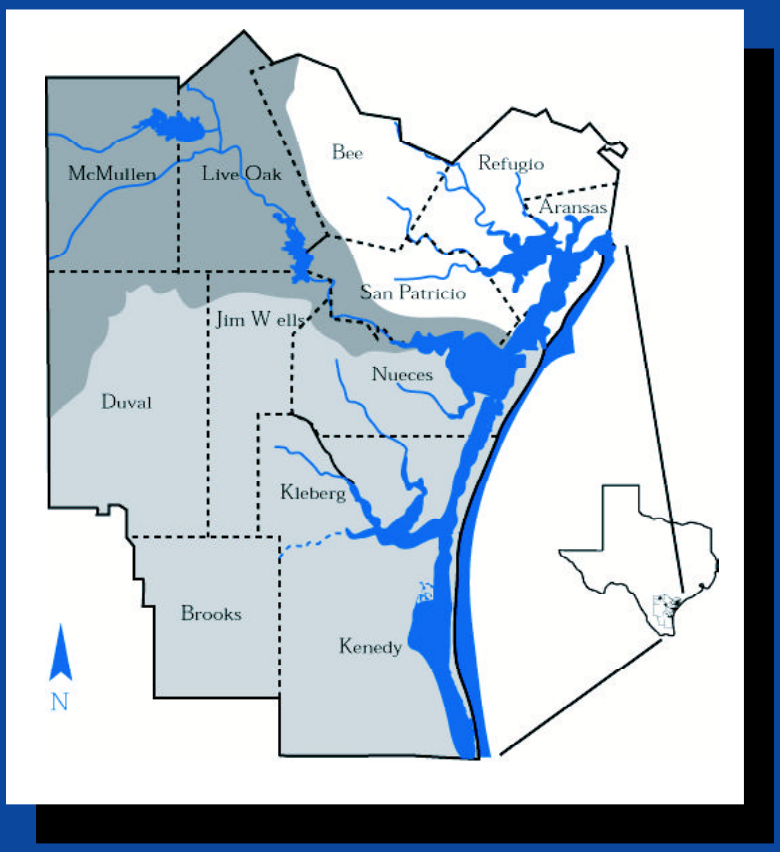
Investigation of Selected Public Health Issues in the Corpus Christi Bay National Estuary Program Study Area



Corpus Christi Bay National Estuary Program
CCBNEP-11 • November 1996

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Investigation of Selected Public Health Issues in the Corpus Christi Bay National Estuary Program Study Area

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CORPUS CHRISTI BAY NATIONAL ESTUARY PROGRAM

The Corpus Christi Bay National Estuary Program (CCBNEP) is a four-year, community based effort to identify the problems facing the bays and estuaries of the Coastal Bend, and to develop a long-range, Comprehensive Conservation and Management Plan. The Program's fundamental purpose is to protect, restore, or enhance the quality of water, sediments, and living resources found within the 600 square mile estuarine portion of the study area.

The Coastal Bend bay system is one of 28 estuaries that have been designated as an **Estuary of National Significance** under a program established by the United States Congress through the Water Quality Act of 1987. This bay system was so designated in 1992 because of its benefits to Texas and the nation. For example:

- Corpus Christi Bay is the gateway to the nation's sixth largest port, and home to the third largest refinery and petrochemical complex. The Port generates over $1 billion of revenue for related businesses, more than $60 million in state and local taxes, and more than 31,000 jobs for Coastal Bend residents.
- The bays and estuaries are famous for their recreational and commercial fisheries production. A study by Texas Agricultural Experiment Station in 1987 found that these industries, along with other recreational activities, contributed nearly $760 million to the local economy, with a statewide impact of $1.3 billion, that year.
- Of the approximately 100 estuaries around the nation, the Coastal Bend ranks fourth in agricultural acreage. Row crops -- cotton, sorghum, and corn -- and livestock generated $480 million in 1994 with a statewide economic impact of $1.6 billion.
- There are over 2600 documented species of plants and animals in the Coastal Bend, including several species that are classified as endangered or threatened. Over 400 bird species live in or pass through the region every year, making the Coastal Bend one of the premier bird watching spots in the world.

The CCBNEP is gathering new and historical data to understand environmental status and trends in the bay ecosystem, determine sources of pollution, causes of habitat declines and risks to human health, and to identify specific management actions to be implemented over the course of several years. The 'priority issues' under investigation include:

- altered freshwater inflow
- declines in living resources
- loss of wetlands and other habitats
- bay debris
- degradation of water quality
- altered estuarine circulation
- selected public health issues

The **COASTAL BEND BAYS PLAN** that will result from these efforts will be the beginning of a well-coordinated and goal-directed future for this regional resource.

STUDY AREA DESCRIPTION

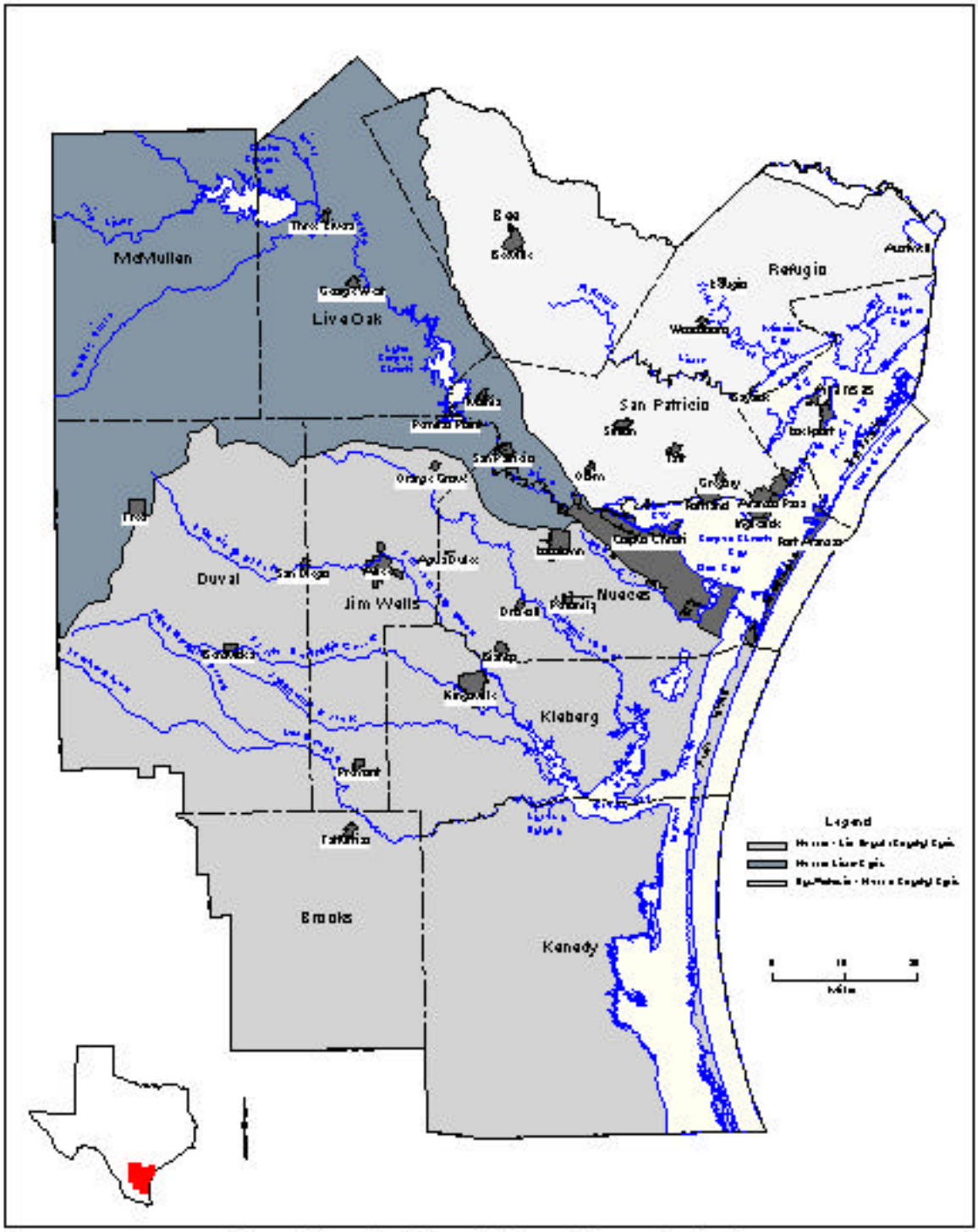
The CCBNEP study area includes three of the seven major estuary systems of the Texas Gulf Coast. These estuaries, the Aransas, Corpus Christi, and Upper Laguna Madre are shallow and biologically productive. Although connected, the estuaries are biogeographically distinct and increase in salinity from north to south. The Laguna Madre is unusual in being only one of three hypersaline lagoon systems in the world. The study area is bounded on its eastern edge by a series of barrier islands, including the world's longest -- Padre Island.

Recognizing that successful management of coastal waters requires an ecosystems approach and careful consideration of all sources of pollutants, the CCBNEP study area includes the 12 counties of the Coastal Bend: Refugio, Aransas, Nueces, San Patricio, Kleberg, Kenedy, Bee, Live Oak, McMullen, Duval, Jim Wells, and Brooks.

This region is part of the Gulf Coast and South Texas Plain, which are characterized by gently sloping plains. Soils are generally clay to sandy loams. There are three major rivers (Aransas, Mission, and Nueces), few natural lakes, and two reservoirs (Lake Corpus Christi and Choke Canyon Reservoir) in the region. The natural vegetation is a mixture of coastal prairie and mesquite chaparral savanna. Land use is largely devoted to rangeland (61%), with cropland and pastureland (27%) and other mixed uses (12%).

The region is semi-arid with a subtropical climate (average annual rainfall varies from 25 to 38 inches, and is highly variable from year to year). Summers are hot and humid, while winters are generally mild with occasional freezes. Hurricanes and tropical storms periodically affect the region.

On the following page is a regional map showing the three bay systems that comprise the CCBNEP study area.



Corpus Christi Bay National Estuary Program Study Area

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INVESTIGATION OF SELECTED PUBLIC HEALTH ISSUES IN THE CCBNEP STUDY AREA

SUMMARY

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This report is an investigation of selected public health issues associated with uses of the Corpus Christi Bay National Estuary Program (CCBNEP) study-area waters. These issues include risks associated with consumption of seafood and diseases and accidents associated with swimming and boating.

To address the health issues with the consumption of shellfish, indicator bacteria data as well as sanitary surveys and shellfish harvesting water classification maps, were compiled and reviewed. In addition, a comprehensive compilation and review of toxic chemical concentrations in area seafood tissue was conducted. To address disease risks, data from the Texas Department of Health (TDH) disease reporting system were analyzed for the study-area and the state. Accident data associated with bay uses was surprisingly difficult to obtain from area police and hospitals due to patient privacy requirements. The information obtained from local newspapers was judged to be reasonably accurate for major accidents and deaths, but did not cover smaller accidents completely.

While there were differences in the level of detail available in the data on different types of public health risks, the overall picture is reasonably complete. The following sections summarize the major study findings.

RISK RESULTS

The major risk mechanisms to public health and safety can be divided into the following categories:

- oyster consumption,
- consumption of toxic substances in seafood,
- contracting a disease directly from the water,
- contracting a disease from insects associated with water, and
- having an accident while engaged in a water-based activity.

