A

SEGMENTATION SYSTEM

for the

SARASOTA BAY PROJECT

NATIONAL ESTUARY PROGRAM

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to the

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EXECUTIVE SUMMARY

Because this Segmentation System is the first technical product to be completed under the Sarasota Bay National Estuary Program, its importance to other elements and phases of the Management Conference is comparable to the selection of data management tools or implementation of the bay monitoring program. Segmentation creates a set of geographically defined areas in the bay and on adjoining uplands or in gulf waters, for the purposes of study design, data analysis, and reporting. The process used to develop a segmentation system for bays is not well described, therefore the Sarasota Bay procedure has been carefully peer-reviewed and reported so that it might be useful to others beginning a new segmentation project. The first task involved a survey of segmentation systems in all NEP projects (in 1989), other federal programs, and selected state and local bay programs. Some of the best such systems were found in San Francisco Bay, Chesapeake Bay, Nueces and Mission-Aransas Estuaries (Texas), and in the Gulf of Mexico (NOAA/NOS). Several established NEP and other estuary projects lack segmentation systems and some beginning programs do not expect to segment their water-bodies for management purposes. The second task involved a review of segmentation systems and geobased data specific to Sarasota Bay. A number of systems exist for uplands within the Study Area whereas only one stream segmentation system was identified. Bay waters are variously subdivided but coverage is uneven and no single or combined set of existing segments are adequate for NEP management purposes. Beaches have been segmented for erosion or nourishment studies, and nearshore Gulf waters have never been subdivided for management or research purposes. The Bay area is generally "data-poor", and few data have been collected, analyzed or reported with regard to geographic place. The chief exceptions are geological, seagrass and wetland studies. No synoptic picture of system-wide water quality presently exists for the Sarasota Bay Study Area. The next set of tasks involved segment definition, moving from general to specific bay areas. The idea of a segment focus was introduced, as the essential feature(s) in a bay area for which one or more segments would generally be needed. The idea of a problemshed was introduced, as the geographic area which most likely encompassed problems that were causally related to the essential features (foci) of each bay area. The problemshed for a given focus ends where

the influence of other foci are manifest. The idea of a soft boundary was introduced, as the general area between problemsheds and within which segment boundaries need to be defined with more precision. Foci and problemsheds were defined for Sarasota Bay based on the findings of these tasks plus a review of the Governor's Nomination Report and related controlling documents of the project. Foci were mapped and aggregated according to their proximity, and then the outermost inclusive limit of their respective problemsheds were established. Broad zones were mapped between the problemshed boundaries using natural features such as watersheds, bathymetric contours, or other natural features as guidelines. These zones were used as the soft boundaries within which segment boundaries were defined.

Basin and sub-basin boundaries are recommended as upland segments. Stream segments established by the Florida Department of Environmental Regulation for biennial water quality reporting are recommended for tributaries. Improvements are also specified for use of basin and stream segments: for example, island watersheds and tidal reaches of tributaries are two recommended improvements. Seven reaches of Gulf beaches are also defined. Due to the regional nature of sediment transport, the beach reaches extend farther south than the official Bay Study Area. Results of the issue focus, problemshed and soft boundary approach were used to establish 16 segments of open bay water. Each is mapped and coordinate positions are given of boundary end-points and turning-points. The segments vary in size from very small inlet units to relatively large open-bay units. The segments will permit aggregation for the sake of data reduction, analysis, and presentation. Some of the segments also allow for further subdivision if needed. Bay segments bracket the mouths of tributaries and encompass the areas of their probable effects (problemsheds). Most boundaries follow natural features, as bourne out by meetings with the leaders of characterization studies and the Technical Advisory Committee. Most uses of the segmentation system in this area should be to separate east shore data from west shore data and the number of instances where precise location of the boundary is critical, will be few. Overall, the use of basins, stream reaches, bay segments, and gulf reaches as primary geographical references in the Sarasota Bay NEP Project should enhance the design of sampling and measurement tasks. The tasks of data management, reduction, and analysis should be simplified. Comparability of data from different tasks should be enhanced. Presentation of technical data to a general audience will be simplified by using geographically sensible units. And ideally, the segmentation system will contribute to comparison of Sarasota Bay data to the findings of NEP projects in other estuaries.

PREFACE

The essential steps in managing a natural resource include knowing its status, setting goals for its future condition, and taking measures to move the resource from its present condition to that described by the goals.

In the vocabulary of the National Estuary Program, the status of an estuary is made known through the nomination process, reviews of historic data, production of **State of the Bay** reports, and characterization studies that begin soon after designation of the bay to the Program. Goals are established early in each project and refined as the Management Conference evolves. The Conference refines and codifies the goal statements and defines the actions needed to accomplish the goal through such reports as the **Framework for Action** and the **Comprehensive Conservation and Management Plan.**

Each management stage is served by the use of a meaningful segmentation system, which system divides the study area into geographically distinct cells. The review of historic data in each segment reveals areas in need of new work. Characterization studies are improved by efforts to sample and measure in every segment. Data management is simplified because data can be retrieved and analyzed for sensible reaches of uplands, tributaries, and open waters. Reports are easier to read when results are presented by segment. Goals can be made specific to the management needs of particular parts of the study area. All of these benefits are further enriched in estuaries for which little modern or synoptic information exist, which is the case for Sarasota Bay, Florida.

This report formally presents the methods used to develop a Sarasota Bay segmentation system, and also describes the system in detail. It borrows a number of good ideas by others who have developed successful systems for estuaries already under study, and suggests a few new approaches that may be specifically useful in estuaries joining the National Estuary Program or undertaking similar resource management projects.

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INTRODUCTION

DEFINITION OF SEGMENTATION

Segmentation systems are geographical subdivisions of an estuary or other natural landscape feature, into connecting parts that reflect the characteristics of each sub-area. Segmentation systems enhance research and management.

For deep and stratified estuaries, segments can also be defined in a vertical axis. Segments can be established for tributaries to an estuary, or for adjacent uplands. Segments are usually closed (bounded on all sides) but segments can also be open, as in the case of nearshore waters along a coastline for which no seaward sides are defined.

END-USES

Historically, segmentation systems have been used primarily as a data management tool. Data would be labelled according to the segments of their origin and this "address" could be used to aggregate data for purposes of reduction, analysis, or presentation. Zip Codes are a literal form of segmentation.

Today, the necessity for segmentation as a data management tool is less great because geographic information systems -- computerized, cartographic records --are in common use and complicated "addresses" and "zip code" systems have been replaced by coordinate system labels (such as latitude and longitude). The capabilities of geographic information systems, or GIS, for data reduction, analysis and presentation are growing rapidly, but already make possible very sophisticated products that were unavailable to resource managers only a few years ago.

Segmentation systems are still used in a narrower and more technical part of estuarine science, namely hydrodynamic modelling. Circulation and water quality models are becoming a regular feature of estuarine management programs because they depict circulation, flushing, tributary input, and the concentration of many relevant constituents, including pollutants. The models are mathematical representations of an estuary and work by computing the exchange of water and other material between segments, according to fundamental laws of physics and chemistry.

Segments developed for hydrodynamic modelling tend to be too small and numerous for general use. On the other hand,

models produce insight to the physical nature of estuaries that enhances general segmentation of the system. Not counting segmentation for modelling purposes, segmentation systems still can play three important roles in estuarine management.

First, they cause existing information on a system to be reviewed for the purpose of defining landscape-level diversity, and the similarity or dissimilarity of areas within the system. This is a useful screening process at the start of a management program.

Second, they facilitate the design of data collection projects such as characterization studies in the National Estuary Program. Reviews of historic data are simplified through the use of segmentation systems. Also, segmentation systems help balance the distribution of effort made by individual studies.

Third, segmentation simplifies data reduction, analysis and presentation. Even though GIS offers very significant opportunities for data management, segmentation can establish a priori rules for grouping data, comparing data from different studies and presenting data. Presentations of technical data to the general public can be made easier to understand when references are made to commonly known areas of the estuary.

LIMITATIONS

In the context of these three uses, there still remain some practical limitations to the development and use of segmentation systems. No one system can be universally useful. Boat traffic studies face the problem of distant originations or destinations. The same is true for studies of highly mobile fauna such as marine mammals, or birds. It may be necessary to establish special segments for unique uses. A headland providing sediments to sandy beaches in a study area may not be in the area itself, but cannot be ignored in the development of a beach management plan.

Segmentation systems are best viewed as advisory in nature and use. In most cases, new research conducted as part of a management program will probably reveal new insights to the structure and function of the estuary, causing revisions and improvements to the original segmentation scheme.

