THE DISTRIBUTION AND AREAL EXTENT OF COASTAL WETLANDS IN THE GULF OF MEXICO, USA

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ABSTRACT

The National Oceanic and Atmospheric Administration is currently developing the first comprehensive data base describing the areal extent and distribution of coastal wetlands in the conterminous USA. These data are being developed using a systematic grid sampling procedure on wetland maps produced by the National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service. The maps, developed from aerial photography, are generally based on 1:24,000 scale U.S. Geological Survey quadrangles and identify wetland habitats classified using the Cowardin et al. (1979) system. Fifteen habitat types are recorded by NOAA in 18.2 hectare (45 acres) cells from each map, and the data input to a microcomputer for processing and manipulation. Digitized study area boundaries can be intersected with the grid sampled data to produce data summaries and color maps for specific units of interest. This paper summarizes the distribution and areal extent of coastal wetlands of the six states (Texas, Louisiana, Mississippi, Alabama, Georgia, and Florida), 153 counties, and 23 estuarine drainage areas (EDA) in the Gulf of Mexico region, an area comprised of over 1,500 NWI maps (Figure 1).

STUDY SITE

The principal spatial unit for which the wetland data are organized is the estuarine drainage area, or EDA. The EDA is defined as that land and water component of an entire watershed that most directly affects an estuary (NOAA 1985). Figure 1 illustrates the 23 EDAs identified in Volume 1 of the National Estuarine Inventory Data Atlas for the Gulf of Mexico (NOAA 1985). Figure 2 illustrates NWI map availability for these same 23 estuaries.

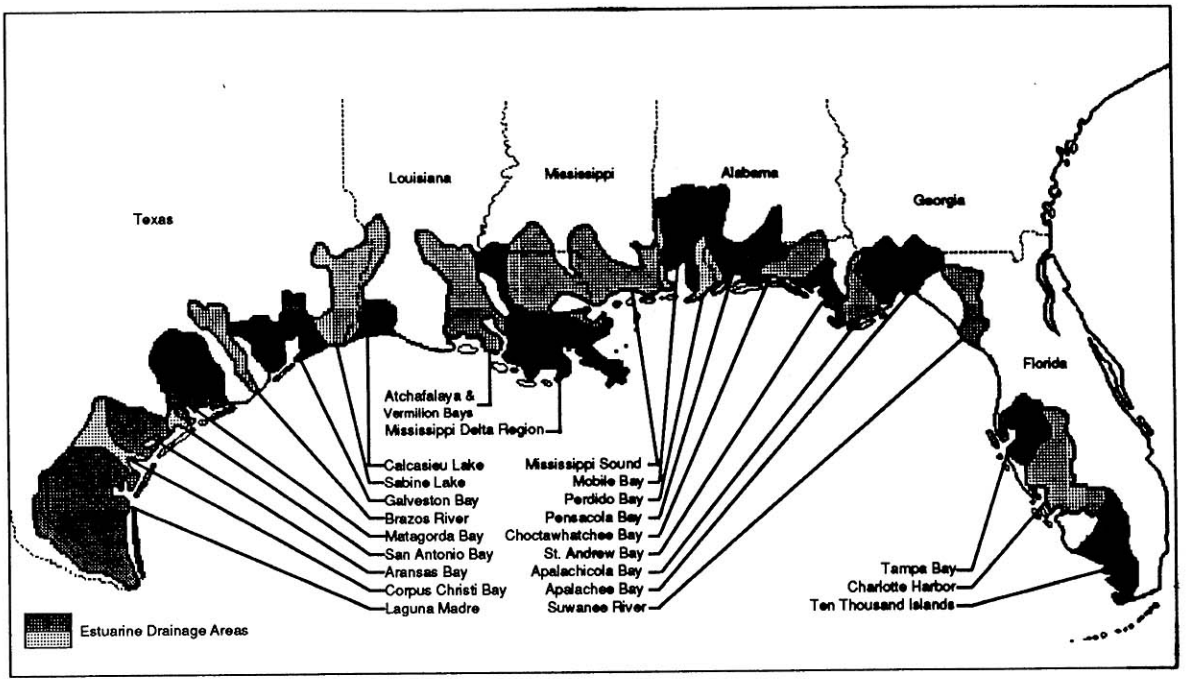

Figure 1. Estuarine drainage areas of the U.S. portion of the Gulf of Mexico.

