



This document contains overall and specific condition of the Galveston Bay Estuary Program from the National Estuary Program Coastal Condition Report. The entire report can be downloaded from

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National Estuary Program Coastal Condition Report

Chapter 5: Gulf of Mexico National Estuary Program Coastal Condition, Galveston Bay Estuary Program

June 2007

Galveston Bay Estuary Program



Background

Galveston Bay is a subtropical estuary located on the southeastern shore of the upper Texas Gulf coast. The Bay is composed of five major subbays: Trinity, Upper Galveston, Lower Galveston, East, and West bays. The combined area of the five subbays is 384,000 acres (600 mi²), surrounded by 1,171 miles of shoreline (GBEP, 2005; HARC, 2005b). The estuary is fed by two major rivers (Trinity and San Jacinto rivers) and is bordered by low-lying wetlands, two barrier islands, and a peninsula. The waters of Galveston Bay can be characterized as

well mixed and quite shallow (averaging 7 feet) and are made shallower in some places by extensive oyster reefs (GBEP, 2005). The Bay has increased in volume during the past 50 years due to natural and anthropogenic subsidence, as well as sea level rise and dredging operations (Lester and Gonzalez, 2003). Major habitats in the Bay include estuarine and freshwater marsh, mudflats, seagrass beds or SAV, oyster reefs, and open water.

Galveston Bay is used extensively for recreational and commercial activities, and the potential for large-scale human impacts is great. Galveston Bay is one of the

largest sources of seafood for Texas, as well as one of the major oyster-producing estuaries in the country. The oysters, crabs, shrimp, and finfish harvested from Galveston Bay are worth a combined \$19 million annually (Sage and Gallaway, 2002). One-third of the state's commercial fishing income and more than half of the state's recreational fishing expenditures are derived from Galveston Bay (GBEP, 2005). The Port of Houston is the second-largest port in the United States in tonnage and the eighth-largest port in the world (Sage and Gallaway, 2002). Along with the ports of Texas City and Galveston, the Port of Houston supports the region's petrochemical industries, which are the largest in the nation and the second-largest in the world (Port of Houston Authority, 2006). These industries combine to produce one-half of the nation's chemicals and one-third of the nation's petroleum refining (U.S. EPA, 2002a).

Extending back from the river mouths, the entire Galveston Bay watershed covers 33,000 mi², includes the metropolitan areas of Houston-Galveston and Dallas-Ft. Worth, and is home to nearly half of the population of Texas (GBEP, 2005). The surrounding watershed is composed of a variety of habitats, ranging from open prairies and coastal wetlands to riparian hardwoods and pine-dominant forests, and these habitats support numerous plant, fish, and wildlife species.

To increase public awareness and help address negative trends in wetland loss, habitat degradation, and non-point source pollution, the Galveston Bay Estuary Program (GBEP) was formed in 1989. Efforts of the GBEP are concentrated in the 4,200-mi² lower watershed, which is demarcated by the dams that form Lake Houston on the San Jacinto River and Lake Livingston on the Trinity River. Following the establishment of its CCMP, *The Galveston Bay Plan: The Comprehensive Conservation and Management Plan for the Galveston Bay Ecosystem*, the GBEP now continues its work as part of the Texas Commission on Environmental Quality (TCEQ) (GBNER, 1995).

Environmental Concerns

With Galveston Bay in the shadow of the nation's fourth-largest city, the environmental concerns of highest priority for the GBEP are wetland loss and

habitat degradation, point and non-point source pollution, and chemical and petroleum product spills from barges and industry (Sage and Gallaway, 2002). Non-point source pollution in Galveston Bay is attributed to a variety of sources, including runoff from thousands of gas stations, residential lawns, failing septic systems, driveways, parking lots, industries, farms, and other sources. Accidental spills and the deliberate dumping of oil and other contaminants potentially harm the habitat and living resources of Galveston Bay. Other priority issues for Galveston Bay include new and existing introductions of aquatic and terrestrial exotic nuisance species, contaminated runoff from urbanized areas, and the increasing and often competing demands for fresh water. Additionally, sediment in the Houston Ship Channel exceeds levels of concern for a number of hazardous chemicals, including PCBs, DDT, dioxin, and heavy metals.

Population Pressures

The population of the 7 NOAA-designated coastal counties (Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, and Waller) coincident with the GBEP study area increased by 182% during a 40-year period, from 1.6 million people in 1960 to 4.4 million people in 2000 (Figure 5-52) (U.S. Census Bureau, 1991; 2001). This rate of population growth for the GBEP study area exceeded the population growth rate of 133.3% for the collective NEP-coincident coastal counties of the Gulf Coast region. In 2000, the GBEP-coincident coastal counties had a population density of 651 persons/mi² (the highest of all the Gulf Coast NEPs).

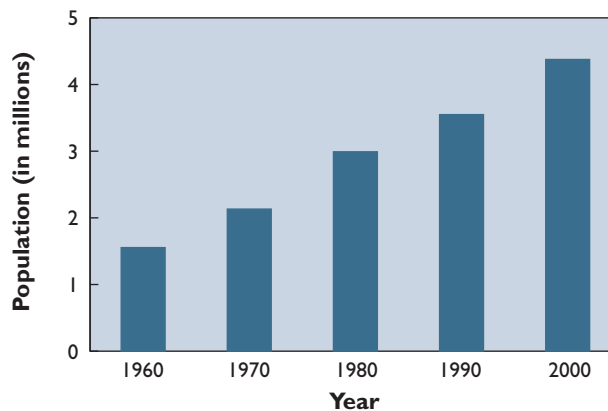


Figure 5-52. Population of NOAA-designated counties of the GBEP study area, 1960–2000 (U.S. Census Bureau, 1991; 2001).

This density was more than double the density of 287 persons/mi² for the collective NEP-coincident coastal counties of the Gulf Coast region (U.S. Census Bureau, 2001). Development and population pressures are especially strong in this NEP because it serves as a major center for international commerce; oil refinery and other petrochemical industries; commercial fish and shellfishing operations; and recreational activities for these coastal communities.