Oysters are treated separately from seafood in general because the primary concern appears to be disease rather than toxic substances and because of the different regulatory structure for commercial oyster harvesting that has existed for many years.

Oyster Consumption

The practice of eating raw oysters is very old, dating back at least to the coastal indians who inhabited the study-area prior to European colonization. One reason might be that oysters were available in coastal areas during the winter when other food might be difficult to obtain. While the practice of eating raw oysters is widespread, there is a very limited oyster fishery in the study area today. Oyster landings in the study area are less than 4% of the state (CCBNEP, Living Resources, 1996), which means that most of the oysters consumed in the area were harvested in other bays.

The existing regulatory program for commercial harvesting and sale of oyster meat was developed at the national level many decades ago in response to strong disease concerns. Some of these disease concerns probably grew out of higher human populations in the coastal areas, with little in the way of proper waste treatment and some from improper handling of the harvested oysters. The regulatory program oriented to dealing with human waste and commercial handling is now well established and it would seem to be quite successful. Oysters are probably the only meat widely consumed in the US without being cooked, and by its very nature of filtering particulate matter from the water, has perhaps the greatest potential of any meat to become contaminated. Nevertheless, oysters are widely consumed raw with a level of risk that a commercially significant portion of the public accepts. This rather remarkable fact appears to be due substantially to the success of the existing regulatory program.

While many types of diseases could be contracted from oysters, the primary risk from oyster consumption appears to be from one of the *Vibrio* diseases. *Vibrio* bacterial infections can produce quite severe symptoms and death can result, particularly if the subject's health is not good. While consuming oysters is one route or mechanism for *Vibrio* infection, it is also possible for infection to result from body contact with bay waters, particularly if an open wound is involved. The TDH data indicate that about one infection per year (0.78/yr) is reported in the study-area population, and that a death from a *Vibrio* infection in the study-area has a probability of 0.12 per year, or one death in eight years.

Consumption of Toxic Substances in Seafood

The tissue data reviewed indicate that detection of potentially toxic substances at concentrations higher than screening levels is relatively rare. For example, out of approximately 5,500 tissue analyses for toxic substances, less than 100 were detected over screening levels. Exceeding a screening level does not mean there is a concern but only that more attention should be provided. These situations were addressed, and after analysis only two (zinc in Nueces Bay oysters and PCBs in Inner Harbor fish) appear to possibly warrant further investigation. Furthermore, neither of these two situations pose significant health concerns. Oysters are not common in Nueces Bay and oyster harvesting, if any existed, is now prohibited. The Inner Harbor is not a major fishing area. Based on the data generated

in this study, it would appear that the current level of public health risk from ingestion of toxic substances in seafood tissue is quite small.

Disease from Water Contact

Contracting diseases from water has long been recognized as a significant exposure mechanism. The major disease concern with contact recreation is gastroenteritis (EPA, 1986) which is a symptom of a number of common diseases, some of which are addressed in the TDH data. From the literature, many diseases can be transmitted by water. However, for the most part the water contact envisioned in this literature is contaminated drinking water. Except for *Vibrio* organisms where bay waters are a natural habitat, most disease organisms do not survive well even if introduced to the bay directly (i.e., without wastewater treatment and disinfection).

The Nueces County Health Department has been monitoring Fecal Coliform (FC) levels in swimming areas for many years. Overall, these data indicate that the areas monitored are suitable for contact recreation using the current state criteria.

Insect Disease Transmission

Of the diseases required to be reported to the TDH, several are primarily transmitted by insect vectors. These include Dengue, Encephalitis, Malaria and Yellow Fever. The rate for all of these diseases is relatively small and the rates for the study-area are quite similar to those for the entire state. Based on that finding, it would appear that disease transmitted by insects is not a major concern or one that is unique to study-area waters.

Water-Related Accidents

As noted, data on accidents and minor injuries from official sources such as police or hospitals, were generally not available due to privacy considerations. The only data readily available from the entire area was from newspaper reporting, which is relatively good for major highly newsworthy events such as deaths, but is very limited on injuries. For water-related deaths, a rate of approximately 6 per year was estimated from newspaper records. Of these, recreational activity accounted for roughly two thirds and commercial activities accounted for the other third of the deaths. Additional water-related fatality data were obtained from the Marine Police records of TPWD. These data showed 11.8 deaths per year for the area.

The water-related injury rate is undoubtedly much higher than the death rate, but obtaining complete quantitative information is quite difficult due to privacy considerations. One of the complicating factors is simply determining what constitutes an injury. For example, it is not clear that a jellyfish sting should be included in injury statistics, although in some cases this can be a painful and serious wound.

Risk Summary

Of the five public health risk mechanisms defined, the largest risk factor by a substantial margin appears to be water-related accidents. The death rate for water-related accidents is roughly one hundred times higher than it is for a *Vibrio* infection. Other diseases are more common in the TDH database, but only a small portion of these diseases are transmitted by bay contact or seafood consumption. While the water-related death rate is high relative to water-related diseases, it is still less than one tenth of the death rate from motor vehicle accidents.

TRENDS

For the most part there is little information that is collected in a uniform fashion for a period of time from which trend information can be derived. Exceptions are the indicator bacteria data and shellfish harvesting area maps which have been produced since the 1950's. The maps indicate that over the years there has been an increase in the bay area where shellfish commercial harvesting is prohibited. It is not clear how much of this increase can be attributed to changes in regulatory and monitoring procedures and how much can be attributed to changes in field data. The review of bacteria data indicated no significant temporal trends existed, suggesting that the increase in harvesting area closures may be attributable to changes in regulatory and monitoring procedures. An example of this type of change is the Upper Laguna Madre, which was not classified as restricted in earlier maps, but is now classified as restricted. It was closed to shellfish harvesting because of lack of harvest interest in the virtually non-existent shellfish resource (TDH, 1993).

DATA GAPS AND CAUSATIVE FACTORS

Probably the biggest data gap encountered in this study was in obtaining information on diseases and injuries associated with water use. Except for a relatively small number of disease types which must be reported to the TDH and the accident reports to the Parks and Wildlife police, the legitimate need for privacy protection makes it difficult for agencies to release this information. Hopefully, future police and hospital records management systems will evolve to the point where it is not a problem for data to be made available for research and management purposes with personal identification information removed.

Another gap observed in the project was the relative scarcity of data in the near-shore Gulf of Mexico portion of the study area. A large part of the recreational and commercial water use occurs in this area, yet there is relatively little monitoring activity. This is understandable to a degree, as one would expect water or tissue concentrations in the bay waters to be more affected by anthropogenic factors than the larger and more remote Gulf. Having data from the near-shore Gulf would still be valuable both as a baseline and because some parameters have sources located in this area.

A third gap observed was in the availability of suitable management measures for dealing with naturally occurring pathogens such as *Vibrios*. Indicator bacteria testing has been generally successful in dealing with wastewater-related health risks, but is not effective with *Vibrios*. Better procedures to manage this risk in a cost-effective manner are needed.

A fourth data need is to standardize tissue sampling on edible portions rather than the whole fish. This would improve the ability to analyze health risks from seafood consumption.

I. INTRODUCTION

This report presents the results of an investigation of selected public health issues associated with human uses of the waters of the CCBNEP study-area. These issues include the risks associated with consumption of shellfish and other fish tissue and diseases and accidents associated with swimming, boating and commercial bay uses. The objective of the investigation is to develop a more complete and comprehensive picture of the public health and safety risks associated with bay uses. This more complete understanding should be useful in the development of appropriate management measures.

Section II of the report describes the data sources consulted and the procedures used for obtaining key data elements. Sections III through VII are analyses of particular aspects:

III -- REVIEW OF SHELLFISH HARVESTING AREA CLASSIFICATION STATUS,
IV -- ANALYSIS OF INDICATOR BACTERIA DATA,
V -- ANALYSIS OF SEAFOOD TISSUE DATA,
VI -- DISEASE INCIDENTS,
VII -- INJURIES AND ACCIDENTS IN WATER ACTIVITIES.

Section VIII is an analysis of the overall subject considering public health and safety concerns associated with all types of bay water uses. The section also includes consideration of trends, possible causes and data gaps.

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II. DATA SOURCES AND PROCEDURES

Data for this investigation were obtained from a variety of sources. This section briefly addresses the methods used to identify data sources, obtain the data and perform various quality checks. Much of the original data were compiled in a separate study for the CCBNEP conducted by Ward and Armstrong (1996). The primary objective of the Ward and Armstrong work was the compilation and assessment of all existing relevant water, sediment and tissue data. Data employed for this public health work is a subset dealing with indicator bacteria and seafood tissue data. A brief description of the original data sources, abstracted from the Ward and Armstrong work, is presented below. The other major block of information included in the analysis is a compilation of local area information obtained from newspapers, police reports, the TDH and local hospitals. The contacts and procedures employed are described below.

The data are discussed in three major blocks--coliform bacteria, seafood tissue, and local sources. The data source descriptions for coliform bacteria and seafood tissue are abstracted from draft material by Ward and Armstrong (1996). For more detailed information such as the locations of stations and specific substances analyzed, the reader is referred to the original source. The intent of this section is merely to provide an overview of the data collection methods, analysis procedures and Quality Assurance/Quality Control (QA/QC) methods reported. Not all sources reported formal QA/QC methods as this documentation requirement is relatively recent.

II.1 COLIFORM BACTERIA DATA SOURCES

The agencies collecting coliform bacteria data compiled by Ward and Armstrong (1996) and made available for this work included: Texas Natural Resource Conservation Commission (TNRCC), TDH, Texas Water Development Board (TWDB), Corpus Christi Bay (CCB) Foundation, and the Corpus Christi-Nueces County Health Department (CCNCHD). Each is briefly described below, with the summaries being adapted from Ward and Armstrong.

II.1.1 TNRCC

Texas Natural Resource Conservation Commission
Statewide Monitoring Network (SMN)
CODE: TNRCC, DATA SET 001

MEASUREMENTS: The TNRCC and predecessor agencies have been monitoring water quality since the late 1960's, and have been maintaining a digital database since the late 1970's. Measurements include a wide range of conventional parameters as well as trace metals, pesticides and a range of organic compounds in water, sediment, and tissue.

PROCEDURES: The SMN is a continuing program of fixed station monitoring, usually carried out by TNRCC Regional Office personnel. Field probe observations are normally made, while water and other samples are sent to laboratories. For many years the TDH laboratory performed the chemical and biochemical testing, while in more recent years the laboratory function has been supplied either by the TNRCC laboratory or a commercial lab.

In addition to routine monitoring, the state conducts Intensive Surveys and other special studies which are entered into the SMN. Each parameter measured is identified by a Storet Code. For example, 31616 is the code for FC using the Membrane Filter (MF) method (typically Standard Methods (1995) number 9222E) while 31619 is FC using the Most Probable Number (MPN) (equivalent to Standard Method 9221E) method. The great majority of the TNRCC FC data are the MF method.

SAMPLING LOCATIONS: Until recently sampling stations were identified using the stream segment as a prefix followed by a unique number. Generally, these stations were identified in reference to landmarks. Ward and Armstrong (1996) worked with Regional Office personnel to obtain corrected latitude/longitude information for the TNRCC stations.

QA/QC: The TNRCC currently maintains a Procedures Manual for Water Quality Monitoring (TNRCC, 1994). The manual sets out standard procedures for each of the sampling and analysis methods employed.

