Most of our efforts to follow habitat change have been focused on wetlands. It would be easier to follow the change of more recognizable habitats, like forest, but it does not have the same direct significance for the bay. It is also nearly as difficult to classify grassland habitats as it is to classify wetlands. Most classifications can not differentiate golf course fairways and improved pasture from natural prairies. In any case, the change in methodology over classifications obviates a long term trend analysis for habitat acreage. The scientific and resource management community will continue to be limited by the episodic nature of land cover change analysis until an organization makes a commitment to continued, standardized image collection and analysis.

3.5 Other Indicators of Bay Health

3.5.1 Seafood Safety

The role of public agencies in protecting the public from health hazards associated with the bay falls into two categories. The Galveston Bay Plan incorporates in its goals the need for reducing the risk of illness (a) from the consumption of seafood harvested from the bay or its tributaries and (b) from contact with or ingestion of the water in the bay and its tributaries. The Texas Department of State Health Services (DSHS) (formerly known as the Texas Department of Health) tracks illnesses associated with consumption of contaminated seafood and operates monitoring programs designed to alert the public to potential risks and to manage exposure to contaminated seafood.

The risk of illness from contaminated seafood is low, but there are occasional outbreaks of infectious diseases, particularly due to several types of bacteria in the *Vibrio* group. *Vibrio vulnificus* is a naturally occurring bacterium that can be contracted from consumption of oysters or from contact between Bay water and an open wound. It can be fatal to sensitive individuals, especially those with damaged livers or compromised immune systems. In 1998 more than 400 people became ill during an outbreak of a related bacteria, *Vibrio parahaemolyticus*, contracted from consumption of oysters. The bacterial strain was one previously found only in East Asia. It was likely discharged into Galveston Bay through ballast water of a ship transporting goods from Asia. Galveston Bay has the potential to host other pathogenic bacterial strains, e.g. *Vibrio cholera*, and viruses such as polio and hepatitis. Consumption of raw oysters is considered a potential pathway for these organisms to infect humans.

Another form of risk from consumption of seafood is the content of hazardous chemicals in the flesh of fish and shellfish. The DSHS monitors the contamination of fish and crabs in the Galveston Bay system with the support of the Galveston Bay Estuary Program. Many compounds are tested, but they can be summarized in two ways: chemical nature and health effect. DSHS tests samples for toxic metals, pesticides, volatile and semi-volatile organic compounds. Most of the organic compounds are tested because they are believed to carry a risk of increased probability of cancer development. Metals, pesticides and some organics are monitored because they can damage a variety of organ systems.

Illness or death from exposure via contact to water of the bay system is very rare, but could occur in some areas. TCEQ and several local agencies monitor the water and sediment quality at multiple locations in the bay system. Monitoring has shown that several of the tributaries have potentially harmful levels of contamination by fecal coliforms; bacteria that normally reside in the intestinal tracts of mammals and birds. They serve as indicators of possible sewage pollution. Sewage contamination is often associated with storm events when rainfall causes sewage treatment plants and collection systems to overflow or sewage from underground septic systems to percolate to the surface. When severe flooding results in the inundation of houses, many people have contact with water that is contaminated with pathogens and chemical pollutants.

Historical Data Trends

There are several ways to look at the historical patterns of the relationship between human health and Galveston Bay. Prior to the advent of water purification plants for drinking water, there were frequent outbreaks of waterborne diseases in the Galveston Bay watershed. Today if drinking water is obtained from a municipal system it has been treated to minimize the likelihood of infectious organisms and monitored for chemical pollutants. On the other hand, seafood harvested from the bay more than 100 years ago was rarely a risk if consumed soon after harvest. The risk from consuming seafood from the bay that is contaminated with microorganisms appears to have increased. Certainly the risk of consuming seafood contaminated with pesticides or toxic chemicals has increased over the last 100 years.

The record of monitoring for public health reasons goes backs to the 1950's. Over the period of record, fecal coliform contamination has increased in some tributaries and has been quite variable in the various sub-bays. It is difficult to obtain a historical pattern from the monitoring data on contamination of seafood with metals and organic chemicals. One problem is a bias in the sampling. There is no random monitoring. Sampling sites are located in areas that are most likely to have contamination problems.