Segmentation is generally easier and more meaningful in data-rich estuaries. In relatively data-poor estuaries such as Sarasota Bay, segmentation provides for balance in the distribution of research effort that must be expended efficiently during a short period of time.

DESCRIPTION OF PROCESS

Very few descriptions are available of the process used to develop a segmentation system for estuaries or other natural resource units. Consequently, this report outlines our methods as well as findings and recommendations, in the hope that the process might find use in other estuary management programs undertaking a segmentation system.

DESCRIPTION OF PRODUCT

This report describes the findings of a survey on segmentation systems used in other NEP projects, other federal coastal programs, segmentation systems used by the State of Florida, segmentation systems in use in Sarasota Bay, and geobased data sets for Sarasota Bay.

This report also describes the process used to develop segment foci, segment boundaries, and segment labels. The process is applied to uplands, streams and open bay waters. A separate system is developed for open waters of the Gulf of Mexico.

ACKNOWLEDGEMENTS

We are grateful to Jean McGuire, Mote Marine Laboratory Librarian, for obtaining many essential reports on short notice. We thank each of the National Estuary Program's project offices for providing information. The cooperation of several state, regional and local governments simplified our search for information. We are especially grateful to members of the Sarasota Bay NEP Technical Advisory Committee, for their input on project design and findings, and to Daniel Basta, for introducing the concept of problemsheds. A preliminary draft of this report was critically reviewed by Richard A. Batiuk (EPA Chesapeake Bay Liaison Office), C. John Klein III (NOAA/NOS Ocean Assessments Division), Andrew Gunther (Aquatic Habitat Institute), and Paul Roat (Sarasota Bay NEP Project Office).

SEGMENTATION AND THE SARASOTA BAY NEP PROJECT

Sarasota Bay joined the National Estuary Program in 1988 and in 1989-90 major project activities have included the establishment and staffing of a project office: appointment of standing committees in the management conference: development of short and long term work plans: production of quality assurance program and project plans: and initiation of characterization studies. The program also produced a "Bay Repair Kit" for citizen use and finalized a "State of the Bay" report published in 1990.

Segmentation relates to the accomplishments and works in progress of the Sarasota Bay project in a number of ways. It will influence the design of data collection efforts for the following characterization studies:

- An inventory and trend analysis of wetlands:

- An inventory and trend analysis of estuarine bottoms:

- A shellfish contamination survey:

- A survey of fish distribution and fishing effort:

- A point and non-point source pollution loading and trend analysis:

- A beach and inlet management plan:

- An inventory of recreation and boating traffic:

- An assessment of potential sea level rise impacts:

- A circulation and constituent transport model.

The segmentation system will also affect the design and execution of a bay-wide monitoring program. In its first year of implementation (1990), the monitoring program will encompass a review of historic water quality and sediment data, a scan of sediments for contaminants, and a continuing sampling and measurement project to determine the bay's characteristic light and nutrient conditions. Other NEP tasks in which segmentation will play a role include development of a data management system, immediate action demonstration projects, citizen monitoring, educational programs, and the production of a benchmark document, "Framework for Action", scheduled for August, 1992.

DEFINITION OF THE SARASOTA BAY STUDY AREA

For the purposes of the NEP, the boundaries of Sarasota Bay and its drainage basin are presented in Figure 1. Palma Sola Bay, Perico Bayou, and Anna Maria Sound form the northern boundary of the study area, which extends southward to the Albee Road bridge over Blackburn Bay near Nokomis.

Additional named water bodies within the study area are Roberts Bay (landward of Siesta Key), Little Sarasota Bay, Dryman Bay and Blackburn Bay. The landward extent of the study area includes: the coastal drainage basins of Perico Bayou, Palma Sola Bay and upper Sarasota Bay: the Bowlees Creek, Whitaker Bayou, Hudson Bayou and Phillippi Creek basins; the coastal drainage basins of Little Sarasota Bay and Blackburn Bay, including North and South Creeks: and the barrier islands between the bay and Gulf of Mexico.

SARASOTA BAY

Sarasota Bay has been called a lagoon, a neutral estuary, and a bay. It meets the Clean Water Act's definition of an estuary as "all or part of the mouth of a river or stream or other body of water having unimpaired natural connection with the open sea and within which sea water is measurably diluted with the fresh water from land drainage." The bay is located between Tampa Bay and Charlotte Harbor, the nation's 17th and 18th largest estuaries, respectively. It exemplifies a number of water bodies along the Florida and gulf coasts by its proximity to open, shallow waters: much greater width than depth: physical dominance by wind and tides rather than tributaries: and intensive recreational uses. In 1989, it was the fourth smallest NEP estuary. Sarasota Bay is a small, subtropical embayment that has not been industrialized but has been affected by development and overuse. It is divided into two counties and two regional planning councils and is affected by several local government comprehensive plans as well as designation by the state as "Outstanding Florida Waters". Part of the bay is also affected by management policies adopted for Charlotte Harbor. These policies and regulations are not presently coordinated, nor do they operate in a larger management framework. Water quality is good in most of the bay, although nonpoint runoff has reduced nearshore salinity. Tributary basins are urbanized and receive septic tank and sewage plant effluents: however, direct sewage plant effluents to the bay are in the process of being diverted. There are no industrial activities or effluents affecting the bay. On the other hand, the bay's natural habitats have been affected adversely by dredging and filling, especially on beaches, inlets, residential shorelines, and the Intracoastal Waterway.

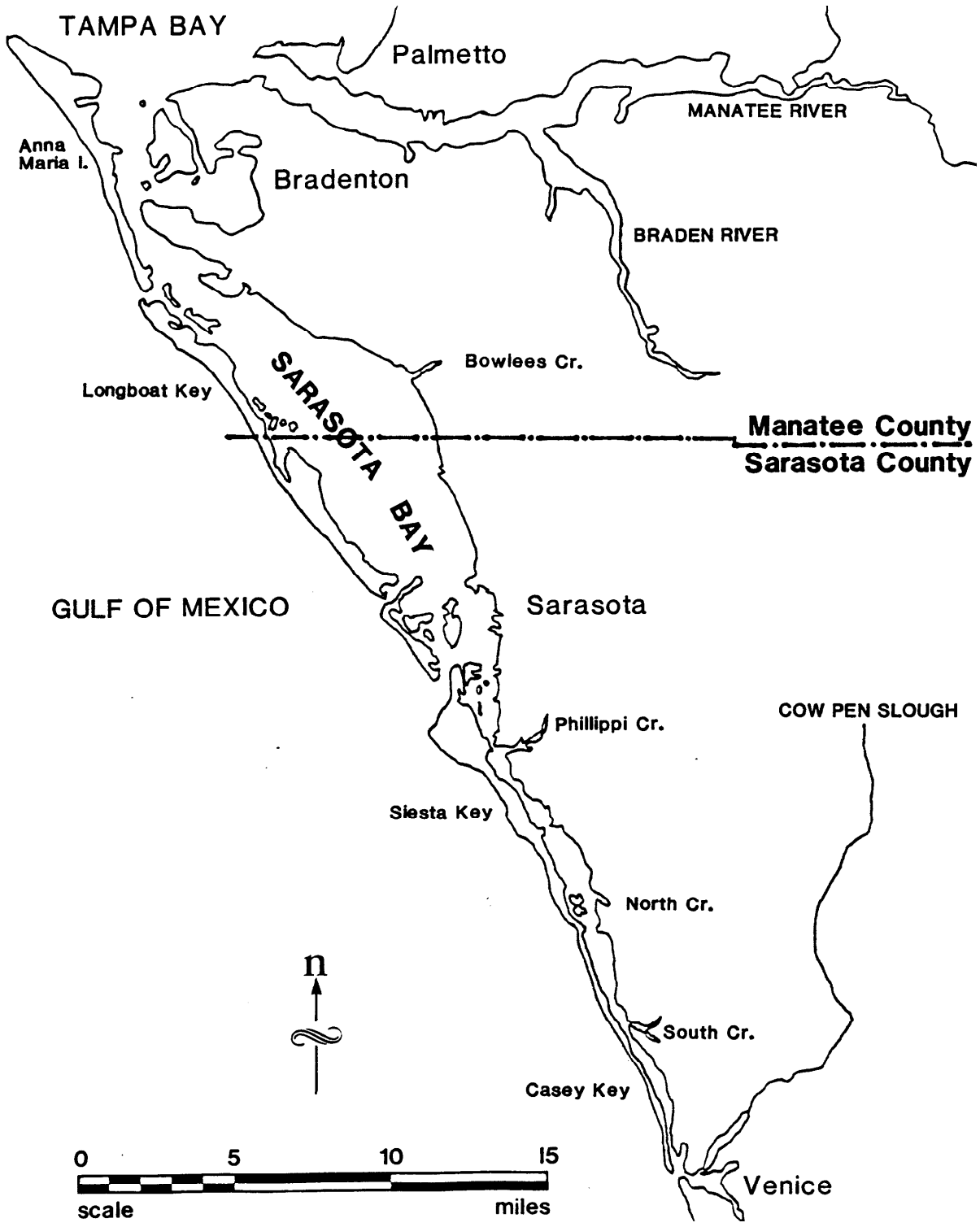

Figure 1. Sarasota Bay NEP Study Area, between Manatee and Braden Rivers, and Cow Pen Slough.

