

3.4 Data Gaps Assessment

3.4.1 Water and Sediment Quality

Water and sediment quality of Galveston Bay and its tributaries is analyzed primarily by data collected via the TCEQ Surface Water Quality Monitoring (SWQM) Program and the H-GAC Clean Rivers Program (CRP). Other ancillary data sets exist including TPWD National Coastal Assessment (NCA) data, TPWD Coastal Fisheries hydrological data (dissolved oxygen, temperature, salinity data etc.), Texas DSHS bacteriological data, and water and sediment quality data from US Army Corps of Engineers channel dredging operations.

While all of these data sets provide important information, they are difficult to pull together to form one cohesive picture. When compared to one another, each agency uses different field and laboratory techniques, reports on differing parameters, and sometimes uses conflicting units of measure. This is the case because each agency must gather data according to its mission, needs (research versus regulatory), and available resources.

Of the parameters analyzed, the greatest spatial and temporal gaps occur for organic and inorganic toxics in the water column. Very little data exists describing concentrations of these contaminants in the waters of Galveston Bay. There are primarily two reasons for this. First, organic and inorganic contaminants often adhere to suspended solids in the water column and become “locked” into the sediments until they are released by water chemistry changes or disturbance. Additionally, it is very expensive to analyze water samples for these types of contaminants.

Three classes of toxic contaminants in sediments of Galveston Bay were analyzed for spatial and temporal gaps: metals, industrial organic compounds, and organic pesticides. Each class included the following contaminants:

- Metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc
- Industrial organic compounds: Acenaphthylene, acenaphthene, anthracene, benzo-a-pyrene, chrysene, fluoranthene, fluorene, naphthalene, phenanthene, pyrene, Benzo(a)anthracene/1,2-benzanthracene, 1,2,5,6-dibenzanthracene, and PCBs
- Organic pesticides: chlordane, DDT, Dieldrin, and lindane

Of the three classes of toxic contaminants analyzed for the period 1973-2004 the largest number of samples were gathered for metals in sediment (Figure 3.4.1). Spatially, the greatest number of samples was collected from the Houston Ship Channel at a rate of nearly two times that of samples collected from the next most sampled areas: Upper and Lower Galveston Bay, Clear Creek/Clear Lake, Trinity Bay, and West Bay (Figure 3.4.1). This same pattern generally holds true for all three classes of contaminants.

