

TEXAS COAST

*EcoHealth Metrics Framework
and Prototype Report Card*

2017

Texas Coastal Health

Gulf of Mexico Coastal Health

Houston

Galveston

Corpus Christi

Brownsville



Why measure the health of the Texas Coast?

Assessing the health of the Gulf of Mexico is a complex and extensive undertaking, requiring the development of an integrated assessment/management framework and a diversity of data sets. The next step is to determine the condition of ecological resources covering approximately 600,000 sq. miles of geographical area. We have begun this project by developing the overall conceptual framework and methodology, but limiting the testing of our approach to the Texas Coast.

The Texas Coast represents the breadth and diversity of Gulf of Mexico ecosystems, including habitats such as coastal marshes, wetlands, soft- and hard-bottom communities (e.g., seagrasses and oyster reefs), and cross-habitat species such as migratory birds and coastal fisheries. By testing our methodology on Texas coastal systems, we capture the range of issues of the wider Gulf of Mexico, while focusing on specific databases available from primarily federal and State of Texas sources.

In the attached prototype Texas Coastal Report Card, we demonstrate the types of components that will be included in a fully-developed EcoHealth Metrics and its potential utility to inform decision-making.

Gulf of Mexico in Perspective

The Gulf of Mexico is among the most ecologically diverse and valuable ecosystems in the world, consisting of offshore waters and coastal habitats of 11 US and Mexican states plus Cuba. The Gulf's wetlands, beaches, coastal woodlands, and islands are major nurseries for breeding birds and provide foraging and stopover habitat for millions of birds that converge from some of the most important migratory flyways. Coastal marshes and near-shore habitats provide essential nursery habitat for ecologically, commercially, and recreationally important species of fish and invertebrates. Offshore habitats and species are biologically diverse and include shallow and deepwater corals, sponges, fish stocks, marine mammals, sea turtles, and other unique species and communities. These habitats are integral to the economic well-being and cultural fabric of the Gulf, providing a range of ecosystem services, including fisheries, food and energy production, infrastructure protection, and recreational and wildlife-related activities.

Stresses on the Gulf

The Gulf's watershed drains over half the continental US; a wide range of environmental stressors have increasingly degraded Gulf coastal ecosystems for both human use and aquatic life. Major threats include:

- erosion or loss of wetlands, coastal marshes, barrier islands, and shorelines caused by development, industry, subsidence, and sea-level rise;
- degraded water quality from nutrients and pollutants (e.g., hydrocarbons, pesticides, industrial wastes);
- large areas of hypoxia offshore the Mississippi River Delta;
- degradation of coastal estuaries impacting essential nursery habitat for Gulf fishery resources;
- overharvesting of commercially and recreationally important fisheries;
- human health threats of methyl-mercury in finfish, harmful algal blooms, and pathogens in shellfish;
- global climate change with increased intensity of storms, accelerated sea-level rise, increased frequency of extreme temperature events, and attendant risks to coastal habitats, natural resources, and economic well-being;
- the largest marine oil spill in history with unprecedented combination of extreme depth of discharge and massive use of chemical dispersants.

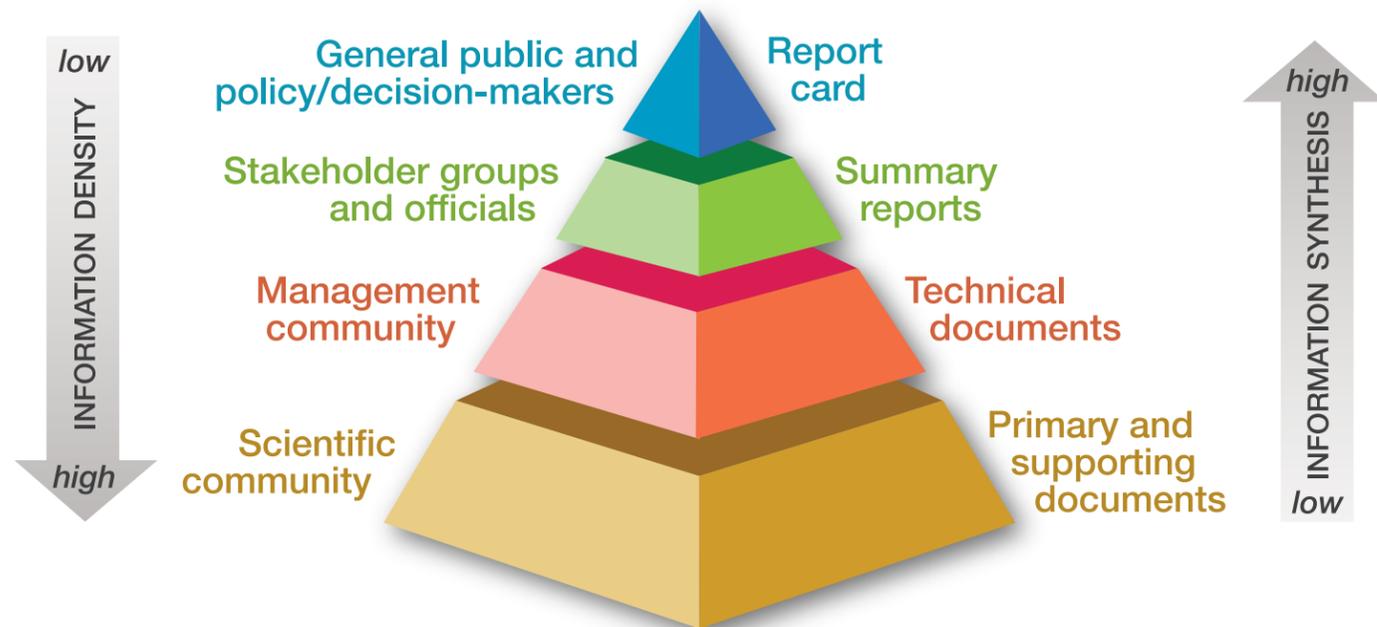
Our Methodology

The Gulf of Mexico EcoHealth Metrics is an initiative of the Harte Research Institute for Gulf of Mexico Studies to evaluate the health of the Gulf, demonstrate progress towards long-term goals, and inform decision-makers on what is needed to achieve sustainability of a healthy Gulf of Mexico. We have developed an integrated assessment/decision framework to link natural processes and human activities to ecological condition and guide management responses. Our vision is to develop a graphical representation of the environmental condition of the Gulf that is scientifically based, widely accessible, and readily understandable by diverse audiences.