NCA Indices of Estuarine Condition—Galveston Bay

The overall condition of Galveston Bay is rated fair based on the four indices of estuarine condition used by the NCA (Figure 5-53). The water quality index is rated poor, the sediment quality index is rated fair to poor, the benthic index is rated fair, and the fish tissue contaminants index is rated good to fair. Figure 5-54 provides a summary of the percentage of estuarine area rated good, fair, poor, or missing for each parameter considered. This assessment is based on data collected by the Texas Park and Wildlife Department (TPWD) and NCA from 28 stations sampled in the GBEP estuarine area in 2000 and 2001. Please refer to Tables 1-24, 1-25, and 1-26 (Chapter 1) for a summary of the criteria used to develop the rating for each index and component indicator.

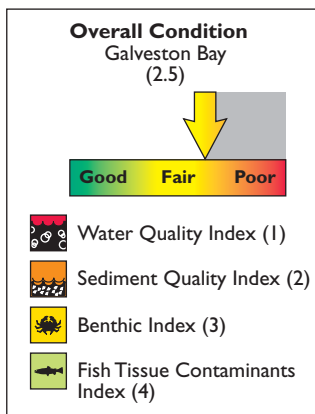


Figure 5-53. The overall condition of the GBEP estuarine area is fair (U.S. EPA/NCA).

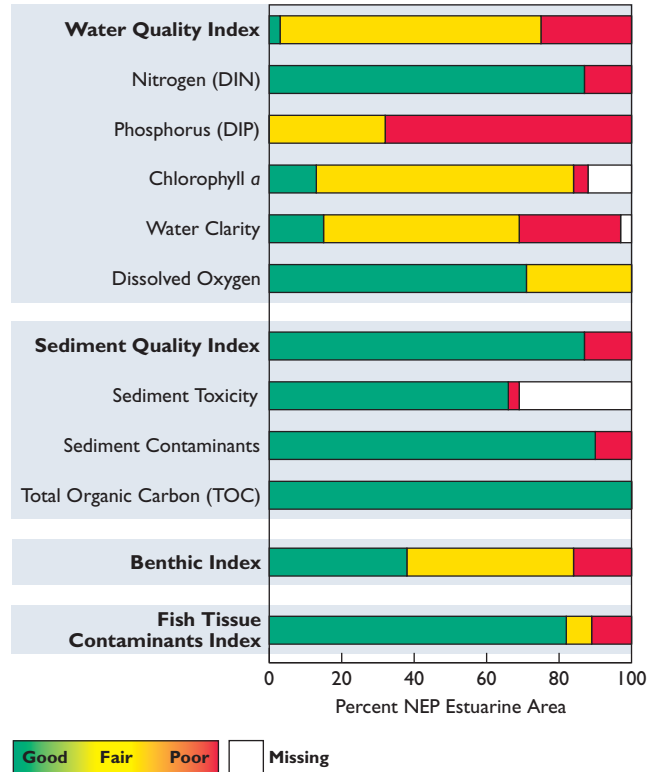


Figure 5-54. Percentage of NEP estuarine area achieving each rating for all indices and component indicators — Galveston Bay (U.S. EPA/NCA).



Significant declines in the number of blue crabs have been noted in the West Bay (Texas Sea Grant College Program).



Water Quality Index

Based on NCA survey results, the water quality index for Galveston Bay is rated poor (Figure 5-55). This water quality index was developed using NCA data on five component indicators: DIN, DIP, chlorophyll *a*, water clarity, and dissolved oxygen. In NOAA's Estuarine Eutrophication Survey, Galveston Bay was listed as having medium chlorophyll *a* and medium-to-low DIN and DIP concentrations, with elevated concentrations occurring in tidal freshwater areas (NOAA, 1997).

Dissolved Nitrogen and Phosphorus | Galveston Bay is rated fair for DIN concentrations and rated poor for DIP concentrations. Thirteen percent of the estuarine area was rated poor for DIN concentrations, whereas 68% of the estuarine area was rated poor for DIP concentrations. As discussed later in this profile, the GBEP also monitors nutrients in the bays and tributaries of the GBEP estuarine area.

Chlorophyll *a* | Galveston Bay is rated fair for chlorophyll *a* concentrations. Although only 4% of the estuarine area was rated poor for chlorophyll *a* concentrations, 71% of the area was rated fair, and 13% of the area was rated good. NCA data on chlorophyll *a* concentrations were unavailable for 12% of the GBEP estuarine area.

Water Clarity | Water clarity in Galveston Bay is rated poor because 28% of the estuarine area was rated poor. Expectations for water clarity are similar to those for normally turbid estuaries, with water clarity rated poor at a sampling site if light penetration at 1 meter was less than 10% of surface illumination.

Dissolved Oxygen | Dissolved oxygen conditions in Galveston Bay are rated good. Seventy-one percent of the estuarine area was rated good for dissolved oxygen concentrations, 29% of the area was rated fair, and none of the area was rated poor.

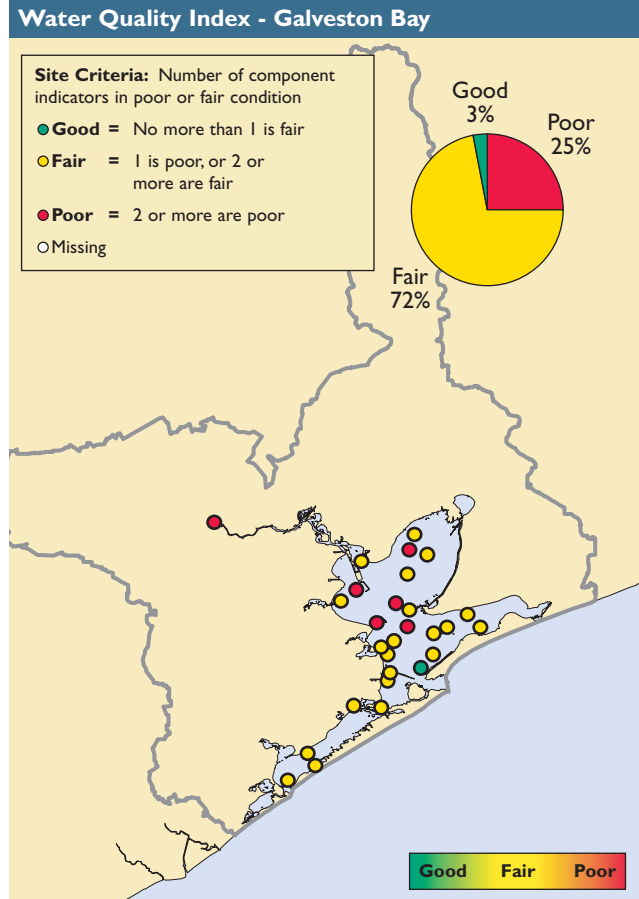


Figure 5-55. Water quality index data for Galveston Bay, 2000–2001 (U.S. EPA/NCA).



