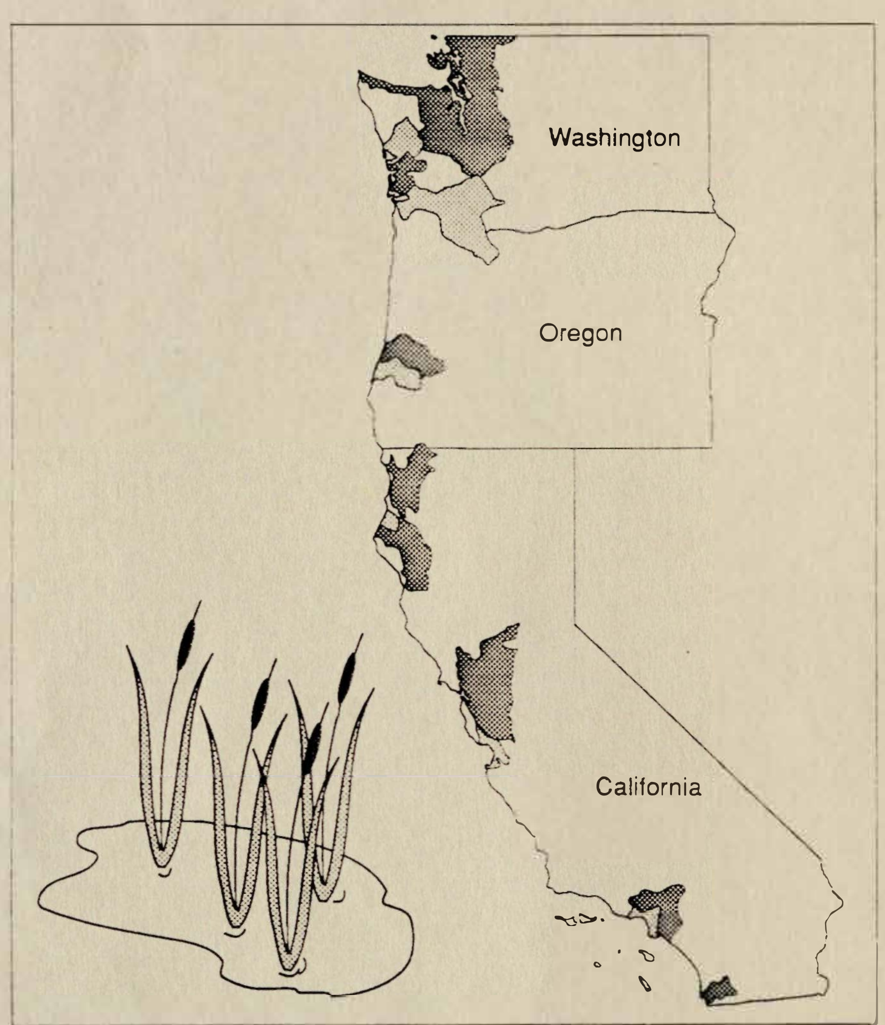
National Coastal Wetlands Inventory

The Distribution and Areal Extent of Coastal Wetlands in Estuaries of the West Coast Region



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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 being 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 127 counties and eight estuaries in the Mid-Atlantic region (New York to Virginia) was published in May 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 for publication in the fall of 1990.

National Coastal Wetlands Inventory

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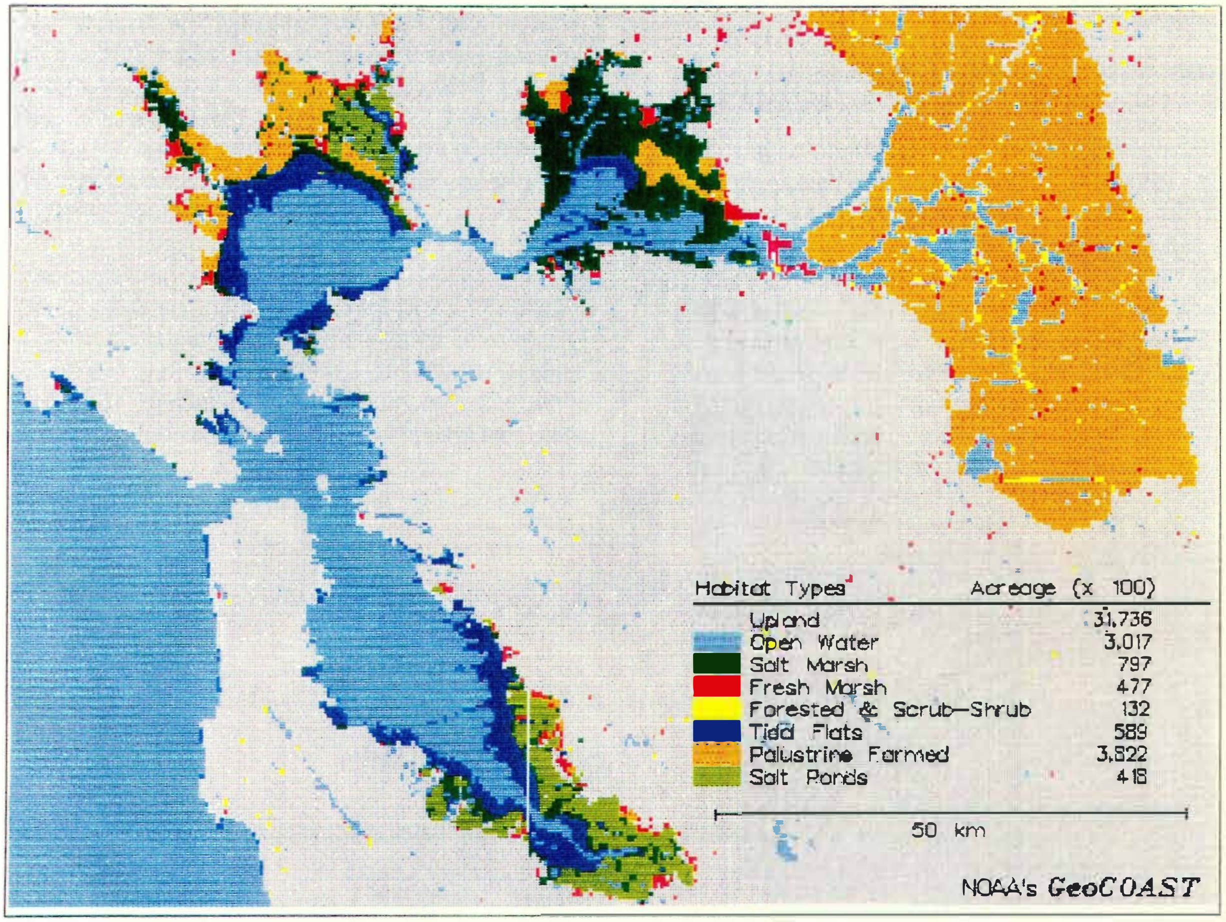


Wetlands of the San Francisco Bay estuarine drainage area.

