Upper Coast of Texas

A T L A S

Oil Spill Prevention & Response

By
Information Systems/Geographic Information Systems Division
and
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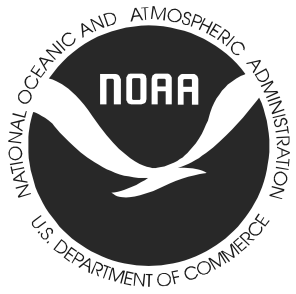
Texas General Land Office

In association with
Hazardous Materials Response & Assessment Division
National Oceanic & Atmospheric Administration

Texas General Land Office



PREFACE

This Texas Oil Spill Planning and Response Atlas contains maps and associated data to be used in oil spill planning and response on the upper Texas coast (from the Texas-Louisiana border to the mouth of the Colorado Rriver). These maps are the combined results of recent mapping and data collection efforts by the Texas General Land Office (GLO) in cooperation with other parties. These efforts include the Habitat Priority Protection Area mapping project, Environmental Sensitivity Index (ESI) mapping project, the Texas Coastal Natural Resource Inventory (NRI), and other GIS-related data acquisition efforts. Some of these projects are summarized below.

This atlas has been created to aid spill responders in making planning and response judgments and has been designed to present relevant data without giving the responder too much information.

The GLO makes no representations or warranties regarding the accuracy or completeness of data or information in this atlas, which is designed solely for use in oil spill planning and response. Maps in this atlas are not suitable for navigation, and do not purport to accurately delinate boundaries between private and public land. The habitat priority protection area information and biological resource data are general and are not meant to replace on-site evaluation. The absence of resources or other map features on the response maps does not necessarily indicate that they are not present.

All data on the maps are stored in digital form in a Geographic Information System (GIS) maintained at the GLO. Some data are to be revised periodically by personnel in the GLO GIS Division. For further information, contact the GLO GIS Division at (512) 463-5257.

ACKNOWLEDGMENTS

Creation of this Atlas was supported jointly by the GLO Oil Spill Prevention and Response Division and the National Oceanic and Atmospheric Administration (NOAA) Hazardous Materials Response and Assessment Division. Project managers were Robert Martin, State Scientific Support Coordinator, and Lee A. Smith, Director of GIS, of the GLO and Robert Pavia, Chief of Scientific Support Coordination, of NOAA.

The documents and maps that form the basis of the habitat priority protection area layer were compiled by personnel with the Texas Parks and Wildlife Department (TPWD) Resource Protection Division led by Anne H. Walton. David R. Sager and Donald E. Pitts, Jr. of TPWD Resource Protection Division provided project oversight.

Biological resource data were collected as part of the Environmental Sensitivity Index (ESI) mapping project, involving a series of projects and workshops with leading experts on the Texas coast. Participants included personnel with the GLO,TPWD, U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service, Texas A&M University-Galveston, and a number of other entities. ESI shoreline habitat classifications were mapped by Robert A. Morton and William A. White of the University of Texas Bureau of Economic Geology (BEG). David Bezanson and Sterling Harris of GLO GIS Division collected and assimilated the biological data used in the atlas. Lee A. Smith and Robert Martin managed both the ESI and the habitat priority protection area projects for the GLO. Additional support for ESI mapping projects in Texas is being provided by the U.S. Minerals Management Service (MMS) in conjunction with Louisiana State University's Center for Coastal Energy and Environmental Resources Program.

Under contract to NOAA, Research Planning, Inc.'s, (RPI) participation in the ESI mapping project included Jacqueline Michel, Miles O. Hayes and Jeffrey Dahlin as the project scientists, Joanne Halls as the project GIS manager, and E. Lee Dively, III who was responsible for data automation and organization. Field checking of the shoreline classification was conducted by Miles Hayes in conjunction with Robert Morton of the BEG. Dot Zaino prepared the ESI project documentation.

Some data in this atlas were collected as part of the Texas Coastal Natural Resource Inventory (NRI). Support for the NRI was provided by the Texas Natural Resource Inventory Trustees, which include the GLO, TPWD, and the Texas Natural Resource Conservation Commission.

Design and cartographic production of the atlas was conducted by David Bezanson, Ron Florence, Sterling Harris, Steven Marquardt, Lee A. Smith, and Marit Tenfjord of the GLO GIS Division. Publication preparation was provided be Leo S. Loza. Cover art was created by Alex Rodriguez of the GLO Graphics Division.

Published by the Texas General Land Office, October 1996.

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DATA AND MAP DISCLAIMER

Components of the “Habitat Priority Protection Area Layer,” ‘Environmental Sensitivity Index Layer,” “Biological Resources Layer,” and certain metadata resources were based primarily on aerial photography and satellite imagery and reflect only the perceived conditions at the instant of the imagery or photography, with limited ground-truthing. In some areas, the land/water interface is heavily dependent on seasonal and long-term tidal variations, and on weather conditions at the time of the photograph or image. The interpreted limits of inundation, and therefore the interpreted range of “tidal/mud flats,” “marsh, wetland,” “inundated areas,” “intermittent water body” and “submerged aquatic vegetation” in the maps which follow, may therefore be subject to wide variation.

Use of the term “shoreline” herein does not refer to the boundary between public and private land, nor does it refer to the place tidewaters intersect upland property. “Shoreline” as used herein refers to areas, described by polygons, along the Texas coast which include habitats listed in the “Environmental Sensitivity Index.” Only the definitions and descriptions contained herein with regard to “Environmental Sensitivity Index” classifications should be ascribed to the listed shoreline habitats. “Riparian Zone” designations were made without benefit of scientific testing for tidal influence and should not be used to identify the limits of coastal public lands. “Spoil Deposits” indicated do not necessarily reflect the full extent of such features and should not be used as an indication of fast land, nor the demarcation between uplands and coastal public lands. Spoil deposits exist which may not be shown on these maps.

DESCRIPTION OF ATLAS DATA LAYERS

1. HABITAT PRIORITY PROTECTION AREA LAYER The habitat priority protection area layer is intended to aid responders in establishing shoreline protection priorities. This information should be used in the initial stages of a spill when a responder needs guidance in setting protection priorities for sensitive areas prior to the arrival of local biological experts. Once on scene, local experts can use the maps as a starting point to be modified based on recent field observations and experience (for example, shifts in nesting locations or feeding areas which cannot be captured in a static map format). The data also provide a source of information for making area and facility contingency plans.

A simple ranking scheme (high, medium, low) is used to prioritize areas for protection from oil. An additional category, caution area, describes areas where caution should be exercised in moving vessels and equipment due to presence of sensitive resources, such as seagrasses, or species such as Texas diamondback terrapin.

The GLO contracted with the Texas Parks and Wildlife Department (TPWD) to compile this data layer for four Texas bay systems. Information was collected in 1992-93 using a consensus approach among local experts attending a series of workshops. Results from the Sabine Lake and Galveston Bay area workshops are contained in this atlas. Participants in the workshops were selected for their expertise with the bay system in question, and included representatives from state and federal agencies, academia, industry, and environmental groups, as well as fishing guides and spill response personnel.

At the workshops, participants outlined the distribution of important coastal resources on U.S. Geological Survey (USGS) 7.5' topographic quadrangle maps. Priority ranking for natural areas was determined by consensus. To encourage efficient mapping and decision-making, small groups were organized to address specific resource themes. These resource themes were: wetlands and submerged aquatic vegetation, birds and other higher vertebrates, oysters and clams, and nursery areas and fishing. Moderators for each group of experts guided the process, while recorders documented the discussions and decisions made by the experts.

Experts delineated habitats as polygonal areas on maps and assigned habitat quality designations based on quality of natural resources in the area, number of functions in the natural community (for example, a wetland area may also serve as a nursery, as habitat for endangered species, and be heavily used by other species) and the area's ability to contribute to restoration of similar habitats damaged by a spill. These quality values are given for each polygon, organized by quad, in the data supplement of this atlas. The separate resource topic maps were combined into a single summary map for each quadrangle.

Again using a consensus approach, habitat polygons were refined and priorities were assigned by a committee of oil spill-experienced biologists following the guidance provided by the workshop participants. In this process, habitat quality designations were reduced to the three habitat priority rankings (high, medium, and low) and one special category (caution area). The committee assigned these rankings based upon (1) uniqueness of resources, (2) the number of resources present, and (3) the quality of the resources. Rare, threatened or endangered species received high priority. Multifunctional systems (such as prime wetlands that are also year-round bird habitat and nursery areas) received higher priority than prime areas for only one resource. Though natural resources are present throughout the bay system, only priority areas are shown.

The habitat priority rankings and caution areas are presented as the priority protection areas on the maps. A summary of habitat quality designations and other factors contributing to the priority rankings is provided in the data supplement.

The habitat priority protection area information is not intended to replace the input of the trustee agencies or other local experts during an oil spill. The guidance of local experts is necessary in order to obtain current and accurate information on coastal natural resources. Also, this layer does not include all natural resources or habitats present, but only priority areas. Accuracy of this data is general, to facilitate use of the information during a spill and because natural resources vary in location and abundance. The habitat priority information lack sufficient detail and accuracy for use as the basis of a complete natural resource damage assessment.