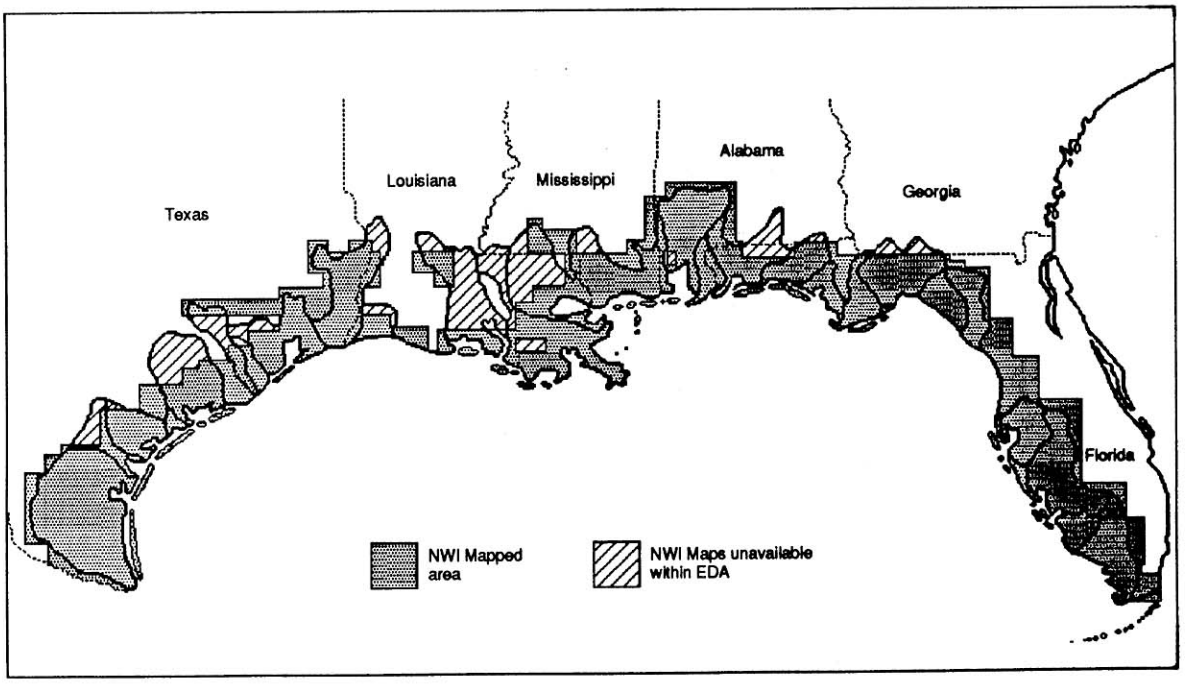

Figure 2. Wetland map availability for the 23 estuarine drainage areas on the USA Gulf of Mexico coast. Two sources of maps were utilized; U.S. Fish and Wildlife Service NWI maps, and, for most of Louisiana, wetland maps prepared for the Louisiana Department of Natural Resources by Coastal Environments, Inc., in Baton Route.

INTRODUCTION

Wetlands are transitional areas between terrestrial and aquatic systems where the water table is at or near the surface or the land is covered by less than six feet of water (Frayer et al. 1983; Cowardin et al 1979). They are vital and irreplaceable natural resources that provide a critical habitat for fish, shellfish and wildlife, filter and process agricultural and industrial wastes, and buffer coastal areas against storm and wave damage. Coastal wetlands also generate large revenues from a variety of recreational activities such as fishing and hunting.

In June 1986, the National Oceanic and Atmospheric Administration (NOAA) initiated a coastal wetland inventory project. The wetland inventory project is being conducted jointly by the Strategic Assessment Branch of the Ocean Assessment Division of the Office of Oceanography and Marine Assessment, National Ocean Service (NOS), and the Beaufort Laboratory of the Southeast Fisheries Center, National Marine Fisheries Service (NMFS), both components of NOAA.

The purpose of this project is to develop a comprehensive and consistently derived national coastal wetlands data base and to improve our understanding and management of this vital resource. The wetlands data developed from this project eventually will be incorporated into NOAA's National Estuarine Inventory and used in conjunction with other information such as land use, coastal pollution, distribution of estuarine fishes and invertebrates, and the status of classified shellfish waters to develop a national estuarine assessment capability. The goal is to build a comprehensive framework for evaluating the health and status of the Nation's estuaries and to bring estuaries into focus as a national resource base. Because wetlands provide an important habitat and food resource for coastal fisheries, their distribution and abundance are of interest to NMFS (Lindall & Thayer 1982). Development of coastal wetlands information is also an integral part of NOS's program of strategic assessments of the Nation's coastal and oceanic region (Ehler & Basta 1984).