Status in the Lower Galveston Bay Watershed

Chemical Contamination of Seafood

The DSHS conducted a series of health consultations for the Galveston Bay system in the years 1998 through 2000. Muscle tissue of adult fish and composite samples of blue crab captured by gill net at various locations were tested for multiple contaminants. Contaminant concentrations were analyzed by the DSHS using standard methodologies. Measured concentrations for each of the tested compounds were compared to a health assessment value obtained from publications of DSHS. Health-based assessment comparison (HAC) values are used by the DSHS to issue seafood consumption advisories. HACs set a conservative limit for safe seafood consumption because they assume frequent consumption of substantial servings.

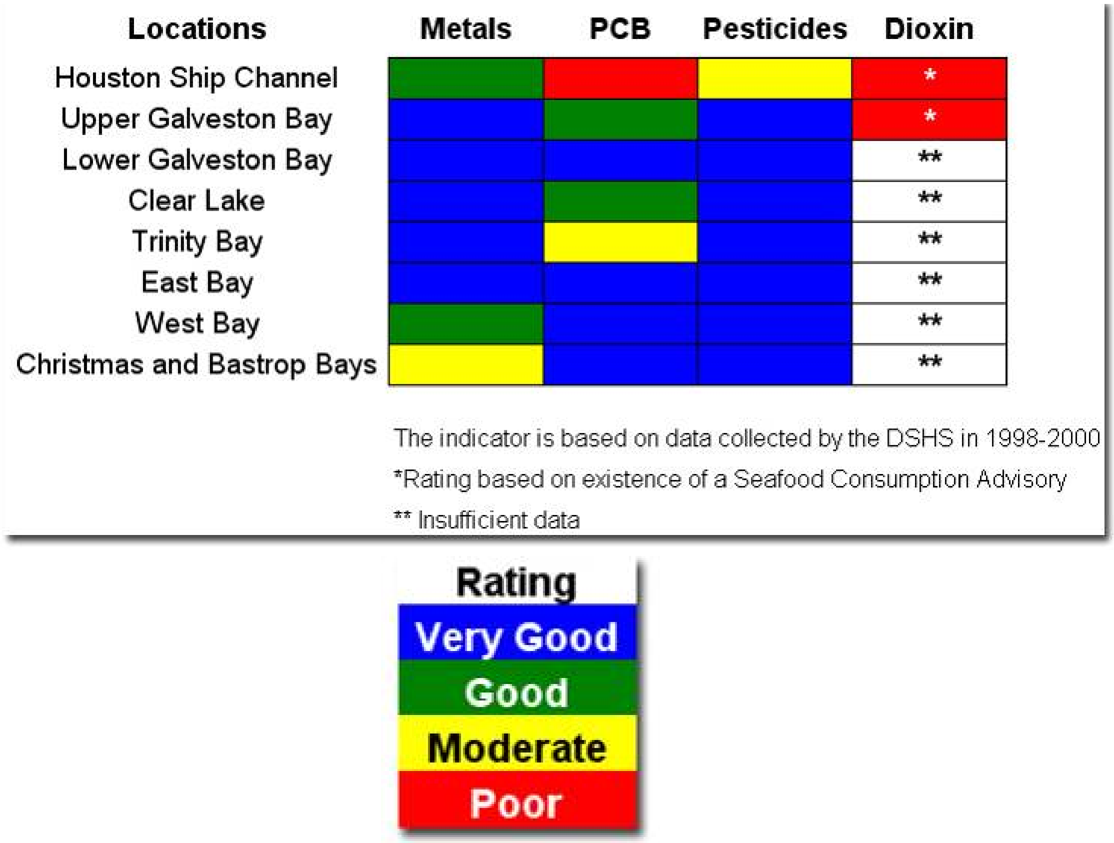
The Galveston Bay Indicators Project calculated risk ratios based on a comparison of average concentrations of selected contaminants to their respective HAC values. A risk ratio equal to one meant that the average concentration of a contaminant was equal to the value at which DSHS considers issuing a seafood consumption advisory. The indicator's rating system suggests that risk increases as the concentration of contaminants detected in the seafood increases. It does not recognize a threshold effect in terms of risk from consumption. However, the relationship between concentration of contaminants and safety of seafood consumption is not simple and may involve thresholds for health effects. This scoring method is a simple way to compile the results over multiple compounds. The DSHS remains the primary source for advisories of seafood consumption.