2. ENVIRONMENTAL SENSITIVITY INDEX LAYER As a part of the Environmental Sensitivity Index (ESI) Mapping Project supported jointly by the GLO and National Oceanic and Atmospheric Administration (NOAA), intertidal habitats of the upper coast of Texas were mapped in 1993-94 and indexed according to relative sensitivity to oil. Where appropriate, multiple habitats were delineated for each shoreline segment. This mapping was conducted by coastal scientists with the University of Texas Bureau of Economic Geology (BEG) on USGS 7.5' topographic quadrangles using a combination of recent aerial photographs, low-altitude color video surveys taken in 1992, and oblique color slides taken in 1992. The maps were then field-checked during overflights and ground stations in June 1994 by coastal geologists from Research Planning, Inc. (RPI) and the BEG.

Prediction of the behavior and persistence of oil in intertidal habitats is based on an understanding of the dynamics of the coastal environments, not just the substrate type and grain size. The vulnerability of a particular intertidal habitat is an integration of the following factors:

1) Shoreline type (substrate, grain size, tidal elevation, origin)

2) Exposure to wave and tidal energy

3) Biological productivity and sensitivity

4) Ease of cleanup

Key to the sensitivity ranking is an understanding of the relationships between physical processes, substrate, shoreline type, product type, fate and effect, and sediment transport patterns. The intensity of energy expended upon a shoreline by wave action, tidal currents and river currents directly affects the persistence of stranded oil. The need for shoreline cleanup activities is determined in part by the speed of natural processes in removal of oil stranded on the shoreline.

The ESI ranks shoreline environments as to relative sensitivity to oil, potential biological injury and ease of cleanup. Generally speaking, areas exposed to high levels of physical energy (wave action and tidal currents) and low biological activity rank low on the scale, while sheltered areas with associated high biological activity have the highest ranking. The following shoreline habitats were delineated for Texas, presented in order of increasing sensitivity to spilled oil:

1) Exposed walls and other solid structures made of concrete, wood, or metal

2A) Scarps and steep slopes in clay

2B) Wave-cut clay platforms

3A) Fine-grained sand beaches

3B) Scarps and steep slopes in sand

4) Coarse-grained sand beaches (not present in study area)

5) Mixed sand and gravel (shell) beaches

6A) Gravel (shell) beaches

6B) Exposed riprap structures

7) Exposed tidal flats

8A) Sheltered solid manmade structures

8B) Sheltered riprap structures

8C) Sheltered scarps

9) Sheltered tidal fats

10A) Salt and brackish water marshes

10B) Freshwater marshes (herbaceous vegetation)

10C) Freshwater swamps (woody vegetation)

Each of these shoreline types is described in pages iv–xii in terms of physical description, predicted oil behavior, and response considerations.

The BEG completed ESI mapping for the upper Texas coast from Sabine Pass to Brown Cedar Cut/Dressing Point. Four map pages in the Matagorda area which are outside the BEG's project area (Matagorda, Matagorda Southwest, Palacios Northeast, Palacios Southeast) include smaller-scale ESI data published in 1992 in the Texas Water Commission's Coastal Region Spill Response Map Series. The legend on these map pages reflects the somewhat different inventory scheme used by the Texas Water Commission. An initiative to map ESI and biological resources in the middle Texas coast area (Matagorda Bay to Corpus Christi Bay) has been approved and will be conducted in 1996-97 by the GLO and BEG with support from the U.S. Minerals Management Service and Louisiana State University.

3. BIOLOGICAL RESOURCES LAYER In 1994-95, the GLO compiled information denoting key biological resources that may be at risk in the event of an oil spill on the upper Texas coast. Species were included either because of likelihood of impact by a spill or threatened or endangered status. Major categories of biological resources considered were mammals, birds, fish, reptiles/amphibians, shellfish and plants. Records of species incidence are based on conversations with field experts representing numerous entities, including the TPWD, GLO, U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service, Texas A&M University-Galveston, Houston Audubon Society, and others. Occurrences of certain fish and shellfish species are based on sampling data compiled by the TPWD Coastal Fisheries Division.

The biological resources layer also includes locations mapped in the Texas Natural Heritage Program (TNHP) database, which includes reported locations of rare, endangered and threatened species and plant communities. The TNHP database, maintained by the TPWD, contains historical and recent records and may in some instances not indicate current presence of a species.

Spatial distribution of species is represented on the maps by icons. The number under each icon or group of icons, or resource-at-risk number (RARNUM), references the list of species records in the tabular data supplement (organized by quad). Listing of a species indicates the presence of a species in the area where the icon is placed; generally speaking, most species will be present in similar habitats throughout the quad (exceptions include some rarer species, especially plants, mapped by the TNHP).

The twenty species icons used on the maps, color-coded by group (mammals, birds, reptiles/amphibians, fish, shellfish, and plants), represent subgroups of species based on behavior and taxonomy. Subgroups of bird species include diving birds, gulls/terns, passerine birds (which are unlikely to be impacted by a spill), pelagic birds, shorebirds, waterfowl, wading birds, and raptors. Mammal species include mustelids (mink and river otter) and dolphins. All fish are represented by a single icon. Shellfish are divided into crabs, shrimp, bivalves and gastropods. Reptile/amphibian subgroups are alligator, turtles, and other (including snakes, frogs and other small reptiles, and amphibians). Plant species are divided into two subgroups: submerged aquatic vegetation (SAV) and terrestrial (upland and emergent wetland) plants. Submerged aquatic vegetation includes both seagrasses (widgeon grass, shoal grass, turtle

grass) and freshwater SAV (such as alligatorweed, water celery, and naiads). Wetland plants include rooted emergent vegetation (cordgrass, rushes, cattails).

Colonial waterbird rookery areas are shaded on the maps with a purple vertical hatch pattern. Oyster reefs in Galveston Bay are shown as polygons with a blue shade pattern without icons or tabular data. This information was collected by biologists led by Eric Powell of Texas A&M University. Submerged aquatic vegetation areas classified by the USFWS National Wetlands Inventory are identified on the maps by use of a seagrass symbol. Other species occurrences are represented by icons only.

The absence of a species in the list does not necessarily imply that the species is not present at a given location. Many coastal species are so ubiquitous or abundant that they are not mapped (for example, gulls and black skimmer are only recorded where breeding populations have been counted), and other species are often indicated only by general category (such as waterfowl and wading birds). These species tend to populate similar habitats, and are only recorded individually where breeding or high concentration areas. Generally common species are recorded at certain locations to indicate the general characteristics of the site.

The tabular data supplement in this atlas contains lists of species found at each location and life-history information for each species. The life-history and seasonality information is general for each species, however, and does not necessarily indicate that the species breeds at a specific location or is present at a particular time. Many bird and fish species migrate and may not be present at a location throughout the year.

The data supplement lists the RARNUM of the location shown on the maps, followed by the names of recorded species. The third and fourth columns denote special status of a species, if any (e.g., endangered (E) or threatened (T) status as designated by either the state (S) or federal government (F). Some other species of special concern (SC) in Texas are also noted). The fifth column gives, for some records, estimated relative concentration of species at the location (HIGH or LOW). These estimates are subjective values based on either local expert opinions on relative species concentrations in the area or (for some records of fish and crustaceans) sampling data compiled by the TPWD Coastal Fisheries Division. Species in colonial waterbird rookery areas may have numeric concentration values denoting the number of nesting pairs of the species counted during 1992 bird counts.

The species seasonality is shown in the next twelve columns as present or absent for each month. If the species is present on the upper Texas coast during a month, an “X” is placed in the month column. An “X” does not necessarily mean the species is present or abundant at the location at a particular time (for example, many fish species migrate seasonally from inshore areas to nearshore areas). The last columns give life stage seasonality for the species in Texas. Again, this information is general for the species in southeast Texas and does not necessarily indicate that breeding occurs at the location. This information is summarized for most species in the lists on pages xiii–xvii. All biological data is subject to revision based on better information from local experts.

4. HUMAN USE LAYERS The human-use features depicted on the maps include facilities such as marinas, boat launch sites and beach access points which could be affected by an oil spill or could provide access for response operations. Some of these features are represented on the maps by icons which are consistent with standard ESI/response mapping symbology. Where an icon could not be placed at the correct location of a feature, a leader line is drawn from the icon to the proper location. The following human-use features are represented by icons:

Aquaculture Facilities—Locations were mapped by the GLO GIS Division based on address information provided by the Texas Department of Agriculture Permitting Division.

Beach Access Points—Selected locations were mapped by the GLO Resource Management Division in cooperation with coastal municipalities.

Boat Launch Sites—Data are maintained by the Texas Parks and Wildlife Department and were given to the GLO as part of the Natural Resource Inventory Project.