II.1.2 TDH

Texas State Department of Health Estuarine Data File
Division of Seafood Safety, Texas Department of Health
CODE: TDH, DATA SET 006

MEASUREMENTS:

Water temperature	deg F
salinity	ppt
dissolved oxygen	ppm
total coliforms (TC)	MPN per 100 mL
fecal coliforms (FC)	MPN per 100 mL

PROCEDURES: Grab sampling is performed, usually either at or near the surface or at mid-depth. Bacterial analyses use only the MPN method rather than the MF method used by the TNRCC and other agencies.

QUALITY ASSURANCE/QUALITY CONTROL: No formal QA/QC plan exists or is reported. In recent years, most of the data (i.e., except bacteriological analyses) are performed *in situ* using electrometric instruments. In earlier years (see Project 007, TSDH Coastal Data), water samples were retrieved, and all parameters measured in the laboratory. Analyses are performed by the TSDH laboratory in conformance with "Recommended Procedures for the Examination of Seawater and Shellfish, 4th edition, 1970."

DESCRIPTION & COMMENTS: This is the data from the active monitoring program of the Seafood Safety (a.k.a. Shellfish Sanitation) Division at the TDH, referred to as the Estuarine Data File. The principal thrust of the program is measurement of coliforms for the purpose of regulation of shellfish harvesting on the coast. Early in the program other water quality variables were taken

with the prospect of uncovering correlations with coliforms; as the program has progressed, most of these measurements have been dropped (though salinity and temperature are nearly always obtained). However, this data file reports temperature, dissolved oxygen, salinity, and laboratory coliforms, only. (See Project Code 007, Coastal Data File.) Moreover, the record is limited to those samples in which FCs were obtained, with or without a companion measurement of total coliforms. In recent years, all measurements and samples are taken at a single depth. Older data include profiles or multiple samples within the water column. The data are keyboarded into a continuously maintained digitized data base.

Three source files were used in the NRI/CCBNEP project, two in the Estuarine Data File format (one for the period from the 1950s through 1979, and the second for the period from 1980 through 1995), and one from the Coastal Data Program (see Project Code 007). Data management and errors in the entries have been a problem with TDH data files in the past, but these appear to have been largely eliminated in the Estuarine Data File. However, data from several stations are included in the file for which we have no location information.

II.1.3 TWDB

Coastal Data System
Texas Water Development Board
CODE: TWDB, DATA SET 002

MEASUREMENTS: General hydrographic and indicator parameters: conductivity (*u*mhos), temperature (°C), pH, dissolved oxygen (ppm), turbidity (JTUs), Secchi depth (cm); vertical profiles at various intervals, typically 5 ft.

Analyses (by TDH for older data) for: CO2, carbonate as CaCO3, total phosphate [these through 1980], BOD (5 day), alkalinity & hardness as CaCO3, HCO3 ion, nitrogen series, phosphates, and carbon nutrients, calcium, magnesium, sodium, potassium, sulfate, chlorides, fluorides, silica, elemental metals and selected organic contaminants, especially pesticides.

PROCEDURES: Specific procedures vary depending upon the particular data-collection entity (see below). For state-collected water samples, the analyses are performed by the Texas State Department of Health laboratory in Austin. Many *in situ* measurements are made with State Hydrolabs. In recent years, the TWDB has been experimenting with the deployment of automatic recording hydrosondes.

QUALITY ASSURANCE/QUALITY CONTROL: No formal QA/QC plan exists or is reported, and no information is available as to QA/QC practices.

DESCRIPTION & COMMENTS: This is the basic data set used by the TWDB for studies of the Bays & Estuaries of Texas. Since the late 1960's the TWDB has sponsored data collection in the bays and estuaries of Texas, with the overall purpose of determining the relations between freshwater inflow and the "health" of the estuary. The actual data collection has been performed through contract with federal agencies (notably the U.S. Geological Survey), state agencies, consulting firms, and universities, as well as by the personnel of the TWDB itself. The objectives, methods, and

procedures have been therefore widely variable. Management of the data base is the primary responsibility of the Bays and Estuaries staff of TWDB, although the data base is part of TNRIS.

The purpose of the Coastal Data System (CDS) is to analyze of relations between measures of estuary health and measures of hydrography. Its objective is not archival maintenance of the data. This is unfortunate, because for most of the data-collection projects sponsored by TWDB, the CDS is the only digital record of the data collected. The fact that it is primarily a research-support data base rather than an archival data-base means that the data is massaged in various ways as it is incorporated into the data base, and one cannot necessarily recover the raw records from the primary data collection entity. For example, the station locations are related to the (rather imprecise) line-site system instituted in the 1960's for the USGS routine surveys. Also, error detection seems to be rather *ad hoc* with no formal procedure for proofing input data or screening for abberants. (In this compilation, for example, the field measurements at depth 34 ft at station 376-2 from 6 October 1970 were discovered to have also been entered as 6 October 1972, an entry error that will defy most traditional screening procedures.) Numerous zero values of turbidity, dissolved oxygen, metals and hydrophobic organics are entered into the data from the 1970s. The latter could mean "below detection limits" though no information on the detection limits is available from TWDB, but the turbidity and dissolved oxygen zeroes look suspiciously like blanks incorporated into the data file as zeroes. There is, however, no practical way for TWDB to verify these data.

One problem with the CDS data base is its overlap with the SMN. As noted above, the CDS is a data base employed primarily for the in-agency use of TWDB in its Bays & Estuaries Program. In principle, all data collected by TWDB and its contractors should be input into the SMN. However, this is not the case: there are numerous field data sets in the CDS, from TWDB activities or its contractors, that are not in the SMN. On the other hand, some of the data in the CDS does appear to be duplicated within the SMN. This posed a data management problem for this project, and created much nonproductive but unavoidable effort. Ultimately, we brought everything in the CDS into the master file, then searched for duplication at a later stage of the processing. (The alternative, of searching for duplication before interleaving would have been much more laborious.) Duplicates may still remain, however, due to the sample station numbering procedure. As noted above, the TWDB assigns an approximate line-site station based upon the sample location of the originating agency. These line-site positions have been plotted and their coordinates determined, but these may differ from the coordinates of the original SMN station, in which case the data will not be recognized as duplicates.

II.1.4 CCBF

Corpus Christi Bay Foundation
Hydrographic & chemical study of La Quinta Channel
PROJECT ABBREVIATION: CCBF, DATA SET 15

MEASUREMENTS: Surface water samples and occasional sediment samples, analyzed for an extensive suite of parameters. Hydrographic profiles, i.e., salinity (conductivity), dissolved oxygen, temperature, with occasional FC determinations. A few fish have been collected for tissue analyses.

PROCEDURES: This program has been conducted since early 1993 as a joint activity of the Coastal Bend Bays Foundation, Oxychem, Eclipse, the Texas Natural Resources Conservation Commission and students of Gregory/Portland Junior High School. Six stations have been established for routine sampling which is carried out generally on a quarterly basis.

Chemical parameters initially included metals and selected hydrocarbons. As the data collection has progressed, the suite of parameters has been expanded to the complete EPA priority pollutants list. All analyses are carried out for the water as sampled, i.e., without filtration.

QUALITY ASSURANCE/QUALITY CONTROL: Profiling is carried out with TNRCC equipment under the supervision of TNRCC staff, and the water and sediment chemistry analyses are performed by a commercial laboratory in strict conformance to EPA protocols.

DESCRIPTION & COMMENTS: The principal objective of this program is to provide quantitative information on the chemical quality of water and sediment in and adjacent to the La Quinta Channel, on the north shore of Corpus Christi Bay.

SAMPLING LOCATIONS: Six stations were established, three in the La Quinta Channel, and three off the channel but immediately adjacent. The area sampled is small enough that location of the stations relative to navigation aids or shore landmarks is more than adequate.

II.1.5 CCNCHD

Corpus Christi-Nueces County Department of Public Health
Fecal coliforms in contact recreation areas
PROJECT ABBREVIATION: NCHD, DATA SET 25

MEASUREMENTS: FC concentrations from surface water samples.

PROCEDURES: Surface samples are obtained from beach sites or the vicinities of outfall drains, especially stormwater outfalls. Frequency has varied over the years, from weekly to bi-monthly, either throughout the year or in the warm-season months of highest recreation activity. Although the samples are taken in nearshore areas, the immediate vicinity of the shoreline is avoided. Samples are obtained by inserting a sterilized glass bottle into a wire basket on a long pole, and dragged

through the water at a depth of 0.2-0.3 m until the bottle is filled. The samples are stored on ice and returned to the lab within two hours. Analyses are performed using the MF technique with mEndo media.

QUALITY ASSURANCE: No formal QA/QC plan was reported, and no information was provided as to QA/QC practices. The lab is, however, regularly inspected by various regulatory agencies and can be assumed to perform all analyses in conformance with *Standard Methods*.

DESCRIPTION & COMMENTS: The prime objective of this sampling program is verifying the safety of the waters of the Corpus Christi Bay system for swimming and contact recreation. In addition to the lab's own data, the department also receives data and reports for the TDH and the Texas Natural Resources Conservation Commission. Data management is therefore not a major objective of the lab; results are maintained as hardcopy lab reports, and were furnished to this project in that form. Data were provided for years 1976-1995, except for 1977, 1983 and 1984. No other data is available. No additional parameters are measured.

A few determinations are described simply as "confluent", by which we presume that the growth was so dense that individual colonies could not be distinguished. As the largest reported concentration was 340,000 col./100 mL, we have replaced the "confluent" entries with ">340000". In the analysis of coliform variation, these instances are replaced with the value 340000, which probably underestimates the actual concentration but is clearly a better strategy than simply omitting these rare but large values.

SAMPLING LOCATIONS: Sampling stations have varied considerably during the past 20 years. Also, since a station is recorded for the internal use of the lab, many of the site descriptions, while perfectly clear to the field and laboratory personnel at the time, depend upon institutional memory for specificity, for example:

Puerto del Sol Beach (trailer park)
Kennedy Causeway - Telephone Pole
CC Beach - near bathhouse, jetty area

The laboratory personnel were very helpful in identifying locations. Some locations were capable of being located approximately from the descriptions. Some had to be guessed at, particularly the multiple stations around the breakwater during the 1970s. All of the stations referenced in the field sheets and various sketch maps provided to the project, with the latitude and longitude coordinates determined by this study.

DISCUSSION: The Nueces County Health Department has been an active data-collection and monitoring entity in the Corpus Christi area since at least the early 1940s. In its earlier programs, salinity, temperature, dissolved oxygen, and various ions were measured as well as coliforms. Also the Department carried out intensive special-purpose investigation of specific areas of the bay, such as the open waters of Corpus Christi Bay and the Inner Harbor. Copies of some of this data were obtained by Southwest Research Institute during its program in the early 1970s, and used to establish the quality of the bay back to about 1960 (Oetking, 1972, Water quality baseline study for Corpus

Christi Bay from June 1970 to June 1971. SwRI Proj. 18-2880-01, Ocean Science and Engineering Laboratory, Corpus Christi, Texas.).

None of this historical data now exists. The Nueces County lab has evidently discarded much of it, for the obvious reason that it is no longer pertinent to monitoring the public health of the estuary. The holdings of the SWRI lab were discarded when the office closed. No other offices of the City of Corpus Christi have provided any indication that they might have such holdings.

