Charleston Harbor

Special Area Management Plan

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Prepared by
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Office of Ocean and Coastal Resource Management

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Foreword

As with any major planning effort, this management plan represents the work of a great many people. What sets the Charleston Harbor Project (CHP) Special Area Management Plan apart, at least in the realm of federally funded projects, is that the impetus and the direction came from the local community. NOAA is to be commended for allowing the local resource managers, local researchers, and local citizens to set the tone and make the decisions on the direction this project should take.

Critical to focusing state and local efforts and seeking assistance from the appropriate federal programs, were Senator Fritz Hollings and his staff. Senator Hollings, well known for his support of vital coastal zone management programs and environmental protection, provided guidance and introduction to the federal programs with mandates to support management of estuarine resources. Along with other members of Congress, his past support of the Sea Grant program and other water resources programs that build significant local research teams in South Carolina universities and elsewhere, and his support of NOAA and other agencies to pursue special area management plans and estuarine studies provided the vital expertise and funding to undertake the Charleston Harbor Project.

Seeing that these vital federal and state resources were effectively and efficiently directed was a strong suit of the Charleston Harbor Project. Heyward Robinson, who shepherded the Project nearly from inception to the final stages, did so with vision and exceptional leadership. We were fortunate to have someone with the hands-on regulatory background necessary to understand the management needs and the technical background to be able to direct the research. This is a unique blend, and Heyward consistently showed his mastery of the issues and used his unusual vantage point to bring a complicated project to successful conclusion.

The CHP was complicated because a new locally led approach was necessary, the magnitude of the problem was extensive, and interdisciplinary investigative teams were needed to efficiently focus the funds available onto common objectives. We appreciate the adaptation that local, state, and federal agencies underwent to support the local vision for investigating Charleston Harbor. Resource degradation of estuaries has rarely been addressed early enough because mandates for air, water, and land protection and preservation are constitutionally and legislatively split between different levels of government and many different agencies. The dominance of urban land uses in the local contributing watersheds affects almost each drop of water flowing through the Harbor. The only effective means to understanding the degradation of Charleston Harbor and relate the degradation to the causes was to employ nationally recognized teams of interdisciplinary experts to evaluate the resources and trends in water quality.

Earlier attempts to protect the environment have been successful. Because of the Clean Water Act, Charleston Harbor is cleaner than thirty years ago. The Clean Air Act has had the same effect on air quality. But the sheer volume of the changes that are occurring begin to overwhelm these single-issue regulatory programs. The Coastal Zone Management Act is largely designed to weave these various programs together for the overall protection of coastal resources. Unfortunately, this approach has seldom been used because it is difficult to develop a system to address the cumulative impacts of hundreds of decisions that affect the environment.

The lack of information about how the ecosystem works is the main stumbling block to developing protective measures. Recognizing this, the CHP assembled a number of experts and gave them the tasks of finding and filling gaps in our knowledge of resource status and protection. The process of watching very competent people uncover relevant questions and explore possible answers was an inspiration. They performed their tasks admirably. Unfortunately, they cannot all be listed in this report, but a brief summary of all their research is given in the appendix.

All of us who worked on the CHP are proud to have been a part of this effort. The problem has been laid out and a plan designed. It is now up to each of us to insure our natural and cultural heritage is protected.

Referenced Sites Within the
Charleston Harbor Project Study Area

Origin and Purpose

The Charleston Harbor Project (CHP) evolved from a grass-roots effort to plan for the rapid urban growth projected for Charleston, Berkeley, and Dorchester counties. With the completion of the Mark Clark Expressway, large tracts of previously inaccessible land became available for development. Knowing that unplanned industrial and urban development could rapidly overwhelm a region's watershed resources, local leaders realized patterns of growth in other coastal communities could provide lessons for Charleston. These communities, similar in character to Charleston, had developed too quickly without an appreciation of the environmental consequences, resulting in the degradation of their watersheds and deterioration of their overall quality of life. In 1989, a volunteer citizens group, the Charleston Harbor Estuary Committee, united in an effort to encourage planning to manage the projected growth. Their objective: *to protect the unique, high quality of life in the Charleston area from the inadvertent resource degradation experienced by many urban coastal communities.* With help from The South Carolina Sea Grant Consortium, a series of educational seminars were held and position papers were designed to obtain federal funding for the preparation of a comprehensive management plan. As a result of these efforts, Department of Health and Environmental Control (DHEC) and Environmental Protection Agency (EPA) worked to have Charleston Harbor designated a part of the National Estuary Program. In 1991 it was finally decided the best way to proceed was for the Office of Ocean and Coastal Resource Management of the National Oceanic and Atmospheric Administration (NOAA) to provide funding for a Special Area Management Plan (SAMP) through the CHP. The objective of the SAMP is to provide guidelines for growth that will protect the natural and cultural resources of the area, strengthen the area's diverse economic resources, and provide managers and leaders with the information necessary to manage and direct this growth. The ultimate goal is *to sustain the rich economic, cultural, and natural resources of the Charleston Harbor Estuary.*

