United States Environmental Protection Agency
Office of Research and Development Washington DC 20460
EPA/620/R-00/006 October 2000

A Framework for an Integrated and Comprehensive Monitoring Plan for the Estuaries of the Gulf of Mexico

GMP Monitoring Subcommittee

A FRAMEWORK FOR AN INTEGRATED AND COMPREHENSIVE MONITORING PLAN FOR THE ESTUARIES OF THE GULF OF MEXICO

Monitoring Subcommittee
of the
Modeling, Monitoring and Research Committee

Gulf of Mexico Program

Acknowledgments: The Monitoring Subcommittee of The Gulf of Mexico Program's Modeling, Monitoring and Research Committee (MMRC) is comprised of:

Name	**Affiliation**
Kevin Summers*	USEPA/ORD
Greg Steyer*	Louisiana Department of Natural Resources
Ed Decker*	USEPA/Region IV
Philip Crocker*	USEPA/Region IV
Flinda Hill*	Mississippi Power Company
Gil McRae	Florida Marine Research Institute
Scott Brown	Alabama Department of Environmental Management
Jeff Thomas*	Mississippi Department of Environment Quality
Jim Simons	Texas Department of Parks and Wildlife
David Brock	Texas Water Development Board
Carter Miska*	Galveston National Estuary Program
Jimmy Johnston*	USGS-NWRC

* Members of MMRC

TABLE OF CONTENTS

SECTION 1

INTRODUCTION

1.1 A JOINT GULF STATES COASTAL MONITORING PROGRAM

The Gulf of Mexico States (Alabama, Florida, Louisiana, Mississippi, and Texas) have agreed, through their interactions with the Gulf of Mexico Program (GMP), to coordinate their estuarine and coastal monitoring and assessment activities and to investigate the development of a joint Gulf states Coastal Monitoring Program on the measurement of the status and trends of ecological condition in coastal resources. Through its involvement with the GMP and several Gulf state resource agencies, EPA's Environmental Monitoring and Assessment Program (EMAP) is assisting in the development of a framework for this integrated and comprehensive monitoring of Gulf coastal resources that will provide a Gulf-wide component for EPA's Coastal 2000 Program.

EMAP is a nationwide EPA/ORD environmental monitoring and assessment program designed to provide information to evaluate the overall condition of a variety of coastal and terrestrial ecosystems. EMAP incorporates a long-term monitoring approach to assess quantitatively how regional resource conditions are changing with time and to evaluate the effectiveness of pollution control measures. EMAP monitoring is based on a stratified-random design which allows probability-based estimates of the extent and magnitude of degraded systems. EMAP is designed to examine ecosystem condition at broad regional scales, although the approach used by EMAP can be adapted to examine smaller geographic scales (e.g., state-level resources). EMAP-Estuaries conducted a demonstration project from 1991-1994 in the Gulf of Mexico estuaries (Summers, et al. 1993, Summers 1994, Macauley et al. 1994, Macauley et al. 1999). The results of this demonstration project can be used to construct a consistent and comparable baseline of ecological conditions throughout the Gulf of Mexico estuaries. The Coastal 2000 Program is designed to assess national, regional and state specific condition of coastal resources. Coastal 2000 is seeking Gulf States support in developing its program.

GMP is a regional EPA/OW program designed to develop and implement a comprehensive strategy for managing and protecting the resources of the Gulf of Mexico. Its goals include the establishment of (1) an effective infrastructure for resolving complex environmental problems in the Gulf and (2) a framework-for-action for implementation of management options for pollution controls, remedial and restoration measures, research direction, and environmental monitoring. The program includes representatives from all state and federal agencies, as well as many private and academic institutions, involved in the management, protection, and/or use of environmental resources of the Gulf of Mexico.

State Resource Agency monitoring programs exist in all five states to collect information for the evaluation of coastal resources (Appendix A). All states collect information for the characterization of their coastal resources for Clean Water Act, Section 305(b) requirements. However, the states employ differing designs and indicators for the collection of that information. In addition, all states have compliance monitoring, drinking water quality monitoring, and specific human health effects monitoring programs in place. Two of the Gulf States, Alabama (Alabama Department of Environmental Conservation) and Florida (Florida Marine Research Institute), have adopted an EMAP-like approach to its coastal monitoring. In another state, Texas' Department of Parks and Wildlife uses a probabilistic monitoring approach to evaluate the condition of fish populations.

Coastal 2000 provides a national framework within which to develop a Gulf-wide coastal monitoring program. Therefore, GMP and the Gulf States are pursuing the establishment of a long-term goal for a Joint Gulf States Monitoring Program (JGSMP) to consolidate wide-scale, non-compliance monitoring programs into a unified state/regional program that serves the state and regional interests of each state and the GMP.

1.2 THE PURPOSE OF THIS DOCUMENT

This document presents a framework for the development of a unified, coordinated, and comprehensive coastal monitoring plan through the use of multiple regional and state workshops conducted by EMAP-Estuaries, GMP, and state resource agency personnel. A "strawman" approach to regional and state-specific design development and indicator selection is provided in this document. All provisions in this report represent initial points of discussion with GMP and State Resource Agencies. The flexibility of the probabilistic designs and ecological indicators requires only that the states and GMP agree on the conceptual use of probability sampling (which offers thousands of design alternatives) and a core set of ecological indicators and methodologies. An initial regional workshop would be used to gain these commitments and the state-specific workshops will be used to hone the general commitments into specific, yet compatible, design alternatives and specific list of regional core and state-specific indicators.

1.3 ELEMENTS OF THE FRAMEWORK FOR MONITORING PLAN

This plan consists of individual sections addressing key design and management elements of a framework to develop a coordinated and comprehensive coastal monitoring plan for Gulf of Mexico Coastal Resources. These elements and corresponding sections are:

- Program Coordination (Section 2.0) Describes the partnership approach suggested to ensure full participation of State Resource Agencies, GMP, EPA Regions IV and VI, and EMAP in the development of the monitoring program.

- Sampling Design (Section 3.0) Provides a detailed rationale and description of the sampling approach for a comprehensive monitoring network as well as "strawman" designs for regional and state-specific monitoring. These "strawman" designs are provided as initial points of discussion for the regional and state-wide workshops.

- Indicator Selection and Evaluation (Section 4.0) Discusses the selection strategy for the choice of critical or core ecological indicators. A "strawman" set of indicators is provided listing those indicators critical for regional assessment. This "strawman" set of indicators is provided as an initial point of discussion for the regional and state-wide workshops. Suggested methodologies for collection and analysis of core indicators are provided.

- Management Plan and Workshops (Section 5.0) Describes the core committee for the planning and execution of the workshops, their scheduling, intended purposes, and interactions with the GMP.

- Bibliography
  (Section 6.0)

- Appendix A - A compendium of the existing coastal monitoring programs in the states bordering the Gulf of Mexico.

SECTION 2

PROPOSED PROGRAM

2.1 PROPOSED PROGRAM

Regions IV and VI, the Gulf of Mexico Program Office and the natural resource agencies of the five Gulf States will combine efforts in the support of the development of a Joint Gulf States Coastal Monitoring Program. The development of this program will span a period of six years (1999-2004) with Year 1 consisting of one or more state pilot projects and a series of state and regional workshops to develop the specific attributes of a coordinated monitoring program for all five states. This coordinated program would be initiated in Year 2 and continue through 2004.

2.1.1 PROPOSED YEAR 1 PROGRAM

In1998, the Gulf of Mexico Program (GMP) invited members of EPA ORD's Gulf Ecology Division, EPA's Regions IV and VI, and senior management from the resource agencies for the Gulf States to discuss the possibility of a joint, comprehensive, and integrated coastal monitoring program. This briefing described the benefits and shortcomings of the 1991-1994 Louisianian Province Pilot conducted by EMAP, existing state programs, and proposed how these results could be used to design state-specific programs that would meet the needs of each of the Gulf states with regard to coastal monitoring information. The members committed their states to participation in the development in the proposed monitoring program and indicated their willingness to discuss the program further both through the GMP and individual workshops held in their states. Chapters 3 and 4 describe much of the information provided at this and subsequent meetings.

In Year 1 (1999), the Gulf of Mexico's Monitoring Subcommittee conducted three follow-up efforts to the above meetings. First, the Alabama Department of Environmental Management (ADEM) initiated pilot programs to demonstrate the utility of monitoring using probabilistic designs at the state-level and at specified sub-state level (Water Use Designation areas).

The second effort in Year 1 was for all five Gulf States to collect one, relatively simple, environmental indicator using a joint design and common methodology. This indicator was instantaneous dissolved oxygen concentration. A continuous measurement was added by Texas to complement the single instantaneous measure.

The final effort in Year 1 was to conduct six (6) workshops. The first workshop was sponsored by the Gulf of Mexico Program and it's purpose was the establishment of a set of protocols to guide each state in the collections desired for the comprehensive monitoring program in 2000. Many of these variables are discussed in Section 4.0. The outcome of this meeting delineated the states' participation in terms of organizational relationships, sponsoring of further workshops,

and EPA participation. The remaining five workshops were sponsored by individual state resource agencies for the purpose of developing a specific monitoring strategy to be used by that state in its participation in the Joint Gulf States Comprehensive Monitoring Program. These workshops were held during the period August-November and their results communicated by February 2000 in terms of monitoring plans to be implemented in 2000.

2.1.2 PROPOSED YEAR 2 PROGRAMS

Year 2 consists of two elements. The first will be a signing by senior representatives of each of the Gulf States' resource agencies of an agreement to participate in the Joint Gulf States Comprehensive Monitoring Program. The second effort will be the implementation of each state's proposed integrated monitoring plan. The results of these monitoring efforts will be "worked up" by each state and made available to GMP [GED will be available to aid any state needing assistance in making quantitative estimates from the data.]. GMP, through its association with GED, will combine the five states' results to estimate the ecological condition of Gulf of Mexico coastal resources. The statistical methods for this combination are discussed in Section 3.4. Years 3-5 would be represented by the continued annual implementation of each state's monitoring plan; however, the sampled resources may represent control systems not included in FY 2000 sampling. These additional resources might include coastal wetlands, beaches, or offshore coastal resources. Alternatively the FY 2001-2004 efforts may be focused to examine FY 2000 sites where specific problems were observed (e.g., hypoxia, eutrophication, and contamination).

2.2 PROGRAM COORDINATION

The ultimate goal of the joint Gulf States/GMP program is to combine efforts to monitor the condition of coastal resources on a regional scale without compromising assessment efforts at a state scale. Recognizing that knowledge of the condition of estuarine resources is as important locally as it is regionally, GMP and EMAP/Coastal 2000 have included representatives of state and local agencies on the GMP's Monitoring Subcommittee. This subcommittee has planned the comprehensive monitoring program, provided state and local agencies with briefings on the proposed monitoring program during the initial planning stages of the program, and conducted regional and state-wide workshops to incorporate the strong local and regional expertise into the planning and implementation processes. This interaction hopefully has resulted in the close cooperation of key elements from resources agencies in all five Gulf States and has directly involved these entities in the planning and implementation of a coordinated and comprehensive monitoring plan for Gulf of Mexico coastal resources. In addition, the planning of the monitoring program has included scientists with strong regional expertise and an ability to integrate the "core" GMP regional monitoring program with ongoing State monitoring and research efforts. This coordination has led to a greater amount of useful science, from the combined efforts, that can be used to enhance the region's and state's information monitoring programs for the successful management of their coastal resources.

The organizational structure for this Monitoring Subcommittee (MS) is shown in Figure 2-1. The purpose of the MS has been to develop a "strawman" for discussion with GMP and the Gulf States and to ensure, through workshops and specific briefings of key state managers, that these state agencies will agree to provide assistance with field sampling, sample processing, analysis and reporting of data for estuarine waters within their state jurisdictions. The MS has striven to get these agencies to participate in the implementation and execution of the monitoring plan. In particular, the MS has worked with the states to promote the standardization of sample collection, laboratory processing and analysis methods for all indicators collected as part of the joint monitoring effort and the establishment of a joint quality assurance program applicable to all activities. This subcommittee will also serve as the Implementation Working Group for the Coastal 2000 Program in the Gulf of Mexico region.

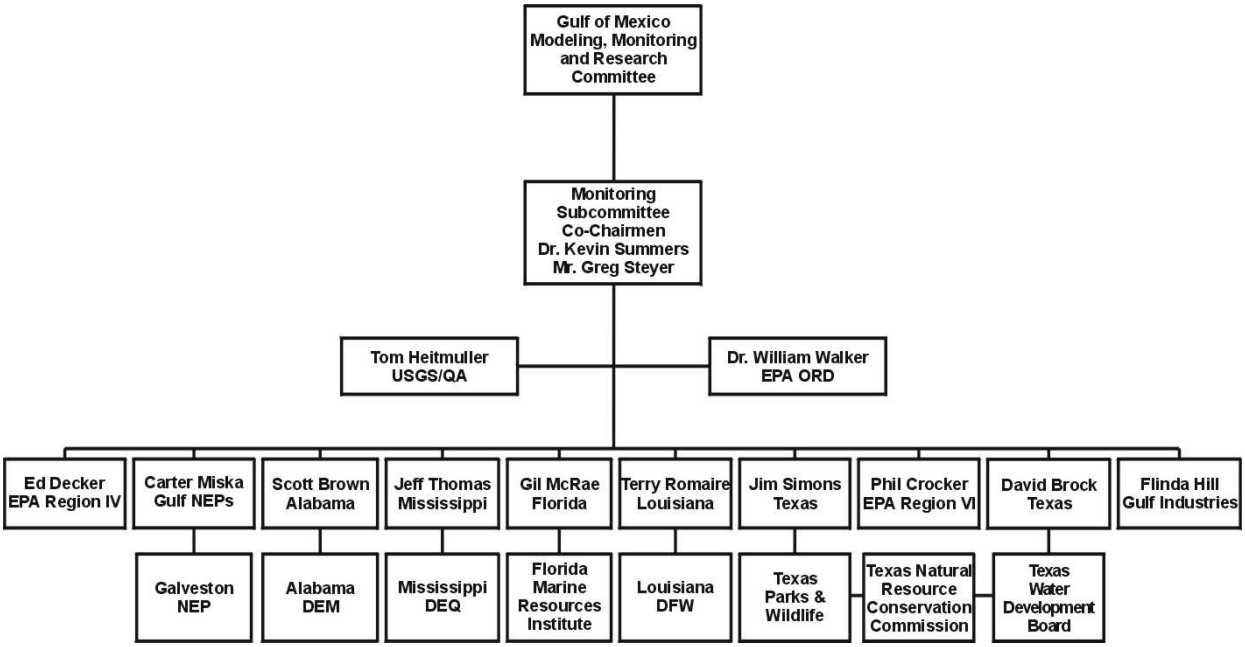

Figure 2-1. Organization of Monitoring Subcommittee to plan and execute the Joint Gulf States Monitoring Program and the relationship between MS and Gulf State Resource Agencies.

SECTION 3

SAMPLING DESIGN APPROACH

3.1 INTRODUCTION

Program objectives are a major factor that control the development of a sampling design for monitoring and assessment programs, including where and when samples are collected and what parameters are measured. In this chapter, the strategy and procedures used to determine when and where samples will be collected for the JGSMP are described. The approach takes two primary courses. The first alternative course is a comprehensive and consistent program jointly executed by the states in which all states participate and take part in coordinated data collection. The second course is in lieu of a coordinated state effort whereby the GMP sponsors the collection of data from representative sites throughout the Gulf of Mexico to estimate the long-term behavior of Gulf estuarine resources.

The initial "strawman" design for the JGSMP is similar to the approach of the EMAP-Estuaries' Louisianian Province Demonstration Project (1991-1994) and the upcoming Coastal 2000 Program. The major goals of the JGSMP are to: (1) obtain the data required to ascertain the present and changing status of the condition of the Gulf of Mexico coastal resources, and (2) develop associations among this changing condition and pertinent environmental stressors and anthropogenic uses of the estuarine environment. These goals correspond to those of the Coastal 2000 Program as well.

The JGSMP seeks to make unbiased estimates of the condition of coastal resources (i.e., to assess status) and to measure changes in condition (i.e., to measure trends) with known confidence at both the state and regional scale. The Program also seeks to identify factors affecting status and trends in the condition of coastal resources (i.e., identify associations). In order to accomplish these objectives, the JGSMP must collect data to:

- Measure the quantity, extent, and geographical distribution of each type of estuary of interest.
- Estimate the proportion of each type of estuarine resource of interest that is in acceptable condition.
- Estimate the proportion of each type of estuarine resource of interest that is in poor and/or marginal condition.
- Measure changes in condition for each type of estuarine resource of concern that occurs over time.

- Identify the factors that are associated with improving and/or declining condition.

3.1.1 DATA QUALITY OBJECTIVES

The JGSMP should seek to identify Data Quality Objectives (DQO) to ensure that the type, amount, and quality of data which are collected by the monitoring programs are adequate to meet program goals. The DQO process balances the costs of sample collection and processing against the uncertainty that users of the data are willing to accept in assessment results. This process results in an acceptable level of data quality and the establishment of standard quality control and quality assurance protocols that can be applied to ensure the specified levels of precision, accuracy, completeness, representativeness, and comparability are obtained.

The proposed DQOs for the JGSMP are not different from those of the original EMAP-Estuaries Program. However, these objectives must be evaluated by GMP and the individual states in order to ascertain that they meet the needs of these management entities. The Joint Program would have two DQOs; one for status and another for trend detection. These are:

- **Status**: Measure the proportion of estuarine area that is in poor or degraded condition for sampling populations of interest (see classification section) within ± 10% in any year.

- **Trends**: Detect a 2% per year monotonic trend in the percent estuarine area that is in poor or degraded condition for the region and estuarine classes of interest over a 10-year period with an α of 0.1 (probability of detecting a trend when one does not exist) and a β of 0.75 (probability of not detecting a trend when one in fact exists).

3.2 GENERAL SAMPLING SCHEME

The general sampling approach used by the JGSMP is proposed to consist of three elements:

- **A regionalization scheme** for partitioning estuarine resources in the Gulf of Mexico into regions of manageable proportions (e.g., states).

- **A classification scheme** for organizing estuaries within each regional unit (state) into populations of interest to facilitate the interpretation and use of the assessment results by the states.

- **A statistical sampling design** for collection of samples that represent ecological condition across the region and within the regional units/classes of estuaries selected in an unbiased and cost-effective manner.

3.2.1 REGIONALIZATION AND CLASSIFICATION

The regionalization scheme proposed for use by the JGSMP is simple and straightforward. All the estuarine resources of the Gulf of Mexico will be divided on the basis of state jurisdictions. Thus, consistent and coordinated sampling designs would be developed for each state's estuarine resources.

Estuarine resources along the Gulf coast vary in size, shape, and ecological characteristics. Previous efforts (e.g., Summers et al., 1993, Macauley et al. 1994) have used a classification system based on the physical size and shape of estuarine resources. Because estimates of condition will be based spatially on the state-scale, the classification of estuarine resources within a state will be determined by state needs given the constraints of a probabilistic design (e.g., minimum sample size per class). For example, Alabama has already adopted a probabilistic approach to monitoring its coastal resources and classified its waters on the basis of "use" categories in conjunction with Clean Water Act, Section 305(b) efforts. Because the regional estimates of condition will be based on the combination of the state estimates, the classification process can be extremely adaptable for each state's needs. The only requirement is that the state adopt a process whereby the minimum number of samples (about 50) will be taken in each year.

In the event that the states do not choose to participate in the coordinated program, a reduced sampling design that does not include any regionalization or classification will be used. This system will sample 50 sites throughout the Gulf of Mexico.