II.2 TISSUE DATA SOURCES

Most of the sources discussed above for coliform bacteria also collected tissue data. These include the TNRCC, TDH, and CCBF. Additional agencies which have collected seafood tissue in the study area and which have been compiled by Ward and Armstrong (1996) are summarized below. These include the:

- National Ocean Survey (NOS) Status and Trends Program,
- The US Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP),
- The US Fish and Wildlife Service's Contaminant Assessment Program (USFWS-CCB), and
- The US Army Corps of Engineers (USCE) predredging sampling efforts.

As with the coliform data, the summaries are extracted from Ward and Armstrong.

II.2.1 NOS

National Ocean Service National Status & Trends Projects
NOSS&T, Data Code 018

MEASUREMENTS: Two separate projects have operated within the project area: the Benthic Surveillance Project which concentrates upon sediment chemistry, and the Mussel Watch Project which collects both sediment and tissue samples. For tissue samples, the same suite of parameters is analyzed excluding TOC, TIC and grain-size. All concentrations are reported on a *dry-weight* basis.

PROCEDURES: Surficial sediment samples are collected at three stations within 500 m of designated ("nominal") site location. Sampling was performed by either a specially constructed box corer or a Smith-MacIntyre bottom grab. Each sediment sample was then subsampled with a 3x15 cm "mini-corer" from the undisturbed surficial matter near the center of the original sample. Samples were frozen for transport and storage until subjected to laboratory analyses. Protocols and methodologies are presented in NOS (1988) and Lauenstein and Cantillo (1993), and references therein. Occasionally, the actual sample site departed from the nominal site by more that 500 m,

whereupon the actual coordinates are given. No information is given on the positioning methodology.

DESCRIPTION & COMMENTS: This is a nationwide program sampling about 290 sites in the coastal U.S., of which eight (8) are located in the Corpus Christi Bay project area. The Benthal Surveillance project began in the mid-1980s, several years before the Mussel Watch project, but we consider the data together in this compilation and combine them into one project data file. Collections are made annually, at best, and dates are given only by year, so we assigned an arbitrary date of mid-July for each year given. Under the presumption that sediment chemistry should vary on a longer time frame, the analyses will be restricted to longer time scales anyway, so this artifice merely enables us to use a uniform data entry format. It has been necessary to supply dates in this manner to other sets of sediment data in the data base.

QUALITY ASSURANCE/QUALITY CONTROL: The laboratory analyses are performed through contract. For the data used in this compilation, the analyses were performed either by the South East Fishery Science Center of NMFS, in Charleston, SC or by GERG at Texas A&M University. The program has emphasized quality assurance as a central element of its strategy, and an extensive documentation of the methodologies and associated QA practices is given in Lauenstein and Cantillo (1993). Detection limits are stated as either LODs (limits of detection) or MDLs (method detection limits).

SAMPLING LOCATIONS: As noted above, each "site" in the data base is a composite of several stations that are "as much as" 1 km separated. Further, there is no information in the data base to allow separation or precise positioning of the individual samples, except for the rare instances when a sample site departed too much from the nominal location. Approximate ("nominal") positions are employed.

DISCUSSION: Clearly the strategy of the NOSS&T program is to emphasize long-term temporal trends on a nationwide comparative basis. The spatial resolution within any estuarine area is very low, limited to one or a few stations, which are selected to be "representative" of the estuary, rather than being unduly influenced by local runoff or wasteloads. The importance of this data to the present compilation is in the extensive chemical analyses that are carried out.

Despite the fact that the data files are available via the Internet in ASCII format, their manipulation became a huge problem, because (1) it was discovered that the filter by Estuarine Drainage Area did not retrieve all of the data for the study area, so the full Gulf of Mexico data file had to be searched manually; (2) the benthic surveillance and mussel watch files are in different formats; (3) the ASCII characters separating fields are not employed uniformly, so the data files had to be completely re-formatted and corrected; (4) zeroes are used to signify unquantifiable concentrations, which had to be replaced with an entry of "<" the applicable detection limit. The lab detection limits are tabulated separately and had to be manually inserted in the data files. (Moreover, there are measurements that are less than the stated detection limit.)

While the tissue data were compiled as part of this process, these data are not directly comparable to other tissue data in the data compilation, because these are reported as dry-weight concentration

rather than weight-weight. For this analysis, the oyster data were converted to wet weight using a standard value of 85% moisture provided by the Texas A&M laboratory (Presley, 1996.

II.2.2 EMAP

Environmental Monitoring and Assessment Program (EMAP)
PROJECT ABBREVIATION: EMAP, DATA CODE 021

MEASUREMENTS: The initial EMAP Demonstration Project, which was initiated in 1991, examined an extensive suite of chemical compounds in sediment and tissue. For sediment samples, these suites are summarized as follows:

Trace metals:	*Organics*:
Antimony	
Arsenic	Butyl tin compounds
Cadmium	pesticides
Chromium	alkanes
Copper	PCBs (various)
Iron	
Lead	PAHs (various)
Manganese	
Mercury	TOC
Nickel	
Silver	*Others*
Selenium	AVS
Tin	TOC
Zinc	Grain-size analysis

For tissue samples, generally the same suites of parameters are analyzed excluding TOC, AVS and grain-size. Many of these are not monitored by other programs hence are not incorporated into the master data bases for the study area.

PROCEDURES: Annual sampling in the summer seasons was carried out at a network of nearly 200 sites along the northern Gulf of Mexico. Sampling included vertical profiling, deployment of hydrosondes for short-period (12 hours) monitoring, marine debris observations, and sediment and biological collections. Sediment sampling was performed by multiple (6-10) grabs with a Young-modified Van Veen sampler, each of which was subsampled from the top 2 cm to create a composite sediment sample, which was preserved on ice and frozen pending analysis. The same sediment samples were used for characterization of the benthos, and for laboratory toxicity bioassays. Vertical profiling was carried out with Hydrolab Surveyor 2. Photosynthetically available radiation (PAR), essentially the visible band, was measured with a LICOR LI-1000 submersible sensor. Provision is made in the data base for other parameters, including TSS and fluorescence, but these are not reported for the stations in the study area.

DESCRIPTION & COMMENTS: In many respects, the EMAP program has similar objectives to the National Ocean Service Status & Trends Project (see Project Code 18), i.e., of building a data base to allow discrimination of very-long-term trends in environmental quality indicators, and to allow regional comparisons. The primary differences between this program and the NOSS&T are:

- even more extensive suite of organic compounds
- more detailed and involved statistical procedure for station selection and data analysis
- more highly organized and controlled field procedures
- biological sampling, including benthal ecological measures, and bioassays
- water profile measurements

QUALITY ASSURANCE/QUALITY CONTROL: The program has emphasized quality assurance as a central element of its strategy, and an extensive documentation of the methodologies and associated QA practices is given in EMAP publications (e.g., Summers and Macauley, 1993, and references therein). Every aspect of the program has been carefully planned and evaluated, from initial station selection, to field procedures and crew training, to the ultimate analysis of the data. The laboratory analyses are performed through contract. For the data used in this compilation, the analyses were performed by GERG at Texas A&M University.

SAMPLING LOCATIONS: Latitude and longitude coordinates are supplied as part of the data base. There is no separate information on station locations, so there is no means to verify the correctness of these locations.

DISCUSSION: The strategy of the EMAP program, like NOSS&T, is to emphasize long-term temporal trends on a nationwide comparative basis. The spatial resolution within any estuarine area is very low, limited to one or a few stations, which are selected to be "statistically representative" of the estuary. The importance of this data to the present compilation is in the extensive chemical analyses that are carried out.

Data files were provided to this project encompassing the period 1991-94. The suite of compounds analyzed was extensively reduced after 1993. Data are maintained in delimited ASCII files. Unfortunately, the formatting is eccentric (presumably governed by the analytical objectives of the project); synthesis of a single record of a tissue analysis, for example, required searching for latitude/longitude in the STATIONS file, for station depth in the EVENTS file, for the organisms species in the FISHCODE file, and the measurement and date in the TISUCHEM file. Moreover, the formats vary with the class of parameters, e.g., TISUCHEM follows a different format (and order of variables) from that of SEDCHEM. All of this translated to a tedious process in building up data files for this project. Blanks are used to signify unquantifiable concentrations, which is certified by a character entry in a separate column, whereupon the applicable detection limit is provided in yet another column. The tissue data compiled as part of this process are the edible portion of the organisms, i.e., filets for finfish, tails for shrimp.

II.2.3 USFWS-CCB

CONTAMINANTS ASSESSMENT OF THE CORPUS CHRISTI BAY COMPLEX

PROJECT ABBREVIATION: USFWS-CCB, DATA SET 027

MEASUREMENTS: A comprehensive suite of trace contaminants, including both metals and organics, in sediment and fish tissue.

PROCEDURES: Stations were established on one-mile centers throughout Redfish Bay, Nueces Bay, Corpus Christi Bay, the Inner Harbor, Oso Bay, the Upper Laguna Madre, and Baffin Bay. The sites were "estimated" in the field by timing boat transects along a fixed magnetic heading, aided as necessary by triangulation on known landmarks. Nearly 300 stations were occupied in the period May-July 1988, at which sediment samples were taken by either Ekman or Ponar dredge, according to EPA (1982) procedures. Trace elements and oil & grease were determined for all of these samples. Fifty stations were selected from this group for extensive organics analyses.

In the following year, 37 sites distributed through the same area were sampled for biota, focusing on six species: hardhead catfish, toadfish, calico crab, blue crab eastern oyster and shoal grass. Organisms were carefully containered and kept on ice in the field then frozen prior to shipping to labs. Analyses were performed for the same extensive suites of organics and trace elements, for the whole organism, except for oysters which were shucked and shoal grass for which only rhizomes were analyzed.

All analyses were performed at commercial or academic laboratories using current analytical methodologies.

QUALITY ASSURANCE/QUALITY CONTROL: While no formal QA/QC procedures are reported in the technical report (Barrera et al., 1995), analyses were performed by state-of-the-art laboratories, and it can be safely assumed that QA procedures met or exceeded EPA protocols that existed at the time of the work.

DESCRIPTION & COMMENTS: This project is one of several recent intensive field investigations carried out by this Field Office of U.S. Fish & Wildlife Service, and a comprehensive presentation is given in the Final Report for the project. The report is remarkably complete. Only two interventions were required to merge this data with those from other programs. First, specific sampling dates were not given; only the three-month or four-month periods during which samples were collected are stated in the report. Therefore, for this compilation, we assumed a sampling date of the midpoint of the periods, i.e., 15 June 1988 for the sediment sampling, and 1 September 1989 for the biota. Sediment concentrations are not envisioned to change over short time scales, compared to concentrations in the water phase, so this is not thought to impose serious corruption of the data, especially for trend analyses carried out over time periods of many years. We note that the same kind of assumptions had to be made for other sediment data bases in this project, e.g., that of the Bureau of Economic Geology. Similarly, the biological organisms act as integrators of contaminants

over time periods long compared to the uncertainty in the precise date of sampling, so again no serious error is anticipated.