Sediment Quality Index

The sediment quality index for Galveston Bay is rated fair to poor because greater than 5% of the estuarine area was rated poor for sediment quality (Figure 5-56). This index was developed using NCA data on three component indicators: sediment toxicity, sediment contaminants, and sediment TOC.

Sediment Toxicity | Sediment toxicity is rated good for Galveston Bay because only 3% of the estuarine area was rated poor; however, NCA data on sediment toxicity were unavailable to evaluate 31% of the GBEP estuarine area.

Sediment Contaminants | Sediment contaminant concentrations were rated poor in 10% of the GBEP estuarine area; therefore, this component indicator is rated fair.

Total Organic Carbon | TOC concentrations in Galveston Bay sediments were rated good in 100% of the estuarine area; therefore, Galveston Bay is rated good for this component indicator.



Benthic Index

Based on NCA survey data and the Gulf Coast Benthic Index, the condition of benthic invertebrate communities in Galveston Bay is rated fair. Benthic index estimates indicate that 16% of the estuarine area had degraded benthic resources (Figure 5-57).

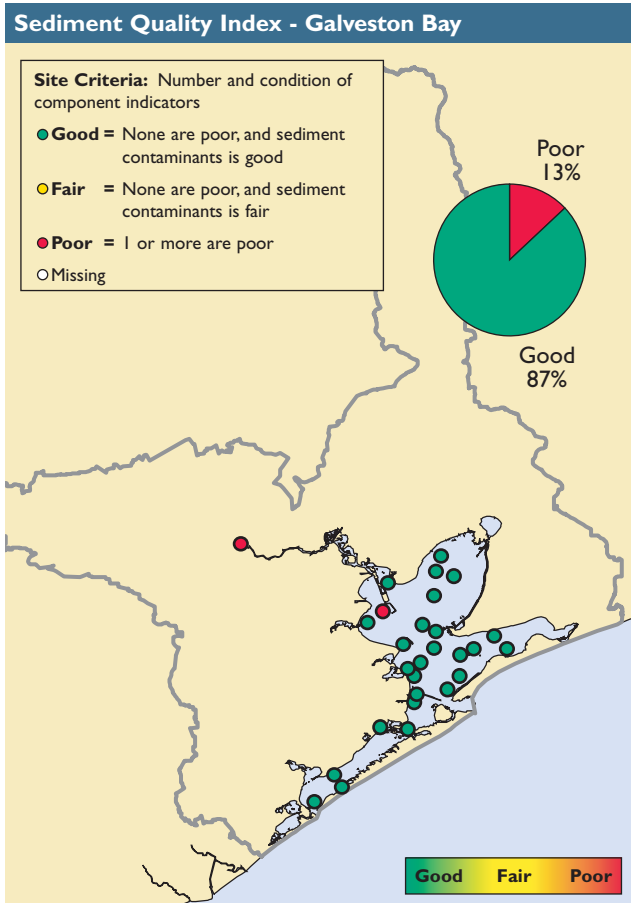


Figure 5-56. Sediment quality index data for Galveston Bay, 2000–2001 (U.S. EPA/NCA).

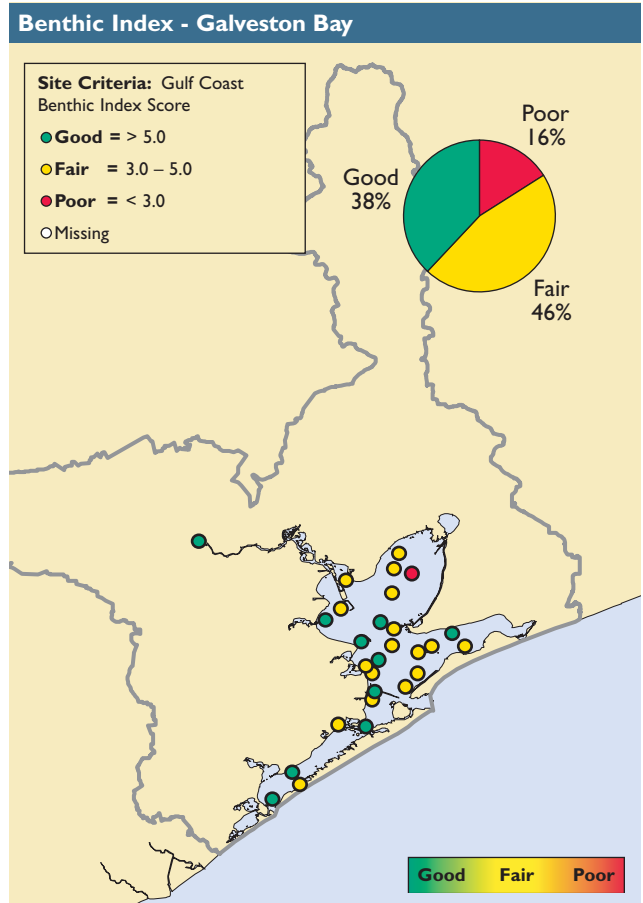


Figure 5-57. Benthic index data for Galveston Bay, 2000–2001 (U.S. EPA/NCA).



Fish Tissue Contaminants Index

The fish tissue contaminants index for Galveston Bay is rated good to fair. Figure 5-58 shows that 11% of all stations sampled where fish were caught exceeded the EPA Advisory Guidance values used in this assessment and were rated poor.