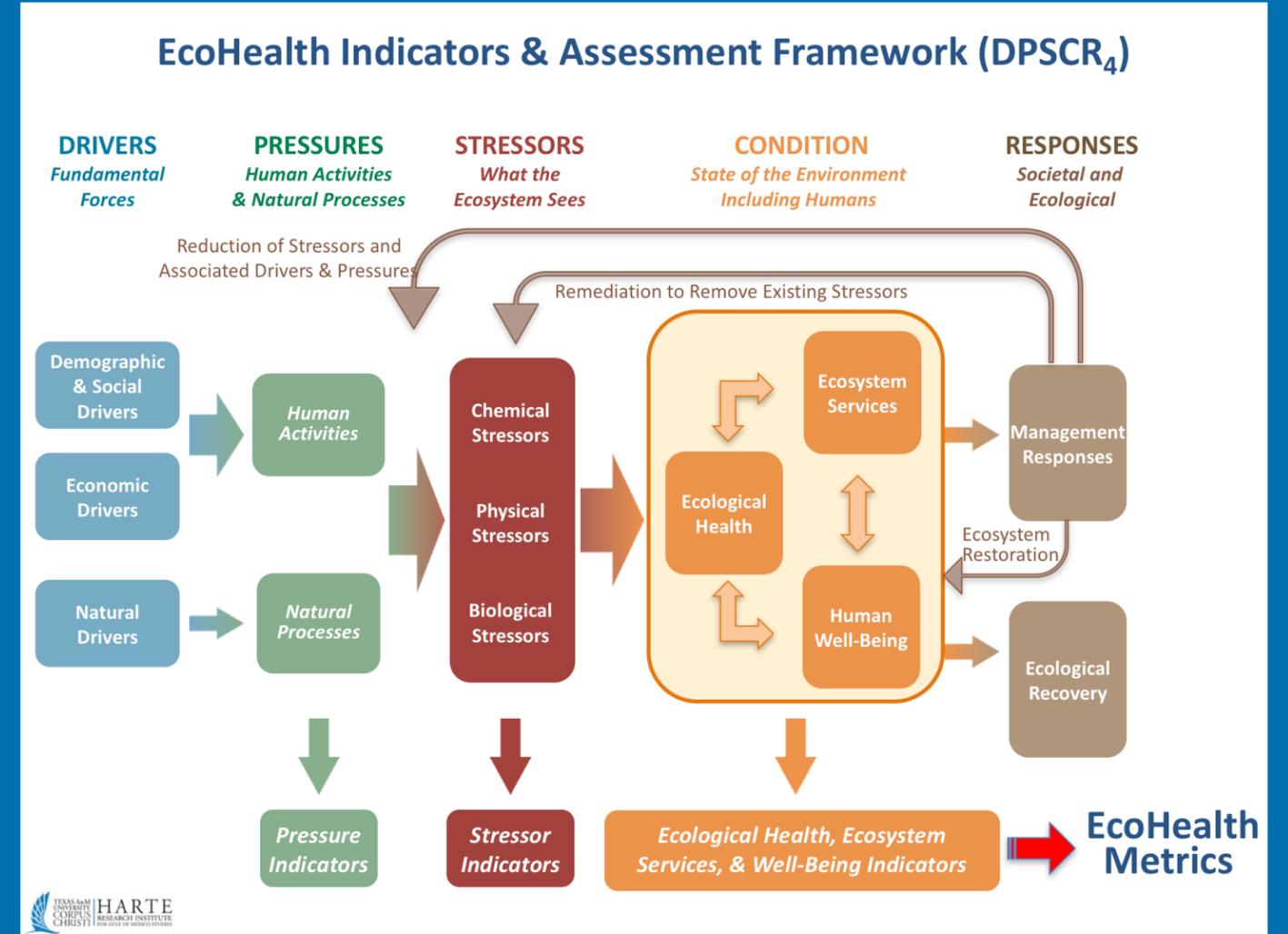
We are testing this approach through a pilot study on four Texas coastal systems: seagrasses, oyster reefs, birds, and fisheries. For each system, we identified the drivers, pressures, and stressors impinging on the system; selected Valued Ecosystem Components (VECs) and their indicators that capture the essential characteristics of each ecosystem; and ranked the strength of each stressor – VEC relationship. This provided the basis for a system-specific, risk-based Conceptual Ecosystem Model (CEM). The status and trends of the VECs/indicators were then used as the basis for qualitatively or quantitatively (when sufficient data are available) assessing the condition or health of the ecosystem.

EcoHealth Metrics Communications Structure

The Report Card, as represented by the following pages, is only the top of the EcoHealth Metrics communications pyramid. It is aimed at the higher-level audiences (general public and policy/decision-makers), while lower levels in the pyramid have increasingly detailed information, targeted at more technical audiences. When fully implemented, the Gulf of Mexico EcoHealth Metrics will comprise all levels of communications, produced periodically to provide continuing updates on progress towards a healthy, sustainable Gulf of Mexico.



EcoHealth Metrics Framework



The integrated assessment/management framework for the Gulf of Mexico EcoHealth Metrics is based upon the Drivers-Pressures-Stressors-Condition-Responses (DPSCR4) that affect ecosystems. Drivers are the fundamental forces driving the coupled human-environment system (e.g., industry, climate change), leading to Pressures, i.e., human activities and natural processes (e.g., oil/gas extraction, coastal development, sea-level rise), which generate the chemical, physical, or biological Stressors (e.g., toxic chemicals, habitat alteration, invasive species) that affect ecosystems. Stressors cause effects on Condition via changes to ecological structure, processes, and/or diversity and associated effects on ecosystem services that link ecological systems, societal systems, and human well-being. Ecological condition is assessed on selected Valued Ecosystem Components (VECs), those ecologically and/or societally important attributes that specifically represent each type of ecosystem of concern.

Management actions feed back to the ecological systems through four types of Responses: 1) Reduction of stressors through regulation or other constraints on the drivers and pressures (e.g., land use policies, air pollution regulations); 2) Remediation, the removal of existing stressors (e.g., clean-up of oil spills or toxic chemical sites); 3) Restoration of damaged ecosystems (e.g., planting seagrasses); and 4) Recovery of ecosystems through natural processes once stressors are reduced or eliminated.

Each component of the DPSCR4 framework has specific sets of indicators that characterize ecological health, ecosystem services, human well-being, and associated pressures and stressors. The status and trends of these indicators as measured on selected VECs (i.e., an ecosystem health Report Card) informs the decision-making process on appropriate actions to improve ecological health and achieve ecosystem sustainability.



