NWRC Open File Report 86-6
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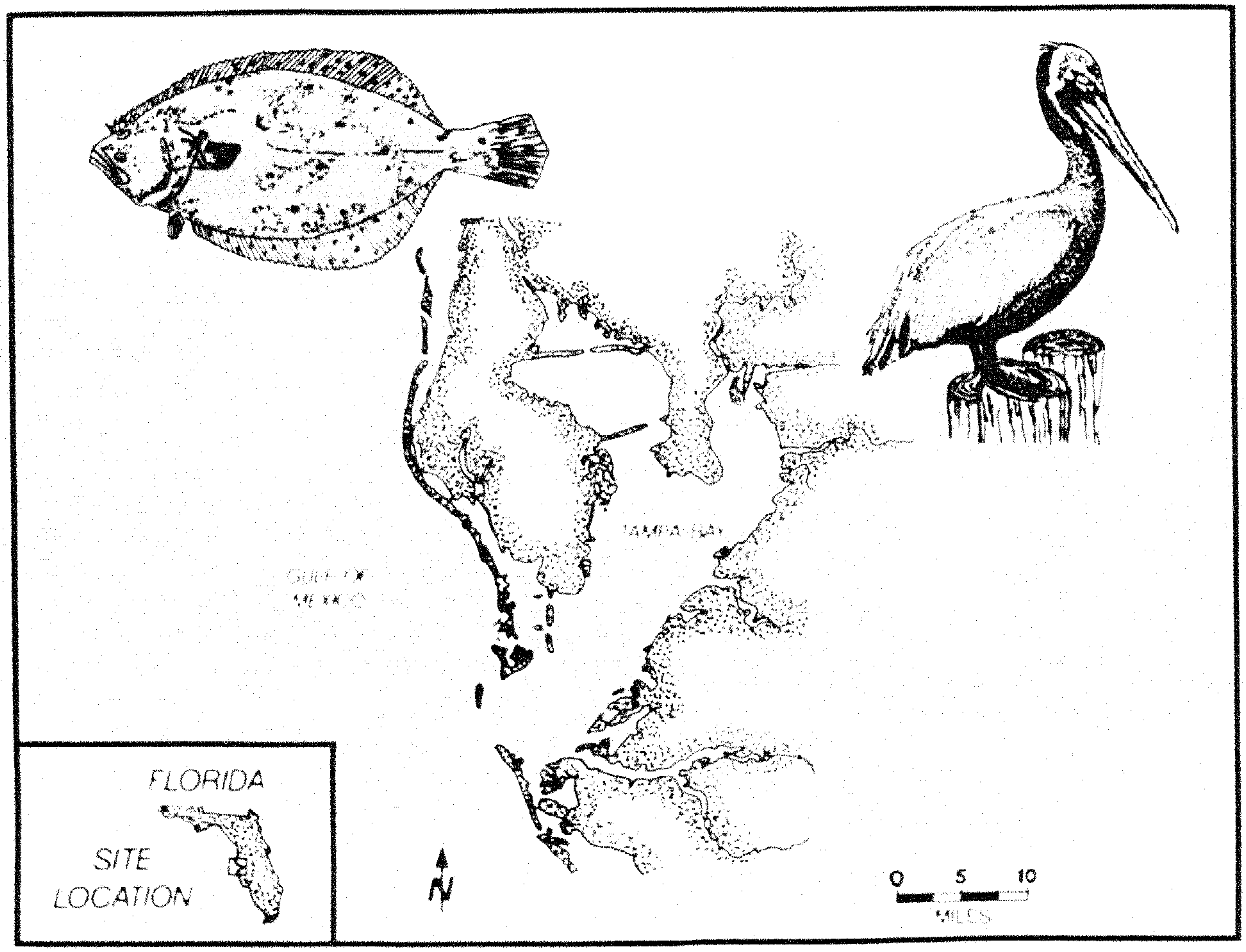
DATA BASES FOR USE IN FISH AND WILDLIFE MITIGATION PLANNING IN TAMPA BAY FLORIDA:



PROJECT SUMMARY

Fish and Wildlife Service
Tampa Port Authority
U.S. Department of the Interior

NWRC Open File Report 86-6
September 1986

DATA BASES FOR USE IN FISH AND WILDLIFE MITIGATION PLANNING IN TAMPA BAY FLORIDA: PROJECT SUMMARY

by

William K. Fehring
Greiner Engineering, Inc.
5601 Mariner Street
Tampa, FL 33630

for

Tampa Port Authority
P. O. Box 2192
Tampa, FL 33611

Project Officer

Millicent L. Quammen
National Wetlands Research Center
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, LA 70458

Performed for

National Wetlands Research Center
Research and Development
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, LA 70458

and

Regional Office
U.S. Fish and Wildlife Service
Richard B. Russell Building
75 Spring Street, S.W.
Atlanta, GA 30303

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PREFACE

This report was prepared to briefly summarize the results of a 3-year cooperative study by the U. S. Fish and Wildlife Service and the Tampa Port Authority and to describe possible applications of the study products to the management of Tampa Bay. The report includes descriptions of mapping activities and the development of descriptive models for estuarine habitats, the results of a study of potential habitat creation sites, and the development of a comprehensive estuarine profile. The products will provide a significant new source of information for agencies and individuals involved in the management of the bay.

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FIGURES

ACRONYMS USED IN THIS REPORT

AFS	American Fisheries Society
AMS	Analytical Mapping System
BASIS	Bay Area Scientific Information Symposium
BMR	Bureau of Marine Research
COE	U.S. Army Corps of Engineers
COS	Cartographic Overlay System
FDER	Florida Department of Environmental Regulation
FDNR	Florida Department of Natural Resources
FWS	U.S. Fish and Wildlife Service
HEP	Habitat Evaluation Procedures
HSI	Habitat Suitability Index
IAFWA	International Association of Fish and Wildlife Agencies
MOSS	Map Overlay Statistical System
NCET	National Coastal Ecosystems Team
NWRC	National Wetland Research Center (formerly National Coastal Ecosystems Team)
TBRPC	Tampa Bay Regional Planning Council
TPA	Tampa Port Authority

ACKNOWLEDGMENTS

The results reported here are the product of separate efforts by the authors of the individual projects described. The author bears full responsibility for any errors in reporting and interpreting those work products.

I would like to recognize the Tampa Port Authority for its financial support and the support of its staff. In addition, I would like to recognize the Port Authority and the Tampa Bay Regional Planning Council for sponsoring the final workshop to present these products to the public.

INTRODUCTION

SCOPE OF REPORT

This report summarizes the history, objectives, activities, and results of a 3-year cooperative project by the U.S. Fish and Wildlife Service (FWS) and the Tampa Port Authority (TPA) to improve the data base available for making decisions regarding port development and wildlife habitat management in Tampa Bay. In addition, the report describes situations in which the study methods, results, and products might be used to improve management and development decisions regarding fish and wildlife resources in the bay. Individual projects which have generated separate products such as maps, booklets, and reports are described. (See these products for specific information regarding individual tasks)

HISTORICAL CONTEXT OF THE STUDY

Since 1980 there has been a widespread effort by interested agencies and individuals to improve the management of Tampa Bay. A driving force behind these efforts has been a concern that many residents of the Tampa Bay region were unaware of the resource values of the estuary and were under the impression that the bay was already "dead." Local scientists feared that the bay was, in fact, approaching the point where its natural resilience would succumb to the myriad of stresses resulting from the region's rapid urbanization.

One of the earliest manifestations of this effort was the Bay Area Scientific Information Symposium (BASIS) which was held in early May, 1982. Concerned local scientists organized this 4-day meeting to develop a comprehensive summary of the information known about many aspects of the bay, including physical and biological characteristics, anthropological history, and anthropogenic impacts. Fifty presentations were made; the range of topics is presented in Table 1. Many of these papers were published in a symposium proceedings (Treat et al. 1985).

As a result of this symposium many significant gaps in the available scientific data became apparent. These needed to be filled if effective management of the bay's resources was to be achieved. In addition, it was made clear that the current fragmented governmental management structure needed to be improved if existing and new information were to be effectively used in management decisions. These findings prompted several concurrent programs to address these issues, most of which continue today.

Following the BASIS meeting, and as a result of an existing program of supporting applied research in habitat creation, the Environmental Affairs Director of the TPA was invited to participate in a September 1982 symposium jointly sponsored

Table 1. Topics presented at Bay Area Scientific Information Symposium (Treat et al. 1985).

Science and the Management of San Francisco Bay
Rationale for Tampa BASIS
Geographic Description of the Boundaries and Subdivisions of Tampa Bay
Meteorology of Tampa Bay
Geology of Tampa Bay
Mineral Resources of the Tampa Bay Region
Regional Groundwaters
Surface Flows to Tampa Bay
Water Quality Monitoring in Tampa Bay
Phytoplankton and Macrophytes in Tampa Bay
Virological Status of Tampa Bay
Effect of Microbes on the Water Quality of Tampa Bay
Occurrence and Potential Roles of Fungi in the Tampa Bay Ecosystem
Zooplankton of Tampa Bay
Benthic Macroinvertebrates of Tampa Bay
Fishes and Ichthyoplankton in Tampa Bay
Current Status and Recent Trends in Bird Populations of Tampa Bay
Marine Mammals, Reptiles and Amphibians of Tampa Bay
Status of Knowledge of Prehistoric Archaeology in the Tampa Bay Area
Underwater Archaeological Resources of Tampa Bay
History and Development of the Port of Tampa
Power Plants: Their Present and Future Impacts
Impact of the Phosphate Industry on Tampa Bay
Natural Radionuclides in Tampa Bay
Special Species and their Endangered Habitat
Habitat Restoration in Tampa Bay

by the International Association of Fish and Wildlife Agencies (IAFWA) and the American Fisheries Society (AFS). The symposium was entitled "Improving Multiple Use of Coastal and Marine Resources," and the TPA presentation dealt with the future coexistence of ports, industries and fisheries in Tampa Bay (Fehring 1983).

As part of this presentation, a series of recommendations was made regarding potential improvements to the process whereby mitigation activities to compensate for the unavoidable impacts of port and maritime projects on habitat resources are developed and negotiated. The chairman of the session in which these recommendations were made, then Assistant Secretary of the U.S. Department of Interior for Fish, Wildlife, and National Parks, G. Ray Arnett, became interested in these problems and encouraged the FWS staff to develop a cooperative study with the TPA to address the problems.

Following the IAFWA/AFS symposium, meetings between the FWS and the TPA were held in December 1982 and March 1983. Participants in these meetings included FWS representatives from the Washington headquarters of the Division of Biological Services, the National Coastal Ecosystem Team (NCET--now the National Wetlands Research Center, NWRC), the Atlanta regional and Panama City field offices. As a result of these discussions and subsequent meetings with local scientists and the Florida Department of Natural Resources, a cooperative agreement between the FWS and the TPA was developed. The project was initiated in September 1983.

