3.0 REVIEW OF ACTIVITIES ASSOCIATED WITH SHELLFISH BED CLOSURES

The Galveston Bay estuarine system, consisting of four larger bays, Galveston, Trinity, East, and West Bays, and numerous smaller bays, creeks, and bayous, has a total surface area of about 533 square miles and is the largest estuary on the Texas coast. It also has the largest shellfish harvesting industry in Texas.

Regarding shellfish harvesting activities, the Galveston Bay system is regulated by the Division of Shellfish Sanitation Control in the TDH and enforced by the Texas Parks and Wildlife Department (TWPD). The objective of this section is to investigate the current and historical regulatory procedures for shellfish harvesting in the Galveston Bay System.

3.1 TDH REGULATORY PROCEDURES (NSSP)

The Food and Drug Administration (FDA) of the U. S. Department of Health and Human Services and the Interstate Shellfish Sanitation Conference (ISSC) updated the Manual of Operations for National Shellfish Sanitation Program (NSSP) in 1988 and revised in 1990 that governs the current regulatory procedures for shellfish growing areas. 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 is 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 Most Probable Number (MPN) (see Sec. 3.7 for a discussion of testing methods) 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 coliform 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 pollution 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 with fecal material, poisonous or deleterious substances 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 fecal 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 polluted. The criteria used for these classifications are the same as those in the NSSP manual with the polluted areas being the same as the prohibited areas. The term "polluted" is mandated by State Law, Health and Safety Code, Subchapter B, Section 436.011. It is somewhat inappropriate since the great majority of areas so classified are based on a judgement as to proximity to waste sources, etc., with no evidence of pollution. The TDH has made repeated efforts to have the legislation changed, but no action has been taken to date (Wiles, pers. comm. 1992).

3.2 HISTORICAL MAPS SHOWING SHELLFISH CLOSURES

As listed in Table 3-1, there have been 40 shellfish classification maps issued for Galveston Bay by TDH. Unfortunately, eight of them can not be found although EH&A has performed an intensive search. The available 32 maps, including the most current 1991 map, are shown in Appendix A and are also provided in ARC-INFO format on diskettes as requested by GBNEP.

TABLE 3–1
SHELLFISH CLASSIFICATION MAPS ISSUED BY TDH

MARINE ORDER NUMBER	DATE ISSUED	AVAILABLE AT EH&A
–	01–Apr–52	YES
–	01–Sep–53	YES
–	01–Aug–55	YES
–	01–Aug–58	YES
–	01–Oct–58	YES
–	01–Oct–60	YES
–	01–Nov–63	YES
–	01–Jun–64	YES
–	01–Jul–64	YES
–	01–Jul–65	YES
–	01–Jul–66	YES
–	01–Jul–67	YES
6	01–Jul–68	YES
10	01–Jul–69	YES
11	14–Jul–70	NO
12	01–Sep–70	YES
13	01–Nov–71	YES
14	28–Feb–72	NO
15	01–Sep–72	YES
17	07–Apr–73	YES
20	12–May–73	YES
22	01–Sep–73	YES
24	21–Feb–74	YES
26	15–Oct–75	NO
29	01–Sep–77	NO
34	16–Nov–79	NO
37	31–Oct–80	NO
42	01–Sep–81	YES
65	01–Sep–83	YES
99	01–Apr–85	NO
108	01–Sep–85	YES
117	15–Oct–86	YES
122	22–Nov–86	YES
154	11–Dec–87	NO
166	01–Jul–88	YES
175	15–Oct–88	YES
205	01–Nov–89	YES
211	15–Dec–89	YES
239	01–Nov–90	YES
299	01–Nov–91	YES

3.3 TRENDS OF BAY AREAS IN TERMS OF "POLLUTED", CONDITIONALLY APPROVED, AND APPROVED

As shown in the appendix, the pattern of regulated areas in the Galveston Bay system has varied considerably over the years. This variation can be attributed to different classification methods, testing procedures, and terminologies. In particular, the terminology used for prohibited areas has varied over the years and has included unapproved, insanitary, and polluted. With some of the older designations, the meaning of the terms is not certain (Wiles, 1992).

