Status and Trends of Wetland Habitats

Corpus Christi Bay National Estuary

Integrated Work Plan

Thomas E. Dahl (Principal Investigator)
Martha C. Caldwell
Richard D. Young

U. S. Fish and Wildlife Service
Wetland Status and Trends Unit
National Wetlands Inventory Center
St. Petersburg, FL 33702
(813) 570-5429/5412

Project Coordinator
Hudson R. DeYoe
Corpus Christi Bay National Estuary Program

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CORPUS CHRISTI BAY NATIONAL ESTUARY PROGRAM

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Work Plan prepared by: Thomas E. Dahl Date: August 1995

CCBNEP
Program Director

_____
Richard Volk Date

CCBNEP
Project Coordinator

_____
Hudson DeYoe Date

U. S. EPA
Project Officer

_____
Laura Radde Date

Project Review Team:

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IV Project Overview

A) BACKGROUND - WETLAND STATUS AND TRENDS

The Wetland Status and Trends Study employs remote sensing techniques to locate, identify and classify wetlands, deepwater habitats and upland land use. High altitude color infrared photography ranging in scale from 1:20,000 to 1:65,000, typically serves as the primary data source for analyzing wetland acreage changes for the Nation, ecoregions and more localized project areas.

The Corpus Christi Bay National Estuary Program (CCBNEP) has determined the need for wetland change information and other important habitat types in the estuary drainage area. Because Wetland Status and Trends has work ongoing along the Texas Coast and because of previous experience in monitoring wetland changes, Status and Trends is in a position to assist CCBNEP. This is an integrated work plan describing the project that will provide wetland status and trends information for the CCBNEP to help fulfill their needs[1].

B) OBJECTIVES OF CORPUS CHRISTI BAY NATIONAL ESTUARY PROJECT.

The Corpus Christi Bay National Estuary Program has work ongoing relating to the ecology and management of the estuary system. The study area includes portions of 71 quadrangles extending from Aransas south to Baffin Bay, Texas (Figure 1). The Scientific-Technical Advisory Committee has recognized seven (7) coastal habitat types that are of concern within the CCBNEP study area. These habitat types include:

- Seagrass beds
- Freshwater and saltwater wetlands and aquatic habitats (deepwater)
- Oyster reefs, serpulid worm reefs and other hard bottoms
- Natural and dredged material islands
- Riparian woodlands along streams and rivers

[1]It should be noted that the Fish and Wildlife Service (FWS) is approaching this project as a joint effort. Total cost will be shared between CCBNEP and FWS (see section VII).

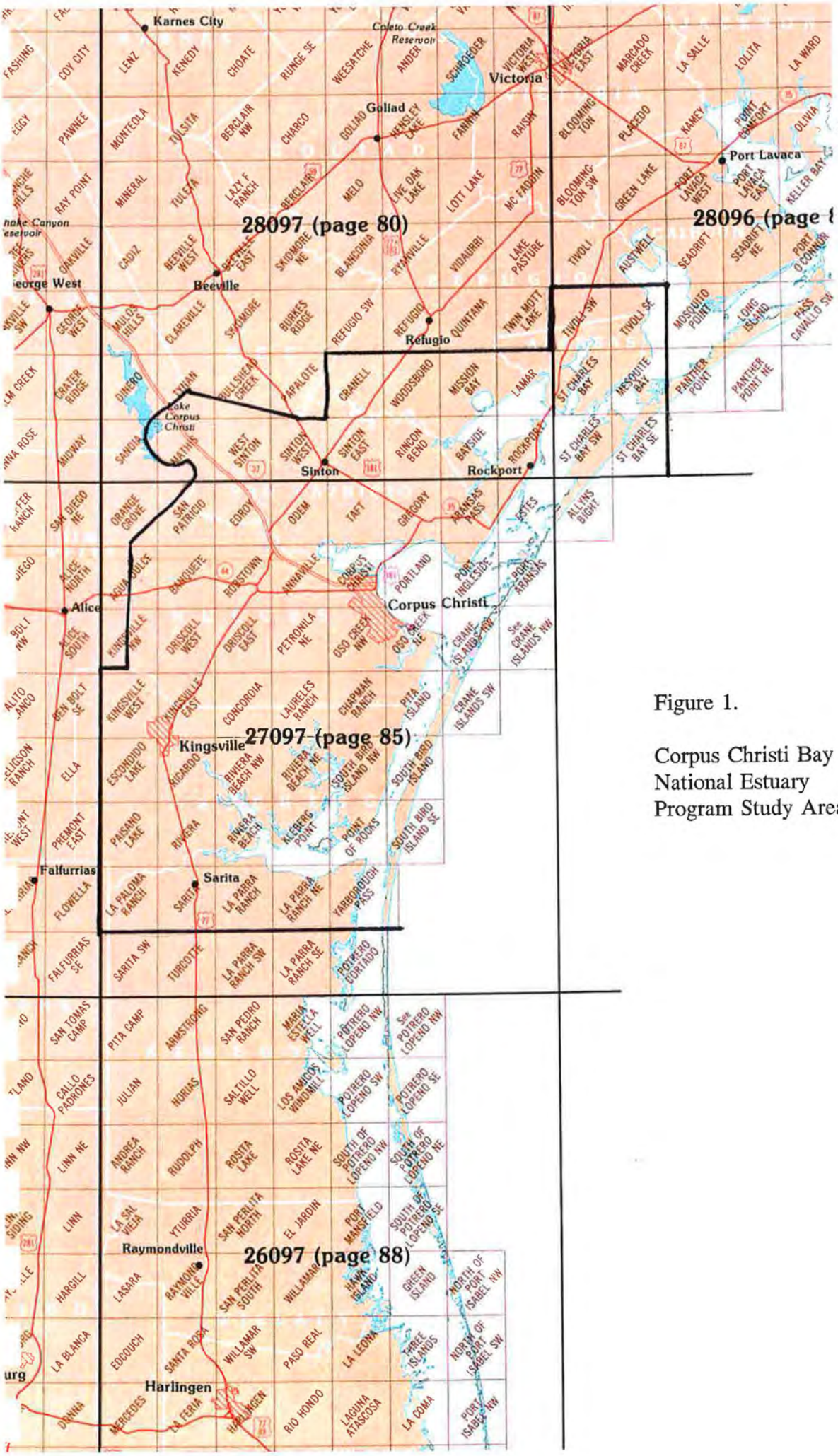


Figure 1.

Corpus Christi Bay National Estuary Program Study Area.

- Coastal oak mottes and brush
- Artificial shorelines including artificial hardened shorelines and beaches.