The compounds depicted in Table 3.5.1 represent a range of potential health impacts. The various compounds and metals are known or suspected to cause acute or chronic diseases of the nervous, circulatory, endocrine and other systems of the body. The compounds have the potential to be more damaging in combination than alone, but very little research has been done on synergistic effects of pollutants.

Risk from metal contamination is based on data collected for cadmium, mercury, and zinc. While other metals were detected, cadmium, mercury, and zinc have been extensively evaluated for health impacts and HACs are readily available.

Pesticides selected for inclusion in the indicator were chlordane, DDE, dieldrin, heptachlor epoxide and hexachlorobenzene. These compounds are the most commonly detected pesticide contaminants in the DSHS data. Inclusion of more pesticides in the calculation of the indicator would not significantly change the risk level or the relationship among locations in the bay. The risk indicator for PCB contamination of Galveston Bay seafood is calculated using the HAC value for all PCBs and based on tissue concentrations of a single compound, Aroclor 1260.

Table 3.5.1. Rating of risk from consumption of contaminants in fish captured in various parts of the Galveston Bay system. Data source: Texas Department of State Health Services.



Bacterial Contamination of Water

Fecal coliform bacteria are monitored as an indication of the probability of the presence of human pathogens. Unfortunately, other mammals and birds excrete bacteria that are detected by this test. Therefore, sources of fecal coliform bacteria are difficult to determine. Concentrations of fecal coliforms are monitored by the TCEQ for assessment of water quality.

Monitoring records were separated into subbay and tributary depending on the type of water body from which samples were collected. The percentage of samples exceeding the TCEQ screening level for fecal coliform bacteria (400 colonies per 100 mL) was calculated by decade for selected subbays and tributaries. The percentage of samples exceeding the screening level in each subbay and tributary was then evaluated according to a rating system established by the Galveston Bay Indicators Project (see Table 2).

As seen in the Table below, the subbays of Galveston Bay rate “good” with nine percent or less of the samples exceeding the fecal coliform bacteria screening level. For the years 2000-2003, four areas rated “poor” for fecal coliform bacteria: Buffalo Bayou, the Houston Ship Channel, Clear Creek, and Dickinson Bay/Bayou. The San Jacinto River, Armand Bayou and Bastrop Bay rated “moderate”.

Table 3.5.2. Rating of water quality with regards to fecal coliform bacteria in the major subbays and tributaries of Galveston Bay over the last four decades. Data source: Texas Commission on Environmental Quality.

SUBBAYS	1970s	1980s	1990s	2000s
Upper and Lower Galveston Bay	Good	Good	Good	Good
Trinity Bay	Good	Good	Good	Good
East Bay	Good	Very Good	Good	Good
West Bay	Very Good	Good	Good	Good
Christmas Bay	Good	Good	Good	Good
TRIBUTARIES	**1970s**	**1980s**	**1990s**	**2000s**
Trinity River	Moderate	Good	Good	Good
San Jacinto River	Moderate	Moderate	Moderate	Moderate
Buffalo Bayou	Poor	Poor	Poor	Poor
Houston Ship Channel	Poor	Poor	Poor	Poor
Clear Creek/Lake	Poor	Moderate	Poor	Poor
Armand Bayou	Poor	Poor	Poor	Moderate
Dickinson Bayou/Bay	Moderate	Moderate	Moderate	Poor
Chocolate Bayou/Bay	Moderate	Moderate	Moderate	Good
Bastrop Bayou	Poor	Moderate	Moderate	Good