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

This report is the fourth 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 the U.S. Fish and Wildlife Service's 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, 1967). 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 81 counties and 14 estuarine systems in the West Coast region (Figure 1). Included are detailed acreage summaries for 12 wetland types and a computer generated map of one estuary, San Francisco 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

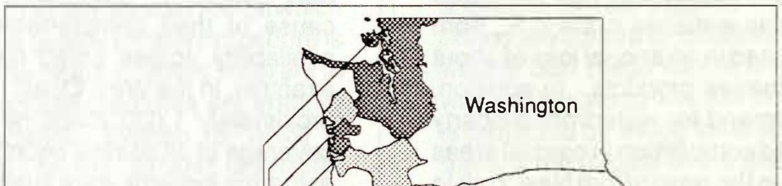


Figure 1. Estuarine drainage areas of the West Coast region.

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 and Selig, 1982). They also generate large revenues from a wide variety of recreational activities, such as fishing and hunting (NOAA, 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, the San Francisco Bay region has lost 95 percent of its wetlands since being settled (Josselyn, 1983).

A major concern over wetland losses is the long-term, cumulative impacts 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 (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, wetland maps are produced in a consistently derived manner by the National Wetlands Inventory (NWI) of the U.S. Fish and Wildlife Service.

The National Wetlands Inventory Program

The NWI program was established by the U.S. 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 the 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 95 percent of the coastal zone. The maps are developed from aerial photography and are generally based on 1:24,000 scale U.S. Geological Survey maps. They illustrate wetland habitats classified using the classification system developed by the FWS (Cowardin et al., 1979).

Although the NWI wetland maps represent the most comprehensive and reliable source of consistently derived coastal wetland information, fewer than 2,000 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 required data are available. Further, the FWS does not anticipate a complete digital data base of NWI coastal maps. 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 West Coast region, 1,525 of approximately 1,630 maps needed for complete coverage of all coastal counties and 14 different estuarine systems were available from the FWS. Most of the maps not available are located in inland 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 placing a transparent grid over an NWI map, as illustrated in Figure 2, and identifying 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 West Coast region contained 725 - 925 sampling points.

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

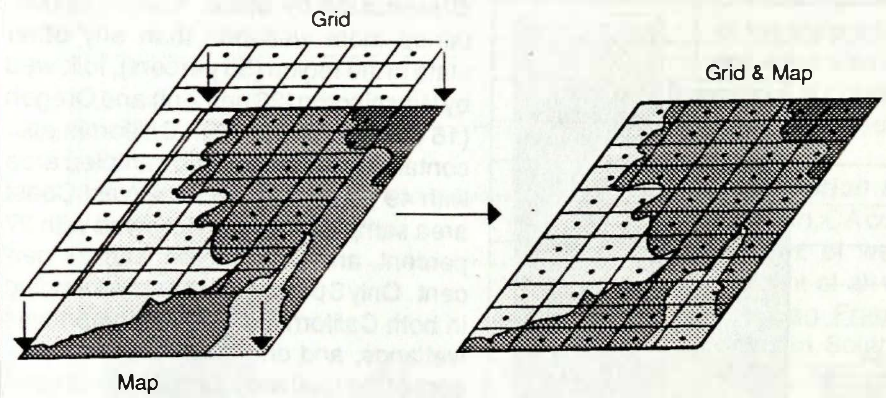


Figure 2. 1:24,000 - scale NWI map and grid.

(Figure 1) and describe their physical, hydrologic and land use charactersitcs. The estuarine drainage areas average about 2,615 square miles and range from about 12,280 square miles in Puget Sound, WA to 231 square miles in Humbolt Bay, CA.

tude of the lower right and upper left corners, 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 West Coast region, a total of 1,525 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 West Coast region and its wetlands. Maps and bar charts 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 West Coast of the contiguous U.S. extends from the Canadian border near Puget Sound, WA, south through Oregon to Cape Mendicino, CA, then southeast to San Diego, CA and the Mexican border. Volumes 1 & 2 of the National Estuarine Inventory (NEI) identify 14 estuaries along the West Coast

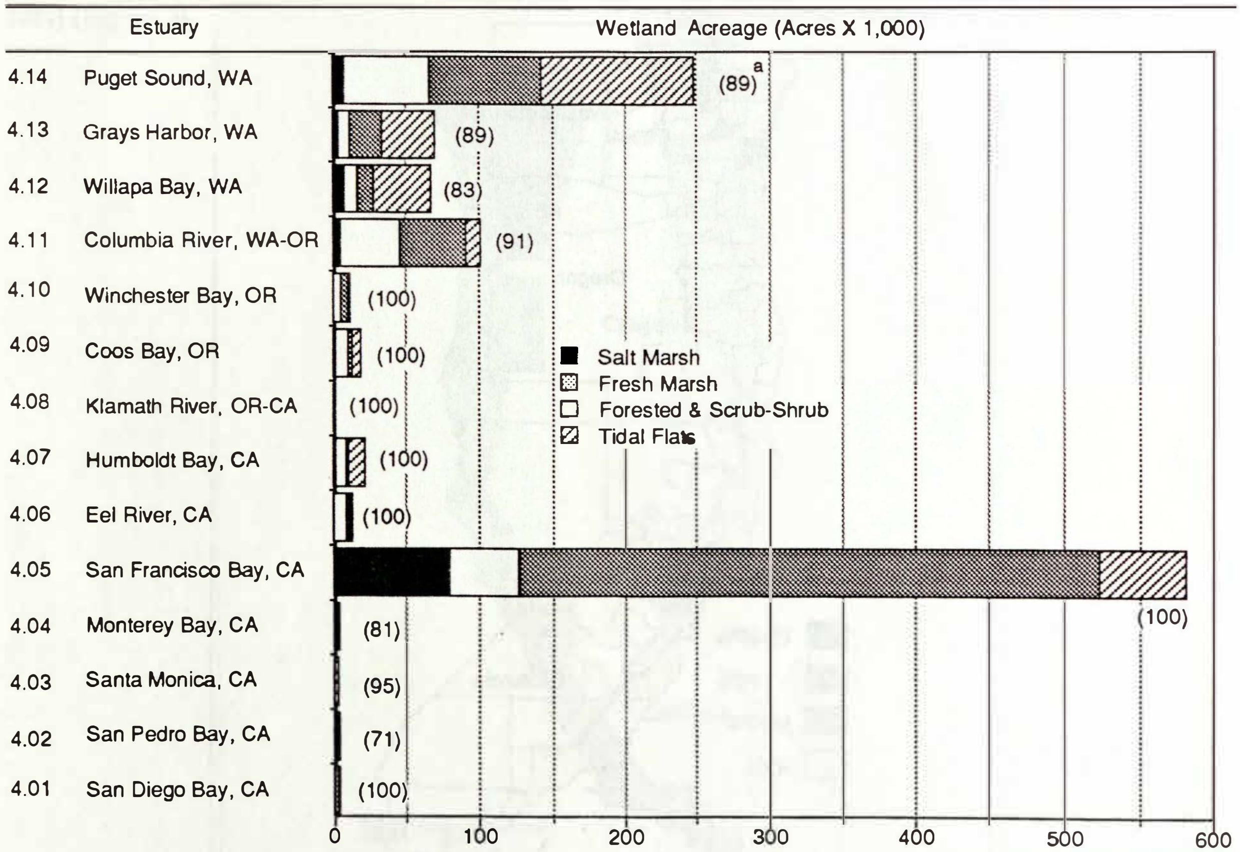
The formation of estuaries in Washington was influenced greatly by glacial activity. Glaciers cut deep, narrow channels through the mountains giving Puget Sound (4.14) its characteristic steep-sided banks and shallow pluggs or sills. Futher south at Soma, CA, Humbolt Bay (4.07) and Eel River (4.06) estuaries were formed when the channels of ancient rivers were submerged by rising sea levels. The increased sea level in turn flooded river valleys, creating marshes and large bays. Continuing southeast, the deeply embayed area of San Francisco Bay (4.05) is found. Sections of the bay's river valley sank below sea level due to active mountain building, thus bringing the shoreline to rest against the sides of valleys previously carved by streams. Continuing southwest is San Diego Bay (4.01), another bay that was influenced by the rise in sea level. The bay is protected by a long sand spit formed from the bay's three largest rivers and the effects of the ocean's currents on the bay (Hunt, 1974).