The CCBNEP has developed study plans to examine the status of these key habitats within the estuary system. As part of that effort, this study has the following specific objectives: accurately describe the status and trends of all freshwater and saltwater wetlands and aquatic habitats; determine changes and current status of natural and dredged material islands; and, determine the extent of and changes that have occurred to riparian woodlands (as they are coincidental with wetlands).

To accomplish these objectives, this project will rely on comparisons between distribution, areal extent and types of wetlands using 1952, 1979 and 1992-94 aerial photography. The photographs will be used in combination with other sources of collateral data and field work to provide important resource information for a comprehensive analysis of the target categories.

C) OUTLINE OF APPROACH

This project will compare wetland and aquatic (deepwater) features as delineated on aerial photography between the 1952, 1979 and the 1992-94. Comparisons will be made between the areal extent as well as the types and location of wetlands and aquatic habitats. The primary objectives are to determine the changes in freshwater and saltwater wetlands and aquatic habitats, natural and dredged material islands, and riparian woodlands; quantify those changes, produce computerized map data relative to the change in status and produce a report of the study findings.

Wetland and Upland Classification: This project will use the classification scheme presented in Table 1. This incorporates additional levels of detail to the standard Status and Trends classification descriptors consistent with project objectives. Definitions of the Status and Trends categories can be found in the document entitled: "Continuous Wetland Trend Analysis Project Specifications", 1994 (Attachment 1).

Table 1. Wetland, Deepwater and Upland Habitat Categories

Attribute	Salt Water Habitat	Common Description
M1	Marine Subtidal	Deepwater
M2	Marine Intertidal	Nearshore
E1	Estuarine Subtidal	Open Water/Bay Bottoms
E2EM	Estuarine Intertidal Emergents	Salt Marsh
E2SS	Estuarine Intertidal Scrub/Shrub	Mangroves or Other Estuarine Shrubs
E2US	Estuarine Intertidal Unconsolidated Shore	Beaches/Bars/Flats
E2FL	Estuarine Intertidal Unconsolidated Shore	Wind-Tidal Flats
E2RS	Estuarine Intertidal Rocky Shore	Rocky Shores
E2RS1	Estuarine Intertidal Rocky Shore	Concrete, Artificial Walls or Rip Rap
E2AB	Estuarine Intertidal Aquatic Bed	Floating or Submerged Aquatic Vegetation
E2RF	Estuarine Intertidal Reef	Reefs
E2RF2		Oyster Reef
E2RF3		Worm Reef
Attribute	**Freshwater Habitat**	**Common Description**
PFO	Palustrine Forested	Forested Swamps/Treed Bogs
PSS	Palustrine Scrub Shrub	Shrub Wetlands
PEM	Palustrine Emergents	Inland Marshes/Wet Meadows
PUS	Palustrine Unconsolidated Shore	Beaches/Bars/Flats
PUB	Palustrine Unconsolidated Bottom	Open Water Ponds
PAB	Palustrine Aquatic Bed	Floating or Submerged Aquatic Vegetation
Pf	Palustrine Farmed	Farmed Wetlands
LAC	Lacustrine	Lakes/Reservoirs
RIV	Riverine (tidal or non-tidal)	River Systems
m	-Denotes Man-made Feature	

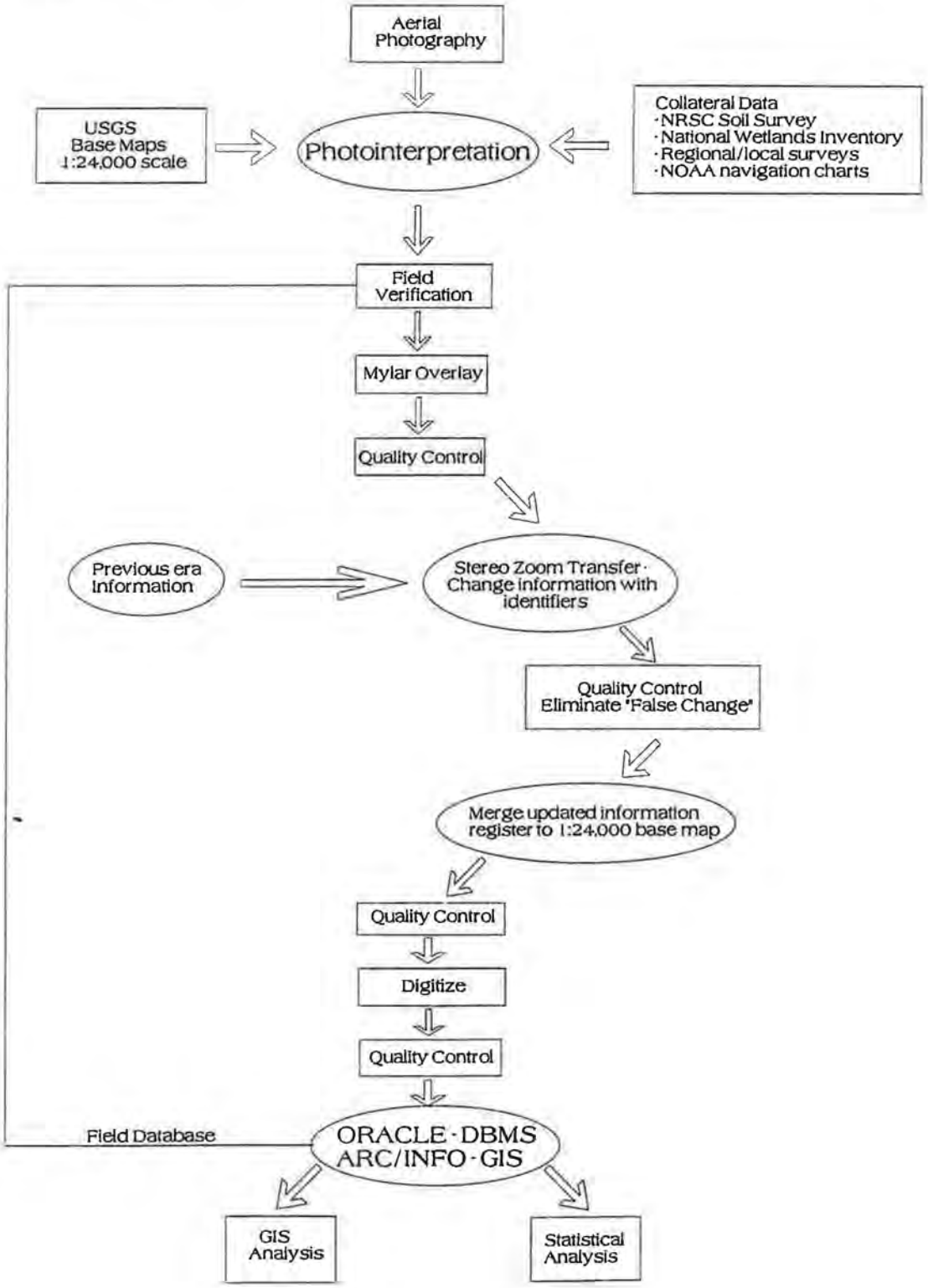
Attribute	Upland Land Use	Common Description
UA	Agriculture	Crop Producing/Pasture
UB	Urban	Cities and Towns
UFP	Forested Plantation	Planted Forest Areas
URD	Rural Development	Rural Building/Development
UO	Other Uplands	Uplands not fitting into any other use categories