U.S. Coast Guard Stations—Mapped by the GLO GIS Division from information provided by the U.S. Coast Guard (USCG).

Heliports—Locations were generated from coordinates provided by the Aviation Division of the Texas Department of Transportation.

Lighthouses—Locations provided by the USCG.

Marinas—Information about marinas is maintained by the TPWD. Verification and mapping were done by the GLO GIS Division.

Water Intakes—Locations were mapped by the GLO GIS Division based on mylar maps and data housed at the Texas Natural Resource Conservation Commission (TNRCC). The tabular data supplement includes the permit owner and type of water right for each record.

Human-use facility information is continually changing and subject to revision by GLO GIS Division personnel.

5. OTHER MAP DATA LAYERS Other base map and thematic data on the maps have been culled from a variety of sources by GLO GIS Division. Hydrography on the maps is primarily based on USFWS National Wetlands Inventory data (which defines inundated and wetland areas, e.g. water bodies, wetlands, mud flats, dunes) and USGS 1:24,000 Digital Line Graph hydrography (including streams and some polygonal features, such as water bodies). Hydrography in Jefferson and Orange counties is derived from digitized aerial photography contributed by the Jefferson County Appraisal District and Southeast Texas Regional Planning Council, respectively. Hydrography data has been modified by GLO personnel to reflect newer information sources, including digital orthophotos, National Aerial Photography and other photography. Wetland information is based on digital files of varying dates and was unavailable for one map page area (Beaumont East).

Highway and road networks, municipal boundaries, railroads, and county parks are extracted from the TxDOT digital County Map Series. Representations of airports and airstrips are taken from USGS 1:100,000-scale Digital Line Graphs.

Ship channels and the Gulf Intracoastal Waterway are from drawings provided by the U.S. Army Corps of Engineers and digitized by GLO Resource Management Division personnel. Anchorage areas and safety fairways were digitized from Minerals Management Service maps. Bird rookery areas are based on hardcopy maps created by the Texas Colonial Waterbird Society and digitized by GLO personnel. National wildlife refuge areas were provided in digital form by the USFWS Realty Division; state parks, coastal preserves and National Audubon Society preserves were digitized from GLO or TPWD documents.

Shoreline Habitat Descriptions

EXPOSED WALLS AND OTHER SOLID STRUCTURES MADE OF CONCRETE, WOOD, OR METAL ESI = 1

DESCRIPTION

- These structures are solid, man-made structures such as seawalls, groins, revetments, piers, and port facilities.
- Many structures are constructed of concrete, wood, or metal.
- Often there is no exposed beach at low water, but multiple habitats are indicated if present.
- They are built to protect the shore from erosion by waves, boat wakes, and currents, and thus are exposed to rapid natural removal processes.
- They are heavily utilized by the public for fishing.
- Attached animals and plants are sparse.

PREDICTED OIL BEHAVIOR

- Oil is often held offshore by waves reflecting off the steep structures.
- Any oil that is deposited is rapidly removed from exposed areas.
- The most resistant oil would remain as a patchy band at or above the high-tide line.

RESPONSE CONSIDERATIONS

- Cleanup is usually not required.
- Access can be difficult and dangerous.
- High-pressure water spraying may be required to:
  - remove persistent oil;
  - improve aesthetics; or
  - prevent leaching of oil from the structure.

SCARPS AND STEEP SLOPES IN CLAY ESI = 2A

DESCRIPTION

- These shoreline types are created by eroding bluffs that are cut by waves, thus they are steep and narrow.
- They may represent natural shoreline features, such as the high clay bluffs along east Trinity Bay, or form along dredge spoil deposits and the Intracoastal Waterway.
- The clay is usually hard-packed and stiff, with an irregular, cracked surface.
- Attached animals and plants are vary sparse.
- There can be accumulations of wood debris and wrack at the base of the scarp.

PREDICTED OIL BEHAVIOR

- Oil will not adhere to the clay surface because it is impermeable, wet, and steep.
- Oil can penetrate in intertidal sediments, if present.
- Persistence of oil is usually short-term, except in crevices.

RESPONSE CONSIDERATIONS

- Cleanup is usually not required.
- Access and trafficability are usually poor.
- Where the high-water area is accessible, it may be feasible to remove heavy oil accumulations and oiled debris.

WAVE-CUT CLAY PLATFORMS **ESI = 2B**

DESCRIPTION

- These shoreline types form by wave or boat wake erosion of muddy substrates along navigation channels, the Gulf shoreline, and bay shores.
- They are characterized by a narrow shelf or platform that can be flooded depending on water levels.
- There can be burrowing animals in the mud.
- They are of very limited extent along the upper coast of Texas, restricted to the vicinity of High Island, just west of Sabine Pass, and at Sargent Beach.

PREDICTED OIL BEHAVIOR

- Oil will not adhere to the wet clay surface, but could penetrate the burrows if present and dry.
- Persistence of oil is usually short-term, except in wave shadows or where the oil was deposited high above normal wave activity.

RESPONSE CONSIDERATIONS

- Cleanup is usually not required.
- Where the high-tide area is accessible, it may be feasible to manually remove heavy oil accumulations and oiled debris.
- The muddy substrate cannot support heavy equipment, and even foot traffic could disrupt the sediments and mix oil deeper.

FINE-GRAINED SAND BEACHES **ESI = 3A**

DESCRIPTION

- These beaches are generally flat and hard-packed; along the Gulf shore they are 50 - 100 meters wide, whereas along bay shores they are approximately 15 meters wide.
- Though they are predominately fine sand, there is often a small amount of shell or shell hash.
- There can be heavy accumulations of wrack present.
- They occur along most of the barrier islands and peninsulas on the Gulf shore, and are common along south Galveston Bay, East Bay, and large spoil islands of the Houston Ship Channel.
- They undergo gradual erosion / deposition cycles.
- They are heavily utilized by birds for nesting, foraging and loafing.
- Upper beach fauna include ghost crabs and amphipods; lower beach fauna can be dense, but are highly variable.

PREDICTED OIL BEHAVIOR

- Light oil accumulations will be deposited as oily swashes or bands along the upper intertidal zone.
- Heavy oil accumulations will cover the entire beach surface; oil will be lifted off the lower beach by the rising water.
- Maximum penetration of oil into fine-grained sand is about 10 cm.
- Burial of oiled layers by clean sand within the first few weeks after a spill typically will be less than 30 centimeters along the upper beach face.
- Organisms living in the beach may be killed by smothering or lethal oil concentrations in the interstitial water.
- Biological impacts include temporary declines in infaunal populations, which can also affect important shorebird foraging areas.

RESPONSE CONSIDERATIONS

- These beaches are among the easiest shoreline types to clean.
- Cleanup should concentrate on removing oil and oily debris from the upper swash zone once oil has come ashore.
- Activity through both oiled and dune areas should be severely limited, to prevent contamination of clean areas.
- Manual cleanup, rather then road graders and front-end loaders, is advised to minimize the volume of sand removed from the shore and requiring disposal.
- All efforts should focus on preventing the mixture of oil deeper into the sediments by vehicular and foot traffic.
- Mechanical reworking of lightly oiled sediments in the upper intertidal zone can be effective along the Gulf shore.

SCARPS AND STEEP SLOPES IN SAND ESI = 3B

DESCRIPTION

- This shoreline type occurs where sandy bluffs are undercut by waves and slump.
- They normally form along embankments of sandy dredge-spoil material.
- Some scarps are fronted by narrow beaches, if the erosion rate is moderate or episodic.
- Biological utilization by infauna and birds is low.

PREDICTED OIL BEHAVIOR

- Oil will concentrate at the high water line, with the potential for penetration up to 10 cm into the sandy sediments.
- There is little potential for burial except when a major slumping of the bluff occurs.
- Burial of oiled layers by clean sand within the first few weeks typically will be less than 30 centimeters along the upper beach face.

RESPONSE CONSIDERATIONS

- Cleanup should concentrate on the removal of oil from the upper swash zone after all oil has come ashore.
- Manual cleanup is advised to minimize the volume of sand removed from the shore and requiring disposal, and to reduce the risk of increasing slumping and bluff erosion.
- All efforts should focus on preventing the mixture of oil deeper into the sediments.

COARSE-GRAINED SAND BEACHES ESI = 4

- Not present on the upper Texas coast.

MIXED SAND AND GRAVEL (SHELL) BEACHES ESI = 5

DESCRIPTION

- These beaches have sediments composed of a mixture of sand and shell.
- They occur on the Bolivar Peninsula, between High Island and Sea Rim State Park, and along spoil islands in East and West Bays and Galveston Bay.
- There can be large-scale changes in the sediment distribution patterns along the Gulf shore depending upon season, because of the transport of the sand fraction offshore during storms.
- Because of sediment desiccation and mobility on exposed beaches, densities of animals and plants are lower than sand beaches.