The objective of the SAMP is to provide guidelines for growth that will protect the natural and cultural resources, and provide managers and leaders with the information necessary to manage and direct this growth.

An initial grant in 1991 allowed for preliminary planning and a review of available information pertinent to the Charleston Harbor Estuary. These actions revealed that no serious ecological or water quality problems were present in the estuary and that toxic pollutants were not a widespread problem. Based on these findings, NOAA set the mission of the Charleston Harbor Project: *to conduct resource management oriented research and develop policies that would protect the balance between economic, cultural, and natural resources of the area for the next twenty years.* To accomplish this, funding of $5,642,500 for the next five years was provided to develop the management plan.

The CHP is administered through the Office of Ocean and Coastal Resource Management (OCRM) of DHEC. Section IV (F) of the South Carolina Coastal Zone Management Plan provides for the development of Special Area Management Plans when conflicts of uses are widespread and these conflicts threaten coastal resources. The "Goals and Objectives" of the CHP were developed by twelve topical task forces consisting of representatives of federal, state, and local governments, industry, the private sector, and interested citizens. These were adopted during the first year of the program and are in effect today:

(1) To maintain and enhance the quality of the environment in the Charleston Harbor estuarine system.

(2) To maintain the range of uses of waters and natural resources of the system.

(3) To anticipate and address potential problems before adverse impacts occur.

Rapid urbanization of the watershed with the consequent nutrient enrichment of the estuary is seen as the most probable cause of future degradation of the Charleston Harbor Estuary.

As these objectives indicate, preservation of the natural resources and maintenance of the quality of the environment for the Charleston Harbor region are supported by an approach to anticipate and address potential problems before they occur.

Rapid urbanization of the watershed with the consequent nutrient enrichment of the estuary is seen as the most probable cause of future degradation of the Charleston Harbor Estuary. Because land use is a vital issue in the future degradation of Charleston Harbor, this Project finds that a local, state, and federal government partnership with industry and the public must continue and focus on gaps between single purpose regulatory programs. Comprehensive coastal zone management requires that minimum requirements of air, water, solid waste, and land use laws be continually examined and upgraded where necessary to protect the unique cultural, natural, and economic resources of the Charleston area.

To achieve the objectives of the CHP the following six vital topics were investigated: (1) stormwater and point and nonpoint source inputs; (2) biological resources; (3) dredged material disposal; (4) land use and population growth; (5) public access and its utilization; and (6) data management and retrieval. Within this framework, sixty-two applied research studies were planned and conducted over a five-year period. These studies were designed to fill the gaps in the current state of knowledge and, thus, effectively complete the overview of Charleston Harbor resources. This body of research establishes a framework of information sufficient for long-term planning and the management of the Charleston Harbor Estuary at the watershed level. It also provides a basis for the methodical management of the estuary in an ecologically meaningful way. Managers can readily focus their activities where they are most needed by identifying areas for protection, research, restoration, and mitigation. Management of the Charleston Harbor Estuary at the watershed level enables managers to make individual decisions in the context of all of the region's resources. This large-scale view will make the permitting process more predictable and flexible for the business community, while providing the public with better resource management and protection.

The Counties of South Carolina and the Boundary of the Charleston Harbor Project

CHP Organization

The CHP was organized into four levels: task forces, focus groups, the Management Committee, and the Administrative Board. The Policy Steering Committee and the Oversight Committee were also created to assist in the implementation of the CHP. The South Carolina Board of Health and Environmental Control has oversight over all actions of OCRM and the CHP. The purpose of each group is described below.

Task Forces

In order to involve as many different viewpoints as possible and have public participation in the Charleston Harbor Project, twelve task forces were organized. Over 200 individuals participated on the task forces, representing the private sector, concerned citizens, and federal, state, and local jurisdictions. They identified research needs and developed investigative proposals within their focus areas. The twelve task forces were organized around the following resource management topics:

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Biological Resources	Marina
Cultural Resources	Point Source
Data & GIS	Public Involvement
Dredge/Spoil Disposal	Recreation
Economic	Storm Water
Land Use	Water Quality Modeling

Each research project was associated with one of the task force groups. However, this division was too narrow in scope to efficiently formulate a comprehensive plan. Therefore, all Charleston Harbor Project research was grouped into three larger categories: water, biological resources, and urban growth. Water Resources Management, Biological Resources Management, and Growth Management were the corresponding focus groups established to analyze data and make management recommendations.