NWI Map Coverage. Figure 4 shows the extent of FWS wetland map availability for the West Coast. State, county, and/or estuary rankings could change if more maps were available. Figure 6 shows the percentage of wetlands in each county for the sampled 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 1,525 NWI maps, covering 55.7 million acres, were grid sampled by NOAA in the West Coast region (WA, OR, and CA). Approximately 2.5 percent, or 1.4 million acres, were identified as wetlands. Eleven of 14 estuarine drainage areas (EDA) had greater than 80 percent map coverage, while 47 of 81 counties had greater than 75 percent coverage. Of these, 6 EDAs and 27 counties had 100 percent map coverage. Forested wetlands were the most common wetland habitat type found in the

Francisco Bay contained the region's largest amount of wetlands, accounting for 51 percent of the estuarine wetland total. It also contained the most salt marsh and forested wetlands, accounting for 72 and 70 percent, respectively, of the regional habitat totals (Figure 7). The forested wetlands of San Francisco Bay accounted for 34 percent of the total estuarine wetlands. Puget Sound had the largest grid sampled area in the West Coast region, containing 13 percent of the regional total, and it also contained the region's largest amounts of fresh marsh and tidal flats, with 30 and 38 percent, respectively, of the regional totals. The remaining EDAs along the West Coast had a somewhat lower abundance of wetlands due to their small size and/or geographic location along the West Coast (Figure 8).

Trends. Wetland loss in the West Coast region can be attributed to such human activities as agriculture, urbanization, and diking. Pacific flyway waterfowl are potentially impacted by the loss of wetlands due to their importance as wintering areas. California has lost approximately 91 percent of its wetlands since being settled (Gosselink and Baumann, 1980). Due to conversion of wetlands to agriculture, the Central Valley of California experienced an average annual net loss of 5,200 wetlands acres from 1939 to the mid-1980s (Frayer et al., 1989). Although the San Francisco Bay area still contains significant wetlands compared to other West Coast estuaries, it is estimated to have lost almost 95 percent of its wetlands since the time of settlement (Josselyn, 1983). Due to diking by settlers and recent human pressures, 11 major deltas surveyed in Puget Sound, WA lost over 19,000 acres of wetlands from the late 1800s to 1980, yielding an average annual net loss of 186 acres per year (Bartleson et al., 1980). Comprehensive trends data for Oregon has yet to be developed.

NOAA (1990), in a recent report entitled *50 Years of Population Change along the Nation's Coasts 1960 to 2010*, projects that the coastal population of the West Coast will increase 18 percent, to over 33 million, in the next 20 years. The coastal population density of the region will increase by 21 percent to an average of 339 persons per square mile during this same time, with California increasing by 22 percent—the



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

Figure 7. Total acreage of 4 wetland types by estuarine drainage

largest in the region—to 718 persons per square mile by 2010. Gosselink and Bauman (1980) reported that wetland loss is directly related to population density. Therefore, as population density increases along the West Coast, greater wetland losses are likely to continue if preventative actions are not taken.

Appendix I describes the steps to develop the data base. 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 14 EDAs of the West 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 resolution 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

