storm occurrence, wind speeds, rainfall, surge levels, and flooding characteristics is being compiled and analyzed.

2. Sediment Dispersal

Because of widespread coastal submergence, wetlands need to grow vertically in order to maintain their elevation. This vertical growth of wetlands is critically dependent on sediment supply during floods. A principal objective of this research is to develop a better understanding of the dispersal and deposition of fine grained sediments during floods. This understanding can

be applied to improve predictions of sediment dispersal following storms and human alterations of the natural environment. Basin-wide dispersal patterns are being determined using remote sensing techniques. At specific sites within the basins, field instrumentation precisely measures the rates and directions of suspended sediment transport, providing verification for the remote sensing effort. In addition, the role of sediment resuspension in the shallow bays during storms and ultimate transport to the marshes is being assessed and compared to the role of sediment supplied during river floods.

3. Salt and Freshwater Dispersal

As the land subsides and sea level rises, salt water progresses farther inland, displacing fresh water, and consequently changing plant and animal distributions. The focus of this research is to determine the processes and patterns of salt and freshwater dispersal so that the impacts of hydraulic changes on wetland habitat can be better forecasted.

4. Physical Processes of Marsh Deterioration

The objective of this research is to determine and quantify the processes responsible for the mechanical deterioration of marshes by waves and currents, and to determine the relative importance of these mechanisms compared to others. Rates of mechanical erosion of marshes are being monitored concurrently with monitoring the waves and currents causing the erosion.

5. Wetlands Soil Development

Wetlands soils are composed of organic components (e.g. decaying plant material) as well as terrigenous sediments. This research involves quantifying and comparing processes of wetland soil development between the sediment-rich and sediment-poor environments. Sedimentation rates in marsh environments are determined by measuring the concentration of Cesium 137 along sediment cores.

6. Subsidence

This research is defining regional rates of land subsidence, the variability of rates within the basins, and determining the causes of subsidence. An important goal of the study is to increase our understanding of the role that human activities may play in accelerating subsidence. The basis for the assessment of subsidence is a detailed investigation of the regional, geologic framework. This task involves obtaining sediment cores and deep boreholes at a spacing suitable for correlating depositional units across each basin.

Interim Results

With the Wetlands Study in only the second year, the major emphasis is on deploying instruments, collecting field data, and making critical measurements in Terrebonne Basin. During the third and fourth years of the study, the data collection effort will shift to the Atchafalaya Basin. In the fifth year, emphasis will be on interpretation and preparation and presentation of the findings and results. Once the information is assembled, data analyses will be done, and like the Barrier Erosion Study, the results will be made available through workshops, reports, maps, and technical presentations at scientific meetings.

Final Reports

In the fifth and sixth years, the emphasis will be on presentation of the results and findings in a series of final reports. These reports will consist of one or more atlas publications for each of the basins studied as well as a narrative report for each. The objective of the reports will be to explain the relevance of the scientific findings to the practical problem of managing and mitigating wetland loss.

CONCLUDING REMARKS

The USGS is conducting two studies dealing with barrier island erosion and wetland deterioration and loss in Louisiana. The barrier island work, conducted in cooperation with the Louisiana Geological Survey, is in the fourth year of a planned five-year effort, whereas the wetlands work, conducted in cooperation with FWS, is just underway. The information being derived from these investigations is providing important technical knowledge and data bases that can be used by the appropriate Federal, State, and local agencies to make strategic decisions and for designing and implementing measures to lessen the rates of land loss and mitigate the effects of erosion. Such a process will result in greater success in dealing with erosion and a more effective use of available resources. Results from the coastal research are already being disseminated in the form of technical reports, maps, and presentations. These publications serve two purposes: they transfer results to managers, planners, and engineers, and they increase the awareness of the public and scientific community that erosion in Louisiana is widespread and a serious problem. The presentation of these results at scientific forums and in public programs across the nation is focusing attention on the fact that erosion in Louisiana is not only a problem for Louisiana, but a problem affecting the entire nation.

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