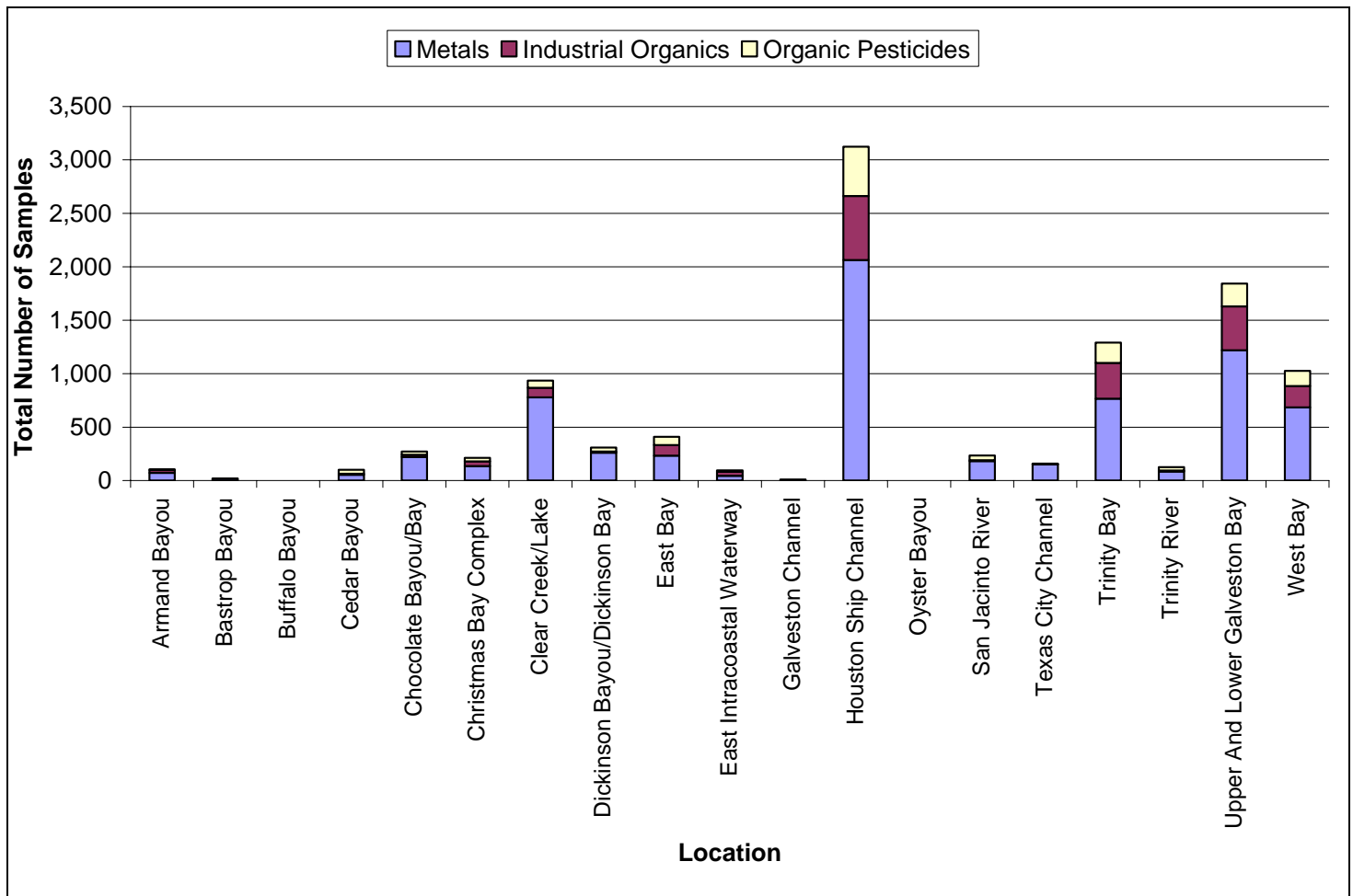


Figure 3.4.1. Total number of samples by area of three classes of toxic contaminants sampled in sediments of Galveston Bay during the period 1973-2004.

The fact that the Houston Ship Channel receives the most attention for this type of sampling is obviously due to the large amount of industrial activities and permits existing in and near the Houston Ship Channel. However, as the human population increases and anthropogenic sources of toxic contaminants are located in other areas of the watershed, the spatial coverage of sampling will undoubtedly have to be increased if we are to analyze trends of these parameters.

Temporally speaking, metals in sediment have been sampled since 1973. As seen in Figure 3.4.2, sampling for toxic compounds in sediments was at its lowest in the early 1990s, but has seen an increase since. Interestingly, it appears that no samples of industrial organics or organic pesticides have been sampled from bay sediments since 2002.