PREDICTED OIL BEHAVIOR

- During small spills, oil will be deposited along and above the upper swash zone.
- Large spills will spread across the entire intertidal area.
- Oil penetration into shelly zones may be up to 50cm, however, in general, oil behavior is much like on a sand beach.
- Burial of oil may be deep at and above the high-water line, where oil tends to persist.
- Oil can be stranded in the coarse sediments on the lower part of the beach, particularly if the oil is weathered or emulsified.

RESPONSE CONSIDERATIONS

- Heavy accumulations of pooled oil from the upper beachface should be removed quickly to prevent penetration into the porous sediments.
- All oiled debris should be removed.
- Sediment removal should be limited as much as possible.
- Mechanical reworking of lightly oiled sediments from the upper intertidal zone can be effective along the Gulf shore.
- In-place tilling may be used to reach deeply buried oil layers in the middle intertidal zone on exposed beaches, as an alternative to sediment removal.

GRAVEL(SHELL) BEACHES ESI = 6A

DESCRIPTION

- Gravel beaches in Texas are composed almost entirely of shell.
- They can be very steep, with multiple wave-built berms forming the upper beach.
- Shell beaches are common in bays near oyster reefs and along spoil islands where the spoil is reworked by waves into steep shell berms.
- Along the Gulf shore, gravel (shell) beaches are found at Sargent Beach, San Luis Pass, and east of High Island.
- Because of sediment desiccation and mobility on exposed beaches, there are low densities of animals and plants.

PREDICTED OIL BEHAVIOR

- Deep penetration of stranded oil is likely on gravel beaches because of their very high permeability.
- On Gulf beaches, oil can be pushed over the high-water and storm berms, pooling and persisting above the normal zone of wave wash.
- Long-term persistence will be controlled by the depth of penetration versus the depth of routine reworking by waves.
- On the more sheltered bay shoreline, sheening and formation of asphalt pavements is likely where accumulations are heavy.

RESPONSE CONSIDERATIONS

- Heavy accumulations of pooled oil should be removed quickly from the upper beach.
- All oiled debris should be removed.
- Sediment removal should be limited as much as possible.
- Low-to high-pressure flushing can be used to float oil away from the sediments for recovery by skimmers or sorbents.
- Mechanical reworking of oiled sediments in the upper intertidal zone can be effective in areas regularly exposed to wave activity (as evidenced by storm berms).
- In-place tilling may be used to reach deeply buried oil layers in the middle intertidal zone on exposed beaches.

EXPOSED RIPRAP STRUCTURES ESI = 6B

DESCRIPTION

- Riprap structures are composed of cobble-to boulder-sized blocks of rock or concrete.
- Riprap structures are placed for shoreline protection and inlet stabilization.
- Attached biota on the riprap can be sparse.
- These structures are highly utilized for shore-based fishing.

PREDICTED OIL BEHAVIOR

- Deep penetration of oil between the boulders is likely.
- Oil adheres readily to the rough rock surfaces.
- If oil is left uncleaned, it may cause chronic leaching until the oil hardens.

RESPONSE CONSIDERATIONS

- When oil is fresh and liquid, high-pressure spraying and/or water flooding may be effective, making sure to recover all released oil.
- Heavy and weathered oils are more difficult to remove, requiring scrapping and/or hot-water spraying.
- It may be necessary to remove heavily oiled riprap and replace it.

EXPOSED TIDAL FLATS **ESI = 7**

DESCRIPTION

- Exposed tidal flats are composed primarily of sand and minor amounts of shell and mud.
- Flats on the Gulf shore can support vehicular and foot traffic, whereas those along bays are usually too soft.
- They are usually associated with another shoreline type on the landward side of the flat and are most commonly associated with tidal inlet systems.
- They can be submerged or exposed to air, depending on water level and wind speed and direction.
- Biological utilization can be very high, with large numbers of infauna, heavy use by birds for roosting and foraging, and use by foraging fish.
- They are also highly utilized for recreational fishing.

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of exposed tidal flats, but rather moves across the flat and accumulates at the high-tide line.
- Oil may be deposited on the flat if concentrations are heavy.
- Oil does not penetrate water-saturated sediments.
- Biological damage may be severe, primarily to infauna, reducing food sources for birds and other predators.

RESPONSE CONSIDERATIONS

- Currents and waves can be very effective in natural removal of the oil.
- Cleanup is very difficult (and possible only during low water levels).
- The use of heavy machinery should be restricted to prevent mixing of oil into the sediments.
- On exposed sand flats, oil will be removed naturally from the flat and deposited on the adjacent beaches where cleanup is more feasible.

SHELTERED SOLID MAN-MADE STRUCTURES **ESI = 8A**

DESCRIPTION

- These structures are solid man-made structures such as seawalls, groins, revetments, piers, and port facilities.
- Many structures are constructed of concrete, wood, or metal.
- Often there is no exposed beach at low water, but multiple habitats are indicated if present.
- Most of the structures in bays are designed to protect a single lot, thus their composition, design, and condition are highly variable.
- They can have high recreational use, particularly in public areas.
- Attached animal and plant life can be sparse.

PREDICTED OIL BEHAVIOR

- Oil will adhere readily to the rough surface, particularly along the high-water line, forming a distinct oil band.
- The lower intertidal zone usually stays wet (particularly if algae covered), preventing oil from adhering to the surface.

RESPONSE CONSIDERATIONS

- Cleanup is usually conducted for aesthetic reasons or to prevent leaching of oil.
- Low- to high-pressure spraying at ambient water temperatures is most effective when the oil is fresh.

SHELTERED RIPRAP STRUCTURES **ESI = 8B**

DESCRIPTION

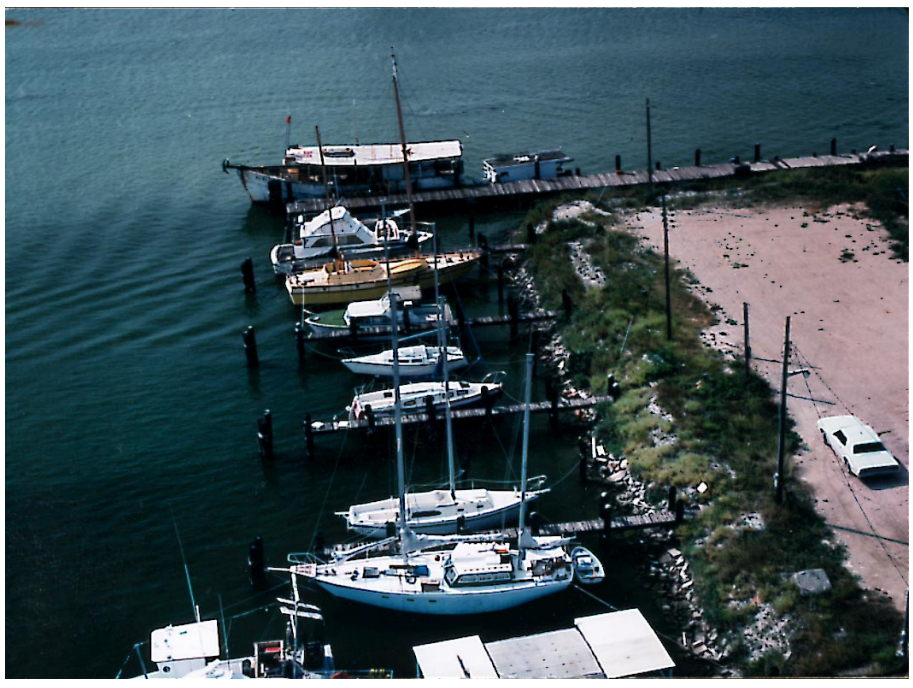
- Riprap structures are composed of cobble- to boulder-sized blocks of rock or concrete.
- These structures include revetments, seawalls, piers, and docks constructed of impermeable materials such as concrete.
- They are found inside harbors and bays in highly developed areas, sheltered from direct exposure to waves.

PREDICTED OIL BEHAVIOR

- Deep penetration of oil between the boulders is likely.
- Oil adheres readily to the rough rock surfaces.
- If oil is left uncleaned, it may cause chronic leaching until the oil hardens.

RESPONSE CONSIDERATIONS

- High-pressure spraying may be required to remove oil for aesthetic reasons and to prevent leaching of oil from the structure.
- Cleanup crews should make sure to recover all released oil.



SHELTERED SCARPS **ESI = 8C**

DESCRIPTION

- Sheltered scarps can be composed of clay formed by dredge-spoil deposits in man-made waterways or steep slopes composed of either clay or sand and covered with terrestrial vegetation.
- There may be some fringing marsh along the water's edge.

PREDICTED OIL BEHAVIOR

- Oil will not adhere to the wet sediment surface, but could penetrate the burrows if present and dry.
- Stranded oil will persist because of low energy setting.

RESPONSE CONSIDERATIONS

- Where the high-water area is accessible, it may be feasible to manually remove heavy oil accumulations and oiled debris.
- The muddy substrate cannot support heavy equipment, and even foot traffic could disrupt the sediments and mix oil deeper.

