Habitat Trends

Status and Trends of Wetlands and Aquatic Habitats, Galveston Bay System, Texas

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Wetland and aquatic habitats are biologically essential to the Galveston Bay Estuarine System. Understanding the spatial and temporal distribution of these habitats is critical if they are to be effectively protected and managed. This abstract presents results of an investigation sponsored by the Galveston Bay National Estuary Program to determine the status and trends of wetlands and aquatic habitats in the Galveston Bay System through aerial photographic analysis supported by field surveys. The investigation, funded by the Texas Water Commission and Environmental Protection Agency, was a cooperative effort of the Bureau of Economic Geology, the National Wetlands Research Center and National Wetlands Inventory program of the U.S Fish and Wildlife Service.

Methods

Status and trends of wetlands in the Galveston Bay system were determined by analyzing the distribution of wetlands mapped on aerial photographs taken in the 1950s, 1979, and late-1980s. Wetlands for all maps (1950s, 1979, and 1980s) were delineated on aerial photographs through stereoscopic interpretation using procedures developed for the U.S. Fish and Wildlife Services National Wetlands Inventory program. Field reconnaissance was an integral part of the interpretation process. Following the classification of Cowardin and others (1979), wetlands were classified by system, subsystem, and class for all years, and by subclass, water regime, and special modifier for the years 1979 and 1989. Upland habitats were delineated on 1979 and 1989 maps. More than 180 field sites were examined as part of an effort to characterize wetland plant communities and define wetland map units in the Galveston Bay system (White and Paine, 1992). Universal Transverse Mercator coordinates were determined for each site, and these data were entered into computer data-management systems, including the geographic information system, ARC/INFO. All numerical data (acreage, percentages) presented herein are approximate.

Status of Wetland and Aquatic Habitats

In terms of current status (1989), wetlands and aquatic habitats are dominated by an estuarine system that encompasses 507,500 acres and represents 89% of the wetland and deep-water habitat system in the 30 U.S. Geological Survey 7.5-minute quadrangle maps that define the Galveston Bay project area. The palustrine system is a distant second at 6% (34,100 acres), followed by the lacustrine (4%), riverine (0.5%), and marine (0.4% excluding marine open water).

Vegetated wetlands (marshes, scrub/shrub, and forested wetlands) have a total area of 138,300 acres. Marshes, or estuarine and palustrine emergent wetlands, cover 130,400 acres, representing 94% of the total vegetated wetlands. Estuarine intertidal emergent wetlands, or salt and brackish marshes, constitute 83% (108,200 acres) of the marsh system, and palustrine emergents (fresh or inland marshes) make up the remaining 17% (22,200 acres). The total area of forested wetland habitat amounts to 5,650 acres, or 4% of the vegetated wetland system. Palustrine scrub/shrub wetlands total 2,000 acres (<2% of vegetated wetlands), and estuarine scrub/shrub wetlands encompass 550 acres (0.4%). The 17,800 acres of estuarine intertidal unconsolidated shores (sand and mud flats and bay beaches) that occur in the Galveston Bay system may be overestimated because of extremely low tides during the 1989 photographic mission. Submerged rooted vegetation, or estuarine subtidal aquatic beds, has a total mapped area of 700 acres (adjusted for photointerpretation errors) in the Galveston Bay project area; 386 acres were mapped in Christmas Bay where the largest distribution occurs. The total area of submerged vegetation is thought to be larger than reported here because of unmappable areas on the margins of the Trinity River delta.

Trends in Wetland and Aquatic Habitats

Comparison of wetland distribution in the Galveston Bay system between the 1950s, 1979, and 1989 indicates that there were gains and losses in wetlands, but the net trend is one in which wetlands were lost. This downward trend is illustrated by acreages of 171,700 in the 1950s, 145,500 in 1979, and 138,300 in 1989 (Fig. 1). The rate of loss, however, decreased over time from 1,000 acres/yr between 1953 and 1979, to about 720 acres/yr between 1979 and 1989. The rate of loss between 1979 and 1989 is lower (<500 acres/yr) if inaccuracies in wetland interpretation on the 1979 photographs are taken

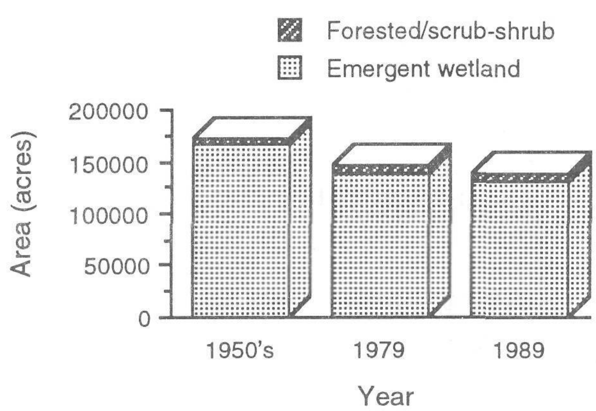

Figure 1. Comparison of the areal extent of emergent wetlands (marshes) and forested-scrub/shrub wetlands for the 1950's, 1979, and 1989.

