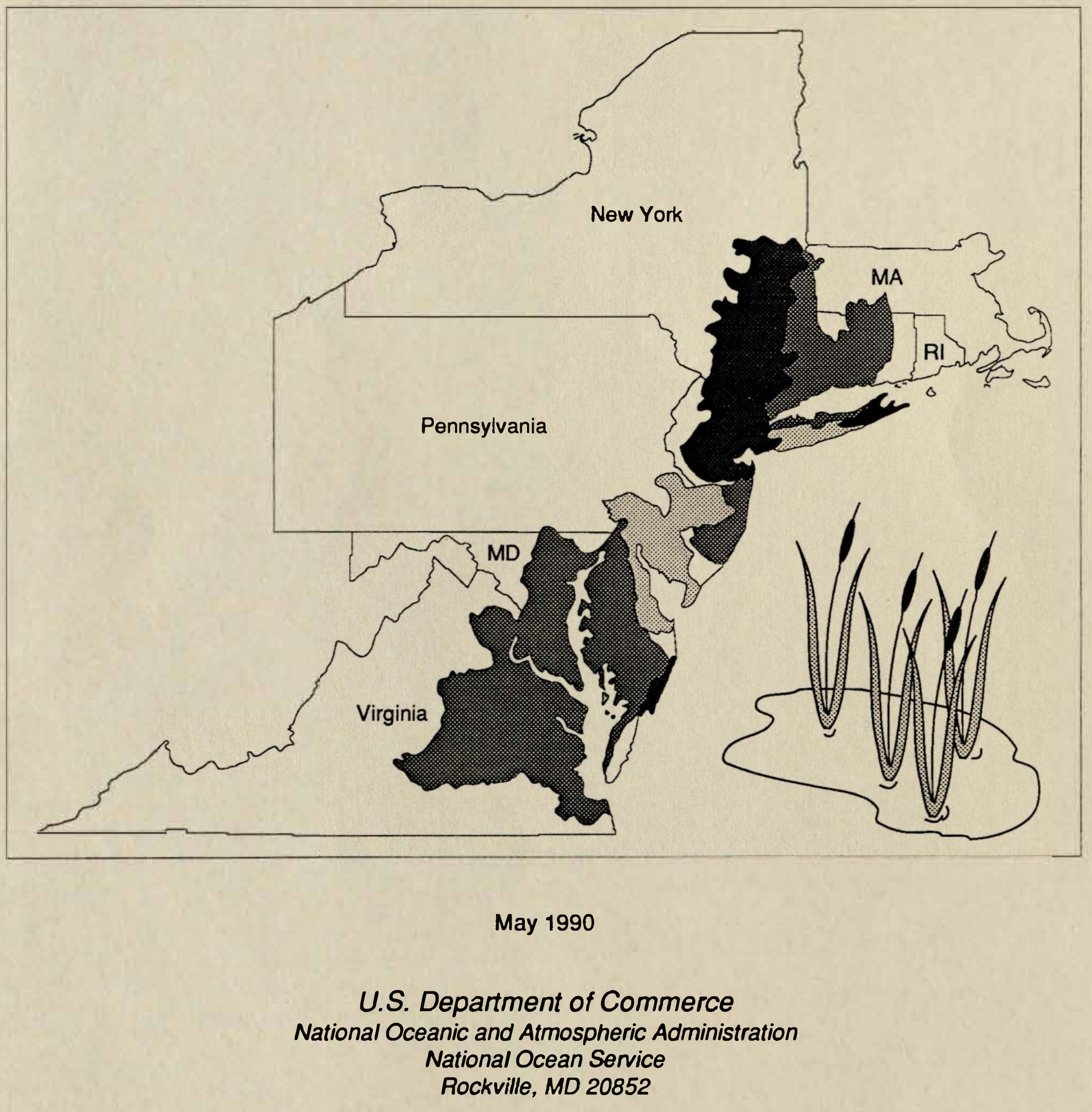
National Coastal Wetlands Inventory

The Distribution and Areal Extent of Coastal Wetlands in Estuaries of the Mid-Atlantic Region



May 1990

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Rockville, MD 20852

National Coastal Wetlands Inventory

Development of the National Coastal Wetlands Inventory was initiated by NOAA in June of 1986 and is conducted by the Strategic Assessment Branch of the Office of Oceanography and Marine Assessment, National Ocean Service (NOS). NOS has a traditional role in the management and protection of the Nation's coastal and oceanic resources.

The purpose of the Inventory is to develop a comprehensive and consistently derived national coastal wetlands data base to increase our knowledge of the distribution and areal extent of wetlands and to improve our understanding and management of this vital resource. The data developed from this project is being incorporated into NOAA's National Estuarine Inventory (NEI) and used in conjunction with other information such as land use, coastal pollution and population trends, distribution of estuarine fishes and invertebrates, and the status of classified shellfish waters, to develop a national estuarine assessment capability. Refer to Appendix II for more detailed information concerning the NEI.

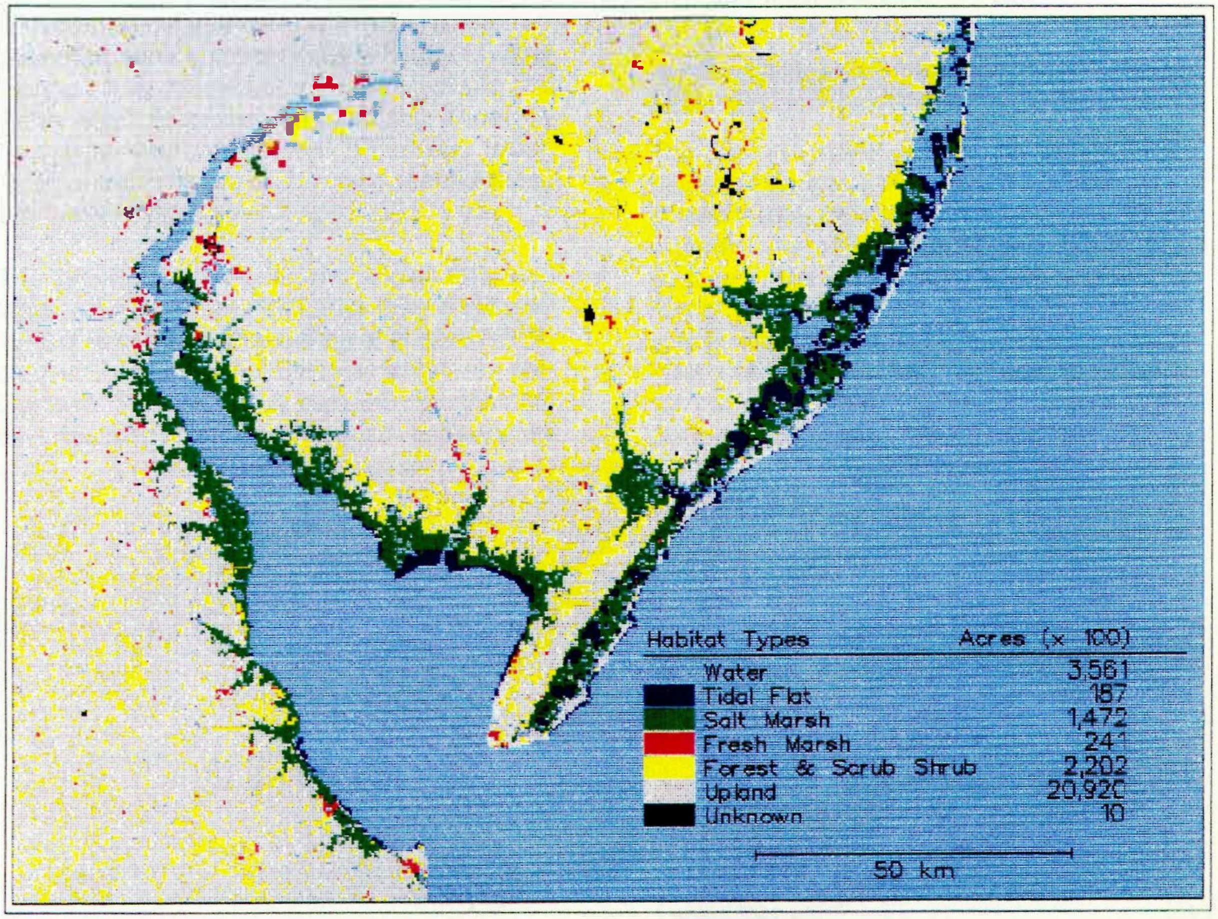
To date, NOAA has published two wetland data atlases. The first, *National Estuarine Inventory Data Atlas, Vol. III: Coastal Wetlands of the New England Region* focuses on wetlands of the 16 estuaries and 42 counties from Maine to Connecticut. The second, *National Estuarine Inventory Data Atlas, Vol. V: Coastal Wetlands of the Gulf of Mexico Region* describes the wetlands of the 157 counties and 23 estuaries from Texas to the gulf coast of Florida. A detailed report describing the coastal wetlands of the West Coast region (Washington, Oregon, and California) is scheduled for publication in the summer of 1990. A national report summarizing the extent and abundance of wetlands for the 22 coastal states, 507 counties, and 92 estuaries that comprise the contiguous U.S is scheduled fof publication in the fall of 1990.

NOAA
U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

National Coastal Wetlands Inventory

The Distribution and Areal Extent of Coastal Wetlands in Estuaries of the Mid-Atlantic Region

Anthony J. Reyer, Beth D. Shearer, Paul V. Genovese,
Cynthia L. Holland, Jennifer E. Cassells,
Donald W. Field, and Charles E. Alexander



Wetlands of the Delaware Bay estuarine drainage area.

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service

This report is the third in a series that describes the distribution and abundance of coastal wetlands in the contiguous United States. The data are based on NOAA's analysis of U.S. Fish and Wildlife Service National Wetland Inventory maps.

Estuaries are among our most productive natural systems and are important features of the Nation's coastal regions, especially along the Atlantic Coast and the Gulf of Mexico. They represent a transition zone between freshwater and marine ecosystems and are most commonly defined as semi-enclosed coastal bodies of water having a free connection with the open sea and within which seawater is measurably diluted by freshwater from land runoff (Pritchard, 1969). Coastal wetlands are a vital component of these productive systems.

The importance that estuaries and coastal wetlands associated with estuaries play in sustaining the health and abundance of marine fishes, shellfish, and other animals has long been recognized. However, only recently has attention been focused on the multiple goods and services these natural systems provide. As the demand for these resources continues to increase, so will conflicts among the competing users.

This report describes the general distribution and areal extent of wetlands in 127 counties and 8 estuarine systems in the Mid-Atlantic region (Figure 1). Included are detailed acreage summaries for 12 wetland types and a computer generated map of one estuary, Delaware Bay. The wetlands data are derived from National Wetland Inventory (NWI) maps produced by the U.S. Fish and Wildlife Service (FWS).

Importance of Wetlands Information

The Nation's coastal wetlands are important natural resources. Most typically, wetlands are unique 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 (Cowardin et al., 1979). They provide critical habitat for fish, shellfish, and wildlife (Shaw and Fredine, 1956; McHugh, 1966; Turner, 1977; Flake, 1979; Lindal and Thayer, 1982; Sather and Smith, 1984), filter and process

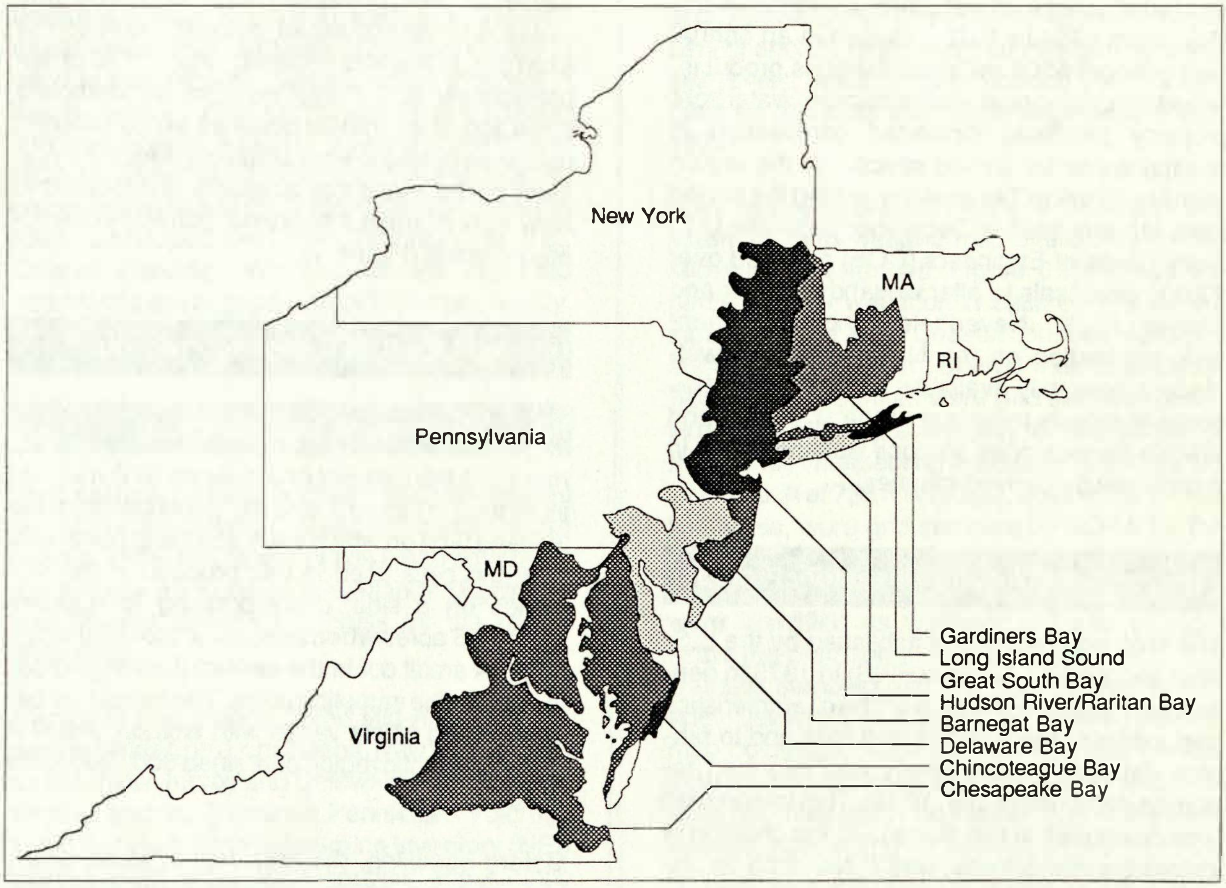


Figure 1. Estuarine Drainage Areas of the Mid - Atlantic Region.