In 1952 and 1953, most of Trinity Bay, the northern and southwestern parts of Galveston Bay, the eastern part of East and West Bays, and Chocolate Bayou in West Bay were all classified as "unapproved oyster areas". In 1955, the unapproved area in Trinity Bay was reduced and the northern and western parts of Galveston Bay were classified as "insanitary oyster areas". This caused a significant reduction in the unapproved area in Galveston Bay. In August of 1958, the unapproved area in Trinity Bay was increased and the insanitary area in Galveston Bay was classified back to unapproved areas with a significant increase in such areas. In October of 1958, the central part of Galveston Bay was reclassified into conditionally approved oyster areas while the previous unapproved areas were renamed to be insanitary areas. This classification remained the same in 1960, 1963, June and July of 1964, and 1965.

In 1966, the previous insanitary area was termed polluted area. As compared to the classification in 1965, there was a reduction in the polluted/insanitary areas in Trinity Bay and north of Galveston Bay and a slight reduction in the conditionally approved area. The same 1966 classification was maintained for 1967 and 1968. In 1969, the polluted areas in northern Trinity and Galveston Bays were reduced while the polluted areas in southern Trinity Bay were increased. These changes were the direct results of the comprehensive sanitary survey performed by TDH in 1969. This same 1969 classification remained unchanged for 1970.

In 1971, the polluted areas remained the same as in 1969 but the conditionally approved area located in central Galveston Bay was reclassified to be approved area. This classification remained unchanged in 1972. In May of 1973, the entire area north of a line drawn from the Houston Ship Channel Marker #53 to the Smith Point was reclassified as polluted areas. This includes all of Trinity and most of Galveston Bays. The reason for this closing might be excessive rainfall. Four months later, in September of 1973, the areas closed in May were opened and the classification was again the same as the one in 1972, except for the eastern part of West Bay where the polluted area was slightly increased.

In 1974, the polluted areas in Trinity and Galveston Bays were increased due to excessive rainfall. From 1975 to 1980, although there were at least four shellfish classification maps issued by TDH, none of them was found. In 1981, the only available map was for West Bay only which had the same classification as the 1973 map. In 1983, the polluted areas in Trinity and Galveston Bays were significantly reduced. In 1985, the polluted area in Trinity Bay was expanded further offshore and hence increased the size. This classification remained the same in 1986.

In 1988, the classification map introduced significant change. First, the classification criteria revised in 1986 and updated in 1988 by NSSP were adopted and the areas were reclassified into approved, conditionally approved, and polluted areas. Second, a comprehensive sanitary survey was performed by TDH in 1988. This was the first survey since 1969 on the Galveston Bay system. The results of this survey reclassified the bay waters significantly. For East and West Bays, all classifications remained the same. However, for Trinity and Galveston Bays, significant changes in classification areas can be seen. First, conditionally approved areas were added into the classification for the first time since 1970. Second, the polluted areas were significantly reduced.

In 1989, the shellfish classification map showed that the polluted areas were increased and the conditionally approved areas were reduced in both Trinity and Galveston Bays. The 1990 and 1991 maps show no change in these classification for Trinity, Galveston, and East Bays, except for the southwest corner of Galveston Bay near the Dollar Reef Markers where the polluted area was reduced. For West Bay, although a comprehensive sanitary survey was performed in 1988, the classification maps remained unchanged in 1989 and 1990. In fact, the classification for West Bay had not been changed for more than 10 years. However, the polluted areas in the eastern part of West Bay were increased in the 1991 map.

3.4 DIFFERENCES IN CLOSURE AREAS WITH CHANGE FROM TOTAL TO FECAL COLIFORM AS REGULATORY CRITERIA

Up to the mid to late 1970's, the TDH was using TC MPN data as criteria for classification of shellfish growing waters (Wiles, 1992). Then, both total and fecal MPN test data were used until about 1983. From 1983 on, only FC data have been used.

As can be seen from Appendix A, the classification maps for September of 1973 and September of 1983 are identical. This result indicates that no significant change can be observed when classification criteria changed from total to FC values. Also, although a slight change in polluted areas occurred in September of 1985 as compared to September of 1983, this change in polluted areas may be due to other reasons than the change in classification criteria.

However, the 1988 map indicated significant changes in the classification of shellfish growing areas. These changes include the addition of conditionally approved area and the reduction in polluted areas compared with the 1986 classification. Although NSSP revised its Manual of Operation in 1986 which may have some effect on this 1988 classification, the significant changes in the 1988 classification map are mostly due to the results of the comprehensive sanitary survey performed by TDH in 1988. Thus, a conclusion can be drawn that the change from total to FC testing did not produce a significant change in the classification results.