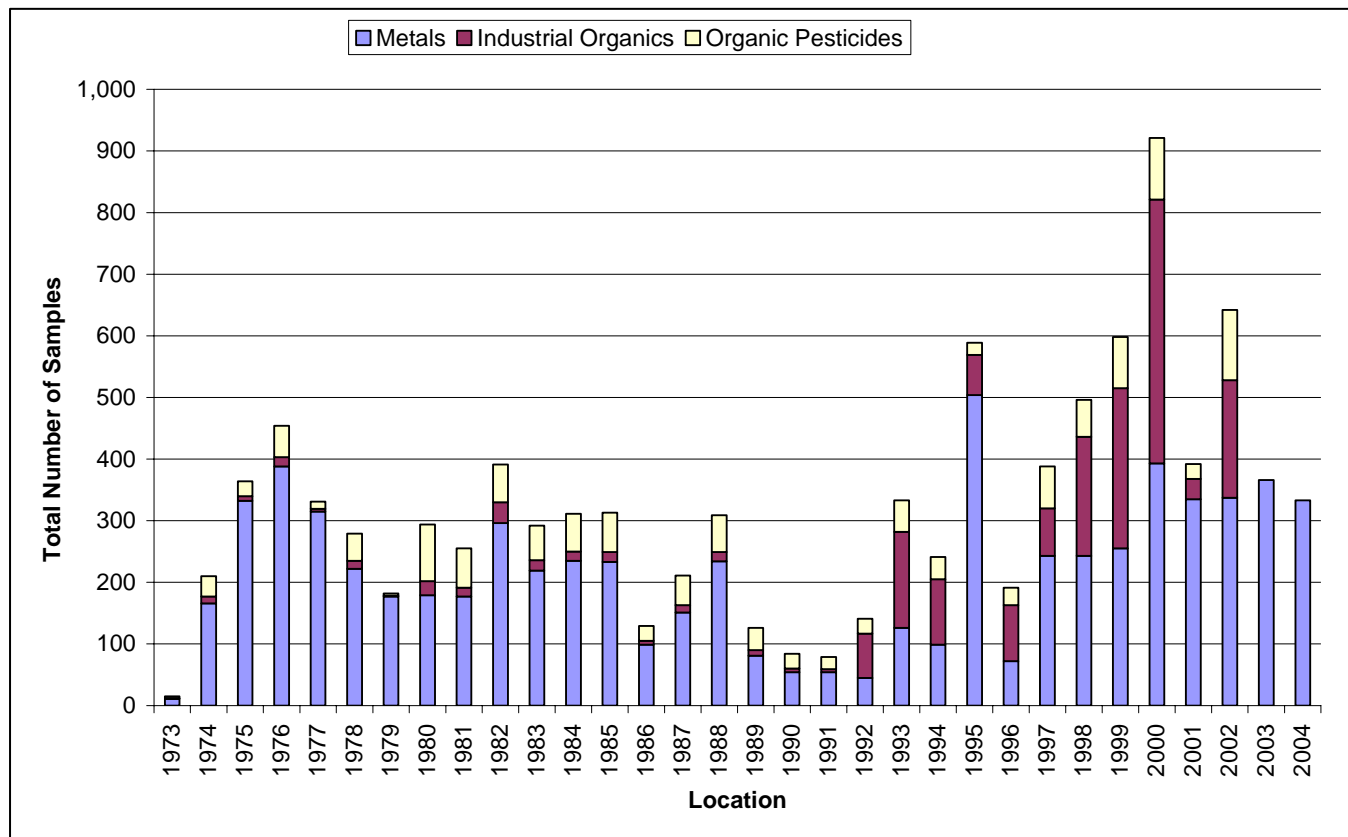


Figure 3.4.2. Total number of samples by year of three classes of toxic contaminants sampled in sediments of Galveston Bay during the period 1973-2004.

In terms of water quality, three classes of parameters are generally sampled: conventional parameters, nutrients, and bacterial pathogens. Of those three water quality classes, the parameters are:

- Conventionals: Water temperature, specific conductance, dissolved oxygen (5:00-10:00 AM), pH, salinity, total suspended solids, and total organic carbon
- Nutrients: 5-day biochemical oxygen demand, ammonia, nitrate-nitrite, orthophosphorus/phosphorus, chlorophyll-a/pheophytin-a
- Bacterial pathogens: Fecal coliform, *E. coli*, and Enterococci