3.2.2 SAMPLING PERIOD

The time(s) of sampling will be determined by the GMP and the states involved in the Joint Monitoring Program. At a minimum, sampling will be limited to a confined portion of the year (i.e., an index period) when measured parameters are expected to show the greatest response to pollution stress and within-season variation is known to be relatively small. Based on earlier efforts, mid-summer was selected as the most appropriate index period because this is the time of year when dissolved oxygen concentrations most frequently approach stressful low levels, when dilution flows are relatively low, and physiological activity is high. Thus, the risks of exposure to contaminants in water and sediments that adversely affect the health of estuarine organisms and/or populations is highest.

3.3 PROPOSED SAMPLING DESIGNS FOR GULF-WIDE AND REGIONAL ASSESSMENTS

Two approaches are proposed for the Gulf-wide monitoring design:

(1) the use of a single design that is representative of the behavior of all estuarine systems in the Gulf of Mexico (to be employed if all five Gulf States do not participate in the

program), or

(2) the use of separate, yet consistent, designs for each of the Gulf States and the combination of these estimates to comprise a Gulf-wide estimate of condition.

3.3.1 GULF-WIDE, NON-STATE-SPECIFIC DESIGNS

The 1991-1994 EMAP-Estuaries Louisianian Province Demonstration provided information from approximately 300 individual estuarine systems throughout the Gulf. Using these data, cumulative distribution functions were created for about 100 separate ecological, chemical, or habitat indicators. Because the Gulf monitoring system cannot reasonably monitor 300 systems without significant state involvement, EMAP-Estuaries undertook an analysis to determine the minimum number of estuarine systems that could be sampled that would provide similar estimates of conditions to the Gulf-wide estimates. While the estimates of condition would be expected to be similar, the variability associated with the estimate would be considerably greater for the estimates based on the subset of estuarine systems.

These analyses resulted in the selection of 50 estuarine sites throughout the Gulf that when combined provided similar estimates of condition based on 40-50 sampling sites compared to EMAP-Estuaries original 450 sampling sites. The location of the 50 proposed sites is shown in Figure 3-1.

Using triangular grids based on center distances of 18 km, hexagonal spaces of 256 km^2 were creating throughout the Gulf estuarine systems. Randomly placing a single sampling location in each hexagon results in the total of 50 samples/year using the grid. The results of this proposed design are shown in Figure 3-1. Because all five Gulf states agreed to participate at a state level of design, the Gulf-wide design is unnecessary.

3.3.2 STATE-SPECIFIC DESIGNS

State-specific designs will be constructed based on interactions with state resource agencies. The only requirement for these designs is that they be probabilistic in nature and can permit combination of all state information to provide a regional assessment of Gulf of Mexico estuarine resources. Figure 3-2 through 3-6 provide preliminary designs for each of the five Gulf States. These designs are based on no stratification into classes with all resources being proportionally sampled according to areal extent. Each design can be revised based on the management and scientific needs of the individual states into a stratified random design structure.

Two examples of such design modifications are programs presently being implemented by the Alabama Department of Environmental Management (ADEM) and designed by Florida Marine Research Institute for implementation in 2000. ADEM decided in 1992 that the use of EMAP-like designs and indicators would provide Alabama with more useful information than it was

presently getting from its existing monitoring system. Discussions between EMAP-Estuaries and ADEM personnel revealed that although total estuarine resources in Alabama accounted for only about 1000 km^2, ADEM needed to characterize five distinct classes of estuarine waters. These classes included two areas within Mobile Bay, and single areas in Mississippi Sound, the Perdido Bay/Wolf Bay complex, and the Mobile Delta (Figure 3-3). The classes are based upon "use" designations used by Alabama for 305(b) reporting (Summers et al. 1998).

Florida Department of Environmental Protection has revamped its monitoring programs to include “Tier 1" probabilistic sampling of all state resources, including estuaries. The basic design is a dual stratification of the state into five Water Management Districts (WMDs) and the Districts into four reporting units based on 8-digit hydrologic codes (e.g. watersheds). A random reporting unit is sampled without replacement each year from each WMD for five years (with one reporting unit being sampled twice). The coastal estuarine resources associated with each reporting unit will be sampled concurrently by the Florida Marine Research Institute (FMRI) (Figure 3-2). All sampling is scheduled to commence in 2000. However, for the sake of the demonstration, FMRI will sample coastal sites in 1999 for at least dissolved oxygen concentration.

3.4 CUMULATIVE DISTRIBUTION FUNCTIONS

One of the principal means JGSMP will use to summarize the data which are collected is through the use of Cumulative Distribution Functions (CDFs). The CDF is an effective graphical tool for presenting information about the distribution of environmental indicators. In the paragraphs that follow, the details of how JGSMP will estimate CDFs and calculate variances for the estuaries in the region as a whole and for major classes of estuaries of interest are presented. These discussions involve the presentation of considerable amounts of detailed technical material (e.g., equations for estimation of variance).

Written as a function of the value of x of the variable of interest, the CDF F(x) is defined to be proportional to the area of the region or class of interest taking values less than or equal to x.

Typically the estimated CDF F(x) is a step function, with steps corresponding to each of the observed values of the variable. thus, all relevant information concerning the distribution of the data is retained by CDFs including central tendency, variability, and extremes. Furthermore, estimates of the proportion of a region have values less than or greater than some critical value can be easily computed.

The CDF may be estimated using the Horvitz-Thompson estimator

$$\hat{F}(x) = \frac{1}{A}\sum_{i=1}^{n} w_i y_i$$

where the sum is over all data points in the sample or stratum and A is the area of the region or class of interest (e.g., resources in a state). The variable y_i is taken to be equal to one if the data at the i-the sample site takes a value $\leq$ x, and is equal to zero otherwise. The weighting factor

$$w_i = \frac{1}{\pi_i}$$

where π_i is the inclusion probability for the ith sample site. Inclusion probabilities are determined from the specification of the sample design and may be regarded as objective criteria for defining the representativeness of each sample site.

The precision of the estimator $\hat{F}(x)$ at a particular point on a CDF is measured by its variance. Variance estimation depends on whether the particular estuarine resource is regarded as an extensive continuous resource, or a discrete resource. Estuaries are extensive resources whose infinite populations are comprised of all the locations of all possible locations within these systems. Here, an estimator for the variance of $\hat{F}(x)$ for estuaries using a common grid is given by:

$$\hat{V}_1(\hat{F}(x)) = \frac{1}{A^2}\left(\sum_{i=1}^{n} w_i^2 y_i^2 + \sum_{i=1}^{n}\sum_{\substack{j=1 \\ i \neq j}}^{n} (w_{iw_j} - w_{ij}) y_i y_j\right)$$

where the pairwise weight function

$$v_{ij} = \frac{1}{\pi_i}\pi$$

and π_{ij} is the pairwise inclusion probability that both sites **i** and **j** are included in the sample.

Small estuaries sampled using a list frame or state-specific estuarine resources sampled using multiple grids are discrete resources. The appropriate estimator for the variance of $\hat{F}(x)$ is given by:

$$\hat{V}_2=(\hat{F}(x))=\frac{1}{A^2}(\sum_{i=1}^{n} w_i(1-w_i)y_i^2+\sum_{i=1}^{n}\sum_{\substack{j=1\\ i\neq j}}^{n}(w_iw_j-w_{ij})y_iy_j).\pi_{ij}$$

Provided that the pairwise inclusion probabilities π_{ij} are strictly greater than zero for all pairs of potential sample sites (whether they are actually included in the sample or not), then both $\hat{V}_1$ and $\hat{V}_2$ are unbiased estimators of the variance of $\hat{F}(x)$ for their respective resources.

The precision of $\hat{F}(x)$ over a range of values of **x** may be assessed by calculating confidence bounds about the CDF. Whether one-sided or two-sided confidence bounds are computed depends on the questions being asked. A one-sided upper (or lower) confidence bound can be used to provide upper bounds on the percent of the region taking a value of the variable below (or above) a particular value. The 95% upper confidence bound for $\hat{F}(x)$ is given by:

$$\hat{F}(x)+1.645\sqrt{\hat{V}(\hat{F}(x))}.$$

Two sided confidence bounds may be used to compare CDFs computed from different strata, regions, years, or other classification variables. The two-sided 95% confidence bounds for $\hat{F}(x)$ are given by:

$$\hat{F}(x)\pm 1.96\sqrt{\hat{V}(\hat{F}(x))}.$$

Estimation of the CDF and its variance requires values for the inclusion probabilities π_{ij} and π_i, both of which depend on the specification of the sampling design. The following gives expressions for each of the three strata:

There are two sources of randomness for sampling based on the grid, the random starting position of the hexagonal tessellation and the random location of sample points within each hexagon. Let $|A|$ = the area of each hexagon in the tessellation. Then, the inclusion probabilities are given by:

$$\pi_{ij} = \frac{1}{|A_i|}; i = 1,...,n.$$

To compute pairwise inclusion probabilities, let A_i denote a regular hexagon of area 282 km^2 centered on the i-the sample point and having the same orientation as the hexagons produced by the tessellation. As shown by the shaded area of Figure 3-30, let $|A_i \cap A_j|$ denote the area of overlap between hexagons A_i and A_j. Then the pairwise inclusion probabilities are given by:

$$\pi_{ij} = \frac{|A| - |A_i \bigcap A_j|}{|A|^3}; i \neq j = 1,...,n.$$

Note that, if the distance between sample points i and j exceeds 18 km, then the two hexagons centered on them will not overlap. For such pairs of sites, pairwise inclusion probabilities are given by:

$$\pi_{ij} = \frac{1}{|A|^2}.$$

3.5 POWER OF THE PROPOSED DESIGN

As discussed in Section 3.1.1, the status DQO for the JGSMP is to estimate the percent of the estuarine area that has indicator values below (or above) some critical value for all estuaries in a region or an estuarine class of interest within ±10% with 90% confidence after four years. The DQO trends being detected are of a 2% per year monotonic trend in the percent of estuarine area for the region and estuarine classes of interest that is below (or above) the critical value over a 10 year period with an α of 0.1 and a β of 0.75. In this section, the power of the sampling design described above to meet these DQOs is evaluated.

3.5.1 POWER OF THE DESIGN TO MEASURE STATUS

Data for the Louisianian Province indicate that the confidence intervals (90%) associated with three years of data (1991-1993) for all of the indicators at the regional scale meet the status DQO. Because the scale of sampling and sampling effort proposed for the JGSMP is similar to that used in the Virginian and Louisianian Provinces, the proposed sampling design should be adequate to meet the status DQO.

3.5.2 POWER OF THE DESIGN TO MEASURE TRENDS

The power of $\alpha = 0.1$ two-sized *z*-test for detecting a temporal trend in selected indicators (i.e., bottom dissolved oxygen concentration, the benthic index, and concentrations of mercury, lead, and chlordane in surface sediments) was computed for large estuaries over the range of spatial and temporal variation observed in the Louisianian Province. These calculations assumed that 12 years of data were available. The *z*-test analyses suggest that the power of the design proposed to detect trends for large estuaries decreased as the scale (in kilometers) of spatial correlation in indicator values increased. For a fixed level of spatial correlation, minimum power to detect trends was observed when indicator values were strongly correlated at a temporal scale of 12 years. Based on the analyses, JGSMP trends DQO should be met provided that the scale of temporal correlation is not too close to 12 years and the scale of spatial correlation does not exceed 20 km.

The above described power analyses for large estuaries are based on the ability of the design to detect trends in the mean for the selected indicators. EMAP-E is, however, most interested in the power of the design to detect trends in the percent of estuarine area that takes on indicator values above or below some critical level. The EMAP-E program conducted analyses to assess the power of the sampling design used in the Louisianian Province to detect temporal trends in the percent of estuarine area having selected indicator values below (or above) some critical low value over a 12 year period. A linear regression and ordinary least squares methods was used for these analyses. All testing was conducted on an $\alpha = 0.10$ level of significance. The annual estimate of the percent of area below a predefined critical value was the response variable, and year was the explanatory variable. These analyses assumed: (1) 12 years of sampling, and (2) a 2% per-year increase in estimates of the percent degraded area for each indicator evaluated. The variance-covariance matrix of the twelve annual estimates for these analyses was not a diagonal matrix, but contained non-zero covariance terms related to interannual and spatial variation. Response variables were, therefore, not independent and identically distributed. The test statistic was the ratio of the area estimate to its standard error, with a critical region based on a standard normal distribution.

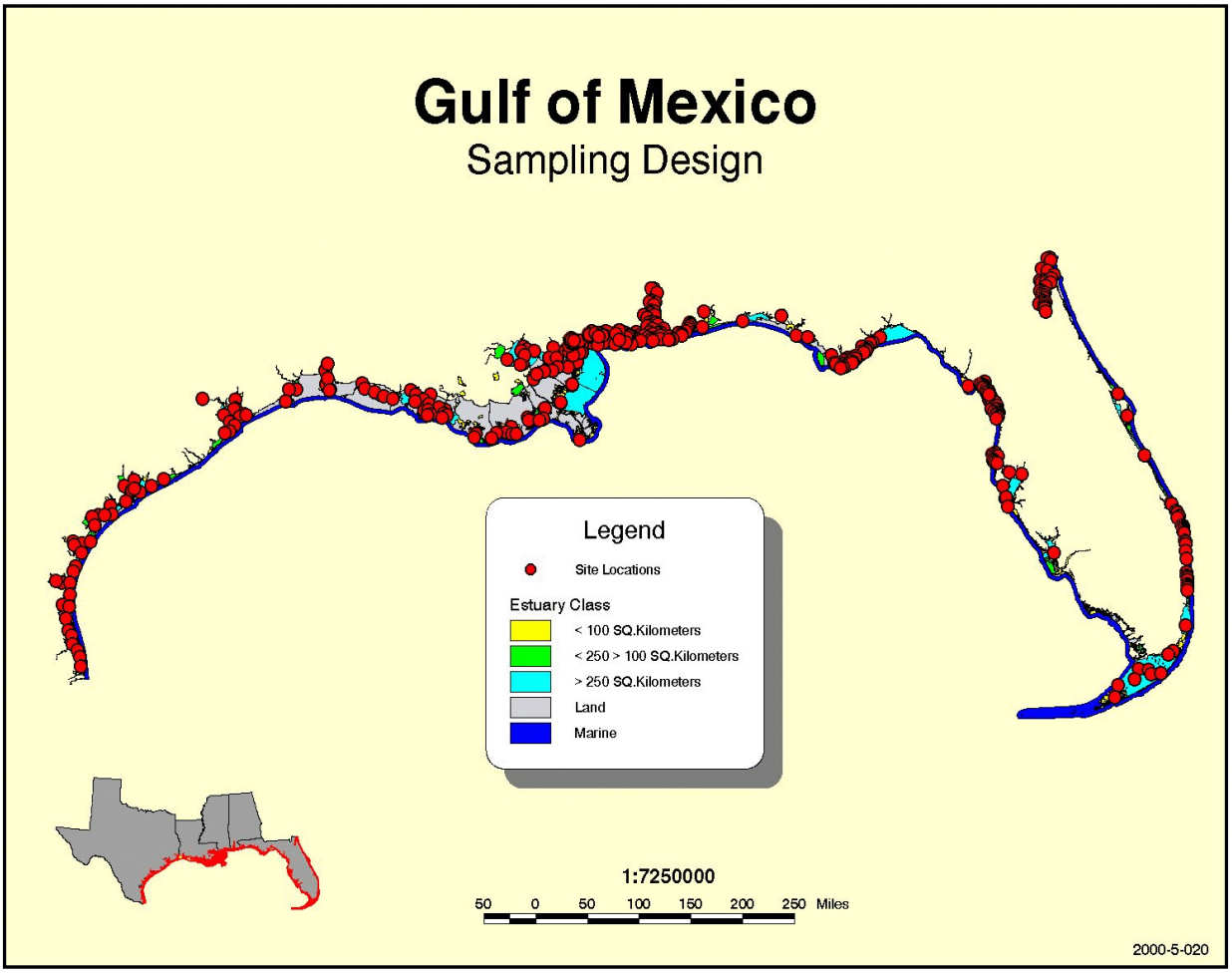

Figure 3-1. Probabilistic design for Gulf of Mexico-wide sampling for estuarine resources.

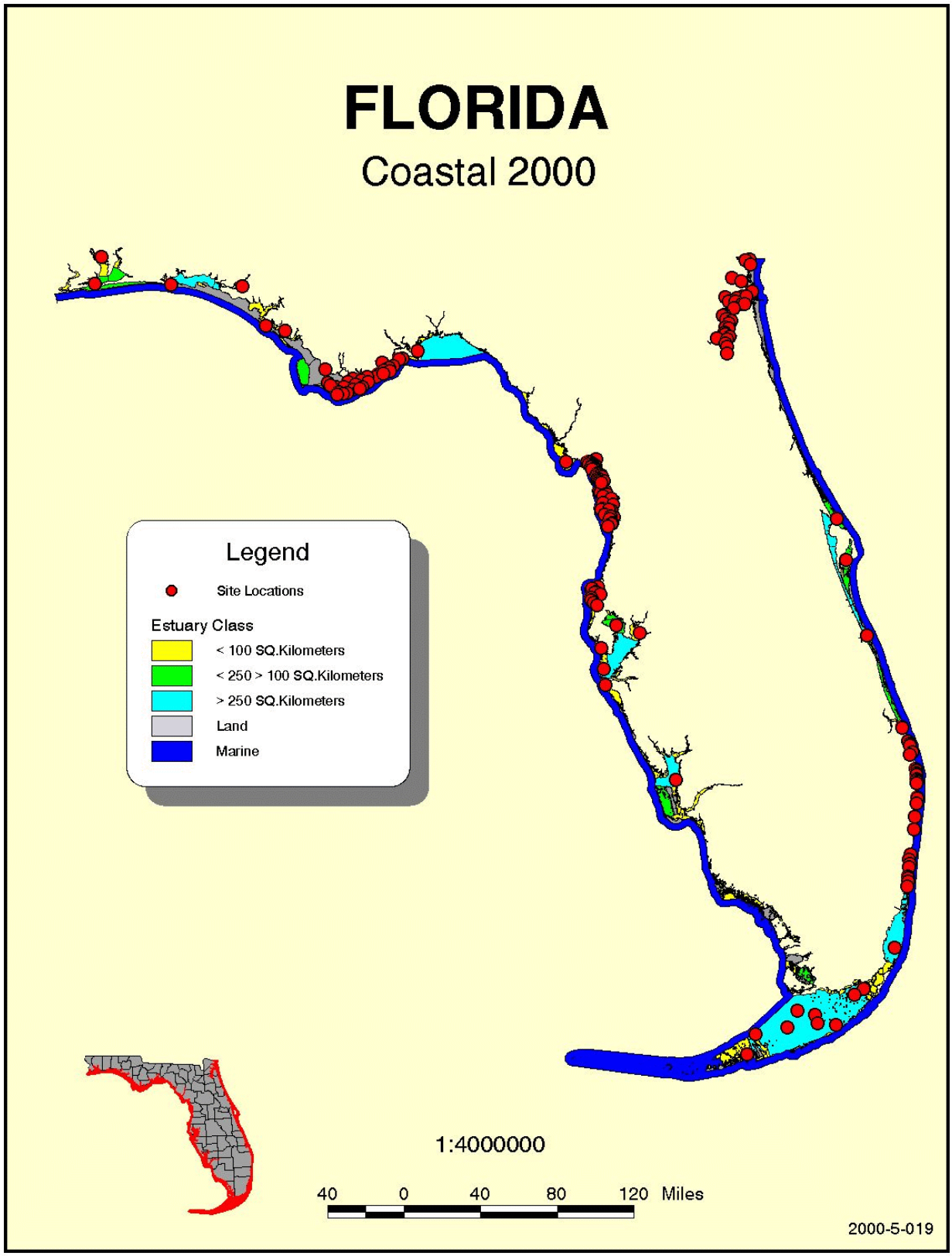

Figure 3-2. Probabilistic design for estuarine resources of Florida for 2000. Stratification based on state-wide monitoring plan by 8-digit hydrologic units.