Texas Coast Fisheries Results

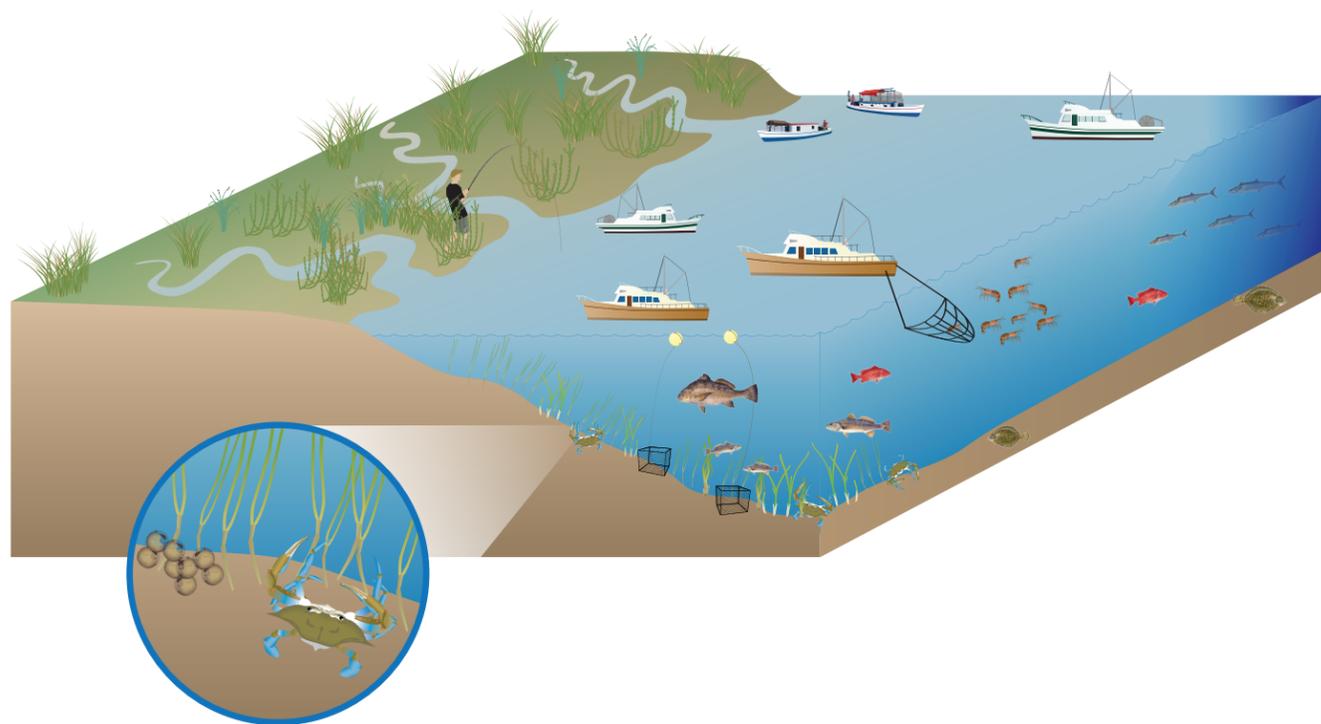
The Texas coast supports a diverse community of inshore and offshore fisheries from finfish such as Red Drum, Spotted Seatrout, Southern Flounder, and Red Snapper to invertebrates such as Gulf Shrimp, Blue Crab, and many more. These resources support vital ecological and economic roles. Understanding and maintaining the sustainability of these fisheries are key to a healthy Gulf of Mexico.

Why do we care?

Texas' commercial and recreational fisheries are billion-dollar industries that create thousands of jobs. Aside from the obvious economic benefits, Texas' fisheries also provide robust recreational opportunities that are part of the fabric of the region's history and culture. Monitoring the health of key fisheries is critical to sustaining, regulating, and improving the marine environment for future generations to use and enjoy.

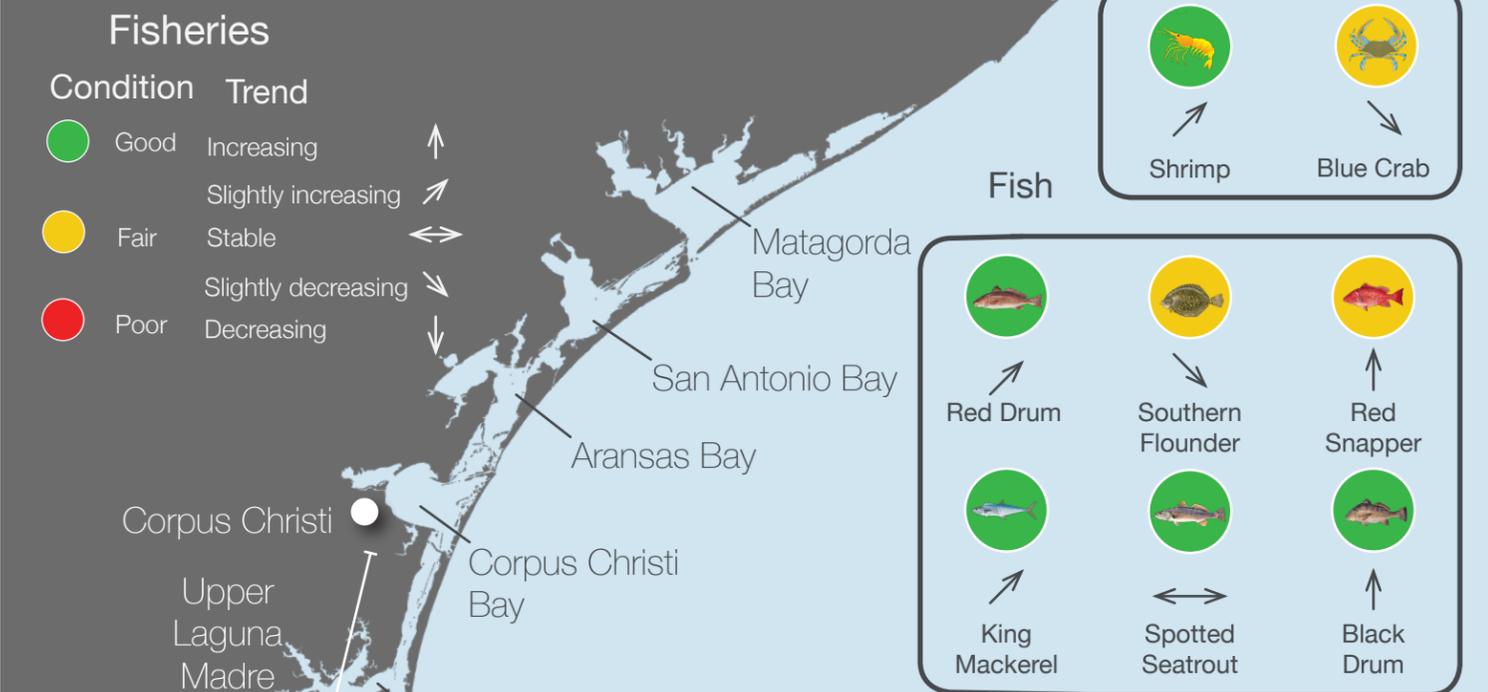
Stressors

Every fishery faces certain stressors that can negatively affect the population, which can be natural or result from human activity. In addition, not every fishery or area responds to stressors in the same manner, meaning that stressors must be evaluated by species and by region. Effective management has resulted in healthy, sustainable populations for many of Texas' fisheries. However, overharvesting, illegal fishing, discard mortality, disease, and a suite of physical changes such as decreased freshwater inflow have the potential to destabilize several fisheries along the Texas coast.