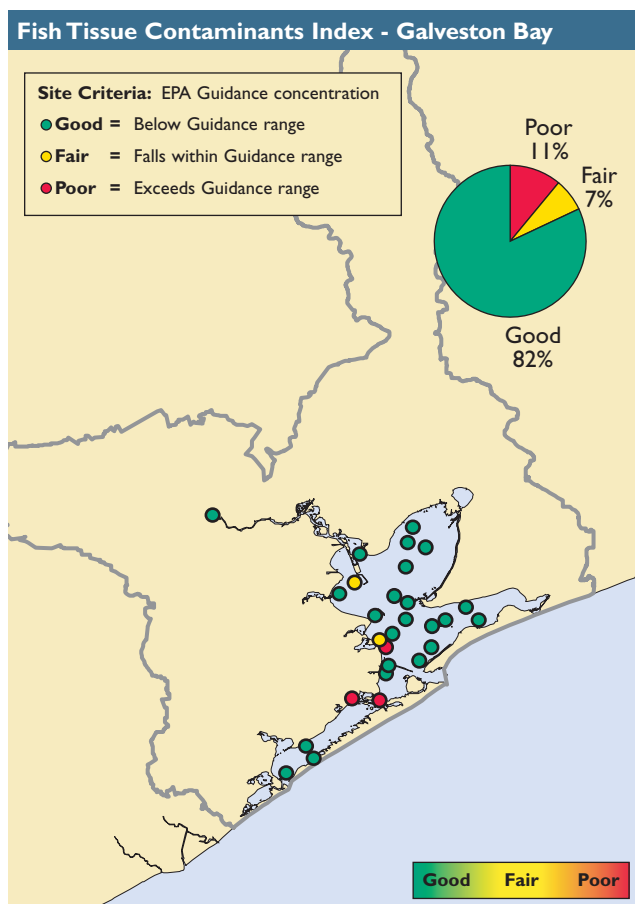


Figure 5-58. Fish tissue contaminants index data for Galveston Bay, 2000–2001 (U.S. EPA/NCA).

Galveston Bay Estuary Program Indicators of Estuarine Condition

The GBEP implements a regional monitoring program to foster effective cooperation by all agencies that participate in monitoring activities for Galveston Bay and to help prevent duplication of effort. Through the coordination of monitoring efforts, the GBEP’s regional monitoring program ensures that data are available to assess trends in ecological condition and

provides online access to this data at <http://www.gbep.state.tx.us>. The GBEP partners include the TCEQ Surface Water Quality Monitoring Program, which collects data describing surface water quality, sediment quality, and benthic organisms; the Texas Clean Rivers Program (administered locally by the Houston-Galveston Area Council), which collects water quality data; and the TPWD, which collects fishery independent and dependent data, as well as data on fish tissue contamination, water quality, and sediment quality in conjunction with the NCA. Other monitoring data tracked by the GBEP include oil spill incidents (Texas General Land Office [GLO]), colonial nesting bird counts (FWS), freshwater inflows (Texas Water Development Board), and fish advisories, oyster harvest area closures, and illnesses related to seafood consumption (Texas Department of State Health Services [DSHS]).

Water and Sediment Quality

The GBEP’s formal indicators for monitoring water quality conditions in the estuary include dissolved oxygen, nitrogen (e.g., nitrate, nitrite, ammonia), total phosphorus, chlorophyll *a*, total suspended solids/turbidity, salinity, water temperature, pH, pathogens (e.g., *Enterococci*, fecal coliform), BOD, and TOC. Of the five subbays in the GBEP study area, only Christmas Bay exhibited a slightly increasing trend in dissolved oxygen concentrations, which rose from 7.0 to 8.0 mg/L between 1969 and 2001 (Lester and Gonzalez, 2003).

To help measure changes in nutrient levels over time, the TCEQ monitors ammonia, total nitrogen, and total phosphorus. Declines in annual average ammonia levels have been observed in several areas of Galveston Bay, with the most dramatic decline seen in the Houston Ship Channel. For the most part, annual average concentrations remain below screening levels. Nitrate-nitrite concentrations were highest in the Houston Ship Channel, which demonstrated an increasing trend from about 0 mg/L in 1969 to 1.75 mg/L in 2001. The Intracoastal Waterway East exhibited a significant declining trend in nitrate-nitrite, and the Trinity River had a significant declining trend in phosphorus (since 1969), which has slowed in recent years. None of the five subbays of Galveston Bay showed trends exceeding

the estuarine screening levels for nutrients (Lester and Gonzalez, 2003).

Annual average concentrations of chlorophyll *a* have declined across all Galveston Bay subbays and tributaries since 1969, with the largest decreasing trend in chlorophyll *a* concentrations found in the Houston Ship Channel, San Jacinto River, and Texas City Ship Channel. Monthly average concentrations of chlorophyll *a* did not show a significant trend in any of the five subbays in Galveston Bay. NCA data collected in 2000 and 2001 for the West Bay region had annual averages similar to those of the TCEQ data, but chlorophyll *a* concentrations were slightly higher in this region (Lester and Gonzalez, 2003).

The Galveston Bay Indicators Project rates the area's subbays and tributaries based on the percentage of data samples that exceed the state's screening criteria (Figure 5-59). Using water quality screening levels developed by the TCEQ and indicator criteria developed specifically for Galveston Bay, the project rates Galveston Bay water quality (for nutrients and chlorophyll *a*) in the subbays as moderate to good for the period 1990–2003, as

compared to the poor rating based on NCA survey data for 2000–2001 (Lester and Gonzalez, 2005). It should be noted that the DIN and DIP criteria used by the NCA survey are much more stringent than those used by the State of Texas; TCEQ estuarine screening levels for nitrogen and phosphorus are 0.26 and 0.22 mg/L, respectively. In addition, NCA sampling does not differentiate between criteria levels for Bay versus tributary waters. Nutrients in Galveston Bay proper remain fairly constant during the year; however, nutrient concentrations in Galveston Bay tributaries are highest in the summer months, when NCA data are collected. In the Galveston Bay Indicators Project evaluation, the tributary Buffalo Bayou was the only Bay segment to receive a poor rating for nutrients and chlorophyll *a* data because it exceeded the screening level more than 30% of the time between 2000 and 2003. It is also worth noting the improving trend overall for Galveston Bay since the 1970s (Lester and Gonzalez, 2005); however, the TCEQ is currently reviewing its estuarine nutrient criteria, which might change the results for this indicator.