agricultural and industrial wastes (Benner et al., 1982; Tchobanoglous and Culp, 1980; Kadlec and Kadlec, 1979), and buffer coastal areas against storm and wave damage (Knutson, 1982). They also generate large revenues from a wide variety of recreational activities, such as fishing and hunting (NMFS, 1981; FWS, 1982).

Rapid loss of wetlands is occurring in many areas due to urbanization, agriculture, hydrocarbon exploration, sea level rise, shoreline erosion, and other factors. More than 11 million acres of wetlands have been lost over the past 25 years (Frayer et al., 1983) due to human activity and natural processes. Although most of the losses have occurred in inland areas, coastal wetlands have also declined at an alarming rate over this period (approximately 20,000 acres or 31 sq. mi. per year). For example, in the Chesapeake Bay region, losses of coastal wetlands are estimated at 6 percent annually (Tiner, 1987).

A major concern over wetland losses is the long-term, cumulative impact on the large number of fish and shellfish that depend on these habitats at some stage in their life histories. The National Marine Fisheries Service (NMFS) (1983) has estimated that loss of estuarine wetlands in the U.S., from 1954 to 1978, resulted in an annual loss of about $208 million in fisheries products. In addition, rising cost and demand for waterfront property promises increased competition in coastal areas for limited space. In the region from New York to Texas alone, during the period from January 1981 to December 1985, the U.S. Army Corps of Engineers (COE) received over 27,000 proposals to alter wetlands (Mager and Thayer, 1986). Nevertheless, no comprehensive information on the Nation's coastal wetlands is presently available. However, the National Wetlands Inventory of the U.S. Fish and Wildlife Service does produce wetland maps in a consistently derived manner.

The National Wetlands Inventory Program

The NWI program was established by the U.S. Fish and Wildlife Service (FWS) in 1975 to generate scientific information on the characteristics and extent of the Nation's wetlands and to provide data for making timely and informed resource decisions (Tiner, 1984). This information was developed in two stages: 1) the creation of detailed wetland maps, and 2) research on historical status and trends of wetlands change. Since 1975, the FWS has produced thousands of detailed wetland maps, covering over 56 percent of the contiguous USA and over 92 percent of the coastal zone. The maps are developed from aerial photography and are generally based on 1:24,000 scale USGS maps. They illustrate wetland habitats classified using the classification system of the FWS (Cowardin et al., 1979).

Although the NWI wetland maps represent the most comprehensive and reliable source of consistently derived coastal wetland information available, less than 1,500 of the over 5,000 maps required for complete coverage of the Nation's estuaries and other coastal areas have been converted to digital data for computer processing and mapping. Therefore, only a fraction of the wetlands data required are available. Further, a complete digital data base of NWI coastal maps is not anticipated by the FWS. Since the current procedure for digitizing is expensive and time consuming, the FWS presently digitizes maps primarily on a user-pays basis (Dahl, 1987).

NWI maps remained, however, the preferred data source for developing the Inventory because of their comprehensive coverage and availability across broad coastal regions. For example, in the Mid - Atlantic region, 735 of approximately 830 maps needed for complete coverage of all coastal counties and 8 different estuarine systems were available from the FWS. Most of the maps not available are located in New York in areas that are not generally considered coastal (Figure 4).

NOAA's Grid-Sampling Procedure

The grid-sampling technique developed by NOAA to quantify coastal wetlands involves the placement of a transparent grid over an NWI map, as illustrated in Figure 2, and the identification of the wetland type on which each sampling point falls. The grid cells used in this procedure are 0.7 inches on a side, corresponding to approximately 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 Mid-Atlantic region contained 800 - 900 sampling points.

Before sampling, the map name, state, scale, date of aerial photography, latitude and longi-

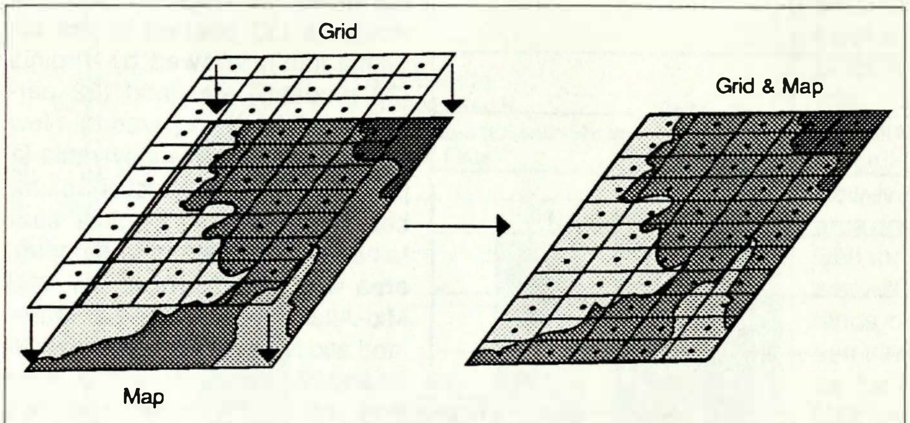


Figure 2. 1:24,000 - scale NWI map and grid.

tude of the lower right and upper left comers, and the number of columns and rows of grid cells are recorded. For the purposes of this technique, the numerous wetland types identified on NWI maps were aggregated into 15 habitat types (Appendix I, Table 1). Appendix IV summarizes the FWS categories included in these 15 habitat types and also gives examples of typical plant communities found in each. For the Mid-Atlantic region, a total of 735 NWI maps were grid sampled.

Each cell is recorded as the habitat type on which its center dot falls. A quality control procedure is used to minimize the types of errors inherent in this technique. Grid-sampled data are entered into the Spatial Analysis System (SPANS) in NOAA's GeoCOAST facility. SPANS is a microcomputer-based geographic information system (GIS) developed by Tydac Technologies Inc., Ottawa, Canada. Wetland acreage and map summaries can be produced by NWI map, county, state, and/or estuary.

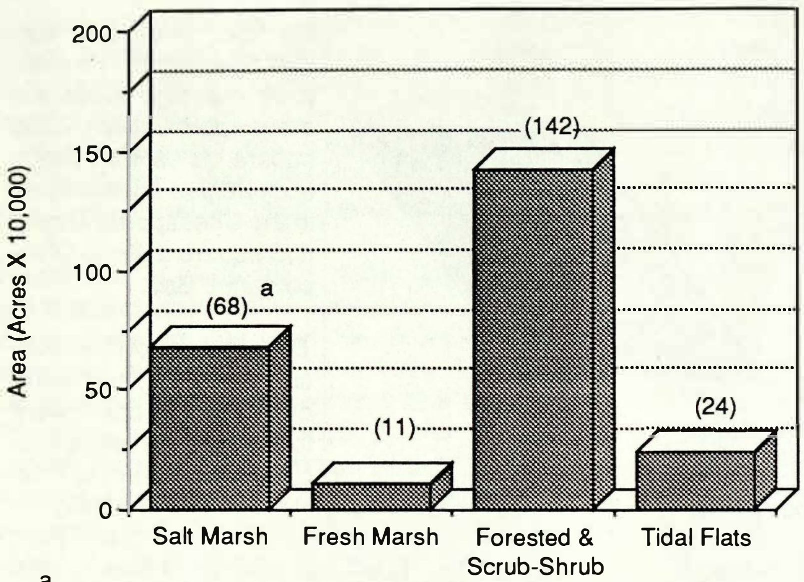
Distribution of Wetlands

This section describes briefly the Mid-Atlantic region and its wetlands. Maps and barcharts are used to show the extent of NWI map coverage, the relative abundance of wetlands (Figures 4 and 6), and dominant habitats for the region (Figure 3).

Regional Geography. The Mid-Atlantic study area extends from Long Island, New York, southwest to New Jersey and Delaware, then south to Virginia and the Delmarva Pennisula. Volumes 1 and 2 of the National Esturaine Inventory (NEI) identify eight estuaries along the Mid-Atlantic coast (Figure 1) and describe their physical, hydrologic, and land use characteristics. The estuarine drainage areas average approximately 4,336 square miles and range from 22,353 square miles in the Chesapeake Bay to 335 square miles in Chincoteague Bay.

The estuaries of Connecticut, New York, and northern New Jersey were formed when melting glaciers caused the sea level to rise covering coastal plains and drowning the mouths of ancient rivers such as Hudson River/Raritan Bay. Due to the outwash of these glacial activites, Long Island Sound developed its characteristic rocky shores. Moving south from Bay Head, New Jersey, barrier beaches extend almost the entire length of the state. In this region the lowermost parts of valleys were drowned, while upstream, stretches of swampy tidal flats can be found, such as in Barnegat Bay. Continuing southward, the Chesapeake Bay, the estuary with the largest surface area in the United States, and Delaware Bay were formed when the channels of ancient rivers were submerged by rising sea levels, which in turn, flooded river valleys creating marshes and these large bays (Hunt, 1974).

NWI Map Coverage. Figure 4 illustrates the extent of FWS wetland map availability for the Mid-Atlantic estuaries. Figure 6 illustrates the percentage of wetlands in each county for the same mapped area. Coastal counties were grid sampled to the extent of NWI map availability. Non-coastal counties were grid sampled to the extent of NWI map availability for that portion of the county intersecting estuarine drainage areas. A total of 735 NWI maps, covering 23.4 million acres, were grid sampled by NOAA for the Mid-Atlantic region (New York to Virginia). Approximately 11 percent, or 2.4 million acres, were identified as wetlands. Three of eight estuarine drainage areas (EDA) and 78 of 127 counties sampled had 100 percent map coverage. Seven EDAs had greater than 90 percent map coverage, while 90 counties had greater than 85 percent coverage. Forested wetlands were the most common habitat type in the Mid - Atlantic, accounting for nearly 58 percent of the region's total wetlands, followed by salt marsh (28 percent), tidal flats (10 percent), and fresh



[a] Value in ( ) is the total wetland acreage.

Figure 3. Total wetlands by habitat for the Mid-Atlantic region.

marsh (4 percent) (Figure 3).

Distribution by State. Of the District of Columbia and the six states in the region, New Jersey contained the largest amount of wetlands (33 percent of the regional total), followed by Virginia (30 percent), Maryland (22 percent), Delaware (9 percent), New York (4 percent), Pennsylvania (1 percent), and the District of Columbia (<1 percent). Virginia contained the largest grid-sampled area with 39 percent of the total Mid-Atlantic area sampled. Maryland and New Jersey followed with 21 and 20 percent of the total. New York was next with only 9 percent of the total area sampled due to poor map availability, followed by Delaware (6 percent), Pennsylvania (5 percent), and the District of Columbia (<1 percent).