Native plant communities have declined, particularly seagrass beds, which have been impacted by turbidity and dredging. Grass beds near sewage plant discharges have nearly disappeared. Since 1960, seagrass losses have been paralleled by the loss of scallop, hard clam, and oyster fisheries. Loss of these commercial fisheries is believed to be due to seagrass decline, closure of approved shellfish areas, and over-harvesting (although the bay could probably support a renewed hard-clam fishery if closed waters were opened). Precipitous declines have occurred in landings of blue crabs, spotted sea trout, red drum and snook, whereas landings of stone crab (claws only) and mullet have increased dramatically. Sarasota Bay supports approximately 1,000 nests of Atlantic loggerhead turtles each year and is a major breeding ground of the bottlenose dolphin. (Dolphin populations in the bay have been studied longer than anywhere else in the world.) Manatees also occupy the bay and use it as a corridor for seasonal migrations.

Sarasota Bay's economic value is a result of its intense recreational use, as well as its indirect effect on waterfront property values. The bay supports about 50 water-dependent industries, institutions, and operations. Recreational uses take many forms, in particular, beach use and saltwater fishing (13 million user events in 1985 alone). The combined expenditures by visitors to the bay area was approximately $1.5 billion in 1987 alone.

Rapid urbanization (mostly since World War II) has placed heavy pressure on the bay's resources, especially in terms of development impacts and overuse resulting from large numbers of people using a relatively small estuary.

METHODS

There are no established methods for the development of a segmentation system generally applicable to estuarine management settings. Consequently, a methodology was defined for the Sarasota Bay Project in collaboration with the project office and Technical Advisory Committee. During the design phase, efforts were made to structure the tasks in such a way that other management programs might benefit from our experiences.

Tasks performed as part of the development process included:

1. Review of existing and new NEP projects

Each existing and new NEP project office was contacted by mail and telephone to determine whether (a) segmentation

systems had been developed or were being developed (b) methods for system development were documented, and (c) there was any interest in the Sarasota Bay segmentation process.

2. Review of other federal management programs.

This task entailed contacts with the Gulf of Mexico Program, Near Coastal Waters Initiative (for Perdido Bay, Florida), and the Chesapeake Bay Program, for purposes stated in Task 1.

3. Review of other bay management programs.

Florida has a number of bay management programs resulting from local initiatives, legislative mandates, and a state-wide comprehensive planning process. Three of these were contacted for purposes stated in Task 1, and one segmentation system from Texas was also reviewed.

4. Review of Sarasota Bay segmentation systems.

A number of segmentation systems for single-mission applications have been developed for Sarasota Bay by federal, state, regional, and local governments. Each was scrutinized for geographic coverage, parameter coverage, ease of use, effectiveness, transferability, and boundary conditions.

5. Review of qeobased data for Sarasota Bay.

Geobased data are the results of inventories, trend analyses, mapping of contaminants or resources, and similar graphic assessments. As many geobased data sets were studied as the 2 month project period allowed. Special emphasis was given to natural features, resources, or structures that could be used in segmenting the bay.

6. Creation of segment foci and problemsheds.

The idea of a segment focus is introduced, as the essential feature(s) in a bay area for which one or more segments will generally be needed. The features can be diverse in nature, ranging from a major point source discharge to a highly productive shellfish ground. The features could be important parks or preserves. Often, sets of these will be clustered together because of circulation, elevation, land use, historical, or geo-political boundaries.

The idea of a problemshed is introduced, as the geographic area which most likely encompasses problems that are causally related to the essential features (foci) of each bay area. A point source discharge has a spatially localized area of influence, for example. Within that area, the discharge is

known or presumed to be a problem for living resources, recreation, or other use or benefit. On the other hand, a major wetland system may be affected adversely by adjacent land or water uses, but less affected by more distant factors. The problemshed for that wetland ends where the influence of other foci are manifest.

The idea of a soft boundary is introduced, as the general area between problemsheds and within which segment boundaries need to be defined with more precision.

Foci and problemsheds were defined for Sarasota Bay based on the findings of Tasks 4 and 5, plus a review of the Governor's Nomination Report and related controlling documents of the project. Foci were mapped and aggregated according to their proximity, and then the outermost inclusive limit of their respective problemsheds were penciled around each aggregation. Broad zones were mapped between the problemshed boundaries using natural features such as watersheds, bathymetric contours, or other natural features as guidelines. These zones were used as the soft boundaries within which segment boundaries were defined,

7. Definition of segment boundaries.

Segment boundaries were defined so as to satisfy four criteria in addition to encompassing foci and problemsheds. First, the boundaries had to be located on maps and charts with a minimum of skill. Second, the boundaries had to correspond to reliable landmarks, navigation aids or other physical features to reduce field error. Third, the boundaries had to define segments of approximately equal length or area, if possible. Finally, the segments had to satisfy the maximum number of different end-uses.

8. Review by characterization project leaders and TAC

The preliminary segmentation system was presented to the leaders of all characterization studies that had begun as of November, 1989. The rationale, data bases, foci and problemsheds, and boundaries were evaluated in light of each project and comparisons were made between the project-specific segments and the preliminary, bay-wide system.

The preliminary segmentation system was adjusted to reflect the input from characterization project leaders and then was presented to the full Technical Advisory Committee for additional review and comment. A revised report was subsequently distributed for national peer review.

9. Refinement of segment definitions.

TAC input and other information arriving late in the project were used to refine the definition of segments. During this process several meetings were held with characterization project staff and the bay was surveyed by fixed wing aircraft, cars, and boats, to decide final boundary features.

RESULTS

NATIONAL ESTUARY PROGRAM

Most existing and new projects in the NEP do not have a formal segmentation system for general purposes and at least one project area, New York and New Jersey Harbors, sees little use for segmentation other than for modelling (Ausebel, personal communication). Highlights of other projects' segmentation status are given below. References to 305(b) water bodies are explained in the next section, on Other Federal Programs.

The best documented and formally presented segmentation system within the NEP was produced by the Aquatic Habitat Institute for San Francisco Bay (Gunther 1987). The segmentation report reviewed four past and present systems in use in the Bay and concluded that segments in each system were generally too large. The report proposed bay sections and a variable number of segments in each section. Sections are place-named ("South Bay") and segments have alpha-numeric codes (SB 1). Major outfalls are tabulated but not distributed across segments. A map of the bay and uplands are given. Segments are described in terms of location, boundaries and major features, but not evaluated with respect to size or usefulness. Apparently, the system has not yet been used in characterization efforts of the NEP project (Monroe, personal communication).

Puget Sound uses river basins for uplands and oceanographic regions for planning and literature reviews (Collias and Andreeva, 1977). Thirteen 305(b) "water bodies" are also defined on the basis of oceanographic features, pollution sources, data density, geographic features, size, and conformity to other segmentation systems (Gries et al., 1989). The Sound is divided into 7 fish management regions, and a GIS system has been developed in conjunction with the U.S. Army Corps of Engineers, which includes a segmentation system based on depth and other natural features (Copping, personal communication).

Santa Monica Bay, the other Pacific coast NEP project, uses a basin and "waste-shed" approach for uplands but has not developed a segmentation system for tidal waters and may not do so given the oceanic aspect of the study area (Hoenicke, personal communication).

In the Gulf of Mexico, the Galveston Bay NEP Project uses watersheds for upland segmentation, following a system developed by the Texas Water Commission, but has not yet segmented the bay (Kiesling, personal communication).

On the Atlantic coast, the Albemarle/Pamlico Sounds project has identified upland watersheds and recognizes river systems, but has not segmented open tidal waters for general management purposes.

Delaware Bay and Delaware Inland Bays has successfully defined the boundaries of the NEP study area, and already have use of a 305(b) water body classification system. In addition, the Delaware River Basin Commission determines use attainability on a basin. basis. Given their small size (about 15 square miles) the inland bays may not require further segmentation (O'Malley, personal communication).