The second intervention is due to the fact that the analyses for organics in sediments are reported in ppm wet weight, rather than dry weight. Fortunately the fraction of water f in the sediment sample is given in the data (as percent water), so an equivalent dry weight concentration could be estimated by the relation:

$$\text{dry-weight concentration} = (\text{wet-weight concentration}) / (1 - f)$$

The problem with this arises in converting the detection limits. In a laboratory setting, the data from replicates and blanks would be re-expressed as dry weight, and the detection limit re-computed. We do not, of course, have access to those data, and have to estimate the equivalent dry-weight detection limit from only the wet-weight DLs. A straightforward application of the same correction factor based upon f to the reported detection limit produces a scattering of values. We chose to assign a DL value to the data equal to the mean estimated DL rounded to the same significance as the original wet-weight DL. For example, for organochlorines and PAHs with a reported wet-weight detection limit of 0.01 mg/g, the dry-weight DL values estimated by the conversion above were determined to have a mean of 0.023 mg/g with a standard deviation of 0.016 mg/g, and a minimum value of 0.012 mg/g. In this case, the assigned dry-weight DL was 0.02 mg/g.

The reverse problem occurs with the tissue data, in that trace elements (mainly metals) are reported as dry weight. Again, since the fraction of water f in the tissue is given, we are able to convert by the relation:

$$\text{wet-weight concentration} = (\text{dry-weight concentration}) / (1 - f)$$

An analogous conversion and rounding of the equivalent DLs was employed. This is also the only instance in the CCBNEP data base for tissue results that fractions of water are provided for various species. It is therefore worthwhile to tabulate these as independent data in their own right:

Average water content of organisms
(% whole body except mean-only for oyster)

Organism	*CCBNEP code*	*number of samples*	*H_2O (%)*	
			mean	*st dev*
OYSTER	4	4	84.5	1.2
HH CATFISH	5	25	71.8	3.6
BLUE CRAB	10	33	71.9	5.8
TOAD FISH	11	1	77.1	-
CALICO CRAB	12	1	60.6	-
SEAGRASS	13	16	74.8	3.1

SAMPLING LOCATIONS: Two independent networks of sampling stations were used for sediment and biology. The sediment stations were laid out in advance on approximately one-mile centers, while the biology stations were selected to represent different habitat types. The station locations are shown in the report as computer-plotted maps. No coordinates are given, so latitude/longitude coordinates were determined for all of the stations. The accuracy of these coordinates is probably overstated, however, because the actual field location technique was to orient the boat along a magnetic course direction and travel for the requisite time based upon the estimate of boat speed. (Of course, some of the stations were situated near identifiable landmarks. Nonetheless, it is unlikely the average position accuracy is better than 500 ft.

DISCUSSION: This is a valuable data set. It is commendable that the Ecological Services Field Office made a concerted effort to preserve and disseminate the raw data, including a digitized version of the data, in spreadsheet format, in a diskette as part of the report. Perhaps illustrative of the pervasiveness of Murphy's famous law, as well as the malevolence of computers, these good intentions were frustrated by the apparent loss of about half of the aromatic hydrocarbons from the sediment analyses, which were simply absent from the spreadsheet, and *all* of the organic analyses for the tissue samples. (It is noteworthy that the missing data records begin at pagebreak positions in the spreadsheet.) As of this writing, the Field Office has been unable to supply a copy of these missing data.

II.2.4 USCE

Operations and Maintenance Division, Galveston District, US Army Corps of Engineers
PROJECT ABBREVIATION: USCE, DATA CODES 007, 008, 009

MEASUREMENTS: The bulk of the USCE measurements are for sediment and overlying water, with a small number of blue crab tissue data collected.

PROCEDURES: A series of samples are generally collected prior to dredging work on a navigation channel. The primary purpose of these samples is to allow determination if special requirements exist for disposal of the material to be dredged. Historically the data have been maintained on typewritten tables, but since 1990 they were placed in LOTUS format. Some of the older data had to be keyboarded for this project.

QA/QC: All sample collection and analyses are according to EPA protocols.

SAMPLING LOCATIONS: All data are logged by Project, Year, and Station Number. These project (e.g., Corpus Christi Ship Channel) and station locations were located on maps and the latitude-longitude manually determined.

II.3 LOCAL DATA SOURCES

The primary local data sources employed included state and local health departments, police, regional hospitals and local area studies related to public health from primary and secondary contact recreation, seafood consumption, and coastal insects. The reviews were conducted under the

TABLE II.1
CONTACTS FOR DATA ON INJURIES AND ACCIDENTS

County/City	Agency	Address	Phone No.	Contact
Refugio/Refugio	Dept. of Public Safety	808 Commerce	526-5173	Sylvia
78377	Sheriff's Office	808 Commerce	526-2351	Joyce Loya
	County Clerk	808 Commerce	526-2233 526-2727	Ida
	Refugio City Police	608 Commerce	526-4533	Josephine
	Refugio Rural Health			Donna
	Clinic	107 1/2 Swift	526-5328	
Refugio/Bayside	City of Bayside	909 First St.	529-6401	
78340				
Refugio/Woodsboro	City Offices	121 N. Wood	543-4505	
78393				
San Patricio/Sinton	Health Dept.	313 N Rachal Ave.	364-6208	
78387	Police Dept.	301 E Market	364-2211	
	Sheriff's Dept.	300 N Rachal Ave.	364-2251	Joanna
San Patricio/	Coastal Bend Hospital	1711 Wheller Ave	758-8585	Mary Ramos
Aransas Pass	Aransas Pass Police	600 W Cleveland	758-5224	Sharon, Arrington
San Patricio/Portland	City Hall	900 Moore Ave	643-6501	
	Police Dept		643-2546	
Nueces/Corpus Christi	Texas Dept of Health, Env. Health	1233 Agnes St.	888-7762	
	Nueces Co. Sheriff		887-2222	
	Nueces Co. Lifeguards	S.P.I.D	949-7023	Cynthia
	City-County Health Dept.	1702 Horne Rd.	851-7200	
	C.C. Police Dept.	Adm. calls central records	886-2600 886-2730	
	C.C. Parks & Recreation	1201 Leopard St.	880-3460	Evelyn
Nueces/Corpus Christi	City of Corpus Christi		880-3360	Norbert Hart
	C.C. Marina Office	Lawrence T-head	882-7333	Todd Jensen
	Padre Island National Seashore	Malaquite Beach	949-8173	Tom Crowsen
	Memorial Medical Center	7102 Hospital Blvd.	902-4000	
	Bay Area Medical Center	7102 SPID	985-3227	
	Dr's Regional	3315 S. Alameda	857-1400	
	Bayview	6629 Wooldridge	993-9700	
	Spohn Health System	600 Elizabeth	881-3000 985-5000	Spohn Spohn South
Kenedy/Riviera	Sheriff [Sarita]		294-5205	
	Kleberg Co. Sheriff		296-3203	
	Kenedy Co. Clerk		294-5220	
Kleberg/Kingsville	Sheriff's Dept.	Admin. calls	595-8500	
78363	City-Co. Health Unit	8604 N Armstrong	592-3324	
	Kingsville Police	203 N Sixth St.	592-4311	
	Spohn Kleberg Memorial	1300 General Cavazos Blvd.	 595-1661	 Labart Grant
Aransas/Rockport	Beach Park		749-9302	
	Health Dept. - Environmental		790-1021	
	Navigation Dist.	Fulton Harbor	729-9122	

direction of Dr. Joanna Mott, Department of Physical and Life Sciences, TAMU-CC. Table II.1 summarizes agency contacts in the six county study area.

A general finding was that for patient privacy reasons, it was very difficult to obtain water-related health and accident data from hospitals and police departments. Ultimately, the best information available on water-related was from newspaper reviews, primarily the Corpus Christi and Rockport newspapers. A limitation that must be recognized is that newspaper reports tend to only include items which are newsworthy or remarkable in some fashion (e.g., man bites dog) and will tend to omit routine incidents.

In contrast, information on infectious diseases that must be reported to TDH was provided with little difficulty by the TDH offices in Austin and Corpus Christi. These TDH data are presented in Section VI of the report.

The final block of information concerned local studies and related published information. A literature search was conducted through the TAMU-CC and UTCAT systems, as well as a range of literature databases. The relevant material found is discussed in sections VI and VII.

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III. REVIEW OF SHELLFISH HARVESTING AREA CLASSIFICATIONS

One of the tasks of this characterization project is to obtain historical shellfish classification maps for the CCBNEP study area, and review changes that have occurred over time. The objectives are to describe the trends associated with shellfish harvesting waters, to determine current status of these waters, and to determine probable causes leading to the institution of an advisory or closure. This section first reviews regulatory procedures and then addresses harvesting map changes over time, current conditions and the reasons for these conditions.

III.1 TEXAS DEPARTMENT OF HEALTH REGULATORY PROCEDURES

The TDH administers the shellfish harvesting regulatory program in Texas. The current regulatory procedures for shellfish growing areas are defined by the Food and Drug Administration (FDA) of the U. S. Department of Health and Human Services and the Interstate Shellfish Sanitation Conference (ISSC). The Manual of Operations for National Shellfish Sanitation Program (NSSP) governs TDH activities.

According to part I of this manual, shellfish growing areas must be classified into approved, conditionally approved, restricted, conditionally restricted, and prohibited areas by the state shellfish control authority (for Texas, this is the Division of Shellfish Sanitation Control in TDH). Furthermore, when a public health emergency resulting from, for instance, a hurricane or flooding, is declared, a closed area where the harvesting of shellfish is temporarily or "permanently" not permitted may be placed on any of these five classified area designations.

According to the NSSP manual, before a shellfish growing area can be classified, a sanitary survey must be made. Each sanitary survey shall:

1. identify and evaluate all actual and potential sources of pollution which may affect the growing area,

2. determine the distance of such sources to the growing area,

3. assess the effectiveness and reliability of sewage treatment systems, and

4. ascertain the presence of poisonous or deleterious substances.

Other environmental health factors that may affect the quality of the shellfish resources and any meteorological and hydrographic effects and geographic characteristics that may affect the distribution of pollutants over the growing area shall also be evaluated and assessed in each sanitary survey.

The Manual requires that water samples be collected and analyzed for bacteriological quality during each sanitary survey. Sampling stations must be established to evaluate all freshwater discharges into the growing area. The sampling is to emphasize adverse meteorological, hydrographic,

seasonal, and point sources of pollution to assure that the requirements for classifying growing areas are met.

The Manual also states that sanitary surveys shall be maintained on an annual basis to assure that data was current and sanitary conditions are unchanged. Also, the sanitary survey shall be reviewed and the growing area classification reevaluated at least every three years. The reevaluation shall include an analysis of laboratory results pertinent to at least the last fifteen water samples. A complete shoreline survey shall be conducted on all approved, conditionally approved, restricted, and conditionally restricted shellfish growing areas a minimum of once every twelve years.

Growing areas may be classified as approved if they are "not subject to contamination from human and/or animal fecal matter in amounts that may present an actual or potential hazard to public health". Also, approved areas must meet one of the following criteria:

1. The TC median or geometric mean MPN of the water does not exceed 70 per dL and not more than 10 percent of the samples exceed an MPN of 230 per dL for a 5-tube decimal dilution test (or an MPN of 330 per dL for a 3-tube decimal dilution test). This TC standard need not be applied if it can be shown by detailed study verified by laboratory findings that the bacteria are not of direct fecal origin and do not indicate a public health hazard. In addition, the standard may not be applicable in a situation where an abnormally larger number of pathogens might be present.