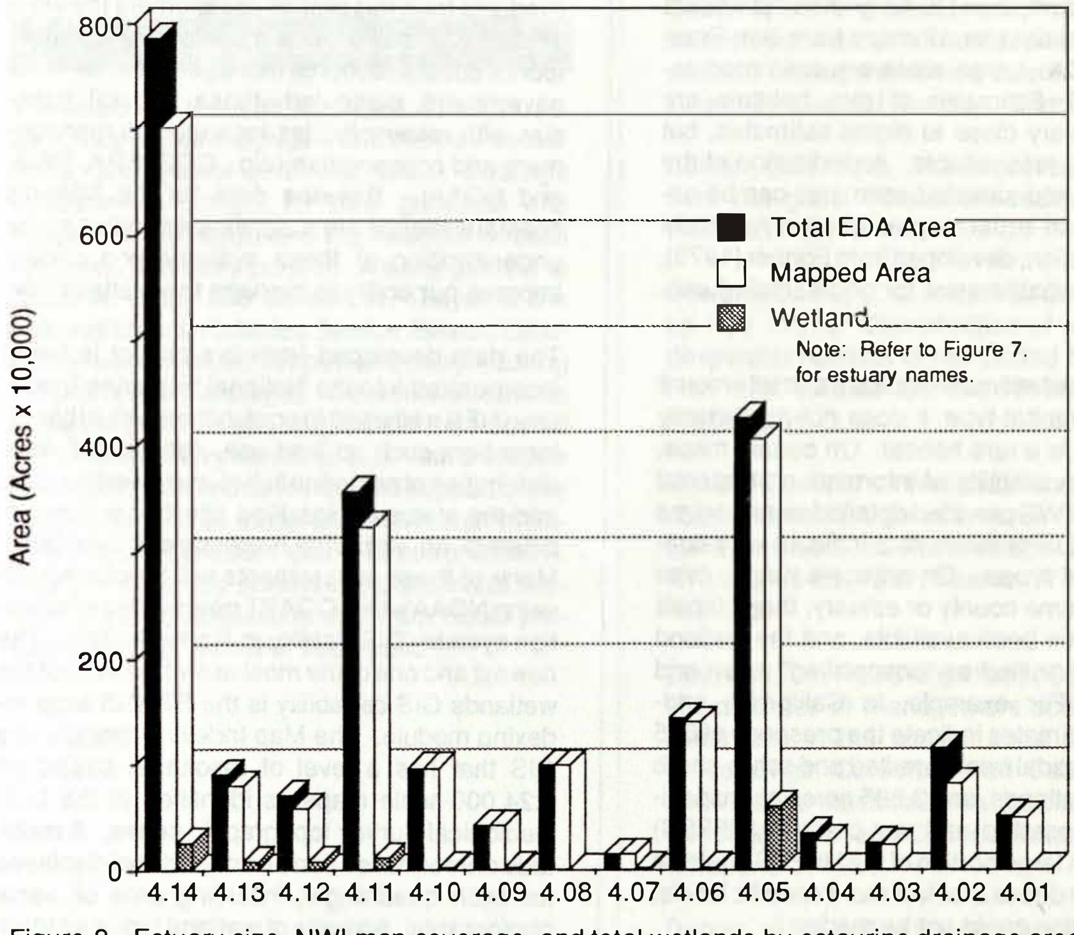


Figure 8. Estuary size, NWI map coverage, and total wetlands by estaurine drainage area.

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

		Year of Photography				
Estuary		N/A[a]	1972-74	1975-78	1979-81	1982-85
4.14	Puget Sound	-	34	7	164	40
4.13	Grays Harbor	-	-	-	20	-
4.12	Willapa Bay	2	-	-	15	-
4.11	Columbia River	9	-	17	79	18
4.10	Winchester Bay	4	7	20	1	7
4.09	Coos Bay	2	-	-	-	9
4.08	Klamath River	13	1	1	-	4
4.07	Humboldt Bay	1	1	-	-	6
4.06	Eel River	2	22	25	-	3
4.05	San Francisco Bay	1	14	41	-	93
4.04	Monterey Bay	-	15	3	-	-
4.03	Santa Monica	1	1	6	-	-
4.02	San Pedro Bay	1	14	15	-	-
4.01	San Diego Bay	1	1	3	-	18

[a] Date of aerial photography not given on the map

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 15 maps from San Francisco Bay, CA. 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 California, grid-sampled estimates indicate the presence of 825 acres of nontidal fresh forested and scrub-shrub (NFFSS) wetlands, and 3,865 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 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 63 percent occurring between 1979 and 1985, and 26 percent occurring after 1981. A complete list of the dates of aerial photography used to produce all maps available for the 14 estuarine drainage areas of the West Coast 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 data base 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, MD. 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. In addition to these GIS applications, 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:

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Appendices

I. Initial Steps Toward Developing the National Coastal Wetlands Inventory

II. National Estuarine Inventory

III. Coastal Wetland Acreages by County/State and Estuarine Drainage Area

IV. Coastal Wetlands Classification for the West Coast Region

V. Accuracy and Precision of Grid-Sampled Estimates

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 5.0 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 West Coast region included published data for wetlands in Washington (Boule et al., 1983), Oregon (Atkins, 1973), and California (Dennis and Marcus, 1984).

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 15 maps from the San Francisco Bay area are presented in Appendix V.

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 "NOAA's Grid-Sampling 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 estimates are based on data from the Land Use and Land Cover Program of U.S.Geological Survey (USGS) and are compiled for three spatial units: (1) the estuarine drainage area (EDA); (2) USGS 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 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 contributing data and information to 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 under way or planned. Based on the review of Volume 1 by estuarine scientists and state and Federal resource managers, several areas have been identified for improvement in future editions. 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 1. 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)