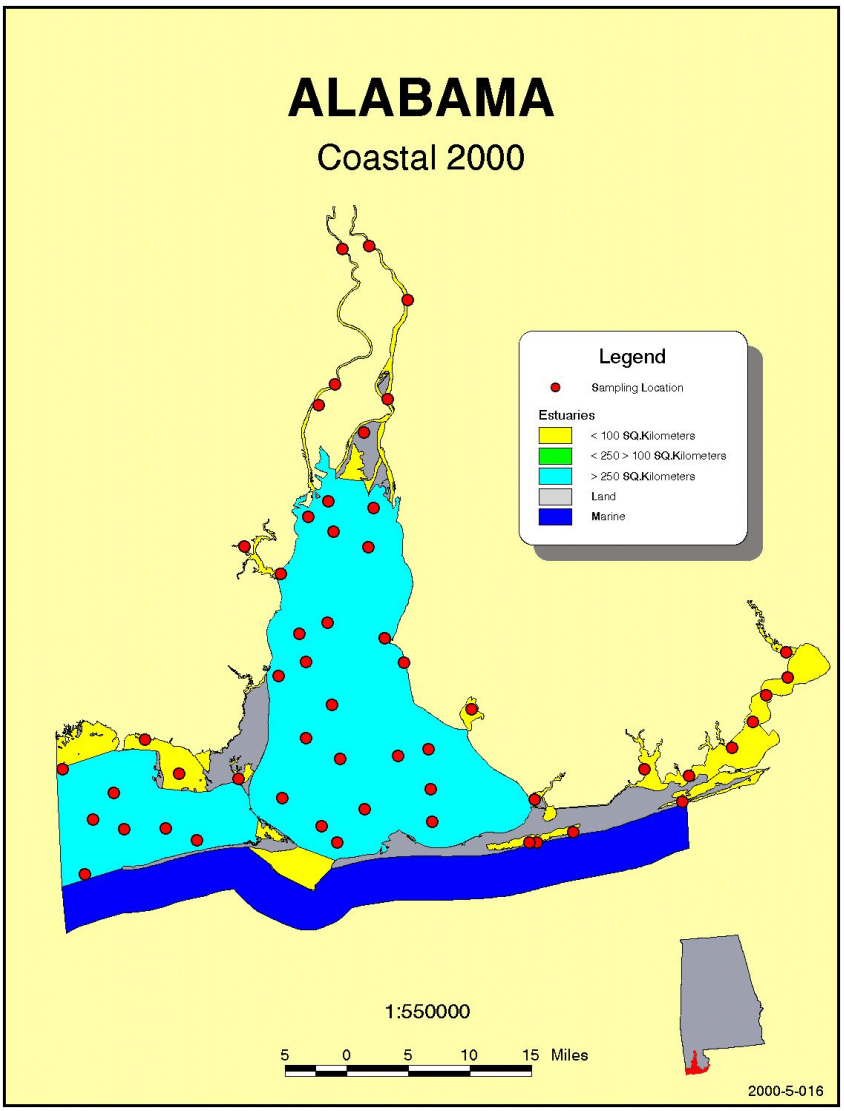

Figure 3-3. Probabilistic design for estuarine resources of Alabama for 2000. Stratification based on state-wide monitoring plan by water use classifications.

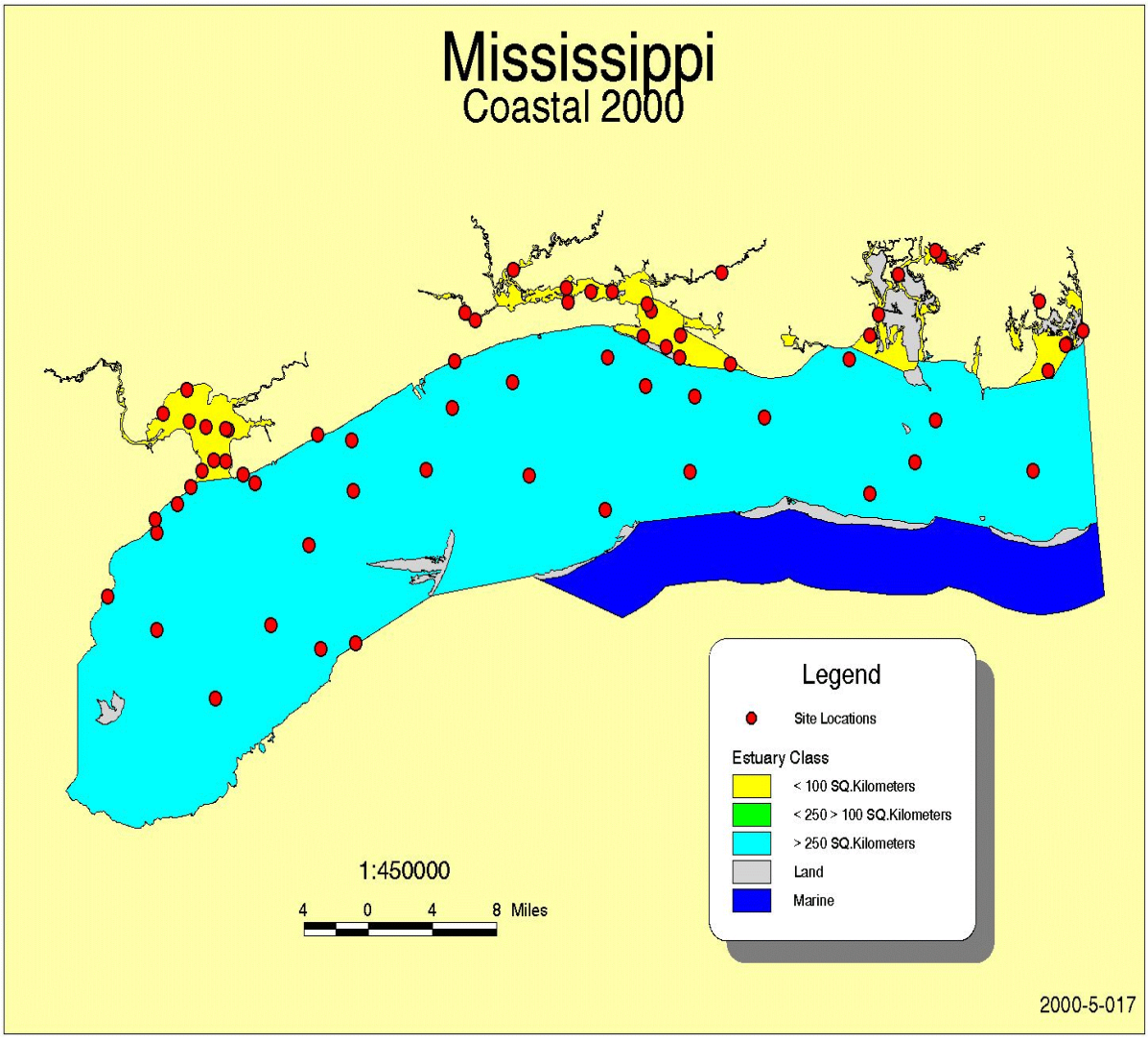

Figure 3-4. Probabilistic design for estuarine resources of Mississippi for 2000.

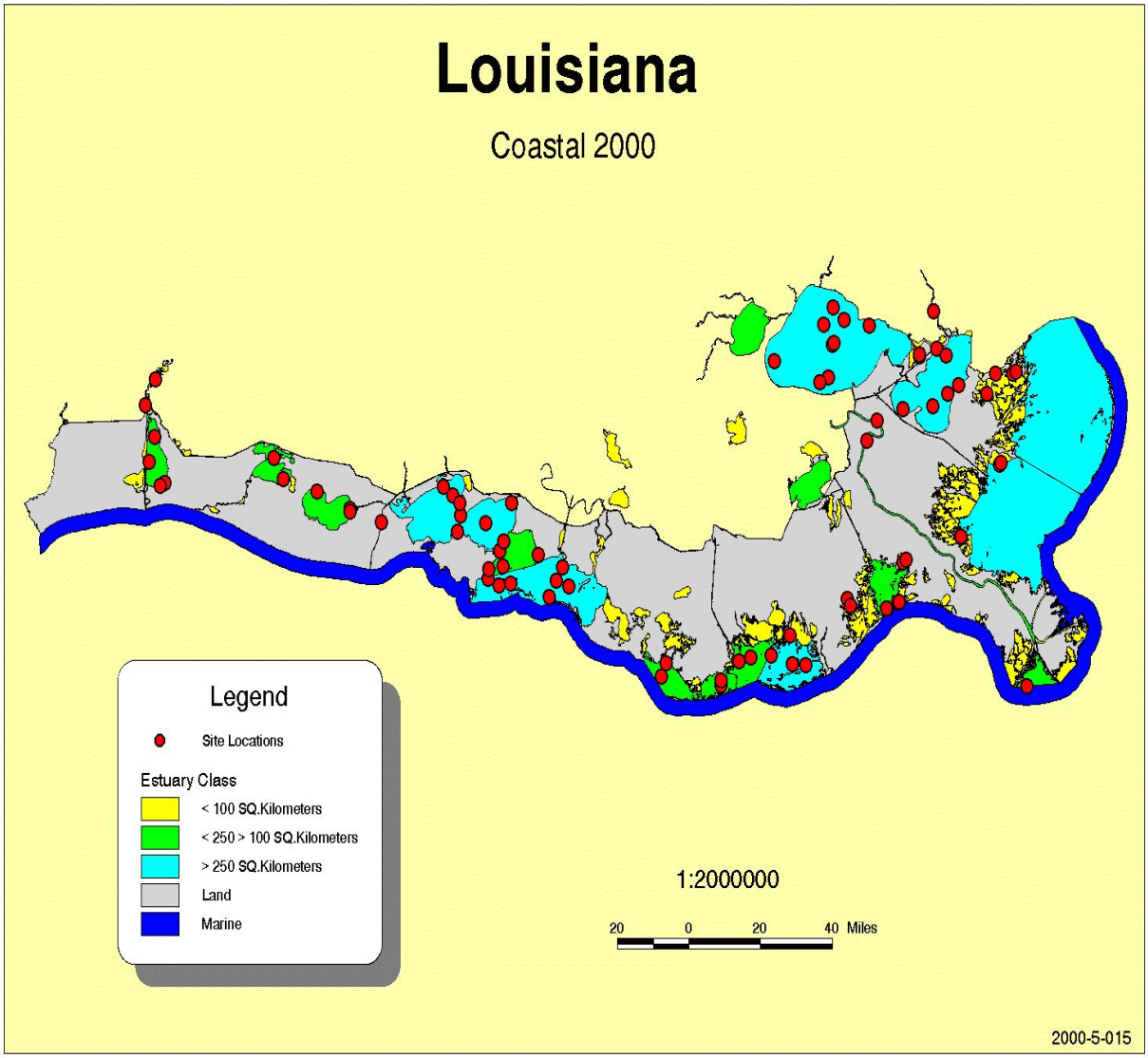

Figure 3-5. Probabilistic design for estuarine resources of Louisiana for 2000.

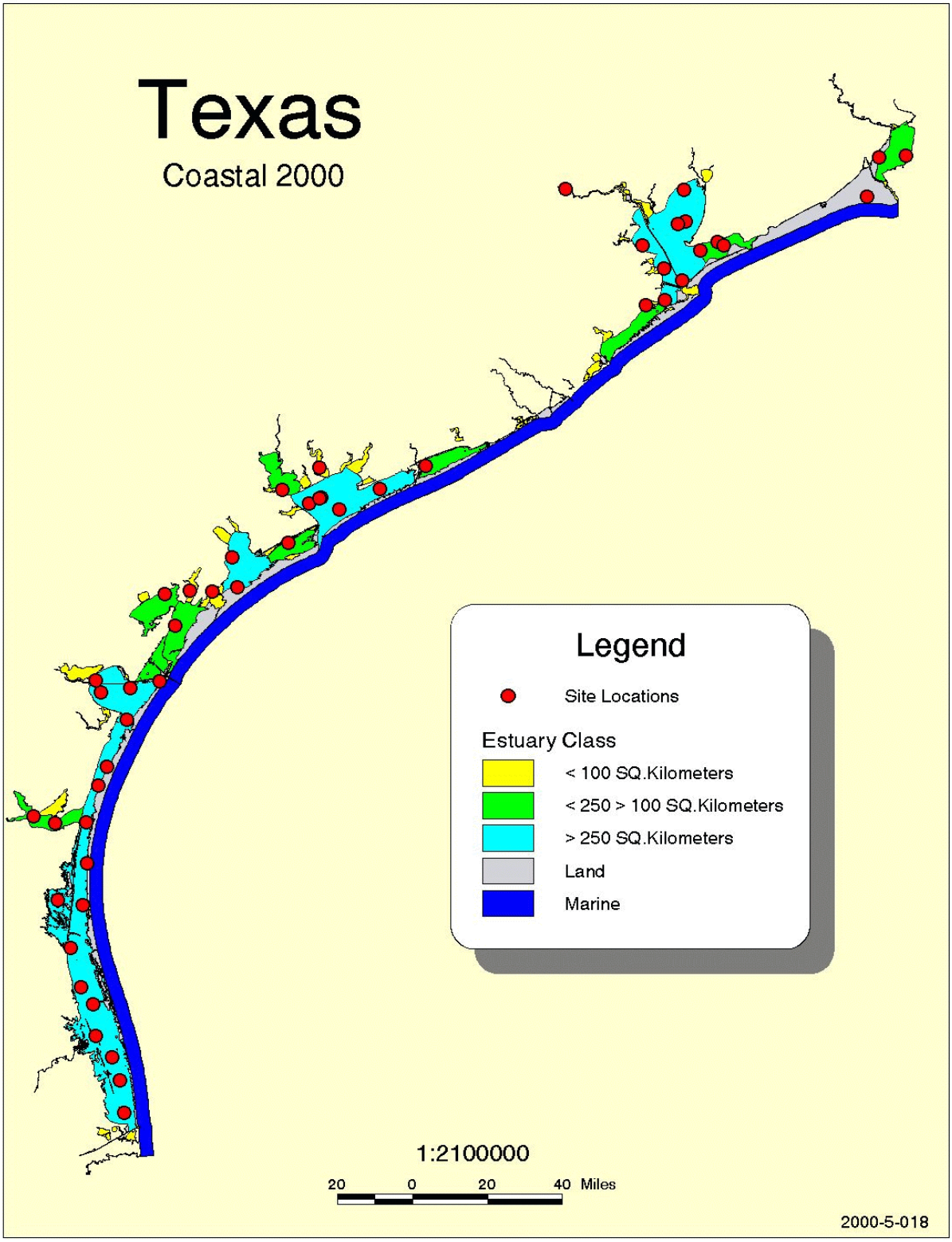

Figure 3-6. Probabilistic design for estuarine resources of Texas for 2000.

SECTION 4

INDICATOR DEVELOPMENT AND EVALUATION

4.1 INTRODUCTION

The process of developing ecological indicators for use in the Joint Gulf States Monitoring Program (JGSMP) has been based on the indicator framework previously developed in the Virginian and Louisianian Provinces. The JGSMP does not have the resources to monitor all ecological parameters of concern. Therefore, the limited resources available must be focused on system attributes that are of greatest concern ecologically and which best address program objectives. Indicator data should be comparable with those from other provinces and contribute to a national assessment of the environmental condition of estuarine resources.

Other goals of indicator development and assessment components are to extend the ability to discriminate between anthropogenic effects and natural variability, and to expand our interpretive power for identifying those systems that are showing signs of chronic or early stress. The mutual advantages of these efforts to address needs of other users (such as local or state management agencies) provide an impetus to collect data in a manner that will maximize the potential information. Results from the Virginian and Louisianian studies indicate that the present methodologies can be used to discriminate effectively between highly degraded and reference areas.

4.2 FRAMEWORK FOR INDICATOR SELECTION

Defined sets of efficient and effective parameters that serve as indicators of environmental quality are first developed. Indicators that are selected and developed should:

- Relate to ecological condition in a way that can be quantified and interpreted.
- Apply across a range of habitats.
- Be a concern of and valued by society.

Furthermore, indicators should possess the following attributes:

- Quantifiable in a standardized manner with a high degree of repeatability.
- Balanced sensitivity (that is, be sufficiently sensitive to enable identification of stressful conditions, but not hypersensitive to natural environmental variables or sampling methodologies).

- Methods that can be applied on a regional scale, incorporating local modifications.

- Balanced costs (minimal incremental costs but high insight value).

The selection of indicators is an ongoing process. The tiered model previously used for indicator selection strategy continues to be used as the operational model (Figure 4.1). In this model, candidate indicators that are consistent with the goals of the monitoring program are evaluated by research activities designed to determine their effectiveness at discriminating between degraded and reference environmental conditions. Those that are promising at the research level are then elevated to developmental status. At this state indicators are evaluated more critically with regard to the feasibility of regional-scale application and value of the data. Finally, those indicators that meet the criteria for regional-scale implementation, and that demonstrate significant power to discriminate between degraded and reference sites, are designated as core indicators. Only core and development indicators are proposed for the JGSMP.

Parameters that serve as indicators of ecological condition have been organized into various categories.

- **Biotic Condition Indicators.** Biotic condition indicators are characteristics of the environment that provide quantitative evidence of the status of ecological resources and biotic integrity. These measurements quantify the integrated response of ecological resources to individual and multiple stressors. Measurements related to this category are benthic community parameters, fish and shellfish community parameters, incidence of gross pathology or disease, and tissue concentrations of contaminants.

- **Exposure Indicators.** Exposure indicators provide measures of the magnitude and extent of pollution exposure. Measures of potential pollutant exposure include physical, chemical, and biological parameters that quantify pollution exposure, habitat degradation, or other causes of degraded ecological condition. Measurements related to this category include dissolved oxygen concentrations, sediment toxicity, and sediment contaminant concentrations.

- **Habitat Indicators.** Habitat indicators describe the physical and chemical conditions of sample sites, and provide basic information about the overall environmental setting. Examples include depth, salinity, temperature, sediment characteristics (such as grain size, percent water, percent silt/clays, total organic carbon), pH, water clarity, etc. Habitat indicators are frequently used to normalize exposure and response indicators across natural environmental gradients.

- **Stressor indicators.** Stressor indicators are economic, social, engineering, and landscape measures that can be used to estimate pollutant loadings to coastal waters and to identify their sources. Examples include land-use patterns, point-source discharge estimates, freshwater inflows, and pesticide use along a watershed. These parameters are not

measurable as part of the annual EMAP sampling efforts but represent data derived from other agencies.

Associations between biotic-condition indicators and exposure indicators serve to validate conclusions and increase the likelihood of appropriate site classification. Statistical analyses should be conducted to identify significant correlations between indicators. Significant correlations should not be used to imply causation, but can be used by researchers to develop and test hypotheses regarding causation. It is important that parameters from each category are measured so that a comprehensive characterization is used for site classification. Correct site classification is essential to the development of regional-scale assessments regarding the status of estuarine resource. The proposed indicators for JGSMP are listed in Table 4-1.

4.3 PROPOSED INDICATORS

The EMAP indicator strategy involves four types of ecological indicators: response, exposure, habitat, and stressor (Fig. 4-2). Response indicators are ecological characteristics that integrate the responses of living resources to specific or multiple pollutants and other stresses and are used by EMAP to assess overall estuarine condition. Exposure indicators quantify pollutant exposure and habitat degradation and will be used mainly to identify associations among stresses on the environment and degradation in response indicators. Habitat indicators provide basic information about the natural environmental setting and are used to normalize exposure and response indicators to natural environmental gradients. Stressor indicators are used to quantify pollution inputs or stresses and identify the probable sources of pollution exposure.