2. The FC median or geometric mean MPN of the water does not exceed 14 per dL and not more than 10 percent of the samples exceed an MPN of 43 per dL for a 5-tube decimal dilution test (or an MPN of 49 per dL for a 3-tube decimal dilution test).

The determination that the approved area classification standards are met shall be based upon a minimum of fifteen samples collected from each station in the approved area. These stations shall be located adjacent to actual or potential sources of pollution. Sample collection shall be timed to represent adverse pollution conditions.

Essentially, for an area to be approved for shellfish growing, it must have relatively low values in coliform sampling data and not be "subject to" potential sources of contamination such as wastewater treatment plants, fresh water discharges from rivers, homes or groups of boats.

Growing areas that are subject to intermittent microbiological inputs may be classified as conditionally approved. These areas shall be able to meet the approved area classification criteria, shown by a sanitary survey, for a reasonable period of time. The factors determining these periods must be known, predictable, and not so complex as to preclude a reasonable management approach. Also, the conditionally approved areas must be evaluated at least once each year.

An area may be classified as restricted when a sanitary survey indicates a limited degree of pollution. Such areas must not be so contaminated that consumption of shellfish might be hazardous after controlled purification or relaying. Relaying or depuration involves placing shellfish harvested from a restricted area into an approved area for a period of time prior to sale. For restricted areas to be used for harvest of shellfish for controlled purification, the bacteriological quality of every sampling station in those portions of the area exposed to contamination during adverse pollution conditions shall meet one of the following standards:

1. The TC median or geometric mean MPN of the water does not exceed 700 per dL and not more than 10 percent of the samples exceed an MPN of 2,300 per dL for a 5-tube decimal dilution test (or an MPN of 3,300 per dL for a 3-tube decimal dilution test).

2. The FC median or geometric mean MPN of the water does not exceed 88 per dL and not more than 10 percent of the samples exceed an MPN of 260 per dL for a 5-tube decimal dilution test (or an MPN of 300 per dL for a 3-tube decimal dilution test).

Sanitary surveys of restricted areas shall be conducted, maintained, and reevaluated in the same manner and frequency as for approved areas.

After a sanitary survey shows that an area will meet the restricted area classification criteria for a reasonable period of time, such area can then be classified as conditionally restricted. The factors determining these periods must be known, predictable, and not so complex as to preclude a reasonable management approach. Also, the conditionally restricted areas must be evaluated at least once each year.

A growing area shall be classified as prohibited if there is no current sanitary survey or evaluation to support the classification of approved, conditionally approved, restricted, or conditionally restricted. As stated in the NSSP manual, growing areas shall be classified as prohibited if the sanitary survey or other monitoring program data indicate that:

1. “Pollution sources may unpredictably contaminate the shellfish, or

2. the area is contaminated with poisonous or deleterious substances whereby the shellfish may be adulterated, or

3. the area is polluted with fecal waste to such an extent that shellfish may contain excessive filth or be vectors of disease-causing microorganisms, or

4. the area contains shellfish wherein the concentration of paralytic shellfish poison (PSP) equals or exceeds 80 micrograms per 100 grams of edible portion of raw shellfish, or when neurotoxic shellfish poison is found in detectable levels”.

Growing areas adjacent to sewage treatment plant outfalls and other waste discharges of public health significance shall also be classified as prohibited.

Although the NSSP manual provides five classifications to shellfish growing waters, Texas waters are currently classified into only three categories, namely approved, conditionally approved, and restricted. Study area waters do not include any conditionally approved areas. The criteria used for these classifications are the same as those in the NSSP manual with the restricted areas being the same as the prohibited areas.

III.2 HISTORICAL MAPS SHOWING SHELLFISH CLOSURES

A request for the shellfish classification maps was sent to Mr. Mike Ordner of the Seafood Safety Division of the TDH in February of 1996. Mr. Ordner and his staff searched through their files and provided EH&A with 44 maps dated from 1959 to 1995. These are reproduced in standard format in Appendix A.

Based on shellfish orders issued by TDH, a total of 52 shellfish classification maps have been issued by TDH for the project areas, as listed in Table III.1. For the period from 1974 to 1984, eight classification maps could not be found. According to Mr. Ordner, maps might have been published during that period of time but they can not be found anymore because TDH has moved several times in the past and some records appear to be lost. In addition, Mr. Ordner stated that only a couple maps were produced for the Upper Laguna Madre area down to Baffin Bay because those areas have little or no shellfish resources and are classified as closed for harvesting.

III.3 TRENDS OF BAY AREAS IN TERMS OF APPROVED AND NON-APPROVED FOR SHELLFISH HARVESTING

As shown in Appendix A, the areas restricted for shellfish harvesting within the CCBNEP study area have been changing over the past 30 years. This variation can be attributed to the results of sanitary surveys, different classification methods, testing procedures and, in particular, terminologies. The terms have included the use of “Not Approved” and “Unapproved” in 1959, “Insanitary” from 1963 to 1965, “Polluted” from 1966 to 1992, and “Restricted” after 1993 for areas closed to shellfish harvesting.

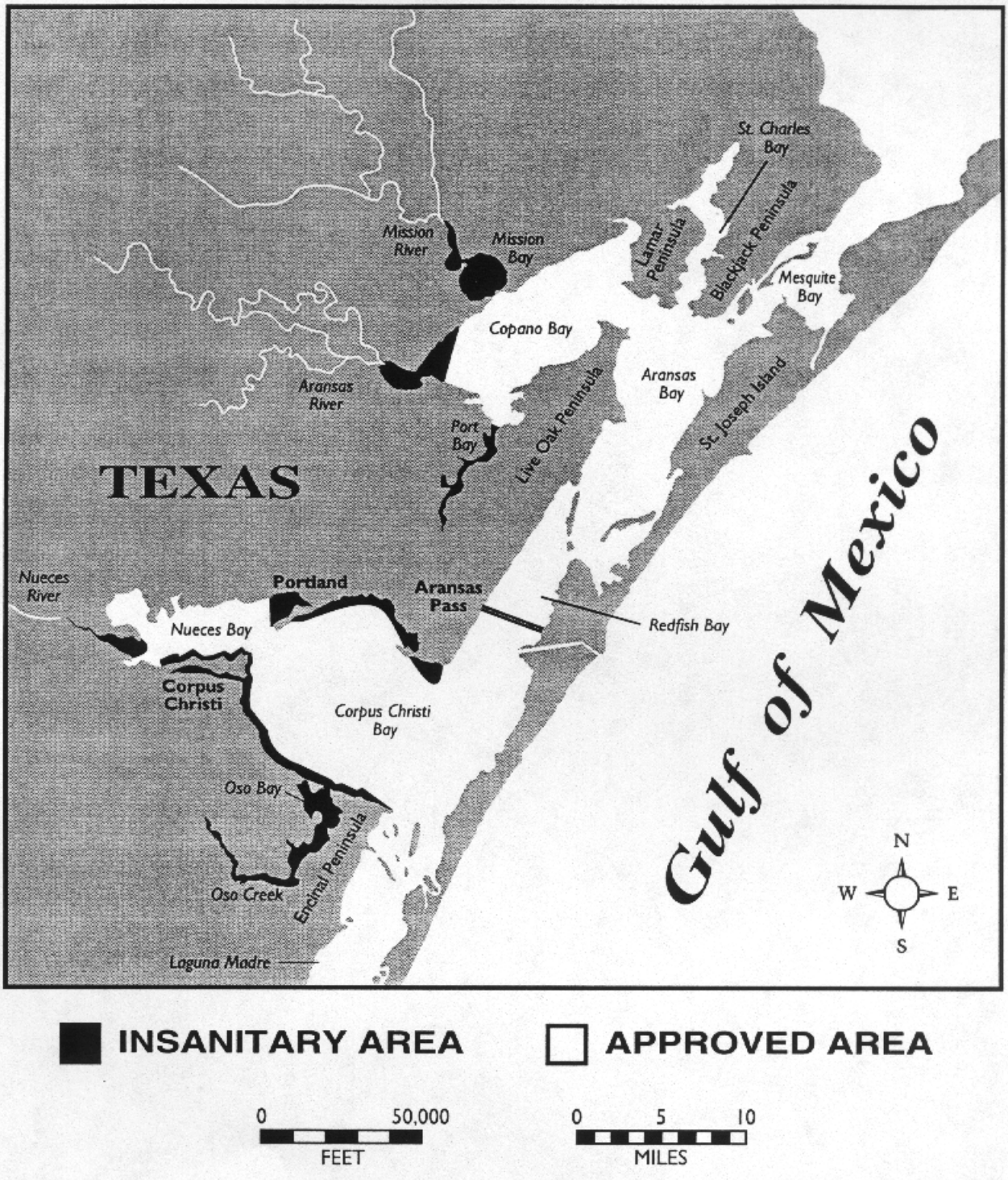
Although some maps before 1963 are available, they are incomplete and do not cover the entire CCBNEP area, nor do they show any information different from the 1963 map. Accordingly, the 1963 map, reproduced as Figure III.1, is considered the starting point for the analysis. As shown in the figure, the 1963 map the following areas were classified as “Insanitary Area” for shellfish harvesting:

1. Nueces River estuary in Nueces Bay, area within 1 mile radius of the entrance of the Nueces River,
2. area within 1 mile radius of the outfall of the Portland Sewage Treatment Plant in Nueces Bay,

TABLE III.1
SUMMARY OF SHELLFISH CLASSIFICATION MAPS RECEIVED FROM TDH

Year	Month	Bay Areas	Marine Order	Available
1959	Oct	Copano, Aransas, Mesquite		Yes
1959	Oct	San Antonio, Mesquite, etc.		Yes
1960 - 61		San Antonio, Mesquite, etc.		Yes
1963	Dec	Corpus-Nueces Bay		Yes
1964	July	Copano, Aransas, Mission,Port		Yes
1964	July	Corpus-Nueces Bay		Yes
1964	July	San Antonio, Mesquite, etc.		Yes
1965	July	Copano, Aransas, Mission,Port		Yes
1965	July	Corpus-Nueces Bay		Yes
1965	July	San Antonio, Mesquite, etc.		Yes
1966	July	Copano, Aransas, Mission,Port		Yes
1966	July	Corpus-Nueces Bay		Yes
1966	July	San Antonio, Mesquite, etc.		Yes
1967	July	Copano, Aransas, Mission,Port		Yes
1967	July	Corpus-Nueces Bay	SR-4	Yes
1967	July	San Antonio, Mesquite, etc.	SR-4	Yes
1968	July	Copano, Aransas	SR-4	Yes
1968	July	Corpus-Nueces Bay	MR-006	Yes
1968	July	San Antonio, Mesquite, etc.	MR-006	Yes
1969	July	Copano, Aransas	MR-010	Yes
1969	Nov	Copano, Aransas	MR-010	Yes
1969	July	Corpus-Nueces Bay	MR-010	Yes
1969	July	San Antonio, Mesquite, etc.	MR-010	Yes
1970	Sep	Copano, Aransas	MR-012	Yes
1970	Sep	Corpus-Nueces Bay	MR-012	Yes
1970	Sep	San Antonio, Mesquite, etc.	MR-012	Yes
1971	Nov	Copano, Aransas	MR-013	Yes
1971	Nov	Corpus-Nueces Bay	MR-013	Yes
1971	Nov	San Antonio, Mesquite, etc.	MR-013	Yes
1972	Mar	Copano, Aransas	MR-014	Yes
1972	Sep	Copano, Aransas	MR-015	Yes
1972	Sep	Corpus-Nueces Bay	MR-015	Yes
1972	Sep	San Antonio, Mesquite, etc.	MR-015	Yes
1973	Sep	Copano/Corpus-Nueces	MR-022	Yes
1975	OCT	Classification Maps	MR-026	No
1977	SEP	Classification Maps	MR-029	No
1979	NOV	Classification Maps	MR-034	No
1980	OCT	Classification Area Maps (9/1/79)	MR-037	No
1981	SEP	Classification Maps	MR-042	No
1983	SEP	Classification Maps	MR-065	No
1984	FEB	Copano, Aransas	MR-070	No
1985	APR	Copano, Aransas, Mesquite, Redfish	MR-098	No
1985	Sep	Copano/Corpus-Nueces/North & Middle Laguna Madre	MR-108	Yes
1986	Oct	Copano/Corpus-Nueces/North & Middle Laguna Madre	MR-117	Yes
1988	Oct	Copano/Corpus-Nueces	MR-175	Yes
1989	Nov	Copano/Corpus-Nueces,Mesquite, South Laguna Madre	MR-205	Yes
1990	Nov	Copano/Corpus-Nueces	MR-239	Yes
1991	Nov	Copano/Corpus-Nueces	MR-299	Yes
1992	Nov	Copano/Corpus-Nueces	MR-344	Yes
1993	Nov	Copano/Corpus-Nueces	MR-409	Yes
1994	Nov	Copano, Aransas, Corpus,Nueces	MR-458	Yes
1995	Nov	Copano, Aransas, Corpus,Nueces	MR-516	Yes