Circulation models have been developed by Hydroqual, Inc. for the New Jersey and New York Harbors and Long Island Sound, and necessarily have segmented the areas for that purpose. Neither NEP project area has developed a general segmentation system. As previously mentioned, one is unlikely for the Harbors area, where data will probably be given coordinate labels, instead. Long Island Sound uses basin definitions and has not decided against general segmentation (Tedesco, personal communication).

Narragansett Bay is in the process of developing a segmentation system. Consistency will be a major goal for NEP purposes because the area has already been segmented for sampling (3 systems), modeling (3 systems), reporting (4 systems) and management (3 systems). In addition, at least two other systems will be developed soon: one for long-term monitoring and another for a water quality box model. A draft system is in review (Hale, 1989).

Buzzards Bay is in the process of developing a segmentation system with finer resolution than the nine areas presently in use. The new system will address long-term data management needs and employ GIS overlays for individual projects and monitoring (Costa, personal communication).

Massachusetts and Cape Cod Bays are not yet officially part of the NEP and have not developed a segmentation system (Maciolek, personal communication).

OTHER FEDERAL PROGRAMS

All coastal waters have been divided into water bodies for purposes of reporting on water quality under Section 305(b) of the Water Quality Act. Federal guidelines for division of state waters are listed in Table 1.

In addition to this national program, other federal projects are underway that have management objectives similar to the National Estuary Program and also employ segmentation systems.

The Gulf of Mexico Program is a multi-state initiative to manage inshore waters from Mexico to Florida. It is organized and managed using an NEP format. The Program is undertaking a number of characterization studies and has adopted a segmentation system for the gulf coast developed by the NOAA Strategic Assessment Program. The EPA commonly uses the system, as in the case of the Near Coastal Waters Initiative (see below). The system is well documented, rationally developed, and very useful for large-scale programs.

It begins with estuarine drainage areas, which are then subdivided into U.S. Geological Survey cataloging units and counties. Tidal areas are designated as sea water, mixing, or tidal fresh and estuarine areas can be further subdivided by isohalines, as multiples of 5 parts per thousand (Basta, personal communication).

The EPA Near Coastal Waters Initiative is another coastal resource management program, with a project in Perdido Bay, Florida. The bay has not been segmented.

Chesapeake Bay, the model for the National Estuary Program, has been segmented in a number of ways for different purposes. Early nutrient loading studies employed basin and sub-basin units. Fishery studies were divided by state, river and river reach, or depth. Watershed, circulation and water quality models have used 30 upland segments based on topography, hydrology and soils, and more than 100 bay segments. The bay segments are divided by approximately even latitude intervals, and are divided longitudinal as symmetrical bands organized along the midline of the bay (Linker, no date).

Table 1. Guidelines for Clean Water Act (CWA) segmentation.

1. Vary water body size to correspond to the need for resolution. Set up the largest water bodies that will support your needs.

2. Think ahead to how you will conduct future assessments and how you might want to report CWA lists and track problem areas.

3. Try to identify areas of uniform conditions. If a large area is affected only by similar nonpoint sources, it might be appropriate to establish a single water body for the area. If a small area within the larger area is significantly different, break it out as a separate water body.

4. Do not set up water bodies only to reflect current water quality. Water bodies should reflect hydrologic entities, sources of problem areas, or management information needs.

5. Try to take advantage of the reduced data requirements for "clean waters".

6. Keep in mind that under the overall option a water body assessment is either "evaluated" or "monitored" (this is a 305(b) requirement). You may want to distinguish water bodies that will only be evaluated from those that will be both evaluated and monitored (at different times, of course).

7. Take advantage of the flexibility provided in the water body designation and indexing procedures. For instance, you can designate everything upstream of a river mile-point, whole cataloging units, and areas excluding portions within the area.

8. Designate water bodies for areas that have not been assessed yet. This will help to structure future assessments and will be useful for planning. In the presumably few cases where the designations may be found to be inappropriate, it would be easy to modify the WBS records because there would not be any historical assessment information.

9. As a rough guide, most States would attempt to divide their State (or the assessed waters) into 200-600 water bodies.

Resource specific segmentation systems have been developed for trend analyses and monitoring. For example, comprehensive mapping of submerged aquatic vegetation employs a "lower", "middle" and "upper" division of the bay, with shallow waters further divided into 20 segments that correspond to separate rivers and sounds (Orth, personal communication).

The most recent and inclusive segmentation system for Chesapeake Bay was adapted from Klein (unpublished) and described in the EPA report, Chesapeake Bay: a profile of environmental change. Originally designed for the purpose of water quality assessment, the system was based on geomorphology, circulation, salinity, and biological features. Three dozen segments are grouped according to 5 categories: tidal-fresh reaches, transition zones, lower estuarine reaches, lower main bay, and embayments. Boundaries and principal segment characteristics are clearly defined for each. The system was introduced in 1983 based on the analysis of historic data, but a more recent assessment of the system was made with data collected since 1984 and only a few changes were deemed necessary as a result of the new information (Batiuk, personal communication).

BAY MANAGEMENT PROGRAMS IN FLORIDA AND TEXAS

A number of bay management programs have developed in the State of Florida, mostly as cooperative efforts between local, regional and state governments. Not all have been successful but many have, and the extent to which segmentation has been a part of these projects is worth noting. In each case, basins and sub-basins are the principal upland segment system. Also, the State of Florida has divided each water body into segments for purposes of 305(b) reporting.

Biscayne Bay, at Miami, is divided in different ways for specific applications. A fisheries assessment employed 33 segments of open water. Ownership patterns and state aquatic preserve boundaries are also important. A map of bottom types, and data on circulation and salinity are important considerations in project-specific segmentation (Markley, personal communication).

The Indian River Lagoon system on the east coast of Florida encompasses 5 counties and 22 surface water drainage basins. For purposes of a state-mandated planning program, 12 problem or target areas have been identified in the system, based on local geography, water quality, runoff, and hydrology (Lund, personal communication).

Tampa Bay, at Tampa, is managed under two separate but coordinated programs, an Agency on Bay Management and the regional water management district. For general management purposes, both programs recognize a broad segmentation of the bay developed by Lewis and Whitman (1985). The system is based on named sub-areas of Tampa Bay, and has 7 segments. Four are open water areas of approximately equal size: two are small bays near the gulf: and one segment is a river. The bay has also been segmented for two circulation models and the state uses a number of reaches for 305(b) reporting. Segmentation of Tampa Bay was a part of a review of scientific information for management, and included a review of previous segmentation systems.

In 1982, the Texas Department of Water Resources published "Nueces and Mission-Aransas estuaries: an analysis of bay segment boundaries, physical characteristics, and nutrient processes" as part of a project to analyze existing data for the purpose of water quality planning under Section 208 of P.L. 92-500. The report assesses the appropriateness of existing bay segments, presents circulation and salinity patterns, and the current state of knowledge on nutrient processes in the estuaries. Although directed at water quality study and management, the segments are probably meaningful for other bay-management tasks. The Texas report is one of the most formal and comprehensive segmentation efforts available today and deserves careful study by programs undertaking new segmentation systems.

EXISTING SEGMENTATION SYSTEMS FOR SARASOTA BAY

Even though Sarasota Bay has not been part of previous management programs there are a number of special purpose segmentation systems for all or parts of the area. Examples are given below of those located during this project period.

1. Federal Systems

Sarasota Bay is divided into two Congressional Districts. Manatee County is part of District 10 (Ireland) and Sarasota County is part of District 13 (Goss).

The U.S. Geological Survey divides the study area into cartographic Townships, Ranges, and Sections. Each section covers approximately one square mile. The Survey has also mapped the study area, each map covering 7.5 minutes of latitude and longitude. The maps are annotated with 10,000 foot grid lines based on the Florida coordinate system, east zone, and the 1000 meter Universal Transverse Mercator, zone 17.

The U.S. Postal Service divides the study area into two dozen Zip Code areas.

The segmentation system developed by NOAA and used for the Gulf of Mexico Program was previously described.

The Federal Emergency Management Administration recognizes risk areas associated with 5 categories of storm. The areas are long, parallel bands along the coast corresponding to elevation, with all of the barrier islands and mainland shores in one segment corresponding to the area affected by Class 1 storms.

The National Park Service administers the Coastal Barriers Resources System, which presently contains three designated areas. Midnight Pass and the Tidy Island areas have been recommended for addition to the System.

The Army Corps of Engineers has three authorized projects in the Study Area, two of which fall within their "Gulf Coast Area", the Intracoastal Waterway and one shore protection project. The Corps' regulatory office boundaries divide the bay between Tampa and Ft. Myers, at the Manatee-Sarasota County line.

The entire bay area falls within one marine extension service area of the Sea Grant Program, administered locally from Manatee County.