New Jersey, Virginia, and Maryland dominated the wetlands of the region, accounting for 85 percent of the regional total (Figure 5). Virginia had the region's largest amount of both tidal flats and fresh marsh, accounting for 43 and 35 percent respec-

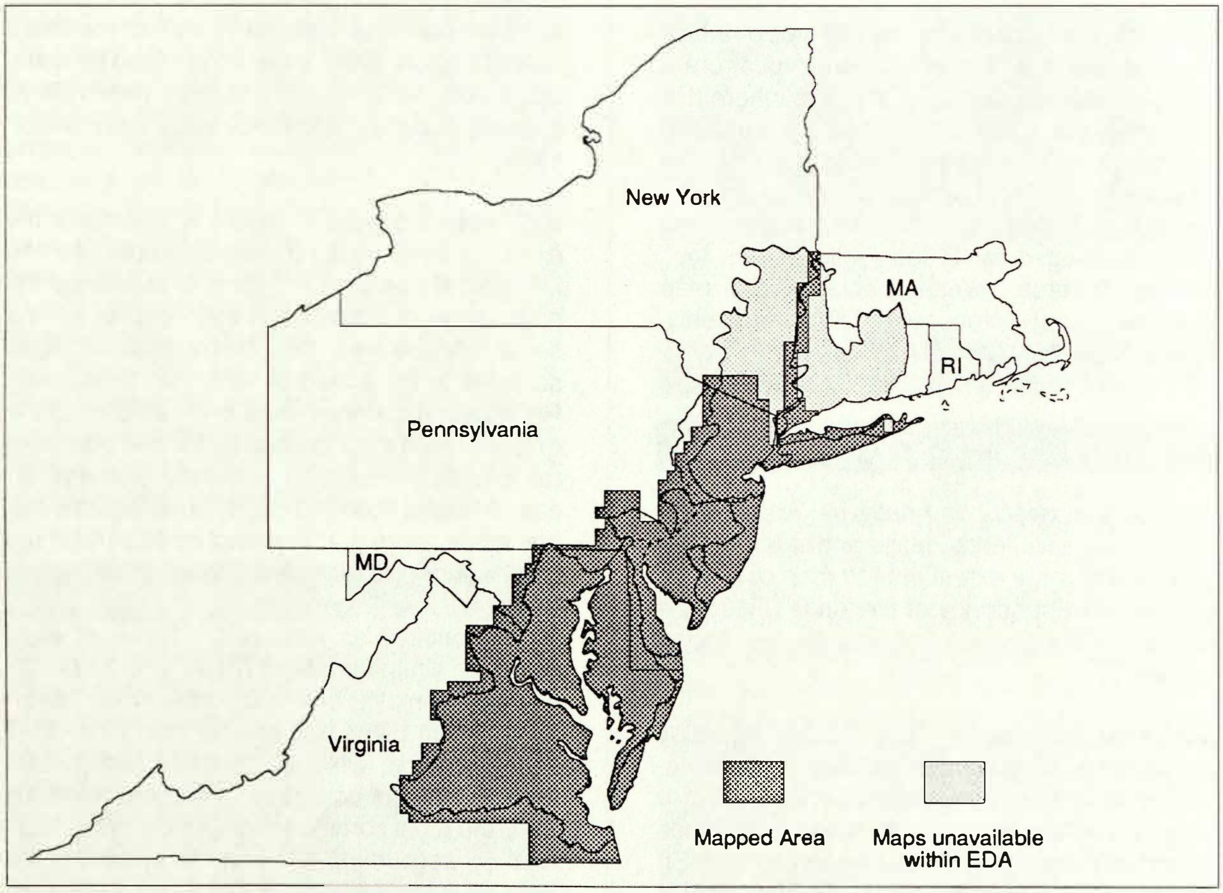


Figure 4. NWI map availability for the eight estuarine drainage areas of the Mid - Atlantic region.

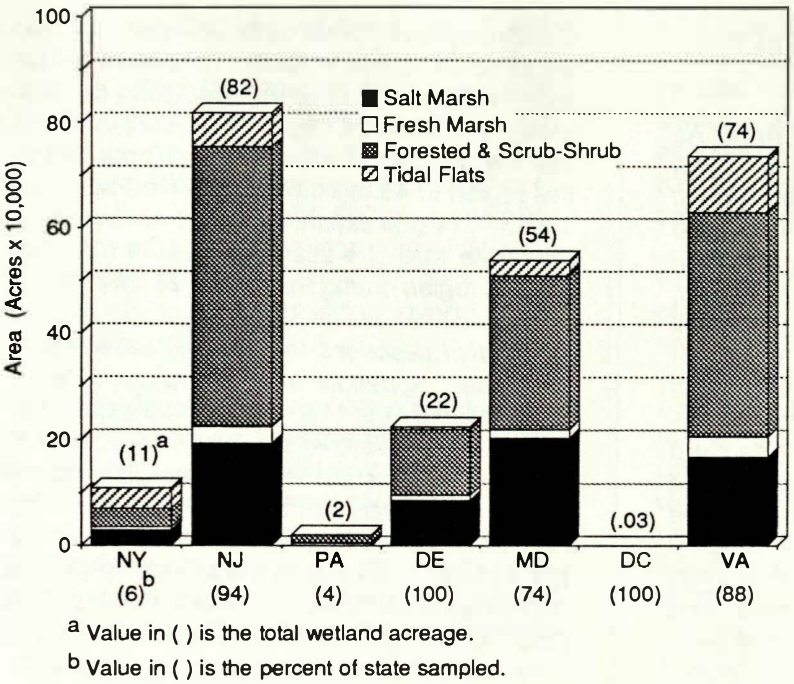


Figure 5. Wetland acreage of four wetland types by state.

tively of the regional total of each habitat. New Jersey contained the most forested wetlands in the region (37 percent of the regional forested total), and Maryland contained the most salt marsh, accounting for 30 percent of the regional salt marsh total. Due to its size, Delaware contained fewer wetlands than New Jersey, Virginia, or Maryland. However, 17 percent of the total area grid-sampled in Delaware was wetlands, second only to New Jersey with 18 percent. Forested wetlands dominated those areas grid sampled in Pennsylvania, accounting for 76 percent of the state wetland total. Thirty-six percent of those wetlands grid sampled in New York were tidal flats.

Distribution by Coastal County. The abundance of coastal wetlands in the counties of the Mid-Atlantic region follow a pattern similar to that of the states. Dorchester County, MD ranked first in the amount of total wetlands and salt marsh. Burlington County, NJ contained the greatest amount of fresh marsh and forested wetlands of all Mid-

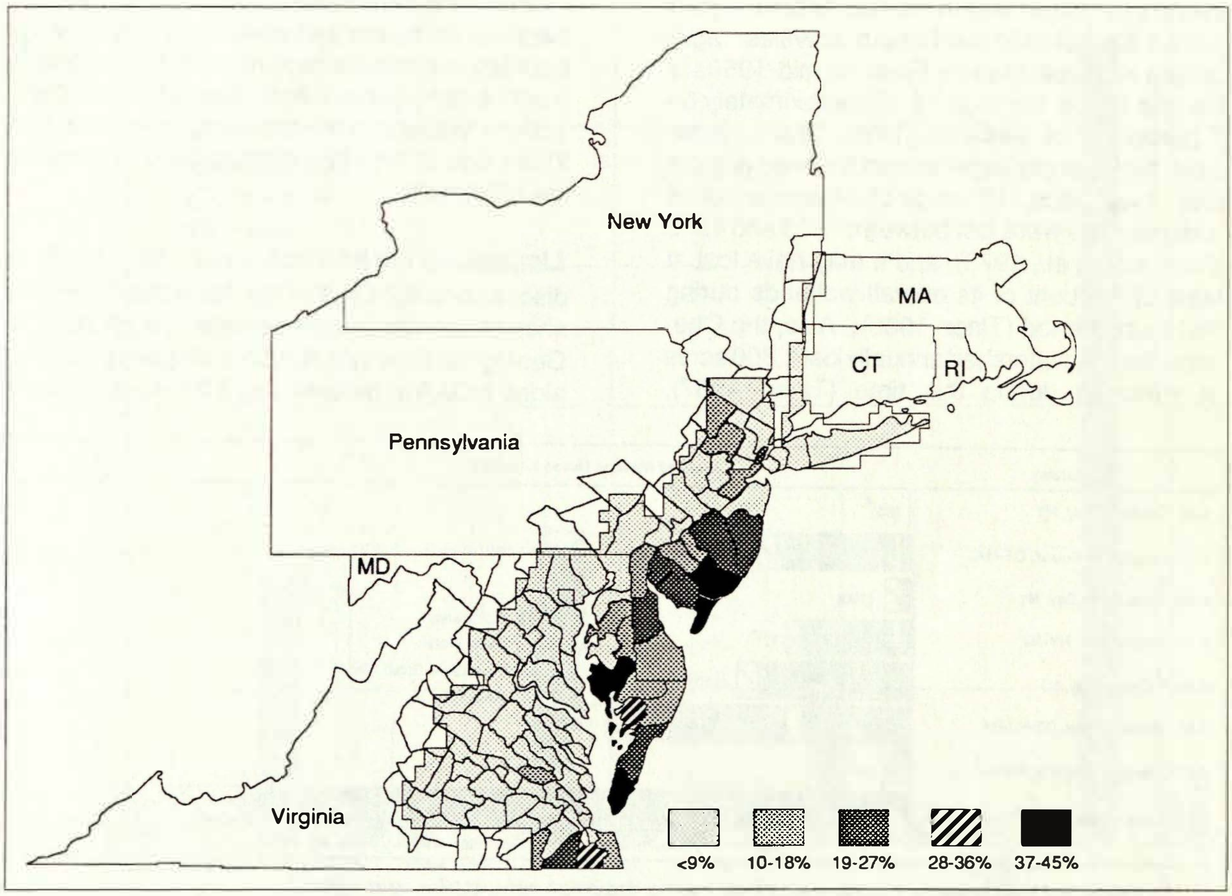


Figure 6. NWI map availability by county. Shading indicates percent of total county area mapped that is wetlands.

Atlantic counties. Tidal flats were most abundant in Northampton County, VA.

Distribution by Estuarine Drainage Area. As expected, the Chesapeake Bay had the largest grid-sampled area in the Mid-Atlantic region, containing 54 percent of the regional total. Due to its large size, the Chesapeake Bay also contained the region's largest amount of wetlands, accounting for 47 percent of the total, and it ranked first in containing the largest amount of each habitat type: salt marsh (51 percent of the regional total), fresh marsh (48 percent), forested (45 percent), and tidal flats (47 percent) (Figure 7). Delaware Bay (see title page) ranked second to the Chesapeake Bay in each of the habitats above except tidal flats for which it ranked fourth. Barnegat Bay in New Jersey had the largest portion of its grid-sampled area comprised of wetlands (29 percent), while ranking second in tidal flats (14 percent of regional tidal flat total). The remaining EDAs of the Mid-Atlantic region had a somewhat lower abundance of wetlands due to areal size and/or geographic location (Figure 8).

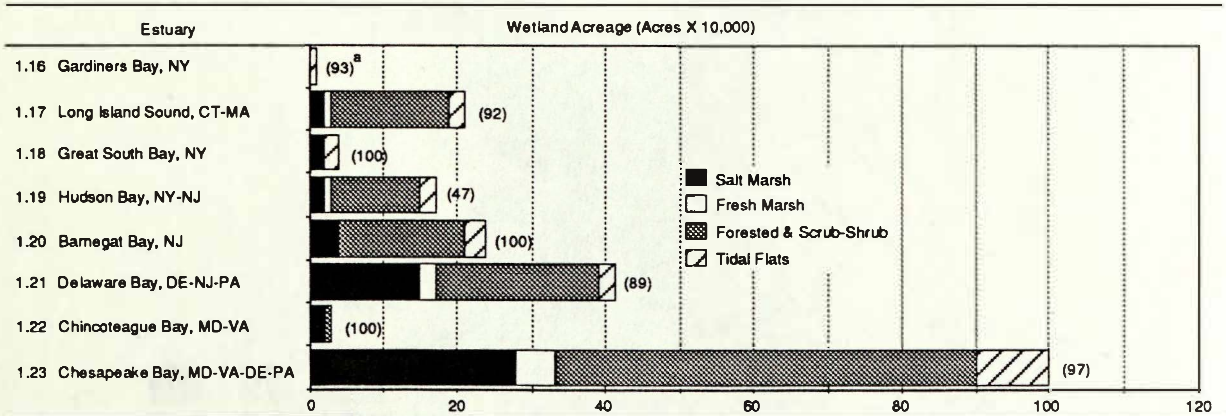
Trends. Wetland loss in the Mid-Atlantic region can be attributed to two human activities: agriculture and urbanization. From the mid-1950s to the late 1970s, the region lost approximately 6 - 7 percent of its wetlands (Tiner, 1987). However, New Jersey experienced an even greater loss of wetlands. Upwards of 24 percent of its tidal marshes were lost between 1953 and 1973 (Ferrigno, et al., 1973), and it may have lost at least 20 percent of its overall wetlands during that same period (Tiner, 1985). Also, the Chesapeake Bay watershed annually lost 2,800 acres of wetlands during this time (Tiner, 1987). Comprehensive trends data for New York has yet to be developed. NOAA (1990), in a recent report entitled, *50 Years of Population Change along the Nation's Coasts 1960-2010*, projects that the population will increase 10 percent in this region to 43 million over the next two decades. This population increase will invariably affect the rate of wetland change in the Mid-Atlantic region during this period of time.