Historical Trends

Many fish populations that are abundant along the Texas coast today were once near collapse. Science-based fisheries management, coupled with public support and wise conservation, have led to dramatic recovery for many fisheries, including Red Drum and Gulf Shrimp. World-class resource monitoring, improved research, and emerging technology have allowed fisheries managers to make well-informed decisions, as well as detect changes to a fishery and implement responsive management strategies.



How are fisheries doing?

Proper management has led to plentiful populations of Red Drum, Spotted Seatrout, Black Drum, King Mackerel, and Gulf Shrimp, despite heavy fishing pressure. Managing the stressors to these fisheries has had minimal effect on their productivity as monitoring data indicate that they have been stable, and in some cases increasing, over the past decade, particularly in State waters. Some challenges still exist with the Southern Flounder and Blue Crab fisheries, which have exhibited their lowest population sizes and an overall decline during the past 20 years. Abundance and landings data for these species suggest that overfishing or other environmental factors may be occurring. These may require additional assessments and regulations to prevent further decline and facilitate rebuilding these populations. Perhaps the most studied and certainly the most discussed fishery on the Texas coast is Red Snapper. This once overharvested species has experienced an impressive rebound over the past decade. However, increased illegal fishing pressure from Mexico, along with high discard-mortality rates, continue to be concerns. Despite recovery, contention regarding access to this fishery, particularly for recreational anglers, continues to be the largest management concern. Managers should continue striving to improve fishery access and proper allocation of this resource.



Texas Coast Seagrass Results

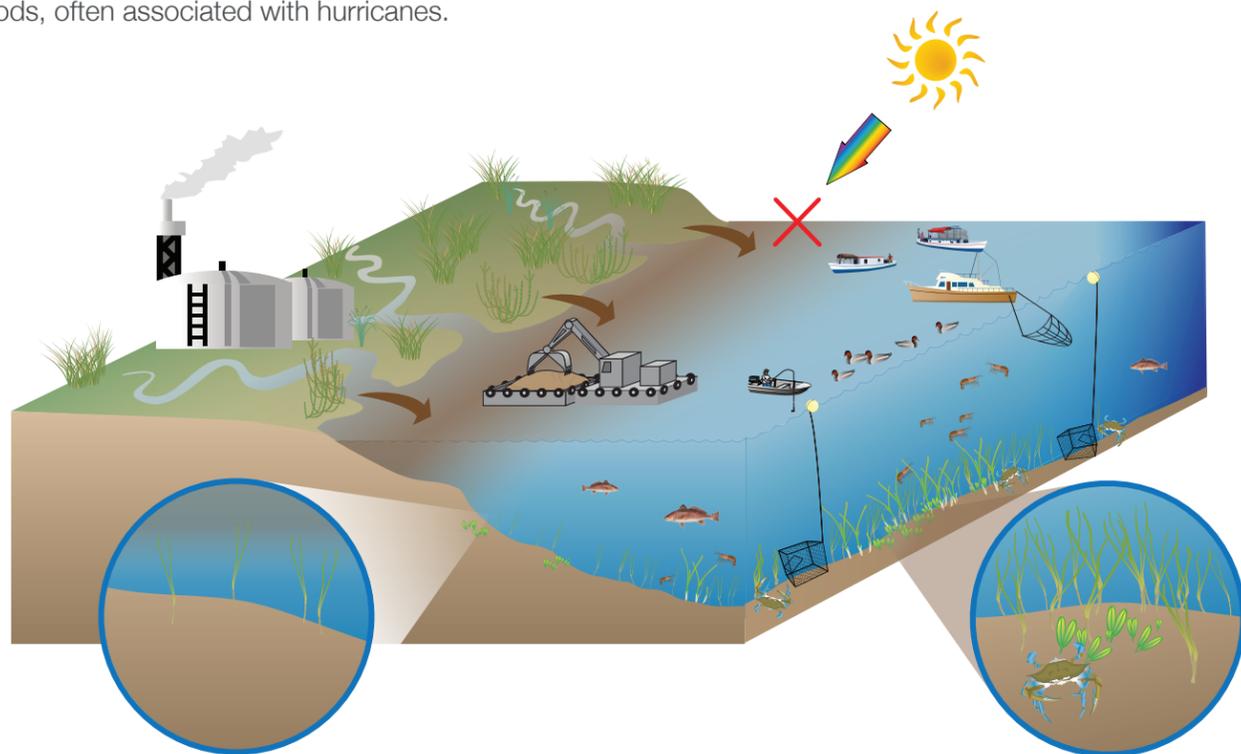
Seagrasses are the only flowering plants that have colonized the sea. In Texas they include, from most to least salt-tolerant, shoal grass (*Halodule wrightii*), turtle grass (*Thalassia testudinum*), star grass (*Halophila engelmannii*), and manatee grass (*Syringodium filiforme*). A fifth species, widgeon grass (*Ruppia maritima*), is a freshwater aquatic plant that can tolerate high salinity, especially in evaporating ponds.

Why do we care?

World-wide, seagrasses provide: nursery habitat for commercially and recreationally important fish and invertebrates; coastal protection from erosion; water purification (e.g., reducing eutrophication and phytoplankton blooms, and removing toxic organic compounds from water column and sediments); sediment stabilization; and a sink for atmospheric carbon dioxide, among other valued services. Specific to Texas, seagrasses provide wintering habitat for over half the world's population of Redhead Ducks and essential nursery for Red Drum and shrimp.