SHELTERED TIDAL FLATS ESI = 9

DESCRIPTION

- Sheltered tidal flats are composed primarily of silt and clay with minor amounts of sand and shell.
- They are present in calm-water habitats, sheltered from major wave activity, and are frequently fronted by marshes.
- They also include wind-tidal flats that are regularly inundated.
- Wave energy is very low, although there may be strong currents on parts of the flat and in channels across the flat.
- The sediments are very soft and cannot support even light foot traffic in many areas.
- There can be large populations of shellfish, worms, and snails.
- They are heavily utilized by birds for feeding and roosting.

PREDICTED OIL BEHAVIOR

- Oil does not usually adhere to the surface of sheltered tidal flats, but moves across the flat and accumulates at the high-water line.
- Oil may be deposited on the flat if concentrations are heavy.
- Oil will not penetrate the water-saturated sediments, but could penetrate burrows and mud cracked sediments.
- In areas of high suspended sediments, sorption of oil can result in deposition of contaminated sediments on the flats.
- Biological damage may be severe.

RESPONSE CONSIDERATIONS

- These are high-priority areas necessitating the use of spill protection devices to limit oil-spill impact; deflection or sorbent booms and open water skimmers should be used.
- Cleanup of the flat surface is very difficult because of the soft substrate and many methods may be restricted.
- Low-pressure flushing and deployment of sorbents from shallow-draft boats may be helpful.

SALT AND BRACKISH WATER MARSHES ESI = 10A

DESCRIPTION

- Marshes are intertidal wetlands containing emergent, herbaceous vegetation.
- Width of the marsh can vary widely, from a narrow fringe to extensive areas.
- They are relatively sheltered from waves and strong currents.
- Sediments are composed of organic muds except on the margins of barrier islands where sand is abundant.
- Resident flora and fauna are abundant, with numerous species with high utilization by birds.

PREDICTED OIL BEHAVIOR

- Oil adheres readily to marsh vegetation.
- The band of coating will vary widely, depending upon the water level at the time oil slicks are in the vegetation. There may be multiple bands.
- Large slicks will persist through multiple water-level changes and coat the entire stem from the high-water line to the base.
- If the vegetation is thick, heavy oil coating will be restricted to the outer fringe, although lighter oils can penetrate deeper, to the limit of inundation.
- Medium to heavy oils do not readily adhere to or penetrate the fine sediments, but can pool on the surface or in burrows.
- Light oils can penetrate the top few centimeters of sediment and deeply into burrows and cracks (up to one meter).

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is to let the area recover naturally.
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing, care must be taken to prevent transporting oil to sensitive areas down slope or along shore.
- Cleanup activities should be carefully supervised to avoid vegetation damage.
- Any cleanup activity *must not* mix the oil deeper into the sediments. Trampling of the roots must be minimized.
- Cutting of oiled vegetation should only be considered when other resources are at great risk from leaving oiled vegetation in place.

FRESHWATER MARSHES (HERBACEOUS VEGETATION)

ESI=10B

DESCRIPTION

- Freshwater marshes are grassy wetlands composed of freshwater vegetation.
- They occur upstream of brackish vegetation along major rivers and tributary bayous and creeks.
- Those along major channels are exposed to strong currents and boat wakes; inland areas are highly sheltered.
- The sediment substrate is seldom exposed since daily water level changes are low; greater changes in water levels result from floods and winds.
- Resident flora and fauna are abundant with numerous species, with high utilization by birds.
- Along the upper coastline of Texas, they are present on the Sabine River delta, along the Neches River, and inland of the Trinity River delta.

PREDICTED OIL BEHAVIOR

- Oil adheres readily to marsh vegetation.
- The band of coating will vary widely, depending upon the water level at the time oil slicks are in the vegetation. There may be multiple bands.
- Large slicks will persist through multiple water level changes and coat the entire stem from the high-water line to the base.
- If vegetation is thick, heavy oil coating will be restricted to the outer fringe, although lighter oils can penetrate to the limit of the marsh.

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is to let the area recover naturally.
- Heavy accumulations of pooled oil can be removed by vacuum, sorbents, or low-pressure flushing. During flushing, care must be taken to prevent transporting oil to sensitive areas down slope or along shore.
- Cleanup activities should be carefully supervised to avoid vegetation damage.
- Any cleanup activity *must not* mix the oil deeper into the sediments. Trampling of the roots must be minimized.
- Cutting of oiled vegetation should only be considered when other resources present are at great risk from leaving the oiled vegetation in place.

FRESHWATER SWAMPS (WOODY VEGETATION) ESI = 10C

DESCRIPTION

- Freshwater swamps consist of shrubs and hardwood forested wetlands (essentially flooded forests).
- They are common along major river valleys, such as the Sabine, Neches, Trinity, and San Jacinto.
- The sediments tend to be silty clay with large amounts of organic debris.
- They are seasonally flooded, though there are many low, permanently flooded areas.
- Resident flora and fauna are abundant with numerous species.

PREDICTED OIL BEHAVIOR

- Oil behavior depends on whether the swamp is flooded or not.
- During floods, most of the oil passes through the forest, coating the vegetation above the water line, which changes levels throughout the flood event.
- Woody vegetation is less sensitive than marshes to oil coating.
- Some oil can be trapped and pooled on the swamp floodplain as water levels drop.
- Penetration into the floodplain soils is usually limited because of high water levels, muddy composition, surface organic debris, and vegetation cover.
- Large amounts of oily debris can remain.
- During dry periods, terrestrial spills flow downhill and accumulate in depressions or reach water bodies.

RESPONSE CONSIDERATIONS

- Under light oiling, the best practice is to let the area recover naturally.
- Heavy accumulations of pooled oil can be removed by vacuum, manual removal, or low-pressure flushing. During flushing, care must be taken to prevent transporting oil to sensitive areas down slope or along shore.
- Under stagnant water conditions, herding of oil with water spray may be needed to push oil to collection areas.
- Oily debris can be removed where there is access.
- Any cleanup activity *must not* mix the oil deeper into the sediments. Trampling of the roots must be minimized.
- Cutting of oiled vegetation should only be considered when other resources present are at great risk from leaving the oiled vegetation in place.

MAMMALS

Species	Life Stage	Seasonality	Habitat
Bottlenose dolphin *Tursiops truncatus*	Present	All Year	Gulf, bays, channels, passes
Mink *Mustela vison*	Present	All Year	Marshes
River otter *Lutra canadensis*	Present	All Year	Freshwater, occasional in bays
Stennelid dolphins *Stenella sp.*	Present	All Year	Offshore, channels, passes

BIRDS

Species	Life Stage	Seasonality	Habitat
American avocet *Recurvirostra americana*	Adult Juvenile	Aug.–Apr. Aug.–Apr.	Beaches, flats, shallow water
American bittern *Botaurus lentiginosus*	Adult Juvenile	Aug.–Mar. Aug.–Mar.	Swamps, marshes
American coot *Fulica americana*	Adult Adult Breeder Juvenile	Sep.–Apr. Feb.–Apr. Sep.–Apr.	Lakes, bays, marshes
American oystercatcher *Haemetopus palliatus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Mar.–Aug. All Year May–Aug. May–Aug. May–Aug. May–Sep.	Beaches, flats, shallow water
American wigeon *Anas americana*	Adult Juvenile	Oct–Apr. Oct–Apr.	Marshes, ponds
Anhinga *Anhinga anhinga*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Mar.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. Apr.–Aug.	Swamps, lakes
Attwater's greater prairie chicken *Tympanuchus cupido attwateri*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Aug. All Year Feb.–Aug. Feb.–Aug. Feb.–Aug. Mar.–Sep.	On federal endangered list; local west of Galveston Bay in prairies
Bald eagle *Haliaeetus leucocephalus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Jan.–Aug. All Year Jan.–Aug. Jan.–Aug. Jan.–Aug. Feb.–Sep.	Threatened in U.S.; rivers, reservoirs, swamps
Black rail *Laterallus jamaicensis*	Adult Juvenile	Sep.–Apr. Sep.–Apr.	Rare; marshes, ricefields
Black skimmer *Rynchops niger*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Sep All Year Apr.–Sep. Apr.–Sep. Apr.–Sep. Apr.–Sep.	Shallow open water, beaches, spoil islands
Black tern *Chlidonias niger*	Adult	Jul.-Jun. Jul.-Jun.	Marshes, open water
Black-bellied plover *Pluvialis squatarola*	Adult Juvenile	Mar.–Dec. Mar.–Dec.	Beaches, flats
Black-crowned night heron *Nycticorax nycticorax*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. Apr.–Sep.	Marshes, shores, swamps
Black-necked stilt *Himantopus mexicanus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Sep. All Year Apr.–Sep. Apr.–Sep. Apr.–Sep. Apr.–Sep.	Ricefields, marshes, flats; winters mainly on lower coast
Bonaparte's gull *Larus philadelphia*	Adult Juvenile	Sep.–Mar. Sep.–Mar.	Bays, Gulf
Brown pelican *Pelecanus occidentalis*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. Apr.–Sep.	Open water, shorelines, piers, spoil islands; on federal endangered list
Bufflehead *Bucephala albeola*	Adult Juvenile	Sep.–Mar. Sep.–Mar.	Lakes, bays
Canada goose *Branta canadensis*	Adult Juvenile	Sep.–Mar. Sep.–Mar.	Marshes, lakes, fields, prairies
Canvasback *Aythya valisineria*	Adult Juvenile	Oct.–Mar. Oct.–Mar.	Lakes, shallower bays
Caspian tern *Sterna caspia*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Mar.–Jun. All Year Mar.–Jun. Mar.–Jun. Mar.–Jun. Mar.–Jun.	Shallow open water, beaches, spoil islands; nests from Galveston Bay south
Cattle egret *Bubulcus ibis*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Jul. All Year Apr.–Jul. Apr.–Jul. Apr.–Jul. Apr.–Aug.	Pastures, marshes
Clapper rail *Rallus longirostris*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Mar.–Aug. All Year Mar.–Aug. Mar.–Aug. Mar.–Aug. Apr.–Sep.	Tidally influenced marshes
Common goldeneye *Bucephala clangula*	Adult Juvenile	Sep.–Apr. Sep.–Apr.	Deeper lakes, bays, Gulf
Common moorhen *Gallinula chloropus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Mar.–Aug. All Year Mar.–Aug. Mar.–Aug. Mar.–Aug. Apr.–Sep.	Fresh or brackish marshes, swamps, ponds
Common snipe *Gallinago gallinago*	Adult Juvenile	Sep.-Apr. Sep.-Apr.	Marshes, wet fields, swamps