Nutrients and Chlorophyll *a* Concentrations

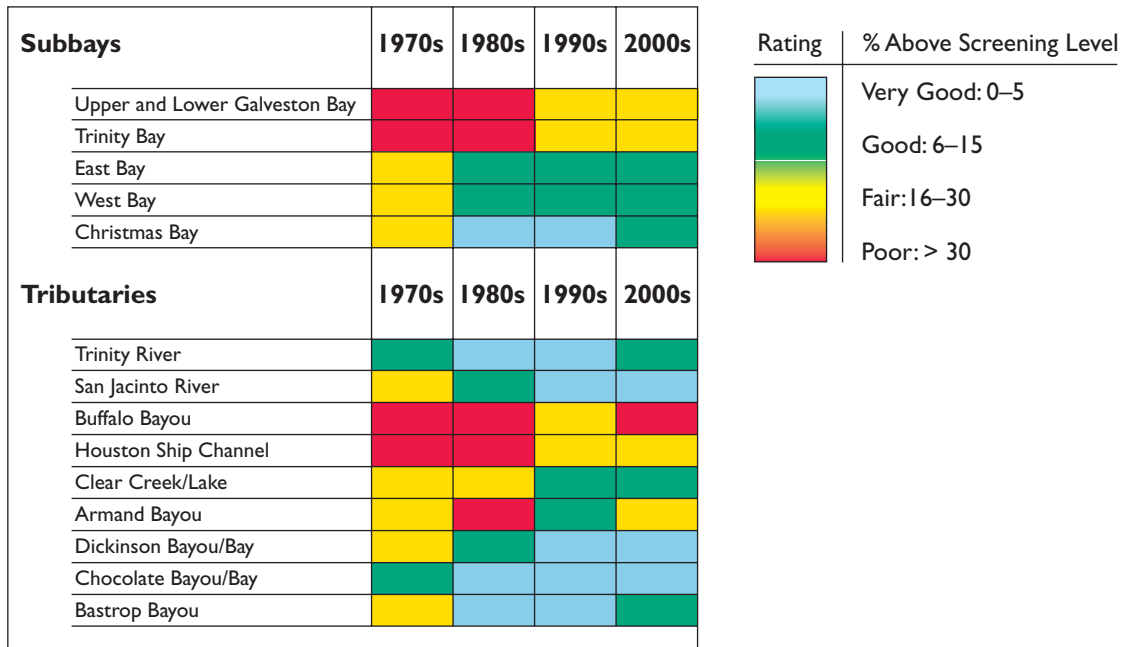


Figure 5-59. TCEQ water quality ratings for Galveston Bay nutrients and chlorophyll *a* concentrations (Lester and Gonzalez, 2005).

HIGHLIGHT

Case Study on Changes in Freshwater Wetland Habitat

The Galveston Bay region is attracting a growing urban and industrial sector, and the region's population is expected to double to approximately 8 million by 2025 (Sage and Gallaway, 2002; H-GAC, 2003). The Galveston Bay watershed contains a wealth of unique freshwater wetland complexes that provide critical human and ecological services, including attenuation of water pollution, floodwater retention, wildlife habitat, and recreational opportunities. The GBEP recognizes that preserving these valuable resources requires a better understanding of the status and trends of the wetland habitat; therefore, the GBEP partnered with the Texas Coastal Watershed Program of the Texas Cooperative

Extension in 2003 to determine the status and trends in the wetlands of Galveston Bay.

To perform a wetlands analysis, the partners conducted an inventory that was similar to the FWS's NWI program. The last FWS NWI for the Galveston Bay region was completed in 1992; however, the 1992 data are not directly comparable to those gathered during the new wetland inventory. The methods of identifying wetland areas have improved since the 1992 NWI, and the new inventory might identify areas that were missed in 1992. To account for this, the GBEP and Texas Cooperative Extension chose to consider the 1992 NWI data as a subset of the wetlands in the region at the time. To analyze changes in the wetlands, these data were directly compared to aerial photographs of the same areas taken in 2000 or 2002 as part of the new inventory.