Rating	% Above Screening Level
Very Good	0
Good	1-9
Moderate	10-25
Poor	>25

Bacterial Concentrations in Shellfish Waters

Harvest of shellfish is regulated according to the likelihood that shellfish will be contaminated with human pathogens. The determination of how to classify an area is made based on the record of monitoring for fecal coliforms. Shellfish harvest areas are classified as approved, conditionally approved, restricted or prohibited. DSHS reviews the classification periodically and issues new classifications. Recent classification of shellfish waters in 1996, 2000 and 2003 were compared in Figure 3.5.1. Surface water acreages were calculated for each category in each year selected and are shown for the classifications approved, conditionally approved and restricted in the chart below. Prohibited areas are very unlikely to change. So that category was omitted. Figure 2 shows that there has been a decrease in the acres of water that are restricted for shellfish harvest.

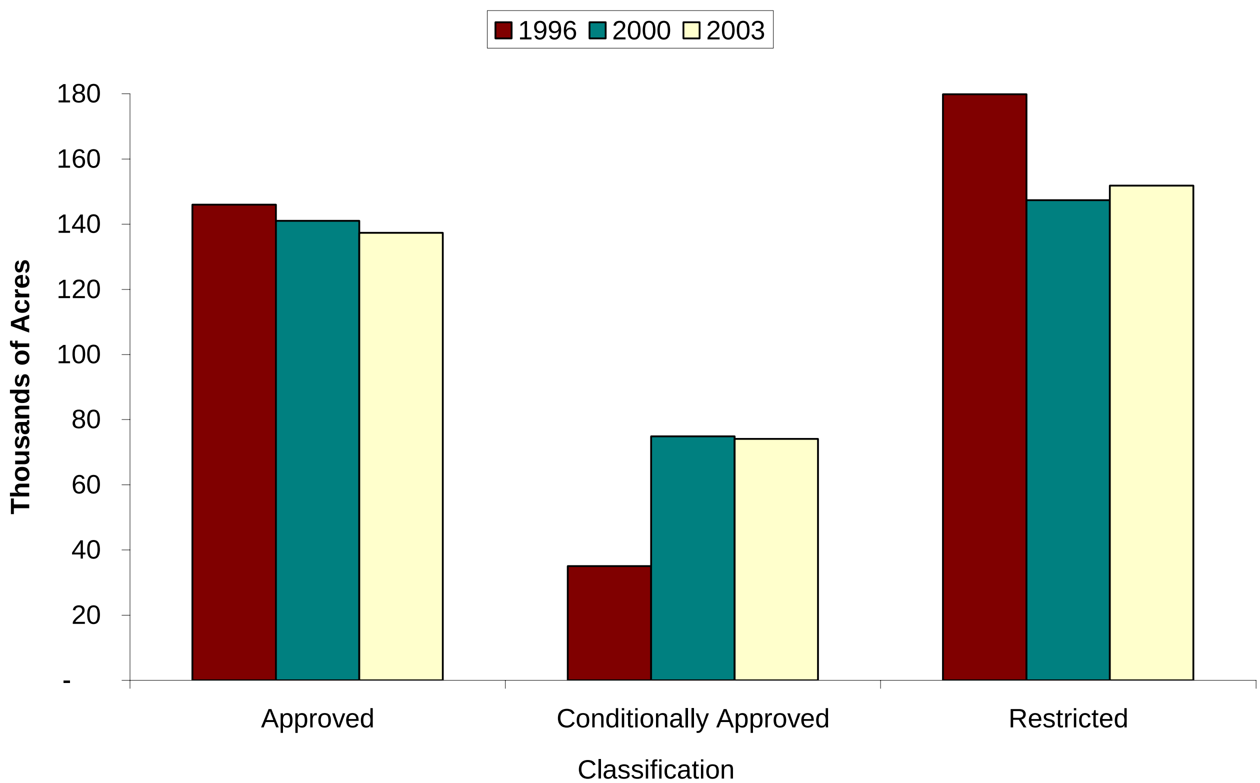


Figure 3.5.1. Comparison of DSHS Approved, Conditionally Approved, and Restricted Shellfish Harvest Areas in Galveston Bay for the Years 1996, 2000, and 2003. Data source: Texas Department of State Health Services.