	Wetlands																Non-Wetlands				
	Salt Marsh					Fresh Marsh				Forested & Scrub-Shrub											
State/County	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
Washington																					
Chelan (2)[a]	-	-	-	-	- -[b]	-	-	-	- -	-	-	<1	-	<1 (100)	- -	<1 (<1)[c]	1	-	431	432	432
Clallam (26)	-	-	-	8	8 (8)	6	1	-	7 (7)	-	-	37	<1	37 (38)	45 (47)	97 (3)	16	60	2,860	2,936	3,033
Cowlitz (89)	-	-	-	-	- -	46	1	-	47 (53)	-	-	42	<1	42 (47)	- -	89 (1)	191	-	6,352	6,543	6,632
Grays Harbor (95)	-	-	-	39	39 (9)	76	12	5	93 (21)	<1	-	209	57	267 (60)	44 (10)	442 (4)	179	36	11,058	11,273	11,715
Island (97)	-	-	-	4	4 (4)	30	-	-	30 (33)	-	-	14	-	14 (15)	43 (47)	91 (6)	12	64	1,259	1,335	1,426
Jefferson (94)	-	-	-	6	6 (3)	40	1	-	41 (18)	-	-	129	3	132 (57)	53 (23)	232 (2)	100	397	10,776	11,273	11,505
King (94)	-	-	-	<1	<1 (<1)	81	-	-	81 (34)	-	-	142	-	142 (59)	16 (7)	239 (2)	456	82	12,456	12,994	13,232
Kitsap (99)	-	-	-	2	2 (2)	24	-	-	24 (24)	-	<1	40	-	41 (41)	32 (32)	99 (3)	26	376	2,432	2,834	2,933
Kittitas (11)	-	-	-	-	- -	5	-	-	5 (35)	-	-	8	-	8 (65)	- -	13 (1)	35	-	1,609	1,644	1,657
Klickitat (1)	-	-	-	-	- -	3	-	-	3 (23)	-	-	8	-	8 (77)	- -	11 (10)	-	-	94	94	105
Lewis (83)	-	-	-	-	- -	186	-	-	186 (56)	-	-	144	-	144 (44)	- -	330 (3)	214	-	12,080	12,294	12,624
Lincoln (92)	-	-	-	4	4 (1)	29	-	-	29 (11)	-	-	149	1	150 (56)	86 (32)	268 (4)	98	390	5,421	5,909	6,178
Pacific (84)	<1	-	-	66	66 (14)	78	7	11	96 (20)	<1	-	121	19	140 (29)	177 (37)	479 (9)	14	67	4,525	4,606	5,085
Pierce (73)	-	-	-	3	3 (1)	69	-	-	69 (28)	-	-	122	-	122 (50)	50 (20)	244 (3)	93	521	7,413	8,028	8,272
San Juan (95)	-	-	-	<1	<1 (<1)	22	-	-	22 (30)	-	-	5	-	5 (7)	48 (64)	75 (5)	19	537	1,030	1,586	1,661
Skagit (90)	-	-	-	23	23 (10)	57	2	<1	59 (26)	-	-	92	4	96 (42)	51 (22)	229 (2)	122	136	10,251	10,509	10,739
Skamania (70)	-	-	-	-	- -	14	-	-	14 (26)	-	-	39	-	39 (74)	- -	52 (1)	120	-	7,096	7,217	7,269
Snohomish (97)	-	-	-	13	13 (4)	86	6	-	91 (30)	-	-	160	5	165 (55)	31 (10)	300 (2)	164	17	12,949	13,130	13,430
Thurston (89)	-	-	-	6	6 (3)	75	-	-	75 (34)	-	-	99	-	99 (45)	42 (19)	222 (5)	62	188	3,659	4,110	4,331
Wahkiakum (58)	-	-	-	1	1 (2)	22	4	-	26 (47)	<1	-	9	17	27 (49)	1 (2)	55 (6)	54	21	864	939	995
Whatcom (78)	-	-	-	2	2 (1)	123	-	-	123 (41)	<1	-	139	<1	140 (47)	34 (11)	299 (3)	314	60	10,872	11,246	11,545
Yakima (5)	-	-	-	-	- -	8	-	-	8 (46)	-	-	10	-	10 (54)	- -	18 (1)	9	-	1,291	1,300	1,318
SUBTOTAL	<1	-	-	177	177 (5)	1,079	32	17	1,128 (29)	2	<1	1,718	107	1,829 (47)	752 (19)	3,884 (3)	2,299	2,953	126,978	132,230	136,118
Oregon																					
Benton (98)	-	-	-	-	- -	14	-	-	14 (12)	-	-	107	<1	107 (88)	- -	121 (3)	37	-	4,136	4,173	4,294
Clackamas (60)	-	-	-	<1	<1 (<1)	7	-	-	7 (15)	-	-	37	-	37 (82)	- -	45 (1)	89	-	7,276	7,365	7,410
Clatsop (88)	-	-	-	52	52 (27)	28	3	-	31 (16)	-	1	38	41	80 (41)	29 (15)	193 (4)	30	168	4,814	5,012	5,205
Columbia (95)	<1	-	-	-	<1 (<1)	86	11	-	97 (55)	-	-	61	18	80 (45)	- -	177 (4)	187	-	4,051	4,238	4,414
Coos (100)	-	-	-	20	20 (5)	228	5	13	246 (62)	-	-	60	1	61 (15)	68 (17)	394 (4)	58	83	9,711	9,852	10,246
Curry (100)	-	-	-	1	1 (1)	10	-	8	18 (29)	-	6	11	-	17 (28)	27 (43)	62 (1)	57	70	10,202	10,329	10,391
Douglas (97)	-	-	-	4	4 (2)	69	6	-	75 (41)	-	-	85	2	87 (48)	16 (9)	181 (1)	220	52	30,084	30,356	30,537
Jackson (13)	-	-	-	-	- -	<1	-	-	<1 (<1)	-	<1	<1	-	1 (99)	- -	1 (<1)	8	-	2,149	2,156	2,157
Josephine (77)	-	-	-	-	- -	1	-	5	6 (24)	-	16	3	-	19 (76)	- -	25 (<1)	28	-	7,585	7,613	7,638
Klamath (5)	-	-	-	-	- -	2	-	-	2 (12)	-	-	13	-	13 (88)	- -	15 (1)	42	-	1,849	1,891	1,906
Lane (88)	-	-	-	9	9 (4)	79	-	1	80 (34)	-	-	130	1	131 (56)	13 (5)	233 (1)	353	25	25,346	25,724	25,957
Lincoln (98)	-	-	-	24	24 (18)	38	2	-	40 (29)	1	-	24	-	24 (18)	48 (35)	136 (2)	24	63	6,111	6,198	6,334
Linn (34)	-	-	-	-	- -	17	-	-	17 (18)	-	-	78	-	78 (82)	- -	95 (2)	40	-	4,928	4,968	5,064
Marion (31)	-	-	-	-	- -	11	-	-	11 (21)	-	-	43	-	43 (79)	- -	54 (2)	42	-	2,300	2,342	2,396
Multnomah (100)	-	-	-	-	- -	44	5	-	49 (52)	-	-	43	2	45 (48)	- -	94 (3)	246	-	2,970	3,217	3,310
Polk (99)	-	-	-	-	- -	15	-	-	15 (15)	-	-	82	-	82 (85)	- -	97 (2)	29	-	4,701	4,730	4,827
Tillamook (96)	-	-	-	22	22 (13)	22	1	-	23 (13)	-	-	16	2	18 (11)	108 (63)	171 (2)	21	119	6,936	7,076	7,247
Washington (95)	-	-	-	-	- -	24	-	-	24 (39)	-	-	37	-	37 (61)	- -	60 (1)	36	-	4,563	4,599	4,659
Yamhill (96)	-	-	-	-	- -	15	-	-	15 (27)	-	-	41	-	41 (73)	- -	56 (1)	25	-	4,519	4,544	4,600
SUBTOTAL	<1	-	-	131	131 (6)	711	32	28	769 (35)	1	23	908	69	1,000 (45)	308 (14)	2,211 (1)	1,572	579	144,231	146,383	148,593
California																					
Alameda (98)	-	-	-	40	40 (14)	41	-	4	45 (16)	-	7	6	-	13 (5)	184 (65)	282 (6)	54	326	4,443	4,823	5,105
Contra Costa (100)	-	-	-	73	73 (13)	25	8	-	33 (6)	-	352	10	3	365 (68)	67 (12)	538 (10)	196	291	4,140	4,627	5,166
Del Norte (95)	-	-	-	-	- -	30	1	1	32 (45)	-	1	37	-	38 (52)	2 (3)	71 (1)	37	100	6,335	6,473	6,544
Fresno (5)	-	-	-	-	- -	-	-	-	- -	-	-	<1	-	<1 (100)	- -	<1 (<1)	<1	-	2,049	2,049	2,050
Glenn (2)	-	-	-	-	- -	1	-	-	1 (100)	-	-	-	-	- -	- -	1 (1)	-	-	142	142	143
Humboldt (97)	-	-	-	18	16 (5)	183	<1	5	189 (48)	-	11	34	2	47 (12)	137 (35)	391 (2)	193	168	22,070	22,431	22,822
Imperial (5)	-	-	-	-	- -	-	-	-	- -	-	-	<1	-	<1 (100)	- -	<1 (<1)	46	-	1,320	1,365	1,366

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 map 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 that is wetlands.