Focus Groups

The focus groups were composed of researchers, task force members, and local, state, and federal experts in each field. Each group formed its own recommendations, based on completed research, which were then synthesized into one set of recommendations by the focus group leaders, policy makers, managers, and other officials. This set of recommendations was presented to the Charleston Harbor Project Management Committee for refinement and approval.

Policy Steering Committee

The Policy Steering Committee was formed to develop initial policy recommendations for the Charleston Harbor Project management plan for the watershed. The Policy Steering Committee was composed of representative stakeholders in the project, from federal, state, county, and municipal governments to industrial and urban development interests in the private sector. The group worked closely throughout the 1997 summer with the CHP focus group leaders and CHP researchers to review research findings and develop policy recommendations, with the ultimate goal of submitting the proposed policy recommendations to the task forces and the Management Committee for review.

Management Committee

The Management Committee is composed of the chair and vice chair of each task force, the CHP Director, and representatives of DHEC/OCRM, the National Marine Fisheries Service (NMFS), and Sea Grant. The Management Committee reviewed the proposals developed by the task forces and recommended projects for funding based on the projects' priority to the overall goals of the CHP. The Management Committee also reviewed the recommendations of the focus groups, decided which would be in the final management plan, and reviewed the drafts of the management plan prior to final plan approval.

Administrative Board

The Administrative Board is composed of a NOAA/OCRM representative, two DHEC/OCRM representatives, and the CHP Director. The Administrative Board reviewed CHP funding proposals and other activities to insure that NOAA mandates were met.

Oversight Committee

The DHEC/OCRM Oversight Committee was composed of the South Carolina Coastal Council Chair and Vice Chair, members of the council whose congressional districts are within the CHP area, and members representing the three counties in the CHP area. However, as a result of the restructuring of South Carolina state government in July 1994, the Oversight Committee was disbanded.

DHEC Board

Like all state agencies in South Carolina, DHEC has an administrative board that is responsible for the overall direction of the agency. The DHEC Board was kept informed of the work of the CHP and approved the management plan.

Organizational Structure of The Charleston Harbor Project

Description of the Project Area and the State of the Harbor Resources

The Human Setting:

The greater Charleston area is better known as the Trident Region and is comprised of portions of Berkeley, Charleston, and Dorchester counties. The area includes twenty-five incorporated communities ranging in size from Jamestown in Berkeley County, with a population of approximately 84, to the City of Charleston with about 104,000 residents. The total population of the three counties doubled between 1960 and 1990 and is expected to increase to 619,500 by the year 2015. Administratively, the counties are served by their respective county councils and the combined Berkeley-Charleston-Dorchester Council of Governments (COG). Charleston County is the state's most urban county with 88% of its residents living in an urban setting (as defined by the U. S. Census). Similarly, Berkeley and Dorchester counties are significantly more urban than rural, with respectively 65.1% and 67.4% of their populations classified as urban.

The total population of the three counties doubled between 1960 and 1990 and is expected to increase to 619,500 by the year 2015.

The economy is heavily influenced by tourism, the Port of Charleston, health care, and several large industrial employers. Charleston Harbor's port facilities, composed of an extensive network of modern shore side facilities, represent the largest economic resource associated with the Charleston Harbor Estuary. Most of the $10.7 billion in 1997 sales revenues attributed to South Carolina's ports came through Charleston. During the State Ports Authority's 1999 fiscal year, which ended in June, 13.3 million tons of cargo moved through the port aboard 2,457 ships and barges. The Port of Charleston is the number one container port on the southeast and gulf coasts and is second only to the combined ports of New York and New Jersey on the entire eastern seaboard. Until 1994, the U.S. Navy maintained its third largest home port on the Cooper and Wando rivers. These facilities consisted of a naval shipyard and weapons station and served more than 70 surface vessels and submarines. Charleston International Airport provides commercial and military air service for the region and currently serves over 1.5 million passengers annually. Six private airports located throughout the region can accommodate both corporate and private aircraft. Approximately 100 motor carriers and three railroads serve the Trident Region and, along with Interstates I-26, I-95, and I-526, provide access to residential, private, government, and commercial concerns. Six colleges and universities are located within the region with a combined annual enrollment of almost 27,000 students.