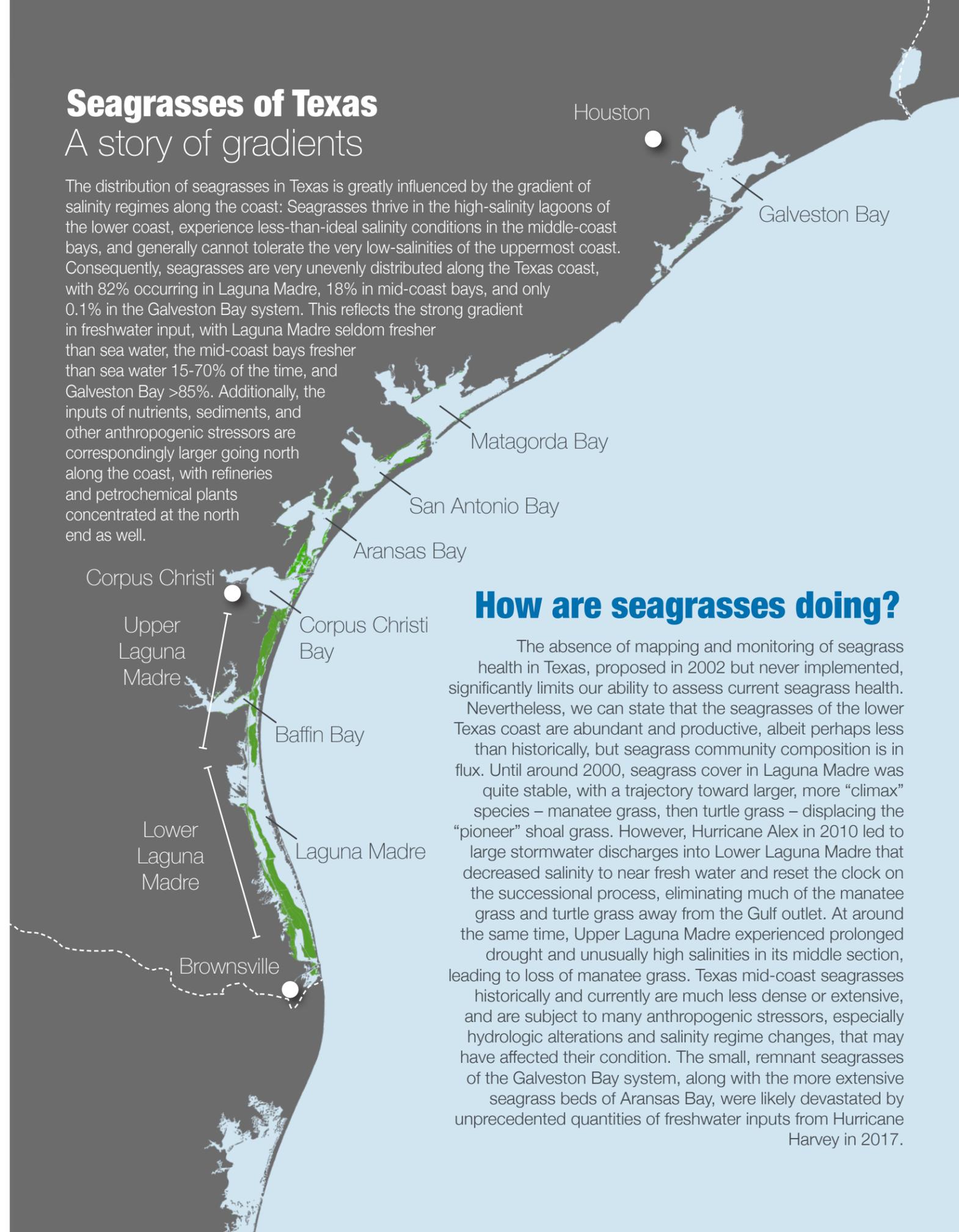
Stressors

The most important stressors on Texas seagrass meadows and the services they provide are those that impact the amount of light reaching the bottom — nutrient loading resulting in more phytoplankton in the water column and harmful micro- and macro-algal blooms, including brown tides; turbidity carried in from the watershed and caused by erosion, dredging, and sediment resuspension within our bays; increased water depth resulting from subsidence and sea-level rise. Although much of the Texas coast is lightly developed, nutrient enrichment from nonpoint sources is a concern, especially for the seagrass-rich lower coast, whereas for the upper coast, where seagrass is largely limited because of the salinity regime, industrial development and urbanization are key pressures. Overarching all is the Texas climate of extremes: long periods of drought alternating with extremely wet periods, often associated with hurricanes.



Seagrasses of Texas A story of gradients

The distribution of seagrasses in Texas is greatly influenced by the gradient of salinity regimes along the coast: Seagrasses thrive in the high-salinity lagoons of the lower coast, experience less-than-ideal salinity conditions in the middle-coast bays, and generally cannot tolerate the very low-salinities of the uppermost coast. Consequently, seagrasses are very unevenly distributed along the Texas coast, with 82% occurring in Laguna Madre, 18% in mid-coast bays, and only 0.1% in the Galveston Bay system. This reflects the strong gradient in freshwater input, with Laguna Madre seldom fresher than sea water, the mid-coast bays fresher than sea water 15-70% of the time, and Galveston Bay >85%. Additionally, the inputs of nutrients, sediments, and other anthropogenic stressors are correspondingly larger going north along the coast, with refineries and petrochemical plants concentrated at the north end as well.



How are seagrasses doing?

The absence of mapping and monitoring of seagrass health in Texas, proposed in 2002 but never implemented, significantly limits our ability to assess current seagrass health. Nevertheless, we can state that the seagrasses of the lower Texas coast are abundant and productive, albeit perhaps less than historically, but seagrass community composition is in flux. Until around 2000, seagrass cover in Laguna Madre was quite stable, with a trajectory toward larger, more “climax” species – manatee grass, then turtle grass – displacing the “pioneer” shoal grass. However, Hurricane Alex in 2010 led to large stormwater discharges into Lower Laguna Madre that decreased salinity to near fresh water and reset the clock on the successional process, eliminating much of the manatee grass and turtle grass away from the Gulf outlet. At around the same time, Upper Laguna Madre experienced prolonged drought and unusually high salinities in its middle section, leading to loss of manatee grass. Texas mid-coast seagrasses historically and currently are much less dense or extensive, and are subject to many anthropogenic stressors, especially hydrologic alterations and salinity regime changes, that may have affected their condition. The small, remnant seagrasses of the Galveston Bay system, along with the more extensive seagrass beds of Aransas Bay, were likely devastated by unprecedented quantities of freshwater inputs from Hurricane Harvey in 2017.