PROJECT OBJECTIVES

There were two objectives for this project:

1. To identify management and mitigation options (including mitigation banking) that will allow development and maintenance of the Port of Tampa to proceed in an environmentally acceptable fashion.

2. To develop an information base in map and text/tabular form that is aimed at analysis and evaluation of mitigation and management options.

The data base was developed to help fill a number of the information gaps identified by BASIS. This data base would assist the development of a bay management plan and future development, management, and regulatory decisions.

One area of environmental impacts generally associated with port dredging projects is that involving water quality. For example, changes in circulation patterns result from the creation of channels. While water quality often has a significant relationship with the quality and use of marine and estuarine habitats, it is generally influenced by a wide range of factors not directly associated with port development such as sewage and septic tank discharges, urban stormwater discharges, and changes in freshwater flow patterns resulting from increased urbanization.

In addition, the FWS is not generally the lead Federal agency in water quality issues per se. Those concerns fall primarily under the responsibility of the U.S. Environmental Protection Agency (EPA) in reviewing federal permit applications. Therefore, it was agreed by FWS and TPA to direct this project primarily toward issues involving floral and faunal communities that would normally fall under the direct responsibility of the FWS. Only limited attention was to be given to water quality issues, primarily in environmental atlas documents and an estuarine profile. The project coordinators recognized that there exist legitimate water quality concerns regarding port development which would not be addressed.

CONCURRENT RELATED PROJECTS IN THE TAMPA BAY REGION

To understand the reasons project tasks evolved as they did the reader needs to be aware of several other projects or programs underway during the same time period. These projects involved a variety of activities ranging from research to public involvement programs.

Tampa Bay Regional Planning Council

A major concurrent program was the development of a bay-wide planning agency under the aegis of the Tampa Bay Regional Planning Council (TBRPC). During 1983-85 a series of "bay study committees" and "bay study commissions" were established to review a broad range of problems associated with Tampa Bay and to develop recommendations for improving the management of the bay's resources. Funding for these programs came largely from Coastal Zone Management grants.

This process involved groups ranging in size from 25 to 40 people, representing many industries, agencies, and public interest groups around the bay which met over a period of over 2 years. Problem areas were identified and prioritized. Management responsibilities were identified, as were areas of duplication and insufficient responsibility. Funding problems and sources were identified and recommendations for research and new regulations were developed.

The final results of these initial efforts were published by the TBRPC in a document entitled The Future of Tampa Bay (TBRPC 1985). This report to the Florida Legislature summarized the findings and recommendations, including a recommendation that a permanent bay-wide planning entity be established to assist in implementing the recommendations. As a result, the Agency on Bay Management was established. This group brings together some 45 representatives of ports, cities, counties, State and Federal agencies, and public interest groups to develop recommendations for legislation and research, to develop recommendations on permits and Federal projects, and to increase public awareness of the bay's resources and problems. While basically advisory in nature this group provides an excellent long-term forum for the development of the bay-wide habitat mitigation and restoration program that was an original objective of the FWS/TPA project.

Florida Department of Natural Resources

Another series of important concurrent projects was and is being conducted by the Florida Department of Natural Resources (FDNR), Bureau of Marine Research (BMR). The first project was the development of a Marine Resource Geographic Information System. Funded by a coastal zone management grant, this project was directly integrated with the FWS/TPA project, permitting a significant geographic expansion of the study area.

The BMR program calls for a continuing mapping and updating program whereby computerized land use and habitat maps will be available at the BMR facility in St. Petersburg, Florida. Information from satellite mapping programs as well as from the FWS/TPA project are being entered into this system. Thus, the basic maps produced by the FWS/TPA program can be repeatedly updated and made available for future analyses related to research or management programs.

Another FDNR program dealing with habitat management is the development of management plans for the Cockroach Bay and Terra Ceia Aquatic Preserves. These two relatively pristine shoreline areas in the southern portion of Tampa Bay have been designated by the State Legislature for special protection. Special regulations regarding water quality impacts, marine structures, and cumulative impacts of coastal development are applicable in these areas. The planning and management of these areas require detailed habitat and resource information, making this program a prime potential user of the products of the FWS/TPA program.

The BMR staff is also studying the habitat of redfish (Sciaenops ocellatus) and sea trout (Cynoscion nebulosus) in Tampa Bay. One key data gap identified during the BASIS symposium was in quantitative information on the value of habitats such as seagrass meadows to aquatic animals of interest. Once studies such as these establish those relationships, the potential value of the maps and computer analyses developed as part of the FWS/TPA project will be greatly enhanced.

Finally, the BMR is involved in a number of habitat-restoration projects around Tampa Bay that are funded by self-imposed fees on local commercial fisherman. These projects involve the planting of mangrove trees (Rhizophora mangle, Avicennia germinans), smooth cordgrass (Spartina alterniflora), and blackrush (Juncus roemerianus). In addition, some limited experimentation with planting of seagrasses is being conducted, but for reasons discussed later in this section, no significant habitat creation projects with seagrasses are presently planned.

Fish and Wildlife Service/Florida Department of Environmental Regulation

An additional concurrent and related project is the development of a report, Ecological Characterization of the Tampa Bay Watershed (Schomer et al. in prep.) under a joint program of the FWS and the Florida Department of Environmental Regulation (FDER). This report is one of five being prepared on watersheds along most of the entire west coast of Florida. Each report describes what resources and habitats are important, how and why they are important, and what effects human alterations have had on them. They include upland habitats as well as freshwater and marine areas. These reports include information on geology, climate, hydrology, water quality, and biological resources.

Though quite extensive, these reports are relatively general because of the large areas they address. They are designed to provide information about habitats along the coast of the Gulf of Mexico and to be used in assessing the impact of potential Outer Continental Shelf leasing for oil and gas development in the Gulf of Mexico. The report in the Tampa area is due for completion in 1987 and will be available from the Information Transfer Specialist of the National Wetland Research Center (NWRC) whose address is given on the title page of this report.

Tampa Port Authority

Finally, the TPA supported a pilot project to directly test the feasibility of restoring seagrass meadows in Tampa Bay under existing water quality conditions. This project involved test plantings in various locations around the bay using different seagrass species. Success with these plantings was limited to a single plot of *Halodule wrightii*. In view of these results, along with the results of restoration projects at the Port of Miami and general knowledge of seagrass trends in Tampa Bay, major seagrass creation projects were avoided in the BMR habitat creation program. For the same reasons the mitigation options study of this project recommended that seagrass plantings not be considered for mitigation programs until there is a better understanding of the biology of these species in Tampa Bay.

TASK AND PRODUCT DESCRIPTIONS

The FWS/TPA projects entailed seven basic tasks which together were designed to provide the data base desired to assist future management decisions. These tasks included workshops, mapping of wetlands and other resources, digitization and analysis of maps, field investigations, and analyses of past habitat restoration projects and potential future habitat creation sites. Each task and the products produced are described below. Where feasible, examples of work products have been included. The potential use of these products in the management of the Tampa Bay estuary is discussed in the following section.

WORKSHOPS

The first task of the project was a 2-day workshop conducted in September 1983. The objectives of this meeting were to

(1) define long-range management scenarios specifying development actions and mitigation actions;

(2) identify concerns of the principal interested parties; and

(3) identify information requirements and availability for evaluating the defined management scenarios.

The workshop, conducted by the FWS Western Energy and Land Use Team (now the National Ecology Center), was attended by 27 representatives of dredging companies, Federal agencies, planning agencies, State resource agencies, and other groups.

A report (Auble et al. 1985) produced from this workshop includes a discussion of the potential impacts of future dredging, disposal, bulkheading and development. These impacts include turbidity and siltation, release of nutrients and toxic chemicals from sediments, burial of benthic biological communities, loss of aquatic habitat, and changes in circulation and salinity patterns in the estuary. The report also discusses methods by which the impacts of certain activities might be reduced. These include improved dredging technologies such as the reduction of overdredging through computerization, improved analysis and selection of disposal options, and reduction of project scope.

The largest section of this report deals with ways to compensate for unavoidable habitat losses associated with potential future projects. This section begins with a discussion of the trends in changes of habitat types in the bay and the probable cause of those trends. The discussion then turns to mitigation or habitat creation options which might be considered. Constraints on such projects identified by workshop participants include cost, life span of the created habitat, maintenance problems, public acceptance, and monitoring of project success.

The types of habitat creation and improvement projects discussed include shoreline and island cordgrass marshes, mangrove forests, seagrass meadows, tidal creeks, and hard-bottom reefs. Each type of habitat is discussed in regard to the constraints listed above as well as to the general benefits which it might provide.

The report concludes with a general discussion of the relationship between development actions and mitigation measures, information needs, and the relation of mitigation to environmental management in Tampa Bay. Subjects addressed in this section include the lack of knowledge about species-habitat relations for the estuary, the confounding influence of water quality impacts, consolidated mitigation programs, and the problem of implementing any mitigation goal other than maintaining the "status quo."

Information needs identified include improved habitat mapping, a clearer understanding of dredged material disposal requirements and options, and a better understanding of seagrass ecology and of sediment and nutrient regimens in the estuary.

Finally, the report concludes that the most important steps for correcting the environmental problems of Tampa Bay involve developing a broader management plan for the estuary and identifying a lead agency to implement such a planning and management effort. Limited numbers of this report are available from the Information Transfer Specialist at the NWRC whose address is given on the title page of this report.

At the conclusion of the overall project, a second workshop was held in conjunction with the newly established Agency on Bay Management of the TBRPC. Its purpose was to present to interested agencies and individuals the products of these efforts and to discuss potential future use of the products and further information needs. No separate report on this workshop was produced, but the results of the meeting are reflected in this report.

HABITAT MAPPING

An important component of this project was the mapping of upland and wetland habitats depicted on aerial photographs of the Tampa Bay area for three time periods: the early 1950s, 1972, and 1982. Maps were prepared using the wetland classification by Cowardin et al. (1979) and a modified version of the upland classification by Anderson et al. (1976). Mapping of the three time periods allows for the analysis of habitat trends. Maps at a scale of 1:24,000 of an area covered by 21 USGS 7.5-min quadrangle maps (Figure 1) were prepared for each time period.

A portion of the completed 1952 map of the Tampa Quadrangle is presented in Figure 2, and a corresponding section of the 1982 map is shown in Figure 3. Excerpts from the legend are shown in Figure 4. These maps are to be available for a reasonable cost from the FDNR.