4.3.1 RESPONSE INDICATORS

4.3.1.1 BENTHOS

Benthic invertebrate assemblages are composed of diverse taxa with a variety of reproductive modes, feeding guilds, life history characteristics, and physiological tolerances to environmental conditions. As a result, benthic populations respond to changes in conditions, both natural and anthropogenic, in a variety of ways. Responses of some benthic organisms indicate changes in water quality while others indicate changes in sediment quality. Because most benthic organisms have limited mobility, they cannot avoid exposure to pollution stress as many other estuarine organisms can (e.g., fish). Benthic communities have proven to be a reasonable and effective indicator of the extent and magnitude of pollution impacts in estuarine environments when studied over extended time scales.

Benthic samples for measures of species composition, abundance, and biomass would be collected at all sampling sites. Samples are collected with a Young-modified Van Veen grab which samples a surface area of 440 cm^2. Three grabs are collected at each site. A small core (60cc) is taken from each grab for sediment characterization. The remaining sample was sieved through a 0.5 mm screen using a backwash technique that minimizes damage to soft-bodied

animals. Samples are preserved in 10% formalin-rose bengal solution and stored for at least 30 days prior to processing.

In the laboratory, macrobenthos are transferred from formalin to an ethanol solution and sorted, identified to lowest practical taxonomic level, and counted.

4.3.1.2 FISH

There are several advantages to using fish as a potential indicator of estuarine condition. Because of their longevity and dominant position at the upper end of the estuarine food web, fish responses can integrate many short-term and small-scale environmental perturbations. Fish are known to respond to most environmental problems of concern in estuaries, including eutrophication, habitat modification, and pathogenic or toxic contamination. However, fish indicators like community composition may vary seasonally and be difficult to evaluate using specific gears.

Fish are collected by trawling with a 16-ft., high-rise otter trawl with 2.5-cm mesh cod end. The net is towed for 10 minutes against the tide (if significant tidal current existed) between 0.7 and 1.0 m/s. All fish caught up in the trawl are identified to species and counted; up to 30 individuals of each species from each collection are measured to the nearest millimeter.

Up to 10 individuals are retained from each trawl for tissue analysis. The specimens are labeled, frozen on dry ice, packaged and shipped to the laboratory where they are stored, frozen, for subsequent tissue contaminant analysis for the contaminants listed in Table 4-2. Based upon historical frequency of catch in each state, composites of individuals will be selected for contaminant analysis.

At all stations where fish are collected, all individuals are inspected for gross external pathological disorders. This inspection includes checking body surface and fins for skin discoloration, raised scales, white or black spots, ulcers, fin erosion, lumps or growths, parasites, and opercular deformity; the branchial chamber for gill discoloration, erosion, deformity, parasites, and lumps and growths; the buccal cavity for hemorrhages, parasites, and lumps or growths; the overall morphology of the fish for skeletal malformations; and condition of the eyes. Specimens with observed gross pathologies will be preserved in Dietrich's solution for laboratory verification and histological examination.

4.3.1.3 CHLOROPHYLL a

The biota often most rapidly responding to changes in water quality are plankton - phytoplankton and zooplankton. Chlorophyll a is an accepted surrogate measure of phytoplankton communities and an expected response to increases in nutrient concentrations and decreases in total sediment concentrations (if sufficient nutrients are available). Chlorophyll a measurements will be taken in conjunction with dissolved oxygen concentrations to assess ecosystem condition associated

with coastal eutrophication.

Concentration of chlorophyll and phaeophyton will be measured from a water sample collected at all locations. The sample taken at surface, mid-water and bottom depths using any common water collector (Niskan bottle, Go-Flo bottle, pump) and filtered through a 25 mm GFF filter. The filter will be frozen in the field and returned to the laboratory for chlorophyll determination. Concentrations of chlorophyll and phaeophyton will be measured using a methanol extraction with subsequent measurement using a flourometer.

4.3.2 EXPOSURE INDICATORS

4.3.2.1 SEDIMENT CHARACTERIZATION

The physical characteristics of estuarine sediments (e.g., grain size, silt-clay content) and certain chemical aspects of sediments (e.g., total organic carbon (TOC) content) influence the distribution of benthic fauna and the accumulation of contaminants in sediments. Sediment grain size and silt-clay content are collected to help interpret the response indicators and sediment contaminant accumulations. TOC is collected not only as an interpretive aid but also as potential covariate for toxic contaminant accumulation.

A subsample from each of the benthic and sediment contaminant grabs will be retained to determine these sediment characteristics. Samples will be shipped, on ice, to the appropriate processing laboratory. Samples for the determination of silt-clay content and grain size distribution will be sieved using a 63μm mesh sieve. Both the filtrate and the fraction retained on the sieve are dried in an oven at 60 C and weighed to calculate the proportion of silts and clays in the sample.

TOC will be determined for each site by drying a minimum of 5 g wet weight of sediment for 48 hours. Weighed subsamples are ground to fine consistency and acidified to remove sources of inorganic carbon (e.g., shell fragments). The acidified sample is ignited in a furnace at approximately 950^{o} C and the carbon dioxide evolved is measured with an infrared gas analyzer. These peaks are converted to TOC.

4.3.2.2 SEDIMENT CONTAMINANTS

Metals, organic chemicals, and fine-grained sediments entering estuaries from freshwater inflows, point sources of pollution, and various non-point sources including atmospheric deposition, generally are retained within estuaries and accumulate in the sediments. Sediment samples for contaminant analysis will be collected from all sites. Samples will be collected from a homogenate created during sampling by combining the top 2 cm of sediment from 6-10 sediment gabs. The sediment is placed in clean glass jars with foil lid liners, shipped on ice, and stored frozen in the laboratory prior to analysis for organic contaminants. In addition, a subsample is taken from the same homogenate and is placed in a plastic bag, shipped on ice, and will be stored frozen in the laboratory for subsequent analysis for metals. The sediments will be

analyzed for the suite of contaminants determined during the Louisianian Province Demonstration (e.g., alkanes, Table 4-3) and will be analyzed using the methods in Table 4-4.

4.3.2.3 SEDIMENT TOXICITY

Sediment toxicity testing is the most direct measure available for determining the toxicity of contaminants in sediments to sensitive indigenous biota. It improves upon direct measurement of sediment contaminants because many contaminants are tightly bound to sediment particles or are chemically complexed and, therefore, are not biologically available. Sediment toxicity testing cannot be used to replace direct measurement of the concentrations of contaminants in sediment because such measurements are an important part of interpreting the results of toxicity tests.

Sediment for the toxicity test will be collected using a Young-modified Van Veen grab used for benthic invertebrate sampling. The top 2 cm of 6-10 grabs will be placed in a mixing bowl and homogenized. Care will be taken to avoid collecting sediment adjacent to the edges of the collection device and the mixing bowl is stored on ice between grabs to control temperature and avoid extraneous contamination. After approximately 3,000 ml of sediment are collected and completely homogenized, the sediment is distributed among containers for sediment toxicity testing, sediment chemistry, and sediment characterization.

Toxicity tests will be performed using the composite sediment samples from each station. Tests are conducted using the standard 10-day acute test method and the tube-dwelling amphipod *Ampelisca abdita*. Because of the difficulty in obtaining this amphipod (i.e., its abundance in the Gulf region is low an and it is not culturable), standard 4-day acute tests using the mysid, *Mysidopsis bahia*, will also be conducted. Five replicate tests are completed for each site. The bioassays is completed under static conditions for 4 or 10 days at 20^{o} C and 30 ppt.

4.3.2.4 DISSOLVED OXYGEN

Dissolved oxygen (DO) is important because adequate levels are a fundamental requirement for maintenance of populations of benthos, fish, shellfish, and other estuarine biota. DO concentrations are affected by environmental stresses, such as point and nonpoint discharges of nutrients or oxygen-demanding materials (e.g., particulates, dissolved organic matter). In addition, stresses that occur in conjunction with low DO concentrations may be even more detrimental to biota (e.g., exposure to hydrogen sulfide, decreased resistance to disease and contaminants). DO levels are highly variable over time, fluctuating widely due to tidal action, wind stress, and biological activity. One of the objectives of the 1991 Louisianian Province Demonstration was to collect regional data to best represent the DO conditions in the estuaries of the province.

In a pilot study to evaluate the best sampling strategy for DO in Gulf estuaries, continuous meters that measured DO, percent DO saturation, salinity, temperature, water depth, and pH were deployed at eight locations over a 4-month period. Monte Carlo analysis of the eight 4-month records showed that tidal influences during summer months were small and that day-night

differences accounted for most of the observed variability with wind stress accounting for most event-oriented phenomena. These analyses revealed that 1, 2, or 3 random instantaneous measures of DO were likely to misclassify a station with unacceptable DO conditions (i.e., DO < 2 ppm for > 20% of time period) as acceptable at a rate of 60-70%. Furthermore, short-term continuous measures of 24, 48, and 72 hours also tended to misclassify unacceptable sites although not as often as instantaneous DO measures (i.e., 50%). However, the use of the minimum DO concentration observed in a randomly selected 24-hour period coupled with the mean nighttime DO concentration, and the concentration at dawn produced a predictor of DO conditions that was correct for 95% of the Monte Carlo trials. As a result, both continuous 24-hour and instantaneous measures were selected to be measured at all Louisianian Province sites.

Dissolved oxygen will be sampled as point-in-time water column profiles. A Hydrolab Surveyor 2 equipped with a DO electrode is proposed to make the instantaneous measurements. In addition to DO, the Surveyor 2 measures salinity, temperature, depth, and pH. This instrument will be calibrated daily using known solutions. Vertical profiles of the water column at meter intervals from surface to bottom will be taken at all sites.

4.3.2.5 NUTRIENTS

The inflow of nutrients from point and non-point sources into aquatic systems is considered one of the major environmental problems of today. The confluence of riverine ecosystems at the heads of estuarine resources can concentrate nutrient flows into coastal ecosystems. Nutrient additions are considered to be the primary cause of coastal eutrophication and can also cause subtle changes in benthic and fish communities.

Concentration of the inorganic nutrients – ammonium, nitrate, nitrite, and phosphate, as well as total nitrogen and total phosphorus will be measured from a water sample collected at all locations. The sample taken at surface, mid-water and bottom depths using any common water collector (Niskan bottle, Go-Flo bottle, pump) and filtered through a 25 mm GFF filter. The filtrate of these samples will be frozen in the field and shipped to the laboratory for determinations of the concentrations of each of the nutrients.

4.3.3 HUMAN USE

Aesthetic appeal is an important factor in the public's perception of the suitability of an estuary for human use. The presence of trash in the water and the clarity of the water are primary visual methods by which the public assesses the aesthetic quality of an estuary. In addition, published information concerning the level of toxic contaminants in indicator species or directly in the edible portions of commercial and recreational fish are an important factor in whether the public views an estuarine water body as useable for human activities.

4.3.3.1 MARINE DEBRIS

The kinds and amounts of floating and submerged (i.e., collected in otter trawls and oyster dredge) marine debris will be noted at all stations. Debris will be categorized as paper, plastics, metal, glass, wood, and other wastes. Only debris of anthropogenic origin is included. Wastes that are comprised of composited materials (e.g., dining room chair that was metal, wood, and plastic) will be categorized based on their dominant material.

4.3.3.2 WATER CLARITY

Water clarity is measured using a LICOR™ LI-1000 containing a submersible light sensor. Underwater readings at 1 m increments are measured simultaneously with ambient surface measurements. The ratio of these two measurements provides the proportion of surface light reaching the ascribed depth. In order to standardize this measure, measurements at 1 m depth (available from all sites) are used to assess the general water clarity throughout the province.

Indicator Type	Indicator
Biotic Condition (Response)	
	Benthic Community Composition
	Benthic Abundance
	Benthic Biomass
	Fish Community Composition
	Fish Lengths
	Pathology in Fish
	Acreage of Submerged Aquatic Vegetation
	Dissolved Oxygen Concentration
	Chlorophyll Concentration
Abiotic Condition (Exposure)	
	Sediment Contaminants
	Sediment Toxicity
	Percent Light Transmittance
	Salinity
	Temperature
	Percent Silt-Clay
	pH
	Water Depth
	Contaminants in Fish and Shellfish
	Nutrient Concentrations

Table 4-1. Ecological indicators proposed.

Alkanes and Isoprenoid

C10	C15	Phytane	C23	C27	C31
C11	C16	C19	C24	C28	C32
C12	C17	C20	C25	C29	C33
C13	Pristane	C21	C26	C30	C34
C14	C18	C22			

Polyaromatic Hydrocarbons (PAHs)

Acenaphthene	Benzo(e)pyrene	2-methylnaphthalene
Acenaphthylene	Biphenyl	1-methylnaphthalene
Anthracene	Chrysene	1-methylphenanthrene
Benz(a)anthracene	Dibenz(a,b)anthracene	Naphthalene
Benzo(b)fluoranthene	2,6-dimethylnaphthalene	Perylene
Benzo(k)fluoranthene	Fluoranthene	Phenanthrene
Benzo(g,h,i)perylene	Fluorene	Pyrene
Benzo(a)pyrene	Ideno(1,2,3-c,d)pyrene	2,3,5-Trimethylnaphthalene

DDT and Its metabolites	
o,p'-DDD	p,p'-DDE
p,p'-DDD	o,p'-DDT
o,p'-DDE	p,p'-DDT

Chlorinated pesticides other than DDT

Aldrin	Heptachlor
Alpha-Chlordane	Heptachlor epoxide
Trans-Nonachlor	Hexachlorobenzene
Endrin	Lindane (gamma-BHC)
Endosulfan	Mirex
Dieldrin	Toxaphene

Major Elements

Aluminum
Iron
Manganese

Trace Elements

Antimony	Mercury
Arsenic	Nickel
Cadmium	Selenium
Chromium	Silver
Copper	Tin
Lead	Zinc

PCB Congeners:

PCB No.	Compound Name
8	2,4'-dichlorobiphenyl
18	2,2',5-trichlorobiphenyl
28	2,4,4'-trichlorobiphenyl
44	2,2',3,5'-tetrachlorobiphenyl
52	2,2'5,5'-tetrachlorobiphenyl
66	2,3',4,4'-tetrachlorobiphenyl
101	2,2',4,5,5'-pentachlorobiphenyl
105	2,3,3',4,4'-pentachlorobiphenyl
110/77	2,3,3',4',6-pentachlorobiphenyl/3,3',4,4'--tetrachlorobiphenyl
118	2,3'4,4',5-pentachlorobiphenyl
126	3,3',4,4',5-pentachlorobiphenyl
128	2,2',3,3',4,4'-hexachlorobiphenyl
138	2,2',3,4,4',5'-hexachlorobiphenyl
153	2,2',3,4,4',5'-hexachlorobiphenyl
170	2,2',4,4',5,5'-hexachlorobiphenyl
180	2,2',3,3',4,4',5-heptachlorobiphenyl
187	2,2',3,4,4',5,5'-heptachlorobiphenyl
195	2,2',3,3',4,4',5,6-octachlorobiphenyl
206	2,2',3,3',4,4',5,5',6-nonachlorobiphenyl
209	decachlorobiphenyl

Organophosphate Pesticides

Dicofol
Carbofenthion
Chloropyrifos
Diazinon
Disulfoton
Ethion
Fenvalerate
Oxyfluofen
Terbufos

Table 4-2. Analytical measurements for sediment samples and fish and shellfish tissue.

Compounds	Method
Inorganics:	
Ag, Al, Cr, Cu, Fe, Mn, Ni, Pb, Zn	Total digestion using HF/HN03 (open vessel hot plate) followed by inductively coupled plasma-atomic emission spectrometry (ICP-AES) analysis.
As, Cd, Sb, Se, Sn	Microwave digestion using HN03/HCI followed by graphite furnace atomic absorption (GFAA) analysis.
Hg	Cold vapor atomic absorption spectrometry
Organics:	
Extraction/Cleanup	Soxhlet extraction, extract drying using sodium sulfate, extract concentration using Kudema-Danish apparatus, removal of elemental sulfur with activated copper, removal or organic interferents with GPC and/or alumina.
PAH measurement	Gas chromatography/mass spectrometry (GC/MS)
PCB/pesticide	Gas chromatography/electron capture detection (GC/ECD) with second column confirmation.

Table 4-3. Analytical methods proposed.

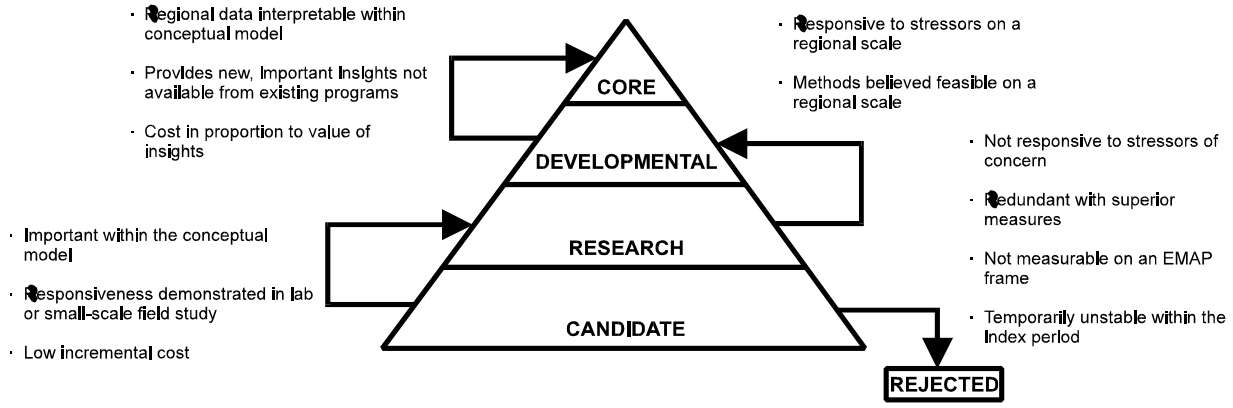

Figure 4-1. Model of evaluation criteria for indicator selection strategy (from Summers et al. 1990).

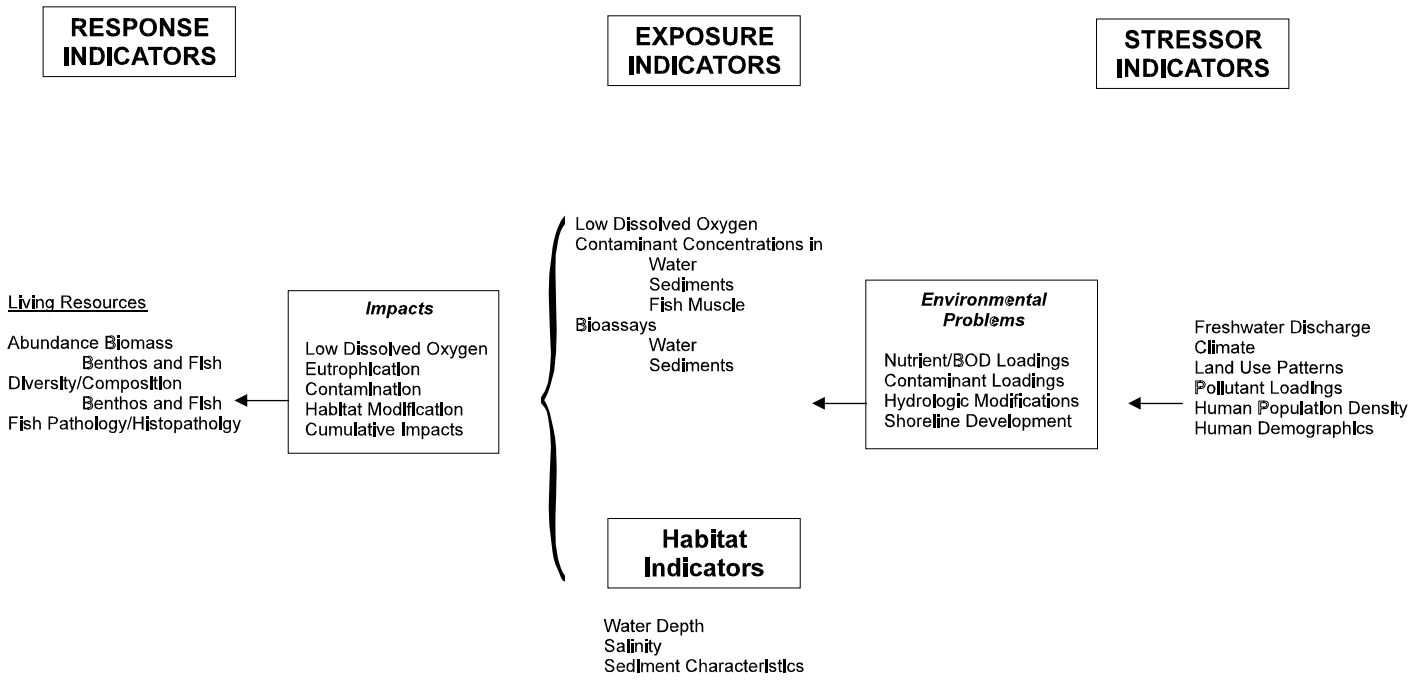

Figure 4-2. Overview of the EMAP indicator strategy giving examples of the types of indicators used to assess estuarine status.