Process: Using aerial photographs taken at different times it is possible to determine changes in the areal extent of wetlands or changes in wetland types over time. This technique has been employed successfully in a number of studies comparing wetland area extent (Tiner, 1987; Frayer *et al.*, 1989; Dahl and Johnson, 1991; Hefner *et al.*, 1994). The Status and Trends Unit routinely uses this technique to monitor land use changes over time and has developed a process that incorporates rigorous quality control reviews at key phases (Figure 2). The aerial photography is stereoscopically interpreted to determine wetland area, and the change between eras.

Cartography and Digital Capture: Once the aerial photography is interpreted and annotated in accordance with the classification scheme, the delineated data are transferred to an overlay on a U. S. Geological Survey (USGS) 1:24,000 scale topographic map using a Zoom Transfer Scope and changes in classification are mapped[2]. Quality control checks are built into this process to prevent false changes from being mapped and provide confirmation of photointerpretation work. This process results in a composite overlay reflecting wetland changes for multiple eras of photography. The cartographic drafting process serves to rectify the wetland/upland data and results in a product ready for digital data capture.

[2]There are limitations to this technique especially when comparing historic information derived from 1952 era aerial photographs with more recent USGS base maps. This can be particularly problematic in coastal areas exhibiting changes in shoreline configuration. Attempting to register a 1950's delineated photograph to a 1970's or 1980's base map may mask changes such as shoreline erosion or deposition. Often older base maps are not available or not available at a 1:24,000 scale for registration. If it appears that there are coastal registration differences it will be noted and a "best fit" transfer will be done.

Figure 2. Process Flowchart



The process of digitizing the wetland change information and yielding historic as well as updated data files in an automated format is described in the document entitled "Technical Specifications and Protocols for Status and Trends Digital Files" (1994) (Attachment 2). All Geographic Information System (GIS) data are to be delivered in ARC/INFO export double precision format.

Deliverables:
At the conclusion of this project CCBNEP will be provided complete map coverage for the study area for each target time frame. In addition, the following materials will be provided to CCBNEP:

- ARC/INFO files for use in GIS analysis
- Metadata to accompany digital files
- Field data sheets, oblique photographs and/or video of the study area check sites.
- Acreage summaries (tabular format) for all wetland/upland types for all time frames.
- Final report with all attachments
- Ancillary data sets CCBNEP may find useful (e.g. historical maps, charts etc.)
- Specialized maps or graphics information that may be generated based on the analysis of the data.

V Task Descriptions

A) LITERATURE REVIEW - IDENTIFICATION OF COLLATERAL DATA SOURCES

The Principal Investigator will survey the available literature, both published and unpublished, pertaining to the habitat types being considered within the CCBNEP study area. A Project task time line is found in Figure 3. Special attention will be given to locating reports which describe and/or discuss long-term trends and their probable causes. A discussion of the literature findings will be developed and included in the final report. Sources of such information may include university libraries, county historical depositories, other Federal agencies, State and local agencies and organizations.

Collateral data sources, specifically map based data, may include but not be limited to the following:

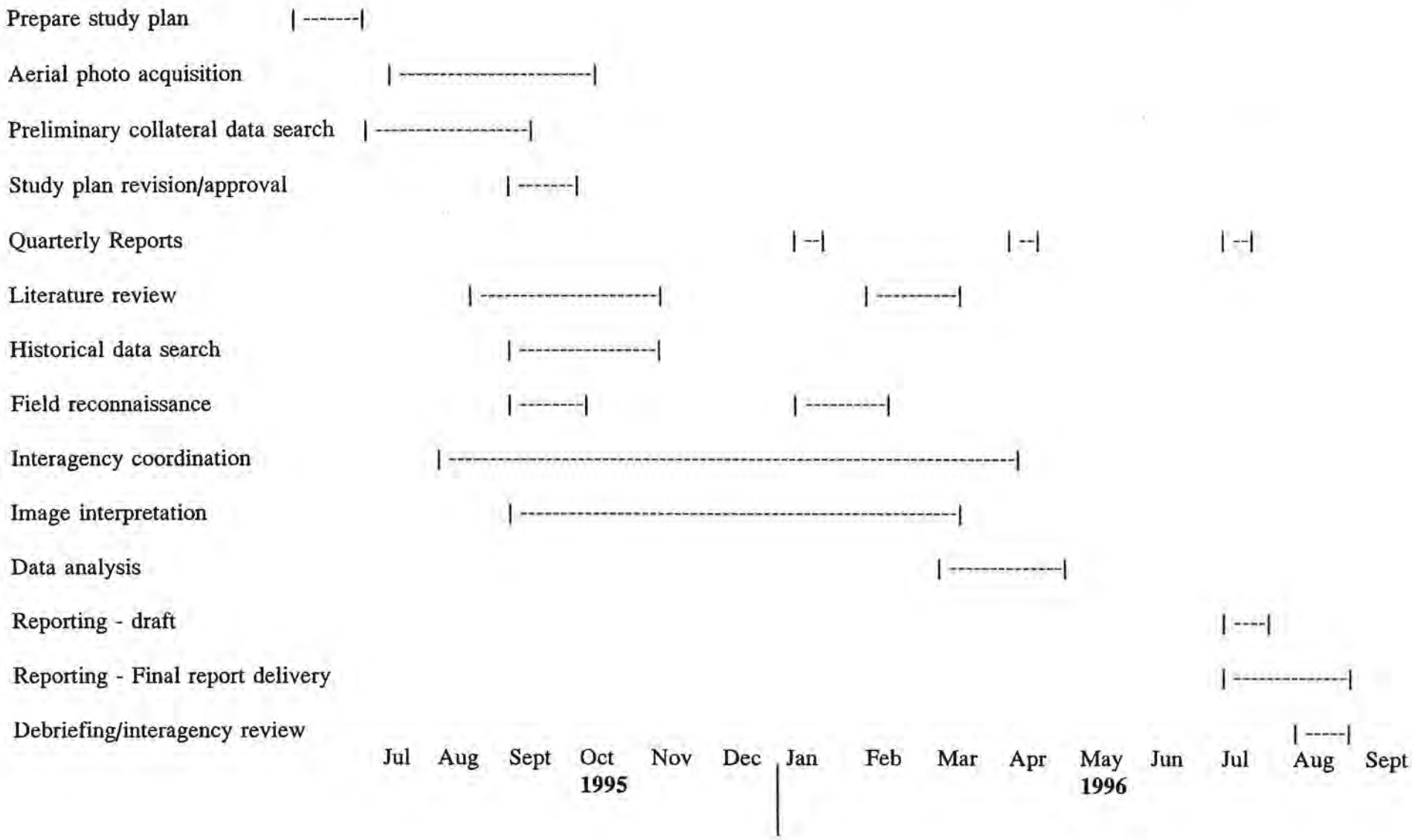
U. S. Fish and Wildlife Service - National Wildlife Refuge Maps.
USDA - NRCS County Soil Surveys
NOAA Navigation Charts
USGS base Maps
USFWS Ecological Inventory maps - Gulf Coast
Priority Habitat Studies for the Texas Coast (FWS)
National Park Service - National Seashore Maps
University of Texas at Austin (White *et al.* 1983)
Published county or regional maps