3.5.2 Colonial Nesting Waterbirds

Galveston Bay serves as a major nesting area for many species of colonial waterbirds. As the name implies, colonial waterbirds require aquatic habitat to complete their life cycle. Colonial waterbirds rely upon a plentiful food supply found in the open bay, mud flats, emergent salt marshes, and seagrass beds. They can also be found feeding along the shores of local bayous, riparian forests (forests near the banks of bayous and streams), and emergent freshwater wetlands.

Colonial waterbirds nest in colonies that range in size from just a few to thousands of nesting pairs. Nesting sites are often in remote areas such as bird islands, isolated stretches of beach, and dense wetlands. This helps to protect breeding adults and fledglings from predators and human disturbance. The nesting season in Galveston Bay is February through August.

The reproductive success of colonial waterbirds is dependent upon the availability of suitable habitat free from disturbance. The following have negative impacts on colonial waterbird populations in Galveston Bay:

- Human disturbance of nesting sites, especially during nesting season
- Habitat loss:
    - Erosion of nesting islands due to dredging, vessel wakes, and loss of shoreline vegetation
    - Subsidence of nesting habitat and conversion to open water
    - Conversion and loss of foraging habitat
- Mortality of colonial waterbird hatchlings due to predation by red-imported fire ants and other animals.

Data describing colonial waterbird populations for the Texas coast are collected by volunteers on an annual basis and are maintained by the U.S. Fish and Wildlife Service Texas Colonial Waterbird Census. In 2006, the Galveston Bay Status and Trends Project analyzed the data for trends in colonial waterbird populations. The database reported nesting pair abundance for 30 species of colonial waterbirds observed at 131 nesting colonies in Galveston Bay during the years 1973-2005.

The indicator below (Table 3.5.3) shows the twenty year trends ($R^2 \geq$ is 0.25) in population abundance for 15 species of colonial waterbirds (eight marsh feeding and seven open water feeding species).

Table 3.5.3. Indicator describing the twenty-year trend in abundance of colonial waterbird nesting pairs.

Feeding Habitat	Species	20 Year Trend (1986-2005)
Marsh	Black-crowned Night Heron	
	Great Blue Heron	
	Reddish Egret	
	Roseate Spoonbill	
	Snowy Egret	
	Tri-colored Heron	
	White Ibis	
	White-Faced Ibis	
Open Water	Black Skimmer	
	Brown Pelican	
	Laughing Gull	
	Least Tern	
	Neotropic Cormorant	
	Royal Tern	
	Sandwich Tern	

Rating	Trend in Abundance of Nesting Pairs Over 20 Years
Good	Significantly increasing
Stable	No trend
Poor	Significantly decreasing

As seen in Table 3.5.3, four species of marsh feeding colonial waterbirds exhibit declining trends: black-crowned night heron, great blue heron, tri-colored heron, and white-faced ibis. Additionally, two species of open water feeders (laughing gull and neotropic cormorant) exhibit declining trends. Brown pelican continues to show an increase in the number nesting pairs (Figure 3.5.2).