2. State Systems

The Florida Department of Natural Resources has segmented the Study Area for purposes of shellfish sanitation, into four categories. Approved waters occur at the north end of Anna Maria Island. Conditionally approved waters occur in Sarasota County, between Longboat Key and the Intracoastal Waterway, and in Palma Sola Bay (the latter is temporarily closed). The remaining waters are either prohibited or unclassified (unapproved). Inland waters south of Big Pass are unapproved.

The Department of Natural Resources also maintains a Marine Fisheries Trip Ticket System, to record effort and catch of sport and commercial fishes. All of Tampa Bay and the Sarasota Bay NEP Study Area fall within the "Tampa" fishing area code (5). The NEP area may be divided off the Tampa area (Ron Schmied, personal communication).

The Environmental Regulatory Commission, through the Department of Environmental Regulation, classifies all inland waters of the study area as "Outstanding Florida Waters", except for mixing zones at the mouths of major tributaries.

The seaward limit of OFW is ambiguous. OFW status affords the bays the most stringent permit reviews allowed by the state.

The Florida Department of Environmental Regulation produces 305(b) water quality reports for the area based on a basin-wide approach (Hand, Tauxe and Watts, 1986). All uplands and tributaries to the Study Area, plus Venice and Lemon Bay, fall within Basin 03100201. A total of 11 tributaries have been assigned EPA Reach codes in the basin, of which Whitaker Bayou, Phillippi Creek, Matheny Creek and North Creek are in the NEP Study Area. None of the creeks are subdivided into reaches.

The Department of Environmental Regulation also divides the Study Area into Class II and Class III waters of the state, which generally describe beneficial uses to which the water can be put. Class II waters occur in the area of Sarasota County that are conditionally open for shellfishing, plus the waters of Manatee County; the remainder of the area is Class III water.

3. Regional and Local Systems

The Sarasota Bay Study Area falls entirely within the Southwest Florida Water Management District and the district's Manasota Basin Board.

Sarasota Bay is divided into two counties, Manatee and Sarasota. Incorporated municipalities include Holmes Beach, Bradenton Beach, Bradenton, Sarasota and the Town of Longboat Key. Waters in Manatee County are either unincorporated or are parts of island towns. The City of Sarasota includes a large area of Sarasota and Roberts Bays, in Sarasota County.

The area is divided at the county line between the Tampa Bay Regional Planning Council and the Southwest Florida Regional Planning Council.

GEOBASED DATA FOR SARASOTA BAY

Geobased data are sets of information that are or can be depicted graphically as maps and charts. A bathymetric chart, for example, uses isobaths and point depths to illustrate shallow and deep areas. Sarasota Bay is not a data-rich area but there are a number of inventories useful for segmentation purposes because they contain information on depth, circulation, bottom types, grass beds, nesting areas, locations of contaminants, and related data. This section highlights some of the geobased data most relevant to segmentation of the bay.

1. Physical Features

Soils have been mapped for both counties by the Soil Conservation Service.

Technically speaking, the USGS, NOAA, and DER hydrologic units are watersheds. The location, size and shape of each of the basins and sub-basins are known for the Study Area (Figure 2). Depending on the level of detail used, there are between 20 to 50 basins in the area. The Phillippi Creek basin, for example, can be divided into 5 sub-basins. It is noteworthy that barrier islands have either not been treated as basins or entire islands have been treated as a singular basin, with the assumption made that all runoff is eastward and evenly distributed.

The condition of beaches was recently inventoried by the Florida Department of Natural Resources (Clark, 1989). The report identifies beach erosion problems in the Study Area. Some 18 miles of beach were classified as eroding, with eroding areas on all barrier islands.

Depths throughout Sarasota Bay and adjacent waters have been charted by the NOAA National Ocean Service (Nautical Chart 11425: Intracoastal Waterway- Charlotte Harbor to Tampa Bay). Inland waters are generally very shallow, with broad expanses of intertidal mud flats and grass beds. Estuarine "shelves" of sediment extend into the bay; these are level areas at depths of 6 to 8 feet at low tide. The central area of Sarasota Bay is a bowl-shaped depression reaching depths of 12 feet. Deepest waters occur in inlets and adjacent bay areas. The Intracoastal Waterway is maintained at a width of 200 feet and a depth of 9 feet. The waterway connects Sarasota and Little Sarasota Bays across the mouth of Phillippi Creek, probably affecting circulation.

Circulation is not yet well studied in most areas. Little Sarasota Bay was modelled using a 2 dimension circulation model and major features of water movement there are known. When Midnight Pass was open, two areas of relatively poor circulation occurred, one on each side of the inlet. When the pass closed the two null zones merged in the area of the inlet. Effects of the Intracoastal Waterway are considered to be significant but are not well documented. The dividing line in Sarasota Bay between influences of Longboat Pass to the north and other passes to the south is not definitely known but is believed to be in the area between White Key on Longboat Key, and Long Bar Point on the mainland.

Figure 2. Sarasota Bay basins and sub-basins.

2. Chemical Features

Salinity has not been formally mapped although a report by the NOAA Strategic Assessments Branch is due in 1990 that will synthesize existing salinity data for the area. In general, the bays usually have marine salinities and dilution due to runoff is limited to the mouths of creeks. The extent to which closure of Midnight Pass has affected salinity patterns of Little Sarasota Bay has not been established.

Coprostanol, a sewage tracer found in sediment, has been mapped in the Whitaker Bayou area of Sarasota Bay (Pierce and Brown, 1984). The tracer is most concentrated near the Bayou and spreads out along the eastern shore, from Stephens Point south to Bird Key.

3. Biological Features

Seagrasses have been mapped throughout the Study Area. Grass beds are most abundant in shallow water and in the northern bay areas.

Mangroves and tidal wetlands have been mapped throughout the area. Most mangroves grow as narrow bands along the bay sides of barrier islands, and the largest remaining forests are in Manatee County.

Dolphin abundance has been mapped in the northern study area for years. Palma Sola Bay is considered to be an area of heavy dolphin occupation, and a dolphin breeding ground.

Manatees use the shallow waters of the Study Area on a year-round basis and have been found in certain areas over a number of years (Nabor and Patton, 1989).

4. Cultural Features

State law requires counties and cities to develop comprehensive plans based on significant levels of inventory, mapping, and projection of existing and future conditions. Both counties and the local municipalities of the Study Area have recently adopted state-approved plans which contain information on conservation, coastal resources, traffic, mass transit, housing, recreation, public facilities, and land use. Interested readers are referred to these plans for detailed data on infrastructure near the bay.

Bay-dependent commerce has been mapped for big Sarasota Bay and Manatee County waters, including waterfront restaurants, marinas, boat yards, fish houses, and related services. The village of Cortez in Manatee county is the major center for maritime commerce in the Study Area.

Boat ramps, beaches, beach accesses and artificial reefs have been mapped throughout the area.

Stormwater drainages have been mapped in Manatee County as part of their Master Stormwater Drainage Plan. Comparable data are available in map form for unincorporated Sarasota County.

5. Other Features

Monitoring stations occupied by Manatee and Sarasota County governments have been mapped. These stations are used for routine water quality sampling, and are more abundant in Sarasota County than Manatee. The stations are also more numerous along the Intracoastal Waterway than not.

SYNTHESIS

GENERAL FINDINGS

Documentation for the development of segmentation systems generally is poor but those which have been documented are useful guides to the general approach. Every estuary and its management needs is unique, so segmentation systems are bound to vary widely. The only universally applicable system seems to be the salinity classification of an estuary, but this method requires data (and therefore cannot be used a priori), works less well in neutral estuaries, and will not be useful for some management applications.

A review of NEP and other estuarine management projects was not as informative as a review of segmentation systems already in use for the Sarasota Bay Study Area, and programs undertaking a segmentation system are advised to concentrate most on local data. The geobased data review for the estuary was especially informative in developing a segmentation system, but this approach will be more difficult in data-poor estuaries.

CATEGORIES AND CHARACTERISTICS OF USER NEEDS

More attention will be given to open bay waters, bay bottoms, and bay shorelines than will be given to waters of the gulf, tributaries or uplands. At present, no characterization studies or monitoring are expected to be made in open gulf waters. There may be some gulf study in connection with artificial reefs, boat traffic patterns, or fisheries but most gulf effort will be directed toward beach and inlet management. Tributaries will be the main focus of only two

efforts, characterization of point and non-point source pollution, and an analysis of historical water quality data. The former will also be concerned with uplands, as will part of a wetland characterization study.

Consequently, the use of existing segmentation systems for uplands and tributaries is proposed, together with the use of a new segmentation system for open bay and gulf waters.

UPLANDS

Basins and sub-basins are already used for a number of inventory, data management and planning purposes and will be the basic working unit for the characterization of point and non-point source pollution.