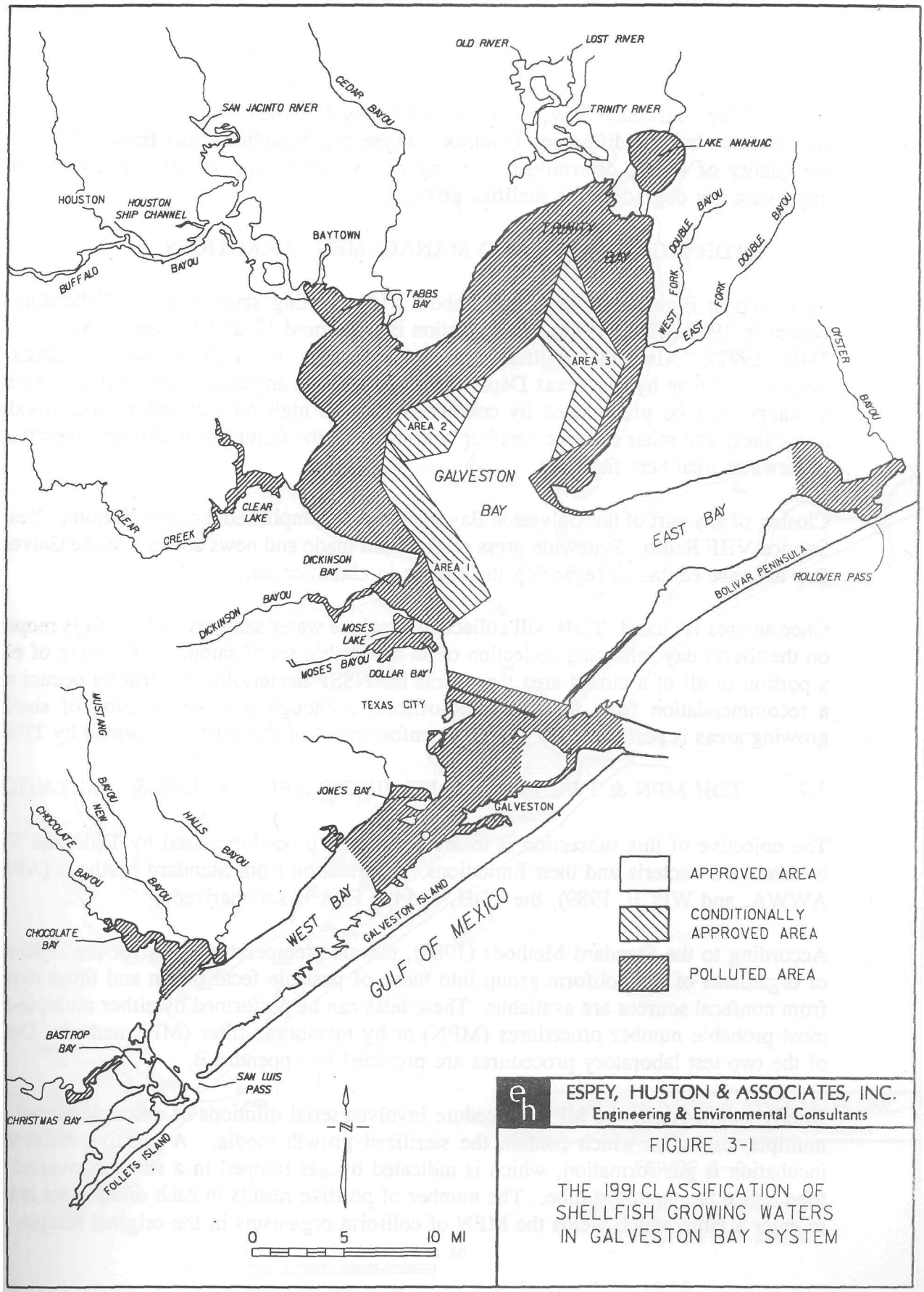
3.5 CURRENT CLASSIFICATIONS OF BAY AREAS

The most current classifications of Galveston Bay areas were issued by TDH on November 1, 1991 according to Marine Order MR-299. This map is shown in Figure 3-1. As in 1990, the eastern portion of East Bay was classified as polluted. In Galveston Bay, the southwestern, western, northwestern, and northern portions were classified as polluted areas. As for Trinity Bay, the northern, northeastern and eastern portions were classified as polluted areas. Also, all areas within a 50 yard radius of recreational cabins located in the Bays were closed for shellfish harvesting.