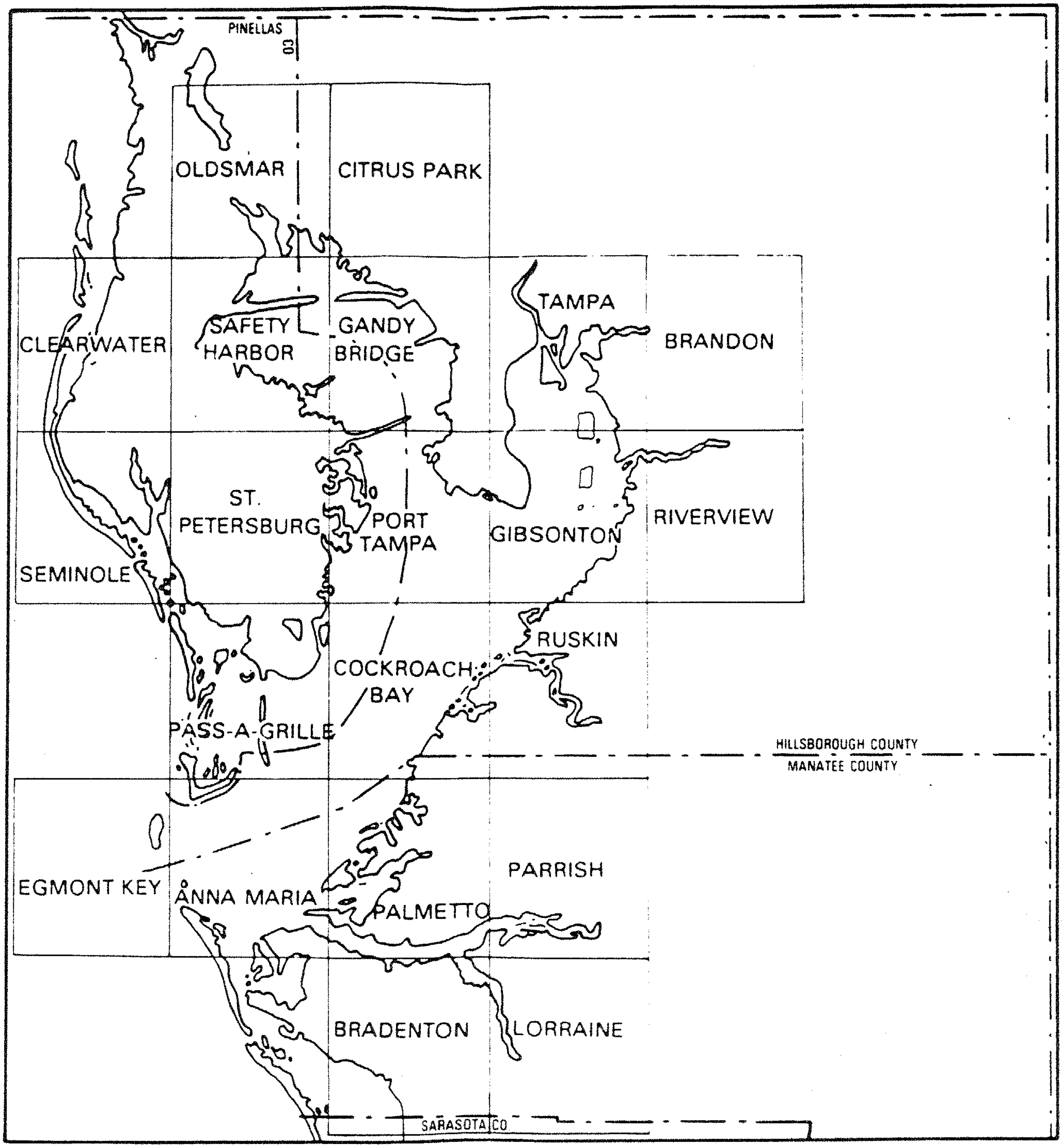


Figure 1. Area mapped for wetland habitat maps and environmental atlas.

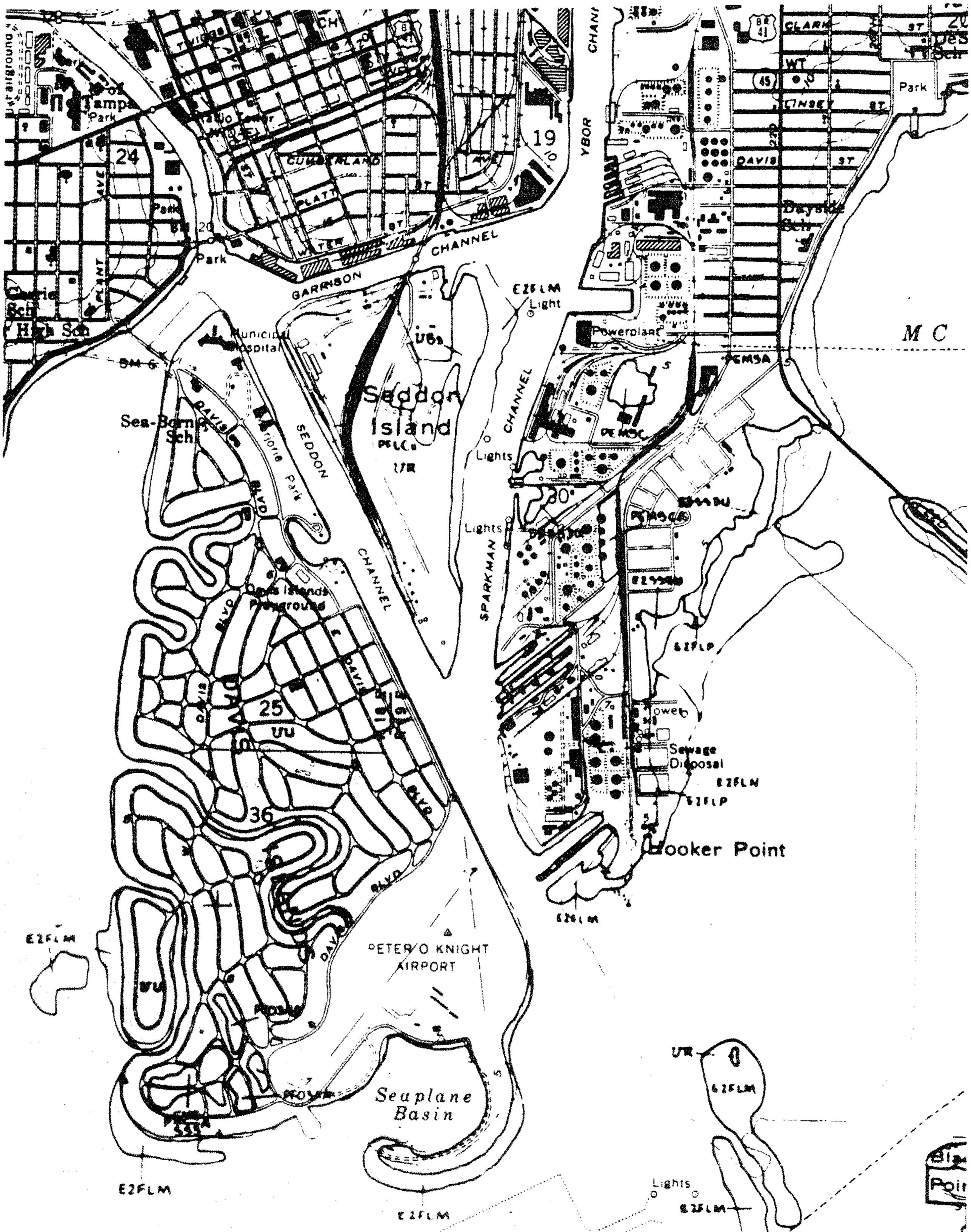


Figure 2. Excerpt from 1952 National Wetland Inventory habitat map of Tampa quadrangle.

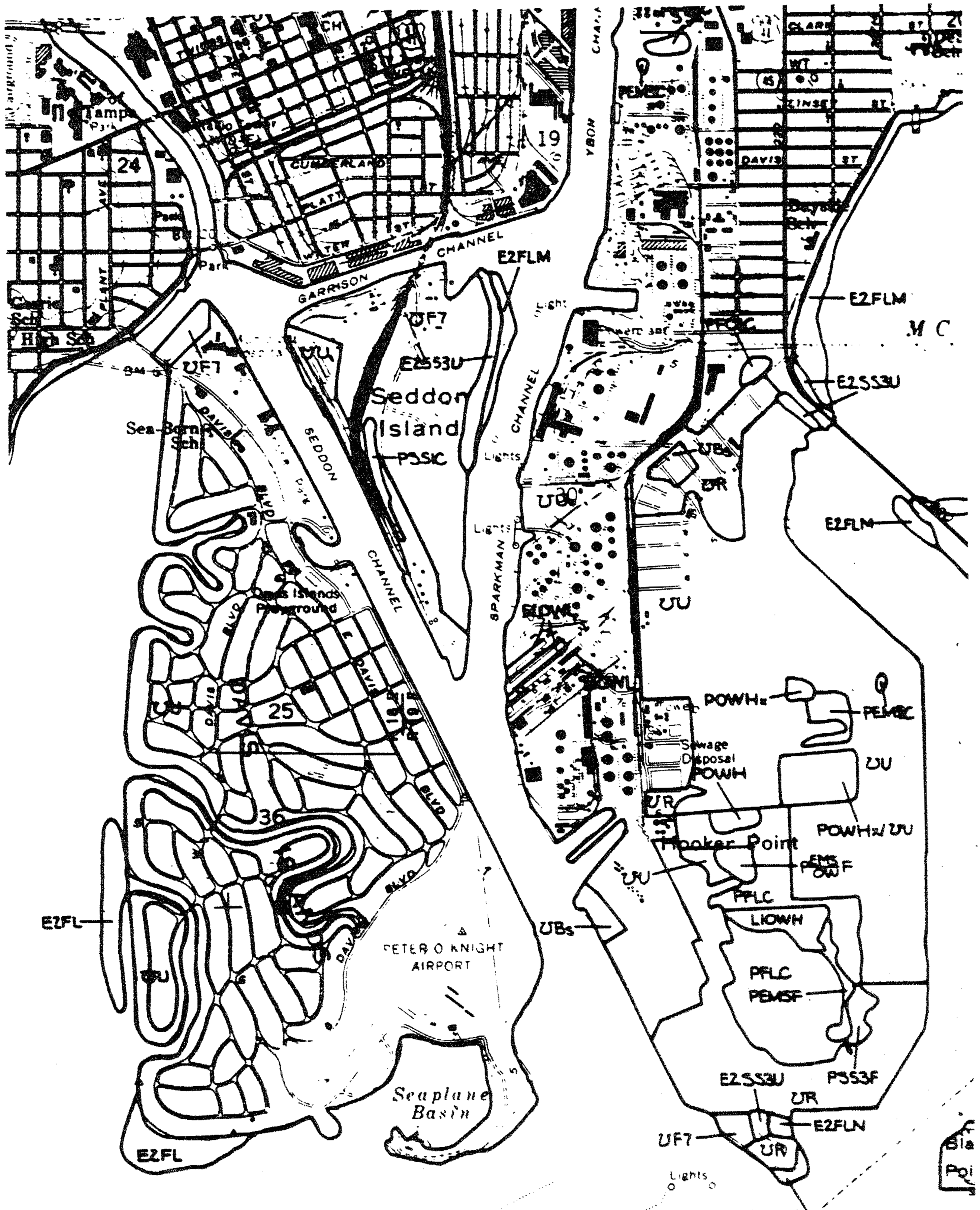


Figure 3. Excerpt from 1982 National Wetland Inventory habitat map of Tampa quadrangle.