This paper describes the areal extent and distribution of coastal wetlands within the U.S. portion of the Gulf of Mexico. This region includes six states (FL, GA, AL, MS, LA, and TX), 153 counties, and 23 estuaries. The wetlands data are based upon available National Wetland Inventory (NWI) maps for this region produced by the U.S. Fish and Wildlife Service. The wetlands data developed in this project pertain only to emergent vegetation and are meant to complement digitized NWI data by allowing rapid organization of data by EDA and county on a national basis. The grid sampling results will also represent a complete data base which extends further inland than digitized NWI data. These maps are based on aerial photography taken from 1972-84. A more detailed presentation of the wetland data for this region will be given in a data atlas to be published in the summer of 1989.

METHODS

As a first step in establishing a coastal wetlands data base, existing data on the areal extent and distribution of coastal wetlands were examined and compiled (Alexander et al. 1986). Twenty-three sources were consulted to compile acreage figures for 242 counties in 22 coastal states. Despite good geographic coverage, much of the existing data is incomplete or outdated. Variability in data quality and consistency and the lack of a unifying theme or purpose also contributed to the difficulty of consolidating the data into a single comprehensive data base. Therefore, the next step was to evaluate alternative sources of information. A key consideration was the ability to develop a data base in a timely and cost-effective manner. Multispectral scanner and thematic mapper Landsat satellite imagery have been successfully used to inventory wetland habitats (May 1986, Haddad & Harris 1985). These techniques, however, are beyond the technical resources of this project. A more timely and cost-effective alternative was to exploit a heretofore under-utilized source of wetland information, the NWI mapping program.

The NWI program was established in 1975 to generate scientific information on the characteristics and extent of the Nation's wetlands (Tiner 1984). This information was to be developed in two stages: 1) the creation of detailed wetland maps; and 2) research on historical status and trends. The maps, developed from aerial photography, are generally based on 1:24,000 scale U.S. Geological Survey quadrangles and identify wetland habitats classified using the Cowardin et al. (1979) system.

Although the NWI wetland maps represent the most reliable source of consistently derived coastal wetland information available, only approximately 1,200 of the over 5,000 maps required for complete coverage of the Nation's estuaries and other coastal areas had been converted to digital data for computer processing and mapping as of January 1986. Therefore, only a fraction of the wetlands data needed for this project were available. Since the current FWS technique for digitizing these maps is expensive and time-consuming, the FWS digitizes maps primarily on a user pays basis and a complete data base is not anticipated or planned for by the FWS in the near future (Tiner, personal communication). NWI maps remained, however, the preferred data source for this project particularly because of their availability across broad coastal regions.

Preliminary tests using a grid sampling technique on NWI maps indicated that this procedure could offer a reasonable alternative to more expensive and time-consuming techniques for quantifying NWI map information with a reasonable degree of accuracy and detail (Field et al. 1988). The grid sampling technique used to quantify coastal wetlands involves the placement of a transparent grid over a NWI map and identification of the wetland type on which each sampling point falls (Figure 3). The grid cells used in this procedure are approximately 1.78 cm (0.7 inch) on a side, corresponding to approximately

18.2 hectares (45 acres) when used on a 1:24,000-scale map. A small dot in the center of each grid cell is used as the sampling point. The exact number of sampling points varies with latitude; maps in the Gulf of Mexico contained 924-990 sampling points.

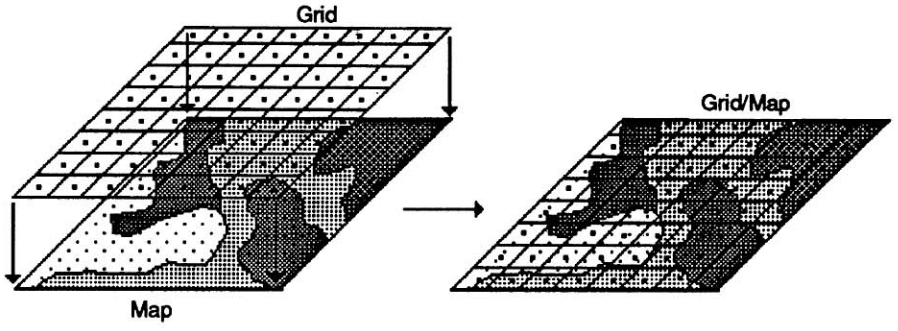

Figure 3. 1:24,000-scale map and grid.