The Tri-County Area, Berkeley, Charleston, & Dorchester Counties with the CHP boundary

Although there are no major industries located on the harbor, the basin is surrounded by urban development and receives secondarily treated effluent from two sewage treatment facilities on Plum Island and in Mount Pleasant. The number of permitted point sources of pollution in the Charleston Harbor estuary decreased from 115 in 1969 to 67 in 1996. The volume of these discharges decreased from 328 to 205 cubic feet per second (9.3 to 5.8 m3/s) during the same time period. Other sources of pollution affecting the harbor include nonpoint source runoff from the city and other urban areas, marina facilities near the mouth of the Ashley River, and runoff and discharges from forested and agricultural lands. Several diked, dredged material disposal areas are located in the harbor area, with the largest being Drum Island. The water quality of the harbor's tidal saltwater is rated as suitable for fishing and boating, but not for swimming, and the harvesting of oysters, mussels and

clams is prohibited. However, reviews of data collected by DHEC reveal that the water quality within the basin often meets higher standards for dissolved oxygen and fecal coliform than the ratings indicate.

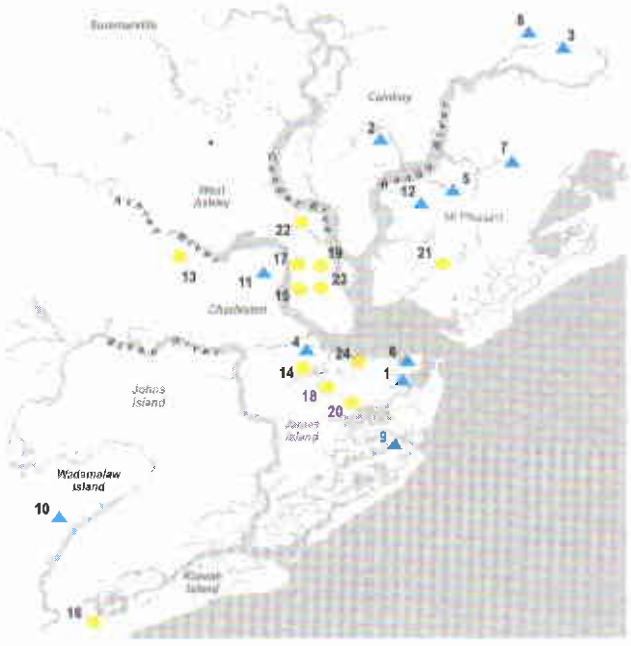
Creeks in Tidal Creek Study

▲ Reference Creeks

1 Battery Simkin Creek
2 Beresford Creek
3 Deep Creek
4 Dill Creek
5 Foster Creek
6 Grice Cove Creek
7 Horlbeck Creek
8 Lachicotte Creek
9 Lighthouse Inlet Creek
10 Long Creek
11 Orange Grove Creek
12 Rathall Creek

● Developed Creeks

13 Bull Creek
14 Cross Creek
15 Diesel Creek
16 Kiawah Creek
17 Koppers Creek
18 Metcalf's Creek
19 New Market Creek
20 Parrot Creek
21 Shem Creek
22 Shipyard Creek
23 Vardell Creek
24 Yacht Club Creek



Among the three river systems that form the Charleston Harbor Estuary, the Cooper River has the greatest number and density of industrial and port facilities. The majority of these are located on the western shore and include the former U. S. Navy port facilities, commercial facilities associated with the State Ports Authority, and numerous private companies. To accommodate shipping traffic, a 40 feet (12.2 m) deep navigation channel is maintained in the lower Cooper River and extends 20 miles (32 km) upstream from the mouth of the river. The eastern shore of the Cooper River is relatively undeveloped, although there are several diked dredged material disposal sites along the length of the maintained channel.

In 1954, Bushy Park Industrial Area was established along the east bank of the Back River and the west bank of the Cooper River. To provide freshwater to the industrial complex, the Back River was dammed near its confluence with the Cooper River and the 11-km Durham Canal was constructed as a freshwater supply from the upper Cooper River. Downstream of Flag Creek, industries dominate the eastern bank of the river and the west bank serves as a dredged-material disposal area. There are 22 industrial and municipal permitted point dischargers into the Cooper River with a combined flow of 127 ft3/s (3.6 m3/s). The water quality rating of the lower basin is rated as suitable for fishing and crabbing, but not for swimming or the harvesting of clams, oysters or mussels. Water quality often meets higher standards than the rating for oxygen and fecal coliform.