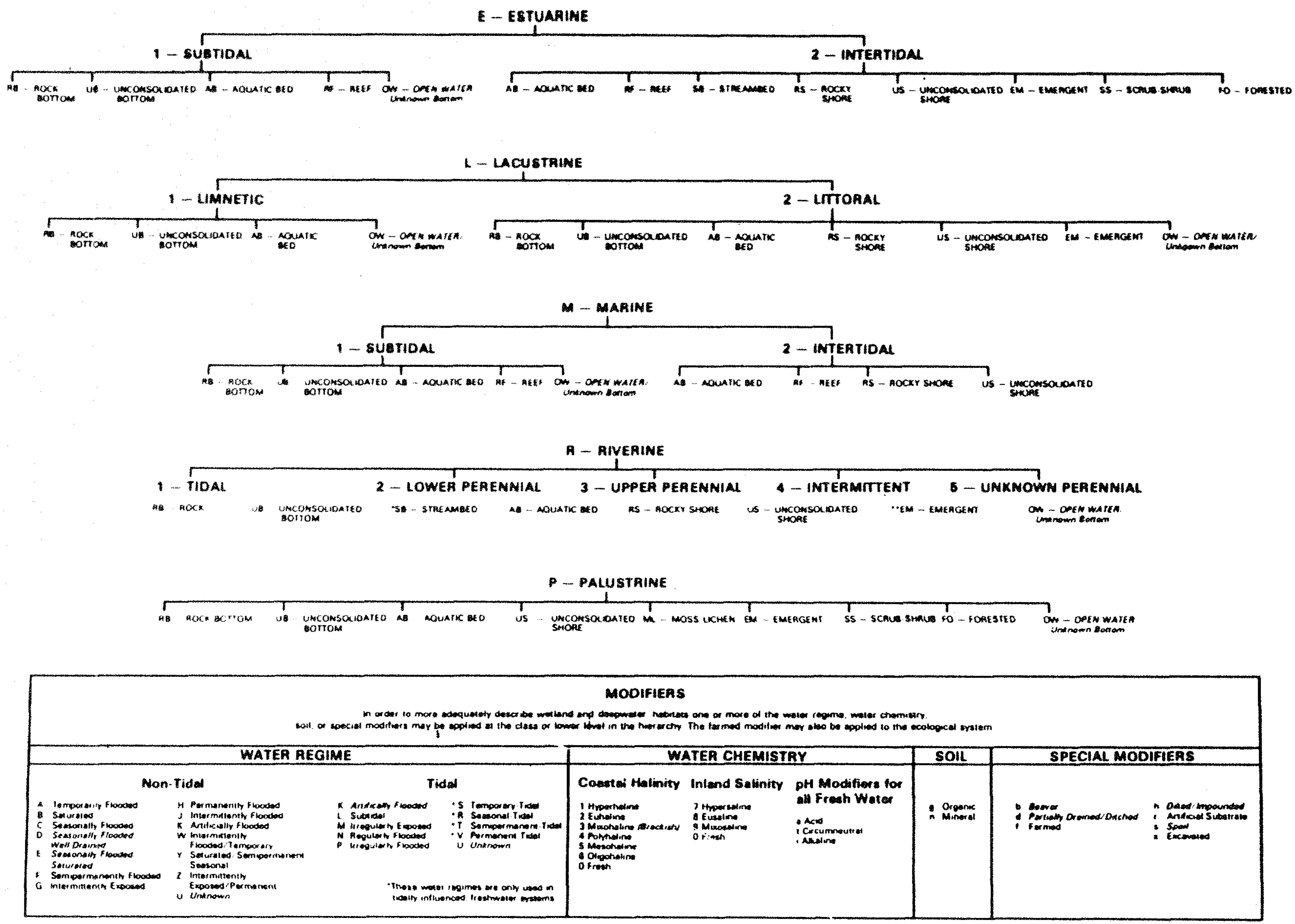


Figure 4. Excerpts from National Wetland Inventory legend.

The 21 quadrangles were chosen to cover not only all of the major portions of the Tampa Bay Estuary, but also a significant portion of its watershed. This extensive mapping was strongly supported by local environmentalists and was made possible by the cooperative effort with the BMR cited in the previous section. Inclusion of the watershed areas will allow future analyses of changes in surrounding land use that may affect the quality and use of estuarine habitats.

Martel Laboratories produced the maps under a contract to the FWS. Existing color aerial photography from a commercial firm was used for the 1982 mapping. Photography by the Florida Department of Transportation was used for the 1950-1956 time period. The 1972 photography had been mapped previously as part of the National Wetlands Inventory, but the maps needed to be updated.

The accuracy of the map deleneation is limited by the fact that many of the areas of greatest interest to this study, such as seagrass beds, are underwater and therefore difficult to distinguish in aerial photographs. This limitation is particularly true for areas lying in deeper water.

Following initial mapping, copies of the 1982 maps were taken into the field by representatives of TPA, FWS, and BMR to be field-verified. Designations on the maps were compared to actual plant communities at a number of locations and corrected. It should be noted that such field verification is very labor-intensive, and many mapped areas were given only a cursory inspection during a single season. Seasonal changes may significantly influence the accuracy of mapping marine habitats such as algal beds. Further, no field verification of maps from the 1950's was available.

The aerial coverage of the three sets of photographs differs, resulting in limited gaps where mapping was not possible. In addition, the mapping does not differentiate the quality (i.e., density) of wetland areas. Therefore, a luxuriant, healthy seagrass bed or marsh may appear equivalent to a sparsely vegetated, stressed area, even though the habitat value of the two areas may be quite different.

MAP DIGITIZATION AND ANALYSIS

The FWS has previously developed a geographic information system technology known as the Analytical Mapping System (AMS) for digitizing and computerizing land cover mapping. Using this technology, the staff of the NCET subsequently analyzed each Tampa Bay map and entered the location, size, and configuration of each delineated wetland or nonwetland area into a data base on a mini computer.

Subsequently, these data were transferred to a Map Overlay and Statistical System (MOSS) whereby the maps can be transferred to different projections and can be mathematically superimposed. For each map, the areas of each designation were computed for each time period, and the differences, or habitat area changes, were computed. The habitat types have been condensed into major habitat types, the areas of which are shown in Table 2.

Finally, a Cartographic Output System (COS) was utilized to produce computer-generated maps that provide a graphic comparison of habitat changes in different

Table 2. Area of various wetland and upland habitats for 21 quadrangles in the Tampa Bay region for three time periods.

Habitat type	1950's acreage	1972 acreage	1982 acreage	1948 - 1982 change	% change
Salt marsh	4,672	3,610	3,238	-1,434	-30.7%
Fresh marsh	20,031	11,820	9,095	-10,936	-54.6%
Forested wetlands	30,255	34,561	29,470	-785	-02.6%
Estuarine vascular aquatics	40,324	25,572	22,526	-17,798	-44.1%
Other aquatics	0	183	298	+298	----
Mangroves	18,645	18,656	18,030	-615	-03.3%
Estuarine open water	206,740	214,043	212,623	+5,883	+02.8%
Fresh open water	6,522	11,620	15,349	+8,827	+135.3%
Beaches, bars, & flats	18,171	16,369	19,825	+1,654	+09.1%
Spoil (non-upland)	0	461	388	+388	----
Upland - urban/developed	78,670	241,414	246,381	+167,711	-213.2%
Upland - other	376,894	262,793	224,396	-152,498	-40.5%

areas of the estuary. The habitat types are usually combined (Table 3) to provide for ease of comparison. From such data, habitat trends which may influence management decisions can be inferred.

The graphic display makes it clear that these analyses have considerable potential to identify trends in habitat changes and, therefore, to assist in estuarine management decisions. There are, however, significant limitations on their use. Most of these result directly from the limits on accuracy, field verification, and habitat quality differentiation inherent to the aerial photographs and habitat maps. As a result, quantitative comparisons must be analyzed and interpreted with considerable caution.

Preliminary comparisons of these data with data collected by local scientists indicate considerable differences in the total area of seagrasses and other submerged vegetative communities--even for the same 1982 photographic survey. These differences appear to be due to a significant divergence in the designation of areas as macroalgal beds or seagrasses and to the application of a vegetation density factor in the local studies.

These problems are inherent to any initial areawide mapping effort and will be reduced over time. The digitized map data was transmitted by the FWS to the BMR for continuing use and refinement under state programs. Through such use, additional field data will be acquired and the accuracy of the data base enhanced. This subject is discussed further in a later section of this report.

TAMPA BAY ENVIRONMENTAL ATLAS

A task closely related to the mapping of wetlands and landuse involved the production of a biological and water atlas for the same study area (Kunneke and Palik 1984). This consists of maps prepared by Martel Laboratories under contract to the FWS and a narrative report. Mapping was done by quadrangle at a scale of 1:24,000. A total of 18 biological and 20 water resource base maps were produced.

Biological resources (Figure 5) depicted in these maps included shellfish harvest areas, oyster beds, clam and scallop beds, finfish areas, manatee habitats, seagrass beds, artificial reefs, and waterfowl areas. Water resource information (Figure 6) included salinity, point source discharges, dredged material disposal sites, tide stations, water quality parameters, bathymetry, intertidal zones, sediment types, tidal currents, and the freshwater/saltwater interface for ground waters. The narrative (Kunneke and Palik 1984) provided a concise discussion of each biological community, physical or chemical parameter, and type of artifical feature depicted in the maps.

The purpose of these products was to provide Federal, State, and local decision-makers with a concise source of information for coastal planning and management of wetland areas. Through the combined use of these maps and the wetland/landuse maps, hypotheses regarding factors related to changes in wetlands might be developed. Further, information contained in the atlas was deemed critical to successful planning for future mitigation projects. A limited number of copies of the atlas are available from the Information Transfer Specialist of the NWRC whose address is given on the title page of this report.

Table 3. Conventions used to condense Tampa Bay mapping data for wetland trend analyses.