Texas Coast Oyster Results

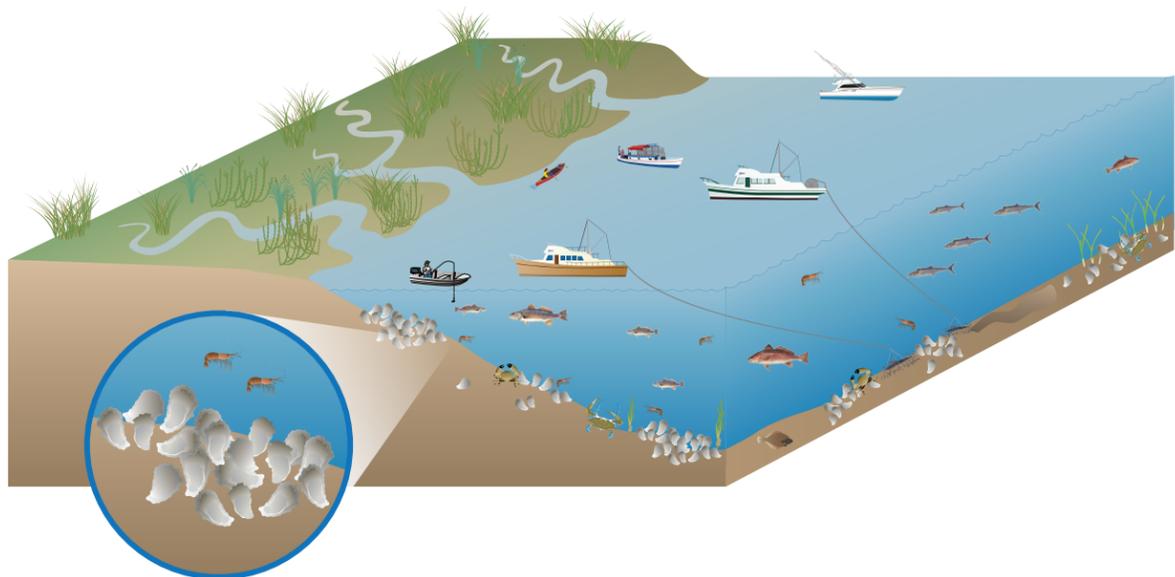
Oyster reefs are fundamental components of healthy estuaries. Vibrant oyster populations occur in many Texas coastal waters, supported by favorable environmental conditions. Year-round warm waters promote oyster growth and extend spawning periods. These unique characteristics support resilience and rapid recovery of oyster populations following disturbance and enhance the success of habitat restoration efforts.

Why do we care?

Oysters provide important ecological and economic benefits. As suspension feeders, they filter and clean bay waters; a single oyster can filter up to 50 gallons in one day. As reef-builders, oysters create 3-dimensional, complex habitat for numerous fish and invertebrates and enhance recreational angling. Oyster reefs protect shorelines from erosion and can reduce wetland loss. Oysters support a robust seafood industry, generating over \$16 million annually in Texas over the past decade.

Stressors

Oyster reefs are among the most threatened marine habitats on Earth, with an estimated 20-50% of the original reefs remaining in the Gulf of Mexico. Declines in the abundance of oysters are a consequence of habitat loss, hydrologic alterations, water quality degradation, resource overharvest, disease, and storms. Because oysters depend on a delicate balance of salt and freshwater, they are particularly sensitive to changes in the salinity regime. After Hurricane Harvey in 2017, a severe oyster mortality event occurred along the upper coast in response to massive inputs of freshwater that decreased salinity below oyster tolerance levels. Increasing salinities can also harm oysters: upstream water diversions and reduced freshwater inflow can increase oyster mortalities by allowing marine predators and diseases to thrive. Excess nutrient inputs to coastal waters can lead to hypoxia, areas of low oxygen that stress oysters and lead to higher mortalities. Oyster harvest occurs by dragging a dredge along the bay bottom. Because free-swimming larval oysters depend on the shells of older generations for attachment and growth, when oyster harvests occur at unsustainable rates, the lack of shells inhibits natural recovery processes and essential habitat is lost.



Oysters of Texas

What's where and why

Oysters in Texas occur primarily on subtidal, or continuously submerged, reefs in low- to moderate-salinity estuaries along the upper and middle coast. High salinities in the southernmost bays create conditions that are not suitable for supporting substantial oyster populations. Harvests occur from November to April, with oysters living along the upper coast and in fresher waters known for having a sweeter taste, and those along the middle-lower coasts and closer to the Gulf of Mexico having a salty flavor. The Gulf of Mexico has produced the greatest numbers of oysters in the U.S. since around 2000, with Texas second only to Louisiana in harvest level. Oysters are bellwethers of change in Texas bays—the marine equivalent of the canary in the coalmine—if oysters are doing well, the upper- and middle-coast bays are healthy.