Species	Life Stage	Seasonality	Habitat
Double-crested cormorant *Phalacrocorax auritus*	Adult Juvenile	Sep.–Apr. Sep.–Apr.	Open water, structures, shorelines
Dunlin *Calidris alpina*	Adult Juvenile	Sep.–May Sep.–May	Mud flats, shores
Eskimo curlew *Numenias borealis*	Adult Juvenile	Mar.–May Mar.–May	Extinct or very endangered migrant, last seen ca. 1980
Forster's tern *Sterna fosteri*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Mar.–Aug. All Year Mar.–Aug. Apr.–Aug. Apr.–Aug. Mar.–Sep.	Shallow open water, beaches; winters on lower coast
Fulvous tree duck *Dendrocygna bicolor*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Aug. All Year Feb.–Aug. Feb.–Aug. Feb.–Aug. Mar.–Sep.	Uncommon in winter; marshes, ponds
Gadwall *Anas strepera*	Adult Juvenile	Sep.–Apr. Sep.–Apr.	Ponds, marshes, bays
Glossy ibis *Plegadis falcinellus*	Adult Juvenile	All Year All Year	Rare; marshes, ricefields, swamps
Great blue heron *Ardea herodias*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Jun. All Year Feb.–Jun. Feb.–Jun. Feb.–Jun. Mar.–Jul.	Marshes, rivers, lakes, shores, vegetated spoil islands
Great egret *Casmerodius albus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Mar.–Jul. All Year Mar.–Jul. Mar.–Jul. Mar.–Jul. Apr.–Aug.	Shallow water, marshes, flats, ricefields, vegetated spoil islands
Greater scaup *Aythya marila*	Adult Juvenile	Nov.-Mar. Nov.-Mar.	Open water
Green-backed heron *Butorides striatus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. Apr.–Sep.	Lakes, rivers, swamps, trees
Gull-billed tern *Gelochilidon nilotica*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Aug. All Year Feb.–Aug. Feb.–Aug. Feb.–Aug. Mar.–Sep.	Shallow open water, beaches
Herring gull *Larus argentatus*	Adult Juvenile	All Year All Year	Beaches, piers, dumps, open water
King rail *Rallus elegans*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. Apr.–Sep.	Fresh and brackish marshes, ricefields

Species	Life Stage	Seasonality	Habitat
Laughing gull *Larus atricilla*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Aug. All Year Feb.–Aug. Feb.–Aug. Feb.–Aug. Mar.–Sep.	Beaches, piers, open water, spoil islands
Least bittern *Ixobrychus exilis*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year May–Sep. All Year May–Sep. May–Sep. May–Sep. May–Sep.	Fresh and brackish marshes, swamps
Least sandpiper *Erolia minutilla*	Adult Juvenile	Sep.–May Sep.–May	Marshes, flats, shorelines
Least tern *Sterna albifrons*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	Mar.–Sep. Apr.–Sep. Mar.–Sep. Apr.–Sep. Apr.–Sep. May–Sep. May–Sep.	Shallow open water, beaches, shell areas
Lesser scaup *Aythya affinis*	Adult Juvenile	Sep.–Mar. Sep.–Mar.	Lakes, ponds, bays
Little blue heron *Florida caerulea*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Jul. All Year Apr.–Jul. Apr.–Jul. Apr.–Jul. May–Aug.	Shallow water, marshes, tidal flats, swamps, ricefields
Long-billed curlew *Numenius americanus*	Adult Juvenile	Sep.–Apr. Sep.–Apr.	Prairies, marshes, flats, shorelines
Long-billed dowitcher *Limnodromus scolopaceus*	Adult Juvenile	Sep.–Apr. Sep.–Apr.	Margins, flats
Loons *Gavia sp.*	Adult Juvenile	Oct–Apr. Oct–Apr.	Lakes, bays
Magnificent frigatebird *Fregata magnificens*	Adult Juvenile	All Year Apr.–Sep.	Occasional in winter; around islands, rigs, piers
Mallard *Anas platyrhynchos*	Adult Juvenile	Oct–Apr. Oct–Apr.	Marshes, lakes, ponds
Mergansers	Adult Juvenile	Oct–Apr. Oct–Apr.	Lakes, ponds, bays
Migratory songbirds	Present	Mar.–Jun. and Aug.–Nov.	Coastal woodlands, forests and swamps
Mottled duck *Anas fulrigula*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Jan.–Aug. All Year Jan.–Aug. Jan.–Aug. Jan.–Aug. Feb.–Sep.	Marshes, ponds, lakes
Northern harrier *Circus cyaneus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. May–Sep.	Marshes, fields

Species	Life Stage	Seasonality	Habitat
Olivaceous cormorant *Phalacrocorax olivaceus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Jan.–Jul. All Year Jan.–Jul. Jan.–Jul. Jan.–Jul. Feb.–Aug.	Open water, structures, shorelines
Osprey *Pandion haliaetus*	Adult Juvenile	All Year All Year	Coastal area, lakes, rivers; occasional nesting
Peregrine falcon *Falco peregrinus*	Adult Juvenile	Sep.–Apr. Sep.–Apr.	Federally endangered; open country, beaches, marshes
Pied-billed grebe *Podilymbus podiceps*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. Apr.–Sep.	Marshes, ponds, lakes
Pintail *Anas acuta*	Adult Juvenile	Aug.–Apr. Aug.–Apr.	Marshes, bays, lakes
Piping plover *Charadrius melodus*	Adult Juvenile	Aug.–May Aug.–May	Beaches, algal flats, coastal area; threatened in U.S.
Purple gallinule *Porphyrula martinica*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. Apr.–Sep.	Freshwater swamps, ponds; uncommon in winter
Reddish egret *Egretta rufescens*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. Apr.–Sep.	Shores, salt marshes, tidal flats, winters on lower coast
Redhead *Aythya americana*	Adult Juvenile	Oct–Apr. Oct–Apr.	Lakes, bays
Ring-billed gull *Larus delawarensis*	Adult Juvenile	All Year All Year	Bays, Gulf, piers, dumps
Ring-necked duck *Aythya collaris*	Adult Juvenile	Oct.–Mar. Oct.–Mar.	Lakes, ponds, rivers
Roseate spoonbill *Ajaia ajaja*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. May–Sep.	Marshes, flats, shores
Royal tern *Thalasseus maximus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Aug. All Year Feb.–Aug. Feb.–Aug. Feb.–Aug. Mar.–Sep.	Shallow open water, beaches, winters on lower coast
Ruddy duck *Oxyura jamaicensis*	Adult Juvenile	Oct.–Mar. Oct.–Mar.	Lakes, bays, rivers
Ruddy turnstone *Areniria interpres*	Adult Juvenile	Sep.–May Sep.–May	Beaches, flats, fields
Sandhill crane *Grus canadensis*	Adult Juvenile	Sep.–Apr. Sep.–Apr.	Prairies, marshes
Sandpipers	Adult Juvenile	Aug.–May Aug.–May	Shorelines, tidal flats