into account. From the 1950s through 1989, vegetated wetlands diminished by 32,400 acres, which amounts to 19% of the vegetated wetland system that existed in the 1950s. The actual loss in wetlands is somewhat less, perhaps closer to 17%, because delineations of wetlands in some areas on the 1950s vintage black-and-white aerial photographs included peripheral upland areas, which inflated the 1950s wetland acreages. The area of mapped emergent wetlands (marshes) decreased from 165,500 acres in the 1950s to 130,400 acres in 1989, producing a total net loss across the Galveston Bay system of 35,100 acres, or 21% of the 1950s resource. As in the case of vegetated wetlands, this amount of loss in emergent wetlands is thought to be on the high side; the actual loss is probably <19%.

Although the general trend in scrub/shrub wetlands for the 1950s through 1989 was one of net loss, this trend was countered by forested wetlands, which had a significant net gain. Scrub/shrub wetlands decreased by 900 acres, representing a loss of 25% of the 1950s resource. Forested wetlands, on the other hand, increased by 3,600 acres — 1.8 times the 1950s area.

Submerged vascular vegetation decreased from 2,500 acres in the 1950s to 700 acres in 1989. Accordingly, the decline in submerged vegetation is 1,800 acres, or >70% that of the 1950s habitat. However, using the total of 5,000 acres for submerged vegetation reported by Fisher and others (1972), the loss by 1989 is 86% of the mid-1950s resource.

Probable Causes of Trends in Wetland and Aquatic Habitats

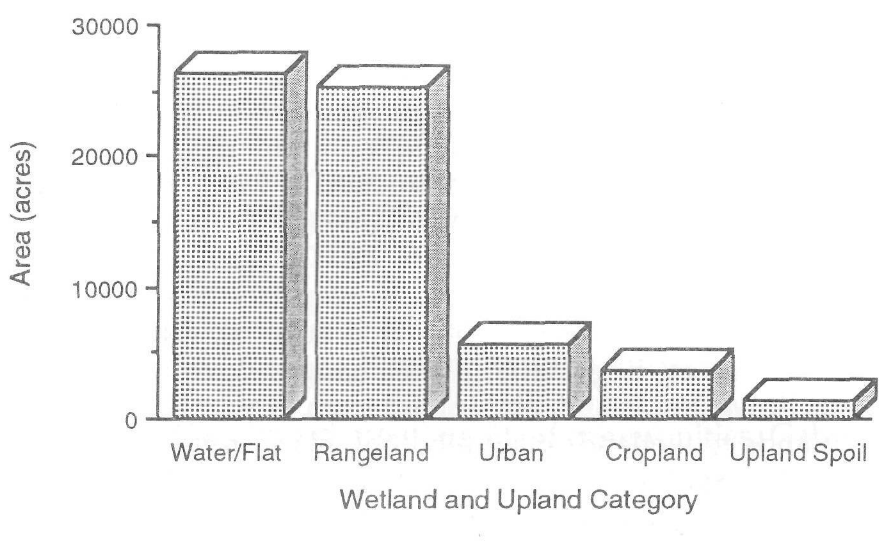

Figure 2. Areal extent of emergent wetlands (marshes) that were converted to other types of habitats and land uses between the 1950s and 1989. The most significant single change (>26,000 acres) in these categories was from emergent wetlands to areas of open water and barren flat. Changes of marshes to upland categories total 35,600 acres, with conversion to rangeland accounting for most of the change.

The causes of wetland losses, both natural and artificial, include man-induced subsidence and associated relative sea-level rise and development for agriculture, transportation, urbanization, industry, and recreation. Estuarine emergent wetlands (salt and brackish marshes) diminished extensively as these habitats were replaced by open water and barren flats (Fig. 2). Major losses in palustrine emergent wetlands (interior, or fresh marshes) occurred when these areas were converted to uplands (Fig. 2).

The net loss in emergent wetlands (marshes) was 35,000 acres from the 1950s through 1989. The gross loss, exclusive of offsetting gains in other areas, was considerably larger, >88,500 acres. Transformation of emergent wetlands, or marshes, to areas of water and barren flats has exceeded 26,000 acres, accounting for 30% of the gross loss in the Galveston Bay system. Evidence shows that the major contributing factor in this change is man-induced subsidence and associated relative sea-level rise. Wetland areas affected by subsidence include the north, west, and south margins of Galveston Bay and the northeast part of West Bay. Subsidence along active surface faults also contributed to replacement of marshes by water and barren flats in some areas.