Habitat type on maps	NWI Classifications
Salt marsh	E2EM
Fresh marsh	PEM
Forested wetlands	PFO + PSS
Estuarine vascular aquatics	E2AB2 + E1AB2
Other aquatics	E2AB1 + E1AB1 + E2AB4,5,6,7, + E1AB4,5,6,7
Mangroves	E2FO3 + E2SS + E2FO4
Estuarine open water	E1OW
Fresh open water	POW + PAB + PFL + PUB + ROW + RAB
Beaches, bars & flats	E2FL + E2BB (except those ending in "s") + E2RF + M2BB
Spoil (non-upland)	All E2FL + E2BB ending in "s"
Upland - urban/developed	UU
Upland - other	UB + UF + UR + UA
Classifications not used for wetland trend analysis	M1OW + M2FL + M2AB

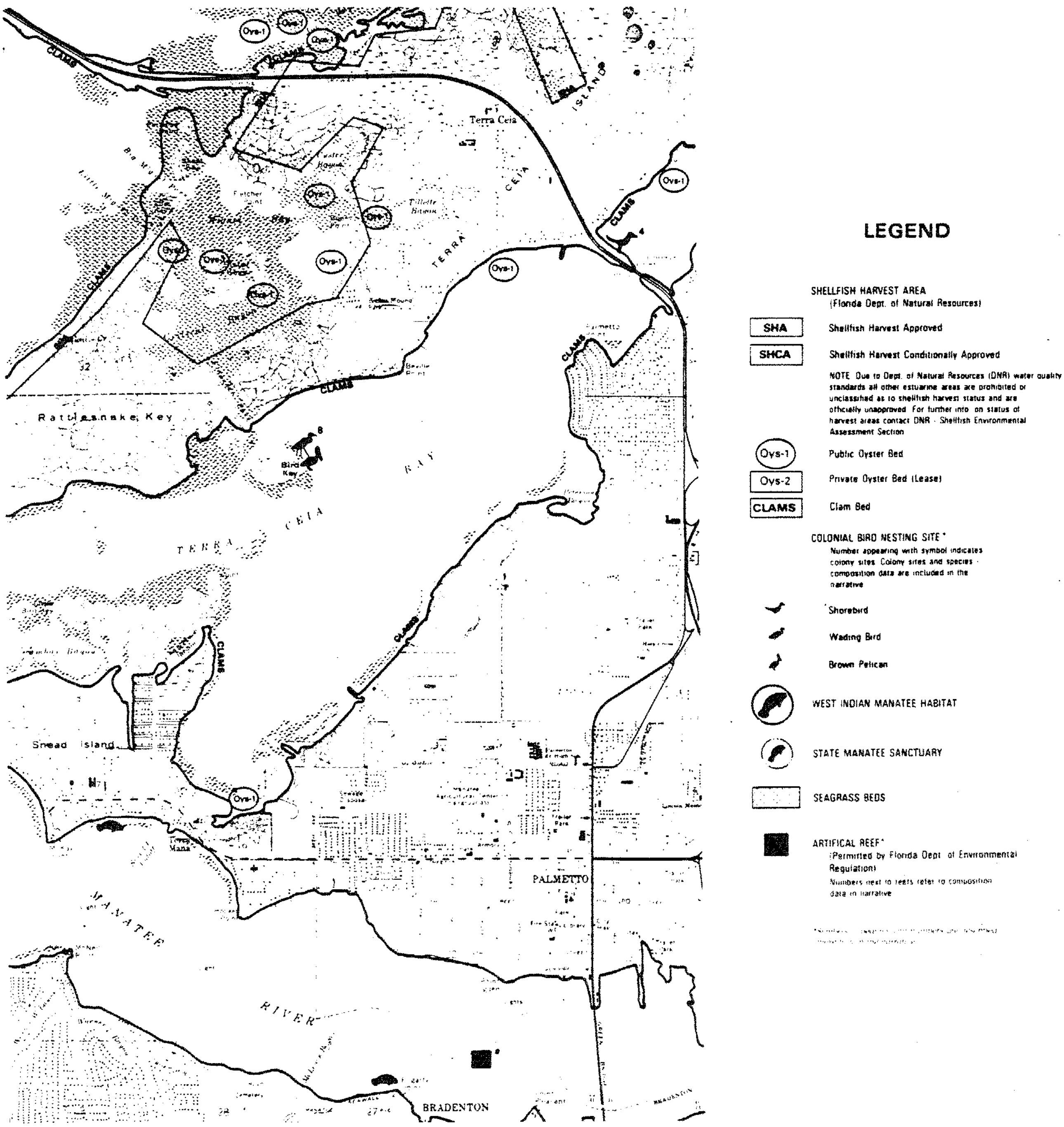


Figure 5. Excerpt from biological resource map for Palmetto.

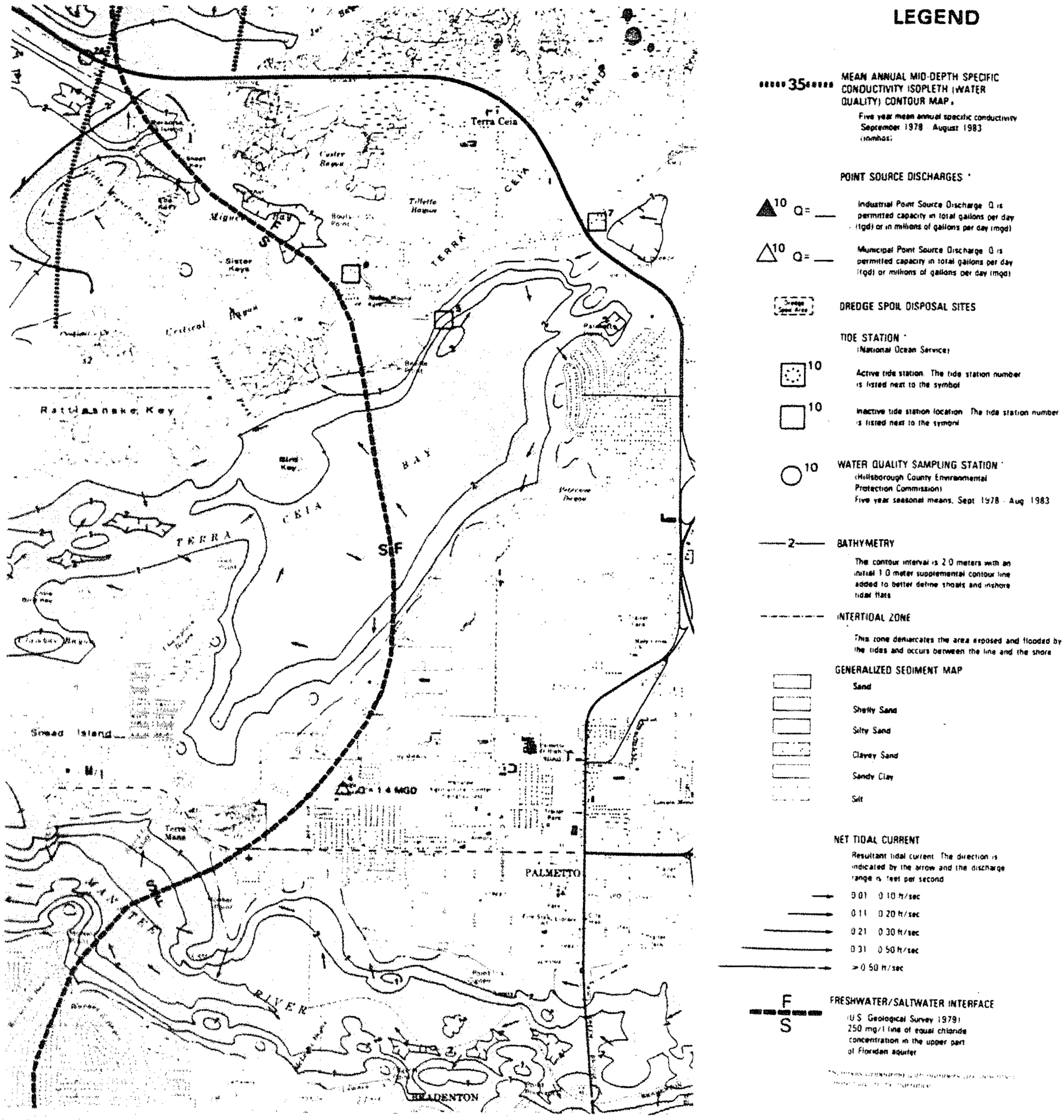


Figure 6. Excerpt from water resource map for Palmetto.

HABITAT SUITABILITY INDEX MODELS

An important process in developing any truly usable habitat mitigation plan is the evaluation of the quality of the habitat which must unavoidably be altered and the quality of the habitat to be improved or developed to compensate for development impacts. In an effort to standardize and quantify the process by which these evaluations are made, the FWS has developed Habitat Evaluation Procedures (HEP; USFWS 1980). Central to this process are habitat suitability index (HSI) models which provide a quantitative method for evaluating existing or potential habitat for a particular animal species of concern.

When HEP were initially developed the procedures were used primarily in regard to upland species. Due to the lack of appropriate habitat suitability models, these procedures have had little historical application in estuarine areas. This is significant since development in estuarine coastal wetlands has been a major source of wetland losses and the site of numerous mitigation efforts, particularly in Florida.

To provide the tools needed to use HEP in developing future mitigation plans, the FWS contracted with the University of Florida's School of Forest Resources and Conservation to develop HSI models for several species of particular interest in Tampa Bay and other southeastern estuaries. Species were chosen to include invertebrates, fish, and birds and included pink shrimp (Penaeus duorarum; Mulholland 1984a), hard clams (Mercenaria sp.; Enge and Mulholland 1985), flounders (Paralichthys sp.; Enge and Mulholland 1985), white ibises (Eudocimus albus; Hingtgen et al. 1985), brown pelicans (Pelecanus occidentalis carolinensis; Hingtgen et al. 1985), lesser scaup (Aythya affinis; Mulholland 1985a), and laughing gulls (Larus atricilla; Zale and Mulholland 1985). Copies of the HSI models can be obtained from the Information Transfer Specialist of the NWRC whose address is given on the title page of this report.

The format for each model is the same and is illustrated by the table of contents for the flounder model presented in Table 4. Each report briefly discusses the life history of the subject species and establishes the habitat variables assumed to control its biological success. The assumed relationships of those variables and life requisites to the habitat suitability are then established as shown in Figure 7. For each variable used a series of graphs such as those shown in Figure 8 is presented, from which a rating for an existing or proposed habitat area may be determined. Finally, a formula is provided for weighting and combining such ratings into an overall rating for the area as habitat for the subject species.

The seven models developed all deal with species of particular concern to the FWS and to bay management interests in general. They have not yet been tested through application to specific projects and may require significant further refinement before they will be generally reliable as a management tool. Guidance for use of HSI models is provided by USFWS (1980).

ESTUARINE PROFILE

In order to provide a more detailed discussion of the specific geological, chemical, and biological aspects of Tampa Bay than would be available through the

Table 4. Typical organization of habitat suitability index model reports.