SECTION 5

MANAGEMENT PLANS AND WORKSHOPS

In 1998, the Gulf of Mexico Program (GMP) appointed a Monitoring Subcommittee as part of its Modeling, Monitoring and Research Committee to develop a consistent, comprehensive (regarding contaminants), and coordinated monitoring program for the coastal resources of the Gulf of Mexico as well as to provide advice and assistance regarding monitoring issues. This subcommittee is comprised of members interested in monitoring the condition of estuarine resources in each of the Gulf States and key federal agencies, as well as being interested in developing a coordinated system to augment the existing state monitoring programs.

The organization of this subcommittee is shown in Figure 5-1. It is the intent of the working group to utilize the successes of the EMAP-Estuaries Program as a starting point and adapt that approach, in concert with state resource agencies, into a coordinated Joint Gulf States Monitoring Program (JGSMP). This coordinated effort would permit the combination of site-specific data collected in each of the Gulf States in order to assess the overall condition of resources across the Gulf of Mexico. This document represents the development of a framework for action for the creation of such a program.

The first step in the program's reaction, beyond the development of this framework, is the use of workshops to introduce the approach to sampling design and indicator selection to the GMP and each of the five Gulf states. The objective of these workshops is to develop an implementation monitoring framework acceptable to the Gulf States that will emphasize and coordinate existing monitoring activities, identify gaps, promote the use of common methods, and focus on the nearshore environment.

Four workshops are proposed between the period July 1999 and January 2000. The first workshop presented the monitoring framework and all indicators for 2000 implementation to key representatives of the five Gulf States, the GMP, and EPA Regions IV and VI. The purpose of this workshop was to receive rapid feedback on the proposed framework and its impact on the present monitoring efforts employed by the Gulf States. This workshop was conducted in late summer in 1999.

The next three workshops would be conducted between September 1999 and January 2000. One workshop would be conducted in each of the remaining Gulf States not using probabilistic sampling (Mississippi, Louisiana and Texas) to explore in detail the potential for implementation, roadblocks to consistent implementation, special difficulties with selected indicators and methods, and the compromises that will be necessary to ensure geographic consistency. The composition of these workshops were determined by that State's representation to the Monitoring Subcommittee.

In early 2000, all States will attend a GMP-sponsored workshop to finalize the plans for a coordinated and consistent program. The objective of this workshop would be a decision by the key representatives of all five states to sign a monitoring consistency pledge (Memorandum of Understanding) to implement the JGSMP. The ceremony will be conducted at the 2000 Gulf of Mexico Symposium re-enacting the signing agreement by each of the States to coordinate their monitoring efforts in a consistent and comprehensive manner.

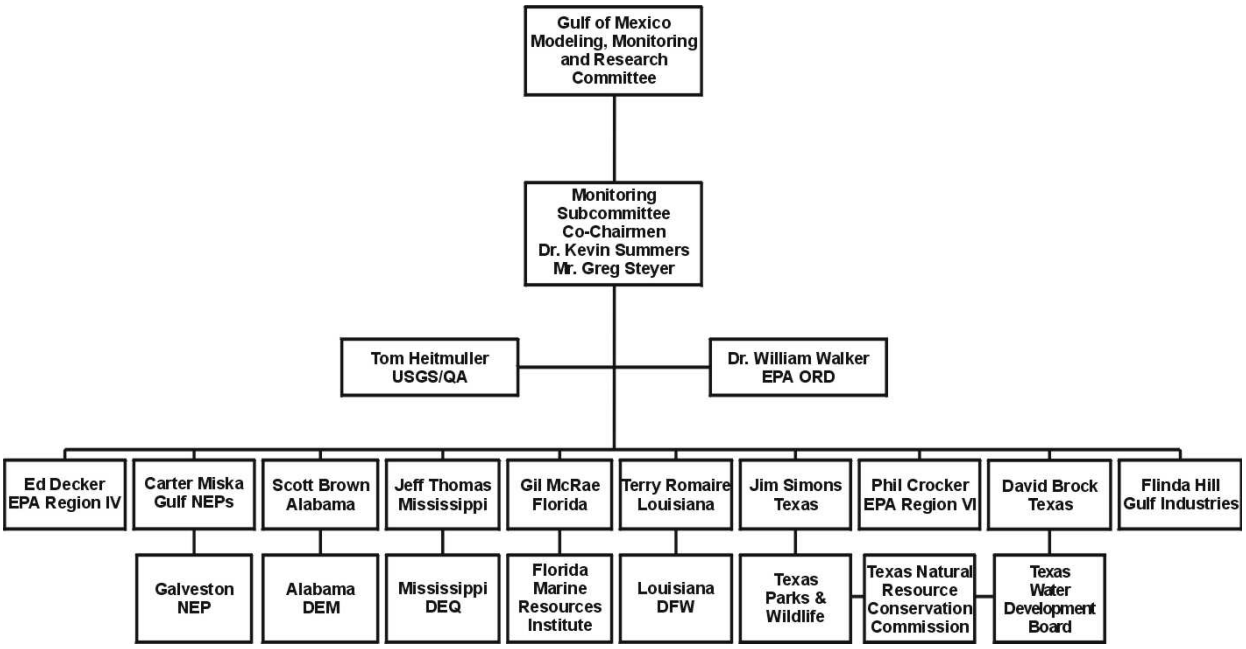

Figure 5-1. Organization of Monitoring Subcommittee to plan Joint Gulf States Monitoring Program and relationship between the Subcommittee and Gulf States Resource Agencies.

SECTION 6

BIBLIOGRAPHY

Heimbuch, D.G., S.J. Schwager, H.T. Wilson, and J.K. Summers. 1998. Power analysis for tests for long term trend in environmental conditions of estuaries. Environmental and Ecological Statistics 5:65-80.

Macauley, J.M., J.K. Summers and V.D. Engle. 1999. Estimating the ecological condition of the estuaries of the Gulf of Mexico. Environmental Monitoring and Assessment.

Macauley, J.M., J.K. Summers, V.D. Engle, P.T. Heitmuller, G.T. Brooks, M. Babikow, and A.M. Adams. 1994. Statistical Summary - EMAP-Estuaries Louisianian Province - 1992. EPA/620/R-94/002.

Summers, J.K., J.M. Macauley, P.T. Heitmuller, V.D. Engle, A.M. Adams, and G. Brooks. 1993. Annual Statistical Summary: EMAP-E Louisianian Province - 1991. EPA/620/R-93/007.

Summers, J.K., J.M. Macauley, P.T. Heitmuller, V.D. Engle, and A.M. Adams. 1994. Louisianian Province Demonstration Report - 1991. EPA/620/R-94/001.

APPENDIX A

Gulf States Monitoring Programs

Texas

Department: Texas Natural Resource Conservation Commission (TNRCC), Surface Water Quality Monitoring Program (SWQM Program)

Mandate:

The Texas Natural Resource Conservation Commission's (TNRCC) Surface Water Quality Monitoring Program (SWQMP), which was initiated in 1967, includes monitoring of streams, reservoirs, estuaries, and the Gulf of Mexico. The SWQMP encompasses the full range of activities required to obtain, manage, store, share, assess, and report water quality information to other TNRCC teams, agency management, other agencies and institutions, local governments, and the public. Primary statutory authority for the SWQMP is Section 26.127 of the Texas Water Code which states, "The executive director of TNRCC has the responsibility for establishing a water quality sampling and monitoring program for the state. All other state agencies engaged in water quality or water pollution control activities shall coordinate those activities with the Commission." The SWQMP is strongly influenced by Sections 104(b), 106, 205(j), 303(d), 305(b), 314, 319, and 604(b) of the Federal Clean Water Act of 1987. The TNRCC SWQMP is largely funded by a Clean Water Act Section 106 cooperative grant agreement with EPA Region 6.

Objective:

SWQM provides overall evaluations of the physical, chemical, and biological characteristics of aquatic systems and their relation to designated use of the water resource, the protection of human health, and ecological condition. The function of the SWQM program is to support the water quality management activities of the agency. These activities promote the protection, restoration and wise use of Texas surface water resources.

Important objectives of the monitoring program include:

1. The characterization of existing water quality conditions, including the compliance with instream water quality standards, and identification of spatial and temporal trends
2. The identification of the causes of water quality problems and sources of contaminants
3. The evaluation of effectiveness of point source controls and best management practices for controlling nonpoint source pollution
4. Water quality and hydraulic measurements to support modeling for wasteload allocation

Number of stations:

The TNRCC currently monitors at 240 stream sites, 43 reservoir sites, 68 tidal stream sites, 83 estuary sites and two sites in the Gulf of Mexico.

Variables collected:

Variables collected include flow, field measurements, routine water chemistry, and fecal coliform analysis. Additional coverages may include toxic substances in water, sediment, or fish tissue, toxicity testing of water and sediment, and analysis of fish and/or macrobenthos community structure.

Routine field and water chemistry parameters measured in situ include temperature, pH, dissolved oxygen, specific conductance, salinity, Secchi disk, fecal coliforms, and stream flow. Laboratory parameters include nitrogen and phosphorus species, chlorophyll and phaeophytin, total organic carbon, alkalinity, total suspended solids, and volatile suspended solids. At selected sites, the TNRCC's SWQM program monitors a large number of organic substances in water, sediment, and fish tissue at selected fixed stations; included are 40 pesticides, 31 volatile, and 63 semivolatile organic substances (Tables 2 and 3). Also monitored at selected sites are 12 metals in water, 13 in sediment, and 7 in fish tissue (Table 4). The SWQM program focuses most toxic substances monitoring on those sites deemed likely to be contaminated and sites which exhibit biological impairment.

Toxic substances in water, sediment, and fish tissue are monitored to determine their prevalence and magnitude, to detect and describe spatial and temporal changes, and to evaluate compliance with applicable water quality standards. Some tidal sites are monitored in the TOXNET monitoring program of ambient toxicity testing Cyprinodon variegatus (sheepshead minnow) is used to evaluate estuarine waters

In addition to monitoring toxic chemical contaminants in sediments, conventional parameters in sediment are also measured: percent solids, for determination of water content; oil and grease or total petroleum hydrocarbons, for petrochemical influences; sediment grain size, for availability of contaminants; total organic carbon, for bioavailability of contaminants that adsorb to organic particulates; and acid volatile sulfide, for bioavailability and potential toxicity of metal contaminants.

The SWQM program conducts some biological monitoring (fish and macrobenthos) to provide integrated evaluations of water quality. Results are used to assess impacts of point and nonpoint sources, assess community condition or "health," determine appropriate aquatic life uses, monitor rates of recovery following implementation of improved wastewater treatment, and to provide early warning of potential impacts. Standard procedures are modeled after the Rapid Bioassessment Protocols developed by EPA for freshwater macroinvertebrate monitoring. In recent years fish community monitoring has been included at some fixed stations.

Frequency:

The number of fixed stations monitored each year and the frequency at which they are sampled vary from year-to-year depending on the amount of funding the SWQM program

receives and the manner in which the funds are allocated. The fixed stations are sampled at varying frequencies, with 86 percent sampled quarterly.

Sampling design:

Streams, reservoirs, and estuaries are divided into segments which correspond to natural divisions and/or divisions suited for administrative or regulatory organization. Usually at least one sample site is established to characterize the water quality of that segment. Within the bays, stations are also established at locations potentially subject to effects of local discharges or other activities.

Data management:

The TNRCC database contains water quality data collected by the TNRCC as well as other agencies such as the United States Geological Survey, the International Boundary and Water Commission, the Texas Department of Health, Texas Watch Volunteers, and some river authorities and cities.

Department:

Texas Coastal Observation Network (TCOON). The Texas Water Development Board (TWDB) and Texas General Land Office (GLO) participate in the funding and management of the TCOON. TCOON participants include the following agencies and institutions: National Oceanographic and Atmospheric Administration; U.S. Army Corps of Engineers; Texas General Land Office; Texas Water Development Board; Lamar University; and The Conrad Blucher Institute (CBI) of TX A&M- Corpus Christi

Mandate:

The 71st and 72nd Texas Legislatures authorized the Texas Water Development Board to invest in the establishment of TCOON. Later legislative action authorized involvement of the General Land Office to continue installation and operation of tide gauges.

Objective:

To collect, analyze, and disseminate high-quality coastal water level data. Data from the tide gage sites are used as driving inputs to oil-spill trajectory models, as inputs to models of bay circulation and salinity used in resource management deliberations, and in the area of coastal boundary disputes as well as for navigation and marine safety.

Number of stations:

TCOON currently monitors 47 sites located in the bays and nearshore waters of the Texas Gulf of Mexico.

Variables collected:

This network supplies data on water level and meteorological data (some sites) in the bays and nearshore waters of the Texas Gulf. Tide gaging is performed in compliance with NOAA National Ocean Service standards. Wind speed and direction are collected at

21 sites, air temperature and barometric pressure at 10 sites, and water quality data (Temp., pH, DO, Salinity) at 6 sites.

Frequency:

Water level data recorded at 6-minute intervals. Other data may be hourly. Data collection is fully automated, using new technology sensor and recording equipment. Sampling design: Some sites are classified as of national historic interest, continuation of NOAA gages. Other sites are located to meet the specific needs of cooperators.

Data management:

Data are archived by NOAA, by TWDB, and by CBI. Data are stored in a searchable database available on the web through CBI, http://dco.cbi.tamucc.edu/sitemap.html.

Department:

Texas Water Development Board (TWDB), Ambient Water Quality Monitoring

Mandate:

The Texas Water Code 16.012 directs the Executive Administrator of the Texas Water Development Board to study and survey the quantity, quality of surface waters of the state, and to guide the development of a statewide water resource data collection and dissemination network. The Executive Administrator of the Board is also directed to monitor the effects of freshwater inflows upon the bays and estuaries of Texas.

Objectives:

Data from these instruments are used along with data from other monitoring programs to establish relationships between freshwater inflows and salinity for each estuary. Another purpose of this high frequency water quality monitoring effort is to support calibration of estuary circulation and salinity simulation models.

Number of stations:

Twelve sites are distributed among the Texas bays. Although the number of sites at which data were collected is small, the instruments still provide an abundance of data and useful characterization of estuarine variability.

Variables collected:

Hydrolab Datasondes are deployed to continuously record temperature, conductance, salinity, and dissolved oxygen. Some of the instruments deployed also record pH and turbidity.

Frequency:

Recording frequency is hourly.

Sampling design:

Locations were determined in part by the need for salinity data near the heads and mouths of major estuaries for purposes of salinity modeling. Locations were also determined by ease of access and availability of anchoring structures.

Data management:

Data are archived as ASCII flat files. Data are available on the web, at: http://www.twdb.state.tx.us/twdb/planning/environmental/envirosystem.html

Department:

Lower Colorado River Authority (LCRA)

Mandate:

The Lower Colorado River Authority was created as a conservation and reclamation district by the Texas Legislature in 1934. The LCRA has six dams on the lower Colorado River that help in flood control and serve as a water supply for municipal, industrial, agricultural and recreational users throughout the 10-county statutory district. The LCRA is directed to take into account the freshwater inflow needs of the Lavaca-Colorado Estuary in its management of water rights in the Colorado River Basin. Presently, Texas law does not mandate specific freshwater inflow needs. However, the public policy of the State does call for the maintenance of a proper ecological environment of the bays and estuaries of Texas and the health of related living marine resources' (SB137, 64th Legislature).

Objectives:

In 1991-92 the Corps of Engineers diverted the Colorado River into West Matagorda Bay to increase biological productivity by increasing the amount of freshwater entering the estuary. One purpose of the LCRA monitoring program is to characterize freshwater inflow relationships to other estuarine indicators under this new inflow regime. Establishing freshwater inflow needs of the Lavaca-Colorado Estuary from the Colorado River is another main objective. Analyses of monitoring data and results of the other estuary studies are used to prepare revisions to the LCRA Water Management Plan. Freshwater inflows greatly influence estuarine biological productivity by lowering salinities, increasing nutrients and providing sediments. Average daily salinity is calculated for each monitoring station and compared to freshwater inflow targets.

Number of stations:

Seven continuous monitoring sites, including three tidal gage sites, throughout the Matagorda Bay system.

Variables collected:

Salinity, dissolved oxygen, pH, height of tide and temperature are recorded by multi-probe water quality instruments.

Frequency:

Hourly.

Sampling design:

Station placement was chosen to provide an estuary-wide characterization of water quality, particularly salinity, with emphasis on secondary bays. The conceptual design was then modified to account for available structures for attachment of instruments.

Data management:

Data is currently stored in Access database and is available in Excel spreadsheets. During the next year, data will be stored in a SQL server.

Department:

Texas Department of Health, Seafood Safety Division

Mandate:

The Seafood Safety Division of the Texas Department of Health (TDH) conducts microbiological monitoring of Texas bays to classify shellfish growing areas in compliance with the National Shellfish Sanitation Program. The mission of the Seafood Safety Division is to protect the consumer of oysters, clams, mussels and scallops and crab meat from disease or other health hazards transmissible by these products produced in or imported into Texas.

Objectives:

To classify all actual and potential shellfish growing areas as to their suitability for shellfish harvesting on the basis of sanitary quality and public health safety. TDH also monitors for the presence of toxic substances in fish and shellfish tissues in order to evaluate the need for consumption advisories and bans.

Number of stations:

The number of stations that are currently active is 338.

Variables collected:

Sample Number, Time of Collection, Type of Sample, Water Depth, Rainfall (24 hr, 4-day, 7-day), Weather Condition (Ex. Clear, Partly Cloudy), Wind Direction, Wind Velocity, Air Temperature (F), Water Temperature (F), Salinity, Conductivity, Current Classification of Station, Status (open or closed to shellfish harvesting). Samples for microbiological assays are also collected.

Frequency:

The TDH program collects water samples at intervals based upon the current conditions of the bay. TDH collects at least 5 sample runs with different dates of collection for each station while the bay is open to shellfish harvesting. An area can be sampled 20 - 30 times per oyster season (Nov. 1 - Apr. 31) , but may only be sampled 5 times.

Sampling Design:

Sample station location is based on the need to monitor areas of the bay that are influenced by runoff from rivers, streams, or ditches surrounding the bay. This is to assess the influence that a particular pollution event has on the current bacteriological conditions of the bay.

Data Management:

The data that is collected is stored at TDH and at local field offices. Currently the data is entered into Fox Pro 4 after quality assurance checking.

Department:

Texas Parks and Wildlife Department, Coastal Fisheries Division A. Resource surveys.

Mandate:

The mission of the Texas Coastal Fisheries program is to conserve and protect the habitat and aquatic resources of Texas' coastal waterways.