The Ashley River has the second largest number of industrial and commercial facilities, most of them located along the eastern shoreline. There are seven permitted municipal dischargers in the basin with a combined discharge of about 53 million gallons per day. Much of the remaining upland area on both sides of the river supports residential developments. Water quality in the Ashley River is suitable for fishing and boating, but not for the harvest of clams or for swimming.
The Wando River presently has the least upland development compared to the other two river systems, except in its lower reaches. In that area on the eastern shore, the State Ports Authority maintains the Wando Terminal facility. There are also several residential communities present and/or being developed on this shore-

line. Large dredged material disposal areas are located on Daniel Island, which forms the western shoreline of the Wando River. The only major industrial facility on this river is the Detyens Shipyard across from Cainhoy. Water quality above the Wando Terminal is suitable for harvesting clams, mussels, and oysters for human consumption. Water quality in the lower Wando River is similar to that of the Ashley River.

The CHP area contains some of the most significant historic and archeological sites in the United States.

The CHP area also contains some of the most significant historic and archeological sites in the United States. Cultural resources include historic buildings, structures and sites, unique commercial and residential areas, unique natural and scenic resources, archeological sites, and educational, religious, and entertainment areas or institutions. In some areas preservation programs are effective in maintaining these resources. In other areas these resources are being lost or neglected primarily because of our limited knowledge. There is a continuing need for surveys to identify the cultural resources, their locations and significance. This knowledge must be made available to local officials and interest groups to gain greater support of preservation programs and other cultural activities.

The Natural Setting:

The Charleston Harbor Watershed

The wide variety of habitats present in the estuary support a diverse array of flora and fauna, including more than 80 species of plants, over 250 species of birds, 67 species of mammals, over 570 species of invertebrates and fin fish, and at least 580 species of plankton.

The Charleston Harbor Watershed lies entirely within the South Carolina Coastal Plain and consists of sedimentary deposits of sand, gravel, clay, marl, and limestone resting on metamorphic and igneous rocks. Overlying these deposits are marine and riverine sediments and a thin veneer of sand, clay, and shell comprising Pleistocene and Recent formations. The watershed is composed of 63% uplands, 19% open water, 11% freshwater wetlands, 6.5% estuarine marsh, and less than 0.5% estuarine tidal creeks. Upland land use patterns within the watershed are 61.6% forested, 11% urban, 9.3% forested wetlands, 7.7% non-forested wetlands, 6.3% scrub/shrub/disturbed, 3.8% agricultural and grasslands, and 0.3% barren. Federal, state, county, and municipal governments own 302,122 acres (122,267 hectares) of the forested watershed lands. Farmers, corporations, and private individuals own the remaining 638,820 acres (258,527 hectares) or 68% of the total forested lands within the watershed. The forests are composed of approximately 45% loblolly, slash, and short- and long-leaf pines, and 20% oak/hickory hardwoods. Annual precipitation is 49 inches per year (124.9 cm). The wide variety of habitats present in the estuary support a diverse array of flora and fauna, including more than 80 species of plants, over 250 species of birds, 67 species of mammals, over 570 species of invertebrates and fin fish, and at least 580 species of plankton.

Within the watershed is the Charleston Harbor Estuary, located in the central portion of South Carolina's coastline and formed by the confluence of the Ashley, Cooper, and Wando rivers. An estuary is a mixing zone where the land and the sea meet, providing habitat for salt water and freshwater organisms and those that live in between. Highly dynamic, estuaries are influenced by the salinity gradient that extends from pure seawater to freshwater upriver, and the tide that provides the energy that mixes the fresh and saltwater.

The average depth of the estuary basin is 12 feet (3.7 m) at mean low water (MLW), but navigation channels have been deepened to 40 feet (12.2 m) MLW. The mean tidal range is 5.2 feet (1.6 m), and spring tides average 6.2 feet (1.9 m). Water temperatures range from 38E to 87EF (3.5° to 30.7°C), and average 67EF (19.4° C). Salinities range from 0 to 35.6 parts per thousand within the estuary. Similarly, dissolved oxygen levels range from 0 to 17.1 miligrams per liter, averaging 7.3 mg/l over the entire estuary.