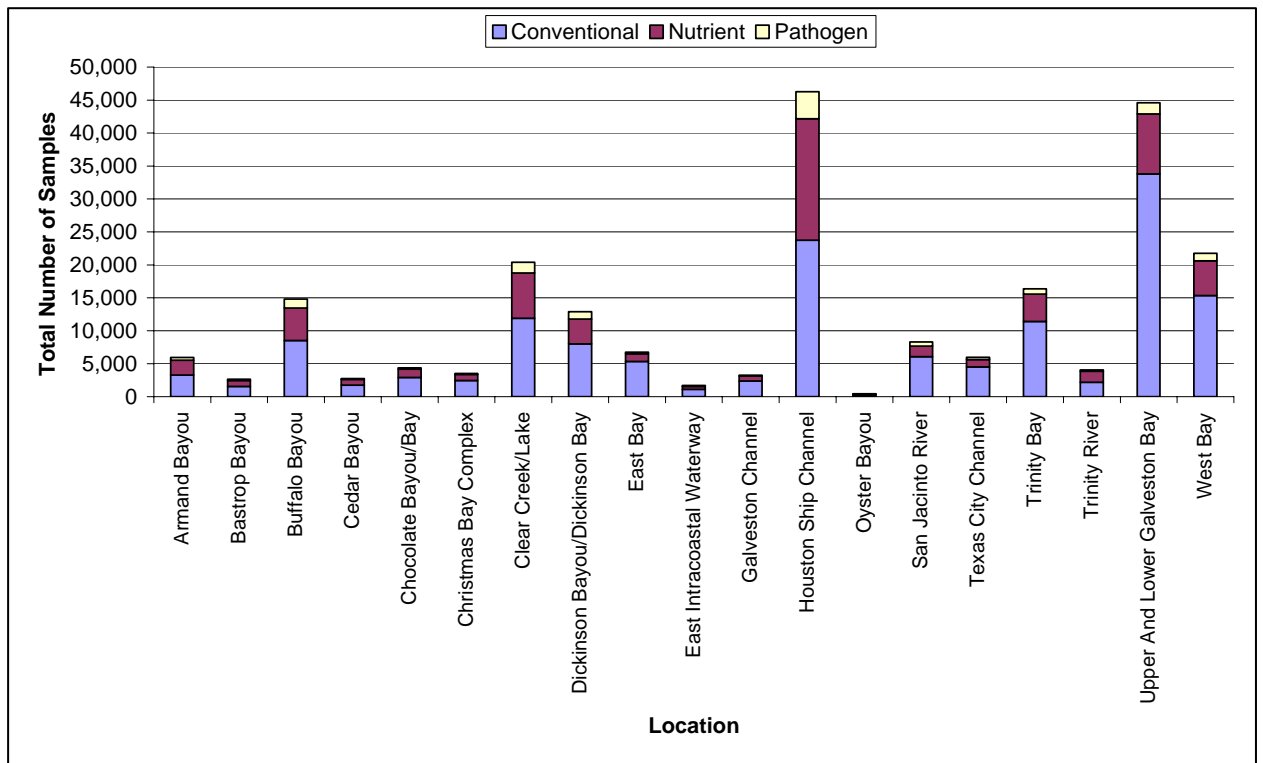


Figure 3.4.3. Total number of samples by area of three classes of water quality parameters sampled in surface waters of Galveston Bay during the period 1969-2004.

When comparing figure 3.4.3 to 3.4.1, one can see the tremendous disparity in terms of the number of water and sediment quality samples obtained. The greatest number of samples occurs in the Houston Ship channel, Upper and Lower Galveston Bay, Clear Creek/Clear Lake, and West Bay. Additionally, water quality is sampled frequently in Trinity Bay, Dickinson Bayou/Bay, and Buffalo Bayou. Conventional parameters are the subject of the greatest sampling effort just before nutrients. Bacterial pathogens account for the fewest water quality samples even though this form of contamination presents one of the greatest public health challenges for the bay.