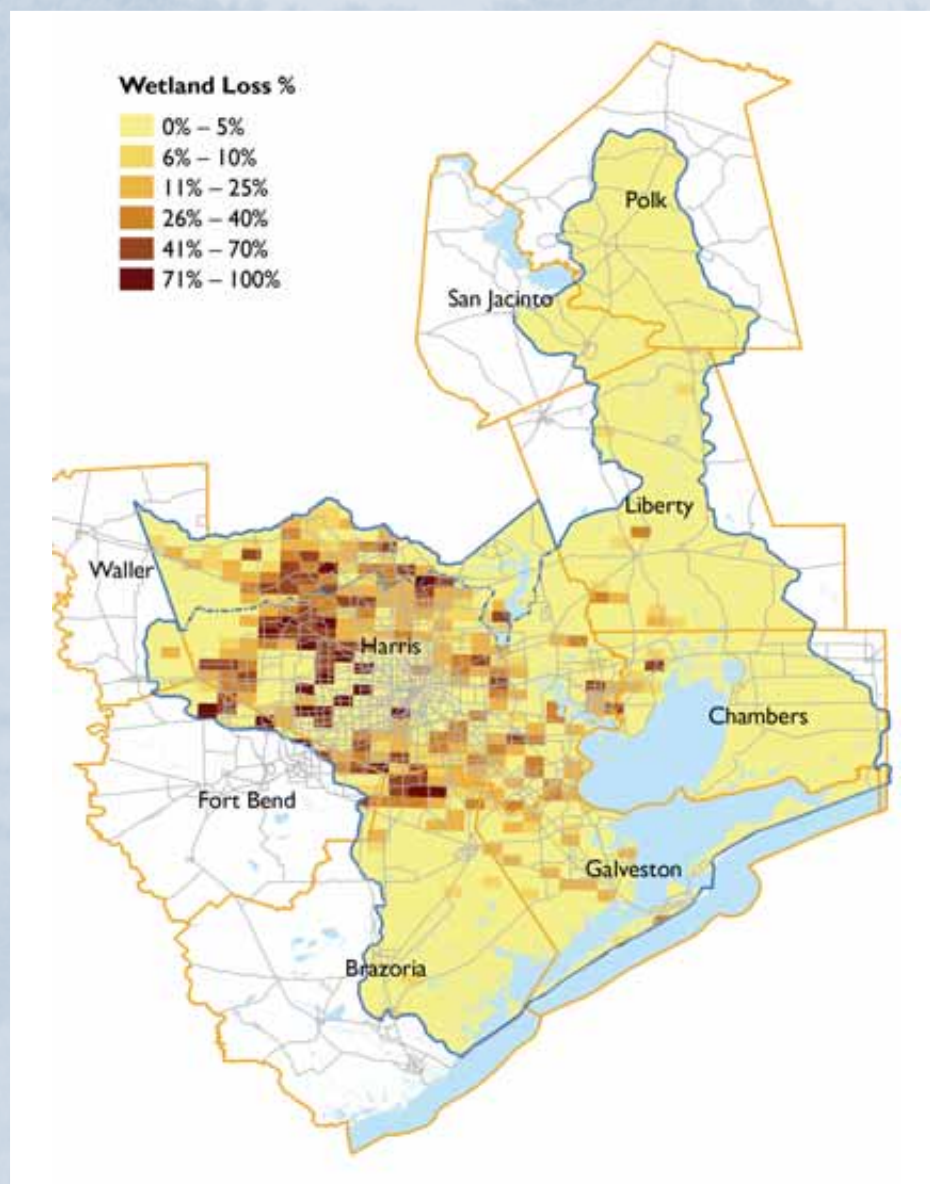


Coastal prairie wetlands in Texas (Dr. John Jacobs, Texas Cooperative Extension/Texas Sea Grant).

In 1992, the Galveston Bay watershed contained 294,556 acres of freshwater, non-tidal wetlands (e.g., palustrine, lacustrine, riverine). The new inventory results showed that 285,432 acres remained in the subset, representing a loss of 9,124 acres or 3.1%. These losses were attributed to industrial, commercial, and residential development (70%); fill activities (26%); and open-water development, such as man-made ponds and lakes (3%). These loss estimates are conservative figures, and resource experts believe that actual losses are much higher due to the wetland areas that were likely

missed in the 1992 NWI. Consistent with the pattern of urban growth spreading into more rural areas, the greatest wetland losses (13%) occurred in Harris County, which includes the city of Houston (see figure) (Jacob and Lopez, 2005).

The results of the GBEP/Texas Cooperative Extension inventory study will be used to educate citizens on the implications of wetland loss, as well as to work with local governments and others to identify key parcels for preservation.



Wetland loss due to urban growth (Jacob and Lopez, 2005).

Total suspended solids showed declining trends in annual average concentrations across all subbays and tributaries of the Galveston Bay system, with the exception of Upper Galveston Bay, Lower Galveston Bay, and Cedar Bayou (Lester and Gonzalez, 2003). Galveston Bay is naturally turbid because of its shallow depth and fine sediments; however, dredging activities, commercial fisheries, and natural and man-made erosion assist in promoting this turbid nature.

The pathogen indicators monitored by the TCEQ in Galveston Bay are *Enterococci*, *E. coli*, and fecal coliform, with concentrations of fecal coliform sampled since 1973. According to the 2005 Galveston Bay Indicators Project, the areas of Galveston Bay with the greatest number of TCEQ criteria-level exceedences for fecal coliform bacteria are Buffalo Bayou, the Houston Ship Channel, Clear Creek, and Dickinson Bayou (Figure 5-60). In addition, Buffalo Bayou, White Oak Bayou, and Dickinson Bayou are the subjects of ongoing TMDL studies (Lester and Gonzalez, 2005). A declining trend in fecal coliform was found in the East Intracoastal Waterway area, but the other four major subareas of the Bay did not show a significant trend for fecal coliform. Elevated concentrations of fecal coliform in the middle reach of Bastrop Bayou have drawn

considerable attention from the public in the past. The areas with the highest concentrations of *Enterococci* were the Houston Ship Channel, East Intracoastal Waterway, San Jacinto River, and Trinity Bay, whereas areas with the lowest concentrations were the Galveston Channel, Texas City Channel, Christmas Bay, Bastrop Bayou Complex, Dickinson Bayou/Dickinson Bay, and East Bay (Lester and Gonzalez, 2003).

Organic matter content in Galveston Bay is measured as TOC, and annual average TOC concentrations have declined in all subbays and tributaries of Galveston Bay since 1973. The TCEQ also reports five-day BOD to help measure the breakdown and decomposition of organic matter in the Bay. Sufficient data only exist for three of the five subbays in Galveston Bay, and none of these subbays exhibited significant trends for BOD (Lester and Gonzalez, 2003). This finding aligns with NCA data, which found Galveston Bay to be in good condition for TOC concentrations.

In Galveston Bay, sediments, metals, and commonly measured organic compounds appear to follow the same general spatial distribution, as do most of the other water quality parameters. Elevated concentrations of these contaminants occur in regions of runoff, fresh-water inflow, and waste discharges, and lower, relatively