Objectives:

Through careful monitoring, resources can be evaluated and management objectives determined.

Number of stations:

The coastal fisheries division samples over 1,600 fixed stations in the seven bay systems (approximately 240 each) using Bay Bag Seines, Bay Trawls, Gulf Trawls, Oyster Dredges, Gill Nets

Variables collected:

Water: Temperature, Salinity, pH, turbidity, DO
Weather Conditions: Wind Direction, Air Temperature
Organisms: Species, Number, Weight (selected individuals), Length (subsample of 19 ind.), Sex and Maturity, Large, live fish tagged for growth and mortality

Frequency:

Approximately 86 samples are visited each month (+ 45 gill nets in each 10-wk spring and fall sampling period) and sampled using the appropriate gear.

Sampling design:

Surveys are conducted within a stratified, randomized design.

Data management:

Historical data has been maintained on an internal mainframe computer system. Currently the Texas Department of Parks and Wildlife is entering all current data and is transferring historical data into a relational Sy-Base system.

B. Harvest surveys.

Objectives:

The objectives of these surveys are to determine estimates of total daylight marine resource landings, catch per unit of effort, and size composition by species for: Bay and Gulf private-boat sport fishermen, and Bay and Gulf party-boat (10 people or fewer) sport fishermen.

Number of stations:

Commercial: 136 commercial seafood and bait dealers
Recreational: 106 Access Sites, 141 survey days/year

Variables collected:

Commercial: Quantity by species, weight, ex-vessel price/lb.
Recreational: Boat Reg. #, trip length, number of people in party and county of residence, minor bay fished, gear used, bait used, species landed, species sought, trip satisfaction
Number of stations:

Monthly data on commercial landings is collected from licensed seafood and bait dealers on a Monthly Aquatic Products Report (MAPR), including location, total weight and price paid.

Shrimp landings are reported to TPWD by the Division of Statistics-Market News, NMFS. May include shrimp harvested from other states or countries. Gulf menhaden are reported to TPWD by NMFS, Population Dynamics Team, Beaufort Laboratory.

Frequency:

Monthly.

Sampling design:

Survey sites are selected randomly but selection is weighted according to mean rove counts, adjusted for trailer location, percent bay and pass pressure and percent angling parties. Catch (landings) rates and size compositions by species are obtained by on-site interviews of boaters completing their trips.

Data management:

Historical data has been maintained on an internal mainframe computer system. Currently the Texas Department of Parks and Wildlife is entering all current data and is transferring historical data into a relational Sy-Base system.

C. Rove surveys.

Objectives:

The objective of these surveys is to estimate fishing pressure by taking roving counts of trailers and empty wet boat slips at all boat access points. The results of these surveys are used to determine and weight the selection of sites at which harvest surveys are conducted.

Number of stations:

A total of 277 stations are located in the seven bay systems of the Texas Coast (27 in Sabine, 111 in Galveston, 42 in Matagorda, 23 in Arkansas, 28 in Corpus Christi, 21 in the Upper laguna Madre, and 25 in the Lower Laguna Madre Bay Areas)

Variables collected:

Roving counts of trailers and empty wet boat slips at all boat access points.

Frequency:

Monthly

Sampling design:

Fixed sites.

Data management:

Historical data has been maintained on an internal mainframe computer system. Currently the Texas Department of Parks and Wildlife is entering all current data and is transferring historical data into a relational Sy-Base system.

F. TPWD Artificial Reef Program

Objectives:

There is currently a grant award to TAMUCC to do some survey work on four of the reef sites in which they will sample fish and fouling communities for amount of cover and biomass, identify and count the fish, do vertical photo transects, and measure light insolation and temperature.

Number of stations:

Each of the 33 reef sites are monitored.

Variables:

Video/photo transects; Trap, tag and release studies; Visual fish and invertebrate surveys.

Frequency:

The 33 reef sites are monitored on an irregular basis.

Sampling design:

Variables are collected in a stratified random sample design.

Data management:

Historical data has been maintained on an internal mainframe computer system. Currently the Texas Department of Parks and Wildlife is entering all current data and is transferring historical data into a relational Sy-Base system.

Department:

Texas Parks and Wildlife Department, Resource Protection Division

A. Fish Kills and Toxic Spills Database

Mandate:

The Fish Kills and Toxic Spills Division (Kills and Spills) has been responding to environmental situations since the 1950s under the authorization of the Texas Parks and Wildlife Code Subchapter (a); seg. 12.0001.

Objectives:

To respond to all fish kills and toxic spills along the coast to determine the species affected, estimate of biological damage, and causative agent. Algae blooms and other natural phenomena are also responded to.

Number of Stations:

A total of 5,200 records have been collected since the 1950s. Sites are dependant are not fixed and are dependant on requests for environmental monitoring.

Variables Collected:

Variables collected include date, location, name and number of the water quality segment, latitude and longitude, fish species affected, and agent responsible.

Frequency:

Dependent on the individual request.

Sampling Design:

Discrete sampling at afflicted site.

Data Management:

Data is entered into Microsoft Access97 relational database.

Department:

City of Houston (COH) - Department of Health & Human Services, Environmental Health Division - Bayou Monitoring

Mandate:

In1991, the Texas Legislature passed the Texas Clean Rivers Act (Senate Bill 818). In 1995, the Texas Legislature amended the original bill to effectively end in 1998.

Objectives:

Based on the premise that water quality is determined by the watershed, the basin also determines how and where pollutants are dispersed and where environmental damage may occur. This act attempted to assess water quality based on basin, rather than by political boundaries.

Number of stations:

The COH Department of Health & Human Services monitor 28 stations in major bayous in the vicinity of Houston.

Variables collected:

Parameters monitored 100% of the time: T, DO, BODs, TSS, TFR, Metals, N-NH3, pH, O&G, Fecal Coliform, SO4, CL, and conductivity. Analyzed as needed for volatile and semi-volatile organics: Ammonia-N; Arsenic, dissolved or total; Cd, dissolved or total; COD; Chloride; Cr, dissolved or total; Cu, dissolved or total; Mn, dissolved or total; Pb, dissolved or total; Hg, total; Nitrate-N and Nitrite-N; Oil and Grease; TOC; Orthophosphate-P; Total Residue; Filterable Residue.

Frequency:

Stations sampled at least 5 times/month at 6 in. below the surface in appropriate containers

Sampling design:

Fixed sampling stations with watershed basin boundaries.

Data management:

Source Person: John Halet, COH, Department of Health and Human Services.

Department:

City of Houston (COH) - Department of Health & Human Services, Environmental Health Division - Lake Houston Monitoring

Mandate:

In 1991, the Texas Legislature passed the Texas Clean Rivers Act (Senate Bill 818). In 1995, the Texas Legislature amended the original bill to effectively end in 1998.

Objectives:

Based on the premise that water quality is determined by the watershed, the basin also determines how and where pollutants are dispersed and where environmental damage may occur. This act attempted to assess water quality based on basin, rather than by political boundaries.

Number of stations:

The COH Department of Health & Human Services monitor 7 stations in Lake Houston at Lake Houston Dam, S. Mid-Lake, RR Trestle, W. McKay Bridge, E. McKay Bridge, West Fork, and East Fork.

Variables collected:

O&G; DO; TSS; TFR; SO_4; Cl; Temperature, pH; BOD; VSS; NH_3; TOC; NO_2; NO_3; P-Ortho; Turbidity; fecal coliform and conductivity, metals (every other week); volatile and semi-volatile organics (as needed)

Frequency:

Samples collected 2-3 times/week at 6 in. below the surface in appropriate containers

Sampling design:

Fixed sampling stations with watershed basin boundaries.

Data management:

Source Person: John Halet, COH, Department of Health and Human Services

Department:

City of Houston (COH) - Department of Health & Human Services, Environmental Health Division - Tributary Monitoring

Mandate:

In1991, the Texas Legislature passed the Texas Clean Rivers Act (Senate Bill 818). In 1995, the Texas Legislature amended the original bill to effectively end in 1998.

Objectives:

Based on the premise that water quality is determined by the watershed, the basin also determines how and where pollutants are dispersed and where environmental damage may occur. This act attempted to assess water quality based on basin, rather than by political boundaries.

Number of stations:

The COH Department of Health & Human Services monitor 40 stations in major tributaries of six watersheds in the vicinity of Houston.

Variables collected:

Temperature; DO; BOD ; TSS ; TFR; Metals ; N-NH_3; pH; O&G; Fecal Coliform; SO_4; CL; conductivity; Analyzed as needed for: Volatile and semi-volatile organics

Frequency:

Stations sampled at least twice/month at 6 in. below the surface in appropriate containers

Sampling design:

Fixed sampling stations with watershed basin boundaries.

Data management:

John Halet, COH, Department of Health and Human Services

Department:

City of Houston (COH) - Department of Public Utilities

Mandate:

In 1991, the Texas Legislature passed the Texas Clean Rivers Act (Senate Bill 818). In 1995, the Texas Legislature amended the original bill to effectively end in 1998.

Objectives:

Based on the premise that water quality is determined by the watershed, the basin also determines how and where pollutants are dispersed and where environmental damage may occur. This act attempted to assess water quality based on basin, rather than by political boundaries.

Number of stations:

The COH Department of Public Utilities monitors 62 sites in 10 bayous and creeks.

Variables collected:

Temperature; BOD ; TSS ; N-NH_3; N-Nitrate; pH; Fecal Coliform.

Frequency:

Weekly

Sampling design:

Fixed sampling stations with watershed basin boundaries.

Data management:

Documentation of analytical data consists of chain-of custody records, raw analytical data, calibration books for analytical instruments, QC checks, and finished laboratory data. (Source: Running, T.A. 1998. Quality Assurance Project Plan for F.Y. 1998 Monitoring Activities for the Texas Clean Rivers Program. HGAC)

Source Person:

Todd Running, HGAC

Department:

City of Houston (COH)- Public Health and Engineering

Mandate:

In 1991, the Texas Legislature passed the Texas Clean Rivers Act (Senate Bill 818). In 1995, the Texas Legislature amended the original bill to effectively end in 1998.

Objectives:

Based on the premise that water quality is determined by the watershed, the basin also determines how and where pollutants are dispersed and where environmental damage may occur. This act attempted to assess water quality based on basin, rather than by political boundaries.

Number of stations:

The COH Public Health and Engineering monitors 40 stations in 16 water bodies.

Variables collected:

Temperature: BOD5; DO; pH; TDS; TSS; Pb; Zn; SO_4; Cu; Cd; Cr; Mn; Ni; Hg; As; Conductivity; FC

Frequency:

Samples monthly.

Sampling design:

Fixed sampling stations with watershed basin boundaries.

Data management:

Source Person: Todd Running, HGAC

Department:

Galveston County Health District (GCHD)

Mandate:

Texas Clean Rivers Program

Number of stations:

The GCHD monitors 125 stations in Galveston County, Texas.

Variables collected:

Ammonia-N; BOD; Conductivity/Salinity - field probe; Dissolved Oxygen - field probe; Fecal Coliform; NO3+ & NO2; pH - field probe; Total Phosphorus; TSS ; Temperature field probe

Frequency:

Periodic data is collected in response to certain citizen complaints concerning water pollution. Some water quality sampling occurs when necessary; for example, in the case of a fish kill. This citizen response service operates 24 hours-a-day, seven days-a-week, and is accessible through their regular telephone number.

Another component of this program is the regular inspection of permitted discharges. There are approximately 50 sites with NPDES permits in Galveston County. Samples and readings are taken according to specific permit contents. Typically, the permits are for five-year periods; although there is a new policy under development to change to a regional permitting period.

Sampling design:

Fixed sampling stations with watershed basin boundaries.

Data management:

Water quality monitoring has been ongoing since1972. More than 25 years of water quality data has been gathered and is stored in electronic form in a Paradox database. Source Person: Robert Fiederlein, GCHD-PCD

Department:

Harris County Pollution Control (HCPC)

Mandate:

Clean Water Act

Number of stations:

HCPC monitors 15 ambient stations, with 9 sites on the Houston Ship Channel and 6 sites on the San Jacinto River.

Variables collected:

Water Probe: Temperature; DO; Flow; pH; TOC; Trace Metals: As, Cd, Cr, Ni, Cu, Mn, Zn; Total solids (residue); TSS; Ammonia - N; FC/Fecal Streptococcus (FS); Volatile Acids (VA); Sulfide and Chloride

Frequency:

1)ambient - datasonde type water probe monthly samples; 2)enforcement - Industrial and Sewage Treatment Plant samples weekly

Sampling design:

Fixed sampling stations with watershed basin boundaries.

Data management:

Monitoring in the Houston Ship channel and on the San Jacinto River both began in 1978. Data is stored in both electronic forms in an IBM System 36 and in a hardcopy format in house. (HCPC will be migrating to a Windows NT platform for data storage in early 1999) Currently no monitoring information or data is available in any publications. None of the HCPC data is available via the internet as of this time. Data stored in both a hardcopy form and on an IBM System 36 computer system. (This storage system will be changed to a Windows NT platform in early 1999).

Source Person:

Melanie Hoepker & Norris Tyer, HCPC

Department:

Texas Department of Health

Mandate:

QA/QC is established for seawater and shellfish sampling by protocols set for in National Shellfish Sanitation Program's "Guide for the Control of Molluscan Shellfish."

Objectives:

To determine the proper classification of shellfish grounds in accordance with the National Shellfish Sanitation Program RS:40, part 5 and part 3.

Number of stations:

600 fixed stations (114 active stations in the Galveston Bay complex)

Variables collected:

Seawater is monitored for fecal coliform, temperature, salinity and conductivity. Rainfall, wind speed and direction, as well as air temperature is also recorded at each site at the time of collection.

Tissues are sampled from Metals; PCB and pesticides; volatile organic compounds; semi-volatile organic compounds and Dioxin-Furans depending on the chemical concerns of areas being sampled.

Frequency:

Sampling protocol requires at a minimum of at least five samples from each station per year. The actual amount varies depending on meteorological events.

Sampling design:

Fixed stations sampled monthly

Data management:

TDH has sampling data from the 1950's through the present. All data are received into the central office as field data sheets and laboratory result sheets. This data is entered into a FoxPro database and cannot be accessed via the TDH web site. Certain information can be requested from TDH by writing to the TDH Seafood Safety Division at 1100 W 49th St., Austin, TX 78756
Source Person: Kirk Wiles, TDH

Department:

Galveston Bay Foundation (GBF)

Mandate:

The mission of the Galveston Bay Foundation is to preserve and enhance the Bay for its multiple uses. To accomplish this mission the Foundation has targeted four goals:

- Education: Provide resources and guidance for education projects aimed at developing a constituency for the Bay, from schoolchildren to public officials.
- Conservation: Develop projects aimed at preserving/enhancing the natural resources of the Bay system.
- Research: Support the allocation of public and private resources for research into the multiple resources of the Bay system and ultimately establish a research endowment.
- Advocacy: Encourage and actively seek solutions to conflicts among the diverse users of the Bay. Wise, prudent and careful utilization of administrative and legal proceedings when required and approved by a 2/3 majority of the Executive Board present and voting.

Objectives:

Galveston Bay Foundation's volunteer monitoring program has always focused on Galveston Bay open water and tidally influenced portions of tributaries. GBF offers training to anyone who is interested in being involved in their monitoring program.

GBF's monitoring program now focuses on Total Maximum Daily Load (TMDL) studies or in response to specific funded projects. If funding can be secured, our goal is to focus on sites that are on the 303(d) list, especially those with current or impending TMDLs planned.

Number of stations:

The GBF monitors 30-40 stations in tidal segments of 17 creeks, channels, rivers, lakes and bays.

Variables collected:

Water: Temperature, DO, pH, salinity, conductivity and turbidity. General observational data regarding the weather and site location is also recorded at the time of the sampling.

Frequency:

Grab samples are collected weekly or bi-monthly and are taken 1 foot below surface.

Sampling design:

Selective sampling.

Data management:

Source Person: Carmen Fitzgerald, GBF

Louisiana

Department:

Louisiana Department of Environmental Quality - Office of Environmental Compliance

Mandate:

The Louisiana Department of Environmental Quality (LDEQ) is charged with maintaining a healthful and safe environment for the people of Louisiana. Specifically, the LDEQ manages Louisiana's surface waters by improving water quality where man's activities have caused degradation and by preserving the integrity of those waters where good quality exists.

Objective:

The LDEQ/Office of Environmental Compliance (OEC) surface water monitoring program is designed to measure stream health relative to the achievement of water quality goals at the state and national levels, to gather data used in establishing and reviewing the state water quality standards, and to provide a database in determining the assimilative capacity of the waters of the state.

Number of Stations:

The surface water monitoring program consists of a long-term network of 21 fixed stations and intensive sampling of all water body sub-segments within two or three different watersheds annually on a five year rotation. In addition, the OEC conducts other activities related to monitoring of ambient water body health such as intensive surveys, special studies, permitted and unpermitted facility inspections, wastewater discharge compliance sampling, and complaint and spill investigations. Aquatic mortalities are tracked and reported for the bi-annual EPA 305b report for Louisiana and to the Gulf of

Mexico Aquatic Mortality Network as appropriate. Unauthorized discharges to waters of the State (spills) are tracked in an integrated database. Spilled substances, responded to and tracked by LDEQ/OEC include hazardous materials, oils of various types, sewage, brine and any other substance which may be considered a pollutant.

Variables collected:

Water samples are analyzed for 23 different chemical parameters and bacteria including: dissolved oxygen, conductivity, pH, temperature, and conductance; as well as laboratory analyses for solids, nutrients, alkalinity, color, turbidity, hardness, total organic carbon, metals, biological oxygen demand and fecal coliform bacteria. All water quality samples are collected from mid-channel at a depth of about one meter or at mid-depth where the depth is less than six feet using a three liter stainless steel wastewater sampler. Lake, coastal bay and near shore Gulf of Mexico samples are also collected at a depth of about one meter using the same equipment.

Frequency:

Water samples are collected on a monthly schedule.

Sampling design:

Grab samples are collected on a routine schedule using procedures detailed in the state and EPA approved Quality Assurance Project Plan.

Data management:

All data verified and stored in the department's Digital Alpha 2100, VMS cluster computer system using FOCUS, Oracle, and SAS computer software packages. All data is also integrated into the EPA STORET data system.

Department:

Louisiana Department of Health and Hospitals/Molluscan Shellfish Safety Office

Mandate:

The Molluscan Shellfish Safety Office is responsible for ensuring safe molluscan shellfish for consumption through setting of closure lines for oyster harvesting.

Objectives:

To determine the proper classification of shellfish grounds in accordance with the National Shellfish Sanitation Program RS:40, part 5 and part 3.

Number of stations:

The Molluscan Shellfish Safety Office monitors 753 fixed stations monthly. Additional sampling is conducted on an as needed basis to ensure public safety.

Variables collected:

Water salinity and water depth, and lab analysis of fecal coliform bacteria and biotoxins

Frequency:

Samples are collected monthly; with laboratory results being obtained within 24-36 hours. If the results indicate potential health risks, additional field sampling is conducted.

Sampling design:

Fixed sample locations are sampled monthly to meet health and safety monitoring criteria.

Data management:

Data is entered in the Department of Health and Hospital's mainframe computer and analyzed using SAS statistical software.

Department:

Louisiana Department of Wildlife and Fisheries/Marine Fisheries Division

Mandate:

It is the mission of the Office of Fisheries to conserve and protect Louisiana's renewable aquatic resources for present and future generations of Louisiana citizens by controlling harvest and replenishing and enhancing stocks and habitat.

This is accomplished by setting seasons, size and possession limits, gear restrictions, or other means of protecting key resources; replenishing species and enhancing or developing species or habitats as needed to provide for the needs of consumptive and non-consumptive users or environmental health; research to provide insights into the proper functioning of natural systems; and educating the public and promoting wise use of these resources. The clients served by this program include present and future generations of Louisiana citizens, as well as national and international interests that derive benefits from consumptive and non-consumptive use of Louisiana's fisheries resources. The Fisheries Program within the Department of Wildlife and Fisheries is needed to fulfill this mission of management and conservation.