Appendix I describes the steps to develop the database. Appendix II summarizes the work being done by the U.S. Fish and Wildlife Service's National Wetland Inventory. Appendix III summarizes coastal wetlands acreage by state/county and estuary for the eight EDAs of the Mid Atlantic coast. The final appendices summarize the various FWS habitats included in the 15 habitat types identified in NOAA's grid sampling procedure (Appendix IV) and review the accuracy and precision of grid sampling (Appendix V).

Interpreting the Data

Although the data used to compile this report are the most complete and up-to-date available for the Nation's coastal regions, two major factors must be considered when interpreting the data: 1) the limitations of the sampling technique; and 2) the age of the photography used to produce the NWI maps.

Limitations of the Technique. As a result of discussions at NOAA's Coastal Wetlands Workshop (Appendix I), representatives from the U.S. Geological Survey's National Mapping Division aided NOAA in determining if the 45-acre reso-



[a] Value in ( ) represents the percent of estuarine drainage area currently mapped.

Figure 7. Total acreage of four wetland types by estuarine drainage area.

lution was adequate for capturing coastal wetlands acreage with a reasonable degree of accuracy. Equations to determine acceptable sample size were calculated at several levels of acceptable error and degrees of confidence. These calculations indicated that the 45-acre cell size and subsequent 800-plus sampling points per 1:24,000-scale map were adequate for the development of wetlands data at the national, regional, and estuarine level of analysis (see Appendix V).

Grid-sampled data, however, are not intended to be accurate enough to make decisions at the site-specific level. In addition, they are not intended to accurately estimate rare habitat types. But when these data are aggregated across geographic areas, such as an estuary, they provide an accurate summary of the general distribution and abundance of major wetland types.

Appendix V compares NOAA grid-sampled data to NWI digital data for maps from Barnegat Bay, NJ. Large areas are estimated extremely well. Estimates of rare habitats are sometimes very close to digital estimates, but are generally less reliable. An indication of the accuracy of grid-sampled estimates can be obtained from an equation presented in Appendix V. This equation, developed from Bonner (1975), gives the probable error for grid-sampled estimates.

If grid-sampled estimates indicate a small amount of a given habitat type, it does not necessarily mean that it is a rare habitat. On certain maps, due to the 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 county or estuary, these labels may not have been available, and the wetland would be classified as "unspecified" when grid sampled. For example, in New Jersey, grid-sampled estimates indicate the presence of 10,400 acres of nontidal fresh forested and scrub-shrub (NFFSS) wetlands, and 507,700 acres of unspecified fresh forested and scrub-shrub (UFFSS) wetlands. A large portion of the UFFSS could be NFFSS, but due to a lack of more

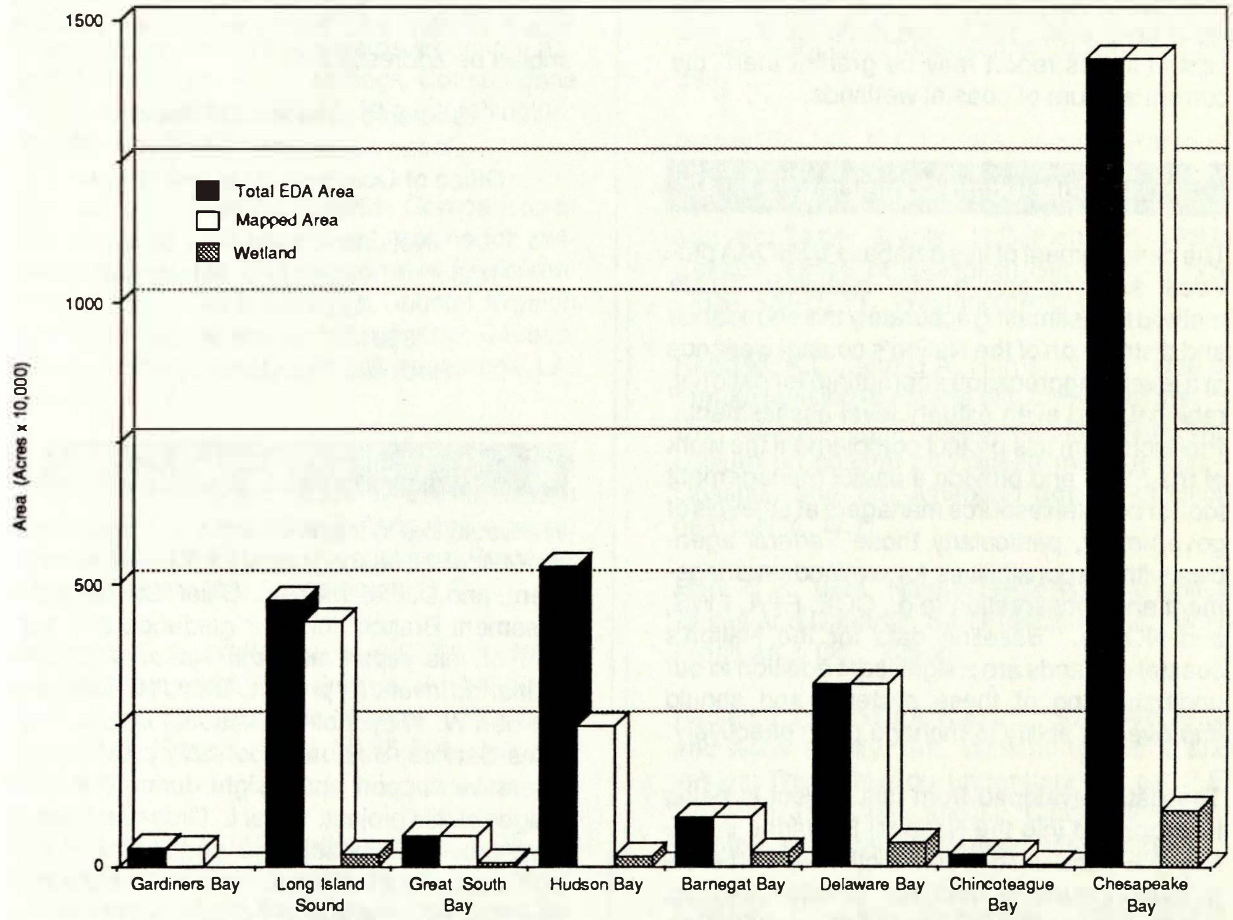


Figure 8. Estuary size, NWI map coverage, and total wetlands by estuarine drainage area.

Table 1. Dates of aerial photography by estuarine drainage area. (number of maps)

Estuary	Year of Photography N/A	1972-74	1975-78	1979-81	1982-85
1.16 Gardiners Bay	-	-	-	13	1
1.17 Long Island Sound	-	14	31	101	-
1.18 Great South Bay	-	-	-	16	-
1.19 Hudson Bay	15	15	46	4	-
1.20 Barnegat Bay	3	-	32	-	-
1.21 Delaware Bay	10	4	34	43	14
1.22 Chincoteague Bay	7	2	16	-	2
1.23 Chesapeake Bay	10	127	107	83	87

specific labels, that distinction could not be made.

Age of Photography. How accurately the grid-sampled data represents present conditions depends on the rate of wetland loss or gain since the maps were developed. The date of aerial photography for the maps used in this study ranged from 1972 to 1985, with 62 percent occuring between 1975 and 1981, and 12 percent occuring after 1981. A complete list of the dates of aerial photography used to produce all maps available for the eight estuarine drainage areas of the Mid-Atlantic region is presented in Table 1. Since national trends indicate that the abundance of most wetland types are still declining (Frayer et al., 1983), the wetlands data presented in this report may be greater than the current amount of coastal wetlands.

Concluding Comments

The development of this database by NOAA provides an inexpensive and relatively simple method for estimating accurately the abundance and distribution of the Nation's coastal wetlands at a level of aggregation appropriate for national, regional, and even estuary level assessments. Products from this project complement the work of the FWS, 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 are a significant addition to our understanding of these systems and should improve our ability to manage them effectively.

The data developed from this project is being incorporated into the National Estuarine Inventory (NEI) 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 an estuarine assessment capability. Many of these assessments will be carried out using NOAA's GeoCOAST geographic information system (GIS) facility in Rockville. The newest and one of the most useful aspects of the wetlands GIS capability is the SPANS Map Indexing module. The Map Indexing module is a GIS that has a level of resolution based on 1:24,000 scale maps as identified in the U.S. Geological Survey topographic series. A multitude of information can be entered and displayed for each quadrangle, including date of aerial photography, acreage of wetland types as identified in the grid sampling process, and percent of quadrangle that is wetland or a specific wetland type. However, some preliminary assessments are already being carried out using computer software developed by NOAA.

Completion of this report on coastal wetlands is an important step in a continuing NOAA effort to organize and apply the best available information and to develop an operational capability to assess the health and use of the estuaries of the USA. Comments on this report or questions about current and future estuarine activities should be addressed to:

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration
6001 Executive Blvd.
Rockville, Maryland 20852

Acknowledgements

We would like to thank Charles N. Ehler, Director, Office of Oceanography and Marine Assessment, and Daniel J. Basta, Chief, Strategic Assessment Branch, for their guidance and support of this report and the National Coastal Wetlands Inventory project. David R. Colby and Gordon W. Thayer of the National Marine Fisheries Service, Beafort Laboratory provided cooperative support and insight during the initial stages of this project. Peter L. Grose and Lita R. Katz provided key software and technical support throughout the project. Kevin D. McMahon provided editorial support of this report.

References

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

Benner, C.S., P.L.Knutson, R.A. Brochu, and A.K. Hurme. 1982. Vegetative erosion control in an obligohaline environment, Currituck Sound, North Carolina. In: Third Annual Meeting of the Society of Wetland Scientists. Wrightsville Beach, NC.

Bonner, G.M. 1975. The error of area estimates from dot grids. Canadian Journal of Forest Research. (5)10.

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

Dahl, T.E. 1987. Wetlands mapping in the coastal zone - progress towards creating a national data base. In Proceedings, Coastal Zone '87. (May 26-29, 1987, Seattle, Washington) Volume 1: 465-473.

Day, J.W., Jr., N.J. Craig. 1981. Comparison of effectiveness of management options for wetlands loss in the coastal zone of Louisiana. Proceedings, Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences, and Options, Baton Rouge, LA, October 5 - 7, 1981.

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.

Ferrigno, F., L. Widjeskog, and S. Toth. 1973. Marsh Destruction. N.J. Dept. of Env'tal. Prot., Div. of Fish, Game, and Wildlife. Pittman - Robertson Report. Proj. W-35-R-1, Job I-G. 20pp.

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)

Fish and Wildlife Service. 1982. The National survey of fish, hunting, and wildlife-associated recreation. Portland, OR.

Flake, L.D. 1979. Wetland diversity and waterfowl. In: Wetland functions and values: the state of our understanding. Minneapolis, MN: ed. P.E. Greeson, J.R. Clark, and J.E. Clark. American Water Resources Association.

Florida Department of Environmental Regulation. 1978. Statistical inventory of key biophysical elements in Florida's coastal zone. Division of Environmental Programs, Bureau of Coastal Zone Planning. Tallahassee.

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.

Gagliano, S.M., and 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.

Gosselink, J.G., C.L. Cordes, and J.W. Parsons. 1979. An ecological characterization study of the Chenier Plain coastal ecosystem of Louisiana and Texas. 3 vols. U.S. Fish and Wildlife Service, Office of Biological Services. FWS/OBS-78/9-78/11. Washington, D.C.

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, N.Y., N.Y.

Hunt, C.B., 1974. Natural Regions of the United States and Canada. San Francisco, CA: W.H. Freeman & Co., 725pp.

Kadlec, R.H., and J.A. Kadlec. 1979. Wetlands and water quality. In: Wetland functions and values: The state of our understanding. ed. P.E. Greeson, J.R. \Clark, and J.E. Clark. Minneapolis, MN: American Resources Association.

Knutson, P.L., and W.N. Selig. 1982. Wave damping in Spartina alterniflora marshes. In:

Third Annual Meting of Wetland Scientists. Wrightsville Beach, NC.

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.

Mager, A., Jr. and G.W. Thayer. 1986. National Marine Fisheries Service habitat conservation efforts in the southeast region of the United States from 1981 through 1985. Marine Fisheries Review 48(3):1-8.

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.

McHugh, J.L. 1966. Management of estuarine fisheries. American Fisheries Society Special Publication no. 3:133-154. Washington, DC: American Fisheries Society.

National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1981. Fisheries of the United States, 1980. Current fishery statistics No. 8100. Washington, DC: U.S. Government Printing Office.

National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 1983. Fisheries of the United States, 1982. Current Fisheries Statistics. Washington, DC: U.S. Government Printing Office. 117 pp.

National Oceanic and Atmospheric Administration. 1985. National estuarine inventory data atlas, volume 1: physical and hydrologic characteristics. Rockville, MD, Office of Oceanography and Marine Assessment, Strategic Assessment Branch, 103 p.

National Oceanic and Atmospheric Administration. 1986. National estuarine inventory data atlas, volume 2: land use characteristics. Rockville, MD, Office of Oceanography and Marine Assessment, Strategic Assessment Branch, 40 pp.