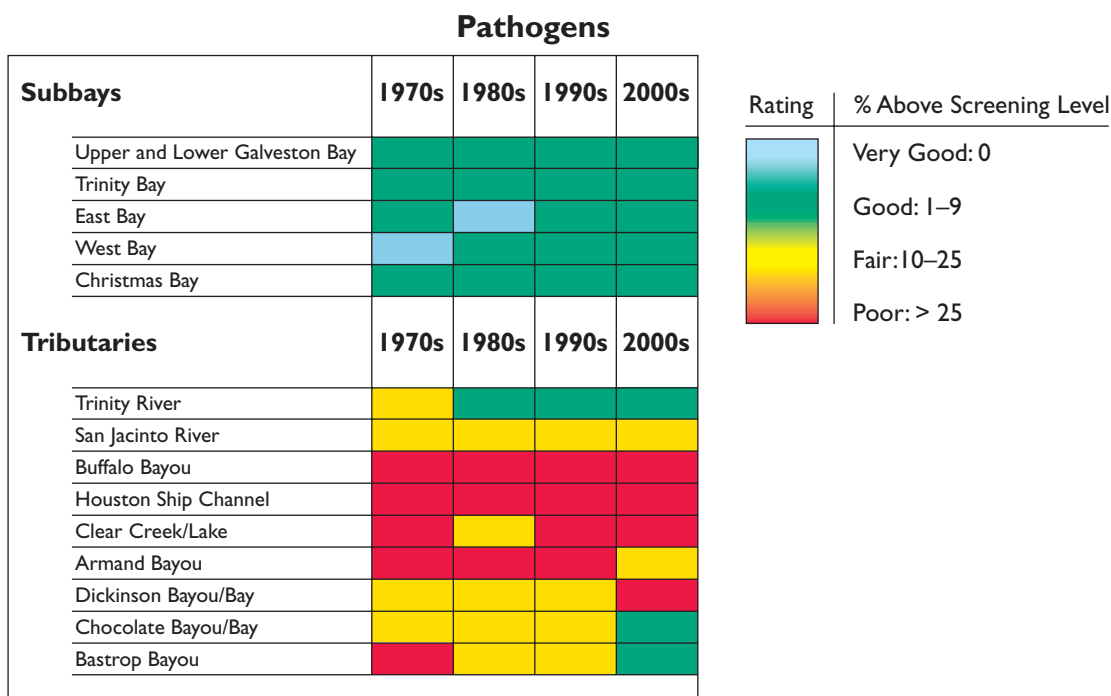


Figure 5-60. TCEQ water quality ratings for Galveston Bay pathogens (Lester and Gonzalez, 2005).

uniform concentrations occur in the open bay. The upper Houston Ship Channel generally has the maximal concentration of these contaminants (Lester and Gonzalez, 2005).

Habitat Quality

Wetland loss and declines in SAV are of significant concern for the GBEP, but support from federal, state, and local agencies; area non-profit organizations; and industry activities are slowly helping to mitigate losses through restoration and preservation. *The Galveston Bay Plan* calls for the restoration of 8,600 acres of estuary marsh and 1,400 acres of SAV (GBNEP, 1995).

Wetland loss between 1950 and 1989 has been estimated to be between 700 and 1,000 acres a year, or a net loss of over 30,000 acres (White et al., 1993). The total acreage of wetlands lost to dredge-and-fill activities over time has increased to 20% of the net losses estimated for Galveston Bay (Sage and Gallaway, 2002). A recent estuarine wetland inventory indicated that more than 1,181 of the 118,072 acres of emergent marsh identified in 1995 were lost by 2002. The loss of approximately 830 of these acres was induced by human activities (Webb, 2005). The GBEP continues to work with its partners to monitor trends in wetlands loss.

Salinity, turbidity, and rainfall patterns seem to be the controlling factors for natural seagrass growth in

Galveston Bay. In the 1950s, SAV was estimated at 2,500 acres; in 1989, SAV was estimated to be approximately 700 acres—more than a 70% decline. Since 1989, evidence suggests a rebound, with new areas being established adjacent to wetland restoration sites in West Bay (Sage and Gallaway, 2002).

Living Resources

The GBEP uses several indicators to measure trends in living resources. Data are collected from a variety of sources, including the TPWD, Texas DSHS, and FWS. These indicators are the following:

- Abundance of selected colonial waterbird species (e.g., great blue heron, white ibis)
- Abundance of selected finfish species (i.e., measured from bag seine, shrimp trawl, or gill net)
- Episodes of seafood contamination and issuance of advisories (e.g., oyster harvest-area closures, fish consumption advisories, and elevated chemical contaminant levels in fish tissue).

Figure 5-61 shows 20-year population trends for several bird and finfish species monitored in the GBEP study area. Of the 19 species of colonial nesting water birds tracked between 1973 and 2001, 9 exhibit negative trends, whereas others appear stable or are

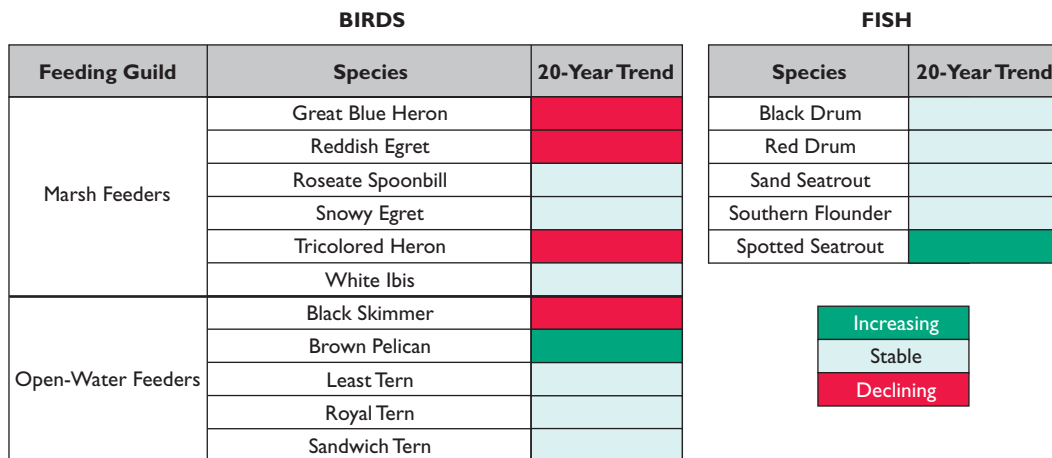


Figure 5-61. Bird and finfish population trends in Galveston Bay (Lester and Gonzalez, 2005).

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increasing. As with other parts of the country, brown pelicans have been a success story in returning from the brink of extinction (HARC, 2005a). Significant declines in blue crab numbers have been noted in West Bay. Gulf killifish have demonstrated a significant decline in the estuary and could indicate a declining quantity of fringing wetlands. Bay anchovy have demonstrated a significant increasing trend in West Bay, and pink shrimp have demonstrated a significant increasing trend in Upper and Lower Galveston Bay (Lester and Gonzalez, 2003). For areas of the Houston Ship Channel and Upper Galveston Bay, the Texas DSHS has issued several seafood consumption advisories for contaminants, including PCBs and dioxins, in species

such as blue crab, catfish, and speckled trout (Figure 5-62) (Lester and Gonzalez, 2005).