For West Galveston Bay areas, the eastern portion and most of Chocolate Bay were classified as polluted areas. Also, all residential subdivision channels and harbor areas up to a radius of 300 yards offshore from the shoreline where the channels become land bound and all areas within a 50-yard radius of recreational cabins located in the bay were closed for shellfish harvesting.

There were three areas in Galveston Bay that were classified as conditionally approved areas. These areas are subject to classification changes based upon meteorological conditions. The first conditionally approved area, Area 1 in Figure 3-1, is located west of the Houston Ship Channel. When seven-day rainfall at San Leon or the closest available National Weather Service rain gauge exceeds 2 inches, this area is closed for shellfish harvesting. The other two areas, Area 2 in Galveston and Area 3 in Trinity Bay, are managed together based on river stage and rainfall. When either the Trinity River exceeds 9 ft at Moss Bluff or when seven-day rainfall exceeds 2 inches at the Baytown National Weather Service rain gauge or the nearest available official rain station, these two areas are closed. The only difference between areas 2 and 3 is that the decision on reopening is made independently based on sampling data. All other areas in the Galveston Bay system not specifically defined above were classified as approved for the harvesting of shellfish.

When comparing this 1991 classification with the 1990's, the following results can be observed. First, the 1990 and 1991 classifications are the same for Trinity, Galveston, and East Bay areas. Second, the 1991 classification includes more polluted area in the east


OLD RIVER
LOST RIVER
TRINITY RIVER
LAKE ANAHUAC
CEDAR BAYOU
SAN JACINTO RIVER
HOUSTON
HOUSTON SHIP CHANNEL
BAYTOWN
BUFFALO BAYOU
TABBS BAY
TRINITY BAY
DOUBLE BAYOU
WEST FORK
EAST FORK
DOUBLE BAYOU
OYSTER BAYOU
AREA 3
AREA 2
AREA 1
GALVESTON BAY
EAST BAY
CLEAR CREEK
CLEAR LAKE
DICKINSON BAY
DICKINSON BAYOU
MOSES LAKE
MOSES BAYOU
DOLLAR BAY
TEXAS CITY
BOLIVAR PENINSULA
ROLLOVER PASS
MUSTANG BAYOU
NEW BAYOU
HALLS BAYOU
CHOCOLATE BAYOU
JONES BAY
GALVESTON
CHOCOLATE BAY
WEST BAY
GALVESTON ISLAND
GULF OF MEXICO
BASTROP BAY
SAN LUIS PASS
CHRISTMAS BAY
FOLLETS ISLAND
APPROVED AREA
CONDITIONALLY APPROVED AREA
POLLUTED AREA
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0 5 10 MI
ESPEY, HUSTON & ASSOCIATES, INC.
Engineering & Environmental Consultants
FIGURE 3-1
THE 1991 CLASSIFICATION OF SHELLFISH GROWING WATERS IN GALVESTON BAY SYSTEM

side of West Galveston Bay, near the West Bay Shellfish Marker #1, than the 1990 classification but the difference is minor. These results indicate that from 1990 to 1991 the quality of water, determined by using FC, in the Galveston Bay system is neither improving nor degrading for shellfish growing.

3.6 TDH MONITORING AND MANAGEMENT PRACTICES

As shown in Figure 3-2, there were about 112 sampling stations in the Galveston Bay system in 1988 (TDH, 1988). Each station is monitored 12 to 30 times per year (Wiles, TDH, 1992). Also, the shellfish classification status of all Texas estuarine areas are subject to change by the Texas Department of Health at anytime. The necessity for such a change may be precipitated by conditions such as high rainfall and runoff, flooding, hurricanes, and other extreme weather conditions or the failure or inefficient operation of wastewater treatment facilities.

Closing of any part of the Galveston Bay system is accomplished through National Weather Service VHF Radio. Statewide press releases are made and news sources in the Galveston Bay area are contacted regarding the change in classification.