National Oceanic and Atmospheric Administration. 1986. Summary of proceedings: NOAA coastalwetlandsworkshop. Rockville, MD, Office of Oceanography and Marine Assessment, Strategic Assessment Branch, 11 pp. (mimeo).

National Oceanic and Atmospheric Administration. 1990. 50 years of population change along the nation's coasts, 1960-2010. Rockville, MD, Office of Oceanography and Marine Assessment, Strategic Assessment Branch, 41pp.

Orlando, S.P., F. Shirzad, J.M. Schuerholz,, D.P. Mathieux, and S. Strassner. 1988. Shoreline modification, dredged channels, and dredged material disposal areas in the nation's estuaries. Strategic Assessment Branch, Rockville, MD, National Oceanic and Atmospheric Administration, 19 p. (mimeo).

Pritchard, D.W., 1967. What is an estuary: Physical viewpoint. In Estuaries, ed. G.H. Lauff. Publication 83. Washington, D.C.: American Association for the Advancement of Science.

Sather, J.H., and R.D. Smith. 1984. An overview of major wetland values and functions. U.S. Fish and Wildlife Service. FWS/OBS-84/18. Washington, DC: U.S. Government Printing Office.

Shaw, S.P., and C.G. Fredine. 1956. Wetlands of the United States: Their extent and their value to waterfowl and other wildlife. U.S. Fish and Wildlife service, Circular no. 39. Washington, DC: U.S. Government Printing Office. 67 pp.

Tchobanoglous, G., and G.L. Culp. 1980. Wetland systems of wastewater treatment: An engineering assessment. University of California. Davis.

Terrell, T.T. 1979. Physical regionalization of coastal ecosystems of the United States and its territories. U.S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-78/80. 30 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.

Tiner, R.W., Jr. 1985. Wetlands of New Jersey. U.S. Fish and Wildlife Service, National Wetlands Inventory, Newton Corner, MA. 117pp.

Tiner, R.W., Jr. 1987. Mid - Atlantic Wetlands; A Disappearing National Treasure. U.S. Fish and Wildlife Service, National Wetland Inventory, Newton Corner, MA. and Environmental Protection Agency, Philadelphia,PA., Cooperative Paper. 28 pp.

Appendix

I. Initial Steps Toward Developing the National Coastal Wetlands Database

II. National Estuarine Inventory

III. Coastal Wetland Acreages by County and Estuarine Drainage Area

IV. Coastal Wetlands Classification for the Mid - Atlantic Region

V. Accuracy and Precision of Grid Sampled Estimates

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

Appendix I.

Initial Steps Toward Developing the National Coastal Wetlands Inventory

First Steps. As a first step in establishing a coastal wetlands data base, NOAA examined and compiled existing data on the areal extent and distribution of coastal wetlands. Twenty-three sources were consulted to compile acreage figures for 242 counties in 22 coastal states (Alexander et al., 1986). These data indicated the presence of over 11 million acres of wetlands along the coastline of the conterminous USA. Approximately five million acres were identified as swamp, 4.4 million acres as salt marsh, 1.5 million acres as fresh marsh, and 0.2 million acres as tidal flats. The Gulf of Mexico had the most wetlands (5.2 million acres), followed by the Southeast (4.2 million acres), the Northeast (1.7 million acres), and the West Coast (0.2 million acres). Detailed information on data sources and a complete table of wetland types and acreages by coastal county are presented in two appendices to the inventory.

Existing data for the Mid-Atlantic region included published data for wetlands in New York (NY Dept. of Env. Conserv., 1974), Pennsylvania (Walton and Patrick, 1973; Wicker,1980), New Jersey (Tiner, 1985), Delaware (FWS, 1984a), Maryland (McCormick and Somes, 1982), Delaware, Maryland, Virginia, and Pennsylvania (Tiner, 1987), and a number of reports for Virginia.

While the compilation and evaluation of existing data were necessary first steps in establishing a national coastal wetland data base, much of the existing information is incomplete or outdated. Variability in data quality and consistency, and lack of a unifying theme or purpose, also contributed to the difficulty of consolidating 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.

Some investigators have successfully used multispectral scanner and thematic mapper Landsat satellite imagery to inventory wetland habitats (May, 1986; Haddad and Harris, 1985). However, these techniques are beyond the resources of the project. A more realistic alternative was to exploit a heretofore under - utilized source of wetland information, the National Wetland Inventory (NWI) mapping program of the U.S. Fish and Wildlife Service.

Evaluating Grid Sampling. 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). To test this procedure, a simple grid sampling technique was used to quantify habitat types for 16 previously digitized 1:24,000-scale NWI maps. For purposes of the preliminary tests, the numerous habitat types designated on the NWI maps were aggregated into six general habitat categories: 1) salt marsh, 2) fresh marsh, 3) tidal flats, 4) swamp, 5) open water, and 6) uplands. After some testing, a 45-acre grid cell size was determined to be both efficient and accurate for estimating these six habitat types at this scale. Each map was sampled separately by mounting a mylar grid sheet over the map and systematically recording the habitat type at each sampling point. The sampling took approximately one hour. Based on the results, it appeared that grid sampling could provide a time- and cost-effective technique for compiling a reasonably accurate coastal wetlands data base. Further comparisons of FWS digital data to grid sampled data for other areas in the Mid - Atlantic are presented in Appendix III.

NOAA's Coastal Wetlands Workshop. Before embarking on a national grid sampling effort, NOS and NMFS organized a workshop bringing together individuals with experience in wetlands mapping and management to discuss NOAA's proposal to compile a national coastal wetlands data base. Sixteen professionals from six Federal organizations participated: U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, U.S. Geological Survey, U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the National Ocean Service. Specific objectives of the workshop were to review current information on the distribution and extent of coastal wetlands and to solicit comments and recommendations from the workshop participants on NOAA's proposed grid sampling project.

In general, workshop participants supported NOAA's proposal to grid sample NWI maps

(NOAA, 1986). Participants suggested, however, that the technique be modified to improve the quality and usefulness of the data being developed. Two key recommendations were proposed:

> 1) Expand the number of habitat types recorded. Participants felt that the six habitat types identified in the preliminary tests were inadequate and suggested a list of 11 habitat categories (Table 1). Since the workshop, a total of 15 habitats have been incorporated into the project.
>
> 2) Conduct a more complete statistical evaluation of the grid sampling procedure.

These recommendations were examined by NOAA and incorporated into the operational phase of the project. The current grid sampling technique is explained in detail in the Procedure section of the report.

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

Salt Marsh
Brackish
High
Low
Unspecified [a]
Fresh Marsh
Nontidal
Tidal
Unspecified [a]
Forested and Scrub-Shrub
Estuarine
Nontidal fresh
Tidal fresh
Unspecified fresh [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.

Appendix II.

National Estuarine Inventory

The Program. The cornerstone of the National Estuarine Inventory (NEI) is the *National Estuarine Inventory Data Atlas*. Volume I, completed in 1985, identifies 92 of the most important estuaries of the contiguous USA and presents information through maps and tables on physical and hydrologic characteristics of each estuary. These estuaries represent approximately 90 percent of the estuarine water surface area and 90 percent of the freshwater inflow to estuaries of the East Coast, West Coast, and Gulf of Mexico. Volume II, *Land Use*, presents area estimates for seven categories and 24 subcategories of land use as well as 1970 and 1980 population estimates. Land use estmates are based on data from the Land Use and Land Cover Program of USGS and are compiled for three spatial units: (1) the estuarine drainage area (EDA); (2) U.S. Geological Survey hydrologic cataloging units; and (3) counties that intersect EDAs. Population estimates are compiled for EDAs only (NOAA, 1986). Volume III, *Coastal Wetlands of the New England Region* (1989) presents wetlands acreage estimates for 12 wetland types in 16 estuaries and 42 counties from Maine to Connecticut. Computer generated color maps of selected regions are also presented. Volume IV, *Public Recreation Facilities in Coastal Areas* (1989), presents data for federal, state, and locally-owned recreation facilities in 327 counties that border tidally influenced water and 25 estuary groups. A total of 1,589 public agencies that owned and/or managed outdoor recreation sites and facilities in coastal areas provided data for the inventory. The NEI represents the most consistent and complete set of data ever developed for the Nation's estuarine resource base.

The goal of the NEI 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. The principal spatial unit for which all data are organized is the "estuarine drainage area," or EDA, which is defined as "that land and water component of an entire watershed that most directly affects an estuary" (NOAA, 1985). The boundaries for each EDA were drawn to coincide, where possible, with those U.S. Geological Survey (USGS) Hydrologic Cataloging Units (CU) within which the head of tide of an estuary fell. These data will be used to make comparisons, rankings, statistical correlations, and other analyses related to resource use, environmental quality, and economic values among estuaries.

The data base and assessment capability under development for the NEI are part of a dynamic and evolving process. Other estuaries and subestuaries have been added to the NEI from around the country. Refinements are being made to physical and hydrologic data estimated in Volume 1. Attributes such as volume and flushing rates have been added to the data base. Other NOAA projects whose data and information will be included in the NEI are: the distribution of estuarine-dependent living marine resources, the quality of shellfish growing waters and related projects, the National Coastal Pollutant Discharge Inventory; and the Inventory of Outdoor Coastal Recreation Facilities.

Additional Estuarine Assessment Activities. A number of additional NEI activities are now underway or planned. Based on the review of Volume 1 by estuarine scientists and state and Federal resource managers, several areas for improvement in future editions have been identified. For example, a number of recommendations have been made to add new estuaries to the NEI based on local or regional importance. Complete physical and hydrologic data for eight estuaries in Oregon have been summarized as the first in a series of supplements to volume one. These systems have been added because of their biological importance to coastal fishery resources. A limited number of additions on the rest of the West Coast, the East Coast, and in the Gulf of Mexico are also planned.

Another recommendation has been to improve the resolution of the salinity regimes mapped for each estuary. A preliminary study was performed in Mobile Bay, AL, to see if bottom and surface salinities could be mapped in zones of five parts per thousand increments for periods of high and low flow. The successful completion of the Mobile Bay study, and further investigations into the availability of salinity data throughout the Gulf of Mexico, indicated that compiling more detailed salinity data would be possible. An effort to compile data for all 23 EDAs on the Gulf Coast was begun in the fall of 1988. This more detailed depiction of estuarine salinity will characterize more adequately the effects of freshwater inflow, tides, and wind on the stability of salinity patterns, and the distribution of pollutants, than the three average annual salinity zones in Volume I of the NEI.

A project that focuses on the agricultural use of 28 selected pesticides on 71 crops in 78 EDAs was initiated in 1987 and was completed in the fall of 1989. Future volumes on additional topics are also planned. For example, a project to determine the distribution and abundance of fishes and invertebrates in estuaries was begun in 1985. To date, information has been compiled on 80 species in 60 estuaries on the West, Gulf of Mexico, and Southeast coasts.

Appendix III.

Table 1. Coastal wetlands by state and county (Acres x 100)