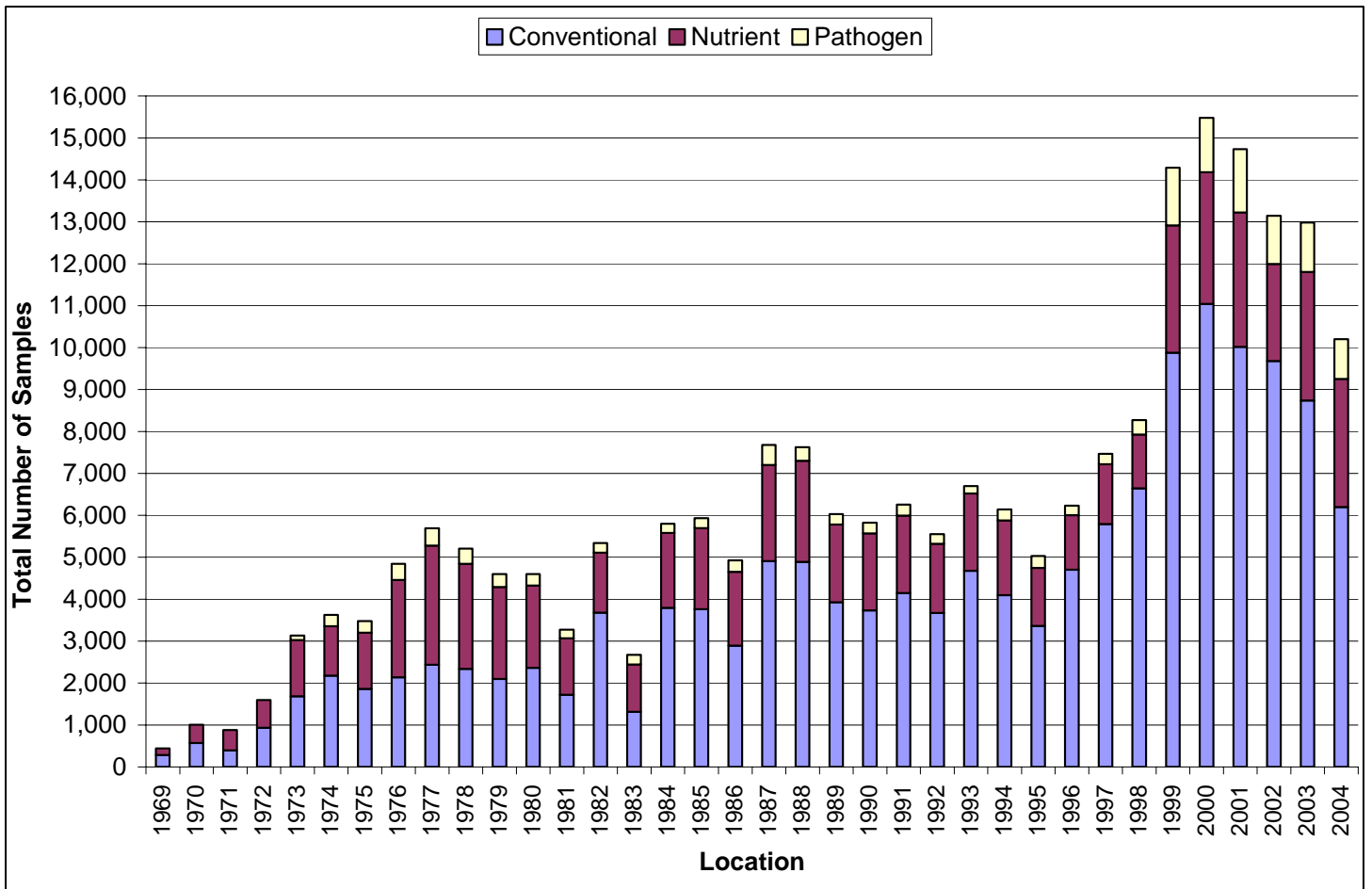


Figure 3.4.4. Total number of samples by year of three classes of water quality parameters sampled in surface waters of Galveston Bay during the period 1969-2004.