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 [b]	Non-Tidal	Tidal	Unsp.	Subtotal	Est.	Fresh (Unsp.)	Non-Tidal Fresh	Tidal Fresh	Subtotal	Tidal Flats	Total Wetlands [c]	O-W Fresh	O-W Non-Fresh	Upland	Subtotal	Total Acreage	
California cont.																						
Kern (10) [a]	-	-	-	-	-	1	-	-	1 (35)	-	-	2	-	2 (65)	-	3 (<1)	102	-	5,176	5,278	5,281	
Kings (3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	240	240	240	
Lake (34)	-	-	-	-	-	6	-	-	6 (78)	-	-	2	-	2 (22)	-	8 (<1)	9	-	2,809	2,819	2,827	
Los Angeles (71)	-	-	-	1	1 (2)	11	-	<1	12 (19)	-	-	30	-	30 (49)	18 (29)	60 (<1)	197	182	17,686	18,265	18,326	
Marin (95)	-	-	-	37	37 (15)	45	6	-	51 (17)	-	47	10	-	57 (21)	130 (47)	275 (7)	34	410	3,013	3,457	3,731	
Mendocino (100)	-	-	-	2	2 (6)	10	-	-	10 (33)	-	-	13	-	13 (44)	5 (16)	29 (<1)	67	89	23,685	23,842	23,871	
Merced (6)	-	-	-	-	-	<1	-	-	<1 (12)	-	-	<1	-	<1 (88)	-	2 (<1)	2	-	842	844	845	
Monterey (94)	-	-	-	14	14 (8)	22	<1	<1	23 (13)	-	-	129	2	131 (76)	5 (3)	173 (1)	130	208	20,075	20,413	20,586	
Napa (85)	-	-	-	30	30 (35)	31	-	-	31 (37)	-	6	9	1	16 (18)	9 (10)	85 (2)	183	10	4,082	4,275	4,360	
Orange (98)	-	-	-	12	12 (18)	14	-	-	14 (21)	-	-	26	-	26 (40)	13 (20)	65 (1)	37	33	4,977	5,047	5,113	
Placer (23)	-	-	-	-	-	20	-	-	20 (62)	-	-	12	-	12 (38)	-	32 (2)	14	-	2,052	2,065	2,097	
Riverside (16)	-	-	-	<1	<1 (<1)	45	-	-	45 (45)	-	-	54	-	54 (54)	-	100 (1)	220	-	7,221	7,441	7,541	
Sacramento (76)	-	-	-	<1	<1 (<1)	46	22	-	69 (9)	-	687	39	6	733 (91)	-	802 (16)	158	1	3,965	4,124	4,926	
San Benito (75)	-	-	-	<1	<1 (2)	5	-	-	5 (21)	-	-	18	-	18 (77)	-	23 (<1)	29	-	6,897	6,926	6,949	
San Bernardino (0)	-	-	-	-	-	1	-	-	1 (33)	-	-	3	-	3 (67)	-	4 (1)	2	-	427	429	433	
San Diego (60)	-	-	-	8	8 (6)	53	-	-	53 (38)	-	-	65	<1	65 (46)	14 (10)	140 (1)	111	157	15,798	16,066	16,206	
San Francisco (100)	-	-	-	-	-	<1	-	-	<1 (16)	-	-	<1	-	<1 (16)	2 (69)	3 (<1)	4	347	297	647	650	
San Joaquin (57)	-	-	-	-	-	19	13	-	32 (2)	-	1,810	21	27	1,859 (98)	-	1,891 (36)	197	-	3,155	3,352	5,243	
San Luis Obispo (97)	-	-	-	7	7 (6)	17	-	-	17 (14)	-	-	86	-	86 (69)	14 (11)	124 (1)	212	40	20,408	20,660	20,784	
San Mateo (86)	-	-	-	32	32 (19)	7	1	2	9 (5)	-	-	13	-	13 (8)	110 (67)	164 (5)	21	540	2,312	2,873	3,037	
Santa Barbara (98)	-	-	-	6	6 (8)	8	1	-	9 (12)	-	-	42	1	43 (57)	17 (23)	76 (<1)	123	101	16,885	17,109	17,185	
Santa Clara (98)	-	-	-	17	17 (24)	15	-	-	15 (21)	-	-	9	-	9 (13)	29 (41)	70 (1)	66	9	7,903	7,978	8,049	
Santa Cruz (50)	-	-	-	<1	<1 (13)	<1	-	-	<1 (13)	-	-	1	-	1 (40)	1 (33)	4 (<1)	10	2	1,503	1,515	1,519	
Siskiyou (23)	-	-	-	-	-	-	-	1	1 (7)	-	7	-	-	7 (93)	-	8 (<1)	38	-	9,469	9,507	9,515	
Solano (99)	-	-	-	524	524 (43)	95	11	-	106 (9)	-	457	4	3	464 (38)	113 (9)	1,207 (21)	86	329	4,191	4,606	5,813	
Sonoma (89)	-	-	-	61	61 (17)	30	<1	-	31 (8)	-	191	26	-	217 (59)	58 (16)	367 (4)	52	124	8,802	8,978	9,345	
Stanislaus (8)	-	-	-	-	-	5	-	-	5 (35)	-	-	9	-	9 (65)	-	14 (2)	6	-	779	785	799	
Sutter (42)	-	-	-	-	-	17	-	-	17 (37)	-	-	30	-	30 (63)	-	47 (3)	25	-	1,509	1,534	1,581	
Tehama (2)	-	-	-	-	-	1	-	-	1 (100)	-	-	-	-	-	-	1 (<1)	-	-	299	299	300	
Trinity (27)	-	-	-	-	-	-	-	<1	<1 (20)	-	1	<1	-	2 (80)	-	3 (<1)	35	-	5,580	5,615	5,618	
Ventura (97)	-	-	-	31	31 (24)	28	<1	-	29 (23)	-	-	56	-	56 (55)	13 (10)	129 (1)	86	36	11,185	11,307	11,436	
Yolo (69)	-	-	-	-	-	86	12	1	99 (24)	-	288	21	4	312 (76)	-	411 (9)	88	-	4,089	4,177	4,588	
Yuba (2)	-	-	-	-	-	2	-	-	2 (19)	-	-	8	-	8 (81)	-	9 (11)	3	-	74	77	86	
SUBTOTAL	-	-	-	916	916 (12)	921	78	13	1,015 (13)	-	3,865	825	50	4,743 (62)	941 (12)	7,615 (3)	2,871	3,505	258,086	264,463	272,075	
Regional Total	1	-	-	1,224	997 (7)	2,711	142	57	2,337 (17)	-	2,779	3,451	226	6,027 (44)	2,001 (15)	13,709 (2)	6,742	7,037	529,295	543,076	556,786	

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 map 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 acrea grid sampled by NOAA that is wetlands.

Appendix III.