Program Authorizations are: LA Constitution of 1974, Article IX, Section 7; R.S. 56:1 et seq.; R.S. 36:601 et seq.; R.S. 30:214 et seq.; R.S. 35:3101 et seq.; and R.S. 30:2451 et seq.

A. Shellfish Monitoring

Objectives:

Maintain Louisiana's premier status as a national leader both in commercial production and in quality recreational fishing opportunities by ensuring that aquatic resource

populations will be sustainable in the present and future.

Number of stations:

approximately 134 fisheries stations (both inland and marine) located throughout coastal Louisiana are sampled for shellfish

Variables collected:

Plankton nets (500 micron mesh) are used weekly from January until the beginning of shrimp season to sample postlarval shrimp in tidal passes in order to ascertain seasonal occurrence and peaks of postlarval shrimp recruitment. Sixteen-foot otter trawls are used weekly or biweekly to sample penaeid shrimp and blue crabs to determine relative abundance, size distribution, and seasonal/long-term trends. Six-foot otter trawls are used weekly to sample juvenile penaeid shrimp to determine relative abundance, size distribution, and seasonal/long-term trends. Hydrological/climatological measurements (air and water temperature, turbidity, conductivity, and salinity, cloud cover, wind speed and direction, wave height, tidal stage, and moon phase) are taken in conjunction with all biological samples.

Frequency:

16ft trawl (inshore) every other week Nov.-Feb. and Weekly Mar.-Oct.
16ft trawl (offshore) every other week Nov.-Mar. (or Gulf opening) and monthly Apr. (or Gulf opening) - Oct.
6ft trawl (regular) weekly Apr. to close of Spring Season
6ft trawl (crash) weekly during the week prior to May Commission meeting
Plankton weekly Jan. to setting Date of Season

Sampling design:

Fixed sample locations sampled seasonally to meet management objectives. Largely based upon methodology utilized during the Cooperative Gulf of Mexico Estuarine Inventory and Study (GMEI) (Perret et al, 1971).

Data management:

Data are entered and stored as SAS data bases. Databases are available upon written request in either hardcopy of digital format.

B. Finfish Monitoring

Objectives:

Maintain Louisiana's premier status as a national leader both in commercial production and in quality recreational fishing opportunities by ensuring that aquatic resource populations will be sustainable in the present and future.

Number of stations:

Fisheries Independent - approximately 131 station sampled across coastal Louisiana;
Fisheries Dependent - number of sites visited are quota driven.

Variables collected:

Fisheries Independent - Biological observations on fish species caught by seine, trammel, or gill net are recorded. Finfish data collected as part of the shellfish monitoring data is also utilized. A 50' bag seine is used to determine relative abundance, size distribution, and seasonal/long-term trends of juvenile finfish, shellfish, and other marine organisms. Indices of abundance, size distribution, and ancillary life history information of selected species are obtained with a 750' monofilament gill net and a 750' trammel net monthly or bimonthly. Hydrological/climatological measurements (air and water temperature, turbidity, conductivity, and salinity, cloud cover, wind speed and direction, wave height, tidal stage, and moon phase) are taken in conjunction with all biological samples.

Fisheries Dependent - Marine Recreational Fisheries Statistical Survey (MRFSS) interviews with recreational fishers to determine catch per unit effort. Trip tickets from commercial fishers to determine effort and commercial landings. TIPS interviews at commercial dock to determine commercial catch information.

Frequency:

Fisheries Independent -
Gill net sampling is conducted monthly during October to March and twice monthly from April to September. Trammel net sampling is conducted monthly from October to March and seine sampling is conducted monthly from January to August and twice monthly from September through December.

Fisheries Dependent -
MRFSS is quota driven by mode of fishing and trip tickets are reported monthly by commercial fisherman. TIPS interviews of fisherman are at no set sampling schedule.

Sampling design:

Fisheries Independent -
Fixed sample locations sampled seasonally to meet management objectives. Largely based upon methodology utilized during the Cooperative Gulf of Mexico Estuarine Inventory and Study (GMEI) (Perret et al, 1971).

Fisheries Dependent -
Trip tickets are required for all wholesale/retail dealers in Louisiana. MRFSS and TIPS sampling are random design.

Data management:

Fisheries Independent - Data are entered and stored as SAS data bases. Databases are

available upon written request in either hardcopy or digital format.

Fisheries Dependent - MRFSS data are available upon request to NMFS. Trip ticket data are scanned into a data base. Trip ticket data is confidential and cannot be released except in aggregate form. TIPS data are entered and stored as SAS data bases. TIPS data are available upon request to NMFS.

C. Oyster Monitoring

Objectives:

Administer a system of oyster leasing and management of public reefs designed for the ordered, rational exploitation of the oyster resource.

Number of stations:

Approximately 91 stations are sampled throughout coastal Louisiana.

Variables collected:

Butler plates non-quantitatively ascertain occurrence and peaks of oyster recruitment (spat set) on a weekly basis from March through October. A one-meter square frame is used on oyster seed grounds during the summer to determine production (seed and sack oysters) per unit area and provide ancillary data on oyster mortality and predators. An 18" oyster dredge provides similar information monthly or bimonthly. Hydrological/climatological measurements (air and water temperature, turbidity, conductivity, and salinity, cloud cover, wind speed and direction, wave height, tidal stage, and moon phase) are taken in conjunction with all biological samples.

Frequency:

Oyster Dredge Monthly Mar. - Apr. Twice Monthly May-Jun. and Aug.-Oct.
Square Meter Annually Jun.-Jul except CSA VII (Calcasieu Lake) - Aug.- Sep.
Butler Plates Weekly Mar. - Oct.

Sampling design:

Fixed sample locations sampled seasonally to meet management objectives. Largely based upon methodology utilized during the Cooperative Gulf of Mexico Estuarine Inventory and Study (GMEI) (Perret et al, 1971).

Data management:

Data are entered and stored as SAS data bases. Databases are available upon written request in either hardcopy of digital format.

D. Habitat

Objectives:

Protect and maintain fish habitat through collection of hydrographic data for use in fisheries management, design and monitor programs for coastal restoration projects and evaluate benefits and impacts to fish and wildlife resources, develop artificial reefs, participate in statewide oil spill planning and maintain readiness to protect fish and wildlife resources and to assess natural resource damages.

1. Hydrographic Monitoring

Number of stations:

Hydrographic data collection: 11 stations in nearshore coastal bays using real-time data collection platforms (DCP's) (14 additional stations on three wildlife management areas using YSI 6000 dataloggers are maintained by another division)

Variables collected:

salinity, conductivity, temperature, water level and at select locations wind speed and direction, rainfall and barometric pressure

Frequency:

Hourly for DCPs

Sampling design:

Fixed sample locations strategically placed to meet management objectives

Data management:

Data are downloaded and stored in SAS databases. Databases are available upon written request in either hardcopy or digital format.

2. Coastal Restoration Projects (Freshwater Diversion)

Number of Stations:

existing LDWF shellfish, finfish, oyster and hydrographic stations are utilized when possible and supplemented as follows:

Caernarvon - 3 additional 6 ft trawl stations, 2 additional 16 ft trawls; 14 Nestier tray stations; 22 isohaline stations

Davis Pond - 6 additional 16 ft trawl stations; 6 each additional gill net and seine stations; 12 Nestier tray stations; 38 isohaline stations

Variables collected:

Sixteen-foot otter trawls are used weekly or biweekly to sample penaeid shrimp and blue crabs to determine relative abundance, size distribution, and seasonal/long-term trends. Sixteen-foot otter trawls are used weekly or biweekly to sample penaeid shrimp and blue crabs to determine relative abundance, size distribution, and seasonal/long-term trends. Six-foot otter trawls are used weekly to sample juvenile penaeid shrimp to determine relative abundance, size distribution, and seasonal/long-term trends. Biological observations on fish species caught by seine, trammel, or gill net are recorded. A 50' bag seine is used to determine relative abundance, size distribution, and seasonal/long-term trends of juvenile finfish, shellfish, and other marine organisms. Indices of abundance, size distribution, and ancillary life history information of selected species are obtained with a 750' monofilament gill net and a 750' trammel net monthly or bimonthly. Nestier trays (70 cm by 70 cm heavy duty plastic trays), with 20 oysters attached, monitor growth and mortality of oysters throughout outfall areas of freshwater diversion projects. Hydrological/climatological measurements (air and water temperature, turbidity, conductivity, and salinity, cloud cover, wind speed and direction, wave height, tidal stage, and moon phase) are taken in conjunction with all biological samples.

Frequency:

16ft trawl (inshore) every other week Nov.-Feb. and weekly Mar.-Oct.
16ft trawl (offshore) every other week Nov.-Mar. (or Gulf opening) and monthly Apr. (or Gulf opening) - Oct.
6ft trawl (regular) weekly Apr. to close of Spring Season
6ft trawl (crash) weekly during week prior to May Commission meeting
Gill Net Monthly Oct. - Mar. and twice monthly Apr. - Sept.
Trammel Net monthly Oct. - Mar.
Seine monthly Jan. - Aug. and twice monthly Sept. - Dec.
Oyster Dredge monthly Mar. - Apr. and twice monthly May-Jun. and Aug.-Oct.
Square Meter annually Jun.-Jul
Butler Plates weekly Mar. - Oct.
Nestier Trays monthly for mortality and quarterly for growth
Caernarvon Isohaline Stations weekly
Davis Pond Isohaline Stations monthly

Sampling Design:

Fixed sample locations strategically placed to meet management objectives

Data Management:

Data are downloaded and stored in SAS and/or ASCII databases. Databases are available upon written request in either hardcopy or digital format.

3. Artificial Reefs

Number of Stations:

Artificial Reef Sites are monitored on a 5 year rotating basis with side scan sonar to ensure the material remains on location and is in a stable condition. Biological sampling is done with hydroacoustic equipment.

Variables collected:

Condition and location of the material. Species composition around reefs and active oil and gas platforms.

Frequency:

Surveys are done on an annual basis on a percentage of reefs.

Sampling design:

Reef sites are placed to meet specific management goals.

Data Management:

Maps of the locations and condition of reef material are stored in a GIS format. SAS data bases are maintained identifying the locations of all oil and gas structures to identify potential artificial reefs.

4. Oil Spill and Natural Resource Damage Assessment (NRDA)

Number of Stations:

Oil spills are monitored and stations are selected and sampled as necessary, based on the specific spill event, to protect the living resources and determine damages to the living resources.

Variables collected:

Parameters vary based on type and quantity of material spilled.

Frequency:

As necessary, based on the specific spill event.

Sample design:

Dependent upon the material, quantity, location and season of the spill.

Data management:

Incident specific.

Department:

Louisiana Department of Natural Resources/ Coastal Restoration Division (LDNR/CRD)

Mandate:

The LDNR/CRD is responsible for monitoring wetland restoration, creation, enhancement and protection projects funded under Act 6 of the 2nd Extraordinary Session of the Louisiana State Legislature in 1989, the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) of 1990 commonly known as the Breaux Bill, and the Water Resources Development Act (WRDA). The monitoring must provide "An evaluation of the effectiveness of each coastal wetlands restoration project in achieving long-term solutions to arresting coastal wetlands loss in Louisiana" and "A scientific evaluation of the effectiveness of the coastal wetlands restoration projects carried out under the plan in creating, restoring, protecting and enhancing coastal wetlands in Louisiana".

Objectives:

Data are collected on restoration projects that are implemented throughout coastal Louisiana. The variables collected are driven by project-specific goals and objectives and are collected periodically or continuously over the life of a project (3, 5, 20 or 50 years). A monitoring plan is developed for each project which outlines the variables collected and their frequency of collection. All protocols and procedures followed in the monitoring program are documented in Steyer et al. (1995).

Number of stations:

As of December 1, 1998, 525 water quality stations, 620 hydrologic stations, 140 soil & sediment stations, and 450 vegetative health stations are sampled. One or more variables are sampled at each station. Additionally, aerial photography is obtained for the entire coast approximately every five years at a scale of either 1:32,500, 1:65,000 or 1:100,000. The most recent flight was in 1995 at a scale of 1:32,500.

Variables collected:

Water quality stations: discrete & continuous salinity, specific conductivity, temperature; Hydrologic stations: discrete & continuous water level, depth, flow, bathymetry, topography, suspended sediments, discharge; Soil & sediment stations: shoreline marker, GPS survey, settlement plate, feldspar marker, sediment erosion table, % organic matter, soil salinity, bulk density; Vegetative health stations: emergent vegetation, submerged aquatic vegetation. One or more variables are sampled at each station.

Frequency:

As outlined in the monitoring plans. Variables range from hourly to once every 3 years.

Sampling design:

Each project has a specific sampling design that is developed by a technical team and reviewed by a contractual statistician. Random, systematic or stratified sampling designs are common using a Before-After-Control-Impact (BACI) model with repeated measures.

Data management:

Temporal data are maintained in an in-house Oracle database and spatial data in an Arcview driven Geographic Information System. All monitoring plans, data, maps, reports and other documents are available through the LDNR/CRD homepage at http://www.savelawetlands.org or the CWPPRA homepage at http://www.lacoast.gov.

Department:

Department of Transportation and Development - Louisiana Offshore Terminal Authority (LOTA)

Mandate:

LA R. S. 34:3113 J (4) requires "a monitoring program by appropriate public or private persons selected by the Board of Commissioners (DOTD Secretary)" as an operational aspect of the Authority (LOTA) development program. L.A.C. 70: Superport Environmental Protection Plan, Section 6 states: The Authority (LOTA) shall establish and maintain, with the approval of the Department of Wildlife and Fisheries, such monitoring programs as recommended by the three Directors and approved by the Board of Commissioners (DOTD Secretary).

Objective(s):

Seasonal environmental and ecological data are obtained to: 1) document conditions existing during operation in order to relate to historical baseline conditions; 2) detect during the operation of the project any adverse alterations or damages to the environment so that corrective action can be taken as soon as possible; 3) determine the cause or causes of environmental damages or alteration so that responsibility can be properly placed; and 4) provide information in order to evaluate long- and short-term impacts of the project.

Number of stations:

There are 320 historical marine sampling stations established throughout the project. In 1995, when LDWF last sampled, there were 87 marine stations.

Variables collected:

Plankton (includes species and biomass measurements, salinity, water temperature, dissolved oxygen, nutrients, Chlorophyll A, Secchi depth, and weather conditions); Benthos (species, biomass, salinity, water temperature, dissolved oxygen, nutrients, Chlorophyll A, secchi depth, and weather conditions); Sediment (salinity, water temperature, pH, nutrients, Chlorophyll A, PAH's, grain size, and weather conditions); 16' and 50' trawls (species, biomass, salinity, water temperature, dissolved oxygen, nutrients, Chlorophyll A, secchi depth, and weather conditions.

Frequency:

Plankton and the 16' and 50' trawls are collected monthly throughout the year. Sediment

and benthos samples are collected quarterly throughout the year.

Sampling design:

Fixed locations are sampled.

Data management:

Data are entered and stored as SAS databases. The databases are available upon written request.

Department:

Louisiana Oil Spill Coordinator's Office (LOSCO) - Office of the Governor

Mandate:

LA R.S. 30:2480 C (1) requires "an inventory that identifies and catalogs the physical locations, the seasonal variations in location, and the current condition of natural resources; provides for data collection related to coastal processes, abandoned pits, facilities, sumps, reservoirs and oil spills; and identifies the recreational and commercial use areas that are most likely to suffer injury from an unauthorized discharge of oil." According to: LA R.S. 30:2480 C (3), the inventory and catalog of current conditions of selected natural resources in the state "shall be determined by, at a minimum, a baseline sampling and analysis of current levels of constituent substances selected after considering the types of oil most frequently transported through and stored near coastal waters."

Objective:

The LOSCO monitoring program is designed to establish baseline hydrocarbon conditions in the environment, which can then be used in natural resource damage assessments.

Number of stations:

There are 1,180 monitoring stations located in coastal Louisiana.

Variables collected:

Wind velocity and direction; visibility and percent cloud cover; air temperature; water temperature, pH, and salinity; and Petroleum Hydrocarbons.

Frequency:

Sampling has occurred once a year for a period of three years.

Sampling design:

Fixed locations are sampled.

Data management:

The database is being developed and will be available on the web once it has been completed.

Mississippi

Department:

Mississippi Department of Environmental Quality, Office of Pollution Control Estuarine Monitoring Program

Mandate:

To protect, maintain and improve the physical, chemical and biological integrity of Mississippi's inland and near-coastal waters as set forth by the Mississippi Air and Water Pollution Control Act and the Federal Clean Water Act.

Three elements of OPC's Surface Water Monitoring Program contribute ambient monitoring data for assessment of long-term water quality status and trends for Mississippi's coastal waters. These are the Ambient Primary Fixed Station Network, a rotating Basin Fixed Station Network and Mississippi's Coastal Beach Monitoring Program Network. These networks are sampled routinely for a broad range of water quality parameters and indices. Parametric coverage at the stations includes physical, chemical, bacteriological, biological, fish tissue and/or sediment components.

A. The Ambient Primary Fixed Station Network

Objectives:

1. To characterize and assess statewide water quality status and trends in the state's stream, lake, and estuarine waters for general reporting in the Section 305(b) Report to Congress and the annual development of the priority list of impaired waters as required in Section 303(d) of the Clean Water Act;

2. To address public interests and concerns on key waterbodies;

3. To support the design and implementation of OPC's Surface Water Division water management programs including NPDES, nonpoint source, water quality standards, TMDL development, basin initiatives and water quality planning/management;

4. To evaluate the effectiveness of OPC's overall pollution control programs;

5.To address economic development interests and concerns.

Number of Stations:

Of the 145 ambient monitoring stations in the statewide Primary Fixed Network , 17 are located in Mississippi estuarine waters. Seven of these stations are located at the mouths

of tidal rivers while ten stations are located in open estuarine waters. Seven of these ten are located in two of Mississippi's significant bays, St. Louis Bay and the Biloxi Bay system and the remaining three fixed stations are located in the waters of the Mississippi Sound between the offshore barrier islands and the mainland coastline.

Variables collected:

These stations are visited either monthly or quarterly depending on the site and sampled for water chemistry (dissolved oxygen, pH, temperature, transparency, salinity, total organic carbon, nutrients, solids, turbidity, heavy metals and phenol) and bacteria (fecal coliform-MPN). Water chemistry samples taken for laboratory analyses are collected either at mid-depth for waters with a total depth less than ten feet or at a depth of five feet for stations with a total depth greater than ten feet. In-situ parameters (dissolved oxygen, pH, temperature, transparency and salinity) are depth profiled. Bacteriological samples are collected from the surface.

Selected estuarine stations are also sampled for fish tissue analysis and chlorophyll a. Fish tissue analyses are conducted annually and allow detection of the presence and accumulation of pesticides, other organic compounds and heavy metals of concern. This is especially important in the determination of exceedances of acceptable levels for human consumption. Phytoplankton sampling is the assessment technique of choice for chlorophyll a analysis at Mississippi's estuarine sites and is collected annually or quarterly depending on the site. In addition, selected Primary Fixed Network stations will also be sampled for sediment toxics every five years as part of the rotating Basin Approach recently adopted by OPC. Sediment samples will be analyzed for the same parameters as fish tissue samples.

Frequency:

Physical/chemical and bacteriological variable are sampled monthly; chemical (metals) variables are sampled quarterly. A complete list of the estuarine Primary Fixed Network monitoring stations, station locations, sampling frequency and parameter group coverage can be found in an in-house Excess database.