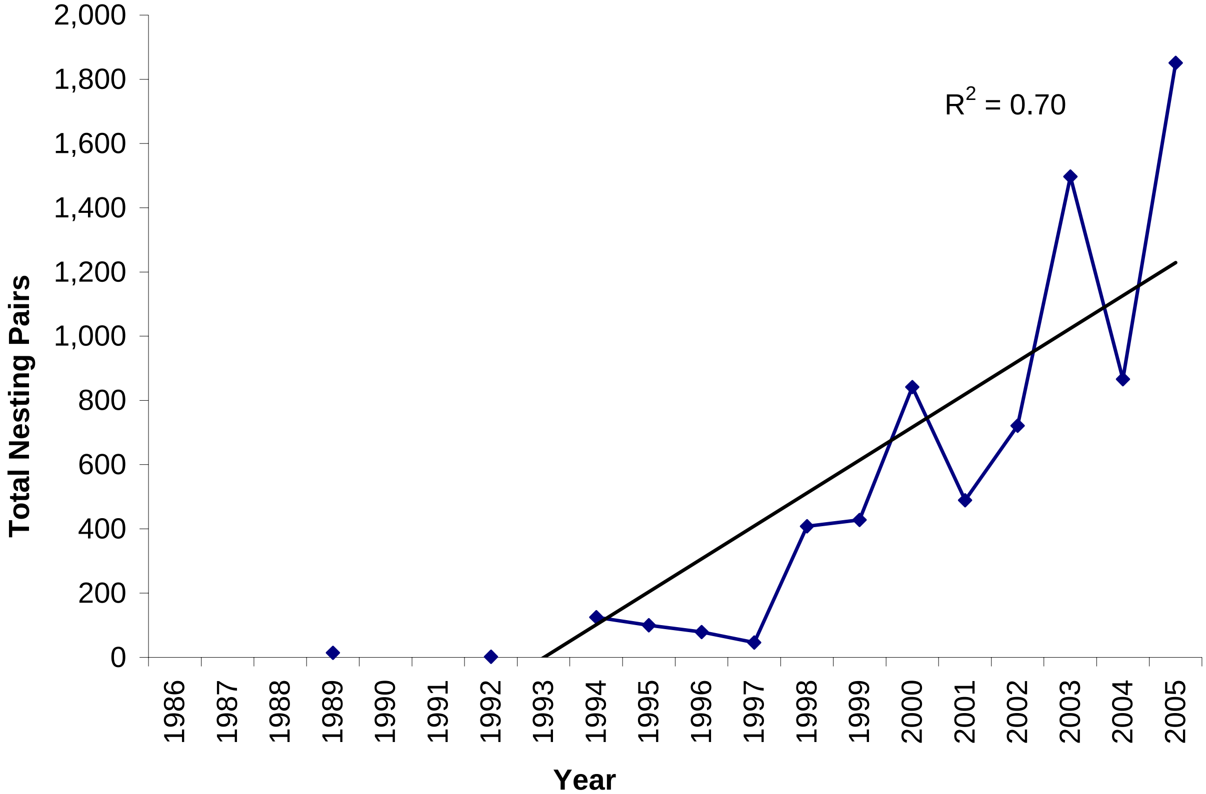


Figure 3.5.2. Increasing twenty year trend in abundance of brown pelican nesting pairs in Galveston Bay.

3.5.3 Galveston Bay Shoreline Analysis

Data classifying the shoreline of Galveston Bay were acquired from the University of Texas Bureau of Economic Geology (BEG). The data, also known as the Environmental Sensitivity Index (ESI), are based on 1995 data and are the most up to date shoreline classification data available in GIS format for the Upper Texas Coast. The ESI was created using "aerial videography and ancillary data from the National Wetlands Inventory (NWI)" (USFWS 1992). Information from the 7.5 minute quads was digitized by BEG and coded to the ESI classification (BEG 1995).

The Status and Trends Project grouped seventeen BEG shoreline classes into two major classes: developed and undeveloped shoreline.

Developed Shoreline-

Any stretch of shoreline that included the following BEG/ESI shoreline classes:

1	= Exposed walls and other structures made of concrete, wood, or metal
6B	= Exposed riprap structures
8A	= Sheltered solid man-made structures, such as bulkheads and docks
8B	= Sheltered riprap structures

Undeveloped Shoreline-

Any stretch of shoreline that included any of the following BEG/ESI shoreline classes and none of the above classes:

2A	= Scarps and steep slopes in clay
2B	= Wave-cut clay platform
3A	= Fine-grained sand beaches
3B	= Scarps and steep slopes in sand
4	= Coarse-grained sand beaches
5	= Mixed sand and gravel (shell) beaches
6A	= Gravel (shell) beaches
7	= Exposed tidal flats
8C	= Sheltered scarps
9	= Sheltered tidal flats
10A	= Salt- and brackish-water marshes
10B	= Fresh-water marshes (herbaceous vegetation)
10C	= Fresh-water swamps (woody vegetation)

The shoreline data were mapped using ArcGIS software. Mileage of developed and undeveloped shoreline was then calculated. The results can be seen in Figure 3.5.3. According to this classification, the total shoreline of Galveston Bay and tidally influenced tributaries within the Lower Galveston Bay watershed measures 1,497 miles. Of that total, 326 miles (22 percent of the total shoreline) are classified as developed shoreline while 1,171 miles of shoreline (78 percent of the total) are classified as undeveloped shoreline. It must be noted that while this data set represents the most recent version of the ESI available at the time of the analysis, the data are now more than ten years old and provide only a baseline for this indicator. An updated data set is needed if change in shoreline development is to be calculated.