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

	Wetlands																Non-Wetlands				
	Salt Marsh					Fresh Marsh				Forested & Scrub-Shrub											
Estuary	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
4.14 Puget Sound (89)[a]	-	-	-	79	79 (3)[b]	579	8	-	587 (24)	<1	<1	752	11	764 (31)	1,048 (42)	2,479 (4)[c]	1,011	13,458	53,238	67,707	70,185
4.13 Grays Harbor (89)	-	-	-	42	42 (6)	48	11	5	64 (9)	<1	-	170	56	227 (32)	373 (53)	706 (9)	109	208	6,920	7,237	7,943
4.12 Willapa Bay (83)	<1	-	-	79	79 (11)	61	6	11	78 (11)	<1	-	98	18	117 (22)	400 (56)	674 (9)	14	302	4,818	5,133	5,607
4.11 Columbia River (91)	<1	-	-	53	53 (7)	368	35	-	403 (35)	<1	1	370	89	460 (49)	98 (9)	1,014 (3)	1,269	404	29,621	31,294	32,308
4.10 Winchester Bay (100)	-	-	-	4	4 (3)	38	6	-	44 (45)	-	-	36	2	38 (41)	14 (10)	101 (1)	85	51	9,615	9,751	9,852
4.09 Coos Bay (100)	-	-	-	15	15 (8)	76	4	-	80 (41)	-	-	24	1	25 (14)	69 (36)	189 (2)	14	184	3,734	3,931	4,121
4.08 Klamath River (100)	-	-	-	-	- -	2	-	2	4 (30)	-	1	8	-	9 (70)	- -	13 (<1)	70	3	9,812	9,886	9,899
4.07 Humboldt Bay (99)	-	-	-	12	12 (6)	80	-	-	80 (38)	-	-	6	-	6 (3)	115 (54)	213 (15)	2	137	1,115	1,254	1,468
4.06 Eel River (98)	-	-	-	5	5 (4)	84	-	1	85 (66)	-	6	19	<1	25 (20)	14 (11)	129 (1)	145	72	13,628	13,845	13,975
4.05 San Francisco Bay (95)	-	-	-	797	797 (14)	401	72	5	477 (8)	-	3,822	87	45	3,955 (68)	589 (10)	5,819 (14)	855	2,162	31,736	34,752	40,571
4.04 Monterey Bay (81)	-	-	-	11	11 (33)	15	<1	-	15 (45)	-	-	1	1	3 (8)	5 (14)	33 (1)	8	152	2,575	2,735	2,768
4.03 Santa Monica (95)	-	-	-	1	1 (3)	<1	-	<1	1 (3)	-	-	-	-	- -	26 (94)	28 (1)	5	84	2,217	2,306	2,334
4.02 San Pedro Bay (71)	-	-	-	9	9 (20)	12	-	-	12 (28)	-	-	13	-	13 (30)	9 (22)	43 (1)	59	128	7,858	8,046	8,089
4.01 San Diego Bay (97)	-	-	-	1	1 (4)	19	-	-	19 (52)	-	-	10	-	10 (26)	7 (18)	37 (1)	43	131	4,593	4,767	4,804
Estuarine Total	1	-	-	1,108	1,109 (10)	1,783	141	23	1,948 (17)	2	3,831	1,594	225	5,652 (49)	2,768 (24)	11,477 (5)	3,689	17,476	181,481	202,645	214,122

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

[a] Values in parentheses represent the percent of estuarine drainage area 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 estuarine drainage area grid sampled by NOAA that is wetlands.

Appendix IV.

Table 1. Coastal wetlands classified for the West Coast region.

NOAA	FWS [a]		Common Plant Community [b]
Salt Marsh			
Brackish	Estuarine intertidal emergent regularly and irregularly flooded salinity ≥ 0.5 ppt and ≤ 30 ppt		three-square (*Scirpus olneyi*) salt hay grass (*Spartina patens*) pickleweed (*Salicornia virginia*)
High	Estuarine intertidal emergent irregularly flooded salinity ≥ 30 ppt		california cordgrass (*Spartina foliosa*) salt hay grass (*Spartina patens*) sea blite (*Suaeda linearis*)
Low	Estuarine intertidal emergent flooded or irregularly exposed salinity ≥ 30 ppt		salt weed (*Distichlis spicata*)
Unspecified	Estuarine intertidal emergent		see "Brackish" "High" and "Low"
Fresh Marsh			
Nontidal	Lacustrine littoral emergent nontidal Palustrine emergent nontidal Riverine lower perennial emergent nontidal		watermilfoil (*Myriophyllum spicatum*) duckweed (*Lemna minor*) water lilies (*Nynphaea odorata*)
Tidal	Lacustrine littoral emergent tidal Palustrine emergent nontidal Riverine tidal or lower perennial emergent tidal		soft stemmed bulrush (*Scirpus Validos*) rice cutgrass (*Leersia oryzoides*) river bulrush (*Scirpus fluvialilis*)
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		douglas spiraea (*Spiraea douglasii*)
Nontidal fresh	Palustrine forested or scrub-shrub nontidal		willow (*Salix Spp.*) sitka spruce (*Picea sitchemsis*) lodge pole pine (*Pinus contorte*)
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*) duckweed (*Lemna minor*) 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.

[b] Source: Weinmann, F., M. Boule , K. Brunner, J. Malek, V. Yoshino, 1984. *Wetland Plants of the Pacific Northwest.* U.S. Army Corps of Engineers, Seattle District. 85pp.

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 15 1:24,000-scale NWI maps in San Francisco Bay, CA (Table 1). These data were developed by the FWS using the Map Overlay Statistical System (MOSS).

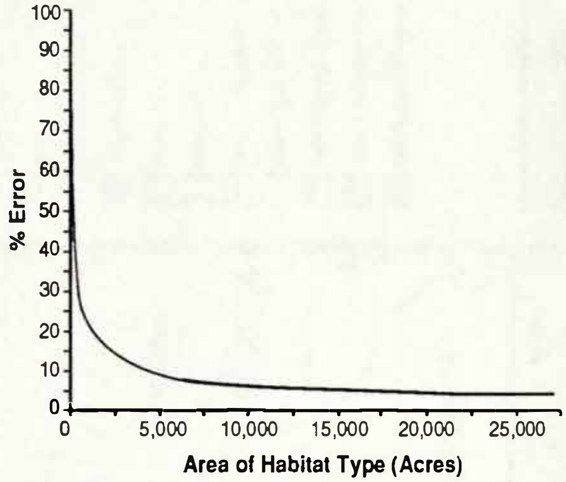


Figure 1. Predicted error as a function of habitat area.