B) HISTORICAL DATA ACQUISITION

Appropriate datasets, aerial photographs, reports, maps, etc. will be acquired which help in the determination of temporal and spatial status and trends (areal extent) for coverages of the following habitat types or structures:

1. freshwater wetlands (including isolated inland depressional wetlands);
2. estuarine emergent wetlands;
3. wetland/upland transitional habitats;
4. unvegetated bay bottom;
5. riparian wooded wetlands;
6. tidal sand/mud and algal flats
7. natural and dredged material islands - for management purposes

Figure 3. Project Task Time Line



it is desirable to know whether vegetative succession has decreased or eliminated bare ground needed by certain species of colonial nesting birds on these islands, therefore the changes over time with regard to vegetated and unvegetated portions of these islands, as well as changes in overall island size will be determined;

8. natural shorelines and beaches; and
9. hardened shorelines

Man-made wetlands (including submerged aquatic vegetation and emergent wetlands) will be distinguished from those which are naturally occurring wherever possible.

Datasets which possess information amenable to trend analyses (i. e., monitoring data collected at near regular intervals over a period of at least five years) will be targeted for early acquisition. Therefore, all important sources of data (universities, government agencies, individual experts, published and unpublished literature, etc.) will be thoroughly investigated.

The Status and Trends Unit will also access archival sources of map and report data to acquire useful information[3]. Historical aerial photographs will be acquired through the USGS EROS Data Center. Similarly any historical photographs held by other agencies will be researched (ASCS, NASA, National Archives, TNRIS).

C) ACCEPTANCE CRITERIA AND DATA LIMITATIONS

Photography - Acceptance criteria is not applicable to historical photography. There is no possibility to re-do 1952 photographs. Thus any problems with inadequate photography coverage, poor quality photographs, cloud cover, etc. becomes a data limitation. All limitations will be clearly noted. Every effort will be made to work with the historic data sets for the time frames indicated.

Collateral Data Sources - Maps, charts, and regional reports are produced for a myriad of purposes. Special note of the quality, completeness and relevance of all data sources will be made. Reference to data quality, scale, projection, themes, dates, and coverage will be provided in metadata forms to be provided to CCBNEP.

Photointerpretation, Cartographic Transfer and Digital Data Capture - Standards for acceptance or rejection of data capture are detailed throughout the two documents provided as attachments. (Continuous Wetland Trends Analysis Specifications - 1994 and Technical

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[3] The utility of historical information for current assessments can have limitations. This is due to changing definitions, priorities and the objectives for which these data sets were collected and displayed originally. The Status and Trends Unit has experience in dealing with a variety of historical data. Careful review of the base information is made to select the most representative data set and document the source material clearly outlining any limitations.

Specifications and Protocols for Status and Trends Digital Files - 1994.)

Statistical Analysis - The maps as well as wetland area figures obtained in this project are both valuable pieces of information. Actual wetland and land use area changes between the three time periods. It is anticipated that some statistical test may be useful to compare temporal geographic data sets, and help characterize wetlands in the Corpus Christi Bay region between 1952 and 1994.

1. Interagency Coordination

Coordination and cooperation with Federal, State and local agencies is imperative to the success of this project. The Status and Trends Unit will make contact with key Federal agencies to seek sources of information, these will include but not be limited to the following:

National Park Service
U. S. Fish and Wildlife Service - National Wildlife Refuges
USDA - NRCS - ASCS
U. S. Army Corps of Engineers
U. S. Geological Survey
NOAA - National Ocean Survey
U. S. Navy
U. S. Coast Guard

State and local agencies will also be contacted as well as private organizations who might have historical or current land use records or information.

2. Aerial Photography Acquisition

The Principal Investigator will obtain aerial photographs of a resolution sufficient to map all wetland types (except seagrasses) within the study area, to distinguish vegetated vs unvegetated areas on islands in the bays, and to accurately map spoil islands and wind-tidal flats.

Aerial photographs of the Texas coast were acquired by NASA under a contract to the U. S. Fish and Wildlife Service during 1992-94. These are 1:40,000 scale color infrared photographs that are being used by the National Wetlands Inventory to re-map Coastal Texas.

The 1979 data set will consist of 1:65,000 scale color infrared photography.

1952 black and white aerial photographs at 1:37,000 scale will be acquired and will be used to represent the 1952's era data set. It will be necessary to supplement these with 1951

1:17,000 scale photography where the 1952 series is not available. It is estimated there is 1952 coverage for 50 percent of the study area.

3. Analysis of Aerial Photo Data Sets:

All three timeframes of photography will be interpreted using the specifications described in the document entitled "Continuous Wetland Trend Analysis Specifications" (1994). These conventions outline the technical procedures used to interpret aerial photography. Minimum mapping units for habitat categories are included however, for this project every effort will be made to identify features such as dredge material deposits, seawalls, etc. that might ordinarily fall below the minimum mapping unit.