Drainage basins and basin codes in use by the U.S. Geological Survey are adequate for upland segmentation, with certain modifications:

A. Island drainage is inadequately addressed. Islands have been discounted as significant sources of runoff due to their relatively small size, but these areas are densely populated, consume proportionately high amounts of water, fertilizers and pesticides, and are located closest to productive environments.

Perico Island should be treated as a discrete basin. Pending detailed study, Holmes Beach and Bradenton Beach should be treated as different basins on Anna Maria Island. Longboat Key should be treated as at least two basins, divided at the county line. The City-Lido-Bird Keys complex should be treated together or separately. Siesta Key should be divided into at least 3 basins: the Grand Canal system (north), the Heron Lagoon system (south), and the central island.

B. An adjustment to the mainland basins near Perico Island will be needed to account for the location of the Study Area's northern boundary, a line connecting Key Royale (School Key on Anna Maria Island) to Mead Point.

C. The hydrology of the upper Whitaker Bayou-Pearce Canal Basin is imperfectly known at present. A determination is needed of where the hydrologic divide occurs in this system because land, runoff and loads could be incorrectly assigned to either the bay or to the Braden River, which is outside of the Study Area.

D. Effects of Interstate 75 on inland drainage basin boundaries and hydrology should be investigated.

E. Upland studies requiring larger geographic units can use U.S. Geological Survey 7.5 minute topographic quadrangles, and studies requiring smaller units can use sections of specified townships and ranges.

TRIBUTARIES

Tributaries will be the subject of historical data reviews and in-stream water quality measurements made as part of the point and non-point pollution studies. There may also be some sediment contaminants or fish stocks measured in tributaries, and wetlands may be characterized along the streams.

The Florida Department of Environmental Regulation uses the EPA Reach System for designating streams in their biennial 305(b) water quality assessments (Figure 3). This system is adequate for most project needs except as noted:

A. Not all tributaries have been assigned reach codes. Bowlees Creek in Manatee County and South Creek in Sarasota County are the most notable examples. The Grand Canal on Siesta Key should have its own reach code, as well. Assistance from the Department should be sought in assigning reach codes for these and lesser streams.

B. Each tributary, including Phillippi Creek, is treated as a unit. None has been further subdivided into additional reaches. Phillippi Creek has at least 5 sub-basins and reaches should be assigned to each corresponding stream segment.

c. At a minimum, each tributary should be divided into a tidal reach and a non-tidal reach, to reflect technical difficulties associated with stream-gauging and constituent loading. This will require direct measurement.

OPEN BAY AND GULF WATERS

Issue Foci

Foci are geographic points and areas for which management attention is desired, either because a valued resource or beneficial use is present or because a pollution source or other problem occurs. Relevant foci are listed in Table 2.

The foci are distributed throughout the bay area and reflect a mixture of beneficial uses and resources, and problems. Two are system-wide (beach management and the Intracoastal Waterway), but others have defined geographic limits within the Study Area.

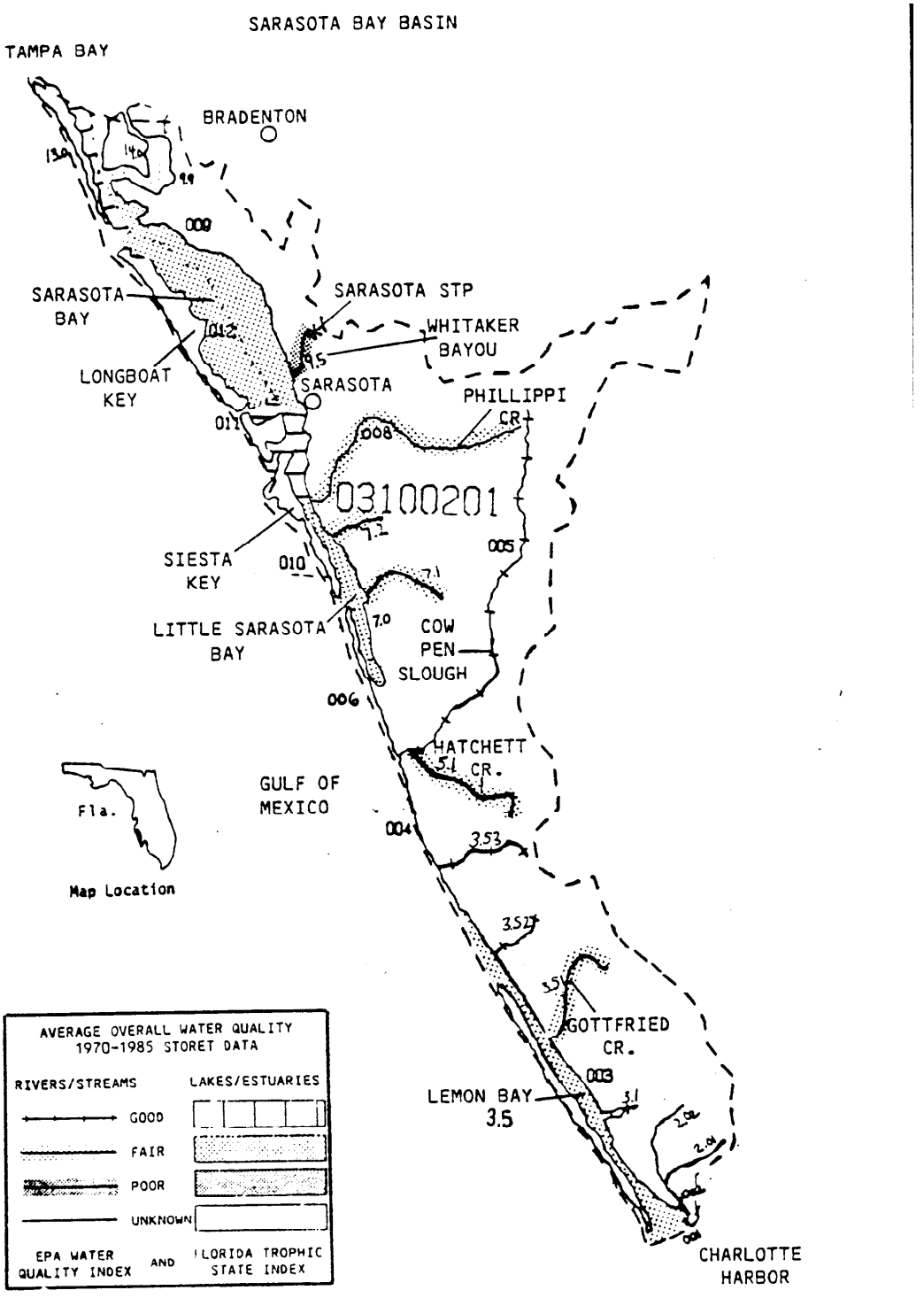

Figure 3. Stream segments, from Hand, Tauxe and Watts (1986).

Table 2. Management Foci in the Sarasota Bay NEP Study Area. (STP, sewage treatment plant; ICW, Intracoastal Waterway.)

1. Perico Island: urbanization, habitat loss and runoff.

2. Palma Sola Bay: recreational use, dolphin breeding area, runoff, possible STP effluent.

3. Cortez: cultural resource, fishing community.

4. Tidy Island: habitat loss, runoff, access conflicts.

5. Long Bar Point: STP effluent, major sea grass system, recreation, ICW impacts.

6. Bowlees Creek: runoff, boat traffic, contaminants.

7. Airport/Museum/College Area: runoff, recreation, education and research.

8. Whitaker Bayou: STP effluent, marina, runoff.

9. Hog Creek: Reverse osmosis reject water, runoff,

10. Marina Jack: marina, runoff, contaminants.

11. Hudson Bayou: habitat loss, runoff.

12. Phillippi Creek: habitat loss, runoff, contaminants, marina, boat traffic, recreation.

13. North and Catfish Creeks: habitat loss, runoff, eutrophication.

14. South Creek: park management, land expansion, runoff, habitat loss, recreation.

15. All barrier beaches: erosion, management conflicts, access, turtle nesting.

16. Midnight Pass: beach management, inlet management, recreation, marinas, boat traffic, erosion, sea grasses, eutrophication.

17. Point of Rocks: geological novelty, recreation.

18. Big, New and Longboat Passes: navigation, maintenance dredging, recreation, water quality, endangered species, spoil disposal.

Table 2, continued. Management Foci in the Sarasota Bay NEP Study Area. (STP, sewage treatment plant: ICW, Intracoastal Waterway.)