Environmental Stressors

The GBEP’s regional monitoring program also uses human activities as indicators to assess the health of the estuary. The Texas GLO has monitored the amount, type, date, and location of 11 petroleum products spilled into the waters of 4 counties in the Galveston Bay watershed (Brazoria, Chambers, Galveston, and Harris). Between 1998 and 2002, a total of 262,010 gallons of petroleum products were spilled into the waters of Galveston Bay (Lester and Gonzalez, 2003).

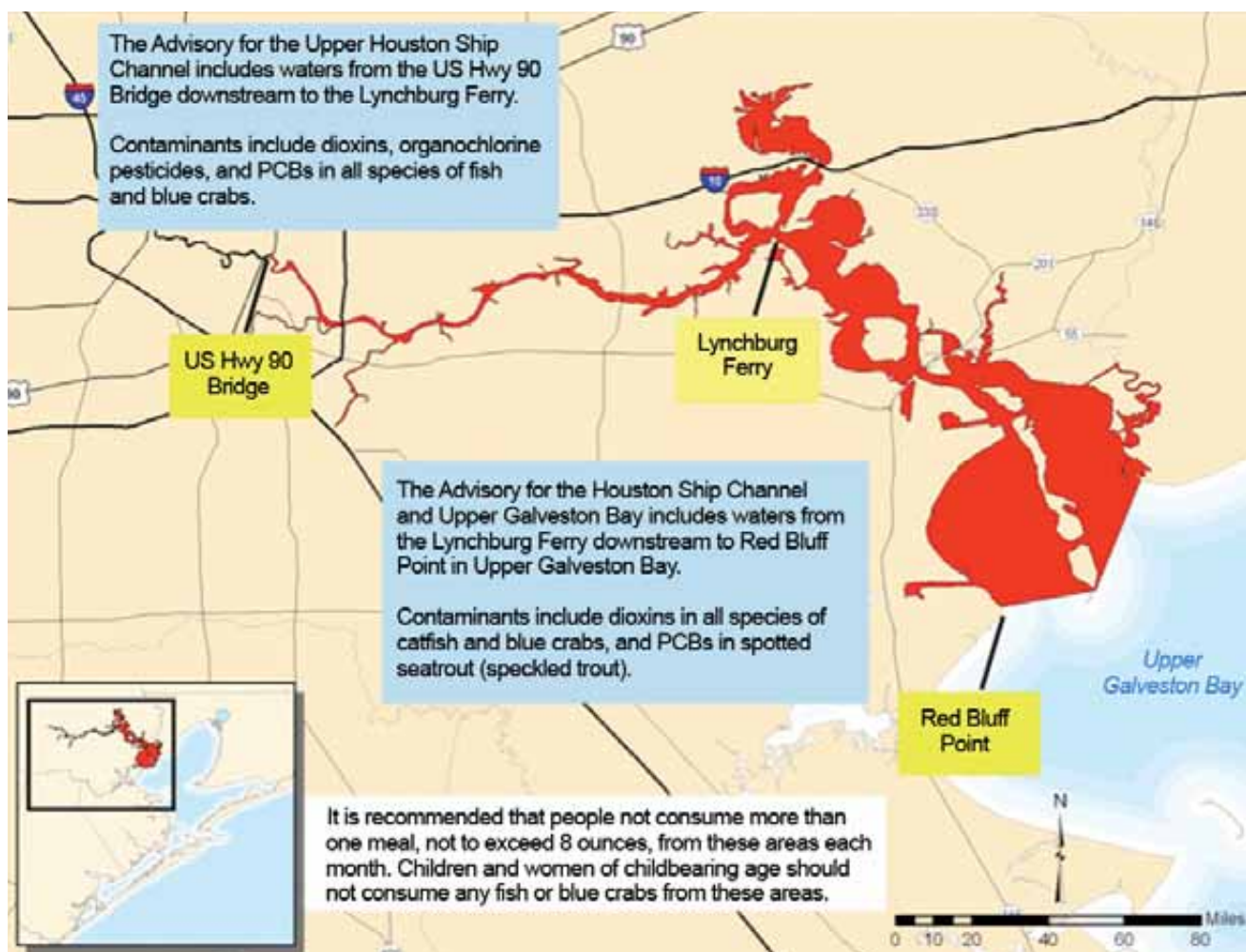


Figure 5-62. Seafood consumption advisory areas designated in 1990, 2001, and 2005 (Lester and Gonzalez, 2005).

Current Projects, Accomplishments, and Future Goals

To protect and restore wetland habitats, the GBEP is encouraging better use of dredge material. When disposed of improperly, dredge materials can adversely modify wetland habitats; however, these materials also can be beneficial if used to create, restore, or enhance estuary habitats (e.g., bird rookery islands). The efforts of the GBEP and its partners have led to the restoration of 8,000 acres of habitat (Personal communication, Johnston, 2006). The GBEP is also working with local governments toward increasing wetland and habitat conservation through the promotion of water quality, recreation, and flood-control benefits and by assisting with grant writing and the development of stormwater management plans. Other priorities of the GBEP include controlling harmful exotic species; promoting water conservation, stormwater management, and technical assistance programs; assessing the safety of consuming seafood from Galveston Bay; and assisting septic system owners and small WWTP operators. Some of the invasive species of highest ecological

concern in Galveston Bay include Chinese tallow, giant salvinia, *Hydrilla*, red imported fire ant, Brazilian pepper, water hyacinth, and channeled apple snail.

Conclusion

Based on data from the NCA estuarine survey, the overall condition of Galveston Bay is rated fair. Data from the GBEP and its partners indicate that, in spite of the large human population and increasing resource demands, Galveston Bay remains productive and, for the most part, healthy. The Bay as a whole is not threatened by eutrophication, and nutrient concentrations are decreasing in many areas of this estuary. Several aquatic species exhibit stable trends in abundance. Galveston Bay is not rapidly degrading in terms of increasing concentrations of toxic or organic pollutants; rather, trends in pollution are mixed. Concentrations of contaminants are decreasing in the most polluted areas of the Bay, but are rising in other areas. Even with these stable and, in some cases, improving trends, focus remains on strategic habitat conservation and pollution control as the region's population continues to expand and land-use patterns trend towards urbanization.



Extensive oyster reefs are found in Galveston Bay (Texas Sea Grant College Program).