PREFACE
ACKNOWLEDGEMENTS
INTRODUCTION
Distribution
Life History Overview
SPECIFIC HABITAT REQUIREMENTS
Adult
Embryo
Larva
Juvenile
HABITAT SUITABILITY INDEX (HSI) MODELS
Model Applicability
Model Description
Suitability Index (SI) Graphs for Model Variables
Component Index (CI) and HSI Equations
Field Use of Model
Interpreting Model Outputs
LITERATURE CITED

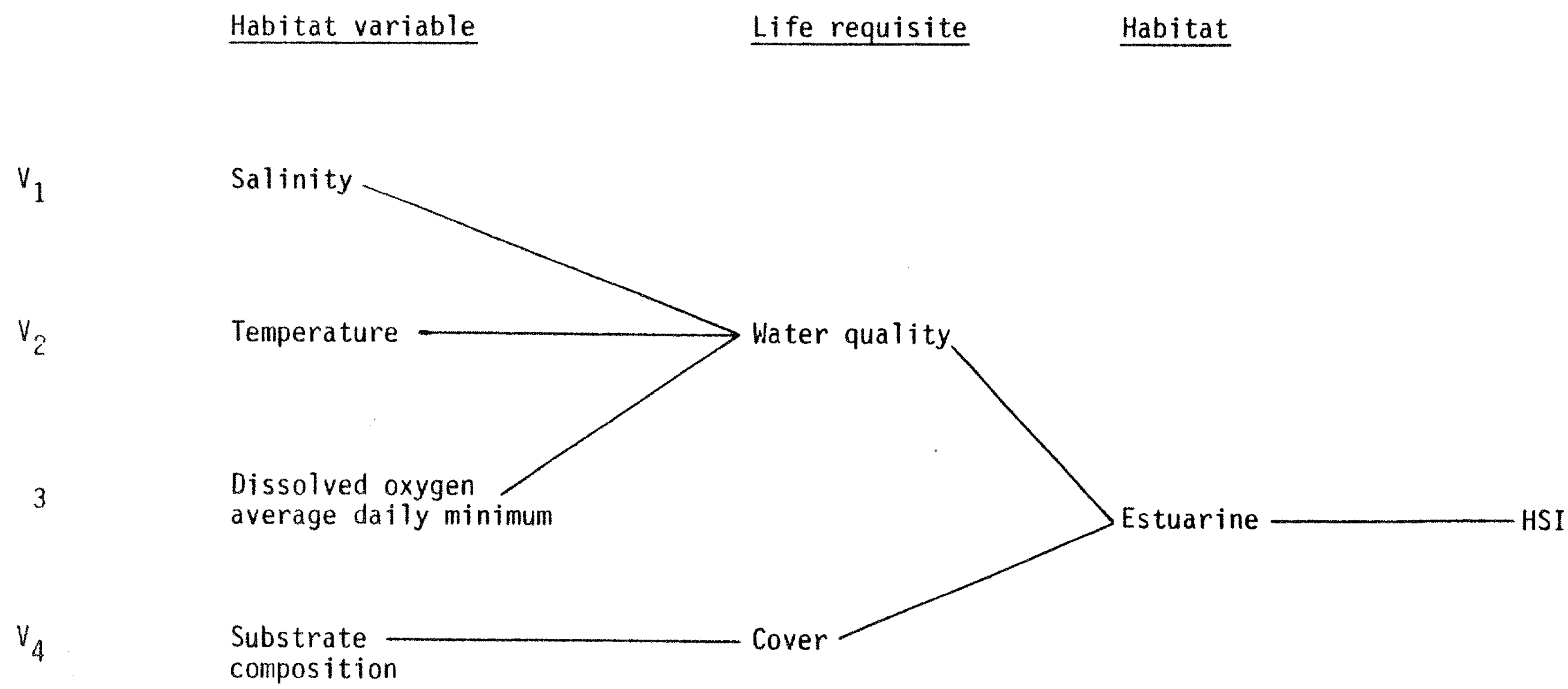


Figure 7. Relationship of habitat variables and life requisites to the habitat suitability index for southern and gulf flounders in estuarine habitats.

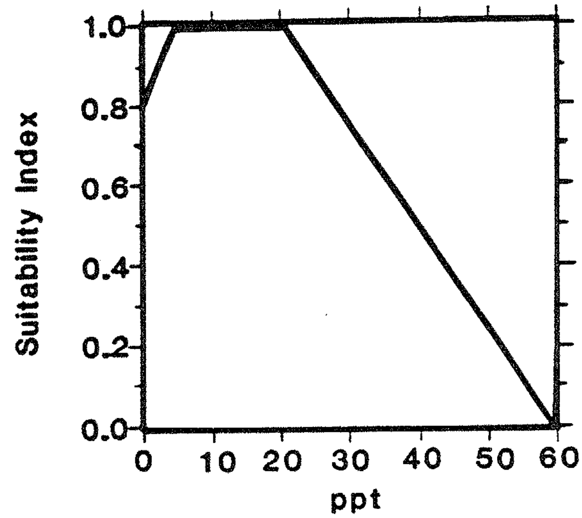
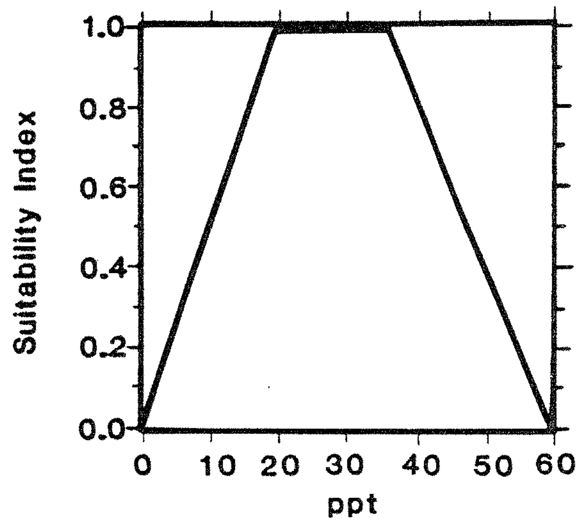
Habitat	Variable		Suitability Graph
E	V_{1_S}	Average annual salinity 10 to 15 cm (3.9 to 5.9 inches) above the bottom for southern flounder.	
E	V_{1_G}	Average annual salinity 10 to 15 cm (3.9 to 5.9 inches) above the bottom for gulf flounder.	

Figure 8. Suitability index graphs for variables used in southern and gulf flounder model.

watershed ecological characterization described in the previous section, the FWS contracted with two local scientists to produce an estuarine profile for Tampa Bay (Lewis and Estevez 1986). Such reports are designed to be complete and current syntheses of ecological information on individual estuaries. The ecological components, values, functions, roles, and processes are integrated from a comprehensive review of current research results and scientific literature. Such reports provide a concise, yet holistic, treatment of the estuary. They include factual information and discussions of management issues. Copies of this report will be available through the Information Transfer Specialist of the NWRC whose address is given on the title page of this report.

The contents of the report are listed in Table 5. Topics addressed include the geological origins and evolution of the estuary, the hydrologic cycle of the estuary, including both surface and groundwater flows, hydrographic characteristics of the estuary, and the chemical regimens of bay waters and sediments. Biological resources of the bay are discussed, including plankton, wetlands, shellfish, fish, birds, and mammals. For each major group a synthesis of important existing data and identification of information gaps are provided.

Significant observations include the variability and high levels of phytoplankton found in portions of the estuary and the need to understand the value of algae beds as habitat. Seagrasses and mangrove forests are important habitats in Tampa Bay and both have experienced significant declines in area. Causes include eutrophication, fill for development, and cold weather. The seagrass communities provide a critical habitat for many marine animals, including juvenile forms of many fish species, though quantitative data on the functional role and total primary productivity of seagrasses as habitat in Tampa Bay are limited.

Important animal species include oysters, 200 species of finfish, aquatic birds, and manatees. Little quantitative information is available on the oyster or finfish populations, and additional research on the role of oysters in filtering particulates from the water column and into life requirements for finfish and their relation to habitat availability is needed. Tampa Bay is a very important breeding and nursery area for colonial aquatic bird species such as pelicans, gulls, and herons. Data for recent years indicates a general decline in the numbers of many species, apparently due to a combination of factors including outbreaks of red tide, parasites, dredge and fill activities, and pesticide use. Tampa Bay serves as habitat to the severely endangered West Indian manatee. A population of up to 55 of these creatures has been noted in the bay, generally concentrated near utility and industrial warm water discharges during winter months.

Ecological relationships in Tampa Bay have received little scientific study and much of current thinking about such relationships is based on anecdotal "evidence." Research is needed into several such areas to improve the ability of resource management agencies to protect and restore the estuary. These include the relative importance of various energy pathways, impacts and relationships of abiotic controls on plant and animal communities, plant and animal relationships, and the relationship of habitat area and quality to fisheries populations.

The report concludes with a discussion of management issues related to Tampa Bay. Foremost among them is the lack of any coordinated bay-wide management

Table 5. Contents of Tampa Bay estuarine profile.

(continued)

Table 5. Concluded.

Attached and Drift Macroalgae
Seagrass Meadows
Tidal Marshes
Mangrove Forests
Riverine Forests and Adjacent Wetlands
Total Primary Production and Organic Material Input
Secondary Producers
Zooplankton
Benthos
Fish
Reptiles
Birds
Marine Mammals
Ecological Relationships
Carbon Productions
Trophic Structure and Habitability
ECOLOGICAL INTERELATIONSHIPS
Energy sources
Abiotic Controls in Communities
Plant and Animal Interactions
Fisheries Habitats
MANAGEMENT
Recent Progress in Bay Management
Dredge and Fill
Freshwater Flow to the Bay
Fisheries
Eutrophication

program for the estuary, and legislative resistance to adding additional management bureaucracy or funding new management programs during the present period of fiscal retrenchment. There is a need for a long-term plan for disposal of dredged material from port operations in light of the fact that port development has caused 60% of the historical filling in the bay. The collapse of most commercial and recreational fisheries needs to be studied and management of both harvesting and critical habitats initiated. The impacts of human withdrawals of fresh water from rivers, and of groundwaters discharging into the bay on larval fish populations need to be studied and those withdrawals and discharges better regulated. Eutrophication, while long a concern, needs continuing study with particular attention given to the apparent shift of primary productivity further toward phytoplankton at the expense of seagrasses and macroalgal communities.

MITIGATION OPTIONS STUDY

To address the future mitigation needs of port and other public projects FWS contracted with Continental Shelf Associates, Inc. to conduct a study of past mitigation projects in the Tampa Bay area and of potential options for mitigating unavoidable impacts of future port projects (Dial and Deis 1986). A limited number of copies of this report are available from the Information Transfer Specialist of the NWRC whose address is on the title page of this report. This study consisted of five tasks: (1) Review and evaluate past mitigation projects in the Tampa Bay area; (2) Prepare a list of feasible mitigation options; (3) Present Task 1 and 2 findings at a public workshop; (4) Develop management and/or restoration recommendations; (5) Identify and rank potential mitigation sites.