The importance of identifying these features to CCBNEP will also necessitate a review and enhancement of the completed National Wetland Inventory (NWI) maps (circa 1994-95). Features that are identified as special concern to CCBNEP include:

- All freshwater and saltwater wetlands and aquatic habitats
- Oyster reefs, worm reefs and other hard bottoms
- Natural and dredged material islands
- Riparian woodlands
- Coastal oak mottes and brush
- Artificial shorelines

In addition upland habitats will be added to the 1994-95 NWI maps by the Status and Trends Unit to provide complete cover typing for the project area.

Special note on Cartographic Support

Status and Trends has relied upon contracted support for photointerpretation and cartography. This has been supplied under a USFWS service support contract that is currently being revised and re-competed. Due to unforeseen delays in the contracting process Status and Trends may be without contractual support until January, 1996. In anticipation of this situation, Status and Trends has entered into an interagency agreement with the U. S. Geological Survey - Water Resources Division, Madison, WI to supply cartographic and computerized mapping support. The agreement became effective in March, 1995 and extends through 1996.

4. Field Reconnaissance

Field reconnaissance plays an important role in verifying photointerpretation work with on the ground features. Field work also yields documentation, photographic evidence and information on plants, soils, water conditions or land use. In general field work will attempt

to accomplish the following:

1) Inspect the quality and completeness of 1994-95 NWI maps.

2) Make necessary adjustments to 1994-95 NWI map products to include small features, features of special concern to CCBNEP, and upland land uses.

3) Correlate interpretation findings from historical photographic data sets with on the ground observations.

4) Ensure overall accuracy of all photointerpretation work.

5) Acquire oblique photographs, video, plant and soil/substrate information for field databases and reporting.

Private Property Rights and Access

Status and Trends respects private property. Many field check sites are accessible and are on public lands. Prior permission to access private property will be sought if necessary.

D) DATA ANALYSIS AND IDENTIFICATION OF PROBABLE CAUSES

The Principal Investigator will synthesize and report all data acquired into a comprehensive assessment of the historical and current coverages of the identified habitat types. This analysis will detail the location, and areal extent of each habitat type. Status and trends data for the three identified time periods shall be submitted to the CCBNEP in ARC/INFO export, double precision format.

Statistical analyses of those datasets with sufficient data to demonstrate temporal and/or spatial trends will be conducted in order to identify potential problems, as indicated by significant changes in habitat distribution. In particular, the study will identify areas of major change in land cover/use.

1. Identification of Probable Causes

Following the completion and analysis of the data base, the Principal Investigator will attempt to explain the observed trends (both positive and negative) by relating them to possible causative factors. Where probable causes are identified, a detailed discussion of the evidence supported by the literature or presenting a rationale used to determine this relationship will be included.

2. Identification of Data and Information Gaps

After an evaluation of the usefulness of the existing data for establishing trends, the Principal Investigator will highlight any gaps or inadequacies in existing monitoring programs, monitoring protocols, coverages, etc. which become apparent as a result of the analysis.

3. Final Report Production

The Principal Investigator will develop a final comprehensive report describing the current status and historical trends of wetland habitats in the CCBNEP study area. The report will contain tabular, graphical or other visual representations of the results of the trend analyses. Statistical calculations will be described and included where appropriate. Automated map data in ARC/INFO export, double precision format will also be appended. In order that the CCBNEP can produce any desired maps directly from the data provided, copies of the digital files and metadata will also be delivered.

The final report will discuss any future implications for the study area if identified trends continue into the future. The Principal Investigator will maintain a descriptive list of potential management actions or recommendations for each problem activity. These shall be presented orally upon request to the Management Committee, but shall not be included in the draft or final reports. The final report will, however, contain recommendations on needs for additional investigation.

E) QUALITY ASSURANCE:

A program of quality assurance is essential to ensure the validity of analytical data (U. S. EPA 1979). A good quality assurance (QA) plan provides appropriate methods to take field measurements, ensure sample integrity, adequately control analyses including reporting of accuracy and precision of data, and provide mechanisms for timely input to the analyst on errors and potential problems. Ideally, a QA program consists of standardized methods and techniques, use of procedures and results (Skougstad et al. 1979).

It is the purpose of this work plan to ensure the quality assurance aspects of this study are met. Wherever possible, assumptions, confidence levels and other pertinent information needed to judge the reliability of the data will be provided.

A successful quality assurance program for this project will involve the following elements:

1. Staff Commitment

All individuals involved with this study will have an understanding and a commitment to fully integrating QA practices into field and office operations. This will require the commitment of 10 to 15 percent of the total manpower resources. Routine review of field and office operations to ensure that QA practices are followed and properly documented is essential.

2. Personnel

A staff with adequate formal training and experience and proper specialization is needed to carry out CCBNEP objectives. The quality and reliability of the data rest heavily on the competence of the staff. The historical and current data sets to be studied require unique skills in data collection and analysis, and in data interpretation. Several disciplines (Biology, Geography, Cartography, Statistics) will be represented on the staff to deal effectively with ecology of coastal and inland wetland systems and monitoring historical changes using remote sensing.

3. Facilities

Adequate field equipment, storage and instrumentation, taxonomic references, computing capability and office support facilities are required. The quality of the data also depends upon the availability and performance of equipment. Such items as field gear, photointerpretation instrumentation, computer hardware and software must be available and must meet performance standards related to the parameters measured. Instrumentation must provide the sensitivity and accuracy required by state-of-the-art techniques for analysis. This means that photointerpretable features that meet the minimum mapping size are detectable. Adequate storage space and office support must also be provided.

4. Advance Planning

Careful advance preparation and design of field work, photointerpretation, and analysis is needed. Thorough advance planning of field and office procedures are necessary to maintain the required control over the technical aspects of the project and to ensure the collection of meaningful data. Factors that should be taken into consideration include the objectives of CCBNEP, the quality of the data required, the parameters to be measured, and QA measures to be incorporated into the various phases of the project.

5. Use of Accepted Methodology

Strict adherence to accepted methodology, and careful consideration of the technical defensibility of the methods and their application is necessary. Wherever possible accepted scientific methods should be employed. Deviations from accepted practice or measurement of other parameters will be fully documented and technically defensible.

6. Instrument Calibration and Maintenance

Proper maintenance of field and photointerpretation and cartographic instruments is necessary. This includes ocular cleaning and alignment for all scopes, digitizing table or scanner verification. Regular performance checks, and service for each device are maintained and documented in such a manner that the history of performance of the instruments may be reviewed.

7. Quality Control Reviews

Any problems or questions are discussed at regularly scheduled meetings and problems are identified and corrected. Problem(s) and corrective action(s) shall be properly documented.