Once the grid is aligned on top of a wetland map, sampling begins in the upper left corner and continues to the right across each subsequent row. Each cell is recorded as the habitat type on which its center dot falls. If the center dot falls exactly on the boundary between two or more habitat types, the cell is counted as the habitat type found in the middle of the square above the center dot. Grid sampled data are entered into a mapping and statistics program on a Sperry microcomputer. The program reproduces grid sampled data in matrix form on a color monitor, with each of the habitat types represented by a different color. Composites of entire estuaries or counties can be displayed using software which overlays digitized boundaries on grid sampled data and illustrates the general distribution of habitat types. Figure 4 illustrates a black and white representation of a portion of the Mississippi Delta EDA (EDA 3:13). The overlaid wetland acreage data can be aggregated by state, county, hydrologic unit and EDA. For the purposes of this technique, the numerous wetland types identified on NWI maps were aggregated into 15 habitat types (Table 1). Table 2 summarizes the FWS categories included in these 15 habitat types and gives examples of typical plant communities found in each habitat.

To determine the effectiveness of the grid sampling technique, grid sampled data for 15 NWI maps in the Mississippi Delta region were compared to NWI digital data (Table 3). These data were developed by NWI using their standard digitizing techniques. The comparisons indicate that common wetland types such as tidal fresh marsh and unspecified salt marsh are estimated extremely well (<1 and -1% difference respectively) while estimates for rare wetland types such as nontidal fresh marsh and estuarine forested and scrub-shrub are generally not reliable for this area (-42 and 59% respectively).

Table 1. The 15 habitat types identified in the grid sampling procedure.

Brackish marsh
High salt marsh
Low salt marsh
Unspecified salt marsh[a]
Nontidal fresh marsh
Tidal fresh marsh
Unspecified fresh marsh[a]
Estuarine forested and scrub-shrub
Nontidal fresh forested and scrub-shrub
Tidal fresh forested and scrub-shrub
Unspecified fresh forested and scrub-shrub[a]
Tidal flats
Non-fresh open water
Fresh open water
Upland

[a]The "unspecified" categories were added to accommodate areas for which more specific information on salinity and water regime was not available.

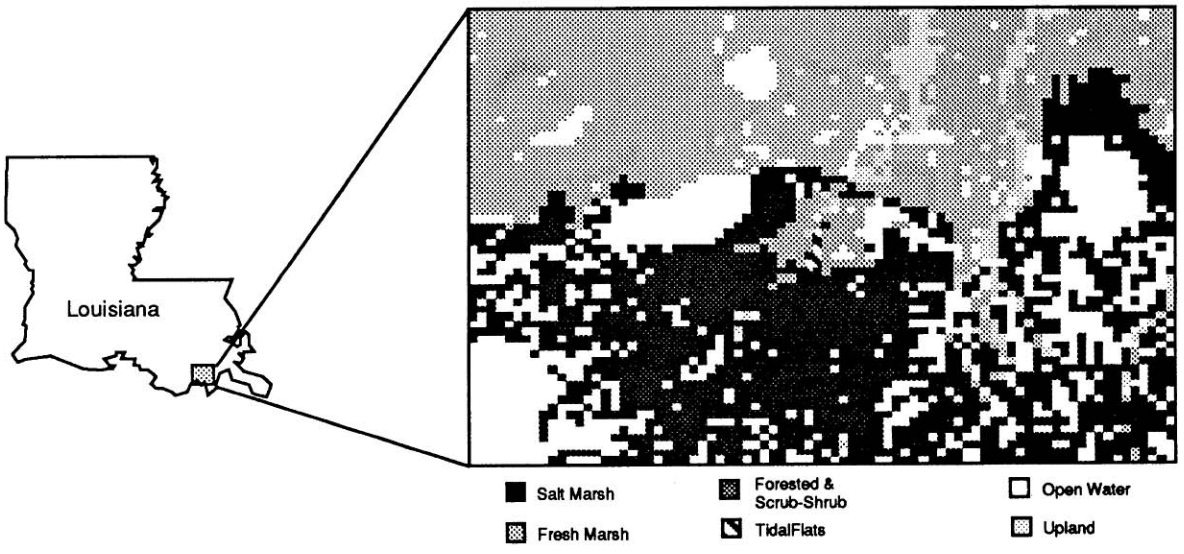

Figure 4. Composite of eight NWI maps in the coastal Mississippi Delta region of Louisiana.

Table 2. Coastal wetlands classification for the Gulf of Mexico, USA.