FIGURE III.1
1963 CLASSIFICATION OF SHELLFISH HARVESTING WATERS



3. area for a distance of 500 yards from shoreline from the causeway at Rincon Point to Avery Point in Nueces Bay,
4. area for a distance of 700 yards from shoreline from Rincon Point to the overhead power cable at the Naval Air Station in Corpus Christi Bay,
5. area for a distance of 500 yards from shoreline from a point 0.5 mile west of Portland to Channel Marker 32 west of Port Ingleside in Corpus Christi Bay,
6. the entire Oso Bay,
7. the entire Ship Channel and Turning Basin,
8. the entire Mission Bay,
9. the entire Port Bay, and
10. Aransas River estuary in Copano Bay, area north of a line drawn from a point 900 yards north of Hotel at Bayside to a point 1,000 yards east of the southeast end of the bridge on State Highway 136.

All other area were classified as open to shellfish harvesting. In 1964, the following changes were made by TDH:

1. Mission Bay and Port Bay were removed from the Insanitary Area list.
2. The entire Redfish Bay was classified as Insanitary Area because of the discharge of sewage from the City of Aransas Pass and that the Bay was considered unsuitable for shellfish culture.
3. The inshore area adjacent to Fulton Beach in Aransas Bay east of a line drawn due north from 9 Mile Point to the point of land adjacent to the southern approach to the Copano Bay Causeway was added into the list of Insanitary Area.
4. In Aransas Bay, the inshore area in the vicinity of Rockport east of a line drawn from 9 Mile Point south to Channel Marker 60 thence due west to the mouth of Turtle Bayou was added to the list of Insanitary Area.

The classification of all remaining areas was the same as in 1963.

The 1965 classification was the same as in 1964. In 1966, no changes were made to the classification of shellfish harvesting areas except that the term “Insanitary Area” was changed to “Polluted Area”. TDH emphasized in the footnote to the maps that the term “Polluted” as used applied only to the classification of shellfish harvesting areas and were not intended to imply that such areas might not be acceptable for other activities.

In 1967, everything was the same as 1966. In 1968, the following changes were made by TDH:

1. The area for a distance of 200 yards from the shore beginning at the southern approach to the Copano Bay Causeway and extending west to Red Fish Point and then south and east to Lone Tree Point was classified as Polluted Area.
2. For Port Bay, the area beginning at the bridge on FM 881 and extending to the southwest was classified as Polluted.
3. In Aransas Bay, the inshore area in the vicinity of Rockport east of a line drawn from the Flashing Red Marker located at 1000 yards southeast of 9 Mile Point south to

Channel Marker 60 thence due west to the mouth of Turtle Bayou was classified as Polluted Area.

4. In Aransas Bay, the inshore area beginning 200 yards south of the northern approach to the Copano Bay Causeway and extending east to the western tip of Goose Island and continuing along the northern shore of Goose Island to the bridge connecting Goose Island to the Lamar Peninsula was added to the list of Polluted Area.
5. The Polluted Area offshore from the causeway at Rincon Point to Avery Point in Nueces Bay was extended from a distance of 500 to 700 yards from the shoreline.

No changes were made in 1969 - 1972. In 1973, the following changes were made:

1. The inshore area of Laguna Madre for a distance of 500 yards offshore beginning at Pita Island and extending in a northerly direction to the overhead-power cable at the east end of the Naval Air Station was added to the list of Polluted Area.
2. All of Corpus Christi Inner Harbor was added to the list of Polluted Area.
3. The inshore area adjacent to Fulton Beach in Aransas Bay east of a line drawn from that point of land adjacent to the southern approach to the Copano Bay Causeway to Nine Mile Point Marker and thence to Intracoastal Waterway Channel Marker #7 was classified as Polluted Area.
4. In Aransas Bay, the inshore area beginning 300 yards south of the northern approach to the Copano Bay Causeway and extending easterly along a line 300 yards off the southern shoreline of Goose Island and continuing northerly 300 yards off the eastern tip of Goose Island to an unnamed point of land located at 1650 yards north of Hail Point was classified as Polluted Area.

No shellfish classification maps from 1974 to 1984 could be found in TDHs files. In the 1985 map, the following areas have different classification from the 1973 map:

1. The area bounded on the north by a line running from Demit Point southeastward to the junction of the overhead power cable and the Intracoastal Waterway, and continuing eastward along the overhead power cable to its intersection with the Padre Island shoreline was classified as Polluted Area.
2. In Corpus Christi, Copano, Aransas, Mesquite, and Redfish Bays, and Laguna Madre, all residential subdivision channels and harbor areas up to a radius of 300 yards offshore from the shoreline where the channels become land bound were added to the list of Polluted Area.
3. The area of Copano Bay and the Aransas River west of a line drawn from a point 3,000 yards north northeast of the Hotel at Bayside to a point due south to where the Cities Service Gas Plant becomes land bound was classified as Polluted Area.
4. The inshore area of Copano Bay for a distance of 200 yards offshore beginning at the eastern end of the fishing pier adjacent to Highway 35 at the end of Live Oak Peninsula and extending west to Red Fish Point and then south and west to Rattlesnake Point was classified as Polluted Area.

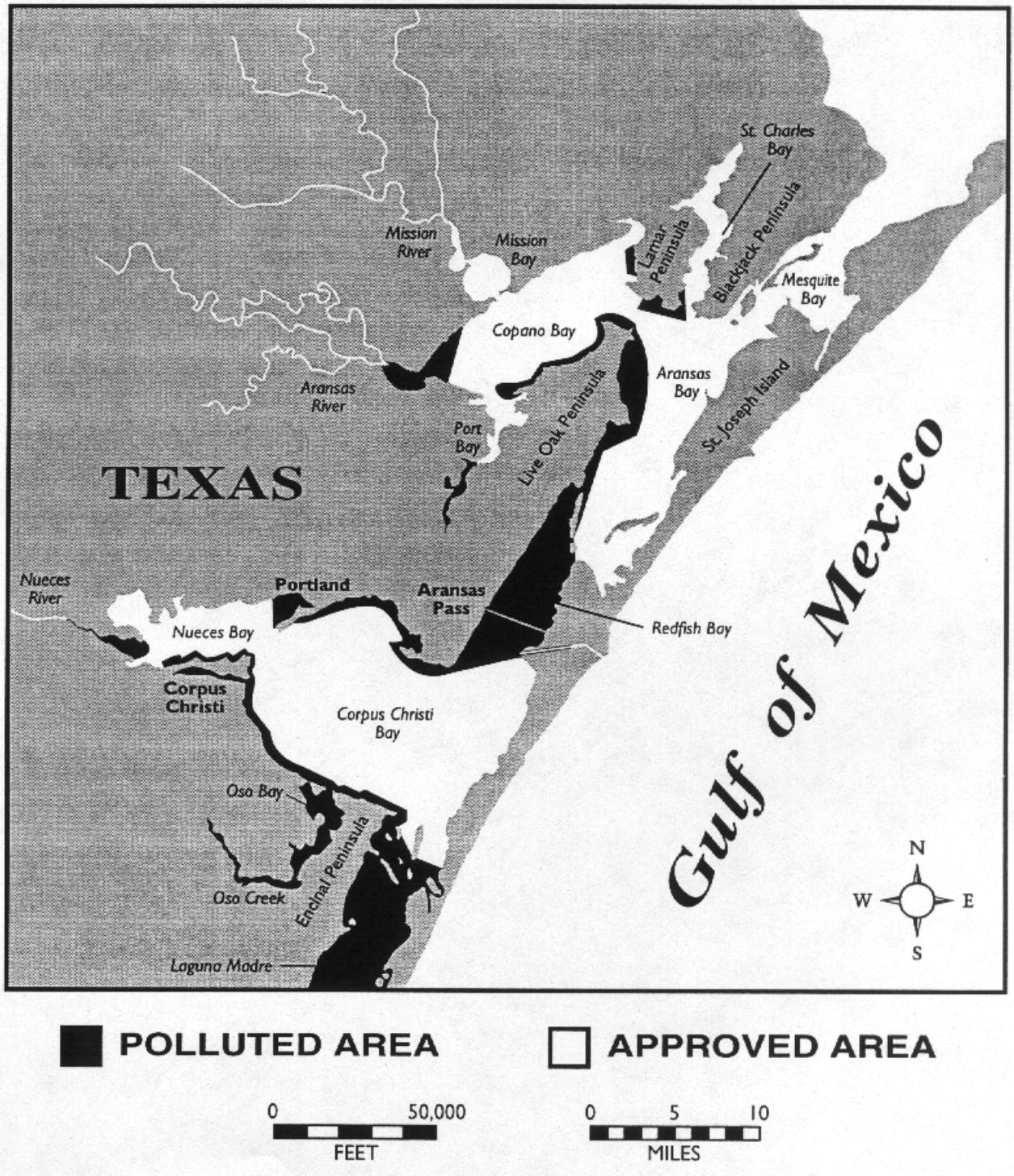
5. The inshore area of Copano Bay for a distance of 200 yards offshore beginning at Shell Point and extending in a southerly direction to the mouth of the tributary entering Copano Bay at Newcomb Bend was classified as Polluted Area.
6. The inshore area of Aransas Bay adjacent to Fulton Beach west of a line drawn from the eastern end of the fishing pier adjacent to Highway 35 at the end of Live Oak Peninsula, to Marker #3 off Live Oak Point to Marker #2 off Fulton Beach to Marker #1 off Fulton Harbor to Marker "N" off Nine Mile Point and thence to Intracoastal Waterway Channel Marker #7 was classified as Polluted Area.
7. The area of the Laguna Madre bounded on the south by a line extending eastward from the Central Power and Light Plant to Intracoastal Waterway Channel Marker #65 and continuing to its intersection with the Padre Island shoreline, and bounded on the north by a line running from Demit Point southeastward to the junction of the overhead power cable and the Intracoastal Waterway and continuing eastward along the overhead power cable to its intersection with the Padre Island shoreline was classified as Polluted Area.
8. All of the Intracoastal Waterway in Laguna Madre extending 150 yards each side from the center of the Intracoastal Waterway was classified as Polluted.
9. All areas in Laguna Madre within 100 yards of any recreational cabin were classified as Polluted.
10. The area of Baffin Bay north and west of a line drawn from Pie de Gallo extending northeastward to Kleberg Point, including Laguna Salada and Cayo de Grullo, was classified as Polluted.