The diversion of the Santee River into the Cooper occurred in 1941 when the Works Progress Administration (WPA) completed the Santee-Cooper Hydroelectric Project. This environmental modification effectively increased the drainage area of the Charleston Harbor Estuary over eleven times to a watershed of approximately 15,800 square miles (41,000 km^2). The increase was primarily due to the inclusion of the Santee River drainage basin, one of the largest river basins on the east coast of the United States. The Cooper River was thus transformed from a tidal slough with an average monthly flow of 417 cubic feet per second (11.8 m^3/s) to a riverine system with a flow of 5,339 cubic feet per second (496 m^3/s). This diversion transformed Charleston Harbor from a well-mixed to a partially-mixed estuary and created an efficient sediment trap. After diversion, average salinities in the harbor dropped from 31 to 16 per cent.

Prior to the construction of the hydroelectric project, shoaling in Charleston Harbor was minor and required the annual removal of 180,000 cubic yards (137,620 m^3) of sand and silt. Following the project's completion, shoaling in the harbor increased to the point where the annual removal of 7,600,000 cubic yards (5,800,000 m^3) was required to maintain the authorized navigation channels. To alleviate the shoaling problems, an 11 mile (18-km) rediversion canal from Lake Moultrie to the Santee River was constructed. Completed in 1985, the Cooper River Rediversion Project diverted approximately 70% of the Santee drainage water back into the Santee River through the canal located near St. Stephens, South Carolina. The rediversion canal reduced the Santee flow into the Cooper River at Pinopolis Dam to approximately 4,520 cubic feet per second (128 m^3/s).

The Cooper River

The Cooper River watershed is extremely complex due to the Santee-Cooper Hydroelectric Project and the subsequent rediversion in 1985. The lower component of the basin, which is the portion located within the CHP management area, extends 50 miles (81 km) from the Pinopolis Dam to the mouth of the Cooper River on the north side of the Charleston peninsula where it flows into Charleston Harbor. This section of the river drains almost 1400 square miles (3,625 km^2) of midlands and lowlands, including fresh and brackish wetlands. The West Branch Cooper River is 17 miles (26.5 km) long and flows from the Tail Race Canal at Moncks Corner to its junction with the East Branch. This reach is a meandering natural channel bordered by extensive tidal marshes, old rice fields, and levees in varying states of disrepair. The area contains volumes of poorly defined overbank storage and immeasurable flows because of broken levees between the channel and old rice fields. The East Branch Cooper River is 7.6 miles (12.3 km) long and flows from its headwaters in Hell Hole Bay to its junction with the West Branch, commonly referred to as the "Tee." The East Branch is a tidal slough throughout its 7.5 miles (12 km) length. The river then flows 17.7 miles (28.5 km) to its junction with the Charleston Harbor basin on the north side of the Charleston peninsula.

The long-term effects of rediversion on the marsh vegetation of the estuary are still unknown.

The long-term effects of rediversion on the marsh vegetation of the estuary are still unknown. A redistribution of plant species may occur along the estuarine gradient, and some plant communities on the upper Cooper River may be influenced by changes in water level due to the lower flow rates. The estuary does not support extensive subtidal seagrass beds or benthic algae communities, except in the upper Cooper River where the freshwater algae (*Egeria densa*) is abundant. This lack of benthic plants is related to the low transparency of the estuarine waters combined with a lack of suitable substrate. A few species of coastal/estuarine algae (*Porphyra sp.* and *Ulva sp.*) are found in the intertidal areas of the lower harbor basin.

The Ashley River

The Ashley River was not affected by rediversion above its juncture with the harbor basin because it is not connected to the Cooper River at any point. The river flows approximately 31 miles (50 km) from its headwaters in Cypress Swamp in Berkeley County to its junction with the Intracoastal Waterway on the south side of the Charleston City Peninsula, where it empties into the lower harbor basin. The river basin drains a 216-square-mile (900 km^2) area of marsh and lowlands, spread out over Dorchester, Berkeley, and Charleston counties. Depths of the natural channel in the river range from 5.9 to 36 feet (1.8 to 11.0 m) and are influenced by tidal action throughout the river's entire length. Essentially a tidal slough, the tidal ranges of the Ashley River amplify progressively upstream. The extent of saltwater intrusion on the river varies greatly with the hydrologic condition of the basin. During extremely dry periods, with little freshwater draining from Cypress Swamp, saltwater extends throughout most of the Ashley River. During periods of heavy precipitation, saltwater can be limited to the lower part of the river below Drayton Hall. The banks of the river are dominated by *Spartina* marshes.