NOAA	FWS*	Common Plant Community
Salt Marsh		
Brackish	Estuarine intertidal emergent regularly and irregularly flooded salinity $\geq 0.5^{o}/_{oo}$ and $\leq 30^{o}/_{oo}$	black needlerush (Juncus roemerianus) salt hay grass (Spartina patens) salt grass (Distichlis spicata)
High	Estuarine intertidal emergent irregularly flooded salinity $\geq 30^{o}/_{oo}$	black needlerush (Juncus roemerianus) salt hay grass (Spartina patens) salt grass (Distichlis spicata)
Low	Estuarine intertidal emergent regularly flooded or irregularly exposed salinity $\geq 30^{o}/_{oo}$	smooth cordgrass (Spartina alterniflora)
Unspecified	Estuarine intertidal emergent	see "Brackish," "High" and "Low"
Fresh Marsh		
Nontidal	Lacustrine littoral emergent nontidal Palustrine emergent nontidal Riverine tidal or lower perennial emergent nontidal	bull tongue (Sagittaria falcata) cattails (Typha spp.) maidencane (Panicum hemitomon)
Tidal	Lacustrine littoral emergent tidal Palustrine emergent tidal Riverine tidal or lower perennial emergent tidal	spike-rush (Eleocharis spp.) three-square rush (Scirpus americanus)
Unspecified	Lacustrine littoral emergent tidal Palustrine emergent Riverine tidal or lower perennial emergent	see "Nontidal" and "Tidal"

Table 2. Coastal wetlands classification for the Gulf of Mexico, USA (continued).

NOAA	FWS*	Common Plant Community
Forested and scrub-shrub		
Estuarine	Estuarine intertidal forested or scrub-shrub	black mangrove (*Avicennia germinans*) marsh elder (*Iva frutescens*) red mangrove (*Rhizophora mangle*)
Nontidal fresh	Palustrine forested or scrub-shrub nontidal	bald cypress (*Taxodium distichum*) black willow (*Salix nigra*)
Tidal fresh	Palustrine forested or scrub-shrub tidal	same as "Nontidal"
Unspecified	Palustrine forested or scrub-shrub	see "Nontidal"
Tidal flats	Estuarine intertidal Marine intertidal (includes aquatic beds, beach/bars, flats, reefs, rocky shores, streambeds and unconsolidated shores)	saltwort (*Batis maritima*) smooth cordgrass (*Spartina alterniflora*)
Open water		
Fresh	Lacustrine limnetic or littoral Palustrine Riverine (includes aquatic beds, beach/bars, flats, open water, rock bottoms, reefs, rocky shores, streambeds, unconsolidated bottoms and unconsolidated shores)	pond weeds (*Potamogeton* spp.) water hyacinth (*Eichhornia crassipes*)
Non-fresh	Estuarine or Marine subtidal (includes aquatic beds, open water, rock bottoms, reefs and unconsolidated bottoms)	shoal grass (*Halodule beaudettei*) turtle grass (*Thalassia testudinum*) widgeon grass (*Ruppia maritima*)

*Based on Cowardin et al. 1979.

Table 3. Comparison of digital versus grid sampled data for 15 NWI 1:24,000 scale maps in the Mississippi Delta region of Louisiana.

Habitat	Area (Hectares)		
	Digital	Grid	% Difference
Tidal fresh marsh	65,510	65,108	<1
Salt marsh (unspecified)	29,930	28,512	-1
Tidal fresh forested and scrub-shrub	4,951	4,828	-2
Tidal flats	727	765	-5
Nontidal fresh forested and scrub-shrub	375	341	-9
Nontidal fresh marsh	155	90	-42
Estuarine forested scrub-shrub	221	90	-59

RESULTS AND DISCUSSION

The date of aerial photography for the maps used in this study ranged from 1972 to 1984 with 28 percent in 1979 and 42 percent occurring after 1980. The age of these maps must be taken into consideration when interpreting grid sampled data. However, because national trends indicate the abundance of most wetland types are still declining (Frayer et al. 1983), the data in this report are probably overestimates of the current resource. In addition, map availability or the lack thereof will not allow for the complete sampling of the region and therefore affect total acreage estimates. Figure 2 illustrates the NWI map availability for the Gulf at the time of this study. Louisiana was the only state where map availability was relatively poor, with only 256 maps available of the approximately 450 needed for complete coverage of the EDAs and coastal counties within the state.

Where grid sampling estimates indicate that only a small amount of a habitat is present, it does not necessarily mean that it is a rare habitat. On certain maps, due to availability of information or special needs, the FWS provided detailed water regime and water quality labels that indicate very specific wetland types. On adjacent maps, even within the same country or estuary, these labels may not have been available. Consequently, the wetland would be classified as "unspecified" when grid sampled. For example, in Louisiana grid sampled estimates indicate the presence of 2,125 hectares of nontidal fresh forested and scrub-shrub (NFFSS) wetlands and 1,574 hectares of unspecified fresh forested and scrub-shrub (UFFSS) wetlands. A large portion of the UFFSS could be NFFSS, but due to a lack of necessary labels, that distinction could not be made.