Once an area is closed, TDH will collect and analyze water samples. The area is reopened on the fourth day following collection of an acceptable set of samples. Opening of either a portion or all of a closed area that meets the NSSP bacteriological criteria occurs after a recommendation from the TDH sub-office. Although the classification of shellfish growing areas is performed by TDH, the enforcement of the law is performed by TPWD.

3.7 TDH MPN & TWC MEMBRANE FILTER APPROACHES & LIMITATIONS

The objective of this subsection is to investigate the procedures used by TDH and TWC to detect FC bacteria and their limitations. Information from Standard Methods (APHA, AWWA, and WPCF, 1989), the TDH, and the EPA is summarized.

According to the Standard Methods (1989), elevated-temperature tests for the separation of organisms of the coliform group into those of possible fecal origin and those derived from nonfecal sources are available. These tests can be performed by either multiple-tube most probable number procedures (MPN) or by membrane filter (MF) methods. Details of the two test laboratory procedures are provided in Appendix B.

Briefly summarized, the MPN procedure involves serial dilutions of a sample placed into multiple test tubes which contain the sterilized growth media. A positive result after incubation is gas formation, which is indicated by gas trapped in a smaller inverted test tube inside the main test tube. The number of positive results in each dilution set is used to enter a table which yields the MPN of coliform organisms in the original sample.

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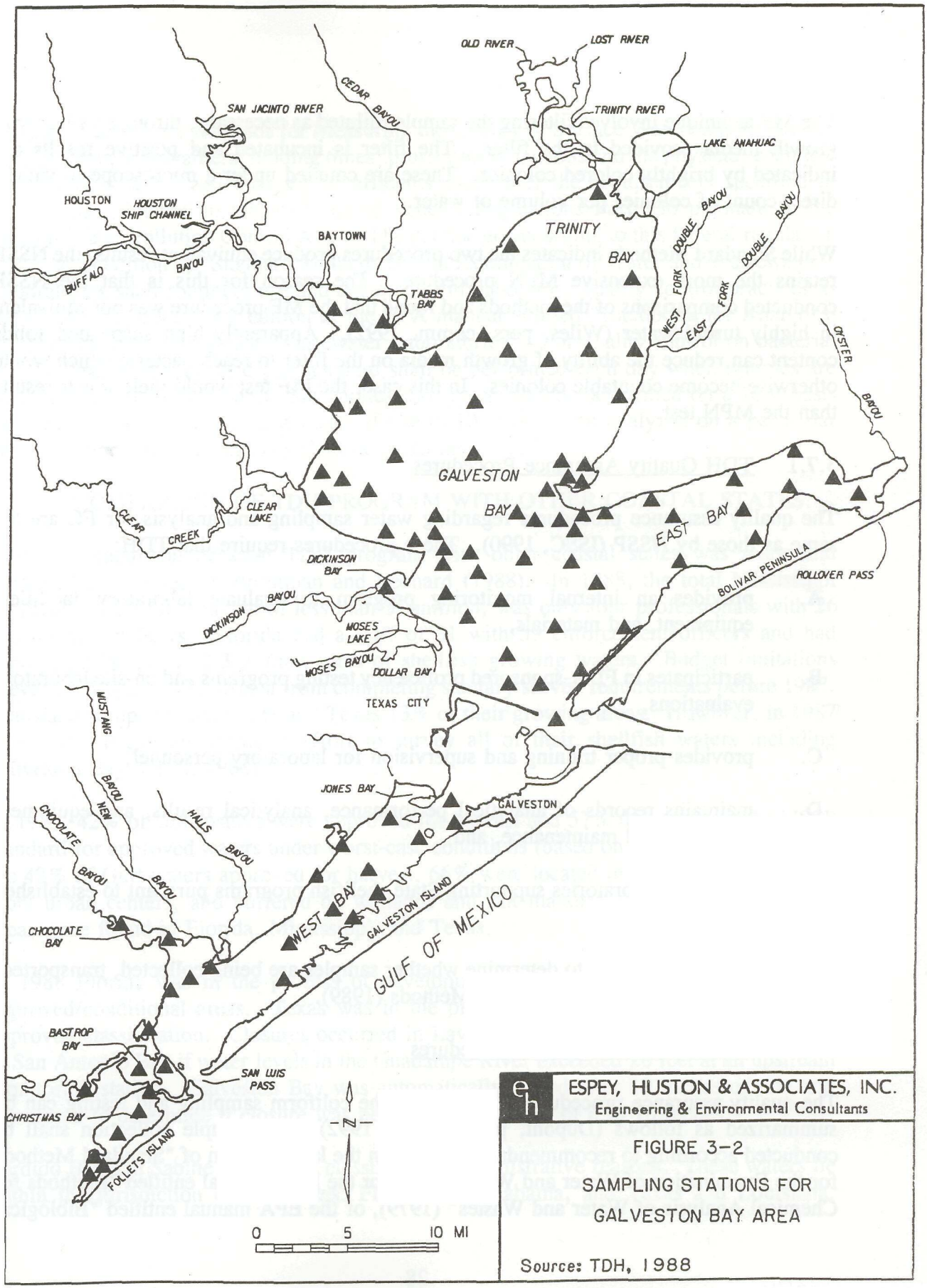