Ten past mitigation projects on Tampa Bay (Figure 9) were selected for detailed analysis. Projects were selected so as to include a range of impacted habitats, spatial distribution around the entire bay, a range of project size, and relevance to future port or other public projects. For each project, written records were researched and a field investigation conducted. The reason each project was undertaken, its objectives, the techniques used, and its apparent success in replacing habitat values were identified.

The projects discussed range from 0.012 ha to 110 ha in area and include both marsh and mangrove planting efforts. The 1-year survival of marsh and mangrove plantings ranged from near 0 to over 90% with the lowest success experienced with slow-growing mangroves and the greatest success with cordgrass (Spartina alterniflora) in protected areas. Of those projects designed to specifically replace wetland habitat, at least three out of seven have experienced a permanant loss of wetland habitat, and in six projects the wetlands have been replaced by a different type of habitat (e.g., marsh replacing mangroves). It was noted that in most cases, Spartina marsh plantings began to succeed into mangrove habitat naturally.

The planting costs ranged from $2,300 to $17,500 per ha. The actual cost of planting has not increased substantially in the past decade, but actual planting costs are generally only a fraction of site-preparation costs.

The review of past projects concludes with several general recommendations, including avoidance of project impacts on habitat as much as possible, and use of

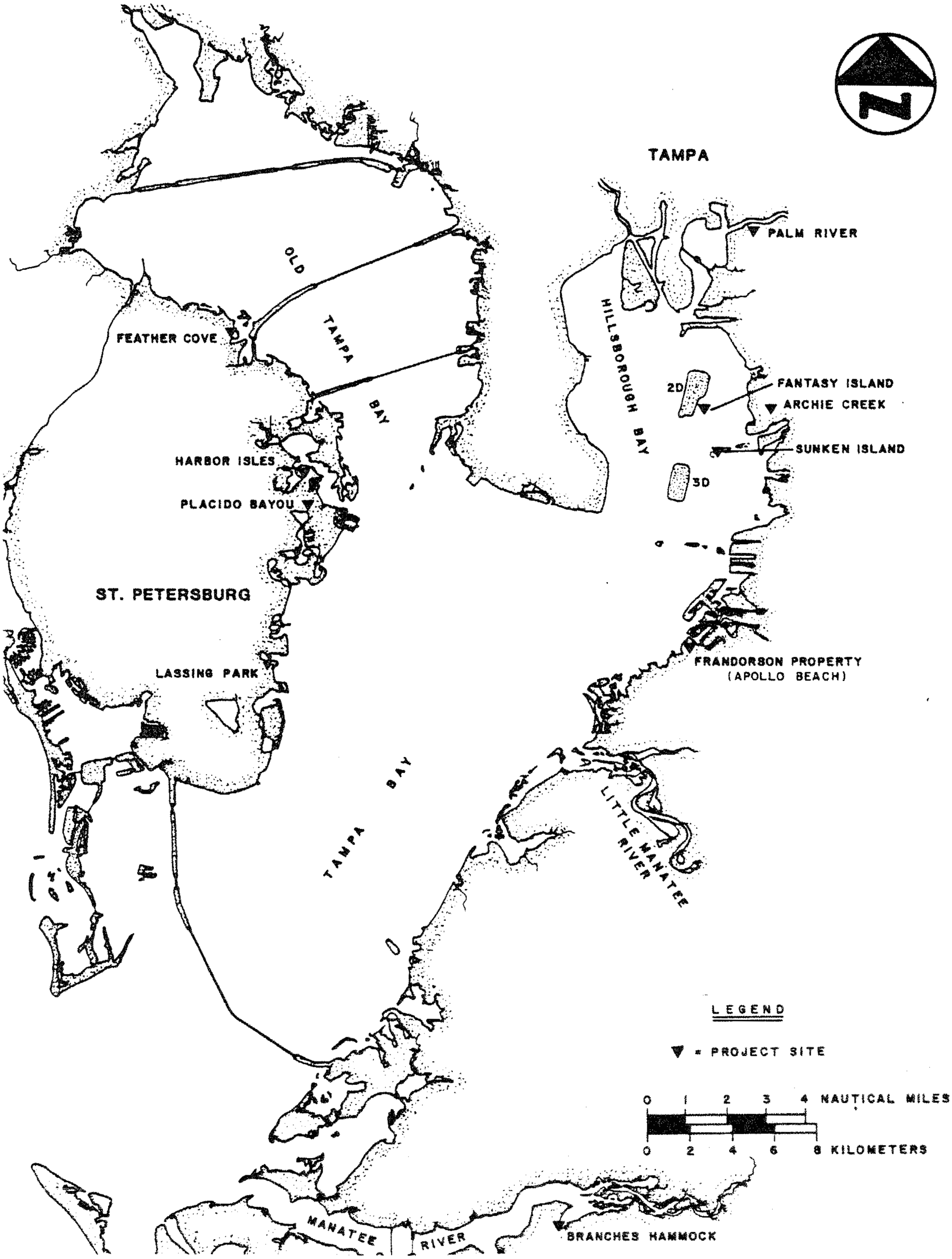


Figure 9. Locations of past mitigation sites selected for study.

upland areas for mitigation. Additional recommendations include development of project-specific goals, requiring that more area be created than is destroyed (particularly where mangroves are replaced by marshes), and development of improved programs to monitor the success of mitigation projects in functionally replacing lost habitat.

The next portion of the study consisted of identifying the types of habitat creation projects which might feasibly be used in mitigation programs in Tampa Bay. Various types of habitat-creation projects used in other locations in south Florida were reviewed, including salt marsh projects, mangrove plantings, seagrass plantings, artificial reef and oyster bar creation, and the use of dredged material in habitat creation.

A detailed discussion of the results of this section exceeds the scope of this document but the recommendations include: (1) the use of smooth cordgrass is recommended for newly-created intertidal areas; (2) the feasibility of expanding or improving mangrove habitat in Florida is good, but problems result from their slow growth and root system spread which require physical protection from wave energy; (3) seagrass restoration in Tampa Bay is not feasible until there is a better understanding of the biological requirement of these species, and light penetration in bay waters improves; and (4) other forms of estuarine habitats (oyster beds, reefs) should be given additional consideration for providing species-specific population enhancement.

The results of these tasks were presented at an informal 1-day workshop. The discussions which occurred during the workshop were used to further refine the general recommendations and to "prescreen" specific sites in Tampa Bay which might be used for future mitigation projects.

The third major task of this study involved identifying and investigating specific sites around the bay which might be used for mitigation projects associated with future port or other public projects. Forty-six potential sites were initially identified. Field investigations were conducted at 19 sites, and 12 potential sites were identified in the final report. The locations of the sites are shown in Figure 10.

In Hillsborough Bay, 47 ha of borrow pits and 165 ha of subtidal areas next to spoil islands were identified for filling to shallow subtidal or intertidal depths as were 52.2 ha of uplands for excavation to intertidal elevations and planting with cordgrass. In the Old Tampa Bay area, some 121 ha of uplands are proposed to be scraped down to intertidal elevations for marsh creation. An additional 132 ha of dredged areas are proposed to be filled to shallower depths. In lower Tampa Bay, 2.5 ha of upland habitat could be scraped down for new wetland habitat.

This section of the report concludes with a discussion of prioritizing these sites for future use. Factors cited which need to be considered in such a selection process include: wetland habitat loss trends, particular species habitat needs, land ownership, engineering feasibility with regard to dredged material use, relation to future port-related and other public projects, and relationships to bay-wide restoration efforts and goals. It is noted that upland sites available for mitigation are scarce, and large sites are practically nonexistent.

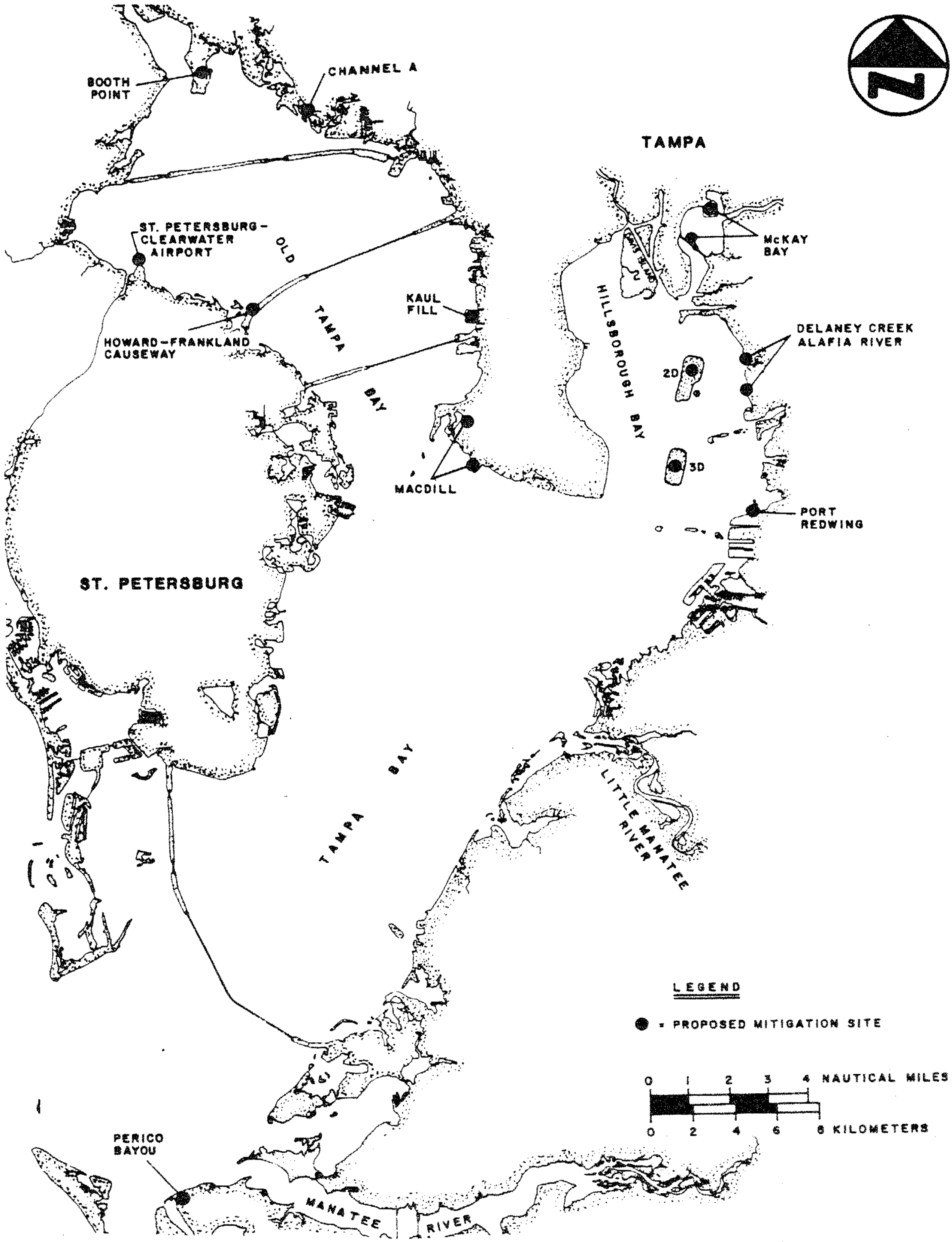


Figure 10. Locations of proposed mitigation sites in Tampa Bay.