As one can see in Figure 3.4.4, water quality sampling in general has been on the increase since 1999. Given the state of bacterial pathogens in surface water of Galveston Bay and its tributaries sampling for bacterial pathogens has noticeably increased since 1999.

3.4.2 Living Resources

The assessment of status and trends of living resources in the Galveston Bay watershed is based primarily on the fisheries independent monitoring program operated by the Texas Parks and Wildlife Department (TPWD) Coastal Fisheries Division. To the best of our knowledge, there is no long term monitoring program targeting terrestrial animals, with the exception of birds. U.S. Fish and Wildlife coordinates two programs: one monitors the number of breeding birds in colonies along the coast and the other monitors numbers of migratory waterfowl over wintering in National Wildlife Refuges along the coast. We make use of the annual survey of colonial nesting water birds in this study. There are other bird surveys conducted by the Audubon Society of birds that are less related to Galveston Bay.

There is no long term monitoring program that collects and identifies plants, aquatic or terrestrial. TCEQ collected and identified phytoplankton species for several years in the 1980's, but the effort was discontinued. There are scientific studies from time to time of the phytoplankton community in Galveston Bay, but episodic studies that lack a consistent method of data collection and quality control are outside the scope of the status and trends program. Attempts have been made to survey the abundance of submerged aquatic vegetation (SAV or seagrass beds), but the efforts are episodic and no consistent methodology has been established to be used in long term monitoring. The majority of terrestrial plants are only surveyed in the form of communities employed as categories in land cover classification. Even this well established application of remote sensing does not have the consistency of methodology required to properly assess temporal trends.

The principal gear types employed by TPWD for collection are bag seine, shrimp trawl, gillnet, and oyster dredge. The gears are used by the agency because they are best suited to monitoring the living resources that support recreational and commercial fisheries. Each of the four gear types limits the minimum size of organisms captured. Occasionally there is an incidental capture of organisms below the minimal size as in the case of grass shrimp captured by gill net, but the general result of employing these collection gears is that a major component of the plankton and some nekton are not collected.

Except for the oyster dredge, which is designed to collect bivalves with shell lengths greater than several centimeters, the collection gear can not collect infauna. The community of polychaetes, crustaceans, mollusks, etc. that live in the sediment are not represented in the TPWD data base. The Texas Commission on Environmental Quality (TCEQ) sampled and analyzed benthic infauna in the past and has renewed that sampling, but there is no data set with sufficient spatial and temporal coverage to employ in the Status and Trends study.

The spatial coverage of the sampling gear used by TPWD appears to be determined by the limitations of the gear itself. As noted above, Christmas Bay is not adequately sampled by shrimp trawl and was omitted from that data set. This is due to the shallow depth of Christmas Bay and not to any decision by TPWD to curtail sampling. The same is generally true of bag seine and gill net. There are characteristics that a location must have in order for the sampling

gear to be deployed. Gill nets are typically deployed perpendicular to a shoreline, bag seines parallel to a shoreline, and shrimp trawls in open water. However, issues such as accessibility and substrate type may limit the ability of a gear to be deployed in all areas.

The TPWD sampling regime has many more gaps in temporal coverage than in spatial coverage due to the way the agency operates and decisions that have been made. While gill net is deployed overnight, bag seine and shrimp trawl collections are not made during hours of darkness. The gill net data is primarily obtained in the spring and fall. There is a paucity of data from winter and summer gill net collections (see Figure 3.4.5). While the temporal limitations are consistent over time and do not prevent trend analysis, they do represent gaps in our knowledge of the ecology of the bay ecosystem.