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FIGURE 3-2
SAMPLING STATIONS FOR
GALVESTON BAY AREA

Source: TDH, 1988

The MF technique involves filtering the sample, diluted as necessary, through a filter with growth media provided to the filter. The filter is incubated and positive results are indicated by brightly colored colonies. These are counted under a microscope to yield a direct count of colonies per volume of water.

While Standard Methods indicates the two procedures produce equivalent results, the NSSP retains the more expensive MPN procedure. The reason for this is that the NSSP conducted comparisons of the methods and found that the MF procedure was not equivalent in highly turbid water (Wiles, pers. comm. 1992). Apparently high suspended solids content can reduce the ability of growth media on the filter to reach bacteria which would otherwise become countable colonies. In this case, the MF test would yield lower results than the MPN test.

3.7.1 TDH Quality Assurance Procedures

The quality assurance procedures regarding water sampling and analysis for FC are the same as those by NSSP (ISSC, 1990). These procedures require that TDH:

A. provides an internal monitoring program to evaluate laboratory facilities, equipment, and materials,

B. participates in FDA-sponsored proficiency testing programs and on-site laboratory evaluations,

C. provides proper training and supervision for laboratory personnel,

D. maintains records of analytical performance, analytical results, and equipment operation and maintenance, and

E. evaluates laboratories supporting State shellfish programs pursuant to established NSSP guidelines.

These procedures are used to determine whether samples are being collected, transported, and analyzed consistent with Standard Methods (1989).

3.7.2 TWC Quality Assurance Procedures

The quality assurance procedures followed for the coliform sampling and testing can be summarized as follows (Dupont, pers. comm. 1992). All sample collection shall be conducted according to recommendations found in the latest edition of "Standard Methods for the Examination of Water and Wastewater", or the EPA manual entitled "Methods for Chemical Analysis of Water and Wastes" (1979), or the EPA manual entitled "Biological

Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents" (1973). Sample containers, holding times, preservation methods and the physical, chemical and microbiological and analyses of effluents shall meet the requirements specified in regulations published in the 40 Code of Federal Regulations Part 136 pursuant to the Federal Water Pollution Control Act, and be conducted according to this federal regulation or the latest edition of "Standard Methods for the Examination of Water and Wastewater". Laboratories shall routinely use and document intralaboratory quality control practices as recommended in the latest edition of the EPA manual entitled "Handbook for Analytical Quality Control in Water and Wastewater Laboratories". For quality control on bacterial tests, at least one blank and one standard shall be performed each day when samples are analyzed. Also, it is required that duplicate analyses shall be performed on a 10% basis each day when samples are analyzed. If one to 10 samples are analyzed on a particular day, then one duplicate analysis shall be performed.

3.8 COMPARISON OF TDH PROGRAM WITH OTHER COASTAL STATES

A brief comparison between TDH program with other coastal states was made and presented here based on Broutman and Leonard (1988). In 1988, the total Mississippi shellfish staff, with a budget of less than $1 million, was only four professionals with 26 enforcement officers. Florida had a staff of 31 with 59 enforcement officers and had surveyed 50% of the 2.3 million acres of shellfish growing waters. Budget limitations prevented Texas and Louisiana from completing sanitary survey requirements before 1987. Louisiana completed only 11% and Texas 13% of their growing areas. However, in 1987 both states began an extensive effort to survey all of their shellfish waters including Galveston Bay (TDH, 1988).