A total of 1,543 NWI maps (1:24,000 scale) covering 22.7 million hectares were sampled by NOAA for the Gulf of Mexico (Gulf). Approximately 24 percent, or 5.5 million hectares, were identified as emergent

wetlands. Eight of 23 EDAs and 50 of 68 coastal counties sampled had 100 percent map coverage. Fourteen EDAs had greater than 80 percent map coverage, while 57 coastal counties had greater than 90 percent coverage. Forested wetlands were the most common habitat type accounting for nearly 59 percent of the total Gulf wetlands, followed by fresh marsh (19%), salt marsh (18%), and tidal flats (4%).

Of the six states in the region, Florida contained the most wetlands (50% of the total) (Figure 5 and Table 4), followed by Louisiana (24%), Texas (12%), Alabama (8%), Mississippi (5%), and Georgia (<1%). Texas and Florida contained the largest grid sampled areas with 37 and 35 percent of the total Gulf area sampled respectively. Louisiana accounted for only 14 percent of the total due to poor map availability, followed by Alabama (8%), Mississippi (6%), and Georgia (<1%). The central to eastern portions of the Gulf (MS, AL, FL) were dominated by forested wetlands, accounting for over 83 percent of the forested total for the entire Gulf. The coastal areas of the western Gulf (TX, LA) were dominated by salt marsh having 86 percent of the regional total, with the highest concentrations in Louisiana (69%). Texas also contained the largest amount of tidal flats in the Gulf accounting for over 54 percent of the total, while Florida contained 38 percent. Fresh marsh is found throughout the Gulf with its greatest abundance in Florida (53%) followed by Louisiana and Texas (26% and 20% respectively).

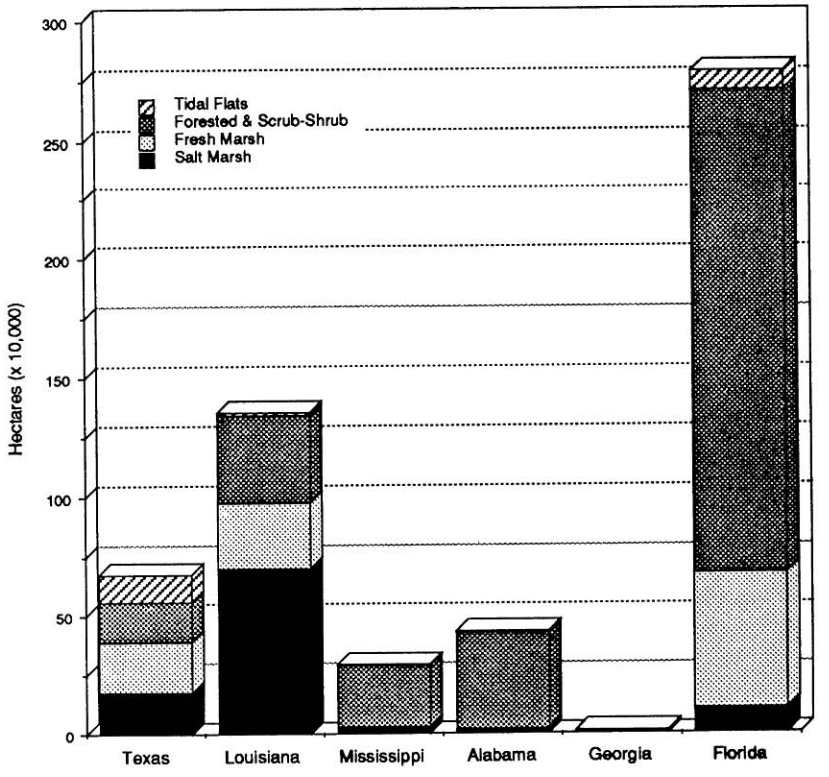

Figure 5. Coastal wetlands by state.

Table 4. Coastal wetlands by state (Hectares x 100).

Habitat	State					
	Texas Totals	Louisiana	Mississippi	Alabama	Georgia	Florida
Salt Marsh						
Brackish	0	4,606	7	0	0	0	4,613
High	0	0	0	0	0	0	0
Low	0	0	0	0	0	0	0
Unspecified	1,748	2,366	230	103	0	1,029	5,477
Subtotal	1,748	6,972	237	103	0	1,029	10,090
Fresh Marsh						
Nontidal	2,070	308	39	52	9	5,648	8,127
Tidal	91	263	0	1	0	40	395
Unspecified	0	2,168	4	6	0	1	2,178
Subtotal	2,161	2,739	43	59	9	5,689	10,700
Forested and Scrub-Shrub						
Estuarine	11	41	7	11	0	2,484	2,551
Fresh (Unspecified)	<1	1,514	72	3	0	0	1,590
Nontidal Fresh	1,662	2,125	2,547	4,136	135	17,807	28,411
Tidal Fresh	31	19	0	9	0	74	132
Subtotal	1,704	3,699	2,626	4,158	135	20,365	32,684
Tidal Flats	1,113	129	9	17	0	781	2,049
Total Wetlands	6,728	13,539	2,915	4,337	144	27,864	55,523
Non Wetlands						
Open Water Fresh	1,384	1,474	126	206	20	1,387	4,597
Open Water Non-Fresh	4,944	6,689	127	207	0	3,323	15,291
Upland	69,698	7,399	8,379	13,187	926	47,835	147,424
Subtotal	76,026	15,562	8,632	13,600	946	52,545	167,312
Regional Acreage	82,754	29,101	11,547	17,937	1,090	80,409	222,835