8. Plant Species Identification

In-house taxonomic keys, botanical experts and computerized data will be used to confirm or help in problem identification. Accurate identification of hydrophytes is essential. This project will utilize; 1)trained personnel to identify wetland plant species; 2) Multiple Attribute Recognition System for Hydrophytes (See Appendix B) and; 3) taxonomic keys and references in the FWS library.

9. Data Records, Certification and Review

Meticulous, dual level review of all data transcriptions and arithmetical calculations will be conducted. For all field data collected, the entries will be checked. Source data that is data entered into an automated database management system will be confirmed by a second person. All manual calculations and electronic calculations will be performed twice. Digitized and key-entered data are carefully proofed before they are submitted for computer manipulation

10. Logic Checking of Computerized Data Files

Status and Trends has developed a system of automated "logic checks" to help ensure that database information is correct and complete. These checks are performed on all databased acreage information.

11. Automated Data Storage and Analysis

The data storage and analysis tools described in this section will be used to help organize and understand the data collected during this project. Figure 2 shows the pathway that data take to enter automated database management and/or analysis systems.

a. ORACLE - Database Management System

ORACLE is the most widely used database in the world (Koch and Muller 1993). It runs on a variety of computer systems ranging from personal computers to mainframes. The functionality of the system is virtually identical across all of these platforms, making it relatively easy for developers and users to share database information regardless of their hardware. ORACLE uses the Structured Language Query (SQL), which employs the normal rules of English speech, and can be readily understood by end users, allowing them to extract information without complex programming assistance. Also, through a software bridge between ORACLE and ARC/INFO, the information stored in the ORACLE database tables can easily be related to ARC/INFO geographic information system files where it can be displayed, analyzed and even modified.

ORACLE is supported by the Oracle Corporation, 500 Oracle Parkway, Redwood City, California 94065. Technical manuals and specifications include the following:

Oracle, 1992 SQL*Plus User's Guide and Reference Version 3.0 Oracle Corp., Redwood City, California

Oracle, 1990. SQL Language Reference Manual Version 6.0 Oracle Corp., Redwood City, California.

b. ARC/INFO - Geographic Information System

ARC/INFO is a widely used and versatile geographic information system (GIS) package, providing users with the ability to capture, display, edit, query, combine and analyze GIS vector data. In addition, the ARC Macro Language (AML) is a tool that allows the user to create complex macros (sequences of commands) that may be used to perform repetitive tasks on an unlimited number of data sets. ARC/INFO has the ability to both input and output a wide variety of vector data interchange formats, such as DLG, DXF, TIGER, IGES, DEM, and IGDS, making it easy to share data with other GIS packages. ARC/INFO also provides the ability to georeference, register and display a variety of raster data formats, including ERDAS, TIFF, BIL, BIP, Sun Raster, RLC, GRASS, and GRID. In recent versions, ARC/INFO has provided the ability to create and use graphical user interfaces (GUI's) that enable users to tailor the ARC/INFO interface to their particular applications. This increases the flexibility of the overall package and greatly reduces the need for extensive training of individual users.

ARC/INFO is supported by the Environmental Systems Research Institute, Inc. (ESRI), 380 New York Street, Redlands, California 92373. Technical manuals and specifications include

the following:

ESRI, 1992 ARC/INFO Data Model, Concepts, & Key Terms. Revision 6.0. Second Edition. ESRI Inc., Redlands, California.

ESRI, 1992. Understanding GIS, The ARC/INFO Method. Revision 6. ESRI, Inc., Redlands, California.

c. ArcView - Raster/Vector Display System

ArcView is a package of software tools that allow users to display and query one or more layers of GIS data. Using ArcView's GUI environment, users can quickly and easily create an on-screen graphic that effectively emphasizes spatial relationships among and between layers of data. Database information can be displayed pertaining to any point, line or polygon feature on any layer within the view. ArcView is an effective tool for visually analyzing several different types of data at one time. ArcView has the capability of displaying both vector and raster data simultaneously, further enhancing the usefulness of this tool. It supports the same array of raster formats as does the ARC/INFO package. ArcView is also valuable for creating quick hardcopy outputs. A digital image of what appears on the screen can be output to a disk and can then be displayed in ARC/INFO or plotted on an electrostatic plotter.

ArcView is supported by the Environmental Systems Research Institute, Inc. (ESRI), 380 New York Street, Redlands, California 92373. Technical Manuals and specifications include the following:
ESRI, 1995. ArcView Users Guide. Version 2.0 ESRI, Inc., Redlands, California.

d. Data Analysis - Statistics

Due to the study design, the analysis will include numeric and geographic analysis of the data. SAS Software is available to assist with these analyses. Specific statistical tests may or may not be warrented depending on the outcome of data collection. Some visual analysis using GIS will be required to determine which tests will be applicable. However, the following analyses may apply:

> Spatial Analysis - including determining proximity of human impact on natural environs. (e.g. spoil islands cover more area near Corpus Christi Bay than Baffin Bay, and area of each type of wetland converted to spoil islands.)
>
> Analysis of Rate of Change - Comparison of area of estuarine emergent converted to open water between 1952 and 1979 versus 1979 to 1992. How much of this change

can be related to human impact and how much is natural change.

Frequency Histograms depicting the distribution of the area of polygons of each classification type can be compared across timeframes.

VI Description of Deliverables

A) REPORTING

Quarterly progress reports will be provided to the project coordinator detailing accomplishments to date, ongoing work, problems and upcoming milestones. Quarterly reports will be delivered to CCBNEP on January 8, 1996, April 8, 1996 and July 8, 1996.

There will be two phases to the delivery of a final report for this project. An initial, technical review draft report will be delivered to CCBNEP 60 days prior to project completion. The report shall contain tabular data, maps, and graphics representing the study results as well as any statistical tests on the data sets. An outline of the final report format appears as Table 2. Following review and submission of comments, a final draft will be prepared for project completion. In the intervening 60-day review period, the Principal Investigator will make an oral presentation of the study results to the CCBNEP. This oral presentation will include discussion of implications, future trends, potential management options relating to the study findings.

B) PHOTOGRAPHS AND VIDEO

Field photographs (prints and/or 35 mm sides) will be taken at key sites within the project area. In addition, video will be taken for select sites to help document water conditions, substrate type(s), wildlife use, etc. All photographs, slides and video will be labelled as to location, date and provided to CCBNEP at the conclusion of the project.

C) HARDCOPY GRAPHICS DATA FILES

It is anticipated that maps and graphics will be important supplements to the final report. All hardcopy computer generated maps and/or graphics will be provided to CCBNEP along with the appropriate metadata files.

Field data files in ASCII format will be provided to generate tabular or narrative data.