Sampling design:

Conventional (i.e. targeted) design

Data management:

All primary and basin fixed station physical, chemical and bacteriological data collected in OPC's Surface Water Monitoring Program are entered into EPA's STORET database. Data collected as part of the Beach Monitoring Program and all biological, sediment and fish tissue data are presently entered into in-house database systems. Once EPA's New STORET system is operational, subsequent upload of all of this data into New STORET will occur and is tentatively scheduled for Fall 1999. OPC's Geographic information system (GIS) capabilities are currently being redesigned with revised coverages being

available in 1999.

B. Basin Fixed Station Network

Objectives:

The primary objective of the Basin Monitoring Network is to increase the total areal coverage of waters monitored in Mississippi. This objective is achieved by concentrating monitoring and assessment resources in specific drainage basins in the state. As a consequence, basin management plans and implementation strategies may be developed. Another major objective of the Basin Network is to verify the actual water quality of waters classified as threatened or potentially impaired in previous Section 305(b) Water Quality Reports to Congress, in cases where these assessments were based on evaluations of information other than current site-specific monitoring data. Such verification by monitoring ultimately confirms the accuracy of the state's Section 303(d) list of impaired waters.

Number of stations:

36

Variables collected:

Basin monitoring requires the collection of additional data, relative to the Primary Fixed Station Network. OPC field staff are already committed to the extensive data collection of the Primary Network. Therefore, to implement basin monitoring, a sampling effort which is cost-effective and rapid must be utilized. The predominant sampling tool for basin freshwater stations is rapid biological assessment monitoring for benthic macroinvertebrates. In addition, multi-media sampling involving limited water chemistry, bacteria, algae, fish and/or sediment is conducted. For estuarine waters, only water chemistry, bacteria, algae, fish and sediment data is collected.

Water chemistry parameters collected are limited to the non-toxic parameters listed in the parameter list for the Primary Network.

Frequency:

For chemical, bacteriological and algal (chlorophyll a) sampling, the stations are visited twice during the sampling year at loosely scheduled times that correlate with typical high flow and low flow periods. However, for our first basin cycle in 1998, chlorophyll sampling frequency was limited to one collection due to startup problems. Fish and sediment sampling occurs once generally during the late summer and fall of the year and are analyzed for pesticides, other critical organics and heavy metals.

Sampling design:

Like the Primary Fixed Station Monitoring Network, the network of basin stations is of a conventional or targeted design and each station must meet both the objectives of the overall Surface Water Monitoring Program and also station specific selection criteria

Data management:

All primary and basin fixed station physical, chemical and bacteriological data collected in OPC's Surface Water Monitoring Program are entered into EPA's STORET database. Data collected as part of the Beach Monitoring Program and all biological, sediment and fish tissue data are presently entered into in-house database systems. Once EPA's New STORET system is operational, subsequent upload of all of this data into New STORET will occur and is tentatively scheduled for Fall 1999. OPC's Geographic information system (GIS) capabilities are currently being redesigned with revised coverages being available in 1999.

C. Coastal Beach Monitoring Network

Objectives:

In response to increased concern over the lack of routine bacteriological monitoring on the state's coastal bathing beaches, OPC in 1997 cooperated with the Gulf Coast Research Laboratory (GCRL) and EPA's Gulf of Mexico Program to reestablish a coastal beach monitoring program to address this concern. From 1971 to 1989, OPC and the Mississippi Department of Health conducted beach monitoring each summer to determine bacterial levels in swimming areas along the Mississippi Gulf Coast. Discontinued in 1989 due to funding constraints, these studies indicated that the principal cause of elevated bacteria levels was urban stormwater runoff, malfunctioning septic tanks and poorly-treated effluents from private wastewater treatment facilities. By the late eighties, much improvement had been shown in bacteria levels since many of these numerous private sewage systems and several unsewered areas had been connected to regional sewage treatment facilities.

In 1997, a comprehensive water quality monitoring program was established to assess the seasonal condition of the immediately accessible waters along the public bathing beaches of the state of Mississippi.

Number of stations:

20

Variables collected:

Year-round monitoring for bacteriological and other water quality parameters began in July 1997 at 20 stations along the Mississippi Gulf Coast. Parameters monitored weekly include in-situ water chemistry (dissolved oxygen, temperature, salinity, pH and turbidity), bacteria (fecal coliform-MPN and MF, *E. coli* and enterococci) and environmental parameters (tide, wind, rainfall and stage of river nearest station). Monthly samples include nutrients (phosphorus, Kjeldahl nitrogen, nitrite/nitrate and ammonia) and chlorophyll a. Stations are sampled by wading directly off the beaches to a specified depth with samples being collected at mid-depth. Sampling is being conducted by GCRL with laboratory services being provided by both GCRL and the OPC

laboratory. A multi-agency Beach Monitoring Task Force has also been established composed of representatives from OPC, GCRL, the Mississippi Department of Marine Resources and the Mississippi Department of Health to address beach monitoring and public health issues. A complete list of the Beach Monitoring Network stations, station locations, sampling frequency and parameter group coverage are shown in the attached tables.

Frequency:

Weekly samples include in-situ water chemistry (dissolved oxygen, temperature, salinity, pH and turbidity), bacteria (fecal coliform-MPN and MF, *E. coli* and enterococci) and environmental parameters (tide, wind, rainfall and stage of river nearest station). Monthly samples include nutrients (phosphorus, Kjeldahl nitrogen, nitrite/nitrate and ammonia) and chlorophyll a.

Sampling design:

Conventional (i.e. targeted) design

Data management:

All primary and basin fixed station physical, chemical and bacteriological data collected in OPC's Surface Water Monitoring Program are entered into EPA's STORET database. Data collected as part of the Beach Monitoring Program and all biological, sediment and fish tissue data are presently entered into in-house database systems. Once EPA's New STORET system is operational, subsequent upload of all of this data into New STORET will occur and is tentatively scheduled for Fall 1999. OPC's Geographic information system (GIS) capabilities are currently being redesigned with revised coverages being available in 1999.

The OPC laboratory serves as the focal point of the agency quality assurance program and its staff has developed and updated a detailed and effective standard operating procedure manual, the MSOPC "Standard Operating Procedures and Quality Assurance Manual" Vol. IV. The manual was originally reviewed and approved by EPA in 1983 and is periodically updated to reflect changes in analytical methodologies and in the Code of Federal Regulations. The current version was completed in November 1991, and was reviewed by EPA in 1993. The manual is currently undergoing review with the updated revision targeted for early 1999. A sub-set of this manual is a detailed field manual and is provided to each staff member. This quality assurance process is set up to ensure that samples are collected and analyses completed within required holding times and all proper preservation techniques are employed. All field sampling and analytical measurements for the OPC's Surface Water Monitoring Program are made according to this manual and/or other EPA - approved methods.

Alabama

Department:

Alabama Department of Environmental Management

Mandate:

305(b)

Objectives:

The overall objective for the comprehensive monitoring plan is to: *Assess the "health" or condition of the coastal waters of Alabama and track changes in that condition through time*. As it is obvious that this statement has a different meaning for different individuals, most of the discussion can be reduced to: (1) A baseline of condition of all coastal waters, (2) A baseline of condition for selected coastal waters, and/or (3) paired sites of affected and unaffected locations within coastal waters.

It is clear that any monitoring strategy will have to address both wide-scale baseline assessment of condition and site-specific issues regarding anthropogenic influences on coastal waters. The Alabama Monitoring and Assessment program (ALAMAP) is designed to incorporate all of these issues through a multi-tiered design that addresses baseline ecosystem-level conditions, long-term trends, and hypothesized environmental problems; and yet, the program remains flexible enough to be useful in addressing future problems.

Number of Stations:

The ALAMAP Program has been adapted as our State-wide sampling program. The following information pertains to the coastal portion. Probabilistic approach: There are about 140 stations throughout four regions that are sampled once over a two-year period. In addition to those 140 stations there are 53 stations that are sampled quarterly.

Fixed station approach: There are 16 fixed trend stations throughout coastal tributaries that are sampled three times a year.

Variables collected:

Probabilistic approach: *WATER COLUMN*: weather conditions, air temperature, water temperature, pH, conductivity, salinity, dissolved oxygen, Secchi depth, wind speed and direction, turbidity, TSS, TDS, chlorophyll a, NH3-N, NO3-N, TKN, PO4-P, and fecal coliform. *SEDIMENT:* various metals, selected pesticides and other *organic chemical* parameters.

Fixed Station approach:

WATER COLUMN: weather conditions, air temperature, water temperature, pH, dissolved oxygen, conductivity, salinity, turbidity, alkalinity, BOD5, chlorides, hardness,

TDS, TSS, NH3-N, NO3-N, TKN, PO4-P, fecal coliform *SEDIMENT:* metals

Frequency:

Probabilistic approach: 140 stations sampled once over 2 years plus 53 stations sampled quarterly. Fixed station approach: 16 stations sampled once during June, August, and October. Sediment metals are collected once during October.

Sampling design:

Probabilistic and fixed station

Data management:

STORET, and personal computer programs (i.e. Microsoft Excel spreadsheet and ArcView)

Department:

Alabama Department of Conservation and Natural Resources

Mandate:

To monitor biological organisms and hydrographic parameters in Mobile Bay.

Objectives:

To compile a long-term data set that will allow Alabama Department of Conservation and Natural Resources/ Marine Resources Division (ADCNR/MRD) biologists to recognize changes in Mobile Bay that are not attributed to naturally occurring variations.

Number of stations:

9 BPL, 2 seine, 45 trawl (with ADEM)

Variables collected:

Water temperature, salinity, and dissolved oxygen, species ID, Species number and length of individuals, weight of spp

Frequency:

Quarterly

Sampling design:

Probabilistic

Data management:

RS data base

Florida

Department:

Florida Department of Environmental Protection/ Division of Marine Resources/ Marine Research Institute

Program:

Inshore Marine Monitoring and Assessment Program (IMAP)

Mandate:

The IMAP program is an EPA sponsored grant program.

Objective:

To provide a statewide estimate of the ecological condition within the estuaries with a known level of confidence.

Number of Stations:

180 stations are visited in estuarine and nearshore coastal waters statewide each year (beginning in Fall, 1999). 30 stations are selected randomly in estuaries statewide, and 150 stations are distributed in five regions (Water Management Districts – 30 per WMD

per year).

Variables collected:

Base indicators measured at all stations include temperature, dissolved oxygen, depth, salinity, pH, nutrients, chlorophyll a, bottom type, macrobenthos, sediment grain size, total organic carbon, percent silt-clay, submerged aquatic vegetation, vegetation species composition, vegetative cover/abundance, vegetative disease, vegetation shoot density, vegetation biomass, leaf area indices, # of leaf scars on lateral shoots, # of vegetative rhizome apices, fishery abundance and fishery gross external pathology. Supplemental indicators on a statewide scale only include sediment contaminants, contaminant residue in fish, stable isotopes of nitrogen in fish, and presence of *Pfiesteria*-like organisms in sediments.

Frequency:

Once per year during a late summer/early fall index period. The program begins sampling in 1999 and is funded for 5 years, with the expectation of long-term funding.

Sampling design:

The IMAP program uses a stratified random sampling on a triangular grid.

Data management:

Data is entered and stored in PCs using the SAS Base software.

Department:

Florida Department of Environmental Protection/ Marine Research Institute

Program:

Integrated Water Resources Monitoring (IWRM) Program

Mandate:

The Integrated Water Resources Monitoring Program (IWRM) utilizes a three tiered approach to integrate monitoring to address point and nonpoint sources of pollution and their related environmental problems.

Objective:

The first tier of IWRM will provide a broad assessment of the status of Florida's water resources including lakes, streams, surficial aquifers, and estuaries. The second tier is directed to providing more detailed information about a basin and is directly linked to the Watershed Management Program's basin management approach. The third tier is directed toward monitoring that supports regulatory programs.

Number of Stations:

Sampling will be conducted on a five year rotating basis, where 20% of the State's basins are

monitored intensively during the first year while the remaining 80% would be monitored at a less intense level.

Variables collected:

Frequency:

Sampling design:

Data management:

Department:

Florida Department of Environmental Protection Marine Research Institute

Program:

Fisheries-Independent Monitoring (FIM) program

Mandate:

The program was developed because of the critical need to provide effective assessment techniques for an array of species and sizes of fish and selected invertebrates, to provide timely information for use in management plans, and to monitor trends in the relative abundance of fishes in a variety of estuarine systems throughout Florida.

Objective:

The Florida Marine Research Institute's Fisheries-Independent Monitoring program (FIM program) is designed to monitor the relative abundance of fishery resources in major estuarine systems in Florida.

Number of Stations:

The FIM program has monitoring programs in Tampa Bay, Charlotte Harbor, Indian River Lagoon, Choctawhatchee Bay/Santa Rosa Sound, Florida Bay, Cedar Key, and Tequesta (Figure 1). In all regions, sampling is conducted in a variety of habitats including different bottom types, shoreline types, and offshore areas. In addition to sampling in estuaries, we sample the tidally-influenced portions of rivers that flow into Tampa Bay (Alafia, Little Manatee, and Manatee Rivers) and Charlotte Harbor (Peace and Myakka Rivers). Tidal river estuaries are the interface between the bay and its watershed, and a critical contributor to estuarine productivity (Estevez et al. 1985). Details of all study areas except Cedar Key and Tequesta are described in the FIM program's 1994 Annual Report; details of the Cedar Key study area are described in the FIM program's 1996 Annual Report; details of the Tequesta study area are described below.

Variables collected:

Environmental data on water quality, habitat characteristics, and physical parameters such as current and tidal conditions were recorded for each sample regardless of gear type or sampling regime.

Abundance estimates were calculated for 21-m seine and trawl data as the number of fish per 100 m^2 of area sampled. Catch-per-unit-effort was calculated for gillnet data as the number of fish per soak hour and for 183-m haul and purse seine samples as the number of fish per haul. Data were summarized separately for each bay system and for each gear type. In the tables, data were summarized separately for all species and for species of special recreational or commercial importance.

Frequency:

Monthly sampling with 21-m seines and 6.1-m otter trawls was conducted at all field labs in 1997, except Tequesta where only the 183-m haul seine was used. Seines and trawls have been used in all study areas since the FIM program was initiated in each area. Gillnet sampling was discontinued in all study areas in 1995, except Indian River Lagoon where routine monthly gillnet sampling continued through February 1997. Monthly sampling with the 183-m haul seine was continued in Tampa Bay and Charlotte Harbor, and initiated in Indian River Lagoon, Cedar Key, and Tequesta. Routine year-round monthly sampling with the 183-m purse seine was initiated in 1997 in Tampa Bay. All sampling ceased in Choctawhatchee Bay/Santa Rosa Sound in April 1997 and in Florida Bay in October 1997.

Sampling design:

A stratified-random sampling (SRS) design was used for all gears in Tampa Bay, Charlotte Harbor, Indian River Lagoon, Choctawhatchee Bay/Santa Rosa Sound, Florida Bay, Cedar Key, and Tequesta. Each study area was divided into sampling zones based on geographic and logistical criteria, and each zone was further subdivided into 1-nm^2 grid cells that were randomly selected for sampling. The number of monthly samples collected in each zone with each gear was proportional to the number of grids in the zone that could be sampled with a particular gear. A single sample was collected at each randomly selected site. Sampling grids were stratified by depth, thereby identifying the gear types that could be used in those areas. Seine samples were further stratified by habitat type: 21-m offshore seine samples were stratified by presence or absence of bottom vegetation, and 21-m boat seine and 183-m haul seine samples were stratified by the presence or absence of overhanging shoreline vegetation. All sampling was conducted during daytime, except gillnet sampling which was conducted during the evening crepuscular period.

A fixed station sampling design for trawls and 21-m seines has been used in Florida Bay since 1994. Thirty fixed stations were distributed throughout Florida Bay and were representative of habitat types in the study area. One sample was collected monthly at

each station. In 1997, SRS sampling began in this system as part of a paired SRS and fixed station sampling design.

Data management:
Data is entered and stored in PCs using the SAS Base software.

Department:
Florida Department of Environmental Protection/ Division of Marine Resources/ Marine Research Institute

Program:
Bay Scallop Monitoring

Mandate:
The Bay Scallop program was mandated to track the population of the Bay Scallop populations on the west coast of Florida.

Objectives:
To assess the bay scallop assemblages as an indicator of habitat dynamics.

Number of Stations:
Sampling to enumerate adult bay scallops is undertaken at 20 sites in each of six areas (Pine Island Sound, Anclote estuary, Homosassa Bay, Steinhatchee, St. Joseph Bay, St. Andrew Bay/St. Andrew Sound).

Variables collected:
Number of adult bay scallops present. Number of bay scallops per recruits per spat collector per day. At each site, SCUBA-assisted diver surveys are conducted to enumerate adult scallops along a randomly-located 300 m transect (all scallops within 1 m of the transect are included). Spat collectors are deployed in triplicate at each of nine stations in Homosassa, Anclote, and Steinhatchee in the fall.

Frequency:
In 1997, sites in Pine Island Sound, Anclote estuary, Homosassa Bay, Steinhatchee, St. Joseph Bay and St. Andrew Bay/Sound were sampled in June, with follow-up surveys conducted in Homosassa Bay, Steinhatchee, and St. Joseph Bay during September and October. Past and subsequent sample years followed a similar pattern. Sampling was initiated in ’93 in Homosassa Bay, and ’94 in all other sites, and is expected to continue in the near future. Spat collectors are deployed at Anclote, Homosassa, and Steinhatchee in the fall and soaked for six weeks.

Sampling Design:
Fixed sampling sites.

Data Management:

Data is entered and stored in PCs using the SASBase software.

Department:

Florida Department of Environmental Protection/ Division of Marine Resources/ Marine Research Institute

Program:

Fisheries Habitat Assessment Program (Seagrass)

Mandate:

The Fisheries Habitat Assessment Program of the Marine Research Institute was initially developed to map and assess seagrass beds in the coastal waters.

Objectives:

To determine the status and trends of Florida's submerged aquatic vegetation habitats.

Number of Stations:

Approximately 300 sites (30-35 sites in each of 10 basins) throughout Florida Bay. Sites within basins are randomly determined within a triangular grid.

Variables collected:

Spring samples – 15 cm cores for quantitative determination of seagrass density (number of shoots/area); 4 replicate 0.25 m^2 quadrats are randomly located at each station and Braun-Blanquet cover/abundance (see table below) values recorded. Fall samples – Braun-Blanquet only. In both seasons synoptic physical data (depth, temperature, salinity, light, PAR, secchi) are collected at each station.

Frequency:

Two times per year, spring and fall. Sampling began in spring of '95 and is funded through fall 2001.

Sampling design:

Stratified random sampling.

Data management:

data is currently entered into the PC based spreadsheet programs Microsoft Excel and Quattro Pro.

Department:

Florida Department of Environmental Protection/ Division of Marine Resources/Marine Resource Regulation and Development Bureau

Program:

Shellfish Environmental Assessment Section (SEAS)

Mandate:

The Shellfish Environmental Assessment Section is responsible for ensuring safe molluscan shellfish for consumption through setting of closure lines for oyster harvesting.

Objectives:

To determine the proper classification of shellfish grounds in accordance with the National Shellfish Sanitation Program RS:40, part 5 and part 3.

Number of Stations:

Approximately 870 sites in 24 Shellfish Harvesting Areas on the Gulf Coast.

Variables collected:

SEAS collects data on water depth; surface and bottom temperature, salinity, dissolved oxygen; wind direction and velocity; and sub-surface pH, turbidity and fecal coliform.

Frequency:

Sites are visited monthly when Shellfish Harvesting Areas are conditionally approve for harvesting. Sampling frequency varies from quarterly to monthly in Shellfish Harvesting Areas closed to harvesting. More frequent re-opening sampling is conducted following temporary closures. Many of the harvesting areas have been monitored since the early 1980s.

Sampling design:

Fixed sites.

Data management:

Data is currently entered into an mainframe system.