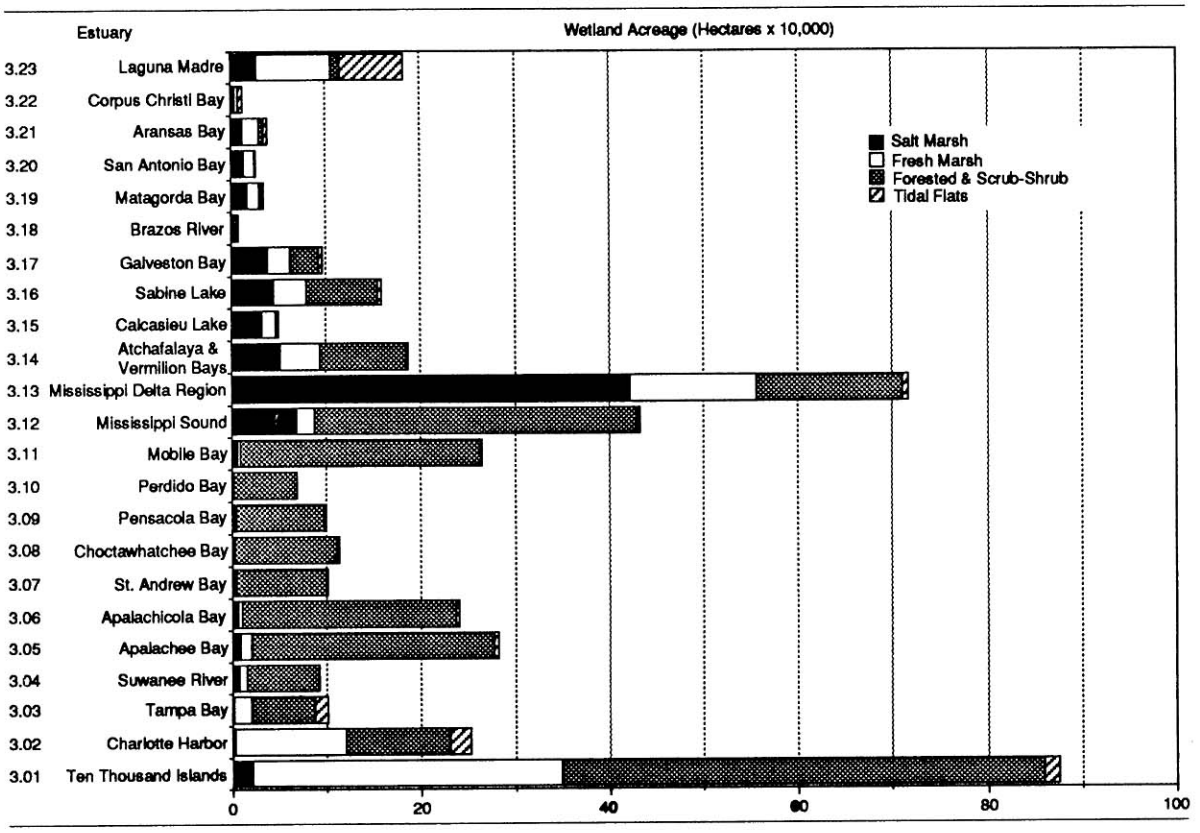

Figure 6. Coastal wetlands by estuarine drainage area.

The abundance of coastal wetlands in the counties of the Gulf follow a pattern similar to that of the states. Collier County, Florida contained the most wetlands of all Gulf counties and ranked first in total forested wetlands. Six counties in Louisiana--Cameron, Terrebonne, Plaquemines, Lafourche, St. Bernard, and Vermillion--accounted for 59 percent of the regional salt marsh total. Kenedy County, Texas ranked first in tidal flats, while Dade County, Florida ranked first in total fresh marsh.