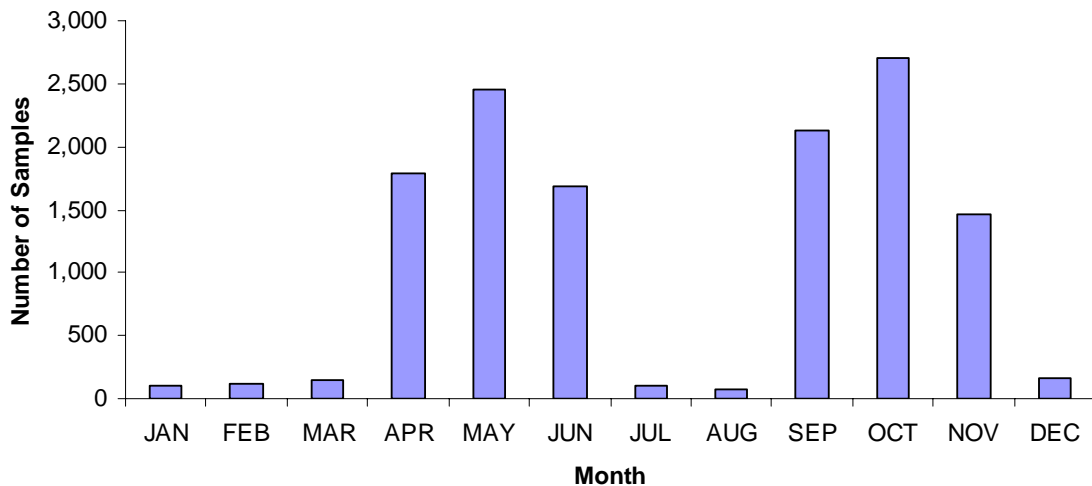


Figure 3.4.5. Total number of TPWD gill net samples by month in Galveston Bay over the period 1976-2004.

In summary, the data sets that are available and meet the criteria of the Status and Trends Quality Assurance Project Plan (QAPP) governing data acquisition and analysis do not provide a complete assessment of the status and trends of living resources in the Galveston Bay system. The data permits the study of aquatic animals that are larger than several centimeters in length and occupy the top of the sediment or the water column. Most of the information on smaller animals is based on daytime sampling, but the data provide good information about the abundance of adult fish and some adult crustaceans at night in spring and fall. Added to this information about aquatic animals is an annual estimate of the number of breeding pairs in nesting water bird colonies. While these data are very useful, they provide an incomplete picture of the ecosystems in the Galveston Bay system.

3.4.3 Habitat

As mentioned above, the absence of regular monitoring of terrestrial plant communities in the Galveston Bay watershed is only partially compensated by periodic land cover analysis from remote sensing data. The term habitat is simply one way of referring to the native plant communities. Some habitats of Galveston Bay are not defined by a plant community, i.e. oyster reef and open bay bottom. However, the plant communities described as fringing marsh and sea grass bed habitats receive special attention for restoration. There is no organization that has committed to a regular periodic assessment of habitats, either aquatic or terrestrial, in the Galveston Bay watershed.

The assessment of change in geographic coverage of sea grass beds over time with aerial photography is precluded by methodological restrictions. Aerial photography can show the presence of SAV when conditions such as very clear bay waters permit, but these conditions do not regularly occur in Galveston Bay. The resources required for vessel/boat based surveys are too great to expect this type of information to be gathered on a regular basis. Therefore, the information describing geographic distributions of SAV can be considered well informed, but anecdotal.

Fringing or estuarine marsh is one of the habitat types classified in land cover analysis using remote sensing images. The absence of a standard methodology for defining marsh boundaries leads to difficulties assessing the extent of this habitat. Emergent estuarine marsh plants such as *Spartina alterniflora* transition into terrestrial plant communities with no sharp boundary. Additionally, an estuarine marsh contains some amount of open water, but there is no established method of defining the boundary of the marsh in the water. As a result of this uncertainty, every classification of marsh acreage around Galveston Bay is based on different assumptions.