The Wando River

The Wando River is a tidal river that flows approximately 24 miles (38 km) from its headwaters in I'on Swamp in Charleston County to its junction with the Cooper River on the north side of the Charleston City Peninsula. The river drains 120 square miles (310 km^2) of marsh and lowlands, and its depth ranges from 5 feet to 42 feet (1.5 to 12.8 m). The Wando is influenced by tidal action throughout its entire length, and estuarine waters extend into the creeks that form its upper limits. Like the Ashley River, the tide ranges are amplified as they progress upstream. The Wando River has the best water quality of the three rivers. Above the Wando Terminal the water quality is suitable for harvesting clams, mussels, and oysters for human consumption. The banks of the River are dominated by extensive *Spartina* and *Juncus* marshes.

Estuarine Habitats

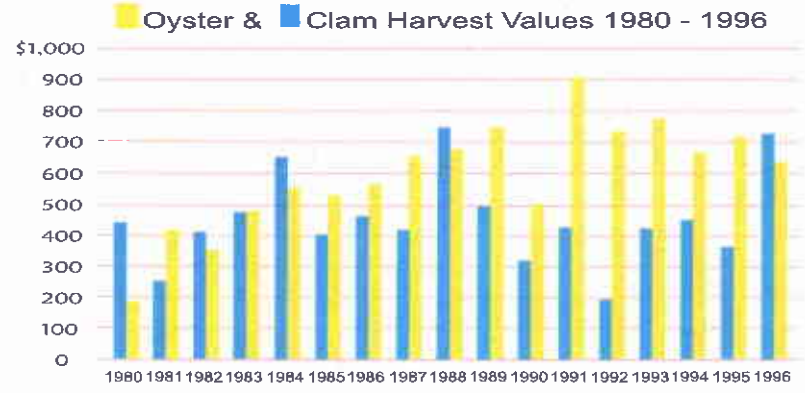
The rise and fall of the tide and the ebb and flood of the tidal currents provide a highly diverse habitat for the plants and animals common to the Charleston Harbor Estuary. Marsh vegetation is extensive in the estuary due to the gently sloping coastal plain and the tidal range. The estimated acreage of the marshes in this area exceeds 52,000 acres (21,000 ha) of which 28,500 acres (11,500 ha) consist of brackish and salt marsh, 18,500 acres (7,500 ha) consist of freshwater marsh, and approximately 5,000 acres (2,000 ha) lie within impoundments. A diverse assemblage of plant species typically found throughout the Southeast is found within the estuary with the distribution determined by salinity and the duration of inundation. The tidal marshes of the Ashley and Wando rivers reflect a strong marine influence, with salt and brackish water marshes existing throughout almost all of their length. The Cooper River marshes exhibit a wide range of vegetation, changing markedly from salt to brackish to freshwater species. The flow rate and salinity of the Cooper has been significantly altered by the diversion of the Santee into the Cooper and the 1985 rediversion project.

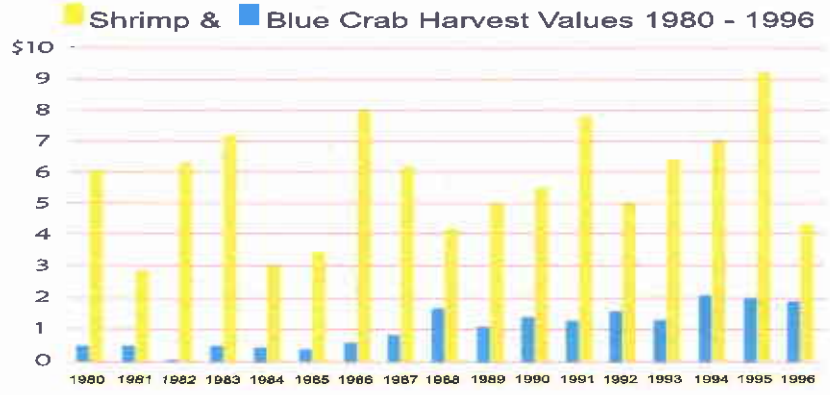
The shallow-water marsh serves as a refuge by providing a diversity of habitat and by excluding predators from the upper reaches of the estuary.

The shallow marsh habitats of the Charleston Harbor Estuary provide seasonal year-round habitats for a diverse assemblage of adult and juvenile finfish and crustaceans. Our understanding of why shallow estuarine habitats are important to the early life histories of many species of finfish, crustaceans, and clams is incomplete, yet much is known. The highly productive marshes provide abundant food resources for early life history stages. The shallow-water marsh also serves as a ref-

uge by providing a diversity of habitat and by excluding predators from the upper reaches of the estuary. These advantages may result in reduced competition, lower mortality, and faster growth rates. Many of these species are either commercially or recreationally valuable. The estuary contributes approximately 20% and 8% of the state's shrimp and crab landings, respectively. Spot, Atlantic croaker, red drum, spotted seatrout, flounder, and catfish inhabit the estuary and are recreationally important. The estuary also supports numerous ecologically important species such as bay anchovy and grass shrimps, which serve as food for economically and recreationally important species. Young of several species of finfish that are spawned in the lower estuary or ocean enter the shallows of the estuary as juveniles and stay until they reach larger sizes or until lowering winter temperatures drive them seaward.