19. Buttonwood Harbor: shellfish, marinas and boat traffic, runoff, contaminants.

20. ICW and Other Channels: maintenance dredging, spoil disposal, recreation, boat traffic.

Problemsheds and Soft Boundaries

The Tidy Island and Long Bar Point area is given as an example for problemsheds and soft boundaries.

The major resources of the north bay area are a large sea grass bed and mangrove forest system. Together these plant communities support a diversity of marine life and important recreational and commercial fisheries. The area is valued for nature study and education. STP effluent is disposed of by irrigating gladioli fields upland of the mangroves. Surplus waters leave the fields and promote algae blooms in intertidal and shallow subtidal waters.

The grass beds grow on a large, triangular shelf of sediments overlying a limestone formation projecting south into the bay. This shallow area controls circulation and water quality by affecting winds, the tidal influence of Longboat Pass, and the discharge of Bowlees Creek. The shelf is defined seaward by a relatively sharp slope, to depths of about 6 feet (westerly) to 10 feet (southerly). The ICW skirts the shoal system but cuts through its southern tip. Spoil from the ICW was placed nearby as subtidal to emergent piles and fine sediments may have escaped, causing sea grass losses.

The shelf is therefore limited by naturally deeper water and the Intracoastal Waterway, which in both cases have unvegetated bottoms. Measurements of water quality in the area suggest that surplus irrigation waters affect the shallow areas along the Tidy Island/Long Bar Point area but do not extend across the bar into deeper waters. As a result, the "problemshed" of this area can be defined for upland areas as the basin(s) delivering runoff to the shore, and can be defined seaward as the physical demarcation of the shoal system.

The problemshed is adjoined by problemsheds with foci involving inlets (Longboat Pass), an extensively dredged reach of the Intracoastal Waterway, and a major tributary (Bowlees Creek). Accordingly, a soft boundary for this segment would be approximately along the 6 foot isobath from the Cortez area to an area north of Bowlees Creek.

A similar process was used for each potential segment in the Study Area to define where segment boundaries would be needed.

Segment Definitions

Sarasota Bay Study area segments are shown in Figure 4. A total of 17 has been established. Technical boundary descriptions for each segment are given in Appendices I and II. All are described below.

Most bridges crossing the bay that are near a segment boundary fall entirely within the segment(s) largest toward the south of each bridge. The middle of the Intracoastal Waterway is used as the dividing line between adjacent segments. The divide between a bay segment and a named tributary is a smooth line connecting the mainland shores across the mouth of the tributary. All other waters, such as canals and boat basins, fall entirely within the adjacent bay segment.

Segments are numbered from north to south and from west to east. Each is also named after a prominent land mark.

Segment B1, **Anna Maria Sound.** Water west of the ICW and south of the Study Area's northern boundary, south to a line 500 feet north of the State Road 684 (Cortez Road) bridge.

Segment B2, **Perico Island.** Water east of Segment B1, completely surrounding Perico Island and including Perico Bayou. Defined to the east by a line drawn due south of Flamingo Cay, and to the south by a line 500 feet north of the State Road 684 (Cortez Road) bridge.

Segment B3, **Palma Sola Bay.** Water east of Segment B2.

Segment B4, **Longboat Pass.** Limited to the west by a smooth line connecting the beaches of Anna Maria Island and Longboat Key, and to the east by a line connecting the north point of Jewfish Key to the bay-side shorelines of the two barrier islands.

Segment B5, **Sister Keys.** Water south of Segment B1 and east of Segment B4, defined to the east and south by Complex Lines A and B, respectively.

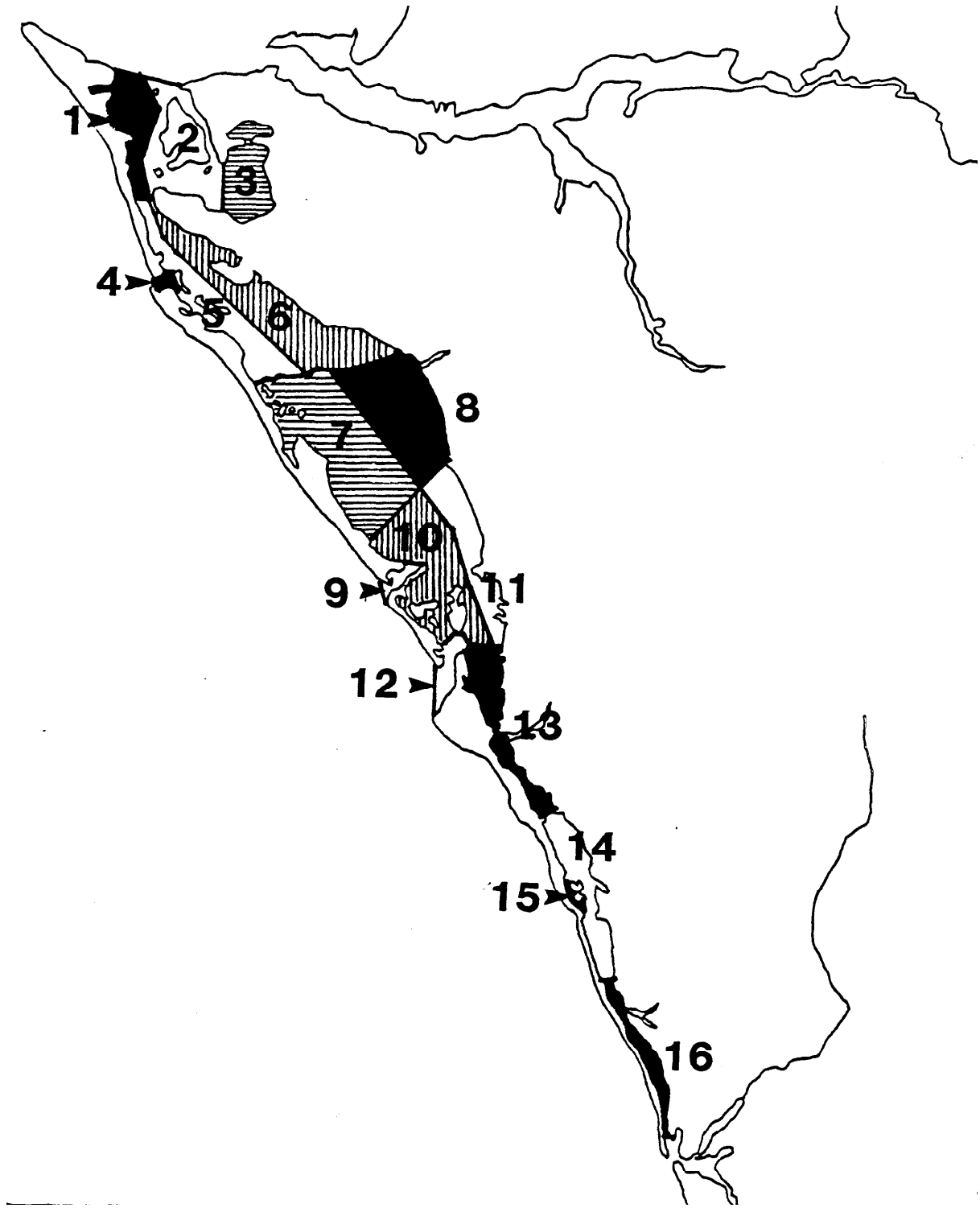

Figure 4. Sarasota Bay NEP Study Area segments. The Gulf of Mexico is a separate segment. Detailed maps appear in the Appendix.

Complex Line A follows the ICW south from the Cortez area to a green day beacon "45" and a flashing red "46". From there the line heads in a straight line toward the southeast to a red day beacon "20" and a flashing green "21", passing near to the east end of Sister Keys.

Complex line B begins at a spoil island next to the access channel to Trailer Estates, runs easterly to day beacon "A" on the north side of a private fish haven and continues on to a flashing green "17" on the ICW. From there the line follows the ICW westwardly to a quick flashing green "23", leaves the ICW, and continues west to Longboat Key, where a privately maintained channel (red "8") meets the shore.

Segment B6, **Long Bar Point.** Water east of Segment B5 and defined to the south by Complex Line B.

Segment B7, **Bishops Point.** Water west of the ICW and south of Segment B5, defined to the south by a line connecting the southernmost long finger-fill to the tip of Stephens [south] Point.

Segment B8, **New College.** Water south of Complex Line B, east of Segment B7, and north of a line connecting the southernmost long finger-fill to the tip of Stephens [south] Point.

Segment B9, **New Pass.** Limited to the west by a smooth line connecting the beaches of Longboat and Lido Keys, and limited to the east by a straight line between the eastern-most bay shorelines of Longboat Key at Quick Point, and City Island.