The 1985 map is also the first one showing the Upper and Middle Laguna Madre areas, including Baffin Bay. A reproduction of this map, that doesn't go as far south as the TDH map is shown as Figure III.2. The 1986 map shows no change from the 1985 map. The 1987 map is missing from TDH files. The 1988 map shows the following changes from the 1986 map:

1. All areas east of the Island Moorings Channel in Corpus Christi Bay were classified as Polluted Area.
2. The area located west of a line drawn from the Tule Lake Bridge to Rosita Point in Nueces Bay was classified as Polluted.
3. The inshore area of Aransas Bay adjacent to Fulton Beach west of a line drawn from the highest part of the Highway 35 Causeway to Shellfish Marker C to the well off Fulton Beach to Fulton Channel Marker #1 off Fulton Harbor to Marker #N off Nine Mile Point and thence to Intracoastal Waterway Channel Marker #7 was classified as Polluted.
4. All of the Mission Bay from the mouth inland was added back into the list of Polluted Areas.

In 1989, the only change made by TDH was that the Polluted Area in Port Bay was expanded to include all areas southwest of the bridge ruins. In 1990, there was no change in the classification. In 1991, the only change was that the area of St. Charles Bay north of a line drawn from Big Sharps Point to Indian Head Point was newly classified as Polluted Area. In 1992, TDH made only one change to a Polluted Area in Corpus Christi Bay. That was the inshore area bounded by a line

FIGURE III.2
1985 CLASSIFICATION OF SHELLFISH HARVESTING WATERS



running east from the north landbound approach of the Causeway at Indian Point to the end of Indian Point Fishing Pier thence in a northerly direction to the observation deck at the end of the bird walk.

In 1993, the term "Polluted" was replaced by "Restricted" for areas closed for shellfish harvesting. In addition, the following changes were made by TDH:

1. In Nueces Bay, the area northeast of a line drawn from the red roof house located on the northeast shoreline of Nueces Bay southeastward to a group of four palm trees located on U.S. Highway 181 was classified as Restricted Area.
2. In Nueces Bay, the area bounded by the Nueces Bay Causeway and a line drawn from a large yellow building located between the Rincon Channels on the south shoreline of Nueces Bay to the tall narrow water tower located just east of U.S. Highway 181 in City of Portland was classified as Restricted.
3. In Aransas Bay, the area north of a line beginning 300 yards south of the northern approach to the Highway 35 Causeway and extending in an easterly direction to a set of double wells off the west point of Goose Island and thence to the end of the pier at Goose Island and thence in a northerly direction to an unnamed point of land located about 1,650 yards north of Hail Point was classified as restricted.

The 1994 map is very similar to the 1993 map.

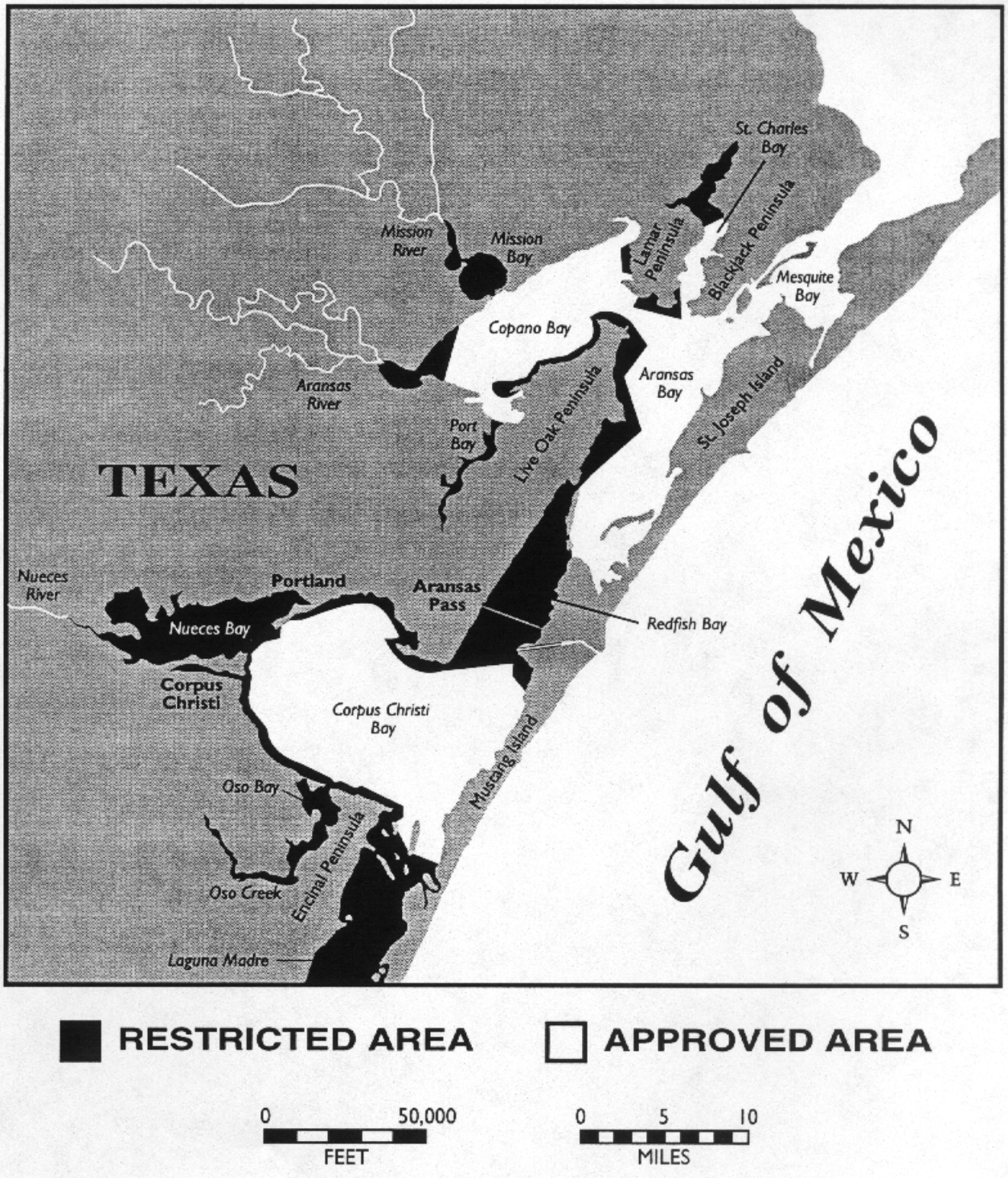
III.4 CURRENT CLASSIFICATIONS OF CCBNEP BAY AREAS

The most recent classification for the Corpus Christi Bay areas was issued by TDH in 1995, shown in Figure III.3. The areas restricted for shellfish harvesting are similar to that in 1994, except for the closure of the entire Nueces Bay. Basically, the restricted areas in the 1995 map include the following:

1. the Upper Laguna Madre and Baffin Bay,
2. the near shore area along Corpus Christi Bay shoreline including Oso Bay,
3. the Nueces River estuary and Nueces Bay,
4. the area in Corpus Christi Bay east of Island Moorings Channel,
5. the entire Redfish Bay, Port Bay and Mission Bay,
6. the near shore area along the Live Oak Peninsula in Copano Bay and Aransas Bay,
7. the northern end of St. Charles Bay,
8. a portion of the west and south shorelines of Lamar Peninsula, and
9. the Aransas River estuary in Copano Bay.

The classifications were based on the results of several sanitary surveys conducted by TDH in 1994 and input received in 1995, as summarized below.

FIGURE III.3
1995 CLASSIFICATION OF SHELLFISH HARVESTING WATERS



Copano Bay:

1. The Aransas River was thought to have an effect on the bacteriological loading of Copano Bay and therefore the Aransas River estuary should be restricted to shellfish harvesting.

2. Data collected from the west side of Lamar Peninsula were thought to indicate an effect of water from Holiday Beach even during dry weather. This area was classified as "Restricted".

3. Data from the shoreline area of Live Oak Peninsula in Copano Bay indicate elevated FC values that were reported to be not a function of rainfall. TDH suspected that the area might be impacted by septic systems from the community of Copano Cove. A "Restricted" classification was therefore issued.

4. For Mission Bay, because water in the bay is very shallow (less than 2 feet deep) and the effect of fresh water inflow to the bay from Mission River, the bay was classified as "Restricted".

5. For Port Bay, it has been classified as "Restricted" since 1989 because of elevated FC data attributed to non-point sources (TDH, 1989). The 1994 map continues this classification.

Aransas Bay:

1. The southeast shoreline of Live Oak Peninsula, including Fulton and Rockport areas, is inhabited and was therefore classified as "Restricted" for shellfish harvesting.

2. The south shoreline of Lamar Peninsula (Goose Island area) is inhabited and was classified as "Restricted".

3. The north end of St. Charles Bay is influenced by runoff from Cavasso Creek and was classified as "Restricted".

Corpus Christi, Nueces and Redfish Bays:

1. Oso Bay was classified as "Restricted" because of the Oso Water Reclamation Plant (Sewage Treatment Plant) effluent and fresh water flow from Oso Creek.

2. The shoreline areas of Corpus Christi Bay receive urban runoff from the City of Corpus Christi and were classified as "Restricted".

3. Prior to 1995, the upper end of Nueces Bay and the shoreline areas in the south had been classified as "Restricted" because of fresh water inflows from the Nueces River, Gum Hollow Creek and a drainage ditch near White's Point, as well as cooling water

discharge from the Central Power and Light power plant near Avery Point and the outfall area of the Portland Wastewater Treatment Plant. In 1995, the TDH completed an analysis of trace metals in fish and oyster tissue in Nueces Bay and the Inner Harbor. The recommendation was made that oysters from Nueces Bay not be consumed. Based on that recommendation the remaining part of Nueces Bay was reclassified as "Restricted".

4. The entire Redfish Bay has been permanently closed since 1964 (TDH, 1964). The closure was due to TDH ' budgetary restraints (Ordner, TDH, 1996). The TDH has resumed sampling activities in Redfish Bay since 1993.

The area of Upper Laguna Madre has been classified as "Restricted" since 1985. This area is shallow with extremely limited fresh water inflow. It is closed to shellfish harvesting "because of lack of harvest interest in the virtually non-existent shellfish resource" (TDH, 1993). For a similar reason no maps were produced by TDH for the Baffin Bay area in recent years. According to TDH (1993), the entire Middle Laguna Madre areas, including Baffin Bay, are classified as "Restricted" because of the lack of shellfish resource sufficient to interest commercial and/or recreational harvesters. Except for the restricted areas described above, all remaining areas in the Corpus Christi Complex are classified as "Approved" for shellfish harvesting.

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