Major losses in marshes occurred as large areas of predominantly palustrine emergent wetlands were transformed to uplands. The magnitude of this change was 35,600 acres from the 1950s through 1989, which accounts for 40% of the total gross loss in palustrine and estuarine emergent wetlands. The change from emergent wetlands in the 1950s to upland rangeland in 1989 affected 25,400 acres (Fig. 2). Conversion of wetlands to urban upland areas totaled 5,700 acres, and to cropland and pastureland, 3,600 acres. Some changes of wetlands to uplands are related to natural conditions, such as annual (and seasonal) changes in moisture levels, which affected photointerpretation, but most change probably resulted from draining of wetlands. Approximately 33% of the gross loss in emergent wetlands occurred because they were replaced by upland rangeland and cropland. This percentage is lower than that reported nationally for the loss of wetlands due to agricultural development estimated at 87% from the mid-1950s to mid-1970s (Tiner, 1984), and 54% from the mid-1970s to mid-1980s (Dahl and others, 1991). Restrictions placed on the alteration and destruction of wetlands since the 1970s may be one factor causing a recent decline in the rate of loss (1970s to 1980s).

Losses in emergent wetlands in some areas were partly offset by gains in emergent wetlands in other areas. Conversions from upland areas to wetland areas accounted for an increase of 21,000 acres. Regionally, these changes were most pronounced inland from East Bay, on Galveston Island, and inland from West Bay and Christmas Bay. The conversion of uplands to wetlands generally took place in transitional areas peripheral to existing wetlands. Additional increases in emergent wetlands resulted after emergent vegetation spread over areas previously mapped as intertidal flats. This type of change was common in intertidal sand flats on the barrier islands.

Loss of scrub/shrub wetland habitat was offset by expansion of forested wetlands. Approximately 1,600 acres of 1950s scrub/shrub habitat in the Trinity River alluvial valley, where the broadest distribution of scrub/shrub and forested wetlands was mapped, changed to forested wetland habitat by 1989. Much of the gain in forested wetland area was due to (1) growth of shrubs and trees in areas previously mapped as scrub/shrub wetlands, and (2) photointerpretation inconsistencies on the different sets of photographs. Some losses were due to changes in hydrology.

The aforementioned loss of 70 to 86% of the submerged vegetation in the Galveston Bay system between the 1950s and 1989 has been attributed to subsidence and Hurricane Carla in western Galveston Bay and to human activities including development, wastewater discharges, chemical spills, and dredging activities in West Bay (Pulich and White, 1991).

The declining rate of loss of wetlands over the more recent period (1979 through 1989), coupled with local gains in wetland habitats in some areas, offers hope that planning and proper management of wetlands can help mitigate the trend toward net loss of these valuable natural resources in the Galveston Bay system.

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Status and Trends Analysis of Oyster Reef Habitat in Galveston Bay

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The purpose of this GBNEP study is to describe the status and trends of oyster populations in Galveston Bay. To do so required the development of a new mapping method designed to discriminate oyster reefs from other bottom types rapidly, accurately, and inexpensively. The method uses an acoustic profiler to differentiate substrate type, a fathometer to assess bottom relief and a global positioning system to accurately establish position. The method has the following desirable traits: can be performed from a small research vessel, usable in most weather conditions, requires only a two-person crew, rapidly discriminates bottom type while underway, usable in shallow (< 1 m) or deep (> 10 m) water, and provides accurate and precise navigation.

We chose a dual frequency acoustic setup consisting of a Datasonics Dual Frequency Transceiver (Model DFT-210), a Datasonics towed fish with dual transducers (22 and 300 kHz), and an EPC Multichannel Chart Recorder (Model 4800). Primary identification of oyster reefs relied on the record from the 300 kHz channel. On the chart paper, an oyster reef appears as a dark, dense series of spikes projecting well above the background signature from a mud or sand bottom. Although we have not investigated the acoustic phenomena involved, we surmise that the oyster reef signature results from more sound energy bouncing back to the transducer. In the case of a muddy bottom, more of the sound energy is absorbed, thus, the signature is reduced. Sand and shell hash give an intermediate, fuzzy signature, still readily distinguishable from reef or other oyster bottom.

In practice, we encountered only two bottom types that required occasional ground-truthing to verify their non-oyster nature: clam beds and coarse shell hash, usually associated with points, nearshore sediments, and dredge spoil. With experience, coarse shell hash, could be discriminated with relative ease and required little ground-truthing. With experience, most clam beds could also be distinguished; however, dense clam beds required ground-truthing. This technique, then, could be used to identify concentrations of most large epifaunal or semi-epifaunal shellfish, not just oysters.