State / County	Wetlands																Non-Wetlands				
	Salt Marsh					Fresh Marsh				Forested & Scrub - Shrub											
	Brack.	High	Low	Unsp.	Subtotal	Non-Tidal	Tidal	Unsp.	Subtotal	Est.	Fresh (Unsp.)	Non-Tidal Fresh	Tidal Fresh	Subtotal	Tidal Flats	Total Wetlands	O-W Fresh	O-W Non-Fresh(	Upland	Subtotal	Total Acreage
New York [a]																					
Bronx (100)	0	0	0	2	2 (49)[b]	0	0	0	0 (0)	0	0	1	0	1 (37)	<1 (14)	4 (1)[c]	1	84	266	351	355
Columbia (13)	0	0	0	0	0 (0)	0	0	0	0 (0)	0	16	1	0	17 (100)	0 (0)	17 (3)	1	0	538	539	556
Dutchess (17)	0	0	0	0	0 (0)	0	0	0	0 (0)	0	<1	<1	0	1 (100)	0 (0)	1 (<1)	1	0	899	900	900
Kings (100)	0	0	0	9	9 (21)	1	0	0	1 (2)	0	0	0	0	0 (0)	32 (77)	42 (7)	2	90	434	526	568
Nassau (100)	0	0	0	99	99 (66)	2	0	0	2 (1)	0	0	14	0	14 (9)	36 (24)	151 (7)	14	235	1,706	1,955	2,106
New York (100)	0	0	0	0	0 (0)	0	0	0	0 (0)	0	0	0	0	0 (0)	0 (0)	0 (0)	1	63	151	215	215
Orange (80)	0	0	0	0	0 (0)	0	0	34	34 (17)	0	163	0	0	163 (83)	0 (0)	197 (5)	90	14	3,936	4,040	4,237
Putnam (12)	0	0	0	0	0 (0)	1	0	0	1 (9)	0	0	14	0	14 (91)	0 (0)	15 (9)	4	0	159	163	178
Queen (100)	0	0	0	22	22 (49)	2	0	0	2 (5)	0	0	<1	0	<1 (1)	20 (45)	44 (6)	3	95	670	768	812
Rensselaer (8)	0	0	0	0	0 (0)	<1	0	0	<1 (14)	0	<1	2	0	2 (10)	0 (0)	3 (1)	1	0	357	358	361
Richmond (100)	0	0	0	9	9 (29)	0	0	5	5 (17)	0	3	0	0	3 (87)	14 (44)	31 (8)	2	40	345	387	418
Rockland (100)	0	0	0	5	5 (8)	0	0	4	4 (6)	0	52	0	0	52 (70)	0 (0)	61 (5)	34	121	1,010	1,165	1,226
Suffolk (100)	<1	0	0	147	147 (29)	6	0	0	6 (1)	3	0	68	1	72 (14)	284 (56)	510 (7)	46	1,125	5,330	6,501	7,011
Sullivan (<1)	0	0	0	0	0 (0)	0	0	0	0 (0)	0	0	0	0	0 (0)	0 (0)	0 (0)	<1	0	11	12	12
Westchester (53)	0	0	0	3	3 (18)	4	0	0	4 (25)	<1	0	4	0	4 (27)	5 (30)	16 (1)	50	163	1,340	1,553	1,569
SUBTOTAL	<1	0	0	295	295 (27)	16	0	43	59 (5)	3	236	105	1	345 (32)	392 (36)	1,092 (5)	250	2,030	17,152	19,433	20,525
New Jersey																					
Atlantic (100)	2	0	0	437	439 (33)	0	<1	14	14 (1)	0	692	<1	<1	693 (53)	168 (13)	1,314 (37)	16	157	2,064	2,237	3,551
Bergen (100)	0	0	0	31	31 (35)	<1	0	5	6 (6)	0	45	4	0	49 (54)	5 (5)	91 (6)	32	51	1,411	1,495	1,586
Burlington (100)	1	0	0	73	74 (6)	0	17	53	70 (5)	0	1,154	1	1	1,156 (89)	2 (<1)	1,302 (25)	75	18	3,804	3,896	5,198
Camden (100)	0	0	0	0	0 (0)	0	3	4	7 (4)	0	189	0	2	191 (96)	0 (0)	198 (14)	40	0	1,220	1,259	1,457
Cape May (100)	1	0	0	332	333 (47)	0	0	17	17 (2)	2	258	0	<1	260 (37)	94 (13)	704 (45)	12	76	782	870	1,574
Cumberland (100)	16	0	0	460	476 (55)	0	0	7	7 (1)	1	359	11	0	371 (39)	9 (1)	863 (26)	39	91	2,246	2,377	3,240
Essex (100)	0	0	0	<1	<1 (<1)	0	0	6	6 (9)	0	63	0	0	63 (91)	0 (0)	70 (8)	8	12	745	765	835
Gloucester (100)	0	0	0	5	5 (1)	1	17	22	40 (12)	0	293	1	0	294 (86)	3 (1)	342 (16)	71	9	1,741	1,820	2,162
Hudson (100)	0	0	0	23	23 (65)	0	0	1	1 (2)	0	0	0	0	0 (0)	11 (32)	35 (10)	0	92	247	339	374
Hunterdon (96)	0	0	0	0	0 (0)	1	0	3	4 (8)	0	36	6	0	42 (92)	0 (0)	46 (2)	52	0	2,627	2,679	2,725
Mercer (100)	0	0	0	0	0 (0)	<1	4	8	12 (9)	0	118	3	0	121 (91)	0 (0)	133 (9)	23	0	1,314	1,338	1,470
Middlesex (100)	<1	0	0	45	46 (20)	1	0	12	13 (6)	<1	133	17	0	150 (68)	14 (6)	223 (11)	17	27	1,793	1,837	2,060
Monmouth (100)	1	0	0	19	20 (7)	0	<1	9	10 (3)	1	206	2	0	209 (73)	46 (16)	285 (9)	22	55	2,716	2,793	3,078
Morris (100)	0	0	0	0	0 (0)	0	0	23	23 (6)	0	356	0	0	356 (94)	0 (0)	379 (13)	80	0	2,513	2,593	2,972
Ocean (100)	0	0	0	260	260 (21)	<1	0	8	8 (<1)	4	681	0	0	685 (56)	270 (22)	1,223 (26)	26	404	3,025	3,455	4,678
Passaic (100)	0	0	0	0	0 (0)	0	0	1	1 (4)	0	37	0	0	37 (96)	0 (0)	38 (4)	67	0	923	990	1,028
Salem (100)	27	0	0	199	226 (43)	15	1	7	23 (5)	<1	197	59	1	258 (49)	15 (3)	522 (23)	27	65	1,619	1,712	2,234
Somerset (100)	0	0	0	0	0 (0)	0	0	14	14 (14)	0	88	0	0	88 (86)	0 (0)	102 (5)	8	0	1,847	1,854	1,956
Sussex (67)	0	0	0	0	0 (0)	0	0	38	38 (16)	0	199	0	0	199 (84)	0 (0)	237 (10)	63	0	1,847	2,134	2,371
Union (100)	0	0	0	3	3 (9)	0	0	2	2 (5)	0	25	0	0	25 (75)	4 (11)	34 (5)	5	9	2,071	648	682
Warren (38)	0	0	0	0	0 (0)	<1	0	8	9 (20)	0	36	0	0	36 (80)	0 (0)	45 (5)	5	0	633	845	890
SUBTOTAL	48	0	0	1,887	1,936 (24)	20	43	262	325 (4)	9	5,165	104	5	5,283 (65)	641 (8)	8,186 (18)	688	1,067	36,182	37,938	46,123
Pennsylvania																					
Berks (8)	0	0	0	0	0 (0)	2	0	0	2 (42)	0	0	2	0	2 (58)	0 (0)	4 (1)	5	0	452	457	461
Bucks (76)	0	0	0	0	0 (0)	6	1	2	8 (10)	0	40	37	0	77 (90)	0 (0)	86 (3)	109	0	2,837	2,946	3,032
Chester (73)	0	0	0	0	0 (0)	17	0	0	17 (28)	0	0	45	0	45 (72)	0 (0)	62 (2)	41	0	3,417	3,458	3,520
Delaware (94)	0	0	0	0	0 (0)	6	3	3	12 (62)	0	1	7	0	7 (55)	<1 (3)	20 (2)	46	7	1,154	1,207	1,227
Lancaster (10)	0	0	0	0	0 (0)	1	0	0	1 (32)	0	0	3	0	3 (68)	0 (0)	4 (1)	5	0	645	650	654
Montgomery (42)	0	0	0	0	0 (0)	1	0	0	1 (5)	0	0	18	0	18 (95)	0 (0)	19 (1)	9	0	1,295	1,304	1,323
Philadelphia (73)	0	0	0	0	0 (0)	1	0	5	6 (74)	0	2	0	0	2 (23)	0 (0)	8 (1)	44	0	609	653	661
York (8)	0	0	0	0	0 (0)	0	0	0	0 (0)	0	0	1	0	1 (100)	0 (0)	1 (<1)	5	0	440	445	446
SUBTOTAL	0	0	0	0	0 (0)	34	4	10	48 (24)	0	43	112	0	155 (76)	<1 (<1)	204 (2)	264	7	10,849	11,120	11,324
Delaware																					
Kent (100)	10	0	0	476	486 (49)	28	<1	0	28 (3)	5	1	443	12	461 (47)	6 (1)	982 (25)	35	61	2,919	3,016	3,998
New Castle (100)	21	0	0	140	161 (54)	26	7	0	33 (11)	<1	<1	85	<1	86 (29)	19 (6)	299 (10)	33	225	2,431	2,689	2,988
Sussex (100)	19	0	0	201	220 (23)	16	17	2	35 (4)	7	0	648	37	692 (72)	18 (2)	964 (15)	54	228	5,055	5,337	6,301
SUBTOTAL	50	0	0	817	867 (39)	70	24	2	96 (4)	12	2	1176	50	1,240 (55)	43 (2)	2,245 (17)	122	514	10,405	11,041	13,286
District of Columbia																					
Dist. of Columbia (100)	0	0	0	0	0 (0)	1	<1	0	2 (67)	0	0	1	0	1 (33)	0 (0)	3 (<1)	44	0	470	514	517
SUBTOTAL	0	0	0	0	0 (0)	1	<1	0	2 (67)	0	0	1	0	1 (33)	0 (0)	3 (<1)	44	0	470	514	517

Abbreviations: Brack., Brackish; Unsp., Unspecified; Est., Estuarine; O-W, Open Water

[a] Values in parentheses represent the percent of county grid sampled by NOAA. Areas with less than 100 percent coverage may or may not be completely mapped by the U.S. Fish and Wildlife Service,
[b] Values in parentheses represent the percent of total wetlands grid sampled by NOAA.
[c] Values in parentheses represent the percent of total county area grid sampled by NOAA.

Appendix III.

Table 1. Coastal wetlands by state and county (Acres x 100) continued.