The problem is compounded by the differences in the remote sensing images employed to perform the classification. Classifications of wetland areas can change depending on image quality factors such as spectral coverage of the image and image resolution. Environmental factors such as recent precipitation, tidal height, season, and condition of plant growth also affect the classification. Additionally, habitat classifications of the Galveston Bay watershed are episodic (completed every five to ten years) and do not employ standard methods.

Oyster reef is another important habitat that receives considerable attention, but is surveyed episodically using different methods. Surveys of oyster reefs in the 1970s and 1980s used manual methods informed by the indigenous knowledge of fishermen and fishery biologists. TPWD produced maps of the known oyster reefs for management and navigation purposes. The advent of side-scan sonar led to a new method of surveying for oyster reefs and maps produced in the 1990s by scientists at Texas A&M University. There are major disagreements between the two methods that are still not resolved. Scientists and resource managers have no way of analyzing the temporal trends in area of bay bottom covered by oyster reefs or the status of particular reefs, except those recognized historically by commercial oystermen and managed by TPWD.

Wetland and terrestrial habitats can be classified from a variety of remotely sensed images. In the Lower Galveston Bay watershed, this has been accomplished from satellite images and aerial photos with different characteristics. While most habitat classification systems are largely based on one classification system (Cowardin 1979), each has resulted in a slightly differing set of habitat classes ranging in number from 5 to 41 (H-GAC 2003; Jacob 2005; NOAA 2006; Pulich 1996; USFWS 1992; Webb 2005; White 1993). Some projects classify habitats at the level of fairly large habitat *classes* (wetland, woody land, grassland etc.) while others are able to achieve a finer level of *subclass* delineation (estuarine emergent marsh, palustrine scrub/shrub, etc.). Others yet are able to classify to the level of *dominance type* based on the species found. The difference in the level of detail that is achieved is due to factors such as quality of the remotely sensed data (spatial, temporal, and spectral resolutions) and the availability of resources to complete the classification.

The Status and Trends Project recognize the importance of the first classification of Galveston Bay wetlands done by White et al (1993), but those methods have not been repeated by any other study. It is therefore, improper to compare classifications and acreages that are based on different methods, especially if the remotely sensed imagery is of different types. A recent analysis of land cover change from 1996 to 2001 (NOAA 2006) uses Landsat images. It provides the best recent assessment of the status of several important habitat types and gives an evaluation of habitat loss for a five year period. This does not allow us to assess historical trends in habitat change or the progress of *The Galveston Bay Plan* goal of increasing estuarine marsh habitat by 14,000 acres by the year 2015.

The Galveston Bay Plan gives wetlands a prominent place in its objectives to protect and restore habitat in the watershed. The Status and Trends Project has tried a variety of ways to collect the data necessary to assess progress in this area. We assume that acquisition of three types of data would enable that assessment. First, we need quantitative data on the destruction and creation of wetlands regulated by the Section 10/404 permitting process managed by the US Army Corps of Engineers (COE). Second, we need quantitative data on the acres of wetland created by restoration and creation projects not associated with permitting. Third, we need consistent land cover classifications from a standard methodology to check the other data and detect natural processes causing changes in wetlands. The remote sensing classification alone will not be sufficient because it often will not resolve small projects and its accuracy is considered to be excellent if it exceeds 75% correct classification of pixels.

We have obtained a fragmentary record of permitted wetland change from the COE. There does not appear to be a record that provides simple quantitative data on acreage destroyed and acreage created or restored under mitigation. The NOAA Fisheries Galveston Laboratory and TPWD have provided a good and useful, but most likely incomplete, record of wetland restoration projects undertaken since the 1970s; primarily of salt or brackish marsh. Freshwater wetland projects performed by other public agencies and non-profit organizations may not be included because there is no broadly organized regional reporting system. While aerial photography extends back to the 1930s and satellite images of our area extend back over 30 years, the differences in image characteristics make direct comparisons very problematic.

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

3.5 Other Indicators of Bay Health

3.5.1 Seafood Safety

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

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

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