Species	Life Stage	Seasonality	Habitat
Sandwich tern *Thalasseus andvicensis*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Aug. All Year Feb.–Aug. Feb.–Aug. Feb.–Aug. Mar.–Sep.	Shallow open water, beaches, spoil islands
Seaside sparrow *Ammospiza maritima*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Sep. All Year Mar.–Sep. Mar.–Sep. Mar.–Sep. Mar.–Sep.	Coastal marshes
Semipalmated sandpiper *Ereunetes pusllus*	Adult Juvenile	Sep.–May Sep.–May	Shorelines, flats
Short-billed dowitcher *Limnodromus griseus*	Adult Juvenile	Sep.–May Sep.–May	Open water, shorelines, salt marsh
Shoveler *Spatula clypeata*	Adult Juvenile	Oct.–Apr. Oct.–Apr.	Marshes, lakes, bays
Snow goose *Chen hyperborea*	Adult Juvenile	Sep.–Mar. Sep.–Mar.	Lakes, fields, bays, prairies
Snowy egret *Leucophoyx thula*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Jul. All Year Apr.–Jul. Apr.–Jul. Apr.–Jul. May-Aug.	Shallow water, marshes, flats, shores
Snowy plover *Charadrius alexandrinus*	Adult Juvenile Nesting Laying Hatching Fledging	All Year All Year Feb.–Aug. Feb.–Aug. Feb.–Aug. Mar.–Sep.	Uncommon; beaches, flats
Sooty tern *Sterna fuscata*	Adult Juvenile	Feb.–Oct. Feb.–Oct.	Rare on upper coast; Gulf, beaches
Sora *Porzana carolina*	Adult Juvenile	All Year All Year	Fresh and brackish marshes
Swallow-tailed kite *Elanoides forficatus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	Mar.–Nov. Apr.–Aug. Mar.–Nov. Apr.–Aug. Apr.–Aug. Apr.–Aug. Mar.–Sep.	Uncommon, but maybe recovering former range; riparian areas, swamps, coastal prairies
Tricolored heron *Egretta tricolor*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. May–Sep.	Shallow water, marshes, flats, lakes, vegetated spoil islands
Virginia rail *Rallus limicola*	Adult Juvenile	Sep.–May Sep.–May	Ponds, fresh and salt marshes
Whimbrel *Numenius phaeopus*	Adult Juvenile	Aug.-May Aug.-May	Shores, flats, marshes
White ibis *Eudocimus albus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Jun. All Year Feb.–Jun. Feb.–Jun. Feb.–Jun. Mar.–Jul.	Marshes, ricefields, shores

Species	Life Stage	Seasonality	Habitat
White pelican *Pelecanus erythrorhynchos*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Aug. All Year Feb.–Aug. Feb.–Aug. Feb.–Aug. Mar.–Sep.	Open water, shorelines, spoil islands
White-faced ibis *Plegadis chihi*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Aug. All Year Feb.–Aug. Feb.–Aug. Feb.–Aug. Mar.–Sep.	Uncommon; marshes, ricefields
White-fronted goose *Anser albifrons*	Adult Juvenile	Sep.–Mar. Sep.–Mar.	Marshes, prairies, fields, lakes
White-tailed kite *Elanus leucurus*	Adult Juvenile	All Year All Year	Uncommon; prairies, marshes
Willet *Catoptrophorus semipalmatus*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Aug. All Year Apr.–Aug. Apr.–Aug. Apr.–Aug. May–Sep.	Salt prairies, shores
Wood duck *Aix sponsa*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Feb.–Aug. All Year Feb.–Aug. Feb.–Aug. Feb.–Aug. Mar.–Sep.	Rivers, ponds, swamps
Wood stork *Mycteria americana*	Adult Juvenile	All Year All Year	Swamps, marshes; occasional breeding
Yellow-crowned night heron *Nyctanassa violacea*	Adult Adult Breeder Juvenile Nesting Laying Hatching Fledging	All Year Apr.–Sep. All Year Apr.–Sep. Apr.–Sep. Apr.–Sep. Apr.–Sep.	Marshes, waterways, woods
Yellowlegs *Tringa sp.*	Adult Juvenile	Aug.–May Aug.–May	Marshes, shores, mudflats
Yellow rail *Coturnicops noveboracensis*	Adult Juvenile	Sep.–Mar. Sep.–Mar.	Uncommon; brackish marsh, thickets

NOTE: Some species are recorded only by subgroup. Subgroups listed in the data are:

Diving Birds: Loons, grebes, pelicans and cormorants.

Gulls/Terns: Gulls, terns, black skimmer.

Migratory Songbirds: Many families of passerine birds: warblers, sparrows, etc.

Raptors: Hawks, merlin, kestrel, kites.

Shorebirds: May include sandpipers, plovers, sanderling, dowitchers, dunlin, red knot, willet, yellowlegs, ruddy turnstone, curlews, American avocet, whimbrel, or other species. Species vary somewhat according to habitat.

Wading Birds: Herons, egrets, rails, ibises, bitterns, roseate spoonbill, black-necked stilt, and wood stork.

Waterfowl: May include ducks (wigeon, teals, gadwall, pintail, shoveler, scaups, mergansers, mottled duck, mallard, ring-necked duck, wood duck, redhead, goldeneye, bufflehead, ruddy duck, canvasback), geese, American coot, and American moorhen. Species will vary according to habitat.

REPTILES

Species	Life Stage	Seasonality	Habitat
American alligator *Alligator mississippiensis*	Adult Juvenile Nesting Laying Hatching	All Year All Year Jun.–Sep. Jun.–Dec. Jul.–Oct.	Marshes, swamps, rivers, estuaries
Diamondback terrapin *Malaclemys terrapin*	Adult Juvenile Nesting Laying Hatching	All Year All Year Apr.-May Apr.-May May–Jul.	Uncommon; estuaries, reefs, seagrass beds
Green sea turtle *Chelonia mydason*	Juvenile	All Year	Threatened in U.S.; occasional strandings on beach in summer
Hawksbill sea turtle *Eretmochelys imbricata*	Adult Juvenile	Apr.–Oct. Apr.–Oct.	Endangered; rare, deep water Coastal waters, beaches, reefs
Kemp's (Atlantic) ridley *Lepidochelys kempii*	Adult Juvenile	Mar.–Nov. All Year	Endangered; shallow coastal waters, bays, passes
Leatherback sea turtle *Dermochelys coriacea*	Adult Juvenile	All Year All Year	Endangered; offshore Occasional in passes
Loggerhead sea turtle *Caretta caretta*	Adult Juvenile	All Year All Year	Threatened; offshore, passes Offshore, large bays

FISH

Species	Life Stage	Seasonality	Habitat
Atlantic croaker *Micropogonias undulatus*	Adult Spawning Larval Juvenile	All Year Nov.–Mar. Apr.–Oct. All Year	Bays, nearshore Shallow Gulf waters Shallow bays, nearshore Shallow bays, nearshore
Bay anchovy *Anchoa mitchilli*	Adult Spawning Larval Juvenile	All Year All Year All Year All Year	Bays, Gulf Bays, Gulf Bays, Gulf Bays, Gulf
Black drum *Pogonias cromis*	Adult Spawning Larval Juvenile	All Year Jan.–Apr. Jul.–Mar. All Year	Coastal bays Large primary bays Estuarine waters Estuarine waters
Blue catfish *Ictalurus furcatus*	Adult Juvenile	All Year All Year	Inland, occasional in bays
Channel catfish *Ictalurus punctatus*	Adult Juvenile	All Year All Year	Freshwater
Crevalle jack *Caranx hippos*	Present	All Year	Offshore, bays
Florida pompano *Trachinotus carolinus*	Adult Juvenile	All Year All Year	Gulf Gulf, bays in summer
Gafftopsail catfish *Bagre marinus*	Adult Spawning Larval Juvenile	All Year Mar–Jul. May–Aug. Jun.–Sep.	Deeper channels, nearshore Shallow Gulf waters Inshore Bays, Gulf, deeper in winter
Gray snapper *Lutjanus griseus*	Present	All Year	Offshore, rare in bays
Gulf kingfish *Menticirrhus littoralis*	Present	All Year	Offshore
Gulf menhaden *Brevoortia patronus*	Adult Spawning Larval Juvenile	All Year Nov.-Feb. Dec.–Mar. Dec.–Mar.	Bays, nearshore, offshore Offshore Upper bays Upper bays