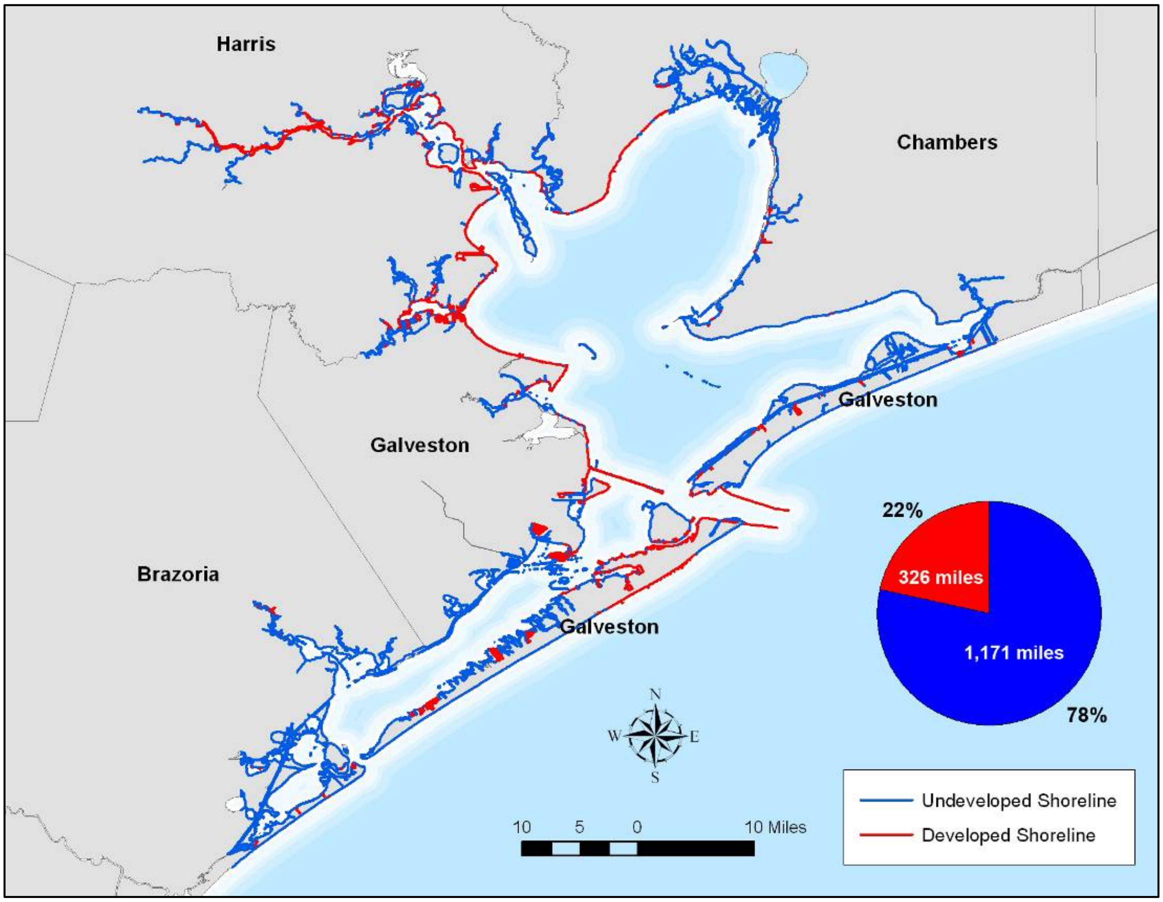


Figure 3.5.3. Developed and undeveloped shoreline of Galveston Bay based on shoreline classification data from the Bureau of Economic Geology and mapped by the Galveston Bay Status and Trends Project.