In 1985, 42% of Gulf waters were approved for harvest and 57% did not meet the NSSP standard for approved waters under worst-case conditions (based on TC MPN values). Of the 42% of Gulf waters approved for harvest, 66% were located in coastal Louisiana, far from urban centers, and buffered by wetlands and salt marshes. Approved/conditional areas were found in Florida, Mississippi, and Texas.

In 1988 Florida was in the process of developing management plans for many of its approved/conditional areas. Texas was in the process of implementing a conditionally approved classification. Closures occurred in Lavaca Bay after three inches of rain, and in San Antonio Bay if water levels in the Guadalupe River exceeded 20 feet at an upstream monitoring station. Galveston Bay was automatically closed after 10 inches of rain and monitored to determine if closure was necessary after rains of 6 to 10 inches.

Perdido Bay and Sabine Lake were classified for administrative reasons. These waters lie within the jurisdiction of two states: Florida and Alabama, and Texas and Louisiana,

respectively. Harvest is prohibited by interstate agreement to avoid problems of bistate management. Neither system contains shellfish resources of commercial importance.

Approximately half (53%) of the 3.4 million acres of harvest-limited waters in the Gulf were affected by a combination of point (sewage treatment plants (STPs), straight pipes, and industry) and nonpoint sources (septics, boating and shipping, urban runoff, agricultural runoff and feedlots, and wildlife) in 1988. The other half (47%) were affected only by nonpoint sources. Point sources alone affected less than 1% of shellfish growing waters. For example, estuaries predominantly affected by sewage treatment plants and urban runoff were the Caloosahatchee River, Tampa Bay, Pensacola Bay, Lakes Pontchartrain and Borgne, Brazos River, and Corpus Christi Bay; by combined urban and nonurban sources were St. Andrew Bay, Mississippi Sound, Galveston Bay, and Laguna Madre; by upstream sources were Apalachicola Bay, Mobile Bay, Mississippi Sound, Mississippi Delta, Atchafalaya and Vermillion Bays, and San Antonio Bay; by septics was Aransas Bay; by septics and straight pipes were Chandeleur/Breton Sounds, Terrebonne/Timbalier Bays, and Caillou Bay; by septics and boating activities were Ten Thousand Islands and Charlotte Harbor; by septics and wildlife were Apalachee and Choctawhatchee Bays; by septics and agricultural runoff was Matagorda Bay; by wildlife was Suwannee River; and by agricultural runoff was Barataria Bay.

NOAA estimates reported by the Office of Technology assessment (1987) showed that 84% of FC loads in the Gulf of Mexico coastal region were from nonpoint sources. The remaining 16% of loading was from municipal point sources (STPs). The loading from industrial point sources was negligible compared to the other two sources.

An estimated 0.4 million acres or 11% of harvest-limited waters in the Gulf were affected only by animal sources (wildlife, agriculture runoff and feedlots). In an additional 1.1 million acres or 34%, animals were a significant contributing source, along with human sources of pollution. Urban runoff, which may or may not contain human fecal material, affected 1.1 million acres or 33% of harvest-limited areas. Industrial sources were contributing factors in the closures of 0.3 million acres or 10% of these waters.

Broutman and Leonard (1988) concluded that: 1) most waters in the Gulf of Mexico did not meet standards for approved waters at all times; 2) the majority of approved waters were in the outer bays of Louisiana where salinities were high and oyster productivity was low; 3) harvest was prohibited in 29% of waters around developed areas; and 4) an additional 27% of waters might not be harvested after heavy rainfall or when river stages were high. These conditionally approved waters were the most productive in the Gulf.

3.9 CONCLUSIONS

The classification of shellfish growing areas is affected by many factors. Among these factors, rainfall runoff has the biggest effect on water quality conditions in bay waters. This can be seen from the conditionally approved areas which are managed from rainfall and/or freshwater inflow levels. No significant trend can be observed from historical classification maps. In fact, the classifications are fairly similar through time unless there is excessive rainfall which may close shellfish harvesting areas significantly for a short period. Other changes that have occurred in the historical maps are due to the comprehensive sanitary surveys which redetermine the water quality conditions and hence reclassify bay waters.

A second conclusion is that no significant changes in the classifications occurred when the criteria switched from using TC to FC. This conclusion suggest that both TC and FC work equally well as a tool to regulate the shellfish growing waters. However, as described in Section 6, no obvious relationship between coliform levels and pathogens such as the Vibrios can be observed. Thus, the validity of using only coliforms to regulate shellfish growing areas may be questionable.