State / County	Wetlands: Salt Marsh: Brack.	High	Low	Unsp.	Subtotal	Fresh Marsh: Non-Tidal	Tidal	Unsp.	Subtotal	Forested & Scrub - Shrub: Est.	Fresh (Unsp.)	Non-Tidal Fresh	Tidal Fresh	Subtotal	Tidal Flats	Total Wetlands	Non-Wetlands: O-W Fresh	O-W Non-Fresh	Upland	Subtotal	Total Acreage
Maryland																					
Anne Arundel (100)[a]	2	0	0	19	21 (13)[b]	4	4	0	8 (5)	0	0	118	6	124 (77)	8 (5)	161 (6)[c]	17	237	2,480	2,734	2,895
Baltimore (100)	1	0	0	18	19 (39)	7	0	0	7 (15)	0	0	17	2	19 (42)	2 (4)	47 (1)	67	165	3,658	3,890	3,937
Calvert (100)	19	0	0	15	34 (28)0	2	0	0	2 (2)	0	0	54	5	59 (50)	23 (20)	118 (8)	4	149	1,265	1,418	1,536
Caroline (100)	24	0	0	0	24 (8)	6	3	0	9 (3)	0	0	258	12	270 (88)	3 (1)	306 (15)	17	23	1,751	1,791	2,097
Carroll (67)	0	0	0	0	0 (0)	6	0	0	6 (28)	0	0	16	0	16 (72)	0 (0)	22 (1)	28	0	1,895	1,923	1,945
Cecil (100)	16	0	0	2	18 (24)	7	5	3	16 (21)	0	0	34	3	37 (48)	1 (7)	72 (3)	41	152	2,032	2,225	2,297
Charles (100)	18	0	0	29	47 (19)	4	1	0	5 (2)	2	0	156	14	172 (71)	20 (8)	244 (8)	55	107	2,718	2,881	3,125
Dorchester (100)	14	0	0	782	796 (51)	8	13	0	21 (1)	26	0	530	133	689 (44)	58 (4)	1,564 (37)	23	607	1,995	2,624	4,189
Frederick (10)	0	0	0	0	0 (0)	3	0	0	3 (34)	0	0	6	0	6 (66)	0 (0)	9 (2)	0	0	411	411	420
Harford (100)	3	0	0	64	67 (55)	4	0	0	4 (3)	0	0	46	5	51 (41)	<1 (<1)	120 (5)	25	131	2,307	2,463	2,583
Howard(100)	0	0	0	1	1 (3)	2	0	0	2 (8)	0	0	25	0	25 (89)	0 (0)	30 (2)	17	0	1,578	1,594	1,623
Kent (100)	4	0	0	31	35 (25)	4	0	0	4 (3)	0	0	99	<1	100 (69)	5 (3)	149 (7)	21	162	1,620	1,803	1,952
Montgomery (74)	0	0	0	2	2 (3)	9	0	0	9 (15)	0	0	49	0	49 (82)	0 (0)	60 (2)	56	0	2,300	2,355	2,415
Prince George (100)	17	0	0	1	18 (10)	9	5	0	14 (8)	0	0	136	11	147 (82)	0 (0)	179 (6)	67	20	2,868	2,955	3,134
Queen Annes (100)	5	0	0	37	42 (14)	5	0	0	5 (2)	1	0	224	3	228 (78)	18 (6)	293 (11)	9	177	2,081	2,267	2,560
St. Mary (100)	2	0	0	29	31 (23)	2	0	0	2 (2)	0	0	36	4	40 (29)	63 (47)	136 (5)	5	257	2,224	2,486	2,622
Somerset (100)	4	0	0	543	547 (68)	8	0	<1	8 (1)	13	0	172	9	194 (24)	56 (7)	805 (33)	4	265	1,334	1,603	2,408
Talbot (100)	23	0	0	23	46 (30)	2	4	0	6 (4)	0	0	71	7	78 (50)	24 (15)	154 (8)	11	305	1,468	1,785	1,939
Wicomico (100)	11	0	0	122	133 (36)	6	6	0	12 (3)	2	0	196	19	217 (59)	5 (1)	367 (15)	18	98	2,045	2,161	2,528
Worcester (100)	0	0	0	161	161 (29) 0	9	1	0	10 (2)0	5	0	318	51	374 (67)	11 (2)	556 (16)	15	646	2,284	2,946	3,502
Baltimore (100)	0	0	0	<1	<1 (20)	0	0	0	0 (0)	0	0	<1	0	<1 (35)	1 (45)	2 (0)	2	70	506	578	580
SUBTOTAL	163	0	0	1,879	2,042 (38)	112	42	4	158 (3)	49	0	2,563	284	2,896 (54)	299 (6)	5,394 (11)	502	3,572	40,820	44,894	50,288
Virginia																					
Acomack (100)	0	0	0	704	704 (66)	1	1	0	2 (<1)	37	0	21	16	74 (7)	280 (27)	1,060 (26)	5	666	2,423	3,094	4,154
Albemarle (10)	0	0	0	<1	<1 (6)	<1	0	0	<1 (6)	2	0	5	0	6 (88)	0 (0)	8 (2)	3	0	473	476	484
Amelia (100)	0	0	0	0	0 (0)	15	0	0	15 (12)	0	0	111	0	111 (88)	0 (0)	126 (6)	13	0	2,164	2,177	2,303
Appomattox (55)	0	0	0	0	0 (0)	2	0	0	2 (12)	0	0	13	0	13 (88)	0 (0)	15 (1)	5	0	1,161	1,166	1,181
Brunswick (<1)	0	0	0	0	0 (0)	0	0	0	0 (0)	0	0	0	0	0 (0)	0 (0)	0 (0)	1	0	7	8	8
Buckingham (74)	0	0	0	0	0 (0)	6	0	0	6 (11)	0	0	49	0	49 (89)	0 (0)	55 (2)	16	<1	2,673	2,690	2,745
Caroline (100)	0	0	0	0	0 (0)	10	2	0	12 (6)	0	0	197	13	210 (94)	0 (0)	222 (6)	57	0	3,195	3,252	3,474
Charles City (100)	0	0	0	0	0 (0)	2	34	0	36 (36)	0	0	48	18	66 (64)	0 (0)	102 (8)	139	0	1,066	1,205	1,307
Charlotte (27)	0	0	0	0	0 (0)	4	0	0	4 (9)	0	0	38	0	38 (91)	0 (0)	42 (5)	6	0	759	765	807
Chesterfield (100)	0	0	0	0	0 (0)	3	11	0	14 (14)	0	0	62	22	84 (86)	0 (0)	98 (4)	92	0	2,578	2,670	2,768
Culpeper (17)	0	0	0	0	0 (0)	<1	0	0	<1 (20)	0	0	2	0	2 (80)	0 (0)	2 (1)	5	0	410	415	417
Cumberland (100)	0	0	0	0	0 (0)	13	0	0	13 (12)	0	0	98	0	98 (88)	0 (0)	111 (6)	18	0	1,805	1,823	1,934
Dinwiddie (75)	0	0	0	0	0 (0)	2	0	0	2 (3)	0	0	81	0	81 (97)	0 (0)	83 (4)	26	0	2,266	2,292	2,375
Essex (100)	<1	0	0	45	46 (33)	5	5	0	10 (7)	<1	0	66	14	80 (59)	<1 (<1)	136 (8)	41	82	1,515	1,638	1,774
Fairfax (100)	0	0	0	0	0 (0)	6	0	0	6 (25)	0	0	16	3	19 (76)	0 (0)	25 (1)	67	1	2,517	2,585	2,610
Fauquier (67)	0	0	0	0	0 (0)	5	0	0	5 (25)	0	0	17	0	17 (78)	0 (0)	22 (1)	21	0	2,828	2,849	2,871
Fluvanna (47)	0	0	0	0	0 (0)	1	0	0	1 (5)	0	0	18	0	18 (95)	0 (0)	2 (2)	13	0	847	860	879
Gloucester (100)	0	0	0	59	59 (48)	1	0	0	1 (2)	1	0	35	9	45 (37)	16 (13)	122 (8)	6	205	1,292	1,503	1,624
Goochland (100)	0	0	0	0	0 (0)	2	0	0	2 (4)	0	0	54	0	54 (96)	0 (0)	57 (3)	26	0	1,772	1,798	1,854
Greene (6)	0	0	0	0	0 (0)	0	0	0	0 (0)	<1	0	0	0	<1 (100)	0 (0)	1 (1)	<1	0	55	56	57
Hanover (100)	0	0	0	0	0 (0)	3	0	0	3 (3)	0	0	119	2	121 (97)	0 (0)	125 (4)	19	0	2,914	2,933	3,057
Henrico (100)	0	0	0	0	0 (0)	1	2	0	3 (6)	0	<1	58	<1	59 (94)	0 (0)	62 (4)	23	0	1,445	1,468	1,530
Isle of Wight (100)	0	0	0	56	56 (33)	1	<1	0	2 (<1)	<1	0	105	1	106 (62)	6 (4)	170 (7)	18	269	1,855	2,142	2,312
James City (100)	0	0	0	13	13 (12)	1	53	0	54 (51)	0	0	25	11	36 (33)	3 (3)	107 (9)	126	104	836	1,066	1,172
King and Queen (100)	0	0	0	31	31 (21)	2	12	0	14 (10)	0	0	96	8	104 (69)	1 (<1)	151 (7)	20	45	1,885	1,950	2,100
King George (94)	3	0	0	7	10 (16)	4	6	0	10 (18)	0	0	24	14	38 (61)	5 (1)	5 (1)	29	19	1,020	1,068	1,131
King William (100)	0	0	0	30	30 (18)	4	23	0	27 (16)	0	0	72	36	108 (65)	<1 (<1)	165 (9)	53	18	1,606	1,677	1,843
Lancaster (100)	0	0	0	11	11 (29)	1	0	0	1 (2)	0	0	13	0	13 (94)	14 (35)	39 (4)	4	93	822	919	958
Loudon (28)	0	0	0	0	0 (0)	3	0	0	3 (17)	0	0	15	0	15 (83)	0 (0)	18 (2)	4	0	952	957	975
Louisa (100)	0	0	0	0	0 (0)	4	0	0	4 (4)	0	0	98	0	98 (960	0 (0)	101 (30	91	0	3,080	3,172	3,273
Lunenburg (100)	0	0	0	0	0 (0)	2	0	0	2 (8)	0	0	22	0	22 (92)	0 (0)	23 (4)	1	0	516	517	540
Mathews (100)	0	0	0	24	24 (47)	0	0	0	0 (0)	0	0	6	3	9 (18)	18 (35)	51 (8)	1	114	491	606	657
Middlesex (100)	0	0	0	12	12 (21)	0	1	0	2 (3)	0	0	30	6	36 (61)	9 (15)	58 (6)	3	72	774	8,494	908
New Kent (100)	0	0	0	21	21 (14)	5	25	0	31 (20)	0	0	67	37	104 (66)	1 (<1)	157 (11)	58	30	1,191	1,279	1,435
Northampton (94)	0	0	0	362	362 (37)	<1	0	0	<1 (<1)	13	0	2	3	18 (2)	599 (61)	980 (44)	5	300	927	1,232	2,212
Northumberland (96)	0	0	0	8	8 (18)	0	0	0	0 (0)	2	0	13	2	17 (38)	20 (45)	45 (3)	3	131	1,166	1,300	1,345
Nottoway (100)	0	0	0	0	0 (0)	11	0	0	11 (15)	0	0	63	0	63 (86)	0 (0)	74 (4)	13	0	1,773	1,786	1,860
Orange (100)	0	0	0	0	0 (0)	3	0	0	3 (16)	0	0	17	0	17 (84)	0 (0)	20 (1)	18	0	2,099	2,117	2,136

Abbreviations: Brack., Brackish; Unsp., Unspecified; Est., Estuarine; O-W, Open Water

[a] Values in parentheses represent the percent of county grid sampled by NOAA. Areas with less than 100 percent coverage may or may not be completely mapped by the U.S. Fish and Wildlife Service.
[b] Values in parentheses represent the percent of total wetlands grid sampled by NOAA.
[c] Values in parentheses represent the percent of total county area grid sampled by NOAA.

Appendix III.

Table 1. Coastal wetlands by state and county (Acres x 100) continued.

State / County	Wetlands																Non-Wetlands				
	Salt Marsh					Fresh Marsh				Forested & Scrub - Shrub											
	Brack.	High	Low	Unsp.	Subtotal	Non-Tidal	Tidal	Unsp.	Subtotal	Est.	Fresh (Unsp.)	Non-Tidal Fresh	Tidal Fresh	Subtotal	Tidal Flats	Total Wetlands	O-W Fresh	O-W Non-Fresh	Upland	Subtotal	Total Acreage
Virginia (continued)																					
Powatan (100) [a]	0	0	0	0	0 (0) [b]	2	0	0	2 (13)	0	0	12	0	12 (87)	0 (0)	14 (7) [c]	9	0	185	194	208
Prince Edward (100)	0	0	0	0	0 (0)	16	0	0	16 (13)	0	0	110	0	110 (87)	0 (0)	126 (6)	9	0	2,153	2,162	2,288
Prince George (100)	0	0	0	0	0 (0)	1	11	0	12 (13)	0	0	61	18	79 (87)	0 (0)	91 (5)	102	0	1,580	1,682	1,773
Prince William (37)	0	0	0	4	4 (13)	3	0	0	3 (12)	0	0	14	6	20 (73)	<1 (2)	28 (1)	33	9	2,233	2,275	2,302
Richmond (100)	0	0	0	47	47 (51)	1	<1	0	2 (2)	0	0	39	5	44 (47)	0 (0)	92 (7)	7	87	1,133	1,227	1,319
Southampton (100)	0	0	0	0	0 (0)	0	0	0	0 (0)	0	0	162	0	162 (100)	0 (0)	162 (12)	12	0	1,235	1,247	1,410
Spotsylvania (24)	0	0	0	0	0 (0)	2	0	0	2 (3)	0	0	65	1	66 (97)	0 (0)	68 (3)	77	0	2,544	2,621	2,684
Stafford (100)	7	0	0	0	7 (13)	0	1	0	2 (3)	0	0	39	6	45 (83)	0 (0)	54 (5)	24	37	1,669	1,730	1,784
Surry (100)	0	0	0	4	4 (3)	1	12	0	13 (10)	0	<1	100	12	112 (86)	2 (1)	131 (7)	136	57	1,653	1,847	1,978
Sussex (100)	0	0	0	0	0 (0)	<1	0	0	<1 (1)	0	0	41	0	41 (99)	0 (0)	42 (6)	3	0	683	686	727
Westmoreland (<1)	0	0	0	8	8 (10)	1	1	0	2 (4)	3	0	23	3	29 (38)	36 (48)	76 (6)	18	61	1,223	1,303	1,379
York (100)	0	0	0	24	24 (45)	1	0	0	1 (2)	1	0	17	4	21 (40)	7 (14)	54 (7)	16	120	617	753	807
Chesapeake (100)	0	0	0	16	16 (2)	2	0	0	2 (<1)	0	0	712	93	805 (98)	1 (<1)	824 (36)	42	82	1,341	1,465	2,289
Hampton (100)	0	0	0	19	19 (61)	0	0	0	0 (0)	5	0	4	1	10 (32)	2 (7)	32 (7)	2	98	299	399	430
Newport News (<1)	0	0	0	28	28 (61)	0	<1	0	<1 (1)	0	0	7	2	9 (21)	8 (18)	46 (6)	7	323	389	719	765
Norfolk (<1)	0	0	0	4	4 (55)	0	0	0	0 (0)	<1	0	0	1	1 (21)	2 (24)	7 (2)	5	67	318	390	396
Portsmouth (100)	0	0	0	1	1 (45)	0	0	0	0 (0)	0	0	0	<1	<1 (14)	1 (41)	3 (2)	1	25	157	183	186
Richmond (100)	0	0	0	0	0 (0)	0	0	0	0 (0)	0	0	1	0	1 (100)	0 (0)	1 (<1)	15	0	386	401	402
Suffolk (100)	0	0	0	39	39 (8)	<1	<1	0	1 (<1)	0	0	449	1	450 (91)	4 (1)	495 (27)	28	33	1,282	1343	1,838
Virginia Beach (90)	0	0	0	98	98 (33)	12	0	0	12 (4)	<1	0	60	112	173 (58)	15 (5)	298 (17)	32	177	1,203	1413	1,710
SUBTOTAL	10	0	0	1,675	1,685 (23)	168	202	0	370 (5)	66	0	3,692	484	4,243 (58)	1,052 (14)	7,354 (8)	1,628	3,326	79,441	84,395	91,747
TOTAL	272	0	0	6,554	6,827 (28)	421	316	321	1,058 (4)	140	5,446	7,752	824	14,162 (58)	2,428 (10)	24,476 (10)	3,498	10,516	195,319	209,335	233,809

Abbreviations: Brack., Brackish; Unsp., Unspecified; Est., Estuarine; O-W, Open Water

[a] Values in parentheses represent the percent of county grid sampled by NOAA. Areas with less than 100 percent coverage may or may not be completely mapped by the U.S. Fish and Wildlife Service.
[b] Values in parentheses represent the percent of total wetlands grid sampled by NOAA.
[c] Values in parentheses represent the percent of total county area grid sampled by NOAA.