In the field, the acoustic system provided reliable data even under unfavorable weather conditions. Signal quality did not deteriorate in 1-m seas, during thunderstorms, or in areas heavily trafficked by boats. Signal quality was satisfactory in depths as shallow as 0.55 m (our minimum running depth) and as deep as 12.5 m (our deepest depths) and at speeds higher than precise navigation would allow (> 5.5 knots).

During data collection, the towed fish was lowered from a boom held perpendicular to the boat, well in front of the stern, to eliminate the effects of "prop-wash". As many running depths were shallow, we positioned the fish < 0.1 m below the water surface to prevent the towed fish from hanging up on underwater obstructions. Signal quality was not affected. To keep the fish from hitting the boat's side during turns and to maintain a proper orientation while underway, the boom was extended 1 m from the boat's rail and a tow rope was run from the fish to the bow to maintain forward aspect during turns and to maintain a vertical downward-facing position for the transducers while underway.

Position was determined while underway using a Magellan Global Positioning System (GPS). Loran C proved to be too inaccurate for precise mapping. We emphasize the necessity of using a GPS system for accurate determinations of position. Many reefs were less than 20 m across in shortest dimension and larger reefs had significant variations in relief of a similar scale. In practice, the precision of our GPS unit was within 0.01 min latitude and longitude on all days. The frequency at which positions were updated by the GPS unit limited maximum running speed to 5 knots. At speeds greater than 5 knots, the positions of reef details and boundaries could not be accurately recorded. In practice, we used a 4-to-5 knot window for running speed that proved adequate for all applications.

Relief was recorded while underway using an Apelco fathometer. Pictures of the fathometer screen were taken with a 35 mm camera (film speed 1000 ASA) to record relief of all reefal area because relief changed too quickly to be recorded manually while underway. A chart recorder attached to the fathometer would have been an adequate alternative. Fathometer accuracy declined at depths < 0.8 m. We found that a substantial change in running speed affected the depth reading so that maintaining a constant running speed was required throughout a line.

For data collection, N-S and E-W lines were run on a 0.125 min grid in areas with reef. An 0.25 min grid was used to map uncharted areas. Subsections having reefal components were then mapped using the 0.125 min grid. The grid choice was a compromise between: (1) the detail required to adequately assess reef coverage and the accuracy of positions permitted by the GPS unit; and (2) the time required to run the lines. Smaller or larger grids might be used in other applications. Because depth changed during the day and from day to day with the tides and wind setup, the bathymetric data were standardized to a constant datum. To do so, we extended the grid over areas of relatively-deep, flat, muddy bottom so that each line and the intersection of several N-S and E-W lines occurred in areas where the depth record was most accurate and where relief changes were minimal. This permitted internal standardization of depth which could then be corrected to some constant datum, such as mean sea level. Army Corps of Engineers tide staffs were used to calibrate the bathymetry to mean sea level. Once the depth corrections were completed, the data were computerized and processed for use by a Geographic Information System (GIS) to produce the maps. We used Arc/Info software.

Twelve maps were produced covering the majority of Galveston Bay, Trinity Bay, East Bay, and West Bay, based upon approximately 75,000 positions each with a determination of substrate type and depth. Reefal area was compared to that determined in the late 1960s and early 1970s by the Texas Parks and Wildlife Department. Detailed analyses are continuing; however, a number of broad conclusions are presently available.

The amount of oyster reef and oyster bottom is substantially higher than depicted on the TPWD charts. The additional reef can be ascribed to several factors. (1) Our technology enabled us to map substantially more of the bay, particularly the deeper areas of the bay, than was possible previously. (2) Some new reef formation has probably occurred in the ensuing 20 years since the TPWD study was completed. (3) Little loss of previously-mapped reef occurred over the last 20 years. Those few areas where reef decline has occurred can be ascribed to regional subsidence and burial by sedimentation.

The oyster reefs of Galveston Bay can be divided into naturally-occurring reef that has existed over historic time and reef that has originated through man's influence. Natural reefs are primarily of four types: (a) alongshore reefs oriented parallel to shore and located near or attached to the shoreline; (b)reefs extending perpendicular from the shoreline or a point nearshore out into the bay; (c) patch reefs composed of one or more relatively small more-or-less circular bodies; and (d) barrier reefs extending across or nearly across the bay. Reefs originating from man's influence include: (a) those associated with the spoil banks of dredged channels; (b) those associated with oil and gas development; (c) those associated with oyster leases; and (d) those produced by natural accretion in areas not previously conducive to reef development because of modifications in current flow. These latter four account for a substantial fraction of all of the present-day reefs in Galveston Bay. In many areas of the bay, they account for 80 to 100% of the entire reefal area.