The spatial distribution of the species living in the bottom of the Charleston Harbor Estuary is similar to that of other estuaries along the mid-Atlantic, southeast and gulf coasts of the United States. Studies suggest that there is little difference between pre- and post-rediversion assemblages, at least at this time. Several dominant species appear to be decreasing in abundance in certain reaches of the estuary. Numerically dominant species include mollusks, polychaetes, oligochaetes, nematodes, and amphipods. Within the harbor basin, several sites show evidence of reduced benthic diversity, low faunal abundance, or small-scale differences in community composition. This is perhaps related to either dredging activities or the Plum Island sewage outfall. Such changes are probably permanent, especially if dredging is the causal agent, as dredging communities become dependent on dredging for their maintenance. Among the three river systems, average diversity values are lower in the Cooper River than in the Ashley and Wando rivers. The lower diversity in the Cooper River may reflect adverse effects from the greater number of industrial and port facilities in this system as compared to the other two river systems.





Studies show that many of the changes experienced within the estuary are atypical of an estuarine system whose freshwater inflow has been reduced. In a typical estuary, the mixing zone is an important nursery area for new recruits. Many species utilize the shallows of these areas independent of salinity. Many species also use the tidal stream transport to initially colonize the upper estuary. Increased flow rates displace the freshwater line seaward, compress the freshwater boundary horizontally and vertically, and prevent flood-tide displacement into the recruitment areas. Hence, a decrease in flowrate, as occurred in the rediversion, should enhance the recruitment process. There are suggestions that reductions of flowrates by diversions result in a reduction in the overall size of the estuarine nursery habitat and in disruption of spawning and nursery cycles. Evidence suggests that a reduction of flow by as little as 30-40% can destroy the dynamic equilibrium of an estuary within three to seven years and may increase the impacts of pollutants by four to twelve times. In many ways the Charleston Harbor Estuary is a typical estuary in its role in recruitment and as a nursery. Yet, rather than the losses and destruction reported in other estuaries, there has been an increase in the use of this estuary by many more species as a nursery area, especially in the main channels of the rivers. It is possible that coincidental environmental conditions (drought or cold winters) may have caused any negative effects of rediversion to be eliminated, masked, or postponed. It may be that the continued regulation of the flow, as opposed to absolute elimination, has contributed to an improved end result. However, another possibility is that changes are occurring on a longer time scale and the current results represent a transitional phase in this process. It is also possible that the estuary is returning to its former, pre-1942 hydrographic/biologic character.

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Growth Management:

The Charleston Harbor Watershed is a complex of places and people who require goods, services, employment, shelter, and recreation. Its character is unique, having evolved out of centuries of human responses to numerous interrelated physical, economic, and social situations. The impacts of a growing population and its associated demands are causing managers to question the sustainability of the region's resources. Throughout the nation, estuaries and coastal waterways are experiencing environmental decline due to the pressure of increasing urbanization. Fortunately, by learning from their experiences and through the use of applied research and informed decision-making, local resource managers can prevent the degradation that other communities have experienced. This can be accomplished while at the same time sustaining the growth needed to ensure a strong economy and a growing population.

Charleston's location, climate, and natural resources are attractive to industrial and commercial investment, as well as to growing tourism and retirement markets. As a result, growth and change in the CHP area are expected to be significant over the next twenty years and will affect all those living in the CHP watershed. Local planning programs must play a major role in providing direction to this future growth and development. Between 1990 and the year 2015 the population is expected to increase by approximately 113,000 persons. Associated with this population growth is a projected increase of approximately 44,500 housing units, 55,600 additional jobs, 61,400 more motor vehicles, 25,500 more individuals enrolled in educational institutions, and the generation of an additional 13,651,000 gallons per day of wastewater. Opportunities for employment should increase and provide significantly more jobs. These increased numbers will generate challenging problems along with benefits. Large rural areas will be converted to urban uses, impacting biological communities and water quality. Associated with these changes is the public's interest in the type, location, quality, scale, rate, and sequence or