GIS files in double precision ARC/INFO export format will be delivered to the CCBNEP at the conclusion of the project.

Table 2. Final Report Format

I Title Page

II Acknowledgements

III Contents
- List of Tables
- List of Figures

IV Executive Summary

V Background (Introduction)

VI Literature Review

VII Study Area and Design.
- A Physical setting and boundaries
- B Study methods

VIII Historical Wetland Trends
- A Prior to 1950's
- B 1950's to 1979 data set
- C 1979 to 1990's data set

IX Current Status of Wetlands in Corpus Christi Bay National Estuary

X Discussion of Changes Within the Estuary System

XI Summary and Recommendations

XII References

XIIII Appendices
- Data Tables
- Maps

VII Budget

Salaries and Benefits	$ 95,200
Travel/per diem	$ 8,300
Supplies and materials	$ 2,100
Photographs, maps and Collateral data	$ 21,280
Equipment	$ 1,000
Reporting	$ 1,000
Subtotal	**$128,880**
Contract support	$ 38,000
Overhead	$ 9,660
Total	**$176,540**
CCBNEP	$ 78,000
USFWS	$ 98,540

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Hefner J. M., B. O. Wilen, T. E. Dahl, and W. E. Frayer. 1994. Southeast wetlands; status and trends, mid-1970's to mid 1980's. U. S. Department of the Interior, Fish and Wildlife Service, Atlanta, Georgia. 32 p.

Skougstad, M. W., M. J. Fishman, L. C. Friedman, D. E. Erdman and S. S. Duncan. 1979. Methods for determination of inorganic substances in water and fluvial sediments. Techniques of water-resources investigations of the United States Geological Survey - Book 5 Chapter A1. U. S. Government Printing Office, Washington, D. C. 626 p.

Tiner, R. W. Jr. 1987. Mid-Atlantic wetlands a disappearing national treasure. U. S. Fish and Wildlife Service. Newton Corner, Massachusetts. 28 p.

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Appendix A.

Resumes of Key Project Personnel.

THOMAS E. DAHL

Education

Post Graduate Studies, University of Minnesota, Itasca, MN, 1983,
Wetlands Ecology.

Post Graduate Studies, South Dakota State University, Brookings, SD, 1983,
Waterfowl Ecology.

Master of Science, Western Kentucky University, Bowling Green, KY, 1978,
Aquatic Biology (Minor-Botany).

Bachelor of Science, Northland College, Ashland, WI, 1976,
Biology (Magna Cum Laude).

Work Experience

1989-Present : U.S. Fish & Wildlife Service, St. Petersburg, FL
Wetland Status and Trends Coordinator.

Responsible for coordinating all activities for the USFWS Wetland Status and Trends study, including budgeting, field work, scheduling and generating report documents. Represents USFWS at both National and International conferences and events. Since 1986 has served as a technical advisor to the U.S. Delegation to Ramsar and is a members of Ramsar's Wise Use Working Group. An active member of the Society of Wetland Scientists and the State Association of Wetland Managers. Works closely with the USFWS Office of International Affairs on various wetland issues.

1985-1988 : U.S. Fish & Wildlife Service, Washington, D.C.
Assistant National Coordinator--National Wetlands Inventory.

Assisted in the administration of the National Wetlands Inventory Project of the U.S. Fish and Wildlife Service. Provided support to the National Wetland Coordinator to fulfill the goals and objectives of the NWI. Served on various technical committees including the Working Group on Environmental Trends for the President's Council on Environmental Quality (1986-87), the Department of the Interior's Task Force on Remote Sensing (1986-89), and as a member of the Interagency Wetland Value Assessment Group (1985-89).

1980-1983 : U.S. Fish & Wildlife Service, Twin Cities, MN
Assistant Regional Wetlands Coordinator--National Wetlands Inventory.

Conducted Regional Quality Control review of all wetland map products produced for USFWS Region 3.

1978-1980 : Martel Laboratories, Inc., St. Petersburg, FL
Remote Sensing Manager.

Supervised a multi-disciplined staff for the purpose of conducting remotely sensed resource inventories.

Affiliations

Society of Wetland Scientists
State Association of Wetland Managers
Tri-Beta Biological Honor Society
Kentucky Academy of Sciences

Publications

Dahl, T.E. 1978. Heavy Metal Content of the Scales of Fishes from Southwestern Kentucky. Ogden College of Science and Technology, Western Kentucky University, Bowling Green, KY.

Dahl, T.E. 1985. Use of National Wetlands Inventory Data for Wetland Assessment. In. J.A. Kuslen and P. Riexinger (Eds.) Proceedings: Nations Wetlands Assessment Symposium, Portland, ME. Assoc. of State Wetland Managers. pp. 146-158.

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Mckee, P.M., T.R. Batterson, T.E. Dahl, V. Glooschenko, E. Jaworski, J.B. Pearce, C.N. Raphael and T.H. Whillams. 1989. Great Lakes Aquatic Habitat Classification Based on Wetland Classification Systems. In. Busch, W.-D.N. and P.G. Sly (Eds.) The Development of an Aquatic Habitat Classification System for Lakes. CRC Press. Boca Raton, Florida.

Smith, B.J., H.W. Browers, T.E. Dahl, D.E. Nomsen and K.F. Higgins. 1989. Indirect Wetland Drainage in Association With Federal Highway Projects in the Prairie Pothole Region. Wetlands. Vol. 9, No. 1. pp. 27-39.

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Dahl, T.E. 1993. Wetland Drainage and Restoration Potential in the Lake Thompson Watershed, South Dakota, U.S.A. In. Davis, T. (Ed.) Wise Use of Wetlands, Ramsar Bureau, Gland, Switzerland. pp. 133-139.

Hefner, J. M., B. O. Wilen, T. E. Dahl, and W. E. Frayer. 1994. Southeast Wetlands; Status and Trends, Mid-1970's to Mid-1980's. U. S. Department of the Interior, Fish and Wildlife Service, Atlanta, Georgia. 32 pages.

Young, R. D. and T. E. Dahl. 1994. Use if GIS in assessing areas of rapid wetland change. *In.* GIS/LIS '94 Annual Conference and Exposition Proceedings. ASPRS. pp 851-859.

Dahl, T. E., and S. C. Zoltai. In Press. Northern Forested Wetlands of North America. *In.* Proceedings, of International Symposium on the Ecology and Management of Northern Forested Wetlands.

Dahl, T. E., and G. J. Allord. 1995. History of Wetlands of the United States. *In.* National Water Summary 1995. U. S. Geological Survey. Washington D. C.