Appendix III.

Table 2. Coastal wetlands by estuarine drainage area (Acres x 100).

		Wetlands																Non-Wetlands				
	Estuary	Salt Marsh					Fresh Marsh				Forested & Scrub - Shrub											
		Brack.	High	Low	Unsp.	Subtotal	Non-Tidal	Tidal	Unsp.	Subtotal	Est.	Fresh (Unsp.)	Non-Tidal Fresh	Tidal Fresh	Subtotal	Tidal Flats	Total Wetlands	O-W Fresh	O-W Non-Fresh	Upland	Subtotal	Total Acreage
1.16	Gardiners Bay (93)[a]	-	-	-	33	33 (24)[b]	3	-	-	3 (2)	3	428	27	-	30 (21)	74 (53)	141 (5)[c]	23	1,116	1,633	2,771	2,912
1.17	Long Island Sound (92)	55	-	-	106	161 (8)	87	13	16	116 (6)	1	-	1,154	4	1,586 (79)	153 (8)	2,016 (5)	958	4,835	35,498	41,291	43,307
1.18	Great South Bay (100)	-	-	-	183	183 (41)	2	-	-	2 (<1)	-	1,218	44	<1	44 (10)	219 (49)	447 (8)	27	866	4,021	4,914	5,362
1.19	Hudson River/ (47) Raritan Bay	-	-	-	166	168 (10)	4	<1	143	147 (8)	<1	171	24	-	1,243 (72)	162 (9)	1,719 (7)	431	1,360	21,302	23,093	24,812
1.20	Barnegat Bay (100)	-	-	-	413	416 (17)	<1	2	32	35 (1)	4	1,628	<1	1	1,710 (70)	299 (12)	2,460 (29)	47	500	5,524	6,070	8,530
1.21	Delaware Bay (89)	76	-	-	1,396	1,472 (36)	81	64	95	241 (6)	8	56	525	41	2,202 (54)	187 (4)	4,102 (14)	502	3,059	20,920	24,481	28,583
1.22	Chincoteague Bay (100)	-	-	-	249	249 (68)	2	-	0	2 (1)	7	-	64	3	73 (20)	44 (12)	368 (18)	4	796	901	1,700	2,068
1.23	Chesapeake Bay (97)	180	-	-	2,599	2,779 (28)	242	262	4	508 (5)	90	1	5,034	560	5,685 (57)	990 (10)	9,962 (7)	2,069	21,047	105,290	128,410	138,368
	Regional Total	311	-	-	5,145	5,461 (26)	421	341	290	1,054 (5)	113	3,502	6,872	609	12,573 (59)	2,128 (10)	21,215 (8)	4,061	33,579	195,089	232,730	253,941

Abbreviations: Brack., Brackish; Unsp., Unspecified; Est., Estuarine; O-W, Open Water

[a] Values in parentheses represent the percent of estuarine drainage area currently mapped
[b] Values in parentheses represent the percent of total wetlands
[c] Values in parentheses represent the percent of total acreage

Appendix IV.

Table 1. Coastal wetlands classification for the Mid - Atlantic region.

NOAA	FWS [a]		Common Plant Community
Salt Marsh			
Brackish	Estuarine intertidal emergent regularly and irregularly flooded salinity ≥0.5 ppt and ≤30 ppt		common reed (*Phragmites australis*) salt hay grass (*Spartinia patens*) smooth cordgrass (*Spartina alterniflora*)
High	Estuarine intertidal emergent irregularly flooded salinity ≥30 ppt		black grass (*Juncus gerardii*) salt hay grass (*Spartinia patens*) spike grass (*Distichlis spicata*)
Low	Estuarine intertidal emergent flooded or irregularly exposed salinity ≥30 ppt		smooth cordgrass (*Spartina alterniflora*)
Unspecified	Estuarine intertidal emergent		see "Brackish" "High" and "Low"
Fresh Marsh			
Nontidal	Lacustrine littoral emergent nontidal Palustrine emergent nontidal Riverine lower perennial emergent nontidal		arrowheads (*Sagittaria spp.* pickerelweed (*Pontederia cordata*) arrow arum (*Peltandra virginica*)
Tidal	Lacustrine littoral emergent tidal Palustrine emergent nontidal Riverine tidal or lower perennial emergent tidal		spatterdock (*Nuphar luteum*) cattails (*Typha latifolia*) arrowheads (*Sagittaria spp.*)
Unspecified	Lacustrine littoral emergent Palustrine emergent Riverine tidal or lower perennial emergent		see "Nontidal" and "Tidal"
Forested and scrub-shrub			
Estuarine	Estuarine intertidal forested or scrub-shrub		black mangrove (*Avicennia germinans*) marsh elder (*Iva fruescens*) red mangrove (*Rizophra mangle*)
Nontidal fresh	Palustrine forested of scrub-shrub nontidal		bald cypress (*Taxodium distichum*) Red maple (*Acer rubrum L.*)
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)	sea lettuce (*Ulva lactuca*) smooth cordgrass (*Spartina alterniflora*)
Open water			
Fresh	Lacustrine limnetic or littoral Palustrine Riverine	(includes aquatic beds, beach/bars, flats open water,rocky bottoms, reefs, rocky shores, stream beds, unconsolidated bottoms and unconsolidated shores)	spatterdock (*Nuphar luteum*) pond weeds (*Potamogen spp.*) water lily (*Nynphaea odorata*)
Non-fresh	Estuarine or Marine subtidal	(includes aquatic beds, open water rocky bottoms, reefs and unconsolidated bottoms)	sea lettuce (*Ulva lactuca*) eel grass (*Zostera maritima*) widgeon grass (*Ruppia maritima*)

[a] Based on Cowardin *et al.* 1979.

Appendix V.

Accuracy and Precision of Grid Sampled Estimates

Accuracy. The widespread use of grid sampling has prompted a number of researchers to examine the accuracy of the methodology. In particular, Bonner (1975) developed an approach for estimating the probable error of estimates of area developed from dot grids of different densities for four area-shape classes. Wetland habitat classes in the Gulf of Mexico tend to be irregularly shaped and dispersed in a manner that most closely resembles Bonner's Class IV area-shape class. We used an equation developed by Bonner for estimating the probable error for that class to examine the accuracy of grid sampled estimates. That equation is:

$$D = 1/A(153.1/E)1.7198$$

where D is the density of dots on the grid (dots/square inch), A is the total area of a habitat (square inches), and E is the percentage error of the estimate. In this case, D is constant and equal to 2.0408. The equation can be rearranged to estimate error for any value of A:

$$E\% = 153.1/(2.0408\ A)0.5814$$

By grid sampling maps previously digitized by the FWS and comparing digitized estimates of habitat area to corresponding grid sample estimates, it was shown that the predicted error as calculated in the above equation serves as a reliable, conservative estimator of the observed error. This equation was used to generate a graph that gives the predicted percentage error of grid sampled estimates as a function of the area of a habitat type (Figure 1). Thus, we predict a less than 10 percent error in estimates that are greater than or equal to 5,000 acres.

Comparisons to FWS digital data. To monitor the effectiveness of the grid sampling technique, grid sampled data are compared to NWI digital data whenever these data are available. Digital data was compared to grid sampled estimates for 39 1:24,000 scale NWI maps in Barnegat Bay, New Jersey (Table 1). These data were developed by the FWS using the Map Overlay Statistical System (MOSS).

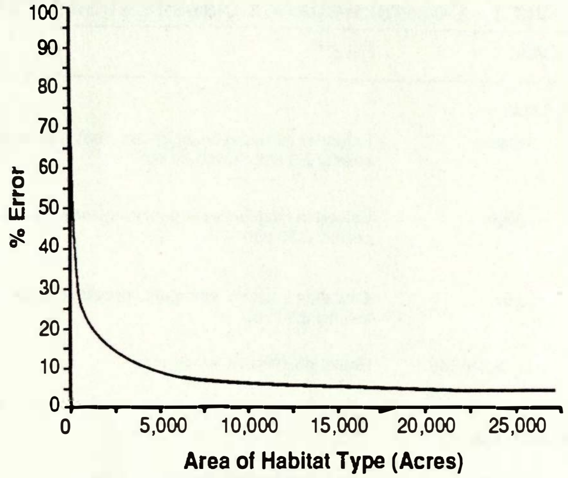


Figure 1. Predicted error as a function of habitat area.

These data indicate that abundant wetland types, such as unspecified salt marsh in New Jersey, are estimated extremely well, while estimates for rare wetland types, such as tidal fresh marsh, are sometimes close to digital estimates, but are generally more variable.

Table 1. Comparison of grid sampled data to FWS digital data for 39 1:24,000 scale NWI maps in Barnegat Bay, New Jersey.

Habitat	NOAA		NWI	
	100 Acres	% Total	100 Acres	% Total
Salt marsh				
Brackish	2	<1	3	<1
Unspecified	603	4	604	4
Fresh marsh				
Nontidal	-	-	-	-
Tidal	2	<1	2	<1
Unspecified	55	<1	59	<1
Forested and scrub-shrub				
Estuarine	2	<1	3	<1
Nontidal fresh	-	-	-	-
Tidal fresh	1	<1	3	<1
Unspecified	2,295	16	2,294	16
Tidal flats	452	3	457	3
Palustrine farmed	55	<1	58	<1
Open water				
Fresh	76	1	84	1
Non-fresh	2,232	16	2,236	16
Upland	8,500	60	8,474	59
Total	14,275	100	14,277	100

National Estuarine Atlas

PHYSICAL AND HYDROLOGIC CHARACTERISTICS

PHYSICAL

Surface Areas (mi²)	
Fluvial Drainage	47,325
Estuarine Drainage	21,955
Estuarine Zones	
Tidal Fresh	153
Mixing Zone	3,562
Seawater	115
Total	3,830
Dimensions	
Length (mi)	198.0
Width (mi) Average	15.4
Minimum	3.2
Maximum	34.8
Average Depth (ft)	27.8
Average Depth to Width Ratio	3.4×10^{4}
Stratification Classification	
3 Month High Flow	MS
3 Month Low Flow	MS

FRESHWATER INFLOW

Flow Rates (1000 cfs)				
Period of Record	1968 1982			
Long Term Average Daily	85.8			
Long Term Average Monthly	J	101.6	J	42.8
	F	140.4	A	33.7
	M	149.4	S	43.6
	A	118.7	O	60.6
	M	93.2	N	68.9
	J	82.6	D	96.1
7 Day 10-Year Low Flow	4.1			
50-Year Flood	2,073.8			
100-Year Flood	2,852.7			
Flow Ratios				
Average Annual	0.063			
High Flow Period	0.100			
Low Flow Period	0.029			

TIDAL DATA

Prevailing Tide: Semidiurnal

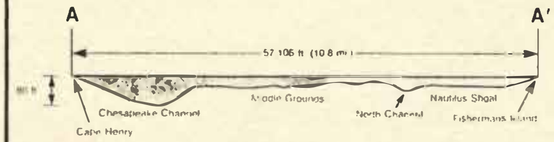
Tidal Prism (cf): 6.06×10^{11}

Phase Range of Tide (ft.)

Map Key	Station	Range
A	1951	2.7
B	2367	2.3
C	1955	2.3
D	2305	2.3
E	1957	1.2
F	2269	0.8
G	2270	0.4
H	2379	1.8
I	2385	0.6
J	2387	0.1
K	2329	2.0
L	2330	1.0
M	2331	0.4

Abbreviations: Vertically Homogeneous, VH; Moderately Stratified, MS; Highly Stratified, HS

Cross Section
(at mean high water)



Notes:
Approximately 95% of Estuarine Drainage Area is shown on map

References:
Blumberg, 1977. Buchanan, 1983. Carpenter, 1983. Chesapeake Bay Commission, 1983. Flippo, 1982. James, et al., 1982. Jordan, 1984. Miller, 1975. Prugh, et al., 1983. U.S. Department of Commerce, 1982. U.S. Department of Commerce, 1983a. Voytik, et al., 1982. Wang, 1979. Wang, 1983. Yarbro, 1983.

Map Sources:
U.S. Geological Survey, State of Virginia, Hydrologic Unit Map, 1974, scale 1:500,000. State of Maryland, Hydrologic Unit Map, 1974, scale 1:500,000. State of Pennsylvania, Hydrologic Unit Map, 1974, scale 1:500,000. USGS Accounting Units of the National Water Data Network, 1979, scale 1:7,500,000. NOAA/NOS Nautical Chart No. 12222, June 1983, scale 1:40,000.

Chesapeake Bay
VA, MD, DE, PA, DC

- Tide Gage
- Flow Gage
- Head of Tide
- Estuarine Drainage Area (EDA)
- Tidal Fresh Zone
- Mixing Zone
- Seawater Zone
- Hydrologic Cataloging Unit Boundary
- County Boundary
- Salinity Zone Boundary - Low Variability
- Salinity Zone Boundary - Moderate Variability
- Salinity Zone Boundary - High Variability

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service/NOAA