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

Table 1. Comparison of NOAA's grid sampled data to FWS' digital data for 15 1:24,000 scale NWI maps from San Francisco Bay, California

Habitat	NOAA	NWI	% Difference
Salt Marsh	42,716	41,970	1.7%
Fresh Marsh	15,762	16,074	-2.0%
Forested & Scrub-Shrub	28,758	29,094	-1.2%
Tidal Flats	45,477	45,713	-0.5%
Upland	281,458	280,000	0.5%
Open Water	153,848	152,448	0.9%

San Francisco Bay
CA

PHYSICAL AND HYDROLOGIC CHARACTERISTICS

PHYSICAL

Surface Areas (mi²)	
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	
Tidal Fresh	[illegible]
Mixing Zone	[illegible]
Seawater	[illegible]
Total	[illegible]
Dimensions	
Length (mi)	82.0
Width (mi) Average	5.2
Minimum	1.0
Maximum	10.7
Average Depth (ft)	22.3
Average Depth to Width Ratio	[illegible]
Stratification Classification	
3 Month High Flow	MS
3 Month Low Flow	VH

FRESHWATER INFLOW

Flow Rates (1000 cfs)			
Long Term Average Daily	[illegible]		
Long Term Average Monthly	J [illegible]	J [illegible]	
	F [illegible]	A [illegible]	
	M 33.6	S [illegible]	
	A 35.0	O [illegible]	
	M 30.3	N [illegible]	
	J 21.0	D 38.4	
7-Day 10-Year Low Flow	6.3		
50-Year Flood	[illegible]		
100-Year Flood	[illegible]		
Flow Ratios			
Average Annual	0.032		
High Flow Period	[illegible]		
Low Flow Period	[illegible]		

TIDAL DATA

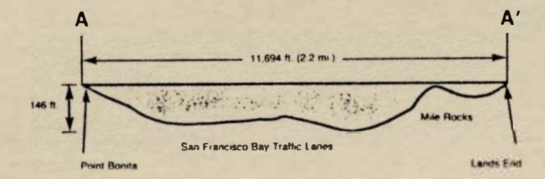
Prevailing Tide: Semidiurnal

Phase Range of Tide (ft)

Map Key	Station	Range
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	585	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	643	[illegible]
[illegible]	659	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	694	[illegible]
[illegible]	[illegible]	0.2

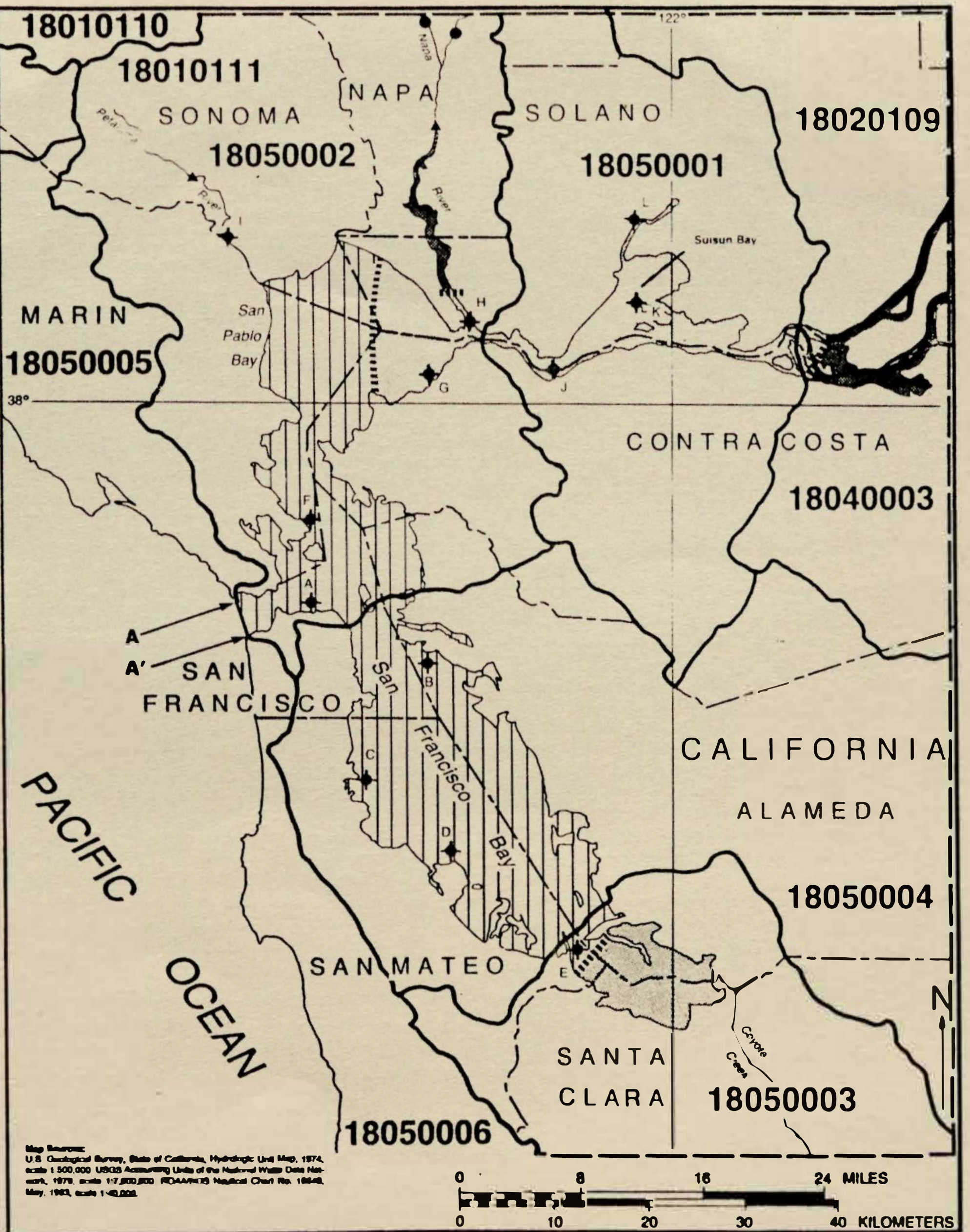
Abbreviations: Vertically Homogeneous: VH, Moderately Stratified: MS, Highly Stratified: HS

Cross Section (at mean high water)



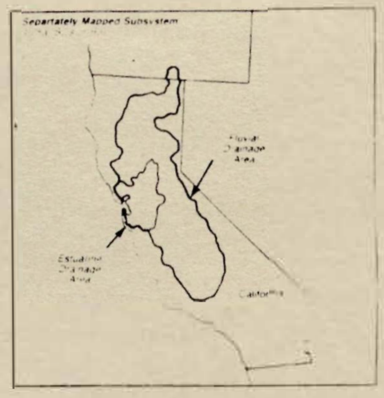
Notes:
Approximately 70% of Estuarine Drainage Area is shown on map

References:
Hamilton and Macdonald, ND. Fogelman, et al., 1982. Crippen and Beall, 1970. Davis, 1982. Hardner, 1977. Kristof, 1979. U.S. Department of Commerce, 1983a.



Map Sources:
U.S. Geological Survey, State of California, 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. 18649, May, 1983, scale 1:40,000.

0 8 16 24 MILES
0 10 20 30 40 KILOMETERS



- 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

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