MARTHA C. CALDWELL

Education

Bachelor of Arts, University of South Florida, Tampa, FL, 1990.
Geography.

Work Experience

1994-Present : U. S. Fish and Wildlife Service, St. Petersburg, FL
Geographer; Wetlands Trends Analyst

Responsible for implementing statistical analysis for Wetlands Status and Trends projects. Planning and participating in Field Reconnaissance trips. Maintaining contact with contractor personnel and answering questions pertaining to Status and Trends procedures. Overseeing quality control of Status and Trends procedures. Maintain various databases pertaining to trends in wetlands. Assist in the preparation of technical documentation pertaining to wetlands status and trends.

1992-1994 : Geonex Corporation
Trends Analyst

Assist USFWS personnel with quality control of data collected through manual and digital techniques. Perform analyses and make recommendations to ensure the integrity of the Wetland Status and Trends study. Assimilate data to map form for digitizing. Coordinate field reconnaissance. Maintain various databases pertaining to trends in wetlands.

1991-1992 : Geonex Corporation
Photointerpreter.

Performed stereoscopic wetland and upland delineation from high altitude aerial photography. Coordinated and participated in field work to identify wetlands in coastal areas of Florida, Alabama, Mississippi, Texas, Georgia, South Carolina and North Carolina. Maintained work load for eight photo interpreters. Performed quality control on Status and Trends photo interpretation.

Related Training

National Wetland Inventory Classification (including field identification of hydrophytic vegetation and hydric soils)
Hydrology
Climatology
Conservation
Physical Geography
Geographic Information Systems (GIS) (ARC/INFO)
Statistics (SAS)
Relational Database Design (ORACLE)

RICHARD D. YOUNG

Education

Bachelor of Science, Colorado State University, Ft. Collins, CO, 1982,
Wildlife Biology.

Work Experience

1992-Present : U.S. Fish & Wildlife Service, St. Petersburg, FL
Assistant Wetland Status and Trends Coordinator.

Responsible for utilizing Geographic Information System (GIS) technologies to produce products and assemble or display data for the Wetland Status and Trends study. Assists in the preparation of technical specification and documentation pertaining to the project. Oversees quality control of digital data delivered by the service support contractor. Develops GIS-based applications for new and on-going Status and Trends project studies.

1988-1992 : Geonex Corporation, St. Petersburg, FL
Senior Applications Analyst.

Responsible for the design, development, debugging and implementation of Computer Aided Design (CAD) and GIS-based applications for a variety of projects. Software platforms used included ARC/INFO, Intergraph, AutoCAD, MOSS/WAMS, CADMAP and UltiMAP. Programming performed using "C", Fortran and ARC AML. Interacted with clients and supervised teams of programmer/analysts to accomplish application development within time and budget constraints. Managed department of 19 programmer/analysts for eight months as acting Programming Manager. Worked as a senior member of the research and development group charged with investigating computer-based technologies and how they might best be implemented for current and future projects.

1984-1988 : Geonex Corporation, St. Petersburg, FL
Computer Operations Manager.

Responsible for round-the-clock operations of multiple mini, micro and personal computer systems. Hardware platforms included DEC, Prime, Data General, IBM, Apollo, and IBM-clones. Supervised up to eight computer operators on three shifts performing data backups, archives, plotting, hardware maintenance and filling a variety of user requests.

1983-1984 : Geonex Corporation, St. Petersburg, FL
Photointerpreter.

Performed wetlands interpretation from high-altitude, color infrared photography under contract with the USFWS National Wetlands Inventory. Participated in ground-truthing field trips to identify wetland signatures on the photography.

Affiliations

Urban & Regional Information Systems Association (URISA)

Publications

Young, R. D., T. E. Dahl. 1994. Use of GIS in Assessing Areas of Rapid Wetland Change. *In.* GIS/LIS '94 Annual Conference and Exposition Proceedings. ASPRS. pp 851-859.

Young, Rich and Tom Dahl. 1995. Locating Wetland Loss "Hot Spots" Using GIS. *In.* Harrison, N. (Ed.), Professional Surveyor, Vol. 15 No. 2. pp.29-34.

Appendix B

Description of Multiple Attribute Recognition System for Hydrophytes (MARSH)

Multiple Attribute Recognition System for Hydrophytes

The Fish and Wildlife Service in cooperation with the Environmental Protection Agency, Army Corps of Engineers and the Natural Resources Conservation Service (formerly the Soil Conservation Service) is developing a computer assisted identification system to aid field biologists to more efficiently identify many of the vascular plant species occurring on the National List of Plant Species that Occur in Wetlands. MARSH is being developed through a cooperative agreement with the Biota of North America Program at the North Carolina Botanical Garden, University of North Carolina, Chapel Hill. Approximately 3,200 species (Pteridophyta, Poaceae, Cyperaceae, Asteraceae and all woody species) have now been reviewed and their morphological characteristics and geographic distribution to the state level recorded and entered into the MARSH system.

Traditional dichotomous keys in botanical manuals require the use of a specific series of characteristics, some of which may be absent or difficult to assign from the unknown specimen being identified. MARSH breaks the tradition of taxonomic dogma which incorporated phylogenetic relationships in identification keys by allowing the specification of characteristics irrespective of taxonomic lineage. Vegetative characters can be used as opposed to floral characters required in many traditional dichotomous keys. Identification through random access of characteristics in a polyclave is based on the specification of diagnostic suites of all consistent characters. It is implicit that all keys, including those based on random access of a polyclave of characteristics, will perform more effectively if directed access is provided to identify those characteristics which historically have proved to be most diagnostic. The additional advantage of a randomly accessed polyclave is that these historically solid characters can be combined with a unique non-traditional characteristics. This allows the efficient identification of an unknown specimen by the specification of a diagnostic suite of a very few characteristics only possessed by this single species. Traditional key typically have to leave out exceptional characteristics which uniquely define each species due to the complexity and volume of text this would entail. Geographical distribution, which is as strong as any morphological character, is totally ignored in most traditional keys but is easily incorporated as a powerful character in random access keys. The efficiency of use of a random access polyclave will be significantly increased as a user becomes more experienced and recognizes strongly diagnostic characters as opposed to weakly differentiating characters.

The current release of MARSH contains keys to the pteridophyta (Ferns and Fern Allies), Poaceae (Grasses), Cyperaceae (Sedges), Asteraceae (Asters) and woody species on the National List which occur in the continental United States. The morphological and geographical information was compiled by the Biota of North America Program. The Multiple Entry Key Algorithm (MEKA) which provides the computer keying program was developed at the University Herbarium, University of California at Berkeley.