Segment B10, **Coon Key.** Water west of the ICW south of Segment B7, east of Segment B9, north of a line connecting the south end of Bird Key to Fishery Point on Siesta Key and Brushy Bayou on Lido Key, and north of a line 500 feet north of the State Road 758 (Siesta Drive), including its crossing of Hansen Bayou.

Segment B11, **Sarasota.** Water south of Segment B8, east of Segment B10 and north of a line 500 feet north of the State Road 758 (Siesta Drive).

Segment B12, **Big Pass.** Limited to the west by a smooth line connecting the beaches of Lido and Siesta Keys, and to the

north and east by a line connecting the south end of Bird Key to Fishery Point on Siesta Key and Brushy Bayou on Lido Key.

Segment B13, **Roberts Bay.** Water south of a line 500 feet north of the State Road 758 (Siesta Drive) bridge, including its crossing of Hansen Bayou, plus water south of Phillippi Creek to a line 300 feet north of the "Narrows" between White Beach on Siesta Key and Coral Cove on the mainland.

Segment B14, **Little Sarasota Bay.** Water south of Segment B13, north of a line 300 feet north of the County Road 789 (Blackburn Point) bridge, and east of Segment B15.

Segment B15, **Midnight Pass.** Limited to the west by Midnight Beach (when the pass is closed) or a smooth line connecting the beaches of Siesta and Casey Keys (when the pass is open). Also limited to the north by a line running due west from the northern tip of the western arm of Bird Key to Siesta Key, and limited to the south by a line running due south from the southern end of Bird Key to Casey Key.

Segment B16, **Blackburn Bay.** Water south of Segment B14, to a line 300 feet south of the County Road 789 (Albee Road) bridge.

Finally, the **Gulf of Mexico** is treated as a separate segment. It is limited to the east by barrier island and the westward limits of inlet segments (B4, B9, B12, and B15). For beach, surf zone, and shallow (less than 12 feet) inshore purposes, the coastline is divided into Gulf reaches (Figure 5). Reaches were situated so as to bracket inlets, and boundaries were chosen to correspond to federal shore protection projects (Atmar, personal communication), local beach nourishment projects, erosion areas (Clark, 1989), and sea turtle study and nesting areas (Mapes, 1986). A total of 7 gulf reaches were established:

Gulf Reach 1, Bean Point south to State Road 684 (Cortez Road):

Gulf Reach 2, Cortez Road south to Whitney Beach: also the southern end of Reach A as defined in the Longboat Key Beach Nourishment Project;

Gulf Reach 3, Whitney Beach south to Sea Horse Resort (3453 Gulf of Mexico Drive: also the southern end of Reach F as defined in the Longboat Key Beach Nourishment Project);

Gulf Reach 4, Sea Horse Resort south to the westerly extension of State Road 789 (Gulf Breeze Drive);

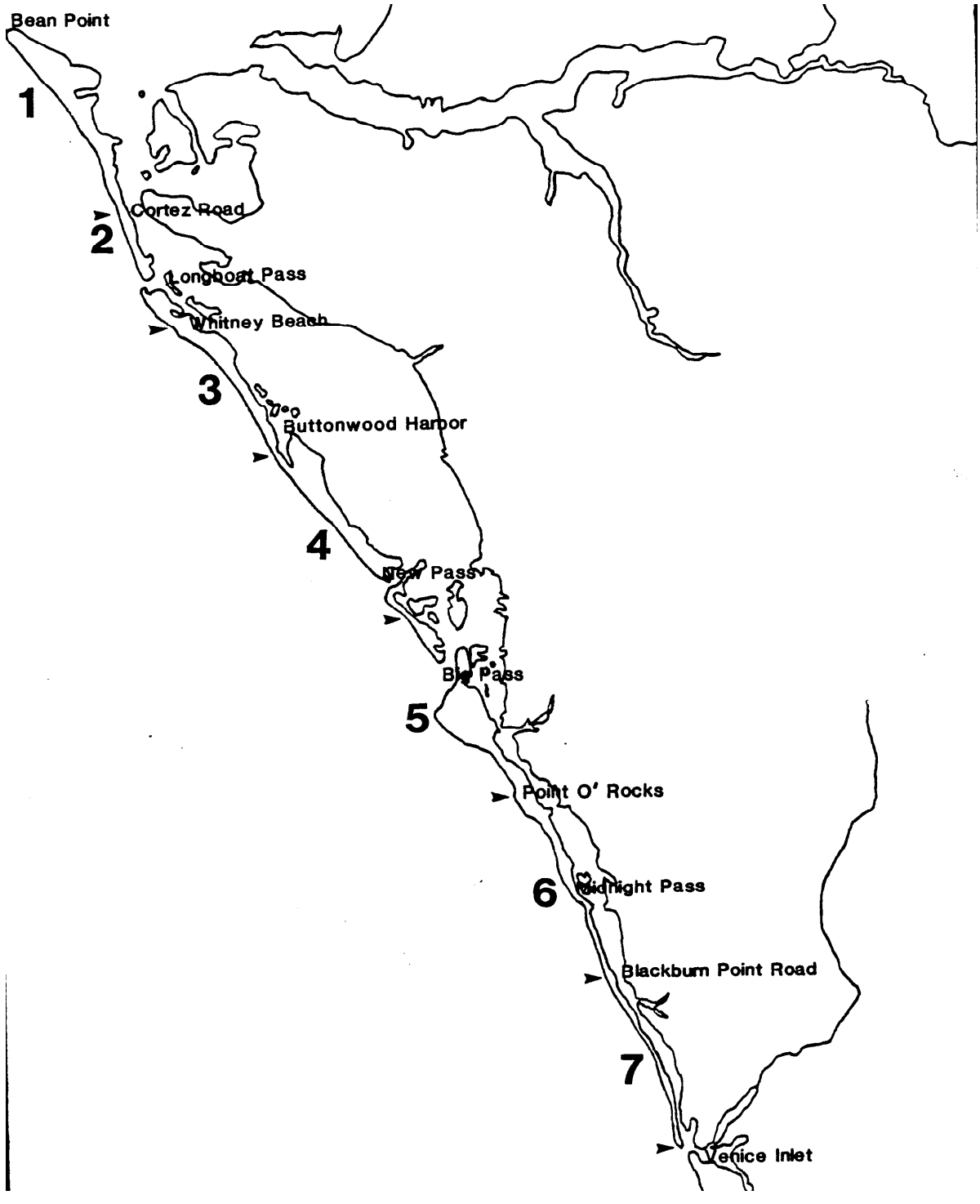

Figure 5. Reaches of Gulf of Mexico beach areas in the Sarasota Bay NEP Study Area.

Gulf Reach 5, Gulf Breeze Drive extension south to Point of Rocks;

Gulf Reach 6, Point of Rocks south to the westerly extension of County Road 789 (Blackburn Point Road);

Gulf Reach 7, Blackburn Point Road extension to Venice Inlet.

The gulf segments G1 - G7 extend farther north and south than the bay or inland segments in order to encompass the entire regional sand system embodied in the beaches and inlets from Venice north to Tampa Bay. The seaward limits of the gulf reaches are undefined for now.

ANALYSIS

The segments vary in size from very small inlet units to relatively large open-bay units, and the long, narrow aspect of southern segments is unavoidable.

The segments will permit aggregation for the sake of data reduction, analysis, and presentation. Segments 1,2, and 3 can be combined naturally, as can many other combinations. Some of the segments also allow for further subdivision if needed, as in the case of Segment 11. This segment could be divided at the causeway and bridge to further narrow the focus on Whitaker Bayou or compare it to the Marina Jack area. (The segment was not so divided because of the overwhelming effect of Big Pass on circulation and water quality along the eastern shore.)

The correspondence of segments with basins is not good but this is the necessary consequence of organized runoff: the bay segments do bracket the mouths of tributaries and encompass the areas of their probable effects (problemsheds).

Most boundaries follow natural and intuitive lines, as bourne out by meetings with the leaders of characterization studies and the Technical Advisory Committee. The most difficult boundary separates Segments 5 and 6, but corresponds in the field to a naturally deep passageway from Cortez, south. Most uses of the segmentation system in this area should be to separate east shore data from west shore data and the number of instances where precise location of the boundary is critical, will hopefully be few.

Overall, the use of basins, stream reaches, bay segments, and gulf reaches as primary geographical references in the Sarasota Bay NEP Project should enhance the design of sampling and measurement tasks. The tasks of data management, reduction, and analysis should be simplified. Comparability of data from different tasks should be

enhanced. Presentation of technical data to a general audience will be simplified by using geographically sensible units. And ideally, the segmentation system will contribute to comparison of Sarasota Bay data to the findings of NEP projects in other estuaries.

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A P P E N D I C E S

Available upon request