The final task of this study was the development of general recommendations for the use of mitigation in the environmental management of Tampa Bay. This last portion of the report includes a discussion of the current management programs dealing with the bay, the definition of mitigation, the information needs for developing regional mitigation planning, and the information needs when restoration or creation of wetlands is required. This section was designed to take the information generated in other parts of the mitigation options study and distill from it specific guidelines which might be used by environmental managers, port managers, and others involved in developing a specific mitigation strategy for all or part of the estuary.

USE OF PROJECT RESULTS AND PRODUCTS IN PLANNING FOR WATER-RELATED DEVELOPMENT AND FOR MANAGEMENT OF TAMPA BAY

The several products presented in the previous section establish a substantial data resource for future decisionmaking regarding Tampa Bay's uses and resources. This portion of this report will address several major areas of potential application for these products, including opportunities and problems.

PORT DEVELOPMENT PROJECTS

Major potential users of these products are, of course, the TPA and, to a lesser extent due to their smaller size, Port Manatee and the Port of St. Petersburg. These public entities have the responsibility for providing transportation facilities directly in the shoreline areas of Tampa Bay toward which this entire effort has been directed. These facilities are water dependent, and as a result, these agencies commonly find themselves dealing with unavoidable habitat impacts.

A major impact of these reports will be the simple recognition that both habitat resources and mitigation opportunities are limited in and around Tampa Bay. This knowledge should serve as an early warning that future port projects must clearly meet the public need and water dependency tests cited in the mitigation options report, and that the mitigation alternatives of avoiding or minimizing actions must be given priority attention. It is through the modification of development expectations resulting from such recognition that these products may have their greatest impact.

Given that even with modified development plans there will still be unavoidable habitat impacts, these products will greatly enhance the ability of port officials to incorporate mitigation at an early stage of their project planning. Habitat resource maps, along with the estuarine profile, will identify potential areas of project impacts and trends which may be indicative of cumulative impacts. Physical, chemical, biological, and human-related features which might affect project impacts and/or mitigation efforts are available through the resource atlas maps and report. Examples would include things such as sewage discharges, salinity levels, sediment types, and clam or oyster beds.

In assessing the impacts of proposed projects, several of the HSI models should be used to at least rank alternative designs. The mitigation options report, the wetland maps, and the HSI models are all valuable resources for identifying, prioritizing, and selecting appropriate projects to compensate for unavoidable habitat impacts.

Examples of potential port projects for which these data resources might be used include the development of the south end of Hookers Point proposed previously by the TPA, the development of an existing spoil island by Port Manatee, the deepening of the Alafia River and Big Bend Channels by the Corps of Engineers, and the possible enlargement of spoil islands in Hillsborough Bay.

OTHER TRANSPORTATION PROJECTS

The use of these products for other transportation projects would not differ significantly from those described above. Potential users include both State and local entities. Examples of projects for which this data might be useful would include the proposed widening of the Courtney Campbell Causeway in Old Tampa Bay by the Florida Department of Transportation and the extension of the primary runway at Albert Whitted Airport in St. Petersburg. In both cases filling of submerged lands would be necessary, and mitigation of habitat impacts would be required.

A key difference with such projects might be that the question of water dependency would have to be addressed more carefully. However, in many cases relocating projects away from the water may simply not be socially or economically acceptable.

REGULATORY AGENCIES

Local, State, and Federal regulatory agencies should all be able to use these products in their decisionmaking procedures. The habitat maps and HSI models could be very valuable in assessing project impacts. Since both the U.S. Army Corps of Engineers (COE) and the FDER must now consider cumulative impacts of proposed projects, the trend analyses possible through use of the MOSS and the COS could be particularly useful in evaluating and defending regulatory decisions.

Since agencies at all levels with responsibility in Tampa Bay are now requiring mitigation, many of these products will be as useful to these agencies as to the ports and other public "development" entities. The HSI models and the mitigation options report may be particularly useful for evaluating impacts and planning mitigation since, as noted above, options for mitigation projects of any significant size are limited.

RESOURCE MANAGEMENT AGENCIES

Submerged lands and the associated benthic or littoral habitats in Tampa Bay belong to either the State of Florida or the TPA. State lands are managed by the FDNR which, as noted in an earlier portion of this report, now has the digitized map data produced by this project. These data will assist the Department in its various management responsibilities, including tracking wetland changes in state aquatic preserves, mapping the results of habitat utilization studies, and developing habitat restoration projects funded by local net fees. As discussed further below, the FDNR must play a major role in the continued use and improvement of this information.

PLANNING AGENCIES

Regional and local planning agencies can use the information contained in the habitat maps in preparation of various elements of their required comprehensive plans. Future land use plans, transportation plans, and conservation and coastal zone management elements will particularly benefit from these data. Similarly, the habitat trend analyses available through the MOSS might be utilized in projecting both land use impacts and habitat protection needs. These products would be useful in the development of regional and county marina-siting plans required by state regulations. Habitat maps and resource atlases will be particularly useful in identifying environmentally acceptable locations for such facilities.

The Agency on Bay Management of the TBRPC is one agency for whom these products may have particular significance. As noted earlier, this agency was established in response to the need for a bay-wide planning framework identified in several of these reports and is trying to initiate solutions to a myriad of bay-related problems. While habitat trends and mitigation are only two of numerous concerns, this is the only agency whose mandate deals with the entire bay and nothing else.

The maps and reports will be useful in developing and refining bay-wide management goals and objectives. These might include the mitigation goals cited in the mitigation options report as necessary to the development of a workable mitigation plan, and would be particularly useful if the Agency became involved with planning for, or management of, a mitigation bank.

As with regulatory agencies, the maps and reports will be helpful in developing positions regarding proposed projects. In addition, the graphic products could play a significant role in the Agency's public education programs.

DEVELOPMENT OF A BAY-WIDE MITIGATION/HABITAT CREATION PROGRAM

The development of a bay-wide mitigation program was an early goal of this project. The products discussed in this report have not addressed several problems which caused that goal to be abandoned. There is no legal framework for the Federal-State-local agreement that is needed for such a program, and the identity of all necessary participants remains largely undefined. In addition, clear habitat needs and mitigation/habitat improvement goals have not been established.

These products have, however, provided the basic tools for measuring and projecting habitat trends, thus allowing comparisons with subjectively selected regional habitat management goals and the identification of habitat and management needs. They have provided the tools for comparing existing and proposed habitats and for matching key physical conditions to habitat planning. They have provided the basic tools for developing design criteria for mitigation projects and for monitoring the success of projects in meeting habitat management goals once they are established.

Thus, this project has provided many of the basic tools needed to develop a bay-wide mitigation program, including a mitigation bank, which can be implemented once the legal and policy framework is created.

RECOMMENDATIONS FOR FUTURE WORK

In this report we have noted a number of areas where further work is needed or desirable. Improved field verification of the "current" habitat maps is one area where further work is clearly needed. Questions have arisen over habitat area calculations because of apparent confusion between algal and seagrass communities, as well as over vegetation-density differences. As field-verified habitat mapping continues for both public and private purposes throughout the 21-quad study area, these additional data could be provided to the BMR and used to refine the current maps.

The HSI models produced are untested. Because of the variety of physical, chemical, and biological parameters that control estuarine biological community structure it will be necessary to develop significant supporting data to both refine the models and to justify their use. This is another area where data from a variety of sources might be needed to generate the necessary additional data base.

As noted in the Introduction, water quality issues were not a prime consideration in this project. However, water quality plays an important role in the utilization of wetlands, particularly by fish and marine invertebrates, and appears to play a critical role in the continuing decline of seagrasses throughout the bay. The role of water quality in influencing habitat utilization and value, as well as the potential for habitat creation, clearly needs to be the subject of research at the earliest possible date.

In addition to questions regarding the role of water quality there are many information needs regarding seagrasses in Tampa Bay. Because seagrasses have suffered the greatest decline of any vegetational community and may have the greatest overall habitat value, it is probably the habitat of first choice for restoration programs. Unfortunately, the current lack of knowledge regarding the physical, chemical, and perhaps biological needs of these species precludes effective initiation of their recovery. This is an additional area of critical research needs.

As development pressures continue to build on the limited shorelines of Tampa Bay, the economic and natural resource "stakes" of management decisions will become greater. To insure that the protection of Tampa Bay's natural resources is given appropriate consideration in these decisions, more data are needed on the social and economic value of those resources. It is important that local citizens and decisionmakers have the tools to consider what the loss of things like a recreational and commercial fishery, clean water for bathing, and abundant aquatic bird life would mean to both the local quality of life and the local economy.

Effective management of Tampa Bay's varied resources will also require significant further work. Comprehensive resource management goals must be identified and a comprehensive management plan developed. A program for mitigation banking for public projects must be carefully considered and a comprehensive long-term strategy for disposal of material generated by both construction and maintenance dredging must be developed. Stronger public commitments must be made to limiting freshwater withdrawals, recycling treated wastewater, improving sewage treatment, and reducing the impacts of stormwater runoff.

Finally, the current fragmented management program for the bay must be consolidated and streamlined. The existing program involves a myriad of agencies, regulations, and interests. This regulatory morass has the benefit of making the approval of many projects affecting the bay extremely slow and tedious, but makes legislators and regulated parties extremely resistant to the addition of additional management programs. It is clear that many of the involved agencies will have to give up some individual control if a consolidated and effective management program is to be developed.

CONCLUSIONS

The objective of this project was to provide a number of the basic analytical tools and data summaries needed to develop mitigation and overall management plans for Tampa Bay. It is clear that the project has been successful in doing this. The long-term value of these tools will, however, be determined in large part by the extent to which local and State entities move forward with the development of a more defined and coordinated management program for the estuary. The impending development of State rules regarding mitigation and the emerging strengthened role of the TBRPC in bay management decisions are encouraging indications that this might happen.

The project will be of reduced value, however, if progress toward an overall management program is delayed for several years and both maps and data become outdated. As indicated, a major obstacle to such progress is the fractionalized responsibility for management among local entities and among different levels of government. The prospects for future use of this information would be greatly enhanced by the development of a legal framework through which all involved agencies could work in concert on a mutually binding program for mitigation requirements, habitat restoration, and the overall management of the bay's resources.

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