The four major wetland habitat types are summarized by EDA in Figure 6. Laguna Madre in Texas had the largest grid sampled area with 15 percent of the total for the Gulf, however, it contained only 4 percent of the Gulf's total wetlands. It was dominated by fresh marsh and tidal flats (43% and 37% of the total wetlands in the estuary respectively), but only 7 percent of the estuary's total grid sampled area of 2.8 million hectares was wetlands. However, it contained the most tidal flats in the Gulf (40% of the total). Ten Thousand Islands in Florida contained the largest amount of wetlands in the Gulf (20% of the total) and the largest percent of wetlands (over 76%). It ranked first in the Gulf in forested wetlands and fresh marsh, 37 percent of the total fresh marsh and 20 percent of the total forested wetlands. In addition, its forested wetlands accounted for 12 percent of the

total Gulf wetlands. Despite low map availability, the Mississippi Delta and Mississippi Sound EDAs combined contained 26 percent of the total regional wetlands. The Mississippi Delta EDA ranked first in total salt march (53% of the regional total). It also contained a large amount of fresh marsh, ranking second (15% of the fresh marsh total). The Mississippi Sound EDA was dominated by forested wetlands that accounted for 13 percent of the Gulf's forested total. The remaining EDAs of the Gulf had a somewhat lower abundance of wetlands due to poor map availability, areal size, and/or geographic location.

The development of these data by NOAA provides an inexpensive and relatively simple method for accurately estimating the abundance and distribution of the Nation's coastal wetlands at a level of aggregation suitable for national assessments. Products from this project will complement the FWS work and provide a useful management tool for coastal resource managers at all levels of government, particularly those Federal agencies with responsibilities for wetlands management and conservation (e.g., COE, EPA, FWS, and NOAA). Baseline data for the Nation's coastal wetlands will be a significant addition to our understanding of these systems and should improve our ability to manage them effectively. In addition, when these data are integrated into the National Estuarine Inventory data base along with other data developed as part of NOAA's Strategic Assessment Program, they will serve as an important component in assessing the overall health and status of estuarine systems.

Wetland reports for the remaining coastal areas of the coterminous USA will be forthcoming in the months ahead. Following this report, a detailed data atlas on wetlands of the U.S. portion of the Gulf of Mexico will be developed by the Spring of 1989. The next region planned for completion is the Mid-Atlantic (New York to Virginia, Summer of 1989). It will be followed by the West Coast (California to Washington, Fall of 1989) and the Southeast (North Carolina to the east coast of Florida, early 1990).

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LITERATURE CITED

Alexander, C. E., M. A. Broutman, and D. W. Field. 1986. An inventory of coastal wetlands of the USA. Strategic Assessment Branch, Rockville, Maryland, National Oceanic and Atmospheric Administration, 25 pp. (mimeo).

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Washington, D.C., FWS/OBS-79/31.

Ehler, C. N., and D. J. Basta. 1984. Strategic assessment of multiple resource-use conflicts in the U.S. Exclusive Economic Zone. In Exclusive Economic Zone Papers. Reprint from Proceedings of Oceans '84, Washington, D.C.

Field, D. W., C. E. Alexander, and M. A. Broutman. 1988. Towards developing an inventory of coastal wetlands of the USA. Marine Fisheries Review. (in press)

Frayer, W. E., T. J. Monahan, D. C. Bowden, and F. A. Graybill. 1983. Status and trends of wetlands and deepwater habitats in the coterminous United States, 1950s to 1970s. Colorado State University, Department of Forest and Wood Sciences, Ft. Collins, Colorado.

Gagliano, S. M., K. J. Meyer-Arendt, and K. M. Wicker. 1981. Land loss in the Mississippi River Deltaic Plain. Transactions of the Gulf Coastal Association Geological Society 31:295-299.

Haddad, K. D., and B. A. Harris. 1985. Use of remote sensing to assess estuarine habitats. In O. T. Magoon (Ed.), Proceedings of the fifth symposium on coastal and ocean management - Coastal Zone '85. American Society of Engineers, New York.

Lindall, W. N., Jr., and G. W. Thayer. 1982. Quantification of National Marine Fisheries Service habitat conservation efforts in the Southeast region of the United States. Marine Fisheries Review 44:18-22.

May, L. N., Jr. 1986. An evaluation of Landsat MSS digital data for updating habitat maps of the Louisiana coastal zone. Photogrammetric Engineering and Remote Sensing (52)8.

National Oceanic and Atmospheric Administration. 1985. National Estuarine Inventory data atlas: Physical and hydrologic characteristics. Strategic Assessment Branch, Rockville, Maryland, 103 pp.

Tiner, R. W., Jr. 1984. Wetlands of the United States: Current status and recent trends. U.S. Fish and Wildlife Service, National Wetlands Inventory, Washington, D.C., 59 pp.