Houston

Sabine Lake*

Galveston Bay *Limited Data

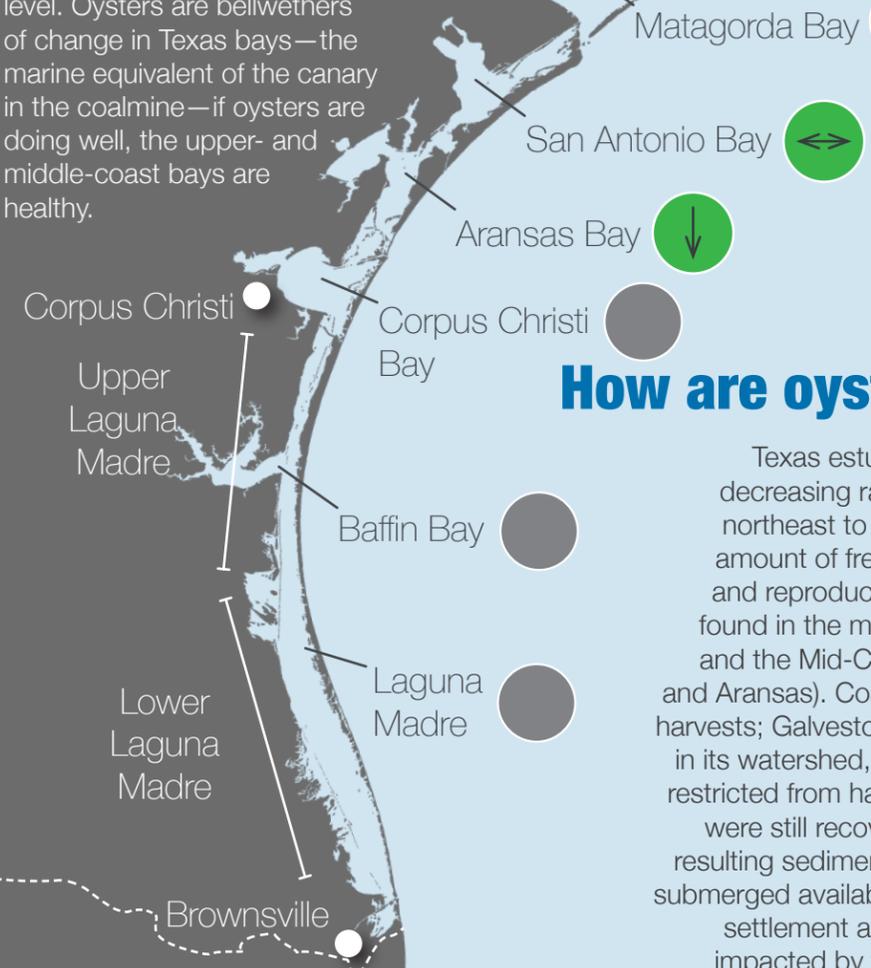
Oyster Fisheries

Condition Trend

- | | | |
|--------------------------------------|---------------------|---|
| ● Good | Increasing | ↑ |
| | Slightly increasing | ↗ |
| ● Fair | Stable | ↔ |
| | Slightly decreasing | ↘ |
| ● Poor | Decreasing | ↓ |
| ● Minimal Natural Oyster Populations | | |

How are oyster fisheries doing?

Texas estuaries are remarkably diverse because of decreasing rainfall and freshwater inflow moving from northeast to southwest. Differences in the timing and amount of freshwater delivery influence oyster growth and reproduction, with the largest numbers of oysters found in the moderate-salinity waters of Galveston Bay and the Mid-Coast estuaries (Matagorda, San Antonio, and Aransas). Coastal development also influences oyster harvests; Galveston Bay has the largest human population in its watershed, and as a result, has more areas that are restricted from harvest. Galveston Bay oyster populations were still recovering from Hurricane Ike in 2008, where resulting sediment deposition smothered live oysters and submerged available hard substrate, deterring larval oyster settlement and reef recovery, when they were heavily impacted by freshwater runoff from Hurricane Harvey. Recognition of the importance of oysters in Texas has led to widespread restoration efforts by a number of federal, state, private, and non-governmental organizations. Habitat restoration, typically involving the placement of oyster shells or other hard substrates in appropriate areas of the bays, have goals ranging from commercial fishery enhancement to replacing lost ecosystem benefits. These efforts have maintained the middle-coast reefs in good condition.





Texas Coast Bird Results

Texas coastal habitats support a wide variety of resident, breeding, and migratory birds. During the breeding season, large colonies of spoonbills, herons, egrets, gulls, terns, and skimmers raise their young in estuarine habitats such as bay islands. In winter, millions of waterfowl and shorebirds find a safe haven where food is plentiful and the climate is mild. During migration, the Texas coast is an important hemispheric stopover where many Neotropical birds rest and refuel.

Why do we care?

Texas is the number one bird-watching destination in North America. With at least 400 species, two-thirds of the State's bird diversity resides near the Gulf. Iconic species like Piping Plover and Whooping Crane attract nature tourists from all over the world. Ecotourism adds hundreds of millions of dollars to the State's economy and creates thousands of jobs, especially in coastal communities. Birds are also important ecosystem components functioning as predators, scavengers, and prey. Because of their mobility, birds link ecosystem processes and fluxes across space and time.

Stressors

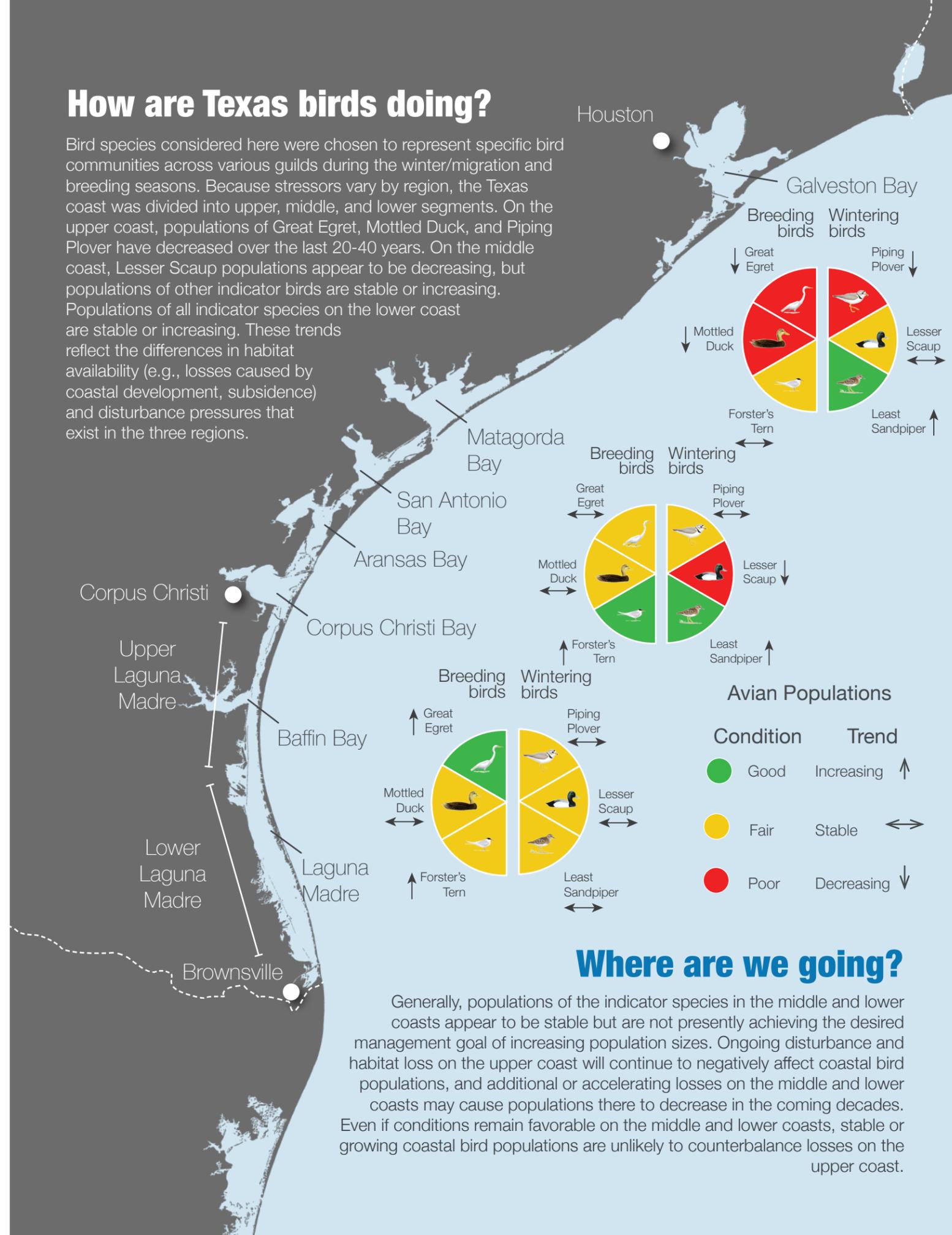
Birds face many natural and anthropogenic stressors that may affect survival or reproductive success. If severe or continual, stressors may cause population sizes to decrease. Stressors include habitat loss or alteration; climate-related changes, including storm surge and sea-level rise; petrochemical or contaminant releases; diminished habitat quality with inadequate food resources; and human disturbance. A bird's response to stressors varies depending on its position within its annual cycle. The cumulative effects of stressors that birds encounter during migration, wintering, and breeding have resulted in population declines in many species. Critical stressors for migrating and wintering birds are reduced habitat quality, most importantly affecting food availability. For breeding birds, disturbance and predation may have the greatest effect. Ensuring that stressors are eliminated or minimized for birds in Texas coastal habitats is key to maintaining healthy bird populations.