Species	Life Stage	Seasonality	Habitat
Hardhead (sea) catfish *Arius felis*	Adult Spawning Larval Juvenile	All Year May–Sep. Jun.–Oct. All Year	Bays, nearshore Bays, nearshore Bays, nearshore Deeper waters in winter
Inland silverside *Menidia beryllina*	Adult Spawning Larval Juvenile	All Year May-Sep. May-Sep. All Year	Bays
Killifish *Fundulus sp.*	Adult Spawning Larval Juvenile	All Year Mar.–Sep. Apr.–Sep. All Year	Bays, margins Estuaries, esp. vegetated areas
Largemouth bass *Micropterus salmoides*	Adult Spawning Larval Juvenile	All Year Feb.–Apr. Mar.–May All Year	Freshwater rivers, lakes
Pinfish *Lagodon rhomboides*	Adult Spawning Larval Juvenile	All Year Mar.–May Mar.–May All Year	Bays, inlets, marshes, offshore Offshore Offshore, moving into bays Bays, esp. inlets, structures
Red drum *Sciaenops ocellatus*	Adult Spawning Larval Juvenile	All Year Aug.–Nov. Sep.–Dec. All Year	Bays, offshore in winter Gulf passes, nearshore Shallow bay waters Shallow bay waters
Sand seatrout *Cynoscion arenarius*	Adult Spawning Larval Juvenile	All Year Mar.–Nov. Mar.–Dec. All Year	Open bays, nearshore waters Gulf passes, nearshore Sand bottom areas Bays, sand bottom areas
Sheepshead *Archosargus probatocephalus*	Adult Spawning Larval Juvenile	All Year Mar.–May Apr.–Aug. All Year	Bays, especially jetties Offshore Oyster reefs, grassbeds Shores, esp. jetties, bulkheads
Sheepshead minnow *Cyprinodon variegata*	Adult Spawning Larval Juvenile	All Year Mar.–Oct. Mar.–Dec. All Year	Shorelines, shallow waters, grass flats
Silver perch *Bairdiella chrysoura*	Adult Spawning Larval Juvenile	All Year Apr.-Oct. Apr.-Oct.. All Year	Bays
Southern flounder *Paralichthys lethostigma*	Adult Spawning Larval Juvenile	All Year Sep.–Dec. Oct.–Dec. All Year	Bays, Gulf in winter Offshore Shallow estuarine waters Shallow estuarine waters
Southern kingfish (whiting) *Menticirrhus americanus*	Present	All Year	Offshore, bays
Spanish mackerel *Scomberomus maculatus*	Present	All Year	Offshore, bays in summer
Spot *Leiostomus xanthurus*	Adult Spawning Larval Juvenile	All Year Nov.–Feb. Nov.–Feb. All Year	Shallow bays, nearshore Nearshore Marshes, nearshore Shallow bays, seagrass beds
Spotted seatrout *Cynoscion nebulosus*	Adult Spawning Larval Juvenile	All Year All Year All Year All Year	Bays, nearshore waters Bays, especially in summer Seagrass beds, bays, marshes Bays, esp. seagrass flats
Striped mullet *Mugil cephalus*	Adult Spawning Larval Juvenile	All Year Nov.–Feb. Dec.-Feb. All Year	Coastal waters and Gulf Gulf Inlets, shallow waters, rivers Bays, rivers
Tarpon *Megalops atlanticus*	Adult Juvenile	All Year All Year	Offshore, uncommon in passes in summer
White crappie *Pomoxis annylaris*	Present	All Year	Freshwater, occasional in bays

SHELLFISH

Species	Life Stage	Seasonality	Habitat
American (eastern) oyster *Crassostrea virginica*	Adult Spawning Spat Juvenile	All Year Mar.-Nov. Apr.–Nov. All Year	Bays
Blue crab *Callinectes sapidus*	Adult Mating Hatching Larval Juvenile	All Year Apr.–Jun. Apr.–Jul. May–Sep. All Year	Bays, nearshore Shallow bays, shorelines Shallow bay waters, shorelines
Brown shrimp *Penaeus aztecus*	Adult Spawning Egg/Larval Juvenile	Mar.–Nov. Nov.–Mar. Feb.–Jun. Mar.–Jul.	Offshore, bays, Gulf in winter Offshore Bays, shallow water areas Bays, shallow water areas
Common rangia *Rangia cuneata*	Present	All Year	Bays with freshwater inflows (Sabine Lake,Trinity Bay)
Grass shrimp *Palaemonetes pugio*	Adult Spawning Egg/Larval Juvenile	All Year All Year All Year All Year	Bays, shallow water areas
Lightning whelk *Busycon contrarium*	Present	All Year	Uncommon; bays
Northern quahog *Mercenaria mercenaria*	Present	All Year	Bays, esp. grass beds, occasionally offshore
Stone crab *Menippe mercenaria*	Adult Mating Larval Juvenile	All Year May–Sep. Jun.–Sep. All Year	Shorelines, riprap, piers, reefs
White shrimp *Penaeus setiferus*	Adult Spawning Egg/Larval Juvenile	All Year May–Oct. May–Oct. All Year	Open bays Offshore Vegetated shallow bays, low salinity

NOTE: The general term "crustaceans" is used to mean all common Texas species, including blue crab, brown and white shrimp, etc.

METADATA

Airports
Sources: U.S. Geological Survey (USGS) Digital Line Graphs, Texas Department of Transportation (TxDOT) files
Scale: 1:100,000
Accuracy: +/- 100 feet

Anchorage Areas
Source: Minerals Management Service (MMS)
Scale: N/A
Accuracy: N/A

Aquaculture Sites
Source: Texas General Land Office (GLO) from Texas Department of Agriculture information
Scale: Approximately 1:24,000
Accuracy: Approximately +/- 40 feet

Audubon Sanctuaries
Source: GLO documents
Scale: Approximately 1:24,000
Accuracy: Approximately +/- 40 feet

Bathymetry
Source: National Oceanic and Atmospheric Administration
Scales: 1:80,000 or better
Accuracy: +/- 75 feet

Beach Access Points
Sources: GLO (from Dune Protection and Beach Access Plans by Jefferson County, City of Port Arthur, Chambers County, City of Galveston, City of Jamaica Beach, Brazoria County, Surfside Beach, Quintana Beach, Matagorda County, City of Port Aransas, City of Corpus Christi, Nueces County, Kleberg County, Cameron County, and Town of South Padre Island)
Scale of Source: Approximately 1:24,000
Accuracy: Approximately +/- 40 feet

Biological Resources
Source: GLO/Research Planning Inc.
Scale: N/A

Bird Rookery Areas
Source: GLO/Texas Colonial Waterbird Society
Scale: 1:24,000
Accuracy: +/- 40 feet

Boat Ramps
Source: Texas Parks and Wildlife Department (TPWD)
Scale: 1:40,000
Accuracy of Data: Variable

City and County Parks
Source: TxDOT digital county map series
Scale: 1:16,000-1:64,000
Accuracy: +/- 50 to 100 feet

City Limits
Source: TxDOT digital county map series
Scale: 1:16,000-1:64,000
Accuracy: +/- 50 to 100 feet

County Boundaries
Source: Texas Natural Resource Conservation Commission (TNRCC)
Scale: 1:24,000
Accuracy: +/- 40 feet

Environmental Sensitivity Index
Source: University of Texas Bureau of Economic Geology (BEG)
(from aerial photography, videography and GLO digital data)
Scale: Approximately 1:24,000
Accuracy: Approximately +/- 40 feet

Environmental Sensitivity Index - TNRCC
Source: TNRCC
Scale: Approximately 1:125,000
Accuracy: Not Available

Heliports
Source: TxDOT Aviation Division
Scale: N/A
Accuracy: N/A

Hydrography
Source: GLO (compiled from USGS Digital Line Graphs and hardcopy maps, U.S. Fish and Wildlife Service digital National Wetland Inventory, and digitized aerial photography from Jefferson County Appraisal District, Southeast Texas Regional Planning Council, and other sources)
Scale: 1:24,000-1:50,000
Accuracy: +/- 40-75 feet

Marinas
Source: GLO
Scale: Approximately 1:24,000
Accuracy: Approximately +/- 40 feet

National Wildlife Refuges
Source: U.S. Fish and Wildlife Service Realty Division
Scale: 1:24,000
Accuracy: +/- 40 feet

Oyster Reefs
Source: Eric Powell, Texas A&M University
Scale: 1:24,000
Accuracy: +/- 40 feet

Priority Protection Areas
Source: TPWD
Scale: 1:24,000
Accuracy: +/- 40 feet

Railroads
Source: TxDOT digital county map series
Scale: 1:16,000-1:64,000
Accuracy: +/- 50-100 feet

Roads/Highways
Source: TxDOT digital county map series
Scale: 1:16,000-1:64,000
Accuracy: +/- 50 feet

Ship Channels and Gulf Intracoastal Waterway
Source: U.S. Army Corps of Engineers engineering maps
Scale: Better than 1:24,000
Accuracy: Better than +/- 40 feet

State Coastal Preserves
Source: TPWD and TGLO documents
Scale: Approximately 1:24,000
Accuracy: Approximately +/- 40 feet

State Parks and Wildlife Management Areas
Source: TPWD and TGLO records, TxDOT county map series
Scale: Variable
Accuracy: Variable

Shipping Safety Fairways
Source: MMS
Scale: N/A
Accuracy: N/A

U.S. Coast Guard Facilities
Source: GLO (from U.S. Coast Guard information)
Scale: Approximately 1:24,000
Accuracy: Approximately +/- 40 feet

Washover Areas
Source: BEG
Scale: 1:24,000
Accuracy: Approximately +/- 40 feet

Water Intakes
Source: GLO (based on TNRCC hardcopy mylars)
Scale: 1:16,000-1:64,000
Accuracy: +/- 50 feet