Historical Trends

Birds are hemispheric resources; thus, the status of any population is affected by the health of ecosystems throughout its range. Populations of many coastal bird species have decreased during the last few decades. Recognition of population decreases is the first step in addressing causes for decline and working toward species recovery. Overall, populations of Mottled Duck, Lesser Scaup, and Least Sandpiper are decreasing, whereas Great Egret and Forster's Tern are increasing. Piping Plover, although currently increasing, remains vulnerable to extinction because its geographic range is limited and its total population is only ~8000 individuals. Piping Plover populations have grown by about 50% since 1985, because of aggressive management of habitat on both wintering and breeding grounds and reduction of stressors, such as disturbance, during the breeding season. However, these gains could be easily reversed if habitat loss were to again accelerate, or other stressors increased in severity.

How are Texas birds doing?

Bird species considered here were chosen to represent specific bird communities across various guilds during the winter/migration and breeding seasons. Because stressors vary by region, the Texas coast was divided into upper, middle, and lower segments. On the upper coast, populations of Great Egret, Mottled Duck, and Piping Plover have decreased over the last 20-40 years. On the middle coast, Lesser Scaup populations appear to be decreasing, but populations of other indicator birds are stable or increasing. Populations of all indicator species on the lower coast are stable or increasing. These trends reflect the differences in habitat availability (e.g., losses caused by coastal development, subsidence) and disturbance pressures that exist in the three regions.



Where are we going?

Generally, populations of the indicator species in the middle and lower coasts appear to be stable but are not presently achieving the desired management goal of increasing population sizes. Ongoing disturbance and habitat loss on the upper coast will continue to negatively affect coastal bird populations, and additional or accelerating losses on the middle and lower coasts may cause populations there to decrease in the coming decades. Even if conditions remain favorable on the middle and lower coasts, stable or growing coastal bird populations are unlikely to counterbalance losses on the upper coast.

Visions and Next Steps



Texas Coast Report Card

The next steps for the EcoHealth Metrics for Texas are: a) to enhance the existing metrics through development of additional databases on ecological condition; b) develop similar databases on the stressors of importance to each system; and c) incorporate other coastal systems of importance in Texas, in particular coastal marshes and mangroves. The initial Texas seagrass EcoHealth Metrics demonstrated a paucity of essential data on seagrass spatial extent and health; thus, one important activity would be to build upon the seagrass mapping and monitoring plans developed for Texas a decade ago but never implemented. Another envisioned project would examine coastal marshes and the mangrove/marsh ecotone utilizing a satellite- and aerial-based hyperspectral imagery as a synoptic indicator for sea-level rise across Texas and the northern Gulf. Expansion of condition and stressor databases will require enhanced linkages to relevant federal and state agencies, non-governmental organizations, and other potential sources of environmental data.

Mexico Coast Report Card

The Mexican Gulf of Mexico shoreline is predominantly sandy beach habitat with some rocky seashores in Veracruz and Campeche. Over 35 coral reefs exist in offshore waters, and over 20 coastal lagoons and estuaries extend from Texas to the Caribbean. Mangroves line lagoon and estuary shorelines, and seagrass beds and oyster reefs are present in some. Fisheries data are the only long-term biotic datasets available in Mexico; report card activity should include collaboration with academic institutions and federal and state agencies.

Northern and Eastern Gulf Coast Report Card

We believe the next step in expanding EcoHealth Metrics Gulf-wide is to tailor our framework to the coastal ecosystems of Florida that comprise the eastern Gulf of Mexico. The process we envision is to convene a workshop that engages knowledgeable practitioners to: develop Florida-specific EcoHealth Metrics for important coastal ecosystems; develop conceptual models of the coupled human-ecological systems for those ecosystems; rank the pressure-stressor-VEC relationships as they exist in Florida; identify specific indicators and metrics and potential data sources; initiate a Florida EcoHealth Metrics communications strategy; and transfer the methodology and approach to an appropriate Florida-based institution. A subsequent step would be to follow the same process, but focused on the unique coastal ecosystems of Louisiana, with their particular vulnerability to sea-level rise and to petrochemical-related stressors, as well as a separate activity characterizing the similar coastal ecosystems that extend from coastal Mississippi through the Florida panhandle.

Gulf-Wide and Pelagic Systems Report Card

A cross-cutting Gulf EcoHealth Metrics initiative would begin by extending the Texas bird and fisheries report cards throughout the Gulf of Mexico, integrating databases from other states and regions with synoptic databases such as Cornell Lab of Ornithology's eBird. Two key at-risk components from the Deepwater Horizon oil spill require attention: a new project needs to be developed on Gulf marine mammals, a critically important cross-Gulf valued ecosystem component; and similarly, the continental slope and abyssal benthic ecosystems are essential but largely unknown components of the greater Gulf of Mexico ecosystem. We also envision explicit linkages to large-scale remote-sensing atmospheric and oceanographic observing systems that are commensurate with the spatial scale of the open Gulf of Mexico.

Cuba Coast Report Card

Cuba's northwestern shoreline from its far western tip to Punta Hicacos, just east of Havana, constitutes the island's Gulf of Mexico region. Coral reefs are common on the narrow continental shelf, and seagrasses exist near shore. The coastline is mostly sandy beaches with scattered limestone rocky shores. There are some barrier islands, which protect extensive mangrove lagoons, and several small estuaries with mangrove shorelines. Fisheries data are the only long-term biotic datasets available in Cuba, and report card activity there should include collaboration with academic institutions and federal and provincial agencies.

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